Upper Slate River Watershed Plan

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The Watershed Plan was created with generous financial support from:

CDPHE

CO

COLORADO

Water Quality Control Division

Department of Public Health & Environment

DNR

CO

COLORADO

Division of Reclamation, Mining and Safety

Department of Natural Resources

ACKNOWLEDGEMENTS

The Coal Creek Watershed Coalition (CCWC) is effective organization thanks to the support of our partners. In 2011, the CCWC Board of Directors and former Executive Director Anthony Poponi recognized the need for a Watershed Plan in the Slate River. The Upper Slate River Steering Committee (Steering Committee) was formed in early 2011 to represent local stakeholders and solicit input regarding the project from as many parties as possible. Steve Glazer, CCWC President, dedicated many hours to assure the success of this planning effort and has provided valuable comments and insights.

The Colorado Division of Mining Reclamation and Safety (DRMS) provided initial funding which was used to complete the Water Quality Data Analysis and Summary (WQ Summary). Tara Tafi was instrumental to securing these funds and others. She has also been an outstanding member of the technical committee. Several of her colleagues from DRMS have provided technical expertise at sampling events.

The Colorado Nonpoint Source Program (NPS Program), a part of the Colorado Department of Public Health and Environment (CDPHE), provided the grant funds to create the Watershed Plan. Bonie Pate has served as a flexible, understanding, and resourceful grant coordinator. Jennifer Bock of High Country Conservation Alliance helped facilitate Steering Committee meetings and other projects.

When CCWC expanded into the Upper Slate River Watershed, the Bureau of Land Management (BLM) and Crested Butte Land Trust (CBLT) became natural partners. Andrew Breibart, Brian St. George, Brent Lewis, and David Lazorchak have provided excellent technical comments for the Watershed Plan. Ann Johnston and Danielle Beamer not only partnered with CCWC, they ran with the findings presented in the Geomorphic Assessment Report to complete projects on CBLT properties. Ben Stratton, Mark Hatcher, and Gay Austin of the U.S. Forest Service (USFS) provided technical input and support during monitoring events. Ben provided valuable expertise during the review of the Total Maximum Daily Load (TMDL) Report.

Sarah Coleman, Crystal Edmunds, and Lulu Nelson built upon Nicki Devanny and others' efforts to improve public education and outreach in the Crested Butte Community. Rodney Due, Matt Peacock, and Shea Earley supported the planning effort as they represented the Town of Crested Butte.

Recent monitoring efforts could not have been completed without the assistance of Tara Tafi and other DRMS staff members, Skip Feeney and field technicians from CDPHE. The National Park Service (NPS), USFS, and BLM field technicians have collected many samples. Wendy Brown has provided many hours of volunteer time in the field and at meetings. Her expertise and perspective has been important on more than one occasion. Several VISTA members have served CCWC in the field and as the Watershed Plan was developed including: Nicki, Zach Guy, Crystal, and Lulu.

This plan was written with assistance from Laurie Rink of Aqua Ria, LTD. John Hess, a founding board member, and Zach Vaughter, execute director, provided excellent comments to draft versions and many hours of administrative support. Other Board, Technical, and Steering Committee members provided feedback to improve the Watershed Plan. Many local residents attended meetings and presentations and their input was also instrumental to this Plan. Thank you to everyone who has participated in the watershed planning process.

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EXECUTIVE SUMMARY

In 2011, the Coal Creek Watershed Coalition (CCWC) recruited local stakeholders to begin the watershed planning process in the Upper Slate River Watershed (Watershed). Watershed plans combine existing information and input of local stakeholders to create a comprehensive plan to address water quality impairments. During the watershed planning process stakeholders and partners identified the following desired outcomes for the Watershed:

1. To minimize water quality impairments attributed to historic abandoned mines.
2. To support healthy and diverse aquatic life.
3. To maintain or improve the overall channel function of the Slate River and its tributaries.

This Plan provides the pathway to implement the projects and activities necessary to achieve the desired outcomes.

CHARACTERISTICS OF THE UPPER SLATE RIVER WATERSHED

The Watershed is located near Crested Butte in Gunnison County, Colorado. The Watershed drains approximately 34 square miles on the east side of the Ruby Mountain Range. There are about 71 miles of streams and rivers in the Watershed. The headwaters of the Slate River lie below Purple Mountain and Yule Pass at nearly 13,000 feet. The first named tributary, Poverty Gulch, enters the Slate River from the west about five miles downstream of the headwaters. Oh-Be-Joyful Creek is a significant tributary that meets the Slate River about nine miles below the headwaters. Redwell Creek, which drains Redwell Basin, is tributary to Oh-Be-Joyful Creek. Beyond the confluence with Oh-Be-Joyful Creek, the Slate River flows on a sinuous trajectory through a large, broad valley to the Watershed outlet. The recreation path bridge, near Rainbow Park in Crested Butte, was designated as the Watershed outlet. The Watershed does not include drainage from the Coal Creek Watershed (Coal Creek Watershed is addressed in an existing Watershed Plan) or drainage from Washington Gulch, which flows into the Slate River downstream of the Watershed.

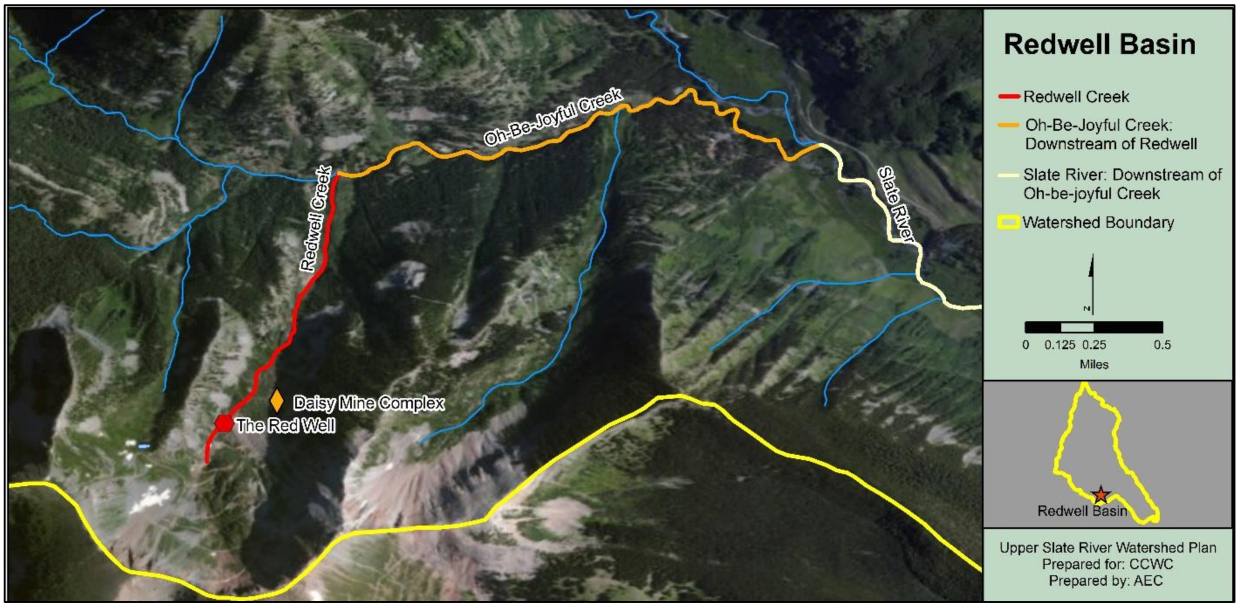
The majority of the Watershed is public land, managed by the United States Forest Service (USFS). The USFS manages 77 percent of the Watershed, 42 percent of which is designated as wilderness. The Bureau of Land Management (BLM) manages three percent of the Watershed. The remaining 20 percent of the Watershed is privately held. A large portion of the private land is owned by, or under conservation easements held by the Crested Butte Land Trust or the Town of Crested Butte. There are a handful of water rights that support irrigated pastures and ponds in the lower Watershed and near the Pittsburg town site. There are instream flow rights for the Slate River and Oh-Be-Joyful Creek and minimum lake level rights for five lakes. The Slate River does not currently serve as a municipal water supply. However, several wells that are hydrologically connected to the Slate River are used as domestic water supplies and the river is tributary to other drinking water supplies.

The Watershed is primarily composed of thin alternating layers of shale, siltstone, sandstone, and other sedimentary rocks. Magma intruded through the sedimentary rocks during a period of mountain building. The magma cooled to form granodiorite and quartz-monzonite intrusive rocks. Fluids along with intense heat and pressure mineralized the intrusion and adjacent rocks. Mineralization creates ores that are enriched with metals. Erosion has exposed the intruded and mineralized rocks in high elevation areas of the Watershed. Waters that interact with mineralized rocks can become acidic and enriched with metals. Prospecting and mining typically occurred in mineralized rocks. By increasing the surface area of mineralized rock exposed to atmospheric conditions, mining or excavation activities increase the likelihood for water contamination.

SURFACE WATER QUALITY

Eighty percent of the water quality data collected from 1995 to 2010 in the Watershed met water quality criteria. Twenty percent of the water quality data from the Watershed exceeded water quality criteria (i.e., failed to meet). Metals are the most problematic pollutants in the Watershed. The most problematic metals are zinc, cadmium, copper, lead, and manganese. Metals that originate from historic abandoned mines are the most common pollutant in the Watershed. This finding is consistent with historic and current land uses in the Watershed.

The water quality standards assessment painted a clear picture. Metals that originate from historic abandoned mines and natural features impair water quality in Redwell Creek. Redwell Creek and the adjacent features accounted for seventy-five percent of the water quality exceedances. Redwell Creek delivers metals to Oh-Be-Joyful Creek and Oh-Be-Joyful Creek below Redwell Creek accounted for ten percent of the exceedances. The water in Oh-Be-Joyful Creek above Redwell Creek generally met all water quality criteria and accounted for less than one percent of the exceedances. Conservatively, Redwell Basin was the origin of eighty-five percent of the pollution in the Watershed. Although Oh-Be-Joyful Creek provides dilution, it is evident that metals that originate in Redwell Creek reach the Slate River. The Slate River below Oh-Be-Joyful Creek accounted for ten percent of the exceedances. The Slate River above Oh-Be-Joyful Creek typically met water quality criteria; only two percent of the evaluations exceeded applicable standards. Water quality exceedances in tributaries to the Slate River, including poverty Gulch, accounted for just over one percent of the exceedances.



Metals that originate from historic abandoned mines and natural features pollute Redwell Creek. Redwell Creek, which has elevated concentrations of several metals, flows into Oh-B-Joyful Creek which is tributary to the Slate River. The effect of metals from Redwell Basin is apparent is Redwell Creek, Oh-Be-Joyful Creek and the Slate River.

CAUSES OF WATER QUALITY IMPAIRMENT

Three features, all of which are located in Redwell Basin, are major sources of metals that impair water quality. Two features, the Drill Hole and the Daisy Mine, are man-made and the Red Well is natural.

DRILL HOLE

In the early 1970s, many holes were drilled to characterize the molybdenum deposit beneath Mount Emmons. In Redwell Basin a drill hole, located in the upper portion of the basin, was improperly abandoned. The Drill Hole penetrates the molybdenum deposit and allows water to flow under pressure to the surface. It delivers poor-quality groundwater to Redwell Creek. At the Drill Hole, metal concentrations increased dramatically over upstream locations in Redwell Creek.

A view of Redwell Basin. The orange slopes on the upper right of the photo are a part of the Daisy Mine, the drainage tunnel is located in the lower portion of the mine waste. In the lower right of the photo, flow from the Drill Hole enters Redwell Creek. The Redwell is in the lower left of the photo. Photo Credit: Nicki DeVanni (2011).

DAISY MINE

The Daisy Mine once produced silver, copper, and zinc. Exploration began in the late 1800s and the operated sporadically until the 1970s. The mine was abandoned prior to the passage of modern reclamation laws. The Daisy Mine is on the east side of Redwell Basin. The mine has multiple levels of underground tunnels with several portals on the slopes above. Gunsight Pass Road traverses between the upper mine portals and the collapsed drainage tunnel. Ore was transported to the Gunsight Processing Area. Much of the mine waste is located near the collapsed tunnel and Gunsight Pass Road.

Water collected from the Daisy Mine exceeded acute criteria by two to four orders of magnitude for zinc, cadmium, copper and iron. The Daisy Mine is the single largest source of zinc in the basin. Because of the poor water quality, the Daisy Mine was recognized as a “high priority abandoned hard rock mine” by the Colorado Nonpoint Source Program (NPS Program) in 2012.

THE RED WELL

The Redwell is the naturally-occurring namesake of Redwell Basin. The Red Well is approximately 2,800 years old. The age was established by analyzing an iron oxide, called ferricrete, collected from the edge of the Red Well. The age indicates the feature is natural, not man-made. Metal concentrations measured at the Red Well are elevated, and occur in ratios similar to those found at the Drill Hole, but in lower concentrations. This suggests the two features share source waters, groundwater associated with the molybdenum deposit and the adjacent mineralized fracture network, but additional dilution occurs at the Red Well. Small seeps and wetland vegetation up-gradient of the Red Well indicate the area is saturated regularly. Given the hydrology of wetlands, some dilution with surface or groundwater is likely at the Red Well.

PROJECTS TO IMPROVE WATER QUALITY

This plan outlines three major projects to improve water quality and environmental health in the Watershed. Additional watershed improvement projects are also proposed in the Plan.

DRILL HOLE CLOSURE PROJECT

The Colorado Division of Mining, Reclamation and Safety (DRMS) closed the Drill Hole in fall 2013. The Drill Hole was closed by injecting cement; a standard procedure for well closures. Water from the Drill Hole no longer reaches the surface. The flow is dispersed to the subsurface, where it flowed as groundwater prior to the existence of the Drill Hole. The closure project eliminated the metal load from the Drill Hole. The metal load reductions associated with the project are important. However, the closure also eliminated an enormous source of acidity. Acidic waters from the Drill Hole increased metal solubility in Redwell Creek. The Drill Hole caused pH in Redwell Creek to fall from approximately 6.7 to 3.7; which is a thousand times more acidic. Decreased acidity should decrease metal solubility in Redwell Creek. This should translate to lower metal concentrations and increased pH in Redwell Creek downstream of the Drill Hole. In the next several years, water quality monitoring will be used to quantify these changes. Monitoring sites are located in Redwell Creek, Oh-Be-Joyful Creek, and the Slate River. Two monitoring events occurred in the summer of 2014; monitoring will also occur in 2015.

DAISY MINE RECLAMATION DESIGN AND IMPLEMENTATION

An effective reclamation project at the Daisy Mine will reduce metal loads that originate from the mine site. An effective design will balance practical considerations with water quality improvement goals. Potential reclamation strategies include: source water control, a waste repository, and passive water treatment. Additional information about site conditions is required to further plan for reclamation. A preliminary reclamation design will be drafted after the characterization work is complete. Once a preliminary design has been created, it will be possible to establish a budget and begin to solicit funds for final design and project implementation.

GUNSIGHT PROCESSING AREA RECLAMATION DESIGN AND IMPLEMENTATION

The Gunsight Processing Area is near the confluence of Oh-Be-Joyful Creek and the Slate River about 3.6 miles northwest of Crested Butte. Gunsight Pass Road is immediately adjacent to the Processing Area and the GB Trail, a popular hiking and biking trail, passes through the site. The site history is somewhat unclear, but it appears that ore from the Daisy, Augusta, and potentially other mines was transported to the Gunsight Processing Area. The mine waste on site suggests some crushing and possibly milling occurred on site. Mining did not occur on site; although there are very small prospect holes in the vicinity. The site consists of four prominent benches made from mine wastes.

The trail and site attract the attention of recreational users in this portion of the Watershed. The waste materials contain elevated concentrations of several metals, especially lead and zinc. Because of recreational traffic on mine waste, the site is a human health risk. The BLM, the landowner, placed signs on site to alert the public about the risk.

A water sample collected from a seep near the Gunsight Processing Area had metal concentrations that exceeded water quality standards for several metals. This and other data will complied into a report to document the need for reclamation. BLM and DRMS will lead the reclamation design effort. After the design is complete, an engineer will be hired to finalize the design. BLM has secured the funds needed for design and a portion of the implementation. Additional funding is needed to completed implementation.

EPA WATERSHED PLAN ELEMENTS

Table 1. Summary of the EPA Watershed Plan Elements and their location in the Watershed Plan.

EPA Element	Section(s)
A) Identification of the causes and sources	5.0, 4.2
B) Estimated load reductions expected from management measures	7.1. to 7.3
C) Nonpoint source management measures	7.0
D) Estimate of technical and financial assistance	8.1
E) Public outreach, education, and involvement	8.2
F) Implementation schedule for NPS management measures	8.3
G) Interim milestones for NPS management measures	8.3.1
H) Criteria to assess progress toward load reductions	8.3.1
I) Monitoring plan to assess progress toward load reductions	9.0

DEFINITIONS AND ACRONYMS

Absolute Decree: a water court decree stating that previously unappropriated water has been put to a beneficial use. A priority date is assigned to the right (Source: Colorado Foundation for Water Education, 2004).

AML or AMLI: Abandoned mine land or abandoned mine land inventory.

Anthropogenic: An effect or impact associated with human activity. Human-caused, human-induced, and Man-made are common synonyms.

BLM: Bureau of Land Management; federal agency.

CBLT: Crested Butte Land Trust. Nationally-accredited land trust organization based in Crested Butte.

Circumneutral: Refers to a pH between 5.5 and 7.4. This range generally supports aquatic and terrestrial life with few restrictions. The US Fish and Wildlife Service pioneered widespread use of this term.

CDPHE: Colorado Department of Public Health and Environment. The Nonpoint Source Program (NPS Program), the Water Quality Control Division (WQCD), the Water Quality Control Commission (WQCC) are a part of the CDPHE.

Conditional Decree: a water court decree recognizing a priority date for a new proposed appropriation. The priority becomes fixed, typically to the original priority date, when the water is actually placed to beneficial use. The applicant for a conditional decree must show that there is unappropriated water available, and must have a plan to divert, store, and control the water. To maintain the conditional decree, the potential water user must prove to the court that they are making diligent progress towards putting the water to a beneficial use. Every six years, the potential water user must show diligence to keep the conditional decree (Source: Colorado Foundation for Water Education, 2004).

DRMS: Colorado Division of Reclamation Mining and Safety.

Endangered Species: “The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.” – US Fish and Wildlife Service.

Endangered Species act of 1973, as amended: “Federal legislation intended to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, and provide programs for the conservation of those species, thus preventing extinction of native plants and animals.” – US Fish and Wildlife Service.

Habitat: "The location where a particular taxon of plant or animal lives and its surroundings (both living and nonliving) and includes the presence of a group of particular environmental conditions surrounding an organism including air, water, soil, mineral elements, moisture, temperature, and topography."– US Fish and Wildlife Service.

Instream Flow Water Right: a water right held by the state to protect or improve the water-dependent natural environment. (Source: Colorado Foundation for Water Education, 2004).

mg/L: Milligrams per liter; equivalent to parts per million (ppm).

NPS: National Park Service

NPS Program: Nonpoint Source Program.

Orographics: Environmental characteristics or functions that are driven by topography and or prevailing weather patterns. Rain shadows are an orographic effect.

Threatened: "The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range - -as defined in the Endangered Species Act." – US Fish and Wildlife Service.

ug/L: Micrograms per liter; equivalent to parts per billion (ppb).

USFS: United State Forest Service

WARSSS: Watershed Assessment of River Stability and Sediment Supply. A method developed for the EPA by Rosgen (2006) to evaluate the extent of sediment impairment in a river and whether the sources are natural or man-made.

WQ Summary: The Upper Slate River Watershed Water Quality Data Analysis and Summary was written in 2011 to summarize surface water quality data. The WQ Summary was written by Alpine Environmental Consultants LLC in the beginning of the watershed planning process.

1.0 INTRODUCTION

The mission of the Coal Creek Watershed Coalition is "to maintain, restore and enhance the environmental integrity of Crested Butte's local watersheds to ensure those watersheds and habitats are of the highest possible quality necessary to support wildlife, aquatic life, and human life"

The mission has driven Coal Creek Watershed Coalition's (CCWC) work since 2003. In the past decade, the CCWC has collected baseline water quality data in the Coal Creek Watershed, provided education and outreach on a wide variety of water–related issues, and served as an informed voice for several pertinent local water quality issues. In 2011, CCWC ventured into the Upper Slate River Watershed (Watershed) to address water quality impairments found in the Slate River and its tributaries.

This Watershed Plan (Plan) incorporates existing data, reports, and the input of local stakeholders to create a comprehensive plan to address nonpoint source water quality impairments in the Watershed. The purpose of the Plan is to identify water quality pollutants and their sources, determine the degree to which they impair water quality, identify projects to address those impairments, create preliminary project designs, and identify appropriate partners and funding sources for the proposed projects.

The Water Quality Data Analysis and Summary (WQ Summary) was completed by Alpine Environmental Consultants (AEC) in 2011 during the initial planning phase. The WQ Summary characterized environmental conditions, compiled and analyzed surface water quality data, and identified data gaps in the Watershed. The WQ Summary informs the scientific and technical issues addressed in this Plan.

The Plan uses a data driven approach to address water quality impairments. The projects proposed in the Plan have been developed to mitigate water quality impairments. The projects were vetted and prioritized by our partners and stakeholders. Public input and stakeholder participation has been sought through a variety of education and outreach efforts.

In addition to developing the Plan, CCWC and our partners collected data to address data gaps and implemented several projects in the past three years. This Plan references recent work, but emphasizes future work.

Watershed: "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course" - John Wesley Powell

During the watershed planning process stakeholders and partners identified the following desired outcomes for the Watershed:

1. To minimize water quality impairments attributed to historic abandoned mines, where:
    a. The Slate River below Oh-Be-Joyful Creek meets applicable water quality standards and water quality improvements are also measured at upstream locations.
    b. Following reclamation projects, metal concentrations and load reductions are apparent locally and in downstream reaches.
    c. Provide water quality data to the Water Quality Control Commission (WQCC) as they establish segment-specific ambient standards for Redwell (Segment 10b) and Oh-Be-Joyful (Segment 10a) creeks.
2. To support healthy and diverse aquatic life, where:
    a. An increased percentage of macroinvertebrate samples collected from the Watershed meet numeric water quality standards for aquatic life. Representative macroinvertebrate samples have a macroinvertebrate multi matrix index score greater than 50 (MMI, CDPHE-WQCD 2010) and remain stable or increase over time.
    b. Fish species density and average size remain at or increase from current characterization levels; as surveyed by the Colorado Division of Parks and Wildlife (CDP&W).
3. To maintain or improve the overall channel function of the Slate River and its tributaries, where:
    a. Channel function refers to a channel that is in a state of dynamic equilibrium and lacks consequential anthropogenic sediment loads.
    b. Infrastructure, such as roads, bridge, culverts or other features are appropriately sized to accommodate peak flows and run-off.
    c. Cooperative projects support both river function and landowner goals.

This Plan provides the pathway to implement the projects and activities necessary to achieve the desired outcomes presented above. Section 2.0 summarizes the characteristics of the Watershed. Sections 3.0 and 4.0 describe water uses and baseline water quality in the Watershed. Section 5.0 identifies the primary pollution sources and Section 6.0 outlines the tools to address pollution and improve water quality. Section 7.0 describes how the Plan will be implemented. Section 8.0 presents the monitoring tools and techniques used to assess our progress toward each desired outcome. Sections 9.0 presents the acronyms and definitions used throughout the report. References cited in the Plan are in Section 10.

2.0 WATERSHED CHARACTERISTICS

Selected watershed characteristics are described in the sections that follow. These characteristics provide a foundation that allows for a better understanding of pollution sources, data gaps, and the most appropriate management strategies. This section is intended to provide readers the background necessary to understand the latter sections of this report. The characteristics are summarized and readers should refer to the references cited in each section to learn more about a given topic. The WQ Summary (AEC, 2011) provides a more detailed account of many of the watershed characteristics and surface water quality.

The Watershed is located near Crested Butte in Gunnison County, in southwestern Colorado (Figure 1). The Watershed drains approximately 34 square miles on the east side of the Ruby Mountain Range. The Watershed contains roughly 71 miles of rivers and streams; including perennial, intermittent, and ephemeral tributaries.

The recreation path bridge, near Rainbow Park in Crested Butte, was designated as the Watershed outlet. The recreation path bridge was selected as the outlet to include the Town of Crested Butte's waste water treatment plant discharge. The Watershed does not include drainage from the Coal Creek Watershed (Coal Creek Watershed is addressed in an existing Watershed Plan) or drainage from Washington Gulch, which flows into the Slate River downstream of the Watershed. The Watershed boundary is considered administrative[1], not physical, because it excludes drainage from Coal Creek. A small portion of the Slate River within the Watershed is below Coal Creek, which influences the water quality of that portion of the Slate River. However examining the effect of Coal Creek on the Slate River is not an objective of this Plan.

[1]. The Level 12 Hydrologic Unit Code delineates the watershed above Gothic Road Bridge. The shapefile was manually modified to include the drainage area between the Gothic road bridge and the recreation path bridge (see Figure 1).

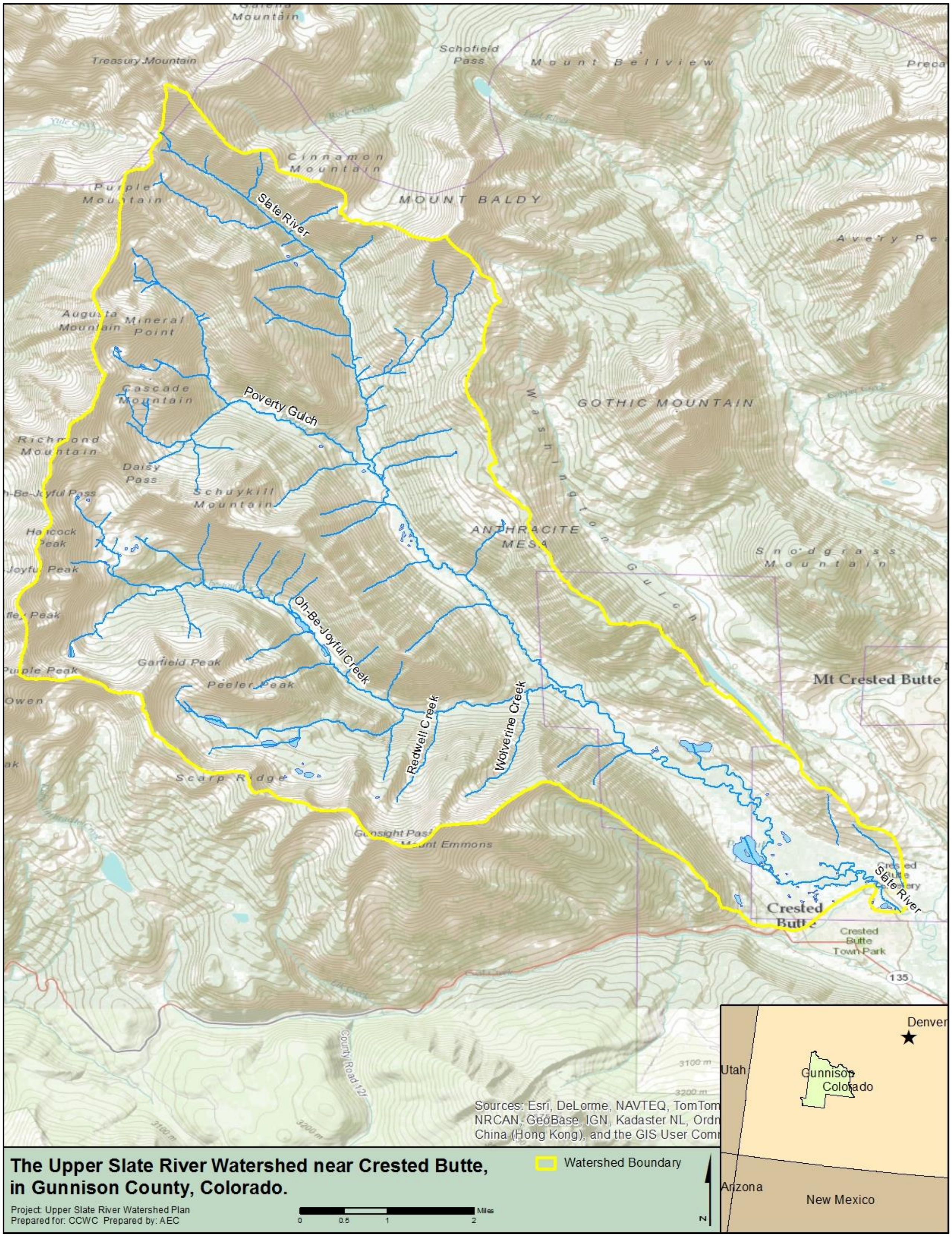


Figure 1. The Upper Slate River Watershed near Crested Butte, in Gunnison County, Colorado.

2.1 LAND OWNERSHIP AND USE

The majority of the Watershed is public land, managed by the US Forest Service (USFS) and the Bureau of Land Management (BLM). The USFS manages 77 percent of the Watershed, a significant portion of which is designated as wilderness (Table 2, Figure 2). The Raggeds Wilderness is about 14 square miles or 42 percent of the Watershed area. BLM manages three percent of the Watershed area. The remaining 20 percent of the Watershed is held by private landowners. A large portion of the privately held land is owned by or under a conservation easement held by the Crested Butte Land Trust (CBLT) or the Town of Crested Butte.

Photo 1. Early summer views from the Lupine Trail. Photo by Crystal Edmunds.

Most of the private land is located in the lower portion of the Watershed below the confluence of Oh-Be-Joyful Creek and the Slate River (Figure 2). Other private holdings exist near Pittsburg, a former town site near the confluence of Poverty Gulch and the Slate River (Figure 2). The towns of Crested Butte and Mount Crested Butte are the closest population centers, with a combined population of approximately 2,300 people (Gunnison County, 2011). Tourism and recreation are a central part of the local economy.

Table 2. Landownership in the Upper Slate River Watershed.

Land Owner	Square Miles	Acres	Percent
US Forest Service- Non-wilderness	11.7	7,481	35
US Forest Service- Wilderness	14.0	8,962	42
Private- Crested Butte Land Trust & Others	6.7	4,306	20
Bureau of Land Management	1.1	717	3
Watershed Total:	**33.5**	**21,466**	**100**

Recreation is the primary land use in the Watershed. Recreation occurs year-round and includes: hiking, biking, camping, fishing, kayaking, Nordic skiing, backcountry skiing and snowboarding, snowmobiling, and hunting, among others. The Lupine, Lower Loop, GB, and Woods Walk are popular trails in the lower Watershed. Other trails and primitive roads provide access to the Raggeds Wilderness and alpine areas in the upper Watershed. Recreational use varies widely by season, however information regarding visitor use is somewhat limited. In July and August of 2013, nearly 50,000 people visited Oh-Be-Joyful Campground (BLM, 2013). Grazing occurs in portions of the Watershed on both public and private lands.

In 2001 the USFS and BLM partnered to complete a travel management plan for the Grand, Mesa, Uncompahgre, and Gunnison National Forests and the Gunnison Field Office. The Watershed accounts for a very small portion of the travel management study area. The planning, environmental analysis, and public scoping took about nine years to complete. During that time the USFS and BLM received approximately 4,000 comments from the general public. In 2010, the USFS and BLM released a Record of Decision and Final Environmental Impact Statement. These documents incorporated scientific analysis, public comments, and applicable regulations to finalize the travel management plan and to protect natural resources.

Implementation of the travel management plan began in 2011. Along the Slate River Road corridor motorized access to dispersed camping was restricted to existing spur roads that extend no more than 300 feet from Slate River Road (USFS and BLM, 2010). Road spurs or camp sites that caused resource damage have been decommissioned to protect soil and water quality. These sites often reduce hydrologic function and increase erosion rates. Restoration was completed at the Musicians Camping Area, a large camping complex between Pittsburg and Oh-Be-Joyful Campground that lies west of Slate River Road, and unauthorized spur roads and campsites in the Poverty Gulch riparian area and other small sites near Slate River Road. The travel management plan restricted vehicle access to Baxter Basin. Travel by foot and horse is permitted on the old mine access road that climbs into Baxter Basin. The travel management plan allows for an extension of the Lower Loop Trail between Oh-Be-Joyful Creek and the Pittsburg town site (USFS and BLM, 2010).

CBLT's mission is "to forever protect and steward open lands for vistas, recreation, wildlife and ranching, thus contributing to the preservation of Gunnison County's unique heritage and quality of life"(CBLT, 2012). CBLT has completed many transactions in the Watershed; which are a combination of fee titles (ownership) and conservation easements. CBLT owns about 110 acres in the Watershed and holds conservation easements on additional lands. In the past decade, they have improved their land management and stewardship practices, which resulted in accreditation from the National Land Trust Accreditation Commission. CBLT has become a vital partner in addressing issues identified in the Geomorphic Assessment (Alpine Eco, 2012). To date, their efforts have secured funding for additional study and to implement restoration and erosion control projects (Section 2.6).

In May 2013, the USFS accepted a Plan of Operations (PoO) submitted by U.S. Energy for the Mount Emmons Project. U.S. Energy has proposed a 12,600 ton per day underground molybdenum mine and processing facility at Mount Emmons (U.S. Energy, 2013). U.S. Energy estimated that production will take roughly 33 years to complete and ultimately mine and mill 143 million tons of molybdenum ore. The footprint of the proposed project is 10,005 surface acres. Most operations and infrastructure associated with the project are slated to occur outside of the Watershed. But a considerable portion of the Oh-Be-Joyful Creek Watershed, below the wilderness boundary, lies within the unpatented mine claim of the project.

If the project proceeds, there will be impacts in the Watershed. The project proposes a large water diversion from the Slate River between Oh-Be-Joyful Campground and Gunsight Bridge (U.S. Energy, 2013). As currently proposed the diversion could remove up to 40 percent of the annual flow from the Slate River. Water from the diversion would be pumped through a pipeline that follows the Gunsight Pass Road right-of-way. Moving water along Gunsight Pass Road would necessitate a pump station near the confluence of Oh-Be-Joyful Creek and the Slate River, a popular and heavily used recreation site. This section of pipeline would be about 2.9 miles long and buried at a minimum depth of two feet. After reaching Redwell Basin, U.S. Energy proposed a borehole near the top of Mount Emmons to transfer the water via underground mine workings the south side of Mount Emmons.

Additional details about the diversion structure, pump station, pipeline, and borehole, among others, are required to make an informed decision about the environmental impact of the project. When the PoO becomes a proposed action, the USFS will initiate a National Environmental Policy Act (NEPA) review to assess the environmental impact of the project. Public scoping and comments are a part of the NEPA process. CCWC will comment on the PoO at that time. Section 3.2 presents more detailed discussion of the water right associated with the project. Appendix A summarizes concerns regarding the PoO.

In 2014, U.S. Energy submitted an additional PoO to conduct baseline studies on Mount Emmons. The PoO was accepted by the USFS. The Baseline Studies PoO has not entered the NEPA process. The USFS anticipates that the Baseline Studies PoO will be available on their website by late 2014 (Lee Ann Loupe, personal communication 9/24/14). Public scoping and comments will be solicited when the Baseline Studies PoO enters the NEPA process. At this time, it is unknown whether baseline studies are proposed in the Watershed.

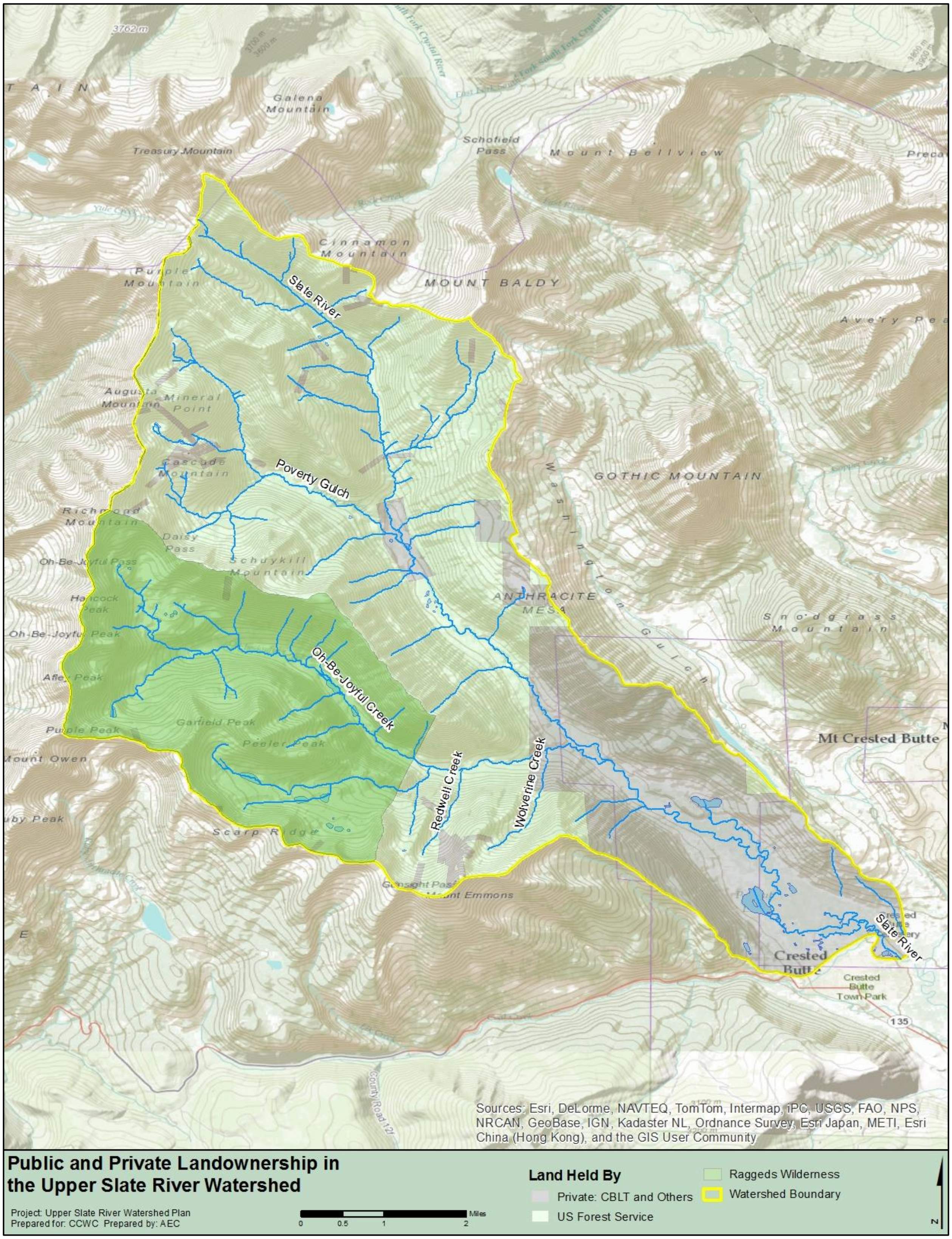


Figure 2. Land ownership in the Upper Slate River Watershed. Eighty percent of the land is publicly held and twenty percent is privately held.

2.2 CLIMATE

Generally speaking summers in the Watershed are cool and comfortable while winters are snowy with low temperatures that fall below zero. Figures three through five summarize average monthly climate characteristics for two SNOTEL sites (USDA-NRCS, 2013). Both sites are outside of the Watershed (data is not available within the Watershed). The Crested Butte site (#380) is on the northern base of Mount Crested Butte near the ski area. The other site Schofield Pass (#737) is near Emerald Lake. The period of record ranges from 10 to 32 years depending on the characteristic (temperature, snow depth, etc.) and station. The elevations are 10,160 and 10,700 feet for the Crested Butte and Schofield Pass stations, respectively. The highest elevations in the Watershed are near 13,000 feet. The Schofield Pass site is far lower than peaks in the Watershed. But topography and prevailing weather patterns near Schofield Pass may allow for reasonable comparison even though the elevation is lower. It is likely that snowfall on the headwaters peaks is higher, especially during the beginning and end of the snowy season. Likewise, the lowest portions of the Watershed are at lower elevations and conditions may be slightly milder.

The warmest average temperatures, which range from 72 to 81 degrees Farenheit, occur in June, July, and August at both climate stations (Figure 3). From November to March the average low temperature remains below zero (Figure 3). The average low exceeds freezing (32° F) in June or July (Figure 3). The average monthly low temperatures do not exceed 40 degrees Farenheit at any point during the summer (Fiugre 3). Which indicates that, on average, frost is possible most days of the year.

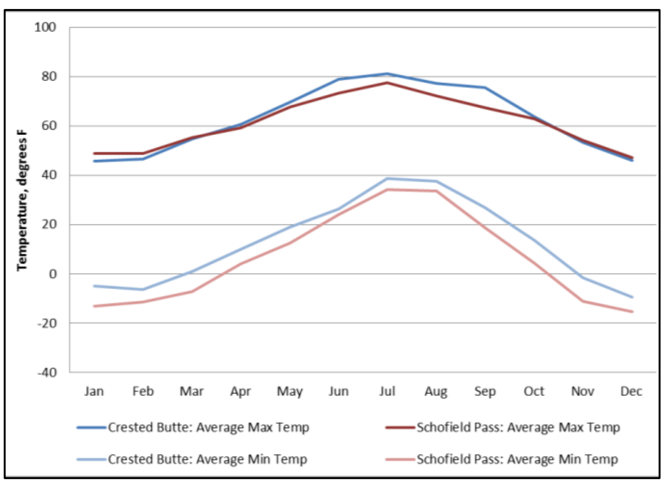


Figure 3. Average monthly minimum and maximum temperatures in degrees Fahrenheit from the Crested Butte and Schofield Pass SNOTEL sites.

Photo 2. A view of the lower Slate River and Mount Crested Butte in late winter. Photo courtesy of Andrew Breibart.

In most years the snowpack remains present at the climate station or snow falls at some point during each month (Figure 4). The Crested Butte site is on a north facing slope and the Schofield Pass area typically has a large "snow plug" that persists through most of the summer. The snow plug is created by avalanche debris from the shoulder of Mount Baldy. So, the summer snowpack found at these sites is not particularly representative of conditions through out the Watershed. But there are certainly snow fields at selected elevations on leeward slopes or where avalanche debris accumulates (Photo 3).

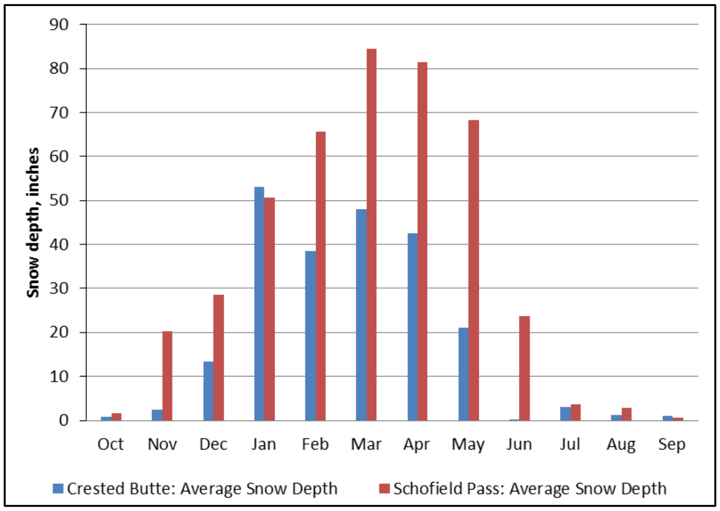


Figure 4. Average monthly snow depth, in inches, from the Crested Butte and Schofield Pass SNOTEL sites.

Photo 3. Avalanche debris forms snow and ice bridges over the headwaters of the Slate River. This photo was taken on August 8, 2012; which demonstrates that even during drought snow can linger in certain places in the Watershed.

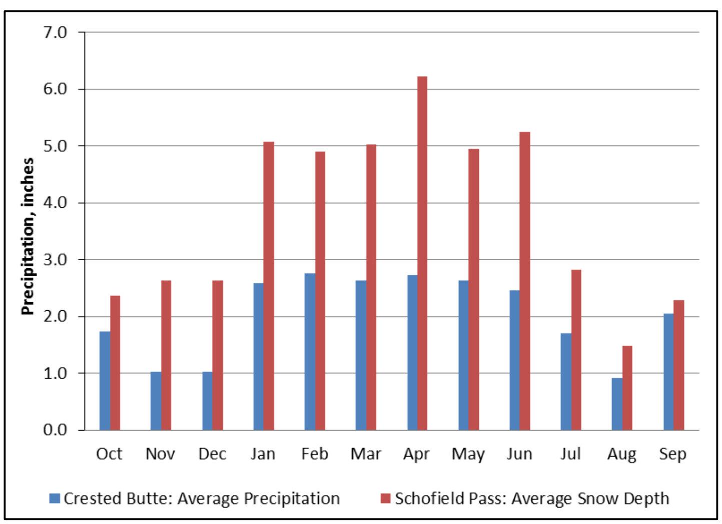


Figure 5. Average monthly precipitation, in inches, from the Crested Butte and Schofield Pass SNOTEL sites.

As air temperatures decrease in October and November, the probability for snow increases and some snow accumulates, about two inches at the Crested Butte site and about 20 inches at Schofield Pass, on average (Figure 4). As winter gains momentum, snow continues to accumulate through the winter months (Figure 4). Orographics, and to some extent elevation, clearly drive snow accumulation. From February to May, the snow pack at Schofield Pass is far larger than at the Crested Butte station (Figure 4).

Precipitation at Schofield Pass is higher than at the Crested Butte site (Figure 5). The difference in precipitation is most pronounced from November to June. The average annual precipitation at Schofield Pass is approximately 46 inches (NRCRS, 2013). The Crested Butte station receives about 24 inches per year on average, or roughly half the precipitation measured at Schofield Pass.

2.3 SURFACE WATER RESOURCES

The headwaters of the Slate River are below Purple Mountain and Yule Pass at nearly 13,000 feet. The first named tributary, Poverty Gulch, enters the Slate River from the west about five miles downstream of the headwaters (Figure 1). Several unnamed, intermittent drainages enter the Slate River above Poverty Gulch. Additional unnamed, intermittent drainages flow into the Slate River below Poverty Gulch. The upper Watershed is a high-gradient mountain stream system. The valley slope of the Slate River above Poverty Gulch is 15.9 percent (Table 3). Poverty Gulch drains a steep basin, with a valley slope of 17.2 percent (Table 3). Virtually no data is available to evaluate flow patterns in the upper Watershed. However, Poverty Gulch drains an area similar in size to the drainage area of the Slate River above Poverty Gulch (Figure 1). It is reasonable to assume that Poverty Gulch substantially increases, perhaps doubles, flow in the Slate River.

Oh-Be-Joyful Creek is a significant tributary that meets the Slate River about nine miles below the headwaters (Figure 1). Richmond Mountain (12, 501 feet) and Purple Peak form the headwaters of Oh-Be-Joyful Creek (Figure 1). Oh-Be-Joyful Creek is six miles long and includes two key tributaries Redwell Creek and Wolverine Creek (Figure 1). The valley slope of Oh-Be-Joyful Creek is 10.4 percent (Table 3), which is lower than the upper reaches of the Slate River and Poverty Gulch, but it is also a high-gradient mountain stream system.

Both Redwell and Wolverine Creeks enter Oh-Be-Joyful Creek from the south (Figure 1). Redwell Creek drains Redwell Basin. Gunsight Pass Road crosses the upper most reaches of Redwell Creek (Figure 1). Wolverine Creek is immediately east of Redwell Creek and is the last tributary to enter Oh-Be-Joyful Creek before the confluence with the Slate River (Figure 1). Both creeks drain the northern aspects of Mount Emmons. Flow from the mouth of Oh-Be-Joyful Creek varies widely. Because of snowmelt, peak flows in Oh-Be-Joyful Creek tend to occur when peak flows occur in the Slate River. Based on existing data from the Watershed, Oh-Be-Joyful Creek is the largest tributary to the Slate River.

Beyond the confluence with Oh-Be-Joyful Creek, the Slate River flows through a wider and relatively low-angle valley to the Watershed outlet. In this reach the Slate River meanders and braids in some areas (Figure 1). The valley slope in this area of the Watershed is 0.2 percent which is substantially lower than other reaches (Table 3).

Table 3. Stream characteristics of major reaches in the Upper Slate River Watershed.

Stream Reach	Length	Elevation Range (ft.)		Valley Slope
	Miles	High	Low	(%)
Slate River and Tributaries above Poverty Gulch	17.1	13,237	9,206	15.9
Poverty Gulch and Tributaries	11.1	12,880	9,206	17.2
Slate River and Tributaries: Poverty Gulch to Oh-Be-Joyful Creek	8.7	9,206	8,923	1.3
Oh-Be-Joyful Creek and Tributaries[3]	20.5	12,686	8,923	10.4
Redwell Creek: tributary to Oh-Be-Joyful Creek	1.2	12,317	9,395	46.5
Slate River and Tributaries: Oh-Be-Joyful Creek to Watershed Outlet	11.8	8,923	8,852	0.2
Mainstem of the Slate River	15.1	13,237	8,852	5.5

Notes
1. Elevations were established from the USGS 1:24,000 topographic map.
2. Valley slope is the change in elevation from the peak to the confluence divided by the river length.
3. Redwell Creek is included in the length of Oh-Be-Joyful Creek and Tributaries.

Flow in the Slate River and its tributaries are typical of snow-melt driven mountain streams. Low flows generally occur from October to March. As spring approaches stream flow increases. Peak flows typically occur in May or June and taper off as the snow pack declines. Smaller tributaries in the Watershed exhibit similar patterns. In general, stream flow in smaller tributaries is more readily increased by intense precipitation events (Hornberger et al., 1998).

2.4 GROUNDWATER RESOURCES

In 2010, the USFS collaborated with the Colorado Geological Survey (CGS) to assess the likelihood of groundwater contamination in the East River Watershed using the DRASTIC method (USFS, 2010). The Watershed is nested in the northwest portion of the East River Watershed and is a small portion of the total study area. The DRASTIC method assesses the vulnerability of groundwater to contamination from surface based activities using a protocol established by the EPA (Aller et al., 1987). The DRASTIC study found that some areas of the Watershed are susceptible to potential groundwater contamination based on the characteristics of the Watershed (USFS, 2010).

The potential for groundwater contamination, whether low or high, does not provide any indication of groundwater quality. The quality of the groundwater in the Watershed is largely unknown. Aside from studies completed in Redwell Basin, groundwater monitoring has not occurred in the Watershed. Appropriate sample design and monitoring objectives should be established prior to sample collection. The lack of groundwater quality is a data gap (see Section 4.5).

2.5 GEOLOGY

The Watershed consists of thin inter-bedded (alternating layers) sedimentary geology, with localized metamorphism, in a mountainous setting. The upper Watershed, including Poverty Gulch and areas adjacent to Oh-Be-Joyful Creek, is Mancos Shale (Figure 6). Mancos Shale is common throughout western Colorado. Mancos Shale is a dark-gray marine shale that formed during the late Cretaceous period (65 to 100 million years ago) and is up to 2,400 feet thick (Day et al., 2000). In arid and semi-arid areas (where annual evaporation is greater than three times the annual precipitation) intensive irrigation on Mancos shale can increase selenium concentrations in adjacent waters (Seiler et al., 2003). The climate and irrigation practices, which occurs primarily on glacial drift, in the Watershed do not suggest selenium concentrations would be elevated due to the presence of Mancos shale. Dissolved selenium concentrations were less than the chronic standard in 47 of 50 samples collected from 1995 to 2010 (AEC, 2011).

The Mesaverde Formation, also from the late Cretaceous period, occurs primarily in the Oh-Be-Joyful and Poverty Gulch drainages (Figure 6). The Mesaverde Formation consists of thin, inter-bedded shale and sandstone, with minor occurrences of coal and carbonaceous shale (Day et al., 2000). The Mesaverde Formation is typically thin and maximum thickness in the area is about 350 feet. The Wasatch and Ohio Creek Formations occur on the south and west boundaries of the Oh-Be-Joyful Basin

(Figure 6). Like the Mesaverde Formation, the Wasatch and Ohio Creek Formations are also thin, inter-bedded strata. However, the composition of the strata is coarser and consists of alternating claystone, siltstone, sandstone, and occasionally conglomerate (individual rocks cemented within a finer-grained matrix). The thickness of the Wasatch and Ohio Creek Formations is generally less than 200 feet in the Watershed (Day et al., 2000).

At the highest elevations in the Watershed, intrusive granodiorites and quartz-monzonites occur on the surface (both rock types are commonly referred to as granite; Figure 6). The intrusive, metamorphic rocks formed 26 to 38 million years ago during the Oligocene Epoch (Day et al., 2000). Contact metamorphism occurred in the adjacent rocks which created localized areas of metamorphic rocks, including hornfels, slate and breccia, in the otherwise sedimentary basins (Gaskill, 1967). Prospecting and mining occurred in the mineralized rock. Historic mining features and mineralized rocks contribute acidic, metal-rich water to Redwell Basin (Tuttle et al., 2000, Berger et al., 2001).

The lower portion of the Watershed is comprised of unsorted glacial drift (Figure 6). Glaciers scoured the upper Watershed and deposited sedimentary materials in the lower Watershed during the Bull Lake and Pinedale glaciations (Day et al., 2000). The most recent period of glaciation in the Watershed was approximately 12,000 years ago. Glaciation accounts for much of the topography and the young landscape with limited soil development.

The molybdenum porphyry deposit below Mount Emmons is a high-fluorine, granite-molybdenum climax type system (Tuttle et al., 2000; Verplanck et al., 2004). A porphyry is an intrusion of large well-developed crystals in a finer-grained matrix rock. The porphyry material is different from the matrix or country rock. In this case, the porphyry contains significant quantities of molybdenum and is quite large. The porphyry system formed during a period of metamorphism (magma intruded into overlying rocks but did not reach the surface). The magma intruded through Mancos shale and the Mesaverde Formation at depth and formed a porphyry (Stein and Hannah, 1985). Simultaneously, contact metamorphism altered adjacent rocks and epithermal mineralization (the formation of mineral veins at a shallow depth due to interaction with heated fluids) occurred in those rocks (Berger et al., 2000). As a result, the molybdenum porphyry lies in a complex web of faulted and mineralized rock (Tuttle et al., 2000). Mineralization also produced breccia pipes (angular rocks cemented within a fine grained matrix) that are found on or near the surface in upper Redwell Basin (Gaskill et al., 1967; Thomas and Galy, 1982). Mineralization produced silver, zinc, lead, copper, and gold ores (EPA, 1998). To date, uranium has not been associated with the metamorphic intrusion or adjacent mineralization (Thomas and Galy, 1982; Hannah and Stein, 1985; Tuttle et al., 2000). These metamorphic rocks tend to direct groundwater flow and over time chemical weathering produced the mineralized features that were mined for silver, zinc, lead, copper and gold ores (US EPA, 1998).

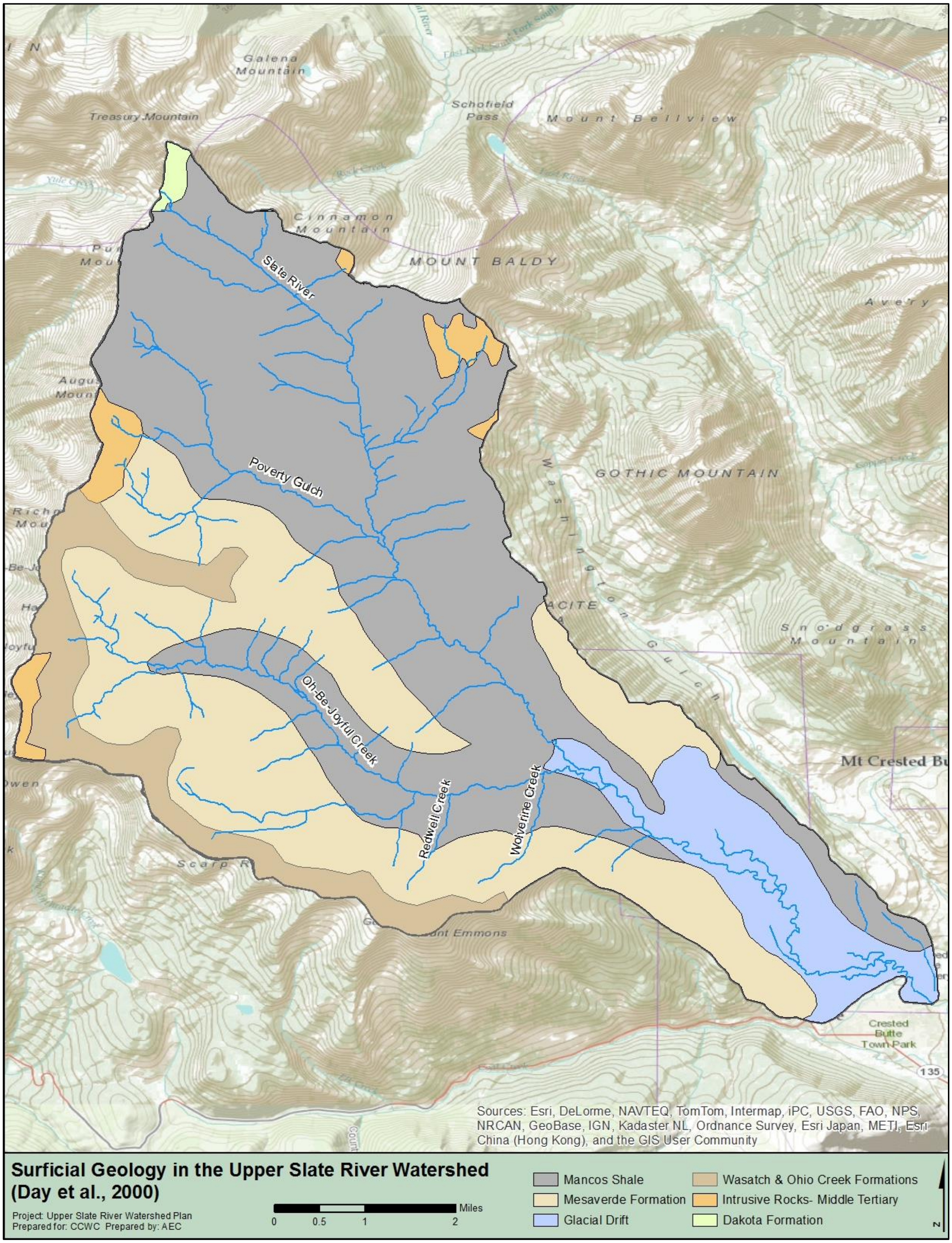


Figure 6. Surficial geology in the Upper Slate River Watershed (Day et al., 2000).

2.6 GEOMORPHOLOGY

Regional uplift created the Elk, Ruby, and West Elk mountain ranges. Together glaciation, mass wasting, and erosion produced the complex mountainous terrain found in the Watershed. Glaciers carved much of the landscape. Mass wasting and erosion formed smaller and younger features. Mass wasting occurs when a mass of soil, sediment or rock moves or in geomorphic terms wastes down a slope in response to gravity. The time scale associated with mass wasting ranges from seconds to tens of years. Some forms of mass wasting, such as soil creep or slumps occur slowly. Other forms of mass wasting occur rapidly and include landslides, debris flows or rock falls. Mass wasting is a natural process, but land use practices, such as vegetation removal, road construction or others, can increase the likelihood or frequency of mass wasting events. In this report, mass erosion refers to the types of mass wasting that occur on short time scales and are episodic in nature. Erosion refers to the process that entrains, or releases, sediment from its original location.

Geomorphology: the study of landforms and the processes that created them. Greek origin: ge- “earth”, morfe “form”, and logos- “study”

In 2012 Alpine Eco completed a geomorphic assessment in the Watershed. The geomorphic assessment used the EPA’s Watershed Assessment of River Stability and Sediment Supply (WARSSS) method (Rosgen, 2006). The objective of the geomorphic assessment was to identify and provide potential strategies to mitigate anthropogenic sediment pollution in the Watershed. The priority reaches identified in the geomorphic assessment have a high degree of impairment created by human-induced stressors and could potentially be addressed through practical implementation measures. Further study should occur on each priority reach prior to implementing any restoration or mitigation measures.

Valley and channel characteristics were used to broadly group the Watershed into three sections (Figure 7; Alpine Eco, 2012):

1. Headwaters Area: The headwaters of the Slate River, Poverty Gulch and Oh-Be-Joyful Creek.
2. Main Slate River Glacial Valley: Slate River from Poverty Gulch to the Gunsight Bridge.
3. Main Slate River Alluvial Valley: Slate River from Gunsight Bridge to the Watershed outlet

Mass Erosion: A term used to describe a variety of mass wasting events that move large quantities of material in an episodic or sporadic manner. Examples include landslides, earth flows, debris avalanches, debris flows, torrents or snow avalanches. In the Watershed these events can be triggered by intense precipitation, flash floods or accelerated snowmelt. The vast majority of mass erosion that occurs in the Watershed is natural (Alpine Eco, 2012).

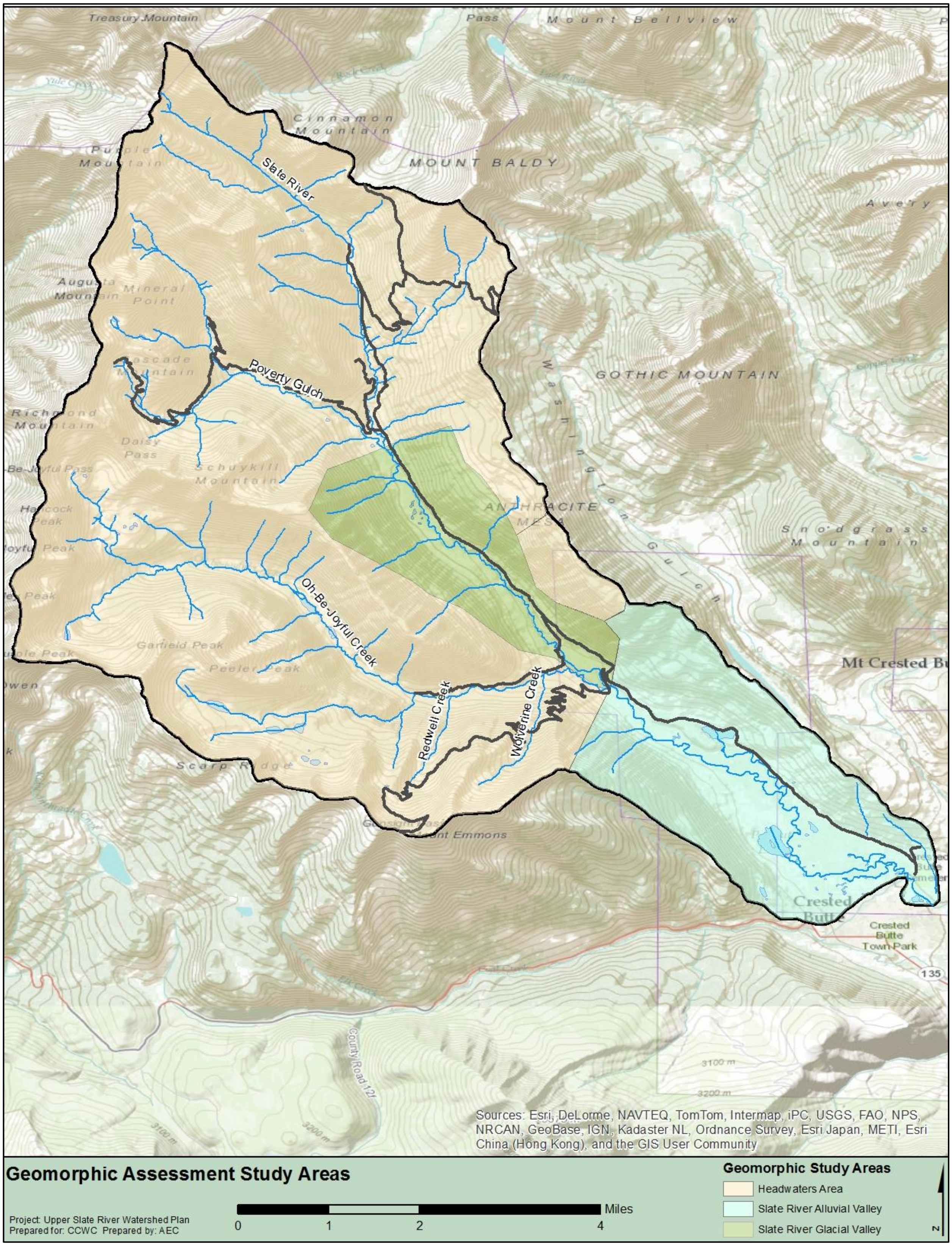


Figure 7. Geomorphic Assessment study areas from Alpine Eco (2012).

2.6.1 The Headwaters Area

Steep valley walls and canyons form the headwaters of the Watershed (Figure 7). These steep areas are covered with talus, debris from mass wasting, mass erosion and other natural deposition processes. Limited soil development has occurred on some of these slopes. The perennial stream channels that drain the headwater valleys are naturally steep, entrenched channels that are often scoured to bedrock. The intermittent tributaries to these headwaters streams are often even steeper and more entrenched and on occasion flow as debris torrents.

Photo 4. Evidence of mass erosion on the slopes of Cinnamon Mountain in the headwaters of the Watershed. Photo courtesy of Alpine Eco.

Due to the steep slopes and the materials found on the slopes, hillslopes in the headwaters areas are naturally susceptible to mass erosion which includes landslides, earth flows, debris avalanches, debris flows, torrents, and snow avalanches. These sporadic events provide massive and natural sediment sources (Photo 4). Evidence of recent mass erosion is very common throughout the headwaters area. These events form the background that human impacts must be evaluated against.

Natural mass erosion events are probable throughout the headwaters area (Figure 7). These natural hillslope processes are clearly an enormous source of sediment to the Slate River. Based on field observations during the geomorphic assessment, the volume of sediment that reaches the Slate River via natural mass erosion is coarsely estimated to range from one thousand to several thousand cubic yards per year (Alpine Eco, 2012). The sediment supplied from all other hillslope processes, including manmade sediment, is likely two full orders of magnitude less than the sediment delivered via mass erosion. The difference in estimated loads suggests that natural mass erosion dominates sediment supply in the headwaters.

Stream channels in the headwaters area are, by nature, extremely efficient at moving sediment. In contrast, the lower portion of the Watershed hosts wider and lower gradient channels due to a broader valley. These changes in the channel characteristics decrease the channel's capacity to carry sediment. When the headwaters channels flow into the valley channel the change in transport efficiency allows sediment to accumulate (aggrade) below the confluence of these channel types. Over time the lower angle valley channel will winnow away the accumulated sediment. In the upper Watershed this process is completely natural and unaffected by human activity (Alpine Eco, 2012).

Stable Channel: The channel shape that, over time, in the present climate, transports the water and sediment supplied by its Watershed in such a manner that the stream maintains its dimension, pattern, and profile without aggrading or degrading (Rosgen, 1996).

Historic abandoned hard rock and coal mine features, livestock grazing, recreation, and roads are potential sources of anthropogenic sediment. The primary sediment concern associated with abandoned mines is erosion and run-off from disturbed areas. Many old, decommissioned roads, previously used to access mines, exist in steep areas of the headwaters basins. However, these decommissioned roads do not act as significant stressors to natural hillsplope processes. Recreational use in the headwaters area is typically contained to roads and trails, but also includes some dispersed activities in the backcountry areas. In 2011, Briebart estimated that trails within the Oh-Be-Joyful drainage produced less than 0.1 cubic yards of sediment; which is less than 1/10,000 of the sediment produced via natural mass erosion. Further it is unlikely that any of the recreational activity would somehow propagate or increase the likelihood of natural mass wasting. The effects typically associated with grazing include riparian vegetation shifts, decreased vegetation cover or direct channel disturbance by trampling. These effects were not observed in the headwaters area (Alpine Eco, 2012).

Four road sections were identified as potential stressors in the geomorphic assessment. The first was Gunsight Pass Road in Redwell Basin. The road traverses a large talus slope and crosses Redwell Creek several times in the upper portion of Redwell Basin. The road may increase the amount of sediment delivered to Redwell Creek, but it is likely negligible compared to the natural sediment load delivered by the talus slope (Alpine Eco, 2012). Further investigation of sediments that originate from Gunsight Pass Road in Redwell Basin is a low priority.

The Paradise Divide Access Road (Forest Road 734) and the upper section of Slate River Road (Forest Road 811) below the divide were identified as potential sediment sources. The steep slope of the road surfaces, active surface and channel erosion, and the roads' proximity to an unnamed intermittent drainage indicate the road may be a potentially significant sediment source. Sediment production from the road could be mitigated with appropriate best management practices (BMP, Alpine Eco, 2012). Improved stormwater management could reduce runoff and erosion from these road sections.

The middle reach of Poverty Gulch Road (Forest Road 552.5) was identified as potentially problematic (Alpine Eco, 2012). The unimproved, but frequently used, road passes through sections of the Poverty Gulch riparian area. Several spurs leave the road to access dispersed camping sites. The roads cross several small ephemeral tributaries and seeps, this water likely transports sediment to Poverty Gulch. Further investigation could identify opportunities to reduce sediment loads that originate on the road.

2.6.2 Main Slate River Glacial Valley

The main Slate River glacial valley begins where the steep walled canyon opens to a wider valley below Pittsburg and extends through two broad valleys that are separated by a steep canyon segment (Figure 7). The first broad valley lies below the confluence of Poverty Gulch and the Slate River. The confluence of Oh-Be-Joyful Creek and the Slate River occurs near the bottom of the second broad valley. The canyon segment that separates the two valleys is steep and entrenched. Both the valleys and the canyon reach are situated in a larger U-shaped valley which is characteristic of glaciated areas. Lateral moraines deposited glacial till on many of the valley hillslopes (Cooper, 1993). The glacial till supports a shallow groundwater aquifer. These aquifers often create the seeps and springs found throughout the Watershed (Cooper, 1993).

In the broad valleys the Slate River typically meanders through a wider, less entrenched channel in response to a decreased channel slope (i.e., Rosgen C3 and D3 channels; Alpine Eco, 2012). In the steep, narrow canyon reach the river channel intercepts bedrock (i.e., Rosgen A1 channel). The majority of the unnamed intermittent tributaries that enter the Slate River in the main glacial valley are similar to the steep headwaters tributaries discussed in the previous section (i.e., Rosgen Aa+ channel). Like in the Headwaters area, dramatic changes in channel form, from steep to lower angle, result in sediment deposition and channel adjustment in the Slate River due to disproportionate sediment transport capacity (Alpine Eco, 2012).

Within the past ten years, dramatic channel transitions have created massive sediment deposits in two areas of the Watershed. Excess cobble and gravel have been deposited in the Slate River as the channel slope decreases above the confluence with Poverty Gulch. Sediment accumulated so rapidly that the entire channel and portions of the floodplain were filled with sediment. The channel that once directed the river was obliterated following this deposition event. Satellite images indicate this deposition event occurred sometime between 2006 and 2011. A large stand of conifers adjacent to the Slate River likely died as a result of the deposition (Alpine Eco, 2012). As the standing dead trees fall, the woody debris will become a part of the channel load.

In the coming years, instability will prevail on this reach as the river employs natural geomorphic processes to create a new channel through the sediment deposit (Alpine Eco, 2012; Low Clouds Hydrology, 2010). The exact response to this deposition is uncertain. Typically, head-cuts and channel formation occur from the bottom to the top of the affected reach. Field observations during the summer of 2012 indicated that channel formation and head cutting had begun to establish a new channel near the bottom of the debris fan (Alpine Eco, 2012). Although the road ford at Poverty Gulch is a direct in-channel feature, Alpine Eco (2012) indicated that the effects on the river are minimal.

> “The magnitude of the deposition in the Slate River near Poverty Gulch is dramatic, yet it is very likely natural” -Alpine Eco (2012).

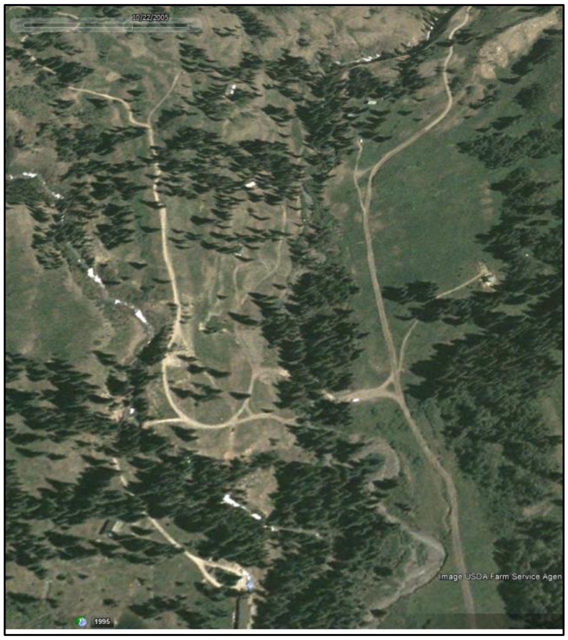


Photo 5. The Slate River near Poverty Gulch in 2006. Note where the river exits the canyon and enters the broad valley near the top of the photo. At this time the conifer stand above the Poverty Gulch Road crossing was alive and the river channel passed through the center. Image courtesy of Google Earth and the USDA Farm Service Agency.

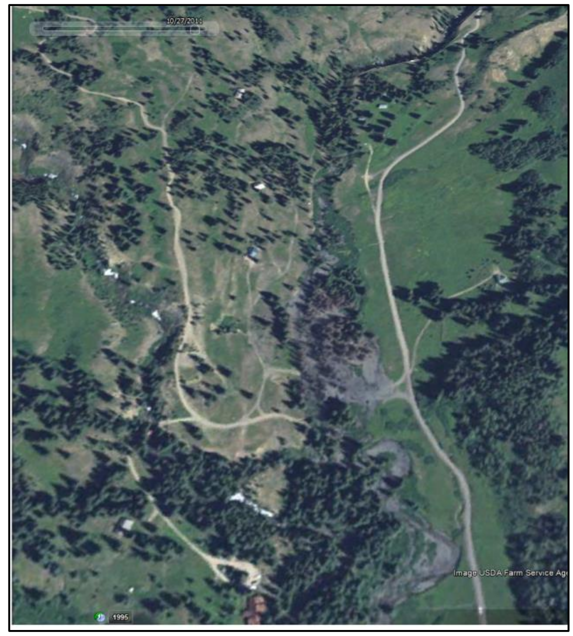


Photo 6. The Slate River near Poverty Gulch in 2011. The conifer stand above the Poverty Gulch Road crossing has died. A large grey sediment deposit extends through the conifer stand and below the road crossing. Image courtesy of Google Earth and the USDA Farm Service Agency.

Previous reports suggest that the Slate River Ranch, a piece of private property about one-third of a mile below the Poverty Gulch Road crossing, was mined for gravel (HRS, 1995). Whether or not the property was actively mined, the river channel was realigned, excavated, and an artificial pond was installed. The channel realignment caused channel incision on the reach which may have traveled upstream and likely led to sediment deposition in downstream reaches (HRS 1995; Alpine Eco, 2012). Livestock grazing and other management activities have shifted the riparian vegetation from woody shrubs to primarily grasses and forbs. Together these activities have contributed to downstream and upstream channel change and sediment deposition (HRS, 1995; Alpine Eco, 2012). Alpine Eco (2012) noted that this reach was one of the only reaches in the Watershed where riparian vegetation has been heavily disturbed.

CBLT holds a conservation easement on the property immediately upstream of the Slate River Ranch. Rapid bank erosion on this reach may compromise Slate River Road (FR 734) if it continues unabated. Alpine Eco (2012) found that the instability on the CBLT conservation easement is likely due to the channel stressors present at the Ranch. Alpine Eco recommended further study upstream and downstream of the Ranch to better understand the current status and function of the river in this area.

The Slate River exits the canyon segment and enters the second broad valley near the junction of the Oh-Be-Joyful Campground and Slate River roads (Figure 7). In recent years, natural sediment deposition below the canyon has filled the channel and adjacent floodplain. Like the reach near Poverty Gulch, this section of the Slate River is evolving in response to sediment deposition. However, the response to the load appears somewhat different. An incipient, or initial, channel formed and continues to adjust to the new floodplain, which is also covered by gravel and cobble from the deposition. Channel instability and adjustment is expected to continue in this reach for some time (Alpine Eco, 2012). The sediment deposition and subsequent response is attributed to natural geologic processes, rather than man-made stressors (Alpine Eco, 2012; Low Clouds Hydrology, 2010).

Sometime during 2010, the Slate River abandoned the large meander bend just above Oh-Be-Joyful Campground (Photos 6 and 7). During peak flow, the river cut through the gravelly sediment that formerly directed water into the meander bend. As this section was breached, the gradient of the river increased substantially. The increased gradient of the reach allowed for dramatic scour as the river established a new and far straighter channel (Photo 7). The new channel passes through a forested area (Photos 6 and 7). The scour, or erosion, that formed the new channel uprooted several large trees and moved a substantial amount of material downstream. These trees became a part of the river channel; some were transported downstream, and others remain where they fell. In the short term, these trees will create additional channel scour as the river continues to adjust to the new alignment. In the long term, the trees will become habitat. Large woody debris tends to create pools; which provide important diversity in fish and macroinvertebrate (MI) habitat.

In 2011 the Slate River and adjacent areas continued to adjust to the new channel alignment. It became apparent that several large trees in the Campground were likely to be lost to the river as well. This stretch of river is an incredibly popular recreation site. The Campground is consistently full during the spring, summer, and fall. The river ford allows hikers and other recreationists improved access to the Oh-Be-Joyful Pass Trail, which is a popular access point to the Raggeds Wilderness Area. Given the value of this recreation site, the BLM initiated a bank stabilization and improvement project in the fall of 2012. Large boulders were used to stabilize the river bank in several areas (Photo 7) especially adjacent to the Campground. The river ford was realigned and improved to prevent channel widening (Photo 7), which is sometimes associated with river fords. Although the ford is a direct in-channel feature, Alpine Eco (2012) indicated that the effects on the river are minimal. Signs and dedicated parking areas are used to reduce excess traffic in other areas near the river (Photo 7).

Photo 7. The Slate River near the Oh-Be-Joyful Campground in 2005. Note the large meander bend and complex braided channel near the Campground. Image courtesy of Google Earth and the USDA Farm Service Agency (2005).

Photo 8. The Slate River near Oh-Be-Joyful Campground in 2012. Note the new channel alignment through the forest; flows no longer pass through the meander bend, and large boulders armor the banks along the new channel in the forest and the Campground. Image courtesy of Google Earth and the USDA Farm Service Agency (2012).

"There is not sufficient evidence of human-stressors of a magnitude capable of explaining the processes. Given the evidence available, we conclude that the high degree of instability and channel evolution present at Oh-Be-Joyful Campground is primarily a natural channel response to geologic activity." - Alpine Eco (2012).

The Slate River Road (FR 734) is the only road to traverse the main glacial valley of the Slate River Watershed. The volume of sediment produced by the road is negligible and the overall impact is insignificant (Alpine Eco, 2012). However, the report identified two road sections where BMPs could be employed to prevent erosion or improve channel function. A culvert that passes water under Slate River Road from an unnamed tributary that drains Anthracite Mesa and enters the Slate River from the northeast may slightly increase the potential for erosion by "shot-gunning" water onto the fill slope (Alpine Eco, 2012). The first section of Gunsight Pass Road was also identified as problematic due to it's proximity to the Slate River and for road fill that encroaches upon the channel and alters sediment transport capabilities. CBLT,the landowner, is addressing the situation with assistance from Alpine Eco and EcoMetrics. A detailed study will be completed to determine the most feasible and cost-effective approaches to improve river stability and function at the Slate River near the road crossing and Gunsight Pedestrian Bridge (Figure 7).

2.6.3 Main Slate River Alluvial Valley

As the Slate River flows downstream from Gunsight Bridge the valley opens from a narrow glacial valley to a wide river or alluvial valley. A terminal moraine lies near Gothic Road (Cooper, 1993). The moraine acts as a grade control by decreasing the river gradient which allowed glacial and river sediments to accumulate in upstream reaches (Cooper, 1993; Alpine Eco, 2012). A landslide formed the outlet of what is now Nicholson Lake (Cooper, 1993). Due to both the increased width of the valley and decreased slopes of the hillsides the likelihood of mass erosion on the hillsides in the lower portion of the Watershed is remote (Alpine Eco, 2012).

The changes in valley form in this portion of the Watershed created changes in the channel form. The river channel in the alluvial valley is comprised of gravels rather than cobbles, boulders, and bedrock which dominate the channels found upstream (Alpine Eco, 2012). In 1995, HRS suggested that without disturbance of any kind the river channel would tend to be wide and shallow as it followed a moderately sinuous course on a relatively low grade (< 2%, i.e., a C4 channel; HRS, 1995). Alpine Eco generally agreed with this assessment and found that the current channel form is over-wide and entrenched or braided in selected segments due largely to anthropogenic stressors. In the main alluvial valley sediment loads produced from man-made channel instabilities likely equals or exceeds the sediment load produced through natural hillslope processes (Alpine Eco, 2012).

Historic and current land use practices employed from Wildbird Bridge to the lower end of Peanut Lake create the largest anthropogenic impacts found in the Watershed (Alpine Eco, 2012). The most severe stressors found in this area are attributed to in-channel gravel mining that occurred in the 1970s (HRS, 1995). As gravel was removed, the elevation of the channel decreased which caused the river to further down-cut the bed in the mined areas, as well as adjacent areas. Over time, this has created an incised channel within the original channel. Alpine Eco (2012) readily found evidence of this on site. The river channel has a perched, abandoned floodplain that is about two to three feet higher than the current bankfull elevation (Alpine Eco, 2012). Like HRS (1995), Alpine Eco concurred that these activities have negatively impacted channel stability and increased sediment production both upstream and downstream of the gravel mine area (Alpine Eco, 2012). Channel cutting in this area has been exacerbated by roads and drainage ditches adjacent to the river. These features, created to support past gravel mining operations, further disconnect the river from the floodplain and alter the characteristics of the vegetation community (Alpine Eco, 2012).

> "In this case the channel instability between Wildbird and Peanut Lake is undeniably human-caused. The problems are a direct result of past and present land use."- Alpine Eco, 2012.

The assessment found that the risk for excessive bank erosion, channel enlargement, and sediment deposition persists. There is potential for further degradation on the reach between Wildbird and Peanut Lake. The reach is considered a high priority for additional study and restoration efforts. CBLT owns several parcels in this area. CBLT is actively working to preserve irrigation head gates found on the properties with interim in-channel BMPs. As well as, arranging for integrated studies to determine the best course of action to assure this reach remains stable and channel function improves over time.

The channel incision that originated near Wildbird, continues as the Slate River approaches Peanut Lake (Alpine Eco, 2012). Like the incised reach upstream, the assessment indicated that excessive bank erosion, channel enlargement and sediment deposition are likely and further degradation is possible (Alpine Eco, 2012). Over time, these channel instabilities have pushed the Slate River west toward Peanut Lake (HRS 1995; Alpine Eco, 2012). A narrow strip of beaver dams, organics, and fragile land, which is just 15 to 20 feet wide in places, currently prevents Peanut Lake from draining into the Slate River.

The property at Peanut Lake once hosted coal and ore processing facilities. In 2005, the site was successfully reclaimed by DRMS and a coalition that included the Town of Crested Butte, the EPA, Gunnison County, the Gates Foundation, CBLT, and Peanut Mine Inc., a non-profit established for the project. Following successful reclamation, recreation has increased in this area. Hikers, bikers and others pass through the site and near the river on the Lower Loop Trail.

Human-induced instability is a source of sediment pollution and a serious risk to Peanut Lake (Alpine Eco, 2012). Due to these factors, a prediction level assessment (PLA) was recommended. In 2014, a PLA was completed in the area from Wildbird to downstream of Peanut Lake. The data will clarify the source of instability and help determine the best way to stabilize or restore the reach. As the landowner, CBLT is leading the project, and will seek partnerships as needed.

Photo 9. The Slate River near Peanut Lake; note the thin section of land that separates the river from the lake. Photo by Chad Martens.

Gothic Road Bridge (County Road 317) is a clear stressor to the Slate River (Alpine Eco, 2012). During high flow, the bridge constricts the floodplain, which forces water to back up above the bridge. The decrease in water velocity causes entrained sediments to deposit in the channel. This process has created the enormous sediment bars and braided channel found upstream of the bridge. Alpine Eco (2012) noted three constrictions in the area. They are the Gothic bridge and the associated road fill, the old bridge abutments, and a natural geologic constriction. The old road abutments are just downstream of the existing bridge. The geologic constriction, which is likely a terminal moraine, would naturally cause some sediment deposition or grade control, but it is far wider than the man-made constrictions, so its effects would be smaller than those imposed by the bridge and old abutments. Sediment transport dynamics and management issues (primarily road maintenance) are further complicated by the confluence with Coal Creek; which is immediately upstream of Gothic Road.

A PLA should occur to better understand sediment dynamics in this reach. A PLA could be used to study the Slate River in areas adjacent to the bridge, including the confluence with Coal Creek. The PLA would provide information regarding river stability, flood control, and stormwater management. The information could ultimately be used to establish bridge dimensions that better align with the channel and floodplain, as well as provide for improved habitat. Gunnison County plans to replace the bridge in 2016. CBLT owns the confluence parcel, which is the primary study area. As the landowner, they have taken initiative to secure funding for the project.

Grazing occurs on several properties in the main alluvial valley. Woody vegetation is well preserved in most riparian areas and sediment or stability problems are not attributed to grazing (Alpine Eco, 2012). CBLT currently has two riparian fencing projects underway in partnership with the U.S. Department of Fish and Wildlife within this reach. Both projects use wildlife friendly fencing to temporarily keep cattle out of recovering riparian areas while still allowing for grazing on the remainder of these properties. Aside from the Gothic Road Bridge, sediment or stability issues associated with roads in this portion of the Watershed were not identified (Alpine Eco, 2012).

2.7 VEGETATION COMMUNITIES

Photo 10. Lupine, one of many wildflowers native to the Upper Slate River Watershed. Crested Butte is the Wildflower Capital of Colorado. Photo: Chris Segal.

The Watershed is home to a diverse set of vegetation communities that are relatively undisturbed. Over eighty percent of the Watershed is managed publicly and use is generally limited to recreation, managed grazing, dispersed camping, and other generally low-impact activities. Environmental factors such as: elevation, aspect, slope, and soil type create the vegetation mosaic found in the Watershed. In the Watershed elevation and orographics create a steep precipitation gradient (Langenheim, 1962). Precipitation near Crested Butte averages about 20 inches per year (NRCS, 2013), while the mountain peaks in the headwaters receive up to 50 inches of precipitation annually (NRCS, 2013). This gradient influences vegetation communities heavily. Vegetation in the Watershed can be coarsely divided into three zones or ecoregions (Omernik, 2004): alpine, subalpine forests, and sagebrush parks (Figure 8). The work of Langenheim and others (1962) was used to further characterize vegetation in these zones. The following paragraphs generally describe the vegetation communities found in the Watershed.

Mapping vegetation presents a considerable challenge as communities do not appear as discrete units. Natural vegetation forms mosaics, which blends with or encroaches upon adjacent communities. Langenheim (1964) noted that considerable gradation occurs between communities in the Crested Butte area, especially between spruce-fur and alpine zones. Those who would like a more detailed discussion should consult Langenheim (1964) and USFS (2010). Tables four through six summarize vegetation communities by zone. The elevation range, characteristics, and common species are from Langenheim (1962); common names were retrieved from the USDA-NRCS Plants Database (2013).

2.7.1 Alpine Zone

This zone is found on the peaks, ridges, and talus covered areas at high elevation (Figure 8). Alpine vegetation is best suited to 12,500 to 13,500 foot elevations, although it can be found as low as 12,000 feet (Langenheim, 1962). This zone is diverse and the actual species composition relates to the nature of the habitat. Upland herb or upland willow communities are common in areas where snow lingers for most of the year (Langenheim, 1962). Talus and boulder fields support different communities that depending on location and may include shrubs, forbs, and grasses. Cirque basins can support fescue grasslands or upland herbs (Langenheim, 1962).

Table 4. Vegetation communities, elevation ranges, characteristics, and common species found in the Alpine Zone.

Ecoregion	Community Type	Elevation Range (feet)	Characteristics	Species	
				Common Name	Scientific Name
Alpine Zone	Alpine	12,500 to 13,500; can extend as low as 12,000	Environmental characteristics determine the actual community compostion which varies among boulders, talus, fell fields and others. Low growth forms with rossettes, tufts, and matts are common.	Graylocks four-nerve daisy	*Hymenoxys grandiflora*
				Alpine bluegrass	*Poa alpina*
				Alpine sagebrush	*Artemisia scopulorum*
				Nodding Locoweed	*Oxytropis deflexa*
				Featherleaf fleabane	*Erigeron pinnatisectus*
	Upland herb	10,500 to 12,500; most common from 11,500 to 12,500 range	This stable community thrives in non-forested areas. It is characterized by tall grasses, sedges and erect forbs, which differentiates it from alpine herb communities.	Thickleaf ragwort	*Senecio crassulus*
				Porter's licorice-root	*Ligusticum porteri*
				Lupine	*Lupinus parviflorus*
				Alpine timothy grass	*Phleum alpinum*
				Cinquefoil	*Potentilla pulcherrima*
	High-Altitude Willow	10,500 to 12,500; most common from 11,500 to 12,500 range	This community shares a range with the upland herb community. This community is less common than the upland herb community	Shortfruit willow	*Salix brachycarpa*
				Grayleaf willow	*Salix pseudolapponum*
				Wolf's willow	*Salix wolfi*
				Barclay's willow	*Salix barclayi*
				Diamondleaf willow	*Salix planifolia*
	Fescue Grassland	8,500 to 13,500	This transzonal community type can appear anywhere in the watershed under the right circumstances. Some stands may occur during early stages of succession.	Thurber's fescue (grass)	*Festuca thurberi*
				Western or common yarrow	*Achillea lanulosa*
				Slender cinqufoil	*Potentilla gracilis*
				Lewis or prairie flax	*Linum lewisii*
				Slender wheatgrass	*Agropyron trachycaulum*

2.7.2 Subalpine Forest

This zone is primarily spruce and fir forest that occurs through the middle portion of the Watershed at elevations ranging from 9,000 to 12,000 feet (Figure 8). This is the largest zone in the Watershed and patches of un-forested areas occur. Gradation between the subalpine forest and the alpine zone occurs (Langenheim, 1962). The forest can be found in alpine zones as krummholz (German for “crooked wood”) islands. The alpine plant community reaches into subalpine elevations (i.e., less than 12,500 feet) where shallow soils or talus prevent forest species. Spruce-fir communities are also common in riparian areas at lower elevations (Langenheim, 1962). Beetle kill has been observed in some forested stands in the Watershed. However, management options are limited as many of the sites occur in wilderness or other inaccessible areas. Over time, natural succession will replace vegetation in these stands.

Patches of aspen are found as successional communities in areas where the forest canopy has opened due to disease, windfall, fire, or disturbance (Langenheim, 1962). Most aspen stands occur as a stable community between 9,500 to 10,500 feet (Langenheim, 1962). The understories of the aspen forests are often controlled by aspect and soil type (Langenheim, 1962). Where wetter conditions persist the understory is lusher and may support sedges, while drier conditions favor grasses (Langeheim, 1962).

Table 5. Vegetation communities, elevation ranges, characteristics, and common species in the Subalpine Forest.

Ecoregion	Community Type	Elevation Range (feet)	Characteristics	Species	
				Common Name	Scientific Name
Subalpine Forest	Spruce-Fir	9,500 to 11,500; occurs as Krummholz at up to 12,500; riparian at 8,500.	The spruce fir community type covers the largest area in the watershed. Forms a well-defined belt from 10,500 to 11,500; typically above aspen communities.	Engelman spruce	*Picea engelmannii*
				Supalpine fir	*Abies lasiocarpa*
				Whortleberry	*Vaccinium spp*
				Wild strawberry	*Fragaria ovalis*
				Lousewort	*Pedicularis racemosa*
				Tall fringed bluebells	*Mertensia ciliata*
				Gooseberry	*Ribes montigenum*
	Aspen Park	8,500 to 11,200; most common between 9,500 and 10,500.	Often borders conifer forests or sagebrush park; can invade fescue grasslands. Considered a stable community type; but also can occur in successional stands where forest canopy has been opened. The understory can vary	Aspen	*Populus tremuloides*
				Aspen pea	*Lathyrus leucanthus*
				Porter's licorice-root	*Ligusticum porteri*
				American vetch	*Vicia americana*
				Tall fleabane	*Erigeron elatior*
	Burn Replacement: Forests	9,500 to 10,500; seldom occurs below 8,500 or above 11,500	This early seral community occurs follows fire; the composition of the community depends upon fire intensity and original community type. The community will form a forest or grassland. This accounts for a very small area of the watershed.	Lodgepole pine	*Pinus contorta*
				Whortleberry	*Vaccinium spp*
				Oregon Boxleaf	*Paxistima myrsinites*
				Heartleaf arnica	*Arnica cordifolia*
				Fireweed	*Epilobium angustifolium*
	Fescue Grassland	8,500 to 13,500	This transzonal community type can appear anywhere in the watershed under the right circumstances. Some stands may occur during early stages of succession.	Thurber's fescue (grass)	*Festuca thurberi*
				Western or common yarrow	*Achillea lanulosa*
				Slender cinqufoil	*Potentilla gracilis*
				Lewis or prairie flax	*Linum lewisii*
				Slender wheatgrass	*Agropyron trachycaulum*

2.7.3 Sagebrush Parks

Sagebrush parks are typically found near the outlet of the Watershed (Figure 8) and occupy the smallest area of the three vegetation types in the Watershed. This community is named for sagebrush, but sagebrush is near its upper elevation range of about 9,000 feet in the Watershed. The elevation of the Watershed allows for additional blending with aspen, grassland, and riparian communities. Sagebrush parks typically lack an overhead canopy, except where trees have encroached. The community includes a variety of grasses, forbs, and shrubs.

Table 6. Vegetation communities, elevation ranges, characteristics, and common species in the Sagebrush Parks.

Ecoregion	Community Type	Elevation Range (feet)	Characteristics	Species	
				Common Name	Scientific Name
Sagebrush Park	Sagebrush	8,500 to 9,500	A shrub and grass land dominated by sagebrush. Generally a stable community type, grazing pressure can increase shrubs. The community is near it's upper elevation range.	Big sagebrush	*Artemisia Tridentata*
				Thurber's fescue (grass)	*Festuca thurberi*
				Western or common yarrow	*Achillea lanulosa*
				Buckwheat	*Eriogonum neglectum*
				Rabbitbrush	*Chrysothamnus spp*
	Fescue Grassland	8,500 to 13,500	This transzonal community type can appear anywhere in the watershed under the right circumstances. Some stands may occur during early stages of succession.	Thurber's fescue (grass)	*Festuca thurberi*
				Western or common yarrow	*Achillea lanulosa*
				Slender cinqufoil	*Potentilla gracilis*
				Lewis or prairie flax	*Linum lewisii*
				Slender wheatgrass	*Agropyron trachycaulum*
	Burn Replacement: Grasslands	9,500 to 10,500; seldom occurs below 8,500 or above 11,500	This early seral community occurs follows fire; the composition of the community depends upon fire intensity and original community type. The community will form a forest or grassland. This accounts for a very small area of the watershed.	Thurber's fescue (grass)	*Festuca thurberi*
				Western or common yarrow	*Achillea lanulosa*
				Mountain thistle	*Cirsium scopulorum*
				Whortleberry	*Vaccinium spp*
				Aspen fleabane	*Erigeron speciosus*

2.7.4 Wetland and Riparian Vegetation

The Watershed supports riparian, spring-fed (upland), and fen wetlands. Wetlands provide critical ecosystem services including: water storage, increased biodiversity, carbon storage, and generally improve overall watershed health.

Fens are a type of peat forming wetland. Unlike bogs which are fed by rainfall, fens are primarily supported by shallow groundwater or runoff from up-gradient areas (USFS, 2012). The anaerobic conditions that allow peat to accumulate tend to create acidic waters. However, the overall acidity is often controlled by the groundwater source or other local conditions. Fens may or may not be rich in iron. Due to generally dry climate conditions, fens are typically the only features capable of forming peat in Colorado. Fens support a unique vegetation community and are often 8,000 to 12,000 years old (USFS, 2012). Like other wetlands, fens provide vital ecosystem services.

To date, five fens have been identified in the Watershed (Figure 8). Four of the fens are in the Oh-Be-Joyful drainage, and the fifth fen is east of the Slate River near Paradise Divide. Fens in the Elk Mountains are generally of high quality (USFS, 2012). Disturbance, if observed, was typically attributed to animal browsing. The fens in the Watershed often include a variety of willows, sedges and rushes. For additional details see the USFS Fen Inventory Report (2012).

Table 7. Vegetation communities, elevation ranges, characteristics and common species in wetlands and riparian areas.

Community Type	Elevation Range (feet)	Characteristics	Species			
			Common Name	Scientific Name	Common Name	Scientific Name
Wetland, Riparian, Snowflushes and Fens	8,500 to 13,500	These streamside and wet meadow communities occur near water throughout the watershed. This community also includes high altitude willos, snowflushes and fens. These communities typically occur in small or narrow patches which makes mapping at most scales difficult. The vegetation maps present wetland distributions with the best available data, but there are clear limitations in the mapping data.	Beaked sedge	*Carex rostrata*	Shortfruit willow	*Salix brachycarpa*
			Water sedge	*Carex aquatilis*	Grayleaf willow	*Salix pseudolapponum*
			Smallwing sedge	*Carex festivella*	Wolf's willow	*Salix wolfi*
			Rocky Mountain rush	*Juncus saximontanus*	Barclay's willow	*Salix barclayi*
			Longstyle rush	*Juncus longistylis*	Diamondleaf willow	*Salix planifolia*
			Mountain rush	*Juncus balticus*	Diamondleaf saxifrage	*Saxifraga rhomboidea*
			Elephanthead lousewort	*Pendicularis groenlandica*	Bog birch	*Betula glandulosa*
			White marsh marigold	*Caltha leptosepala*	Twinberry honeysuckle	*Lonicera involucrata*
			Northern green orchid	*Habenaria hyperborea*	Shrubby cinquefoil	*Potentilla fruticosa*
			Common selfheal	*Prunella vulgaris*	Engelman spruce	*Picea engelmannii*
			Sudetic lousework	*Pedicularis scopulorum*	Blue spruce	*Picea pungens*
			Dane's dwarf gentian	*Gentiana tenella*	Thinleaf alder	*Alnus tenuifolia*
			Booth's willow	*Salix pseudocordata*	Western dogwood	*Cornus stolonifera*
			Dusky willow	*Salix melanopsis*	Balsam poplar	*Populus balsamifera*
			Dewystem willow	*Salix irrorata*	Narrowleaf cottonwood	*Populus angustifolia*

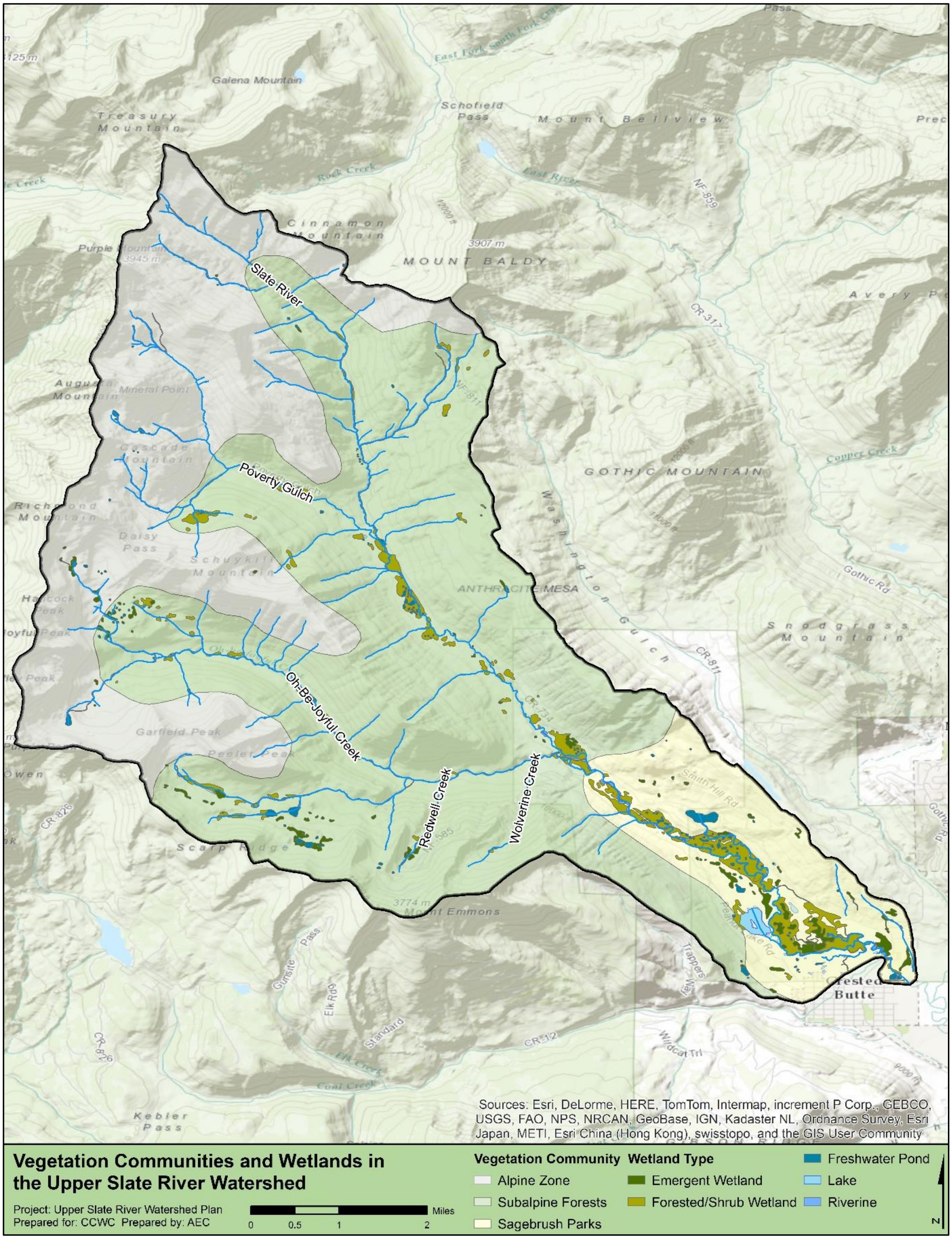


Figure 8. Vegetation communities and wetlands in the Upper Slate River Watershed.

2.8 AQUATIC LIFE

The health and diversity of aquatic life provides a unique signature that characterizes the quality of a waterbody or watershed. Environmental conditions such as temperature, chemistry, flow regime, and habitat type dictate which aquatic species are suited to the waterbody. Aquatic life responds to fluctuations in water temperature, chemistry, and quantity. Fish and other mobile species will migrate if unsuitable conditions persist. Aquatic insects, also called macroinvertebrates (MI), cannot readily escape unsuitable conditions. Therefore, the species composition and diversity of macroinvertebrate communities can provide insight into the long term character of a waterbody. Desirable macroinvertebrates tolerate very little pollution, especially organic pollutants (Hilsenhoff, 1988). Undesirable macroinvertebrates thrive as pollution increases.

The following paragraphs summarize macroinvertebrate data collected from the Watershed. In 2011, when watershed planning was initiated, macroinvertebrate data was a considerable data gap (AEC, 2011). In 2011 and 2013, MI samples were collected at several locations to characterize baseline conditions in the Watershed. The sample collection protocols varied between 2011 and 2013, but the protocols used during both events allowed for the calculation of MMI scores (Methods: 2011- CDPHE, 2013- NAMC).

Table 8. Summary of macroinvertebrate communities in the Upper Slate River Watershed.

Sample Location	Location Description	9/4/2011[2] MMI Score	Attains MMI Criteria	Hilsenhoff Biotic Index[5]	Shannon's Diversity[6]	7/29/2013[2] MMI Score	Attains MMI Criteria	Hilsenhoff Biotic Index	Shannon's Diversity
	Aquatic Life Use Criteria[3,4]:	**> 50**	**Criteria**	**< 5.1**	**> 3.0**	**> 50**	**Criteria**	**< 5.1**	**> 3.0**
SR-4	Slate River above Pittsburg Mine	58.0	Yes	3.78	1.91	74.3	Yes	2.43	2.15
POV-3	Mainstem of Poverty Gulch below Confluence with Baxter Creek	64.5	Yes	2.94	2.56	58.4	Yes	4.52	1.72
SR-6	Slate River below Poverty Gulch, above Wetland	58.0	Yes	3.55	1.82	79.6	Yes	2.95	2.38
SR-7	Slate River above Oh-Be-Joyful Creek and Campground	58.6	Yes	3.71	1.69	76.6	Yes	3.62	2.13
OBJ-4	Oh-Be-Joyful Creek at Mouth, above Slate River	51.0	Yes	4.19	1.96	81.7	Yes	3.35	2.17
SR-8	Slate River Below Oh-Be-Joyful Creek and Campground	55.2	Yes	3.54	1.80	62.7	Yes	2.21	2.28
SR-9	Slate River above Coal Creek	Not sampled				37.0	No	4.32	1.94

Notes

1. In 2011 samples were collected to characterize conditions throughout the watershed and to determine changes in MI communities near the campground. CDPHE protocol was used to collect the samples.
2. In 2013 samples were collected to characterize conditions throughout the Watershed. NAMC protocol was used to collect the samples. The NAMC protocol is compatible with the MMI.
3. Where MMI scores range from 42 to 50, the Hilsenhoff Biotic Index must be < 5.1 and the Shannon's Diversity must be > 3.0 for attainment. If these criteria are not met the waterbody is not in attainment of aquatic life uses.
4. For streams where the biotype is mountains, MMI scores that exceed 50 are in attainment for aquatic life use. MMI scores that range from 42 to 50 are in a grey zone which requires evaluation relative to additional criteria, see footnote 3. MMI scores below 42 are not in attainment with aquatic life use criteria. For streams where the biotype is transitional (SR-8 and SR-9) the impairment threshold is 42, the grey zone ranges from 42 to 52, and attainment is an MMI score greater than 52.
5. Hilsenhoff Biotic Index: in summary intolerant taxa (HBI of 0-2) live only in high quality habitats with unpolluted water. Intolerant taxa are the first to respond (i.e. struggle to survive) to declining water quality or habitat conditions. Conversely, tolerant taxa (HBI of 8-10) are well-adapted to very poor water quality conditions (Hilsenhoff, 1987).
6. Shannon's Diversity Index: a calculated value that incorporates both species richness and evenness and ranges from 1.5 (low) to 3.5 (high).

The Slate River above the Pittsburg Mine was the highest elevation location sampled in the Watershed. In this area the Slate River flows through a narrow canyon with very steep hillslopes that support primarily alpine vegetation. The sediment load in this portion of the Watershed is nearly all natural and very large; with significant input from mass erosion events (Alpine Eco, 2012). The MMI scores calculated for this location were 58.0 and 74.3 for the events in 2011 and 2013, respectively (Table 8). The results indicate that conditions were supportive of aquatic life.

Poverty Gulch below the confluence with Baxter Creek (POV-3) meanders through a wetland near the sample location. POV-3 had the highest MMI score measured in 2011 and supported aquatic life use in both years (Table 8). This result is consistent with the water quality results collected from Poverty Gulch. Although the basin has several abandoned mine features, most notably the Augusta Mine Portal, the features do not substantially impair water quality (AEC, 2011; CCWC dataset).

The Slate River below Poverty Gulch also supported aquatic life use in 2011 and 2013 (Table 8; SR-6). This is promising given recent grade and channel adjustments in response to a large sediment deposit. The deposition event(s) likely occurred following large runoff or precipitation events in 2008.

At the Slate River above Oh-Be-Joyful Campground MMI scores were 58.6 and 76.6 in 2011 and 2013, respectively (Table 8; SR-7). The MMI scores from these events and a sampling event in 2010 do not clearly indicate whether the channel change and subsequent stabilization efforts have changed the MI community. The MMI scores and other metrics from all of the sample events indicate the area has remained supportive of aquatic life in recent years.

Oh-Be-Joyful Creek is a documented source of metals due to drainage associated with historic abandoned mine and natural geologic features in Redwell Basin (AEC, 2011). The extent to which increased metal concentrations effect MI communities at the mouth of Oh-Be-Joyful Creek is unclear. The MMI scores were 51.0 and 81.7 in 2011 and 2013, respectively (Table 8). Aquatic life use is supported at the mouth of Oh-Be-Joyful Creek.

In the Slate River below Oh-Be-Joyful Creek and the Campground MMI scores were 55.2 and 62.7 in 2011 and 2013, respectively (Table 8). The scores indicate the site was supportive of aquatic life use. The MMI score measured in the Slate River below Oh-Be-Joyful Creek and the Campground was lower than the scores observed in the Slate River above these features; however, the diversity found at the lower site was greater. So the effect of Oh-Be-Joyful Creek, the Campground, and the recent sediment deposition event and stabilization efforts remain unclear.

In the Slate River above the confluence with Coal Creek the MMI score was 37 in 2013, which failed to meet the aquatic life criterion (Table 8). The combined influence of increased sediment loads and elevated metal concentrations in the lower Slate River make identifying the cause(s) of impairment difficult. Based on the geomorphic assessment, it appears that channel instability and sediment deposition are problematic in areas downstream of Wildbird. These factors have several potential implications that may reduce the habitat quality. Instability in the Slate River below Wildbird has created sections of down cut and over-widened channel. Anecdotal observations suggest that embeddedness (a measure of pore space) increases in the Slate River below Wildbird. Increased embeddedness could limit the health of the macroinvertebrate community by decreasing the habitat quality. Elevated metal concentrations may also affect the overall health of the macroinvertebrate community. However, macroinvertebrate samples collected from the mouth of Oh-Be-Joyful Creek and the Slate River immediately below Oh-Be-Joyful Creek readily met aquatic life criteria although metal concentrations in those waters tend to be higher than concentrations measured in the lower Slate River. Physical limitations of the stream habitat due to sediment deposition and channel instability may be the prime cause of impairment, but additional data collection and analysis should occur to better characterize the problem.

The Slate River from the confluence with Coal Creek to the confluence with the East River (Segment 8) is on the M&E List for potential impairment of aquatic life. Macroinvertebrate samples collected from the Watershed in 2013 suggest that the macroinvertebrate community may be impaired in other portions of the Slate River, perhaps below beginning near Wildbird. Additional studies should be completed to better delineate the portion(s) of the Slate River where the MI community may be impaired. Such a study should include sample locations in the Slate River near Wildbird, Peanut Lake, the Recreation Path Bridge and other downstream locations, along with samples from the lower reaches of Coal Creek.

In recent years, Colorado Parks and Wildlife (CP&W) has completed fish surveys on the Slate River and Oh-Be-Joyful Creek. Brook and brown trout are abundant in the Slate River and Oh-Be-Joyful Creek. Fish densities are typically high, but fish tend to be somewhat small. In 2012, CP&W surveyed two reaches near Oh-Be-Joyful Campground. The first location featured pools formed by large woody debris (from the channel change event). There were fewer fish in these pools than in the river at large, but they were bigger, on average, than the fish found in open habitats (Table 9). In fact, the pool habitats on the Slate River met the criteria for Gold Medal Waters (Table 9; 60 pounds and 12 fish over 14 inches per acre). However, the pools are not representative of the Slate River as a whole, so it does not qualify as a Gold Medal Water (Dan Braugh, personal communication 2013).

Table 9. Fish survey results from the Slate River, collected on June 27, 2012. The survey excluded fry.

Location	Fish Species	Number Caught	Number per Mile	Pounds per Acre
Slate River upstream of Oh-Be-Joyful Campground: Pools created by Large Woody Debris	Brook Trout	5	129	6
	Brown Trout	15	405	58
Slate River at Oh-Be-Joyful Campground	Brook Trout	40	482	15
	Brown Trout	34	452	23

In 2013, CP&W surveyed the fish population in Oh-Be-Joyful Creek near the confluence with the Slate River. The surveyed area included a desirable mix of riffles, runs, pools, undercut banks, and robust riparian vegetation. The fish community in this area is considered resident because the surveyed reach was isolated from the Slate River. A waterfall upstream of the survey area may preclude or limit upstream migration in Oh-Be-Joyful Creek (CP&W, 2013). The fish density, for both brown and brook trout, was higher in Oh-Be-Joyful Creek in 2013 than measured in the Slate River in 2012.

2.9 ENDANGERED, THREATENED OR SPECIES OF SPECIAL CONCERN

Colorado is home to 16 animal and 16 plant species that are federally listed as endangered or threatened. Gunnison County has been identified as critical habitat for eight of these species; seven are animals and one is a plant. None of the threatened or endangered fishes (bonytail chub, Colorado pikeminnow, greenback cutthroat trout, humpback chub, and razorback sucker) is known to occur or have historic ranges in the Watershed (US FWS, 2013). Colorado River cutthroat trout are considered sensitive, species by the USFS and BLM (USFS, 2008). A sensitive species designation by these agencies allows for special management efforts on public land, but differs from the protection requirements associated with a federal designation as threatened or endangered. Colorado River cutthroat have not been found in the Watershed. But the Watershed appears to meet the habitat criteria associated with the historic range of the species (USFS, 2008).

The endangered, threatened or special concern species that could potentially occur in the Watershed are: Gunnison sage-grouse, skiff milkvetch, Uncompahgre fritillary butterfly, Canada lynx, Gunnison's prairie dog, and North American wolverine. Table 1 in Appendix A presents information on each endangered, threatened, proposed threatened or candidate species found in Gunnison County where the habitat range extends to the USR Watershed. At this time, there are no known populations of these species in the Watershed.

2.10 INVASIVE SPECIES

This section introduces the most problematic invasive species found or potentially found in the Watershed. The goal of this section is to provide basic information about identification of these species. The focus is on invasive species found in the water or in riparian areas. Landowners or others should contact the references provided at the end of the section if they have specific concerns.

Photo 11. Didymo, also called rock snot, occurs in some portions of the Slate River. Photo courtesy of Clancy Brown.

Didymo (*Didtmoshenia geminata*): are algae that prefer cold water streams and rivers. Didymo does not present a human health risk, but reduces the quality of stream habitat. Didymo forms large mats that cover most of a streambed. Didymo attaches to the streambed by a stalk. These stalks have a rough texture, and look somewhat like toilet paper when dry (Photo 10). Widespread didymo infestation degrades the overall health of a stream and may increase the risk associated with other invasive species or diseases. The best way to prevent the spread of didymo is to prevent transport. Clean equipment that may have been exposed to didymo and thoroughly dry it before returning to the water. First, while near the water check for didymo on your footwear, clothing or equipment. Remove any visible algae and leave it at the site. Second, clean or thoroughly dry your equipment. Cleaning solutions can be made with two percent bleach or five percent dish detergent or salt. If you dry the equipment rather than wash it, allow it to dry thoroughly for a minimum of 48 hours. Absorbent materials like waders, life jackets, kayak skirts, etc. may require additional time to completely dry (EPA, 2006). Didymo occurs in some areas of the Watershed.

Photo 12. Zebra and quagga mussels grow in dense colonies on hard surfaces. Each mature mussel is about one inch in length. Photo courtesy of David Britton, USFWS.

Zebra and Quagga Mussels (*Dreissena polymorpha* and *Dreissena rostriformis bugensis*): are small mussels that attach to hard surfaces found in waterbodies. These invasive mussels originally hail from Eurasia and are incredibly problematic in North America, where they lack predators. To date, zebra and quagga mussels have spread from the Great Lakes Region to the 100th Meridian in the United States (ANS Task Force, 2013). The mussels have been found in selected lakes or reservoirs in the west; where the water is sufficiently warm and calcium-rich. Due to the cold temperatures and generally low calcium concentrations, waters in the Watershed are not at an especially high risk for infestation. However, we all need to be aware of the ecological threat posed by these invasive mussels. Locally, the National Park Service requires decontamination for all launched water craft prior accessing any of the waters at Curecanti National Recreation Area (Blue Mesa, Morrow Point, and Crystal Reservoirs). Other equipment should be decontaminated using mild acids (like vinegar), strong cleaners, heat above 140 degrees Fahrenheit or dried very thoroughly.

New Zealand Mudsnails *(Potamopyrgus antipodarum):* The New Zealand mudsnail has been found in parts of Colorado. At this time, it is not found in the Gunnison River Watershed. If introduced to local streams, the snail could devastate the fishery (National Park Service, 2013). New Zealand mudsnails change the physical characteristics of the river by quickly reproducing in high density masses, which in turn impairs MI communities and alters the dynamics of the food chain.

Photo 13. New Zealand Mudsnail. Photo by USGS

Photo 14. Yellow toadflax, an invasive weed found in the Watershed. Photo by CSU Extension

Yellow toadflax *(Linaria vulgaris):* Yellow Toadflax is an escaped ornamental. This perennial has narrow leaves that are one to two inches in length. The stem of the plant is somewhat woody at the base and becomes smooth at the top. Yellow toadflax has many leaves along the stem that range in height from one to three feet (CSU Extension, 2008). The white and yellow flowers are similar to those of snapdragons. Due to the appearance of the flowers this plant is sometimes called butter and eggs. Disturbance or bare ground allow this plant to colonize the most quickly. To avoid this, maintain native vegetation cover. Mechanical treatments such as hand pulling or tilling are not recommended for this plant due to the extensive root system (CSU Extension, 2008). If mechanical treatments are used the problem may get worse since the root system has not been eradicated (CSU Extension, 2008). Yellow toadflax is a Class B noxious weed that must be eradicated or contained according to the Colorado State Noxious Weed Act. Yellow toadflax is found along road ways and other areas in the Watershed.

Photo 15. Dalmatian toadflax. Photo from CSU Extension.

Dalmatian toadflax (*Linaria dalmatica):* This plant grows up to three feet tall. The base of the plant is formed by blue heart-shaped leaves with a waxy texture. Flowers are bright yellow and similar to snapdragons. A single plant can produce half a million seeds per year, in addition to creeping root systems that can further accelerate the spread of this aggressive invasive (CSU Extension, 2008). The key to beating Dalmatian toadflax is early detection and eradication.

Dalmatian toadflax is aggressive and readily adapts to a wide variety of conditions and even herbicides (CSU Extension, 2008). Pulling these weeds by hand can be an effective strategy for small stands. Contact the references provided below for information about chemical and biological control techniques. Declamation toadflax is a Class B noxious weed and is actively controlled by the Upper Gunnison Weed Management Team.

Photo 16. Oxeye daisy, photo courtesy of CSU Extension.

Oxeye daisy (*Chrysanthemum luecanthemum*): This perennial is typically 10 to 24 inches in height (CSU Extension, 2008). Leaves are toothed with long stems and decrease in frequency as height from the ground increases. The flowers form rays with white petals and a yellow center (CSU Extension, 2008). Each stem typically has just one flower. These shallow-rooted plants can be pulled from moist soils. Goats and sheep can be used as biological controls. Herbicides applied while the plant is flowering are also effective. Herbicides used to eradicate oxeye daisies require surfactants as well. As with all herbicides, professional application or advice is recommended. Oxeye daisy is a Class B noxious weed, but is not included on the Gunnison County noxious weed list. Oxeye daisy occurs in the Watershed.

Canada thistle (*Cirsium arvense*): This non-native thistle forms deep roots that are capable of growing horizontally and forming new plants (CSU Extension, 2008). The leaves are spiny, oblong and bright green especially in the spring. Flowers occur in small clusters and range in color from purple to white. About 1,000 to 1,500 seeds are dispersed from downy puffs near the flower. The root system, which stores nutrients is often more problematic than the seeds. Aggressive mechanical treatments can be successful against Canada thistle. Removing the root system is critical. Grazing can be incorporated into effective treatments. In the spring, grazing animals will eat succulent leaves. For large stands, herbicides often need to be incorporated into the treatment strategy. Canada thistle is a Class B noxious weed in Colorado (CSU Extension, 2013). The Gunnison Basin Weed Management Plan recommends management to reduce the impacts of Canada thistle. There are native thistle species in Gunnison County.

Photo 17. Canada thistle, photo courtesy of CSU Extension.

Scentless chamomile (*Tripleurospermum perforata*): is an annual, biennial or short-lived perennial forb that is native to Europe (CSU Extension, 2008). The plant has fern like leaves (one way to differentiate from oxeye daisy) and white ray flowers with yellow centers. This plant can form dense mats that allow it to out-compete native or desirable species. Flowers continually produce seeds during the growing season and a single plant can create 300,000 seeds per growing season (CSU Extension, 2008). Plant height varies from 0.5 to 3 feet. Scentless chamomile irritates the muzzles of grazing animals and is especially troublesome in areas where grazing or browsing occurs (CSU Extension, 2008). Maintaining healthy ground cover is the best way to prevent infestations. Hand pulling can effectively eliminate small stands. Frequent shallow tilling can effectively treat larger stands (CSU Extension, 2008).

Mowing can prevent seed formation, but will not eliminate the original population as growth will continue from existing roots (CSU Extension, 2008). Herbicides are an effective option; there are not biological controls for scentless chamomile (CSU Extension, 2008). Although it is a Class B noxious weed in the state of Colorado, scentless chamomile is not considered a noxious weed in Gunnison County (Gunnison County Extension, 2013).

Photo 18. Scentless chamomile.
Photo by CSU Extension.

Cheatgrass (*Bromus tectorum*): is an early sprouting grass that dies quickly and does not provide suitable forage (hence the name). The seed heads are brittle and sharp which makes them unpalatable (NRCS, 2006). The seeds are also a bane to hikers as they often work their way through clothing and cause skin irritation. This is the most problematic grass in the western United States (NRCS, 2006). It can severely decrease the productivity of pastures or cropped areas. Seeds caught in clothing or equipment, on vehicles or elsewhere can spread cheatgrass (NRCS, 2006). After visiting an area with cheatgrass remove any seeds to help prevent the spread. Mowing before the seed heads are mature can help eliminate cheatgrass (NRCS, 2006). There are

Photo 19. Cheatgrass seed heads. Photo by CSU Extension

also herbicides to eliminate cheatgrass.

We are fortunate that the major landowners, the USFS, BLM, CBLT, and Gunnison County work cooperatively to prevent the spread of invasive plants in our Watershed. The towns of Crested Butte and Mount Crested Butte, as well as local residents, value our native vegetation and generally cooperate with weed management efforts.

In 2012 Gunnison County treated just over 5.8 acres of weeds located adjacent to Slate River Road (Gunnison County, 2012). This is a ten-fold increase over the 0.6 acres treated in 2011 (Gunnison County, 2011). Interested parties may contact the county for a consultation about invasive species management. The Gunnison County Weed District can be reached at (970) 641-4393. The Colorado State University Extension Office in Gunnison is also an excellent resource: (970) 641-1260. Other invasive species may be present in the Watershed, so please consult the local weed management agencies for additional information.

3.0 WATER USE

In 2005, the state legislature passed the Colorado Water for the 21st Century Act (HB 05-117). As part of the act the Gunnison Basin Roundtable (GBRT) was formed, along with eight other roundtables in the state. The basin roundtables are used to facilitate water management discussions on a local level. The efforts of each roundtable are regularly integrated into statewide water management initiatives. Each roundtable was directed to complete a consumptive and non-consumptive needs assessment for their basin. Consumptive water uses remove water from streams and rivers to support agricultural, industrial, and municipal water uses. Non-consumptive uses do not remove water from the stream or river and includes recreational, aquatic life, and environmental uses. The Gunnison Basin Roundtable completed the consumptive needs assessment in 2006 and commissioned additional study in 2009. The first phase of the non-consumptive needs assessment was completed in 2010.

Absolute Right: a water court decree stating that previously unappropriated water has been put to a beneficial use. A priority date is assigned to the right.
Conditional Right: a water court decree recognizing a priority date for a new proposed appropriation. The priority becomes fixed, typically to the original priority date, when the water is actually placed to beneficial use. The applicant must show that there is unappropriated water available, and must have a plan to divert, store, and control the water. To maintain the conditional decree, there must be diligent progress towards putting the water to a beneficial use. Every six years, the potential water user must show diligence to keep the conditional decree.
Instream Flow Water Right: a water right held by the state to protect or improve the water-dependent natural environment.
(Source: Colorado Foundation for Water Education, 2004).

The Gunnison River Basin, the area drained by the Gunnison River from the headwaters to the confluence with the Colorado River, is over 8,000 square miles and includes the following counties: Gunnison, Montrose, Delta, Uncompahgre, Ouray, Hinsdale, and parts of Saguache and Mesa counties. Agriculture is the largest water use in the Gunnison Basin (GBRT, 2006). The Watershed is a small portion of the headwaters on the north edge of the Gunnison River Basin.

3.2 CONSUMPTIVE USES


Photo 20. An irrigation head gate in the Slate River.

Colorado operates a very sophisticated water rights system to administer water to a diverse group of users for a wide variety of uses. Because of the complexity of the legal system surrounding water use in our state, we recommend that interested readers consult the "Citizens Guide to Colorado Water Law" (2009). The guide is prepared by the Colorado Foundation for Water Education and offers an introduction to water law.

There are a handful of absolute surface water rights in the Watershed. These surface water rights are used to support irrigated pastures and ponds near Pittsburg and in the lower portion of the Watershed (Table 10). Other water rights include those used for wells and springs in the Watershed. These rights are typically for small quantities of water and are conditional in nature. The largest water right in the Watershed is a conditional water right held by U.S. Energy. The conditional water right is decreed for 30 cfs of water from the Slate River (Water Right Reference Case Number- 96CW311; U.S. Energy, 2013). The priority date associated with the conditional water right is 1996 (Upper Gunnison River Water Conservancy District, 1998). Like other water users, U.S. Energy has 25 years to put the water to beneficial use and must maintain the right in water court every six years. As mentioned earlier, the diversion point and pumping station would be located between Oh-Be-Joyful Campground and Gunsight Bridge (U.S. Energy, 2013). Table 10 summarizes the known and active water rights in the Watershed (this table does not include supplemental, augmentation or transfer water rights).

Table 10. Summary of consumptive water rights in the Upper Slate River Watershed.

Water Right Name[1]	Water Volume (cfs)	Appropriation Date	Use
Berg Ditch, Pond and Spring	1.5	1976	Irrigation, pond & domestic uses
Slate River Intake: Mt. Emmons Mine[2]	30	1996	Mine Pipeline
Peanut No 1 & 2 Ditches	2.7	1906, 1941	Irrigation
Kapushion Ditch[3]	Unknown	Unknown	Irrigation

Notes

1. This table does not include supplemental, augmentation or transfer water rights.
2. The Slate River Intake is a conditional water right.
3. There is a water right associated with the Kapushion Ditch, but it has not been located in the Colorado Division of Water Resources Water Rights Database.

3.3 NON-CONSUMPTIVE USES

During the non-consumptive needs assessment, the Gunnison Basin Roundtable identified the Slate River and its tributaries as major environmental segments (GBRT, 2010). The assessment identified a need for additional in-stream flow rights to protect fisheries and environmental uses in the Slate River and Oh-Be-Joyful Creek. The existing instream flow rights, appropriated in 1980, on the Slate River and Oh-Be-Joyful Creek protect flows during low flow conditions. However, they do not assure that during peak flow conditions there will be adequate water in the river to move sediment and allow the river to function naturally. In 2011 the BLM, CDP&W, and the Colorado Division of Water Resources (CDWR) began an analysis to increase the existing instream flow rights for the Slate River and Oh-Be-Joyful Creek. The primary goal was to determine if water is available to allow for increased instream flow rights during peak flow in the Slate River and Oh-Be-Joyful Creek, without injury to existing water rights. The analysis also sought to determine whether the instream flow right on Oh-Be-Joyful Creek was adequate to protect the existing fishery. In February 2014 additional instream flow rights, to protect peak flows in the Slate River and Oh-Be-Joyful Creek and an overall increase in Oh-Be-Joyful Creek, were approved by the Colorado Water Conservation Board. The new instream flow rights have an appropriation date of 2014. The original appropriation date remains effective for the 1980 instream flow rights.

Table 11. Instream flow rights in the Upper Slate River Watershed.

Instream Flow Water Rights Stream Segments	1980 Appropriation Quantity (cfs)		2014 Appropriation Date Quantity (cfs)			Combined Quantity (cfs)[8]		
	Winter[1]	Main Season[2]	Winter[3]	Peak[4]	Summer[5]	Winter	Peak	Summer
Oh-Be-Joyful: Blue Lake to Unnamed Tributary (1.5 miles)	1	1		NA[6]		1	1	1
Oh-Be-Joyful: Unnamed Tributary to Slate River (4.8 miles)	3	3	2.45	17.8	2.45	5.45	20.8	5.45
Slate River: Headwaters to Poverty Gulch (4.5 miles)	5	5		NA		5	5	5
Slate River: Poverty Gulch to Oh-Be-Joyful Creek (3.7 miles)	8	15	NC[7]	35.5	NC	8	50.5	15
Slate River: Oh-Be-Joyful to Coal Creek (5.2 miles)	10	20	NC	41	NC	10	61	20

Notes
1. Winter is defined as 12/1 to 3/31.
2. The main season is defined as 4/1 to 11/30.
3. Winter is defined as12/1 to 3/31.
4. Peak is defined as 5/1 to 7/15.
5. Summer is defined as 4/1 to 4/30 and 7/16 to 11/30.
6. NA= Not applicable, the instream flow rights for these segements were not increased in 2014.
7. NC= no change to the existing 1980 instream flow right.
8. The combined quantity is the sum of the 1980 and 2014

The 2014 instream flow rights for the Slate River segments are effective during peak flow only (5/1 to 7/15). The 2014 instream flow rights are 35.5 and 41 cfs for the upper and lower segments of the Slate River, respectively. During peak flow, the 1980 and 2014 instream flow rights total 50.5 and 61 cfs, for the upper and lower segments of the Slate River (Table 11). The 2014 instream flow right in Oh-Be-Joyful Creek increased the instream flow right from 3.0 cfs to 5.45 cfs (Table 11). During peak flow, the instream flow right increases to 20.8 cfs in Oh-Be-Joyful Creek.

Minimum lake levels were established for five lakes in the Watershed in 1977 (Table 11). In 1980, the Colorado Water Conservation Board established instream flow rights on the Slate River and Oh-Be-Joyful Creek.

Table 12. Minimum lake level water rights in the Upper Slate River Watershed.

Minimum Lake Level Water Rights Appropriation Date: 1977	Quantity
Upper Angel Lake	13 acre-feet
Lower Angel Lake	3 acre-feet
Upper Peeler No 1 Lake	18 acre-feet
Lower Peeler No 1 Lake	35 acre-feet
Nicholson Lake	498 acre-feet

3.4 WATER TREATMENT

The Town of Crested Butte Wastewater Treatment Plant is located near the outlet of the Watershed in the northeast corner of town (Figure 1). The Crested Butte water supply is from Coal Creek, but treated waters are discharged to the Slate River. The wastewater division treats wastewater, maintains storm sewers, and operates an RV waste dump on behalf of the town of Crested Butte. Wastewater is treated, according the specifications of state approved permits, prior to discharge in the Slate River. Fine screening and grit removal are the first treatment steps. The main treatment consists of activated sludge, which occurs in an oxidized ditch, and clarification. Ultraviolet light is used to disinfect the waters. Waste solids are de-watered and sent to the Gunnison County Landfill (Town of Crested Butte, 2013). Currently, the wastewater treatment plant is the only point source discharge in the Watershed.

4.0 WATER QUALITY CONDITIONS

This section presents a synopsis of the WQ Summary (AEC, 2011); where possible new data has been incorporated into the analysis.

4.1 STATE WATER QUALITY STANDARDS AND USES

Water quality standards are the foundation of the water quality-based pollution control program mandated by the federal Clean Water Act (CWA). Water quality standards define goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions such as antidegradation policies to protect waterbodies from pollutants. In Colorado, water quality standards are assigned to all waterbodies, including streams, river, lakes, and reservoirs. Standards are established through a public hearing process conducted by the Colorado Water Quality Control Commission (WQCC) within the Colorado Department of Public Health and Environment (CDPHE). The Water Quality Control Division (WQCD) is the department in CDPHE that implements WQCC policies and regulations. Regulations 31, 35, and 93 were used to complete a water quality analysis in the Watershed and are described in the paragraphs below.

Regulation 31, the Basic Standards and Methodologies for Surface Water, describes a set of "beneficial uses" for Colorado's waters and defines the water quality conditions generally necessary to attain and maintain each beneficial use. In addition, it establishes procedures for classifying waters of the state, for assigning water quality standards, and for periodic review and modification to the classifications and standards.

Regulation 35, Classifications and Numeric Standards for Gunnison and Lower Dolores River Basins, classifies and assigns numeric water quality standards to surface waters located in the Gunnison and Lower Dolores River Basins. All waterbodies are partitioned into segments, which are discrete pieces that share similar characteristics, uses, and other features. These segments are assigned beneficial uses and numeric water quality standards that must be met in order to protect those uses.

The Watershed contains nine segments. Streams account for seven of the segments. Lakes, reservoirs, and ponds are grouped into two segments. Table 13 presents the segments and numeric water quality standards from Regulation 35 with an effective date of 3-30-2013. Figure 9 displays the segments in the Watershed. In this report the segments are referred to by abbreviated names (e.g. Segment 10a). Regulation 35 uses the formal segment names (e.g. Segment COGUUG10a). Table 13 provides the official descriptions for each segment; in other tables the segment descriptions may be condensed.

In the Watershed water uses of aquatic life, recreation, agriculture, and water supply apply to some or all of the segments. Each of the use classifications has specific standards for many water quality parameters. The water use classification with the most conservative criteria (i.e., lowest value) is applied as the effective standard for each parameter (e.g., pH, temperature or lead). This approach assures that all water uses are protected because the use with the most conservative criteria is applied as the standard. In the Watershed, the numeric standards associated with aquatic life or water supply are typically the lowest and are therefore applied as the numeric standard for many parameters.

The criteria to protect aquatic life generally have two standards associated with each parameter: chronic and acute. Chronic conditions cause stress in aquatic organisms during prolonged or repeated exposures resulting in physical abnormalities, impaired growth, reduced survival, and lowered reproductive success. Acute conditions cause extreme stress during instantaneous or brief exposures that can result in sub-lethal and lethal effects on aquatic life. This approach requires an understanding of both the species expected in a given waterbody and the tolerance of those species to various water quality parameters. The chronic and acute standards are designed to protect 95 percent of the genera in a given waterbody (WQCC, 2013). Colorado relies on guidance from Federal, State, and local scientists to establish these standards which are frequently reviewed. Because chronic standards are designed to prevent problems associated with long term exposure to parameters, the value of a chronic standard is always lower than the acute standard, which is designed to prevent lethal effects. If the concentration of a given parameter exceeds the applicable standard, the quality of the water is not protective of the given use. This condition is referred to as an “exceedance”.

Table 13. Numeric water quality standards for segments in the Upper Slate River Watershed (Regulation 35: effective date: 3/30/13) Page 1 of 2.

Segment	Classifications	Numeric Standards[1,2,3,4,5]					
		Physical and Biological	Inorganic (mg/l)		Metals (ug/l)		
1: All tributariesto the Gunnison River, including wetlands, within the La Garita, Powderhorn, West Elk, Collegiate Peaks, Maroon Bells, Raggeds, Fossil Ridge, or Uncompahgre Wilderness Areas. ***Outstanding Waters***	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS[6] CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.02 NO_3= 10 Cl= 250 SO_4 (ch)= 250 (WS)	As(ac)= 340 As (ch)= 0.02 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac)= 50 (Trec) Cr III(ch)= TVS Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe (ch)= 300 (dis) (WS) Fe(ch)= 1000 (Trec) Pb (ac/ch)= TVS Mn (ac/ch)= TVS Mn (ch)= 50 (dis) (WS) Hg (ch)= 0.01 (tot) Mo(ch)= 160 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS
7: Mainstem of the Slate River from its source to a point immediately above the confluence with Coal Creek	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.05 NO_3= 10 Cl= 250 SO_4 (ch)= 250 (WS)	As(ac)= 340 As (ch)= 0.02 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac)= 50 (Trec) Cr III (ch)= TVS Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe (ch)= 300 (dis) (WS) Fe(ch)= 1000 (Trec) Pb (ac/ch)= TVS Mn (ac/ch)= TVS Mn (ch)= 50 (dis) (WS) Hg (ch)= 0.01 (tot) Mo(ch)= 160 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS
8: Mainstem of the Slate River from a point immediately above the confluence with Coal Creek to the confluence with the East River.	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.05 NO_3= 10 Cl= 250 SO_4 (ch)= 250 (WS)	As(ac)= 340 As (ch)= 0.02 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac)= 50 (Trec) Cr III (ch)= TVS Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe (ch)= 300 (dis) (WS) Fe(ch)= 1000 (Trec) Pb (ac/ch)= TVS Mn (ac/ch)= TVS Mn (ch)= 50 (dis) (WS) Hg (ch)= 0.01 (tot) Mo(ch)= 160 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS
9: All tributaries and wetlands to the Slate River except for specific listings in Segments 1, 10a, 10b, 11, 12, and 13.	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.05 NO_3= 10 Cl= 250 SO_4 (ch)= 250 (WS)	As(ac)= 340 As (ch)= 0.02 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac)= 50 (Trec) Cr III (ch)= TVS Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe (ch)= 300 (dis) (WS) Fe(ch)= 1000 (Trec) Pb (ac/ch)= TVS Mn (ac/ch)= TVS Mn (ch)= 50 (dis) (WS) Hg (ch)= 0.01 (tot) Mo(ch)= 210 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS
10a: Mainstem of Oh-Be-Joyful Creek from the boundary of the Raggeds Wilderness Area to the confluence with the Slate River.	Aq Life Cold 1 Recreation E Agriculture	T=TVS(CS-I)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.05 NO_3= 100	As(ac)= 340 As (ch)=7.6 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac/ch)= TVS Cr III (ch)= 100 (Trec) Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe(ch)= 1000 (Trec) Pb (ac)= TVS Pb (ch)= 6.6 Mn (ac/ch)= TVS Hg (ch)= 0.01 (tot) Mo(ch)= 160 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS
10b: All tributaries, including wetlands, to Redwell Creek.	Aq Life Cold 1 Recreation E Agriculture	T=TVS(CS-I)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.05 NO_3= 100	As(ac)= 340 As (ch)=7.6 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac/ch)= TVS Cr III (ac)= 100 (Trec) Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe(ch)= 1000 (Trec) Pb (ac)= TVS Pb (ch)= 407 Mn (ac/ch)= TVS Hg (ch)= 0.01 (tot) Mo(ch)= 160 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS

Table 13. Numeric water quality standards for segments in the Upper Slate River Watershed (Regulation 35: effective date: 3/30/13) Page 2 of 2.

Segment	Classifications	Numeric Standards[1,2,3,4,5]					
		Physical and Biological	Inorganic (mg/l)		Metals (ug/l)		
33: All lakes and reservoirs that are tributary to the Gunnison River and within the La Garita, Powderhorn, West Elk, Collegiate Peaks, Maroon Bells, Raggeds, Fossil Ridge, or Uncompahgre Wilderness Areas. ***Outstanding Waters***	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.02 NO_3= 10 Cl= 250 SO_4 (ch)= 250 (WS)	As(ac)= 340 As (ch)= 0.02 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac)= 50 (Trec) Cr III (ch)= TVS Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe (ch)= 300 (dis) (WS) Fe(ch)= 1000 (Trec) Pb (ac/ch)= TVS Mn (ac/ch)= TVS Mn (ch)= 50 (dis) (WS) Hg (ch)= 0.01 (tot) Mo(ch)= 160 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS
34: All lakes and reservoirs tributary to the Taylor River and the East River, from their source to their confluence at the inception of the Gunnison River, excluding the listing in Segments 33, 35, and 37. This segment includes Meridan Lake, Nicholson Lake, Peanut Lake, Lake Grant, Lily Pond, Pothole Reservoirs 1 and 2, Texas Lake, Mirror Lake, and Spring Creek Reservoir.	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CL)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.05 NO_3= 10 Cl= 250 SO_4 (ch)= 250 (WS)	As(ac)= 340 As (ch)= 0.02 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac)= 50 (Trec) Cr III (ch)= TVS Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe (ch)= 300 (dis) (WS) Fe(ch)= 1000 (Trec) Pb (ac/ch)= TVS Mn (ac/ch)= TVS Mn (ch)= 50 (dis) (WS) Hg (ch)= 0.01 (tot) Mo(ch)= 160 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS
35: All lakes and tributaries to Redwell Creek[7]	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CL)°C D.O.= 6.0 mg/l D.O. (sp)= 7.0 mg/l pH= 6.5-9.0 s.u. E. Coli= 126 col/100ml	NH_3 (ac/ch)=TVS CL_2(ac)= 0.019 Cl_2(ch)=0.011 CN=0.005	S= 0.002 B= 0.75 NO_2=0.05 NO_3= 10 Cl= 250 SO_4 (ch)= 250 (WS)	As(ac)= 340 As (ch)= 0.02 (Trec) Cd (ac)= TVS (tr) Cd (ch)= TVS Cr III (ac)= 50 (Trec) Cr III (ch)= TVS Cr VI (ac/ch)= 16, 11 Cu (ac/ch)= TVS	Fe (ch)= 300 (dis) (WS) Fe(ch)= 1000 (Trec) Pb (ac/ch)= TVS Mn (ac/ch)= TVS Mn (ch)= 50 (dis) (WS) Hg (ch)= 0.01 (tot) Mo(ch)= 160 (Trec)	Ni (ac/ch)= TVS Se (ac/ch)=18.4, 4.6 Ag (ac)= TVS Ag (ch)= TVS (tr) Zn (ac/ch)=TVS

Notes
1. Segments and standards are from the Colorado Water Quality Control Comission Regulation 35: Effective Date 3-30-2013.
2. There are no temporary modifications in place in the Upper Slate River (USR) watershed.
3. TVS= Table Value Standard. The value of these standards are hardness-dependent.
4. Ac= Acute, Ch= Chronic, Dis= Dissolved, Sp= Spawning, Tr= Trout, Trec= Total Recoverable, WS= Water Supply, tot= total.
5. Metal concentrations are dissolved, unless otherwise specified.
6. NH_3= Unionized ammonia. The standard relies on both water pH and temperature.
7. The National Hydrography Dataset (NHD) does not include any waterbodies in Redwell Basin, so they are not presented on report maps.

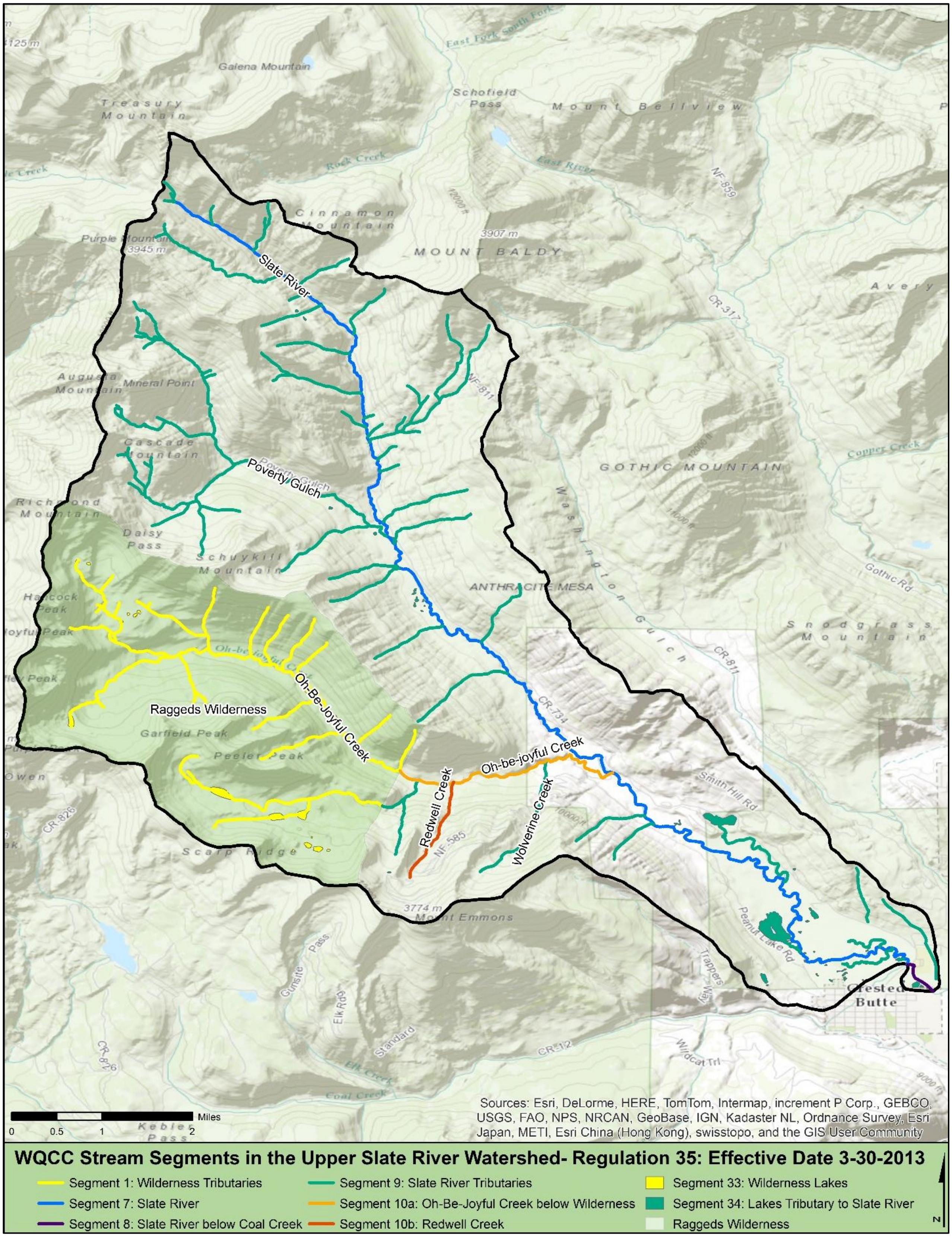


Figure 9. Water Quality Control Commission Segments in the Upper Slate River Watershed; effective date 3-30-2013.

4.1.1 Outstanding Waters

The tributaries and lakes found within the Raggeds Wilderness, referred to as Segments 1 and 33, have been designated as Outstanding Waters (Figure 9). An Outstanding Waters designation provides the maximum level of protection for a waterbody and helps prevent water quality degradation (WQCC Regulation 31).

4.1.2 Impaired Waters

Section 303(d) of the CWA, requires that each state prepare a list of waters that do not meet water quality standards. Regulation 93 is used to document the Colorado List of Impaired Waters (also call the 303(d) List). The list must describe the waterbody and the parameter for which it is impaired. Typically, these lists are updated and reexamined every two years; Colorado's next update occurs in 2016. In order to assemble the list, the Colorado WQCD reviews readily available water quality data, typically collected within five years of the assessment period, by segment relative to state water quality standards. When water quality data do not pass the evaluation, the waterbody is added to the 303(d) List. When impairment is in question because the available data is somehow insufficient (typically too few samples), the waterbody is added to Colorado's Monitoring and Evaluation (M&E) List. The 303(d) and M&E List was finalized on 3-30-2012 and predates the revisions to Regulation 35; which were finalized on 3-30-2013. So the segment numbers and descriptions that appear on the 303(d) and M&E List differ from those presented in the most current revision of Regulation 35.

Table 14. 2012 303(d) and Monitoring and Evaluation List for segment in the Upper Slate River Watershed. Effective date: 3-30-2012.

Segment	Description	Portion	M&E Parameters	303(d) Impairment	TMDL Priority
7	Slate River from source to Coal Creek	Below Oh-Be-Joyful Creek	-	Zn	High
8	Slate River Coal Creek to East River	All	Aquatic Life	Cd, Zn	High
10	Oh-Be-Joyful Creek and tibrutaries from Wilderness to Slate River	All	-	Cd, Cu, Pb, Zn	High
10	Oh-Be-Joyful Creek and tibrutaries from Wilderness to Slate River	Redwell Creek	pH	-	-

Generally, after a segment is placed on the 303(d) List an assessment of contaminant sources is completed. The assessment is referred to as a Total Maximum Daily Load (TMDL). TMDL assessments use water quality data and stream flow to determine the amount, or load, of a given parameter than can be in the stream without exceeding applicable water quality standards, plus a margin of safety. The TMDL also documents contaminant loads that originate from point and nonpoint sources within the study area. A plan is then developed to address how each of the sources can be reduced in order to meet the allowable load, and therefore the water quality standard.

The WQCD released the first draft of the TMDL, which addresses 303(d) Listed segments in the Watershed, in 2011. The third draft of the TMDL report will be released in late 2014. Following the public comment period, the TMDL will be finalized. Where possible, information from the TMDL has been incorporated into this plan.

4.2 SURFACE WATER QUALITY

Eighty percent of the water quality data collected from 1995 to 2010 in the Watershed met water quality criteria (Figure 10; AEC, 2011). Twenty percent of the water quality data exceeded water quality criteria (i.e., failed to meet criteria). The following discussion identifies where the water quality problems originate and uses the existing data set to determine the pollutant sources. For more detailed information refer to the WQ Summary (AEC, 2011).

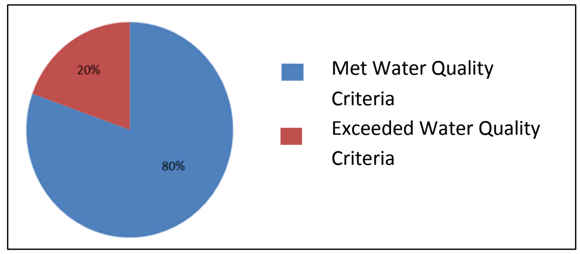


Figure 10. Water quality standards evaluation results. Eighty percent of the data met the criteria; twenty percent did not.

Metals that originate from historic abandoned mines are the most common pollutants in the Watershed. The most problematic metals are zinc, cadmium, copper, lead, and manganese. This finding is consistent with both the current and historic land uses in the Watershed.

The standards assessment clearly illustrated the origin of water quality pollutants in the Watershed. Metals that originate from historic abandoned mines and natural features in Redwell Basin impair water quality in Redwell Creek. Water quality samples collected from Redwell Creek and adjacent anthropogenic and natural features accounted for 75 percent of the water quality exceedances in the Watershed (Table 15 and Figure 10). Redwell Creek flows into Oh-Be-Joyful Creek and delivers metals. The mainstem of Oh-Be-Joyful Creek below Redwell Creek accounted for ten percent of the exceedances. The water in Oh-Be-Joyful Creek above Redwell Creek, which includes streams in the Raggeds Wilderness, accounted for 0.2 percent of the exceedances. Conservatively, Redwell Basin is the origin approximately 86 percent of the pollution in the Watershed. This phenomenon is not an artifact of sample frequency (i.e., not attributed to a higher number of samples relative to other areas; AEC, 2011).

Although Oh-be-Joyful Creek provides dilution, it is apparent that metals that originate in Redwell Basin reach the Slate River. The Slate River below Oh-Be-Joyful Creek accounted for ten percent of the exceedances. The Slate River above Oh-Be-Joyful Creek typically meets water qualtiy criteria; only 2.6 percent of the evaluations exceeded applicable standards during the fifteen year study period. Which is approximately one-fourth of the rate observed in the Slate River below Oh-Be-Joyful Creek. Water quality exceedances in tributaries to the Slate River, including Poverty Gulch, accounted just over one percent of the exceedances.

Table 15. Water quality exceedances by segment in the Upper Slate River Watershed.

Stream Segment	Total Exceedances	Percent of Total
Redwell Creek (10b)[1]	320	75.3
Mainstem of Oh-Be-Joyful Creek (10a)	44	10.4
Slate River below Oh-Be-Joyful (7)[2]	43	10.1
Slate River above Oh-Be-Joyful (7)	11	2.6
Slate River Tributaries (9)	6	1.4
Wilderness Tributaries (1)	1	0.2
Watershed Total	**425**	**100.0**

Notes:

1. The segment number is provided in parentheses.
2. The WQ Summary (AEC, 2011) was updated to reflect segment changes and data from the Slate River below Coal Creek, was removed from the data set to eliminate the effect of Coal Creek.

4.2.1 Water Quality in Redwell Basin

This section discusses water quality in Redwell Basin and identifies specific features. The discussion and graphs that follow, present the data from upstream to downstream (Figures 11, 12 and 13). Figures 12 and 13 present metal concentrations on a log base-10 scale. Log scales (e.g., 1, 10, and 100) are used to present data that varies widely and wouldn't otherwise fit on the same graph. The estimated acute standards are included in Figures 12 and 13.

In the headwaters of Redwell Creek the water pH was near neutral, 6.79. Dissolved aluminum, iron, cadmium, and copper concentrations were low in the headwaters of Redwell Creek (RW-3). In the headwaters metal concentrations were much lower, typically by one to four orders of magnitude, than other locations in Redwell Basin (Figures 12 and 13). However, zinc and cadmium concentrations exceeded water quality standards in some samples.

In the early 1970s, many holes were drilled to characterize the molybdenum deposit beneath Mount Emmons. One of the holes drilled in the upper portion of Redwell Basin was improperly abandoned. The Drill Hole penetrates the molybdenum deposit and adjacent mineralized rocks. Groundwater flows under pressure to the surface and delivers poor quality water to Redwell Creek. Water quality samples collected from the Drill Hole are referred to as RW-1 (Figure 11).

At the Drill Hole, metal concentrations increased dramatically over the concentrations measured at upstream monitoring locations in Redwell Creek (RW-1; Figures 12 and 13). Dissolved aluminum, iron, and zinc concentrations increased by three orders of magnitude. Copper concentrations increased by four orders of magnitude. Cadmium concentrations increased nine-fold. Sulfate concentrations increased six-fold; this indicates that the Drill Hole also supplies considerable acidity to the system. Water from the Drill Hole is very acidic; pH ranges from 2.7 to 3.0. At the Drill Hole aluminum, iron, zinc, cadmium, and copper concentrations exceeded acute criterion.

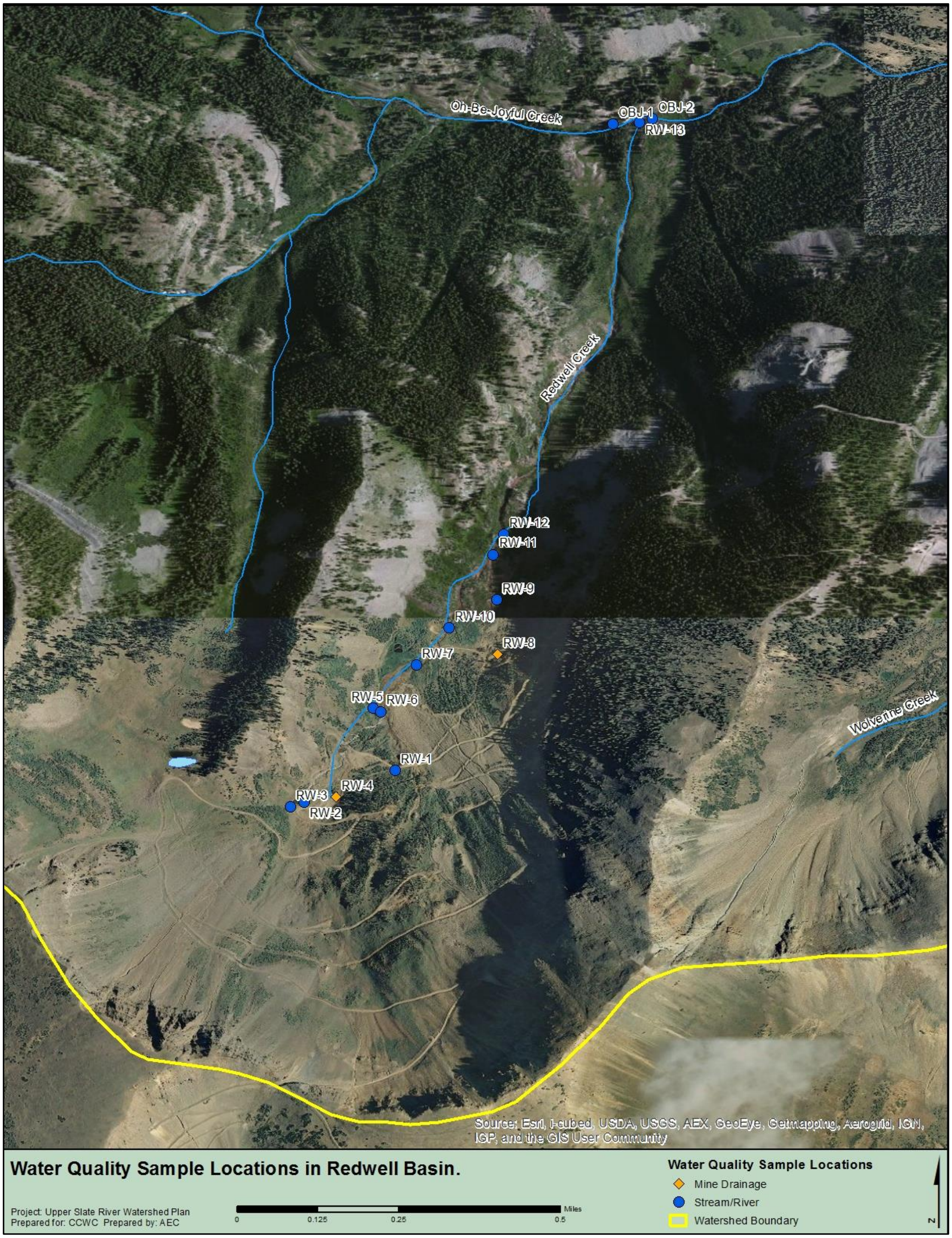


Figure 11. Water Quality Sample Locations in Redwell Basin. There are four man-made features: an open stope (RW-4), prospect pit (RW-2), the Drill Hole (RW-1), and the Daisy Mine (RW-8) and nine stream locations.

Photo 21. The Redwell, the namesake of Redwell Basin, is sampled at RW-5. Due to the shallow, dispersed flow that exits the lower side of the Redwell it is virtually impossible to measure flow at this location. Notice the wetland vegetation and seeps on the hillside in the background of the photo. Photo by Ashley Bembenek.

Photo 22. A view into the Redwell, the red-orange iron deposits, called ferricrete, on the edges of the pool have been age dated. The Redwell is at least 2,800 years old and predates any human activity in the basin (Fall et al., 1997). Photo by Ashley Bembenek.

The Red Well is the naturally-occurring namesake of the basin (RW-5; Figure 12, Photos 18 and 19). Analysis of ferricrete, a red-orange iron-oxide, collected from the Red Well was dated as approximately 2,800 years old (Fall et al., 1997). The age indicates the feature is natural, not anthropogenic (Fall et al., 1997).

Metal concentrations measured at the Red Well were elevated but remained substantially lower than those measured at the Drill Hole (Figures 12 and 13). The ratio of dissolved aluminum, iron, and zinc at the Red Well was similar to water from the Drill Hole. However, water from the Red Well had lower concentrations. This suggests that the two features share source waters, groundwater associated with the Molybdenum deposit and the adjacent mineralized fracture network, but additional dilution occurs at the Red Well. Small seeps and wetland vegetation up-gradient of the Redwell indicate the area is saturated regularly. Given the hydrology of wetlands, some dilution with surface or groundwater is reasonable.

Metal concentrations declined in Redwell Creek as the stream attenuated inputs from the Drill Hole and the Red Well (RW-7, Figures 12 and 13). Although declines occurred on the reach below the Drill Hole and the Red Well, metal concentrations were still one to two orders of magnitude higher than concentrations measured in the headwaters of Redwell Creek. With the exception of iron, metal concentrations exceeded acute criterion for aluminum, zinc, cadmium and copper.

Figure 12. Median dissolved aluminum, iron and zinc concentrations in Redwell Basin. The zinc standard was estimated using the average hardness measured at locations in Redwell Creek.

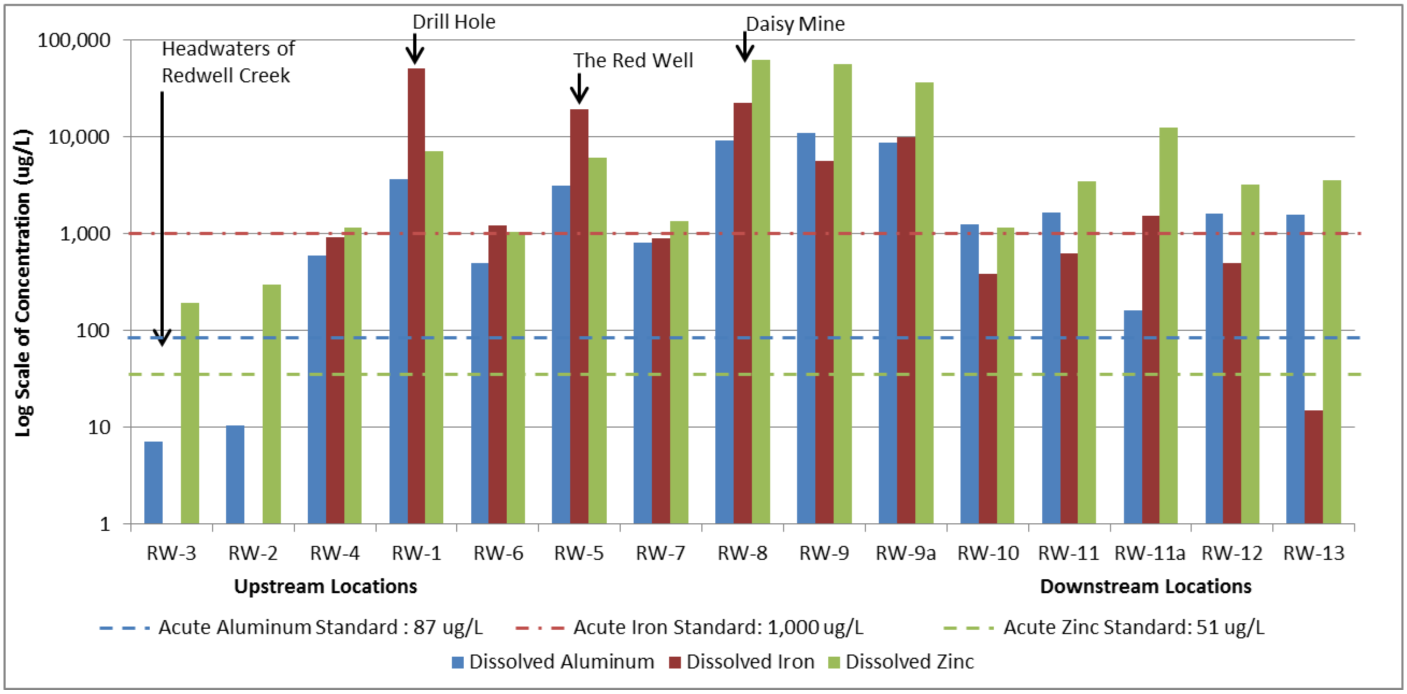


Figure 13. Median dissolved cadmium, copper and total sulfate concentrations in Redwell Basin. The cadmium and copper standards were estimated using the average hardness measured at locations in Redwell Creek.

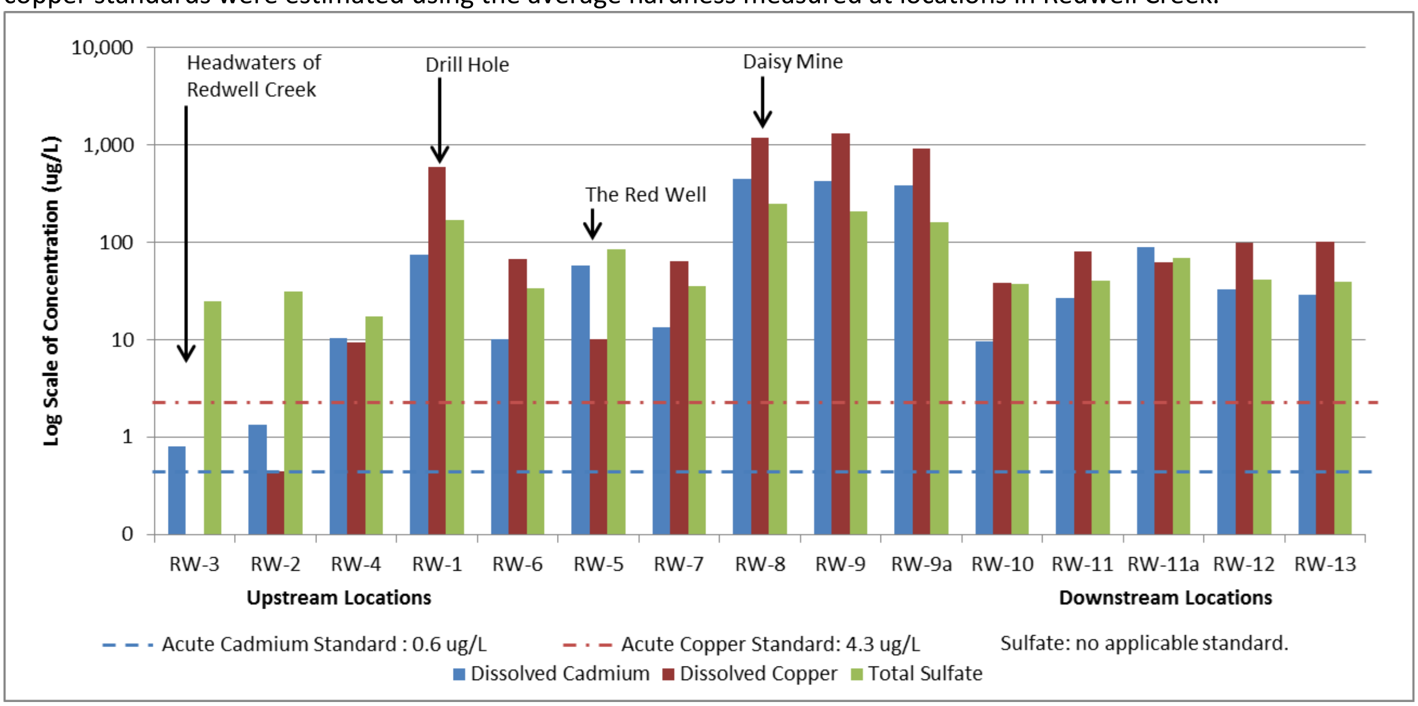


Photo 23. The Daisy Mine in Redwell Basin. The collapsed adit is in the foreground of the photo. An access road to the Peeler Lake Trail passes through several waste rock piles. Gunsight Pass Road is near the top of the photo. Photo courtesy of Ashley Bembenek.

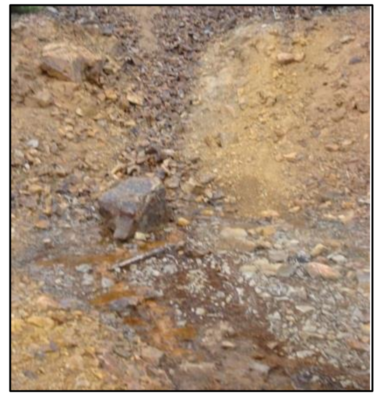


Photo 24. Flow from the collapsed tunnel at the Daisy Mine forms a small channel that reaches Redwell Creek about 300 feet from the tunnel.

The Daisy Mine is on the east side of Redwell Basin (RW-8; Figure 11 and Photo 23). The Daisy Mine once produced silver, copper, and zinc ores. Exploration began in the late 1800s and the mine operated sporadically until the 1970s. The mine was abandoned prior to the passage of modern reclamation laws. The mine has multiple levels with several portals. Gunsight Pass Road traverses between the upper mine portals and the collapsed drainage tunnel. Poor-quality water flows from the collapsed tunnel into Redwell Creek (Photo 24).

The Daisy Mine, measured at RW-8, RW-9, and RW-9a, was the largest source of zinc and the source of most of the copper in Redwell Basin (Figure 12). Water from these sample locations exceeded regulatory criteria by two to four orders of magnitude for acute aluminum, iron, zinc, cadmium, and copper (Figures 12 and 13). The median pH measured at the collapsed tunnel was 2.9; which is very acidic.

Samples collected from Redwell Creek at the outlet of upper Redwell Basin had elevated metal concentrations (RW-12; Figure 11). Metal concentrations declined relative to the concentrations measured at the Daisy Mine. However, metal concentrations were still two orders of magnitude greater than the concentrations measured in the headwaters of Redwell Creek (Figures 12 and 13). Aside from iron, metal concentrations exceeded regulatory criteria at the outlet of upper Redwell Basin (Figures 12 and 13).

At the mouth of Redwell Creek, above the confluence with Oh-Be-Joyful Creek, iron concentrations fell substantially from the outlet of upper Redwell Basin (RW-13; Figure 12). Redwell Creek is stained with iron precipitates, so it appears that iron precipitates from the system as Redwell Creek flows from the upper basin to the confluence Oh-Be-Joyful Creek. Aside from iron, dissolved metal concentrations at the mouth of Redwell Creek remained similar to those measured at the outlet of the upper basin (RW-12 and RW-13; Figures 12 and 13). At the mouth of Redwell Creek aluminum, zinc, cadmium and copper exceeded acute water quality criteria. The median zinc concentration was almost two orders of magnitude higher than the acute criterion. The median cadmium concentration was approximately 50 times the acute standard. The median copper concentration was 25 times the acute standard.

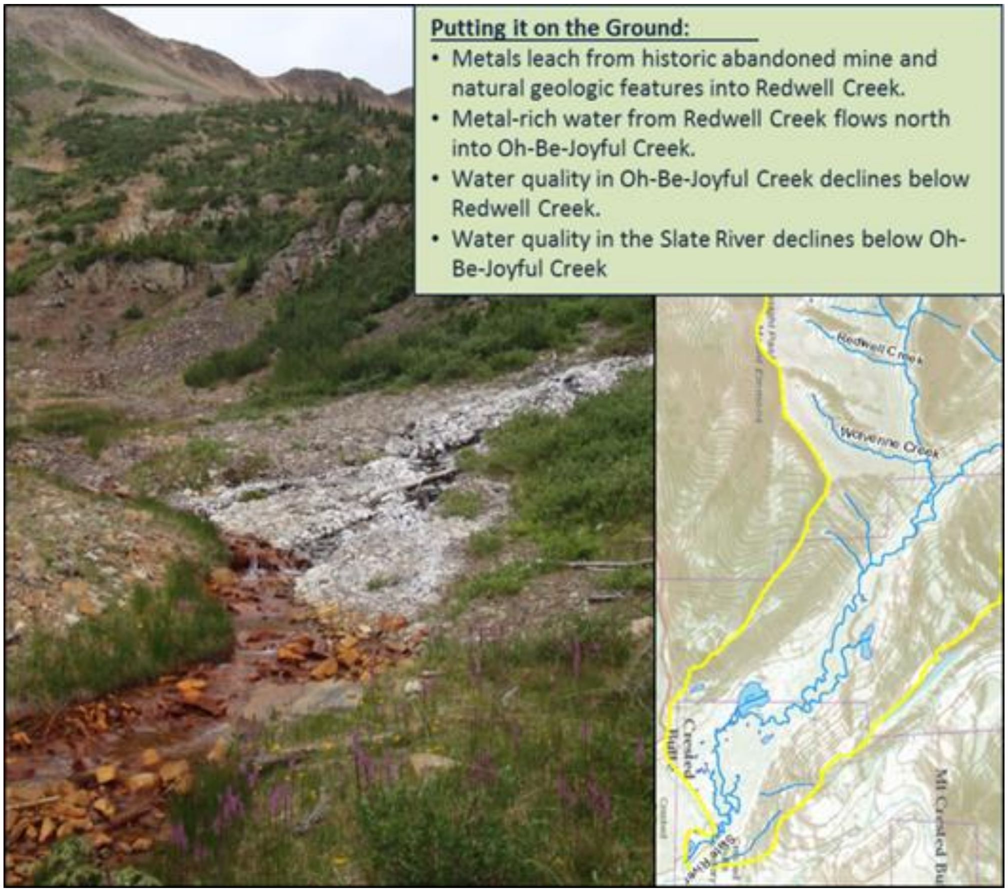


Photo 25. Redwell Creek near the headwaters. The red stream that enters from the left originates from the Drill Hole and the white stream on the left drains the uppermost portion of Redwell Creek. As the colors suggest the streams have very different characteristics. Photo by: Ashley Bembenek.

5.0 POLLUTION SOURCES

Metals that originate from historic abandoned mines are the most common pollutants in the Watershed. The most problematic metals are zinc, cadmium, copper, lead, and manganese.

The Colorado Geological Survey completed an inventory of historic abandoned mine lands inventory (AMLI) in western Colorado (CGS, 1998). Data from the inventory and other sources have been compiled to better delineate historic abandoned mine features in Redwell Basin. There are an assortment of abandoned mine features in Redwell Basin. They range from small dry adits and prospect pits on the west edge of Redwell Basin to dumps and pits, associated with the Daisy Mine, that litter the east side of the basin near Gunsight Pass Road. Fortunately, many of these abandoned mine features are dry during most of the year and do not typically influence water quality. However, poor-quality water flows consistently from the Drill Hole and the Daisy Mine Complex. The following paragraphs detail the chemistry and loads from each of the historic abandoned mine features.

5.1 THE DRILL HOLE

The Drill Hole angles from north to south and penetrates the molybdenum porphyry deposit beneath Mount Emmons (Sharp, 1978; Berger et al., 2001). The Drill Hole delivers poor-quality groundwater to Redwell Creek. Flow from the Drill Hole was estimated at approximately 15 gallons per minute and tends to be relatively steady through time. In 2002 under drought conditions, the Drill Hole increased flow in Redwell Creek by nine percent (Kimball et al., 2010). Due to variation in the flow in Redwell Creek, the increase in flow attributed to the Drill Hole fluctuates through time.

The pH at the Drill Hole is very acidic. The pH ranges from 2.67 to 3.02; and was consistent throughout the ten year period of record (Table 16). The *lowest* metal concentrations measured at the Drill Hole are greater than the *highest* concentrations measured in the headwaters of Redwell Creek. Metal concentrations at the Drill Hole vary widely. Cadmium concentrations show the least variation, and yet the highest value is over two times the lowest value (Table 16). Dissolved lead concentrations show the largest variation; where the largest concentration is nearly twenty times the lowest concentration (Table 16).

Table 16. Concentration summary for the Drill Hole (RW-1).

Concentration Summary for RW-1: Artesian Drill Hole (n=6)											
Value Type	pH	Dissolved Cadmium (ug/L)	Total Cadmium (ug/L)	Dissolved Copper (ug/L)	Total Copper (ug/L)	Dissolved Iron (ug/L)	Total Iron (ug/L)	Dissolved Lead (ug/L)	Total Lead (ug/L)	Dissolved Zinc (ug/L)	Total Zinc (ug/L)
Low	2.67	29.2	27	273	488	32,900	32,300	1,110	1,340	3,720	3,470
Median	2.8	66.75	70	733	930	50,750	50,300	1,515	1,560	7,060	6,870
High	3.02	92.3	80	1,600	1,600	68,600	71,400	2,200	2,400	8,700	8,800

5.2 DAISY MINE COMPLEX

The Daisy Mine Complex is on the east side of Redwell Basin (RW-8; Figure 11 and Photo 23). The mine had several levels, many of which have portals on the slopes above (south) the collapsed drainage tunnel. Gunsight Pass Road traverses between the collapsed drainage tunnel and the upper mine portals. The Daisy Mine is the largest man-made nonpoint source metal load in the Watershed. In the 2012 NPS Management Plan, the Daisy Mine Complex was recognized as a "high priority abandoned hard rock mine" (NPS Program 2012, Appendix C). The plan calls for additional data collection on site to facilitate reclamation design.

Water pH at the Daisy Mine is very acidic. The median pH measured at the collapsed adit was 2.89 (Table 17). The Daisy Mine is the single largest source of zinc, copper and manganese in Redwell Basin (Kimball et al., 2010). Dissolved zinc concentrations at the Daisy Mine ranged from 47,000 to 66,500 ug/L. The lowest zinc concentrations measured at the Daisy Mine was over five times greater than the *highest* zinc concentrations measured at the Drill Hole. The cadmium and copper concentrations found at the Daisy Mine are among the highest in Redwell Basin. Samples collected from seeps on tailings material adjacent to the collapsed adit were similar to those collected from the collapsed adit (Tables 17 and 18).

Table 17. Concentration summary for the Daisy Mine Collapsed Adit (RW-8).

Concentration Summary for RW-8: Daisy Mine Collapsed Adit (n=5)											
Value Type	pH	Dissolved Cadmium (ug/L)	Total Cadmium (ug/L)	Dissolved Copper (ug/L)	Total Copper (ug/L)	Dissolved Iron (ug/L)	Total Iron (ug/L)	Dissolved Lead (ug/L)	Total Lead (ug/L)	Dissolved Zinc (ug/L)	Total Zinc (ug/L)
Low	2.43	380	320	860	830	20,600	20,300	2,210	2,230	47,000	52,000
Median	2.86	394	485	1,250	1,365	23,450	24,600	2,400	2,300	53,650	55,400
High	3.02	540	527	1,920	1,770	28,200	37,000	3,000	2,650	66,500	65,000

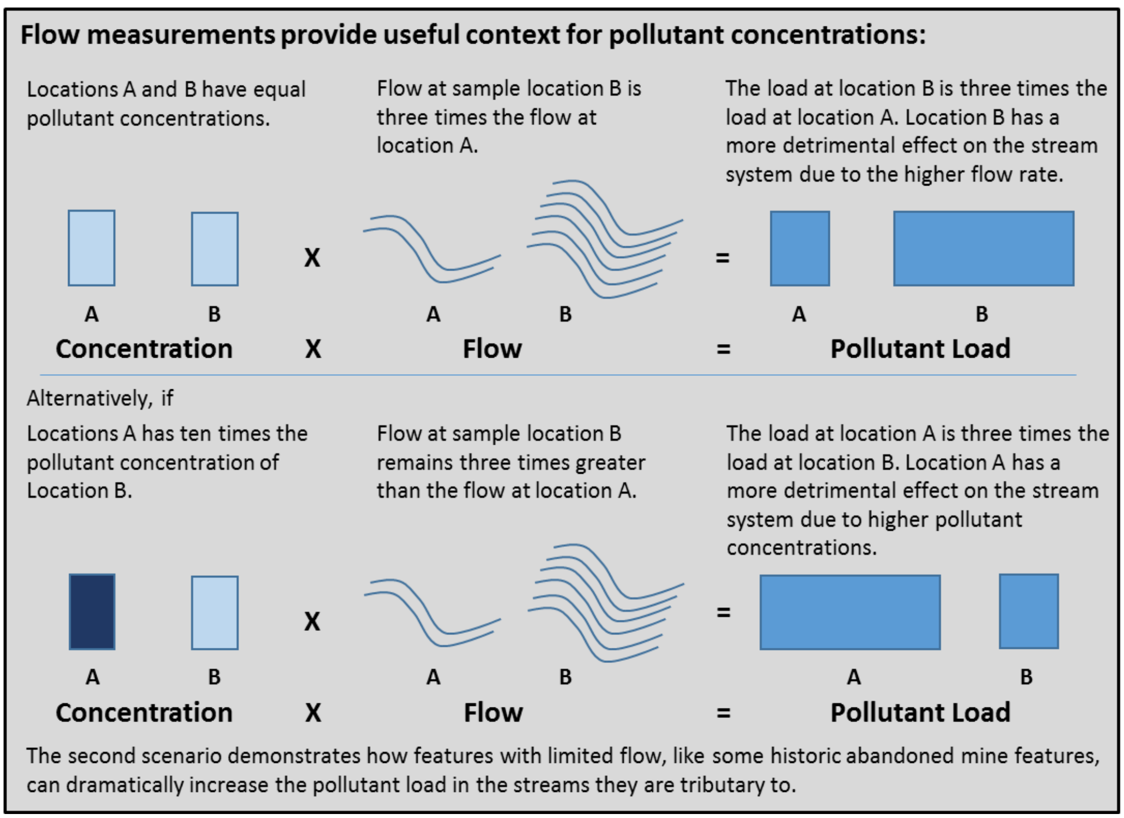
Table 18. Concentration summary for the Daisy Mine Seeps (RW-9).

Concentration Summary for RW-9: Daisy Mine Tailings Seep (n=5)											
Value Type	**pH**	**Dissolved Cadmium (ug/L)**	**Total Cadmium (ug/L)**	**Dissolved Copper (ug/L)**	**Total Copper (ug/L)**	**Dissolved Iron (ug/L)**	**Total Iron (ug/L)**	**Dissolved Lead (ug/L)**	**Total Lead (ug/L)**	**Dissolved Zinc (ug/L)**	**Total Zinc (ug/L)**
Low	2.55	230	240	700	710	2,100	2,260	2,500	2,600	34,900	33,800
Median	2.89	421	350	1,290	1,140	5,030	5,250	2,820	2,780	54,800	44,550
High	3.01	507	415	1,590	1,330	16,300	16,600	3,230	2,900	70,000	54,400

5.3 LOAD ALLOCATIONS IN REDWELL BASIN

It is often difficult to measure stream flow in Redwell Creek. Very low flow, shallow dispersed flows, and unstable or excessively steep channels are obstacles that prevent or limit the ability to measure flow. The loads presented below are from the best available data, but should be interpreted with caution.

Metal loads for dissolved cadmium, copper, lead, and zinc are presented in this analysis. These metals were selected because they are the 303(d) Listed pollutants for Redwell Creek. Additional metal were included in the WQ Summary.



Three sample events, with the best quality and most consistent flow measurements, were selected to calculate metal loads and determine load allocations in Redwell Creek. The results are summarized below and in Tables 19 to 24:

- There are three major metal sources in Redwell Basin. The Red Well, a natural feature, and the Daisy Mine and the Drill Hole, which are man-made features.
- In all three sample events the Daisy Mine created the largest load increases in Redwell Creek.
  - Dissolved cadmium loads increased from 0.04 to 0.14 lbs/day due to the Daisy Mine.
  - Dissolved copper loads increased from 0.11 to 0.38 lbs/day due to the Daisy Mine.
  - Dissolved lead loads increased from 0.44 to 1.34 lbs/day due to the Daisy Mine.
  - Dissolved zinc loads increased from 6.05 to 15.79 lbs/day due to the Daisy Mine.
- In all three sample events the Drill Hole created the second largest load increases in Redwell Creek.
  - Dissolved cadmium loads increased about 0.01 lbs/day due to the Drill Hole.
  - Dissolved copper loads increased about 0.05 to 0.09 lbs/day due to the Drill Hole.
  - Dissolved lead loads increased from 0.16 to 0.42 lbs/day due to the Drill Hole.
  - Dissolved zinc loads increased from 0.71 to 2.08 lbs/day due to the Drill Hole.
- The Red Well increased dissolved metal loads in Redwell Creek, but to a lesser extent than the man-made features.
  - Dissolved cadmium and copper loads increased by very small margins (less than 0.05 lbs/day).
  - Dissolved lead loads increased from 0.11 to 0.42 lbs/day due to the Red Well.
  - Dissolved zinc loads in Redwell Creek increased from 0.39 to 0.95 lbs/day due to the Red Well.
  - During all three sample events the Red Well created the smallest load increase of the three major metal sources.
- In Redwell Creek at the mouth the majority of the metal load was attributed to anthropogenic sources.
  - 74 to 85 percent of the dissolved cadmium load was attributed anthropogenic sources.
  - 90 to 98 percent of the dissolved copper load was attributed anthropogenic sources.
  - 68 to 71 percent of the dissolved lead load was attributed anthropogenic sources.
  - 87 to 88 percent of the dissolved zinc load was attributed anthropogenic sources.
- Flow at the mouth of Redwell Creek was 1.81, 0.3, and 0.44 cfs for the July 2010, September 2011, and July 2013 events, respectively. A regional flow model, called Stream Stats (USGS, 2009), estimated that median monthly flows range from 0.1 to 9.0 cfs at the mouth Redwell Creek. This indicates the sample events characterized receding or low flows and therefore loads may be far higher during peak runoff or following large precipitation events.
- The regional flow model estimated a ten-year recurrence interval peak flow of 39 cfs, which is over twenty times the highest flow observed during the sample event in July 2010. Under such conditions the load estimates could be twenty times greater than those calculated for the July 2010 sample event.

Table 19. Redwell Basin metal loading summary July 8, 2010.

Location	Description	Site Type	Dissolved Cadmium Load	Dissolved Copper Load	Dissolved Lead Load	Dissolved Zinc Load
			lbs/day			
RW-3	Headwaters of Redwell Creek	Background	0.004	0.002	0.008	0.563
RW-2	Redwell Creek downstream of the Prospect Pond	Mine Feature	0.005	0.011	0.112	0.902
RW-1	Drill Hole flow. Major Anthropogenic load	Mine Feature	0.005	0.097	0.287	0.699
RW-6	Redwell creek below drill hole above Red Well	Stream	0.019	0.085	0.534	2.980
Net Effect of Drill Hole Flows (i.e. RW-6 - RW-2):			**0.014**	**0.073**	**0.422**	**2.079**
RW-5	The Red Well- a natural geologic load *(outflow flow used for load calculation)*	Stream	0.003	0.005	0.081	0.297
RW-7	Redwell Creek below the Red Well	Stream	0.030	0.144	0.952	3.871
RW-10	Redwell Creek above Daisy Mine	Stream	0.029	0.132	1.112	4.087
RW-8	Daisy Mine. Major Anthropogenic load	Mine Feature	0.013	0.046	0.072	1.588
RW-9	Daisy Mine Seeps. Major Anthropogenic load	Mine Feature	1.086	3.748	11.314	142.564
RW-11	Redwell Creek below Daisy Mine and Seeps	Stream	0.166	0.512	2.449	19.879
Net Effect of Daisy Mine Complex (i.e. RW-11 - RW-10):			**0.137**	**0.380**	**1.337**	**15.792**
RW-12	Redwell Creek below additional mining	Stream	0.172	0.534	2.700	21.658
RW-13	Redwell Creek at mouth	Stream	0.158	0.544	2.904	19.424

Table 20. Estimated load allocation in Redwell Basin on July 8, 2010.

Load Description	Load Type	Load Allocation Description	Percent of Dissolved Cadmium Load	Percent of Dissolved Copper Load	Percent of Dissolved Lead Load	Percent of Dissolved Zinc Load
Net effect of Drill Hole (RW-1) on Redwell Creek at RW-6	Anthropogenic	Effect of Drill Hole: (Load at RW-6 - Load at RW-2) ÷ (Load at RW-6)	74%	87%	79%	70%
	Natural	Background: (Load at RW-6- (Load at RW-6 - Load at RW-2)) ÷ (Load at RW-6)	26%	13%	21%	30%
		Total:	100%	100%	100%	100%
Net effect of the Drill Hole (RW-1), the Red Well (RW-5) and wetlands on Redwell Creek at RW-7	Anthropogenic	Effect of Drill Hole = (Load at RW-6 - Load at RW-2) ÷ (Load at RW-7)	47%	51%	44%	54%
	Natural[1]	Effect of Red Well = (Load at RW-7 - (Load at RW-6 - Load at RW-2)) ÷ (Load at RW-7)	53%	49%	56%	46%
		Total:	100%	100%	100%	100%
Net effect of the Daisy Mine Complex (RW-8 & RW-9), Drill Hole (RW-1) and Red Well (RW-5) on Redwell Creek at RW-11	Anthropogenic	Effect of Drill Hole = (portion of load at RW-10 attributed to Drill Hole) ÷ (Load at RW-11)	8%	13%	20%	11%
	Natural[2]	Effect of Red Well = (portion of load at RW-10 attributed to Red Well) ÷ (Load at RW-11)	10%	14%	22%	9%
	Anthropogenic[3]	Effect of Daisy Mine Complex: (Load at RW-11 - Load at RW-10) ÷ (Load at RW-11)	82%	74%	55%	79%
		Total:	100%	101%	96%	99%
Net effect of the Daisy Mine Complex (RW-8 & RW-9), Drill Hole (RW-1) and Red Well (RW-5) on Redwell Creek at RW-13	Anthropogenic[4,5]	Effect of Drill Hole = ((portion of load at RW-10 attributed to Drill Hole) ÷ (Load at RW-11)) x (Load at RW-13)	14%	43%	20%	11%
	Natural	Effect of Red Well = ((portion of load at RW-10 attributed to Red Well) ÷ (Load at RW-11)) x (Load at RW-13)	15%	2%	30%	12%
	Anthropogenic	Effect of Daisy Mine Complex = (portion of load at RW-11 attributed to Daisy Mine Complex) x (Load at RW-13 ÷ Load at RW-11)	71%	55%	48%	77%
		Total Anthropogenic= Drill Hole + Daisy Mine Complex at Mouth of Redwell Creek:	85%	98%	68%	88%
		Total[3,4]:	100%	100%	99%	100%

Notes

1. The load at the Red Well was assigned by subtracting the load attributed to the Drill Hole from the load in Redwell Creek below the Redwell, RW-7. This value also includes the natural background load.
2. This estimate assumes that the metal load does not precipitate, the percent of the metal load attributed to natural sources at RW-7 was calculated and preserved as the natural load at RW-11 (i.e. for Zn at RW-7 natural sources: 0.46 x 3.87 = 1.78 lbs/day, so 1.78 lbs/day or 9% of the load at RW-11 is attributed to natural sources).
3. This estimate assumes that the metal load does not precipitate, the percent of the metal load attributed to anthropogenic sources (Drill Hole) at RW-7 were calculated and preserved as a portion of anthropogenic load at RW-11 (i.e. for Zn- anthropogenic sources: 0.79 x 3.87 = 2.94 lbs/day, so 2.94 lbs/day or 79% of the load at RW-11 is attributed to the Drill Hole).
4. The estimate assumes that metals precipitate from RW-11 to RW-13 regardless of the load type. So the natural and anthropogenic ratios reported at RW-11 are preserved at RW-13.
5. Metals precipitate as pH increase from approximately 3 to 4.5 as Redwell Creek flows from the outlet of the upper basin to the mouth.

Table 21. Redwell Basin metal loading summary September 7, 2011.

Location	Description	Site Type	Dissolved Cadmium Load	Dissolved Copper Load	Dissolved Lead Load	Dissolved Zinc Load
			lbs/day			
RW-3	Headwaters of Redwell Creek	Background	0.000	0.000	0.000	0.006
RW-2	Redwell Creek downstream of the Prospect Pond	Mine Feature	0.000	0.001	0.001	0.057
RW-1	Drill Hole flow. Major Anthropogenic load	Mine Feature	0.012	0.287	0.269	1.559
RW-6	Redwell creek below drill hole above Red Well	Stream	0.008	0.093	0.194	0.933
Net Effect of Drill Hole Flows (i.e. RW-6 - RW-2):			**0.008**	**0.093**	**0.193**	**0.876**
RW-5	The Red Well- a natural geologic load *(outflow flow used for load calculation)*	Stream	0.028	0.005	0.805	3.649
RW-7	Redwell Creek below the Red Well	Stream	0.010	0.077	0.307	1.325
RW-10	Redwell Creek above Daisy Mine	Stream	0.016	0.097	0.471	1.928
RW-8	Daisy Mine. Major Anthropogenic load	Mine Feature	0.010	0.031	0.060	1.403
RW-9	Daisy Mine Seeps. Major Anthropogenic load	Mine Feature	0.008	0.025	0.090	1.252
RW-11	Redwell Creek below Daisy Mine and Seeps	Stream	0.056	0.217	0.910	8.521
Net Effect of Daisy Mine Complex (i.e. RW-11 - RW-10):			**0.040**	**0.119**	**0.439**	**6.593**
RW-12	Redwell Creek below additional mining	Stream	0.054	0.201	0.882	8.050
RW-13	Redwell Creek at mouth	Stream	0.043	0.145	0.635	6.513

Notes

1. Where cells are shaded grey, the result was less than the method detection limit (MDL). For these results a concentration of half the MDL was assigned so a load could be estimated. The MDL was 5 and 1 ug/L for copper and lead, respectively.

Table 22. Estimated load allocation in Redwell Basin on September 7, 2011.

Load Description	Load Type	Load Allocation Description	Percent of Dissolved Cadmium Load	Percent of Dissolved Copper Load	Percent of Dissolved Lead Load	Percent of Dissolved Zinc Load
Net effect of Drill Hole (RW-1) on Redwell Creek at RW-6	Anthropogenic	Effect of Drill Hole: (Load at RW-6 - Load at RW-2) ÷ (Load at RW-6)	97%	99%	99%	94%
	Natural	Background: (Load at RW-6- (Load at RW-6 - Load at RW-2)) ÷ (Load at RW-6)	3%	1%	1%	6%
		Total:	100%	100%	100%	100%
Net effect of the Drill Hole (RW-1), the Red Well (RW-5) and wetlands on Redwell Creek at RW-10	Anthropogenic	Effect of Drill Hole: (Load at RW-6 - Load at RW-2) ÷ (Load at RW-10)	48%	95%	41%	45%
	Natural	Effect of Red Well: (Load at RW-10 - Load at RW-6) ÷ (Load at RW-10)	51%	4%	59%	52%
	Natural	Background: Load at RW-10- (Effect of Drill + Effect of Redwell)	2%	1%	0%	3%
		Total:	100%	100%	100%	100%
Net effect of the Daisy Mine Complex (RW-8 & RW-9), Drill Hole (RW-1) and Red Well (RW-5) on Redwell Creek at RW-11	Anthropogenic	Effect of Drill Hole: (portion of load at RW-10 attributed to Drill Hole) ÷ (Load at RW-11)	14%	43%	21%	10%
	Natural[1]	Effect of Red Well: (portion of load at RW-10 attributed to Red Well) ÷ (Load at RW-11)	15%	2%	30%	12%
	Anthropogenic[2]	Effect of Daisy Mine Complex: (Load at RW-11 - Load at RW-10) ÷ (Load at RW-11)	71%	55%	48%	77%
		Total:	100%	100%	100%	99%
Net effect of the Daisy Mine Complex (RW-8 & RW-9), Drill Hole (RW-1) and Red Well (RW-5) on Redwell Creek at RW-13	Anthropogenic[3,4]	Effect of Drill Hole: ((portion of load at RW-10 attributed to Drill Hole) ÷ (Load at RW-11)) x (Load at RW-13)	14%	43%	20%	11%
	Natural	Effect of Red Well: ((portion of load at RW-10 attributed to Red Well) ÷ (Load at RW-11)) x (Load at RW-13)	15%	2%	30%	12%
	Anthropogenic	Effect of Daisy Mine Complex: (portion of load at RW-11 attributed to Daisy Mine Complex) x (Load at RW-13 ÷ Load at RW-11)	71%	55%	48%	77%
		Total Anthropogenic: Drill Hole + Daisy Mine Complex at Mouth of Redwell Creek:	85%	98%	68%	88%
		Total[3,4]:	100%	100%	99%	100%

Notes

1. This estimate assumes that the measured metal load does not precipitate, the percent of the metal load attributed to natural sources at RW-10 was calculated and preserved as the natural load at RW-11 (i.e. for Zn at RW-10 natural sources: 0.53 x 1.92 = 1.02 lbs/day, so 1.02 lbs/day or 12% of the load at RW-11 is attributed to natural sources).
2. This estimate assumes that the metal load does not precipitate, the percent of the metal load attributed to anthropogenic sources (Drill Hole) at RW-10 was calculated and preserved in load at RW-11 (i.e. for Zn- anthropogenic sources: 0.47 x 1.92 = 0.92 lbs/day, so 0.92 lbs/day or 10% of the load at RW-11 is attributed to the Drill Hole).
3. The estimate assumes that metals precipitate from RW-11 to RW-13 regardless of the load type. So the natural and anthropogenic ratios reported at RW-11 are preserved at RW-13.
4. Metals precipitate as pH increase from approximately 3 to 4.5 as Redwell Creek flows from the outlet of the upper basin to the mouth.

Table 23. Redwell Basin metal loading summary July 24, 2013.

Location	Description	Site Type	Dissolved Cadmium Load	Dissolved Copper Load	Dissolved Lead Load	Dissolved Zinc Load
			lbs/day			
RW-3	Headwaters of Redwell Creek	Background	0.014	0.089	0.022	2.885
RW-2	Redwell Creek downstream of the Prospect Pond	Mine Feature	0.000	0.000	0.001	0.041
RW-1	Drill Hole flow. Major Anthropogenic load	Mine Feature	Not sampled			
RW-6	Redwell creek below drill hole above Red Well	Stream	0.006	0.048	0.160	0.748
Net Effect of Drill Hole Flows (i.e. RW-6 - RW-2):			**0.006**	**0.048**	**0.159**	**0.707**
RW-5	The Red Well- a natural geologic load *(outflow flow used for load calculation)*	Stream	0.011	0.010	0.326	1.203
RW-7	Redwell Creek below the Red Well[1]	Stream	0.015	0.069	0.462	1.694
RW-8	Daisy Mine. Major Anthropogenic load	Mine Feature	0.007	0.026	0.041	0.901
RW-11	Redwell Creek below Daisy Mine and Seeps	Stream	0.058	0.201	1.017	7.748
Net Effect of Daisy Mine Complex (i.e. RW-11 - RW-7):			**0.043**	**0.132**	**0.555**	**6.054**
RW-13	Redwell Creek at mouth	Stream	0.056	0.189	1.017	6.779

Notes

1. RW-7 which is immediately upstream of RW-10 was used as the upstream reference to determine the effect of the Daisy Mine in 2013.

Table 24. Estimated load allocation in Redwell Basin on July 24, 2013.

Load Description	Load Type	Load Allocation Description	Percent of Dissolved Cadmium Load	Percent of Dissolved Copper Load	Percent of Dissolved Lead Load	Percent of Dissolved Zinc Load
Net effect of Drill Hole (RW-1) on Redwell Creek at RW-6	Anthropogenic	Effect of Drill Hole: (Load at RW-6 - Load at RW-2) ÷ (Load at RW-6)	95%	99%	99%	95%
	Natural	Background: (Load at RW-6- (Load at RW-6 - Load at RW-2)) ÷ (Load at RW-6)	5%	1%	1%	5%
		Total:	100%	100%	100%	100%
Net effect of the Drill Hole (RW-1), the Red Well (RW-5) on Redwell Creek at RW-7	Antropogenic	Effect of Drill Hole: (Load at RW-6 - Load at RW-2) ÷ (Load at RW-7)	37%	69%	34%	42%
	Natural	Effect of Red Well: (Load at RW-7 - Load at RW-6) ÷ (Load at RW-7)	61%	31%	65%	56%
	Natural	Background: Load at RW-10- (Effect of Drill + Effect of Redwell)	2%	1%	0%	2%
		Total:	100%	100%	100%	100%
Net effect of the Daisy Mine Complex (RW-8), Drill Hole (RW-1) and Red Well (RW-5) on Redwell Creek at RW-11	Anthropogenic	Effect of Drill Hole: (portion of load at RW-7 attributed to Drill Hole) ÷ (Load at RW-11)	10%	24%	16%	9%
	Natural[1]	Effect of Red Well: (portion of load at RW-7 attributed to Red Well) ÷ (Load at RW-11)	16%	11%	30%	12%
	Anthropogenic[2]	Effect of Daisy Mine Complex: (Load at RW-11 - Load at RW-7) ÷ (Load at RW-11)	74%	66%	55%	78%
		Total:	100%	100%	100%	99%
Net effect of the Daisy Mine Complex (RW-8), Drill Hole (RW-1) and Red Well (RW-5) on Redwell Creek at RW-13	Anthropogenic	Effect of Drill Hole: (portion of load at RW-11 attributed to Drill Hole) ÷ (Load at RW-13)	10%	24%	16%	9%
	Natural	Effect of Red Well: (portion of load at RW-11 attributed to Red Well) ÷ (Load at RW-13)	16%	11%	30%	12%
	Anthropogenic	Effect of Daisy Mine Complex: (portion of load at RW-11 attributed to Daisy Mine Complex) ÷ (Load at RW-13)	74%	66%	55%	78%
		Total Anthropogenic: Drill Hole + Daisy Mine Complex at Mouth of Redwell Creek:	84%	90%	71%	87%
		Total[3,4]:	100%	100%	100%	99%

Notes

1. This estimate assumes that the metal load does not precipitate, the percent of the metal load attributed to natural sources at RW-7 was calculated and preserved as the natural load at RW-11 (i.e. for Zn at RW-7 natural sources: 0.56 x 1.69 = 1.02 lbs/day, so 0.95 lbs/day or 12% of the load at RW-11 is attributed to natural sources).
2. This estimate assumes that the metal load does not precipitate, the percent of the metal load attributed to anthropogenic sources (Drill Hole) at RW-7 were calculated and preserved as a portion of anthropogenic load at RW-11 (i.e. for Zn- anthropogenic sources: 0.42 x 1.69 = 0.92 lbs/day, so 0.77 lbs/day or 9% of the load at RW-11 is attributed to the Drill Hole).
3. The estimate assumes that metals precipitate from RW-11 to RW-13 regardless of the load type. So the natural and anthropogenic ratios reported at RW-11 are preserved at RW-13.
4. Metals precipitate as pH increase from approximately 3 to 4.5 as Redwell Creek flows from the outlet of the upper basin to the mouth.

5.4 GUNSIGHT PROCESSING AREA

The Gunsight Processing Area is located 3.6 miles northwest of the town of Crested Butte, in the lower portion of the Watershed. The land is owned by the BLM and CBLT owns land near the site. The site is 0.1 mile south of the confluence of Oh-Be-Joyful Creek (segment 10a) and the Slate River (segment 7) and adjacent to Gunsight Pass Road and the GB Trail.

The Gunsight Processing Area consists of four prominent benches constructed of mine wastes. Loose unconsolidated mine waste is eroding between each of the benches. Several prominent rills and gullies drain the site towards the Slate River flood plain. Seeps are present during wet periods on the toe slopes of debris piles and benches. The site has large impervious areas that produce runoff during snowmelt or precipitation events.

The history of the site is somewhat unclear. It appears that ore and other materials from the Daisy Mine, and potentially the Augusta or other mines, were transported to the Gunsight Processing Area. The mine waste and abandoned equipment on site suggests some crushing and possibly milling occurred on site. Local sources suggest that operators intended to build a large mill, but commodity prices fell and funds for construction disappeared before the project could be completed. Mining did not occur on site; although there are small, dry prospect holes in the vicinity. A large shed, referred to as the “Core Shed” housed drilling cores from the molybdenum exploration project on Mount Emmons. The shed was removed in 2012. Remnants from the original facilities and other equipment remain on location and miscellaneous metal scraps litter the site.

Sediment samples collected from the mine waste had elevated concentrations of lead and zinc. Due to recreation on site and in the vicinity, the mine waste is a human-health hazard. The site also poses a risk to wildlife and domestic animals in the area. The BLM has placed signs on location to alert the public of the risk associated with the mine waste.

In 2011, water quality samples collected from seeps down-gradient of mine waste confirmed that surface waters exiting the site had elevated concentrations of lead and zinc along with other metals. Metal concentrations in the water quality sample exceeded applicable standards for several metals and pH. Additional water quality samples were collected in July 2014 to further characterize surface water quality (lab results are pending).

Table 25. Summary of water quality results from the Gunsight Processing Area and the Slate River.

Monitoring Location	Location Description	Location Type	Sample Date	Flow (cfs)	Dissolved Cadmium (ug/L)	Dissolved Copper (ug/L)	Dissolved Iron (ug/L)	Dissolved Lead (ug/L)	Dissolved Zinc (ug/L)
SR-7	Slate River above Oh-Be-Joyful Creek and BLM Campground	Stream, upstream reference	7/14/2011	218.8	<0.6	<5	99	<1	6
			9/7/2011	14.9	<0.6	<5	5	<1	7
OBJ-4	Oh-Be-Joyful creek at mouth, above Slate River	Stream, upstream reference	7/14/2011[1]	161.2	<0.6	<5	15	6.9	56
			9/8/2011	4.0	<0.6	<5	13	8.7	160
GSM-1	Runoff and seeps from the Gunsight Processing Area	Mine feature	7/14/2011	NM[2]	320	1800	3400	1200	41,000
			9/7/2011	NM	2.5	10	610	8.7	540
SR-8	Slate River below Oh-Be-Joyful Creek	Stream, downstream reference	7/14/2011	380.0	<0.6	<5	11	1.8	26
			9/8/2011	17.2	<0.6	<5	7	<1	36

Notes
1. Stream flow for OBJ-4 on 7/14/2011 was determined by subtracting SR-7 from SR-8; due to high flows that prevented flow measurement.
2. Flow could not be measured from the seeps.

Seeps at the Gunsight Processing Area had metal concentrations that were two to three orders of magnitude greater than the concentrations observed at reference sites in the Slate River (Table 25). Although the concentrations at the seeps are elevated, it is not clear whether metal concentrations or loads in the Slate River are effected by the Processing Area. Loads estimates computed from 2011 data do not indicate an increase in loads in the Slate River due to the Processing Area. However, the data are confounded by missing or un-paired flow data.

6.0 DATA GAP ANALYSIS

When the watershed planning process began in 2011, stakeholders identified several data gaps in the Watershed (see Section 7.0 and Table 10 in the WQ Summary). In the past three years, sample collection has occurred to address several of the original data gaps. Stakeholders have identified additional data gaps that they would like to address in the future. Table 26 summarizes current data gaps in the Watershed. The high and medium priority data gaps are incorporated into the long-term monitoring plan (Section 9.2).

Photo 26. CCWC volunteers collect data from the Augusta Mine Portal in July 2011.

Photo 27. Baxter Creek, above confluence with Poverty Gulch during high flow in July 2011.

To date, the lakes in the Watershed have not been sampled. A baseline characterization should be completed. There is general interest to support this effort, however funds are not currently available. Developing a proposal to seek funding for a baseline assessment has been assigned a medium priority (Table 26).

There is a lack of groundwater quality data in the Watershed. Groundwater in some areas of the lower Watershed may be susceptible to potential contamination based on the characteristics of the aquifer and its proximity to the surface (USFS, 2010). There are 38 wells in the Watershed, some are used for domestic water supply (CDRW, 2011). Nearly all of the wells are concentrated in the lower Watershed, adjacent to the Slate River. There are at least four wells in the river corridor where the groundwater surface water exchange is likely. The WQ Summary provides additional details about the study referenced above and a map of the well locations. A baseline characterization of wells used for domestic water supplies is recommended. If landowners are interested in collecting samples from their wells, CCWC can direct them to appropriate resources for water quality testing.

The Slate River from the confluence with Coal Creek to the confluence with the East River (Segment 8), is on the M&E List for potential impairment of aquatic life. Additional data collection is needed to determine whether aquatic life is impaired in the lower Slate River (Section 2.8).

Table 26. Assessment and evaluation of data gaps in the Watershed (page 1 of 2).

Area or Item	Issue(s)	Current Objective(s)	Proposed Method	Considerations	Priority
Redwell Basin	Existing data clearly indicate that anthropogenic and natural features in Redwell Basin impair water quality. Additional data are needed to better characterize spatial and temporal patterns in metal loading. Additional baseline data were collected in 2011. In 2013 and 2014, monitoring occurred to evaluate changes following the Drill Hole Closure Project.	Analyze data from 2011 to 2014 to determine whether metal loads in Redwell Creek were reduced. Continue water quality monitoring in 2015. If needed, use the analysis results to revise monitoring efforts.	Collect water quality samples and flow measurements in 2015 to assess outcomes for the Drill Hole Closure Project. Monitoring may continue beyond 2015.	Redwell Basin is geologically and chemically complex. Monitoring efforts must be designed to accommodate these challenges.	High, the Drill Hole was closed and post-project monitoring is underway. Understanding changes in water quality is essential to evaluate the outcome of the project, the feasibility of other reclamation efforts in the basin, and to establish ambient water quality standards.
Oh-Be-Joyful Creek	Existing data clearly indicate that anthropogenic and natural features in Redwell Basin impair water quality in Redwell and Oh-Be-Joyful creeks.	Analyze data from 2011 to 2014 to determine whether metal loads in Oh-Be-Joyful Creek were reduced. Continue water quality monitoring in 2015.	Collect water quality samples and flow measurements in 2015 to assess outcomes for the Drill Hole Closure Project. Monitoring may continue beyond 2015.	Improvements to water quality may be more readily measured in Oh-Be-Joyful Creek, because Redwell Basin is geologically and chemically complex.	High, the project is underway and understanding the outcome is essential to establishing ambient water quality standards in Oh-Be-Joyful Creek.
Mainstem of the Slate River	Existing data clearly indicate that metals that originate from anthropogenic and natural features in Redwell Basin impair water quality in the Slate River.	Analyze data from 2011 to 2014 to determine whether metal loads in the Slate were reduced. Continue water quality monitoring in 2015.	Collect water quality samples and flow measurements as directed by the long-term monitoring plan.	None known at this time.	High, especially for sites on the lower Slate River. These locations provide a "big picture" perspective for reclamation outcomes.
Macroinvertebrates	There is very limited historic data and in 2010 the State adopted regulatory criteria for macroinvertebrates. In 2011 and 2013 samples were collected to characterize baseline conditions. In 2012 Segment 8, the Slate River below Coal Creek, was added to the M&E List for potential impairment of aquatic life.	Provide data to help resolve the M&E Listing for aquatic life on Segment 8. Incorporate macroinvertebrate sampling into the long-term monitoring plan.	Collect samples at locations in the lower Slate River and Coal Creek during 2015 to help resolve the M&E Listing.	The combined influence of natural sediment loads, and elevated metal concentrations make identifying the cause(s) of impairment difficult.	High, recently collected data suggests that aquatic life may be impaired, but the cause of impairment is not clear.
E. coli	There are limited historic data; however, the data do not indicate that *E. coli* concentrations do not exceed the standard. Samples collected from targeted locations in the Watershed in 2011 and 2013 confirmed this finding. All concentrations measured in 2011 and 2013 were less than the standard for primary contact recreation.	Incorporate *E. coli* sampling into the long-term monitoring plan.	Collect samples at locations presented in the long-term monitoring plan.	—	Medium, additional data collection should occur to confirm that *E. coli* concentrations remain low and below standards.

Table 26. Assessment and evaluation of data gaps in the Watershed (page 2 of 2).

Area or Item	Issue(s)	Current Objective(s)	Proposed Method	Considerations	Priority
Nutrients	There are limited historic data; however, the data do not indicate that nutrient concentrations do not exceed the standard. Samples collected from targeted locations in the Watershed in 2011 and 2013 confirmed this finding. All concentrations measured in 2011 and 2013 were less than the interim standards for nitrogen and phosphorus.	Incorporate into nutrient sampling the long-term monitoring plan.	Collect samples at locations presented in the long-term monitoring plan.	—	Medium, additional data collection should occur to confirm that nutrient concentrations remain low and below standards.
Water Quality in Lakes	There is little or no water quality data available for lakes in the Watershed.	Secure funds to monitor lakes in the Watershed. Monitoring should emphasize lakes used for recreation. Collect water quality samples from selected lakes with methods appropriate for lakes.		There is general interest, but limited funding.	Medium, until funding is secured other projects take priority.
Groundwater Quality	In most of the Watershed, groundwater quality has not been characterized.	Work with interested parties to fund and complete monitoring. An appropriate strategy needs to be developed for this effort.		There is general interest, but limited funding.	Low, until funding is secured other projects take priority.
Upper Portion of the Watershed	There are several small historic abandoned mine features in the upper Watershed. The historic data set lacks water quality data in the upper Watershed. The upper Watershed was sampled at three locations during two events in 2011. Metal concentrations were generally low and do not suggest that historic abandoned mines impair water quality.	Incorporate SR-3a, the Slate River a half-mile above the last road crossing, into the long-term monitoring program to validate existing data, and better characterize ambient conditions.	Collect water quality samples and flow measurements as directed by the long-term monitoring plan.	Monitoring at this site does not directly address any implementation goals, so funding may be difficult.	Low, existing data does not indicate a need for further investigation.
Poverty Gulch and Tributaries	There are several historic abandoned mine features, including the Augusta Mine, in Poverty Gulch. The historic data set lacks water quality data in Poverty Gulch and its tributaries. In 2011 several locations in Poverty Gulch were sampled on two occasions. Most metal concentrations were below method detection limits. Selected samples had detectable concentrations of copper, iron, manganese, and zinc. However, these concentrations were generally below applicable standards. The Augusta Mine Portal was also sampled; but metal concentrations do not warrant further investigation.	Incorporate POV-4, Poverty Gulch at the mouth, into the long-term monitoring program to validate existing data, and better characterize ambient conditions.	Collect water quality samples and flow measurements as directed by the long-term monitoring plan.	Monitoring at this site does not directly address any implementation goals, so funding may be difficult.	Low, existing data does not indicate a need for further investigation.
Channel Stability and Sediment Transport	To better understand sediment transport and channel stability, a geomorphic assessment was completed in 2012. It found that most of the sediment transport is natural, but there are selected reaches where channel instability and sediment are attributed to human activities.	Support CBLT in their efforts to complete PLA studies, and possibly restoration, on selected reaches of the Slate River.	None proposed at this time.	—	None assigned at this time.

7.0 PROPOSED MANAGEMENT STRATEGIES

The goal of this section is to outline the approaches used to translate our desired outcomes into actions that are informed by the existing data set and stakeholder priorities.

7.1 DRILL HOLE CLOSURE PROJECT

In September 2013, DRMS grouted and properly abandoned the Drill Hole. Eighteen thousand pounds of grout were injected into the Drill Hole. The volume of grout is sufficient to fill the entire hole, child holes, and any small fractures that may intercept the hole. The grout prevents groundwater from reaching the surface. To date, the closure has been successful and water has not been observed at the surface near the Drill Hole. Poor quality water that flowed from the Drill Hole should no longer reach Redwell Creek.

Groundwater flowed steadily under pressure to the surface via the Drill Hole for nearly forty years. If an alternate route to the surface existed, the system would have lacked the pressure needed to support steady artesian flow at the Drill Hole. Because the Drill Hole penetrated an artesian aquifer isolated from other groundwaters in Redwell Basin, it is very unlikely that groundwater from the artesian aquifer would flow to the Daisy Mine workings or other features in Redwell Basin due to the closure. The groundwater flow is dispersed to the subsurface, where it flowed prior to the drilling efforts.

Due to the complex geology and chemistry attributed to both anthropogenic and natural features in Redwell Basin, it is essential that a robust post-project monitoring program be completed to characterize water quality changes in Redwell Creek following the Drill Hole closure. The outcome of the Drill Hole closure will provide valuable insight into the effectiveness of reclamation in a system that is naturally acidic with elevated metal concentrations. It is difficult to determine the time required for Redwell Creek to reach a new equilibrium, especially with respect to variation found in natural systems. The overall length and frequency of this monitoring effort is one of the most challenging elements of the program design. In 2014 two basin-wide monitoring events were completed to assess changes in metal concentrations in Redwell Creek, Oh-Be-Joyful Creek, and the lower Slate River. Two basin-wide monitoring events are also scheduled for 2015 and 2016.

In 2010, Kimball and others simulated water quality conditions in Redwell Creek prior to mining. The geochemical model suggested that Redwell Creek had a substantially higher pH (less acidic) prior to mining and other anthropogenic disturbances. The simulated pre-mining pH in Redwell Creek was 5.1 versus the current, acidic pH of 3.85 (Kimball et al., 2010). Metal concentrations remained elevated; although much lower than current conditions (Kimball et al., 2010). The simulation suggested that even without anthropogenic disturbance Redwell Creek would not meet acute water quality criteria for copper, zinc, and possibly other metals (Kimball et al., 2010). Water quality data collected following the

Drill Hole closure offers a chance to validate or refute the modeled results that simulated the effect of the Drill Hole.

7.1.1 Estimated Load Reductions from the Drill Hole Closure

The net effect of the Drill Hole on Redwell Creek was estimated by subtracting the load in Redwell Creek above the Drill Hole (RW-2) from the load in Redwell Creek below the Drill Hole (RW-6) using data collected from three sample events (Tables 19-21). Dissolved zinc and lead were the largest components of the metal load attributed to the Drill Hole.

In the summer of 2013, flow from the Drill Hole was stopped for two weeks using a valve. Water quality samples collected from Redwell Creek below the Drill Hole (RW-6) before and after the temporary closure showed load reductions that ranged from 13 to 64 percent even though stream flow increased between sample events (due to intense summer precipitation). The temporary closure also demonstrated that it will take time for Redwell Creek to reach a new equilibrium.

Because the Drill Hole was sealed from the surface to the source, the load reduction attributed to this project should be one hundred percent. The closure also eliminated an enormous source of acidity. Acidic waters from the Drill Hole allowed for increased metal solubility in Redwell Creek. The median pH in the headwaters of Redwell Creek is 6.8 (AEC, 2011). The Drill Hole caused the pH in Redwell Creek to decrease to approximately 3.7 (Table 16); this is over 1,000 times more acidic than the conditions found in the headwaters of Redwell Creek. Less acidity in the system should decrease metal solubility. Increased pH on this reach, should translate to lower metal concentrations downstream. The headwaters of Redwell Creek have far lower metal concentrations than Redwell Creek below the Drill Hole. The closure should allow such conditions to persist on a longer portion of Redwell Creek. It appears that metal loads in Redwell Creek below the Drill Hole could be reduced to a level similar to the headwaters. Monitoring data collected from 2011 to 2016 will be used to determine the actual load reductions attributed to the project.

7.2 DAISY MINE RECLAMATION

The Daisy Mine Complex is on the east side of Redwell Basin. The mine had several levels, many of which have portals on the slopes above (or south of) the collapsed drainage tunnel. Gunsight Pass Road traverses between the collapsed drainage tunnel and the upper mine portals. Most of the waste is concentrated near Gunsight Pass Road by the drainage tunnel and lower portals. Drainage from the collapsed tunnel of the Daisy Mine is the largest man-made nonpoint source metal load in the Watershed.

The degree of weathering and particle size, determines how readily mine wastes leach contaminants like metals or sulfate. Fine-grained sediments more readily release metals, due to an increased surface area. Fine grained waste piles are a higher priority for reclamation than coarse-grained materials. Most of the fine-grained waste is near the collapsed drainage tunnel and the lower portals.


Photos 28 a and b. The road to Peeler Lakes Trail passes through mine waste near the collapsed tunnel of the Daisy Mine (Left photo). The right photo illustrates the variation in waste types. Some of the material is fine and heavily weathered and some is coarse and less-weathered.


Photos 29a and b. Small abandoned mine features litter Redwell Basin and most are a part of the Daisy Mine (right Photo). Flow from the collapsed tunnel passes through waste en route to Redwell Creek (left photo).

Much of the ground cover is talus in the upper portion of Redwell Basin. Vegetation surrounds many of the smaller waste piles (Photo 26). Steep slopes may also limit access to certain areas. Constructing roads to reclaim small piles where vegetation has recolonized adjacent areas may not create a "net improvement". Such considerations should be incorporated into the reclamation design.

An effective reclamation project at the Daisy Mine will reduce metal loads in Redwell Creek by reducing metal loads that originate from the mine site and drainage tunnel. An effective design will balance practical considerations with water quality improvement goals. At this time, additional data is required to further plan for reclamation. This data includes more detail on site conditions and characteristics. An on-site characterization and x-ray fluorescence (XRF) survey should be used to determine the size, character, and metal content of various mine waste piles. The water flow and groundwater hydrology on site need to be better delineated. Such delineations will determine the water management strategies employed in the reclamation design.

7.2.1 Estimated Load Reductions from Reclamation at the Daisy Mine

The net effect of the Daisy Mine Complex is best captured by the change in chemistry and metal loads measured in Redwell Creek above the Daisy Mine (RW-10) and in Redwell Creek below the Daisy Mine (RW-11). During the July 2010 sample event the load attributed to the Daisy Mine was approximately 0.14, 0.38, 1.34, and 15.8 lbs/day for dissolved cadmium, copper, lead, and zinc, respectively (Table 19).

Samples have also been collected from the collapsed drainage tunnel (RW-8) and nearby seeps (RW-9 and RW-9a) that converge into a tributary that flows to Redwell Creek. The loads measured at the Daisy Mine drainage tunnel and seeps were the largest measured in the basin. During the July 2010 event, which occurred during moderate flow conditions, the loads in the Daisy Mine tributary were about 1.1, 3.7, 11.3, and 142.4 lbs/day for dissolved cadmium, copper, lead and zinc, respectively (RW-9; Table 19). The loads observed in July 2010 were substantially higher than observed during the September 2011 and July 2013. Some of the variation may be attributed to the difficulty of measuring flow in such a wide and shallow channel (Photo 29b), which may result in under-estimation during lower flow conditions.

The elevated metal loads measured in the Daisy Mine tributary and at the collapsed drainage tunnel indicate that reclamation efforts should be concentrated in this area. There are several reclamation practices that could potentially be used to reduce metal loads and acidity in this area. The options are described below in order of their suitability at the Daisy Mine.

Source water control is a technique that prevents water from interacting with mine waste. At the Daisy Mine, it may be possible to implement source water controls to prevent water, primarily rain or snowmelt, from entering the mine workings and flowing to the collapsed drainage tunnel. There are several shafts, portals and bore holes where water may enter the mine workings and exit the mine via the collapsed drainage tunnel. Because flow from the collapsed drainage tunnel could be reduced and water that does not enter the mine workings would be less likely to become contaminated, the load reduction attributed to this technique could be quite large. At this time, it is unknown whether surface based infiltration at the mine workings is a substantial source of drainage water. Additional data collection is needed.

Waste repositories isolate problematic waste materials and prevent or limit water from interacting with the waste. Typically repositories are designed to be permeable or impermeable depending on the site characteristics. Impermeable repositories constructed with clays or geo-membrane fabrics are often more effective, but they are more costly. Permeable repositories are often capped with large rock to create a capillary break that limits water movement. Topsoil can be applied over the cover rock or impermeable membrane to allow for re-vegetation. Waste repositories are typically located in upland areas to further prevent interaction with surface waters. At the Daisy Mine, a repository could be used to store fine-grained wastes. Some of the most problematic waste is located near the collapsed drainage tunnel and adjacent to the Daisy Mine tributary. The entire area is saturated frequently which may accelerate metal loading from these wastes. A repository could be used isolate the waste from the drainage area. Without additional data, the composition of the waste and actual designs, it is not possible to the estimate load reductions associated with a repository. Although, given the very poor quality of the water that interacts with the waste there is substantial potential to reduce metal loads by isolating the waste in a repository.

Bioreactors are engineered systems that rely on vegetation and sometimes chemical amendments (such as lime or fertilizer) to stimulate plant and microbial growth which can alter sediment and water chemistry to sequester metals in the bioreactor. At the Daisy Mine, it may be possible to design a bioreactor in the tributary that flows to Redwell Creek. Some portions of the tributary support limited plant or algae growth. Adjacent areas support grasses, sedges and other species. The environmental conditions may be well-suited to a bioreactor (i.e., not too dry). It is not possible to determine the potential load reductions from a bioreactor without additional data.

Bulkheads, which are essentially large concrete plugs, are sometimes used to control water flow from mines. Bulkheads require very solid bed rock to serve as an anchor and attachment point, so they can withstand the water pressure that builds in the mine workings behind the bulkhead. When installed in mines, it is often necessary to rehabilitate portions of the tunnel to assure the bulkhead can be properly anchored. Because flow originates from what appears to be a drainage tunnel, which may have been hastily constructed, and that is also collapsed, it would be infeasible to anchor a bulkhead in the tunnel. Thus, it is not likely a bulkhead will be installed at the Daisy Mine due to installation challenges and the associated costs to rehabilitate the collapsed tunnel.

Collectively, a properly designed set of BMPs could substantially reduce the metal load and acidity in Redwell Creek due to unconsolidated waste and drainage at the Daisy Mine. Without a specific design in place, estimated load reductions would be speculative at best. Additional data is needed to create a reclamation design. Additional data, possibly a tracer study or underground mapping, is needed to determine whether meteoric waters (water from precipitation and snowmelt) increase flows from the drainage tunnel. This will determine whether source water control BMPs should be included in the design. XRF surveys and detailed mapping is needed to characterize the type and quantity of waste. This information will be used to determine the size and type of waste repository, and evaluate the utility. The chemical composition of the waste will also help determine whether a bioreactor can be a suitable BMP.

7.3 GUNSIGHT PROCESSING AREA RECLAMATION

Due to recreation on mine waste the Gunsight Processing Area is a human-health risk. Although the extent to which the site impairs water quality in the Slate River remains unclear, water from the seeps is of very poor quality and is also a potential risk to humans and animals in the area. The BLM and others have made reclamation at this site a priority.

In 2014 additional water quality data was collected to better characterize the extent of the water quality problem attributed to the site. In addition, waste and other features were mapped in 2014. This data will be combined with the existing data set to create a Removal Assessment Report. A preliminary reclamation design will be created from the report by BLM and DRMS staff.

A series of best management practices (BMP) will be used to restore natural topography, permanently stabilize mine waste materials, and allow for re-vegetation with suitable native species. These practices will restore hydrologic function on the site and minimize water contact with waste materials. The reclamation design is preliminary at this stage, but BLM, DRMS, and other stakeholders are working together to solidify the design by early 2015. An engineer will be contracted to complete the final design.

7.4 WATERSHED IMPROVEMENT PROJECTS

The following sections outline smaller projects that will be implemented to improve the health and aesthetics of the Watershed.

7.4.1 Facilities Improvements

The Watershed lacks an adequate number of toilets. Oh-Be-Joyful Campground is the only facility equipped with a pit toilet in the entire Watershed. During a six week period beginning in July 2013, BLM estimated that nearly 50,000 users visited the Campground.

To date, E. coli concentrations in the Watershed readily met the primary contact recreation standard. However, stakeholders have identified human waste in the Watershed as an aesthetic problem. To address the problem CCWC has partnered with the BLM and USFS to maintain a portable toilet. The portable toilet was placed in an area referred to as Squatter’s Flats, which is northwest of Nicholson Lake. The pilot period began in August 2014 and initial results suggest the unit was heavily used. The initial success of the pilot project will be used to recruit additional partners to support an extended season and or additional units in 2015. Providing an appropriate number of facilities will improve the quality of the recreation experience for many people. Public education and outreach regarding appropriate waste management techniques is also a part of the project.

7.4.2 Paradise Divide Road Stormwater Management

Portions of Paradise Divide Road were identified as potentially problematic in the Geomorphic Assessment and other surveys, due to the potential for stormwater runoff and subsequent erosion on the road surface and in down-gradient areas. Limited maintenance and a lack of BMPs, especially culverts, appear to be the responsible for some of the erosion. However, the grade of the road makes stormwater management exceptionally difficult. CCWC would like to secure funds to allow for installation and maintenance of additional BMPs.

7.4.3 Gothic Road Bridge

Gunnison County plans to replace the Gothic Road Bridge in 2016. The project will be planned in 2014 and 2015. The current bridge is undersized and causes sediment deposition in the vicinity. A properly sized bridge would help to alleviate channel instability and sediment deposition in this portion of the Slate River.

8.0 WATERSHED PLAN IMPLEMENTATION

The watershed planning process has developed strong partnerships among local stakeholders. CCWC will continue to work with partners as the Plan is implemented. For many projects to proceed additional funding must be secured. Thus, grant writing and fund raising are a substantial part of the implementation effort.

Evaluating changes in water quality following the Drill Hole Closure Project is the first priority. Water quality data collected in the coming years will be used to evaluate the changes.

The Gunsight Processing Area Reclamation Project is the second priority. Initial characterization work was completed in 2011 and 2012. In 2014, additional data was collected to address data gaps that remained. In late 2014 all of the characterization data will be compiled into a Site Removal Assessment report. Reclamation design will be completed through a collaborative process led by BLM and DRMS staff. The group plans to complete reclamation design in early 2015. Construction could occur as early as the summer of 2015. Interim measures, including temporary exclusion fencing will be installed during fall 2014.

The reclamation design is needed to calculate the actual project cost. Initial estimates indicate that the project budget will likely exceed $250,000, including reclamation design and construction. A portion of these funds, approximately $100,000 have been appropriated by BLM and DRMS. The funding gap is approximately $150,000. The funds secured to date will cover design and a small portion of construction. The reclamation design will be used to create an estimated budget. Grant funding or other sources will be pursued based on the needs identified in the budget.

Reclamation at the Daisy Mine is the third priority, but is the largest and most ambitious project proposed in the Plan. Due to the size of the project, it may be necessary to secure funding for the design separately from funding for construction and post-project monitoring. Funding is needed to complete the characterization and initial design efforts.

As time passes this plan and the goals outlined within are only as good as the efforts to update and improve the original plan. To maintain an effective plan and increase the momentum needed to improve water quality in the Watershed, existing partnerships should continue and new partnerships should be established. CCWC will complete bi-annual updates to revise project priorities, monitoring plans, education efforts, and other items included in this plan.

Table 27. Summary of the implementation strategy for the Drill Hole Closure Project.

Problem:	Water flowed from an improperly abandoned Drill Hole for forty years. The water originates in a highly mineralized formation and is of very low quality and flows to Redwell Creek. The Drill Hole was closed in September 2013 and the pollutant source was eliminated. Post-project monitoring is essential to evaluate the outcome and to improve our understanding of Redwell Basin.
Impairments:	Redwell: acidic pH, cadmium, copper, lead and zinc. Oh-Be-Joyful: cadmium, copper, lead and zinc. Slate River: zinc
Action:	Implement the post-project monitoring program in 2015 and 2016 analyze data from 2011 to 2016 to evaluate changes in water quality.
Measureable Improvements:	In Redwell Creek and Oh-Be-Joyful Creek metal loads should decrease and pH should increase due the Closure Project.
Funding:	DRMS and CDPHE have secured funding to complete monitoring in 2015. Additional funding may be needed for 2016.

Table 28. Summary of the implementation strategy for reclamation at the Gunsight Processing Area

Problem:	Recreation at and near the Gunsight Processing area poses a human-health risk due to elevated metal concentrations in the waste. Water that originates from seeps on the site is of very poor quality.
Impairments:	May contribute to water quality impairments in the Slate River.
Action:	Partner with BLM, DRMS, EPA and others to design and implement reclamation, and complete post-project monitoring.
Measureable Improvements:	Reduce human health risk by removing or isolating mine waste. Prevent water infiltration and run-off to improve surface water quality.
Funding:	Potentially large project. BLM, DRMS, and NPS program are all potential sources.

Table 29. Summary of the implementation strategy for reclamation at the Gunsight Processing Area.

Problem:	The Daisy Mine Complex impairs water quality in Redwell Creek, Oh-Be-Joyful Creek, and the Slate River via a collapsed draining tunnel and waste rock material.
Impairments:	Redwell: acidic pH, cadmium, copper, lead, and zinc. Oh-Be-Joyful: cadmium, copper, lead, and zinc. Slate River: zinc
Action:	Partner with DRMS, USFS, CDPHE and others to design and implement reclamation and post-project monitoring.
Measureable Improvements:	Eliminating or reducing flow from the collapsed tunnel and waste will improve water quality in Redwell Creek and downstream in Oh-Be-Joyful Creek and the Slate River.
Funding:	Very large project that could be phased to improve likelihood of funding. Potential sources include NPS, Power and Water Authority Funds, State Revolving Fund, and others.

8.1 EVALUATION OF REQUIRED TECHNICAL AND FINANCIAL RESOURCES, AND ENGAGEMENT OF PROJECT PARTNERS

The following tables outline technical, financial and partnership needs for each of the priority projects.

Table 30. Technical, financial, and partnership needs for the Drill Hole Closure Project.

Technical Requirements:	This project requires qualified personnel to design the monitoring program and evaluate the outcomes of post-project water quality monitoring efforts. The initial time frame is three years, through 2016. Field personnel who complete water quality monitoring must be well-trained, especially with respect to flow measurements. Many of the monitoring sites require alternative flow monitoring techniques. Data management, including upload to CDSN, and analysis is required to communicate outcomes.
Financial Resources:	DRMS and CDPHE have funding to complete post-project monitoring in 2014 and 2015; additional funds may be required for 2016. In 2015 the Gunnison Basin will be the WQCD's priority monitoring basin. Proper communication could reduce monitoring costs. Communicating monitoring results with interested parties will improve the likelihood for funding this project and others.
Project Partners & Roles:	DRMS: Project leader CDPHE: Provide monitoring support and additional funding for second and possibly third year of monitoring. Coordinate with WQCD Basin monitoring teams USFS: Provide monitoring support CCWC: Provide monitoring support and lead outreach efforts.

Table 31. Technical, financial and partnership needs for the Gunsight Processing Area Reclamation Project.

Technical Requirements:	This project requires qualified personnel to complete the final characterization efforts. Qualified personnel are needed for reclamation design and construction. Data management and analysis is required to communicate outcomes.
Financial Resources:	The BLM and DRMS have allocated funds for the project. The available funds will be sufficient to complete the final characterization, design, and a portion implementation. Funds for implementation and post-project monitoring need to be secured.
Project Partners & Roles:	BLM: will coordinate all elements of the project and lead community outreach effort. This project has a significant community outreach element because the site is adjacent to popular recreation areas. DRMS: will lead design and implementation with BLM, assist with characterization CCWC: will provide monitoring and outreach support.

Table 32. Technical, financial and partnership needs for the Daisy Mine Reclamation Project.

Technical Requirements:	Site characterization, such as surveys, material characterization, and water flow patterns, require qualified personnel to begin project design. Design objectives: provide source water control, isolate mine wastes, passive water treatment (bioreactor), and stormwater controls. Land owner permission is required for this project. Post-project monitoring design.
Financial Resources:	This large scale project has not been funded. The NPS program identified the Daisy Mine as a priority in the 2012 NPS Management Plan. The NPS program may be an ideal funding source; other sources include the State Revolving Fund, Power and Water Authority, DRMS, USFS, and EPA. The project can be phased to improve funding eligibility.
Project Partners & Roles:	DRMS: Lead agency for reclamation efforts at the Daisy Mine. USFS: Owns adjacent lands, may require environmental review for the project. CDPHE: Restoration program has supported monitoring in Redwell Basin. CCWC: Provide local coordination and support.

Table 33. Implementation schedule for the Upper Slate River Watershed Plan.

Priority	Task	2014				2015				2016				2017				2018				2019			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Watershed Plan	Present Watershed Plan to local governments and agencies																								
	Present Watershed Plan to local stakeholders																								
	Discuss Gothic Bridge with BOCC; partnered with CBLT																								
	Submit Final Watershed Plan to CDPHE: 10-15-2014																								
	Approved Watershed Plan submitted to CDPHE's FTP Site: 10-31-2014																								
Drill Hole	Finalize post-project monitoring plan for Drill Hole																								
	Post-project monitoring for Drill Hole project																								
	Evaluate Drill Hole post-project data																								
Gunsight Reclamation Project	Compile Gunsight characterization data																								
	Complete Gunsight characterization report																								
	Finalize Gunsight reclamation design																								
	Identify funding sources for Gunsight project construction																								
	Write grant for Gunsight reclamation project construction																								
	Complete Gunsight reclamation project																								
	Begin post-reclamation monitoring at Gunsight																								
Daisy Mine Reclamation Project	**Complete site characterization at the Daisy Mine**																								
	Identify funding sources for Daisy Mine reclamation design																								
	Secure grant for reclamation design at the Daisy Mine																								
	Complete reclamation design for the Daisy Mine																								
	Prepare grant for reclamation construction at the Daisy Mine																								
	Finalize reclamation design and select contractor																								
	Complete reclamation at the Daisy Mine																								
	Begin post-reclamation monitoring at the Daisy Mine																								

Notes:
Items in dark blue have been completed.
Dates in teal are firm.
Dates in grey are tentative or estimated.
The Gunnison Basin is a funding priority for the NPS Program in the Fiscal Year 2017/2018 (light blue).
Evaluation milestones are in bold.

8.2 INFORMATION AND EDUCATION OUTREACH

CCWC's mission includes the following goals to address education and outreach efforts:

1. Facilitate cooperative assessments and the exchange of information in order to identify and address water quality concerns in a proactive manner by providing high quality, objective data.
2. Increase public awareness of watershed issues by communicating water quality and Watershed related information in relevant and understandable ways.
3. Expand the public's participation in protecting Crested Butte's watersheds.

Develop the internal capacity of the organization's staff, board, and other volunteers to accomplish the mission of the organization.

Photo 30. Watershed based education for K-6 students regularly occurs at local libraries. Project WET curriculum is used often.

Photo 31. Crested Butte Art Festival Attendees learn about Watershed characteristics from the NRCS Watershed Trailer at a CCWC Booth

8.2.1 Outreach Activities

Since initiating the watershed planning process in 2011, CCWC has hosted several education and outreach events. The steering committee and stakeholder groups were formed in May 2011. Since that time, the steering or technical committees have met monthly (with few exceptions) and the stakeholder group has met on a quarterly basis. These meetings have allowed for a public dialog during the planning process. The following paragraphs highlight the most successful outreach efforts to date.

During CCWC's tenure monitoring and implementation projects have been a very effective tool to engage local stakeholders. The following events were completed with the support of stakeholders and volunteers:

- July and September 2011: Baseline water quality characterization in the Upper Slate River Watershed. Partners included DRMS, CDPHE, BLM, USFS, NPS, and local volunteers.
- August and September 2012: Local volunteers, including students from Western State Colorado University, assisted DRMS and CBLT staff to plant vegetation at the Smith Hill Reclamation site.
- July and August 2013: DRMS, CCWC, CDPHE, BLM, USFS, NPS and local volunteers collected water quality samples in Redwell Basin.
- August 2013: CCWC, BLM, and volunteers collected *E. coli* and macroinvertebrates samples from the Slate River to address two data gaps identified earlier in the planning process.
- July and September 2014: DRMS, CCWC, CDPHE, BLM, USFS, NPS and local volunteers collected water quality samples in Redwell Basin.
- Many of these events were planned during the technical or steering committee meetings. These efforts have improved the strength of the partnerships.
- Data from each event was summarized in meetings open to the public. Which helped keep local stakeholders informed regarding recent activities.

Since 2010 CCWC has used Project WET curriculum as part of the K-12 education and outreach. CCWC has very successfully partnered with local libraries to add water education to the libraries' programming. Programs at the library include indoor and outdoor education sessions and multiple learning formats.

In 2012 CCWC hosted two successful outreach and fundraising events to share the results of the WQ Summary (AEC, 2011) and increase participation in the watershed planning process in a less formal setting. The first event was hosted by a local stakeholder and included a community potluck at a beautiful home overlooking the Lower Slate River. The second event was hosted at the Brick Oven Pizzeria, with support from Sierra Nevada. Both events increased public awareness of the Watershed Plan.

In 2012 CCWC partnered with local artist, Ivy Walker to promote watershed based art. Ms. Walker created two water inspired pieces of art. The installations were displayed in the Watershed adjacent to the Lower Loop trail. CCWC staff and partners led a mountain bike tour of the Watershed that featured the art work, recent reclamation projects, and other educational sites.

CCWC partnered with High Country Conservation Alliance and the local radio station, KBUT, to create a radio series called "Wading in the Water". The series which airs four times weekly provides a local perspective on water quality and watershed issues. A variety of local experts have participated on topics ranging from drought to public lands access, and geomorphology. To date seventeen episodes have been produced. Episodes are archived at www.KBUT.org. In addition to the original air time which reaches listeners across the entire Gunnison Valley, episodes have been played up to thirty times on the website. In October 2013, CCWC staff created a "Wading in the Water" episode about the Watershed

Plan. The episode aired on local radio station KBUT to increase awareness about the draft Watershed Plan and to solicit comments.

In 2013 a local reporter attended the Redwell Basin water quality monitoring events. She published a story in the Crested Butte News that helped inform the broader community about the Drill Hole and the closure project. Several local stakeholders and the Watershed Plan were quoted in the article, which helped increase community involvement and input.

A second mountain bike tour and similar hiking tour was completed on the Lower Loop Trail in August and September of 2014. Summaries of the Watershed Plan were distributed to people that attended the tour.

In the fall of 2014 the Watershed Plan was presented to the Crested Butte Town Council and the Upper Gunnison River Water Conservancy District. Both presentations were well-received.

A Summary of the Watershed Plan was created as an outreach tool. The Summary is a ten page full-color booklet was created. The Summary is available on CCWC's website (coalcreek.org). The Summary was circulated to local stakeholders and will be included in CCWC's end-of-year fundraising effort.

8.3 EVALUATION OF IMPLEMENTATION PROGRESS AND SUCCESS

Evaluation criteria and milestones have been established for the implementation projects presented in Section 7.0.

8.3.1 Evaluation Criteria and Milestones

Evaluation criteria for the Drill Hole Closure Project are based upon water quality characteristics measured during post-project monitoring. To date, metal concentrations in Redwell Basin have varied widely. Ten established monitoring locations have been selected to monitor post-project outcomes at the Drill Hole (see Section9.1).

Table 34. Evaluation criteria and milestones for the Drill Hole Closure Project.

<table>
<tr><th>Evaluation Criteria</th><th>Milestones</th></tr>
<tr><td>1. Determine metal concentration and load reductions in Redwell Creek with post-project monitoring data from 2014.</td><td>2015: Determine initial metal load reductions and pH changes, evaluate the effectiveness of the monitoring plan.</td></tr>
<tr><td>2. Characterize pH increases, metal concentrations, and load reductions in Redwell Creek, Oh-Be-Joyful Creek, and the Slate River with post-project monitoring data from 2015 and 2016. Where,</td><td rowspan="10">2015 and 2016: Determine whether the system has stabilized. pH in Redwell Creek above the Redwell should increase to circumneutral, similar to the pH found in the headwaters of Redwell Creek. Once the system has stabilized the loads measured in Redwell Creek above the Redwell should be similar to the loads measured in the headwaters of Redwell Creek. Water quality improvements should occur in other reaches of Redwell and Oh-Be-Joyful creeks. The effects of the Red Well (natural) and the Daisy Mine Complex (anthropogenic) will also be better understood.</td></tr>
<tr><td>a. Stream pH at RW-6 is greater than 5.0</td></tr>
<tr><td>b. Metal concentrations at RW-6 are within 30 percent of the concentrations measured at RW-3.</td></tr>
<tr><td>c. Metal loads are composed of the same metals at RW-3 and RW-6 and are no more than 30 percent different after accounting for changes in flow.</td></tr>
<tr><td>3. Characterize pH increases, metal concentration and load reductions in lower Redwell Creek. Where,</td></tr>
<tr><td>a. The effect of the Daisy Mine Complex, as measured by RW-7 and RW-11, is isolated from the outcome analysis</td></tr>
<tr><td>b. pH has increased over pre-project measurements by one unit or more at RW-11, RW-13, and OBJ-2.</td></tr>
<tr><td>c. Metal concentrations and loads measured at RW-7, RW-11, OBJ-2, OBJ-4 and SR-8 have declined</td></tr>
<tr><td>d. Dilution provided by upper Oh-Be-Joyful Creek and the upper Slate River are accounted for in the analysis</td></tr>
</table>

Table 35. Evaluation criteria and milestones for the Gunsight Processing Area Reclamation.

Evaluation Criteria	Milestones
1. Reduce the human health hazard associated with the processing area by isolating mine waste materials through an appropriately designed cap and cover strategy.	Use XRF survey data to determine which mine wastes must be sequestered to meet applicable EPA criteria for waste materials. Isolate the wastes from the surface and surface waters with an appropriately designed cap and cover strategy.
2. Improve water quality measured at seeps on and near the site, if possible eliminate or reduce flow from these seeps.	Metal concentrations from post-project seep samples will be lower than pre-project samples by 30 percent or more.
3. Increase vegetation cover in reclaimed areas.	Vegetation cover will exceed 30 percent by post-project Year 3.

Table 36. Evaluation criteria and milestones for the Daisy Mine Reclamation Design and Implementation.

Evaluation Criteria	Milestones
1. Characterize pH increases, metal concentration and load reductions in Redwell and Oh-Be-Joyful creeks with post-project monitoring data from years 1 through 3.	Following stabilization, pH in Redwell Creek at the mouth (RW-13) should exceed 5. A pH of 5 was selected as the target based on the findings presented in Kimball et al. (2012). Metal concentrations at RW-11, RW-13, OBJ-2, OBJ-4 and SR-8 should decline by 20 percent or more. Metal loads at RW-11, RW-13, OBJ-2, OBJ-4 and SR-8 have decreased due to reclamation at the Daisy Mine. Stormwater monitoring indicates installed BMPs are effective and large rills or gullies are not present.
2. Stable soils and minimal erosion.	
3. Vegetation is preserved where possible and seeded or planted areas reach 20 percent cover by year 3.	

9.0 MONITORING

Two types of monitoring plans are presented below. Project specific monitoring refers to the monitoring activities that will be used to elevate the outcomes individual projects and may include water quality, vegetation, or stormwater monitoring as appropriate for the project. Project specific monitoring also includes characterization projects to address data gaps. Long-term monitoring emphasizes water quality monitoring and evaluates the overall health of the Watershed through time. Generally, the time frames associated with project specific monitoring is shorter than the time frame associated with long-term monitoring.

9.1 PROJECT SPECIFC MONITORING PLANS

The materials below present the goals, objectives, outcomes and schedule for priority projects.

9.1.1 Drill Hole Closure Project

Ten locations are proposed for post-project monitoring to determine the outcome of the Drill Hole closure project (Table 37). Monitoring at these locations will provide outcomes on a local scale, as measured at RW-3 and RW-6, a basin scale, as measured at RW-11 and RW-13, and a watershed scale at OBJ-2, OBJ-4 and SR-8. RW-7 is included to control for the effect of the Daisy Mine. Samples from OBJ-1 will provide an upstream reference for Oh-Be-Joyful Creek and SR-7 serves the same role in the Slate River.

Table 37. Monitoring locations for the Drill Hole Closure Project.

Monitoring Location	Description	Rationale	Coordinates[1]		Samples or Analyses[2]					
			Northing	Easting	FP	Flow	TM	DM	MA	Hard
RW-3	Redwell Creek headwaters, upstream of "aluminum" pond	Upstream reference site	4306705	321503	x	x	x	x	x	x
RW-6	Redwell Creek above the Red Well	Downstream reference site 1	4306937	321684	x	x	x	x	x	x
RW-7	Redwell Creek below the Red Well	Redwell Creek Reference Site-above Daisy Mine	4307051	321755	x	x	x	x	x	x
RW-11	Redwell Creek below Daisy Mine, at outlet of upper basin	Redwell Creek Reference Site-below Daisy Mine	4307322	321911	x	x	x	x	x	x
RW-13	Redwell Creek above Oh-Be-Joyful Creek	Downstream reference site 3	4308387	322218	x	x	x	x	x	x
OBJ-1	Oh-Be-Joyful Creek above Redwell Creek	Oh-be-Joyful Creek reference site	4308385	322167	x	x	x	x	x	x
OBJ-2	Oh-Be-Joyful Creek below confluence with Redwell Creek	Downstream reference site 4	4308396	322243	x	x	x	x	x	x
OBJ-4	Oh-Be-Joyful Creek at mouth above confluence with Slate River	Downstream reference site 5	4308827	323817	x	x	x	x	x	x
SR-7	Slate River above Oh-Be-Joyful Creek and BLM Campground	Slate River reference site	4309370	323669	x	x	x	x	x	x
SR-8	Slate River below Oh-Be-Joyful Creek and Gunsight Pass Footbrigde	Downstream reference site 6	4308533	324403	x	x	x	x	x	x
				Total by sample type:	**10**	**10**	**10**	**10**	**10**	**10**

Notes
1. The coordinates in decimal degrees in Nad 83 UTM Zone 13S.
2. FP= field parameters (temperature, dissolved oxygen, specific conductance, etc.) TM= total metals DM= dissolved metals MA= major anions, Hard= hardness.

9.1.2 Gunsight Processing Area Reclamation

The reclamation design and characterization data will be used to determine the post-project monitoring approach. The waste is a human health risk due to recreation at the site and is an ecological impact to the Watershed. A cap and cover repository will isolate the mine waste from both human contact and water. The need to understand groundwater flow at the site is minimized because reclamation will prevent interaction between the mine waste and groundwater. At this time, groundwater monitoring is not proposed at this site. Post-project monitoring will focus on a reduction in the concentration of metals in surface waters, improved vegetation cover, stabilized slopes, and decreased stormwater run-off.

9.1.3 Daisy Mine Reclamation

The following sites are proposed to evaluate water quality improvements following reclamation at the Daisy Mine Complex. Additional sites or monitoring approaches, such as vegetation or stormwater monitoring, will be identified when the reclamation design is completed. Data collected from RW-7 will serve as an up-gradient reference. Data from RW-11 will measure local effects. RW-13, OBJ-2, OBJ-4, and SR-8 will measure watershed level outcomes. Data collected from OBJ-1 and SR-7 characterize upstream conditions in Oh-Be-Joyful Creek and the Slate River, respectively.

Table 38. Monitoring locations for reclamation at the Daisy Mine.

Monitoring Location	Description	Rationale	Coordinates[1]		Samples or Analyses[2]					
			Northing	Easting	FP	Flow	TM	DM	MA	Hard
RW-7	Redwell Creek below the Red Well	Redwell Creek Reference Site-above Daisy Mine	4307051	321755	x	x	x	x	x	x
RW-11	Redwell Creek below Daisy Mine, at outlet of upper basin	Redwell Creek Reference Site-below Daisy Mine	4307322	321911	x	x	x	x	x	x
RW-13	Redwell Creek above Oh-Be-Joyful Creek	Downstream reference site 3	4308387	322218	x	x	x	x	x	x
OBJ-1	Oh-Be-Joyful Creek above Redwell Creek	Oh-be-Joyful Creek reference site	4308385	322167	x	x	x	x	x	x
OBJ-2	Oh-Be-Joyful Creek below confluence with Redwell Creek	Downstream reference site 4	4308396	322243	x	x	x	x	x	x
OBJ-4	Oh-Be-Joyful Creek at mouth above confluence with Slate River	Downstream reference site 5	4308827	323817	x	x	x	x	x	x
SR-7	Slate River above Oh-Be-Joyful Creek and BLM Campground	Slate River reference site	4309370	323669	x	x	x	x	x	x
SR-8	Slate River below Oh-Be-Joyful Creek and Gunsight Pass Footbrigde	Downstream reference site 6	4308533	324403	x	x	x	x	x	x
				Total by sample type:	**8**	**8**	**8**	**8**	**8**	**8**

Notes
1. The coordinates in decimal degrees in Nad 83 UTM Zone 13S.
2. FP= field parameters (temperature, dissolved oxygen, specific conductance, etc.) TM= total metals DM= dissolved metals MA= major anions, Hard= hardness.

9.2 LONG-TERM MONITORING PLAN

Table 39 and Figure 14 present the proposed long-term monitoring locations for the Watershed. CCWC needs to secure funds to complete long-term monitoring. In several cases the proposed long-term monitoring locations are a part of project specific monitoring efforts. This overlap is intentional, by tying long-term monitoring efforts to project specific monitoring; CCWC can leverage funds from local stakeholders and project partners to create economies of scale by completing concurrent monitoring (e.g., lower personnel, shipping, and analysis costs because monitoring was completed simultaneously) and potentially increase the overall frequency or timespan of the monitoring program.

9.2.1 Goals and Objectives

Long-term monitoring extends beyond project specific monitoring efforts, although many locations will be monitored as part of project specific monitoring efforts. The primary goal of long-term water quality monitoring is to characterize water quality changes through time and evaluate relative to the desired outcomes. The paragraphs below relate how specific monitoring locations or activities relate to the desired outcomes.

Desired Outcome One: To minimize water quality impairments attributed to historic abandoned mines, where:

a. The Slate River below Oh-Be-Joyful Creek meets applicable water quality standards and water quality improvements are also measured at upstream locations.
   i. Monitoring location SR-8 will be used to assess water quality conditions in the Slate River.
   ii. Monitoring locations OBJ-4, OBJ-2, and RW-13 will be used to assess water quality conditions in upstream locations.
   iii. Monitoring locations SR-7 and OBJ-1 will be used as reference locations to control for conditions in the Slate River above Oh-Be-Joyful Creek and in Oh-Be-Joyful Creek above Redwell Creek, respectively.

b. Following reclamation projects, metal concentrations and load reductions are apparent locally and in downstream reaches.
   i. Project specific monitoring will be used to assess reclamation outcomes.
   ii. Monitoring locations RW-7, RW-11, and RW-13 have been incorporated into both project specific and long-term water quality monitoring to evaluate water quality changes through time.

c. Provide water quality data to the Water Quality Control Division (WQCD) as they establish segment-specific ambient standards for Redwell (Segment 10b) and Oh-Be-Joyful (Segment 10a) creeks.
   i. Both project specific and long-term water quality data will be shared with the Division during data calls via CDSN.

Desired Outcome Two: To support healthy and diverse aquatic life, where:

a. An increased percentage of macroinvertebrate samples collected from the Watershed meet numeric water quality standards for aquatic life. Where, representative macroinvertebrate samples have an MMI score greater than 50 and remain stable or increase over time.
   i. Monitoring locations POV-3, SR-6, OBJ-4, SR-8, and SR-9 have been selected for long-term macroinvertebrate monitoring.
   ii. Macroinvertebrate monitoring will occur bi-annually.
   iii. Macroinvertebrate samples will be collected to better characterize the status of the Slate River below Coal Creek, (segment 8).

b. Fish species density and average size remain at or increase from current characterization levels; as surveyed by the CDP&W.
   i. Review CDP&W data following surveys.

Desired Outcome Three: To maintain or improve the overall channel function of the Slate River and its tributaries, where:

a. Channel function refers to a channel that is in a state of dynamic equilibrium and lacks consequential anthropogenic sediment loads.
b. Infrastructure, such as roads, bridge, culverts or other features are appropriately sized to accommodate peak flows and run-off.
c. Cooperative projects support both river function and landowner goals.

As the landowner, CBLT has leadership of the channel stability projects currently underway. CCWC will provide assistance for channel improvement projects and monitoring to evaluate the effectiveness of such projects, if needed.

Table 39. Upper Slate River Watershed Long-Term Water Quality Monitoring Locations and Rationale.

USR Watershed Long Term Water Quality Monitoring Locations and Rationale													
Monitoring Location	Description	Rationale	Coordinates[1]		Samples or Analyses[2]								
			Northing	Easting	FP	Flow	TM	DM	MA	Hard	Nut	E.c.	MI
SR-3a	Slate River about 1/2 mile above last road crossing	Upper watershed reference location	4315858	321059	x	x	x	x	x	x	x	x	
POV-3	Mainstem of Poverty Gulch below confluence with Baxter Creek	Poverty Gulch reference location	4314214	319388	x	x	x	x	x	x	x	x	x
SR-6	Slate River below Poverty Gulch, above Wetland	Evaluate effect of Poverty Gulch on Slate River	4312889	321398	x	x	x	x	x	x	x	x	x
SR-7	Slate River above Oh-Be-Joyful Creek and BLM Campground	Slate River upstream reference for Oh-Be-Joyful Creek	4309370	323669	x	x	x	x	x	x			
OBJ-1	Oh-Be-Joyful Creek above Redwell Creek	Upstream reference for Oh-Be-Joyful Creek	4308385	322167	x	x	x	x	x	x			
RW-7	Redwell Creek below the Red Well	Redwell Creek Reference Site-above Daisy Mine	4307051	321755	x	x	x	x	x	x			
RW-11	Redwell Creek below Daisy Mine, at outlet of upper basin	Redwell Creek Reference Site-below Daisy Mine	4307322	321911	x	x	x	x	x	x			
RW-13	Redwell Creek above Oh-Be-Joyful Creek	Redwell Creek Reference Site-Basin outlet	4308387	322218	x	x	x	x	x	x			
OBJ-2	Oh-Be-Joyful Creek below confluence with Redwell Creek	Downstream reference for Oh-Be-Joyful Creek	4308396	322243	x	x	x	x	x	x			
OBJ-4	Oh-Be-Joyful Creek at mouth above confluence with Slate River	Evaluate effect of Oh-Be-Joyful Creek on Slate River.	4308827	323817	x	x	x	x	x	x	x	x	x
SR-8	Slate River below Oh-Be-Joyful Creek and Gunsight Pass Footbrigde	Slate River downstream reference for Oh-Be-Joyful Creek	4308533	324403	x	x	x	x	x	x	x	x	x
SR-9	Slate River immediately above confluence with Coal Creek	Watershed outlet	4305031	328467	x	x	x	x	x	x			x
				Total by sample type:	**12**	**12**	**12**	**12**	**12**	**12**	**5**	**5**	**5**

Notes
1. The coordinates in decimal degrees in Nad 83 UTM Zone 13S
2. FP= field parameters (temperature, dissolved oxygen, specific conductance, etc.) TM= total metals DM= dissolved metals MA= major anions, Hard= hardness, Nut= nutrient suite, E.c.= E. coli, MI= macroinvertebrates

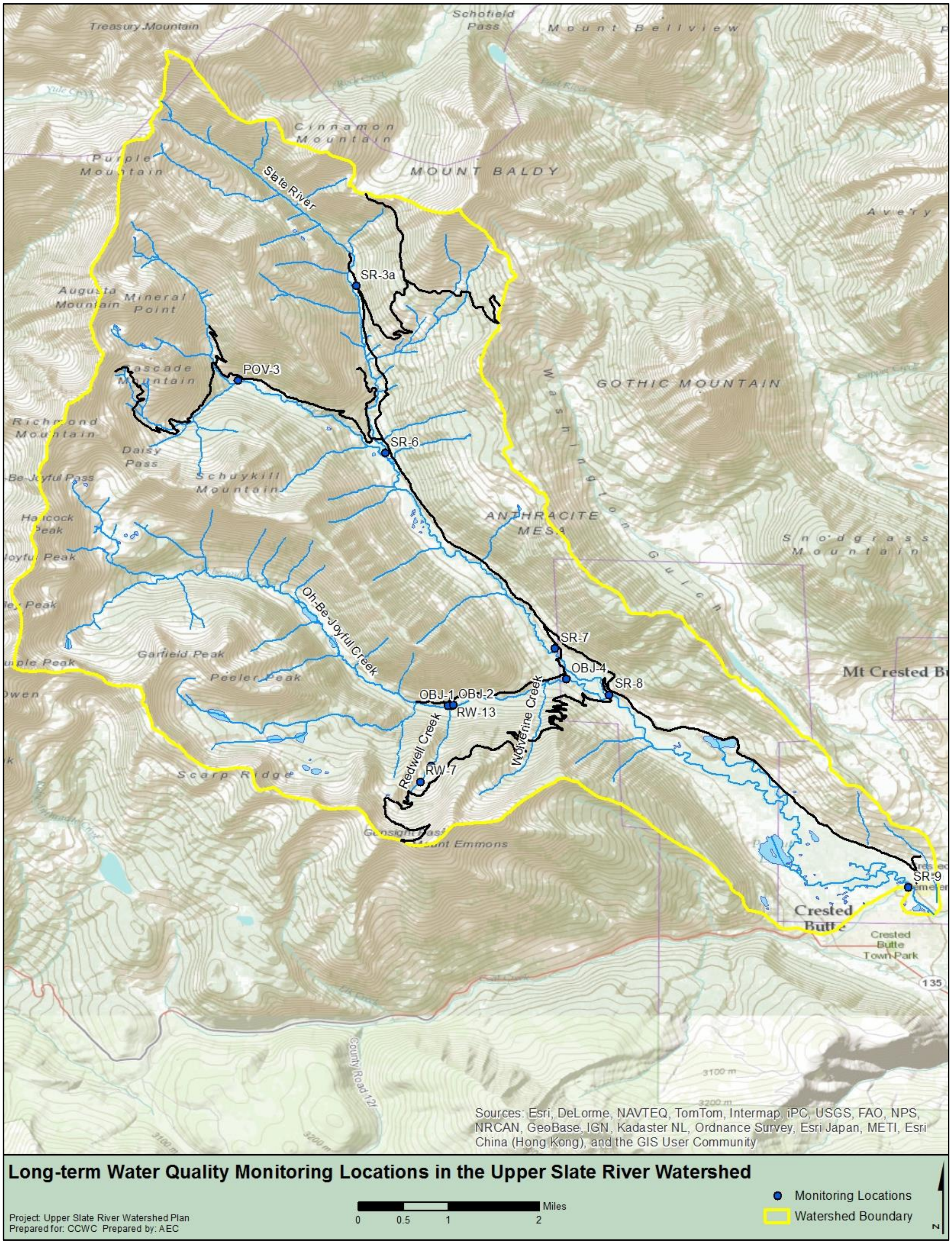


Figure 14. Long-term water quality monitoring locations in the Upper Slate River Watershed.

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APPENDIX A: SUPPLEMENTAL MATERIALS

SUMMARY OF CONCERNS REGARDING THE MOUNT EMMONS PROJECT PLAN OF OPERATIONS FOR THE UPPER SLATE RIVER WATERSHED

The US Forest Service accepted the Plan of Operations (PoO) for the Mount Emmons Project in May 2013. The PoO has not moved forward into a project proposal and NEPA review as of June 2014 (USFS Lee Ann Loupe personal communication, 6/24/2014). The analysis of a project of this scale will entail a substantial investment of time and resources from both the USFS and US Energy. The analysis will proceed at a mutually agreed upon time; which is unknown at this time (USFS Lee Ann Loupe personal communication, 6/24/2014). When the Forest Service completes a NEPA review, there will be a scoping and public comment period. Due to a lack of information about the design of project elements in the Watershed, it is a priority for CCWC to address these concerns during the PoO public comment period. Briefly, these items include:

Diversion rate and pattern for water removed from the Slate River: The project proposes a large water diversion from the Slate River between Oh-Be-Joyful Campground and Gunsight Bridge (U.S. Energy, 2013). Water from the diversion would then be pumped through a pipeline that follows the Gunsight Pass Road right-of-way (U.S. Energy, 2013). Moving water along Gunsight Pass Road would necessitate a pump station near the confluence of Oh-Be-Joyful Creek and the Slate River, a popular and heavily used recreation site. This section of pipeline would be about 2.9 miles long and buried at a minimum depth of two feet (U.S. Energy, 2013). After reaching Redwell Basin, U.S. Energy proposed a borehole near the top of Mount Emmons to transfer the water via underground mine workings the south side of Mount Emmons (U.S. Energy, 2013). Additional details about the pump station, pipeline and borehole are required to make an informed decision about the environmental impact of the project.

In 2008 Golder and Associates estimated that the mean annual flow at the Slate River Diversion would be 51.02 cfs per year (U.S. Energy, 2013). The USGS reports the mean annual flow of the Slate River is approximately 135.08 cfs per year (Gauge ID 09111500; U.S. Energy, 2013). Conservatively, this diversion pipeline could remove forty percent of the water in the Slate River. Such a diversion would impact the fishery and habitat below Oh-Be-Joyful Campground. The lower reaches of the Watershed support large relatively undisturbed wetlands that have been preserved or placed under conservation easements. These wetlands have been characterized as high quality (Cooper, 1995). Practical considerations would likely mandate that much of the water is removed during the growing season, to avoid freezing, which would further exacerbate stress created during low flow conditions. An instream flow right, senior to U.S. Energy's water right, exists on this section of the Slate River; a junior instream flow right was established in 2014. A well-designed diversion structure, capable of accurately measuring the volume of water diverted and possibly a stream gauge, would be necessary to protect instream flows if the project proceeds. The plan fails to provide details about the size of the pump station, which is proposed near the Slate River and Gunsight Pass Bridge. It is likely that the BLM is the landowner in the area where the diversion structure may be located.

Pipeline Design Characteristics: The PoO proposes that water diverted from the Slate River will be conveyed via a 3.71 mile long pipe line (U.S. Energy, 2013). About 2.9 miles of the pipeline could be buried in the Gunsight Pass Road right-of-way. The final 0.81 miles of pipeline could be routed through the mountain via a bore-hole to the vent raise location, on the south side of Mount Emmons. From the vent raise, the water will be routed through the underground workings to the mill complex and ultimately to the storage reservoir located in the Elk Creek drainage. The PoO does not specify the diameter of the pipe or of the proposed borehole. The plan does not clearly state where the borehole would be placed; nor does it indicate the angle or direction of the borehole. The Plan of Operations does not identify the geologic strata that the bore hole would pass through. It is unlikely that the borehole would pass through the molybdenum porphyry because it is the target of the proposed mine. However, geologic and groundwater studies suggest the water associated with adjacent strata, such as contact metamorphic rocks in the cupola and breccia pipes, is of poor quality. Drainage from the bore hole must be addressed if mining operations were to proceed.

SUMMARY OF ENDANGERED SPECIES

The table below presents information on each endangered, threatened, proposed threatened or candidate species found in Gunnison County where the habitat range extends to the USR Watershed. At this time, there are no known populations of these species in the Watershed. The information was generated from IPaC, a program used to manage endangered species (USF&WS, 2013).

Appendix A: Table 1. Endangered, threatened or special concern species that **could potentially be found** in the Upper Slate River Watershed, part 1 of 2.

Species		Status	Characteristics	Habitat	USR Watershed
Common Name	Scientific Name				
Gunnison's prairie dog	*Cynomys gunnisoni*	Federal: candidate State: NA	"Gunnison's prairie dog adults vary in length from 12 to 15 inches and weigh 23 to 42 ounces, with males averaging slightly larger than females. The dorsal color is yellowish buff intermixed with blackish hairs. Bubonic plague has significantly reduced the number and size of populations" -US FWS	"Habitat includes level to gently sloping grasslands and semi-desert and montane shrublands, at elevations from 6,000 to 12,000 feet." - US FWS	The USFWS service predicts that Gunnison's prairie dog may occur in the USR Watershed.
Canada Lynx	*Lynx Canadensis*	Federal: Threatened State: species of special concern	"The lynx is a medium-sized cat with long legs, large, well-furred paws, long tufts on the ears, and a short, black-tipped tail. The winter pelage of the lynx is dense and has a grizzled appearance with grayish-brown mixed with buff or pale brown fur on the back, and grayish-white or buff-white fur on the belly, legs and feet." - US FWS	"The lynx is found in dense subalpine forest and willow-choked corridors along mountain streams and avalanche chutes" CDP&W	The CDP&W predicts that the USR Watershed has habitat suitable for summer and winter ranges.
North American wolverine	*Gulo gulo luscus*	Federal: Proposed threatened State: species of special concern	"Relatively unproductive habitats are areas where daily low temperatures can fall below freezing most of the year, growing seasons are short and snow persists into the summer months. The wolverine occupies a unique niche by accessing scarce food resources available in these environments, despite the presence of deep snow-cover, and caching these resources in cold, rocky areas that inhibit competition from insects, bacteria and other scavengers." - CDP&W	"Wolverines do not appear to specialize on specific vegetation or geological habitat aspects, but instead select areas that are cold and receive enough winter precipitation to reliably maintain deep persistent snow late into the warm season (Copeland et al. 2010, entire)." - US FWS	The CDP&W have confirmed that Wolverines have been found in central Colorado. There are no known wolverines in the USR Watershed, but the habitat is suitable in some areas.

Appendix A: Table 1. Endangered, threatened or special concern species that **could potentially be found** in the Upper Slate River Watershed, part 2 of 2.

Species		Status	Characteristics	Habitat	USR Watershed
Common Name	Scientific Name				
Uncompahgre Fritillary butterfly	*Boloria acrocnema*	Federal: endangered State: endangered	"The Uncompahgre fritillary is a small butterfly with a 1 inch wingspan. Males have rusty brown wings crisscrossed with black bars; females' wings are somewhat lighter. The body has a rusty brown thorax and a brownish black abdomen. The Uncompahgre fritillary butterfly was discovered on Uncompahgre Peak, Hinsdale County, Colorado on July 30, 1978. It was subsequently described as a new species."- US FWS.	"Associated with large patches of snow willow above 12,400 feet which provide food and cover. The species has been found only on northeast-facing slopes"- US FWS	The USR is included in the potential habitat range. These butterflies have very specific habitat requirements. It is possible, but unlikely, that they occur in the USR Watershed.
Skiff Milkvetch	*Astragalus microcymbus*	Federal: candidate State: species of special concern	This perennial herb is highly branched and grows to a height of about 12 inches. Flowers are white, tinged with purple; and bloom in May and June (Natureserve.org).	Open sagebrush or juniper-sagebrush communities on moderately steep to steep slopes. Often found in rocky areas (Lyon 1990). Elevation Range: 7,900 to 8,600 feet.	**Given the elevation range of Skiff Milkvetch it is unlikely in the USR Watershed.** The plant has been identified at Hartmans Rocks.
Gunnison Sage-Grouse	*Centrocercus minimus*	Federal: proposed endangered. State: species of special concern	"Unique species of sage-grouse found south of the Colorado River. They are about one-third smaller than the typical sage grouse, and males have more distinct, white tail feathers and filoplume. Female Gunnison and typical sage grouse have nearly the same plumage, but the female Gunnison is again about one-third smaller than other sage grouse." - CDP&W.	Requires large expanses of sage with diverse grasses and forbs along with healthy riparian areas.	**The CDP&W does not include the USR Watershed in the historic habitat or known populations.**

SUMMARY OF REVISIONS TO REGULATION 35 COMPLETED DURING THE 2012 HEARING PROCESS

Regulation 35 provides classifications and numeric standards for the Gunnison and Lower Dolores River Basins. During the 2012 hearing process the WQCC revised Regulation 35. The revisions occurred following the completion of the Upper Slate River Water Quality Data Analysis and Summary (AEC, 2011). The hearing process resulted in the following changes:

1. Portions of the Upper Gunnison River Basin were re-segmented. In the Watershed these changes include:
   - Segment COGUUG10, Oh-Be-Joyful Creek, its tributaries and Redwell Creek, has been split into two segments. They are Segment COGUGU10a: Mainstem of Oh-Be-Joyful-Creek and Segment COGUUG10b: Redwell Creek and tributaries and wetlands.
   - Other tributaries to Oh-Be-Joyful Creek have been transferred to Segment 9. This includes Wolverine Creek.
   - The tributaries to Oh-Be-Joyful Creek that lie in the Raggeds Wilderness have been moved from Segment COGUUG02 to Segment COGUUG01. The outstanding waters designation remains.
2. Lake segments were established to allow for temperature standards specific to lakes. Three lake segments occur in the Watershed.
   - Segment COGUUG33 was established for lakes and reservoirs in wilderness areas. This includes Blue Lake and others in the Raggeds Wilderness in the watershed.
   - Segment COGUUG34 was established for lakes and reservoirs tributary to the East River. This includes several lakes in the Watershed.
   - Segment 35 was established for lakes and reservoirs tributary to Redwell Creek.
3. Sculpin, which is a small and unique benthic fish, does not occur in the Upper Slate River. Therefore, the sculpin designation has been removed from the chronic zinc criterion on Segments 7 and 8.
4. The WQCD updated segment specific ambient lead standards for Segment COGUUG10a: Oh-Be-Joyful Creek, and Segment COGUUG10b: Redwell Creek.