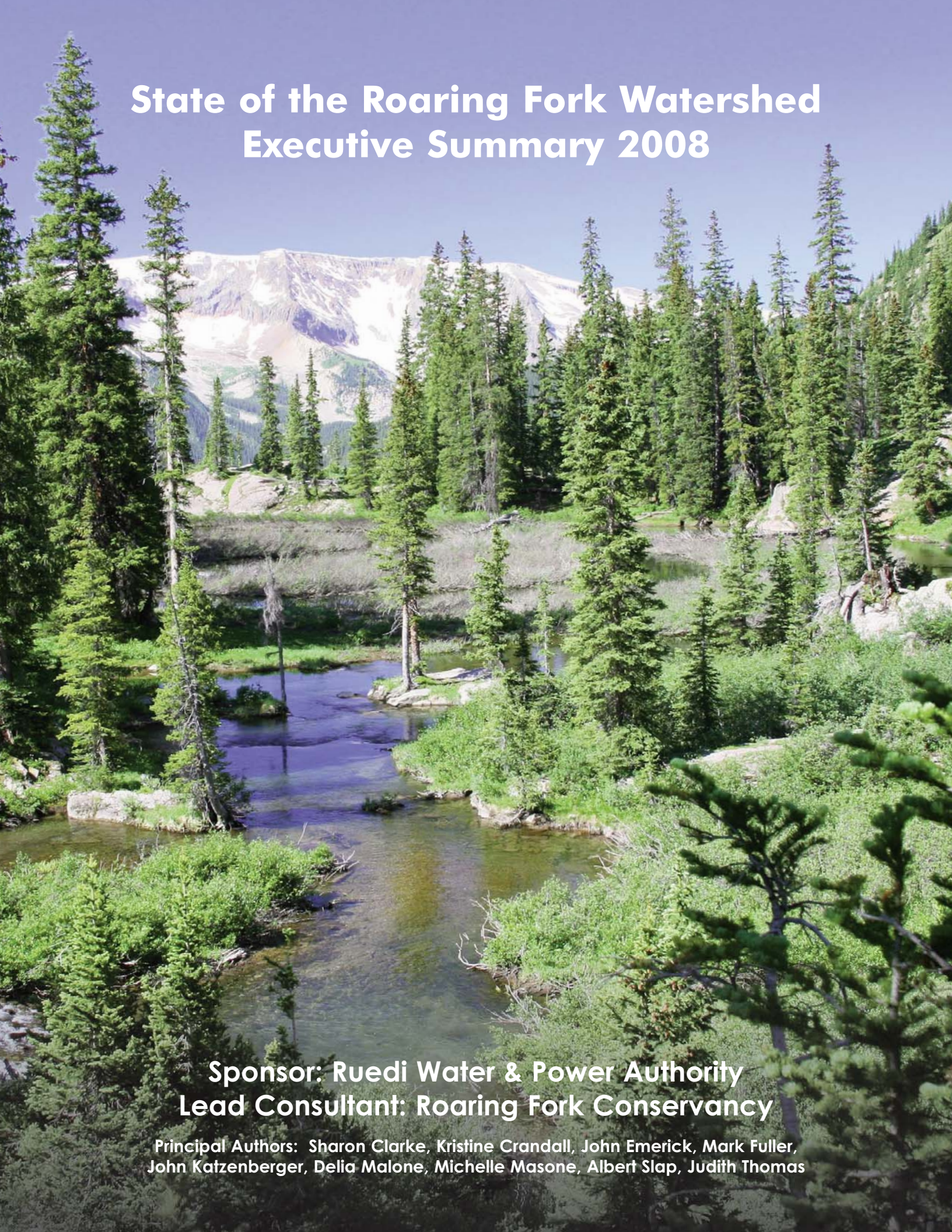
State of the Roaring Fork Watershed
Executive Summary 2008



Sponsor: Ruedi Water & Power Authority
Lead Consultant: Roaring Fork Conservancy

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Preface

This "State of the Watershed Report," which comprises Phase I of the Roaring Fork Watershed Plan, is the product of dedicated effort by a host of people including technical experts, government planners and administrators, conservation professionals, and water managers. Also involved are residents of the Roaring Fork Watershed who care about issues of water quality and quantity and have expressed that caring by participating in the public meetings, forums, and interviews that have been part of this project. We would like to thank all of these participants for their time, energy, and thoughtfulness and to invite them, along with all other readers of this report, to stay involved in the future phases of the Roaring Fork Watershed Plan.

Paul Hills

The Watershed Plan had its origins in the Roaring Fork Watershed Collaborative, an informal group of planners, government officials, and interested citizens who began meeting several years ago to discuss issues of valleywide interest including transportation, affordable housing, open space and trails, and, of course, water. That group eventually appointed a Water Subcommittee to focus on the need to address water concerns in the valley without regard to political or jurisdictional boundaries. When the Ruedi Water and Power Authority and Roaring Fork Conservancy took on their respective roles of institutional overseer and principal author of the Watershed Plan, the project developed real momentum. All who will benefit from this plan owe gratitude to the groups and individuals who had a role in this work and to the elected and appointed officials who encouraged them to think beyond their own bureaucratic boundaries.

Few question that healthy water resources, along with air, soil, wildlife, and vegetation, are critical to the maintenance of a healthy environment and to the outdoors-oriented lifestyle enjoyed by those of us who live in the Roaring Fork Watershed. Two things set water apart from these other basic resources. First, water is inherently scarce in some areas and becoming more so. Despite an occasional heavy snow year like 2007-08, ample evidence exists that the arid West is becoming more arid, and that increasing development and population will bring ever more pressure to bear on existing water resources. Second, water, at least in Colorado, is bought and sold in the open marketplace as a commodity. This means that water management is often subject to the ebbs and flows of the free market economy and also to the interests of those who own water rights. These two factors add unique challenges to any attempts at water resource planning. However, it has been clear from the beginning of this process that a Roaring Fork Watershed Plan is needed and welcomed both by those who are charged with managing local water resources and by the public at large.

The following report illustrates the current status of the Roaring Fork Watershed in terms of its water quality and quantity and its water-dependent ecosystems. It also points out areas where insufficient data prevent an accurate assessment of that status. Finally, the report provides a starting point for Phase II of the Plan, which will translate the data and findings in the report into recommended action steps aimed at preserving and enhancing local water resources.

The next step in the Roaring Fork Watershed Plan will be the development of a series of goals and objectives, which are based on the findings of the State of the Watershed Report. These goals and objectives then will be translated into action steps that can be taken by water managers, governments, and individual water users. This Phase II of the Plan will move forward through 2009 and eventually will be turned over to local governments and water management agencies to adopt and codify within their individual policy frameworks. As with Phase I, Phase II will feature many opportunities for public input, education, and discussion. We look forward to that process and to a healthy future for the waters of the Roaring Fork Watershed.

Mark Fuller
Director
Ruedi Water and Power Authority

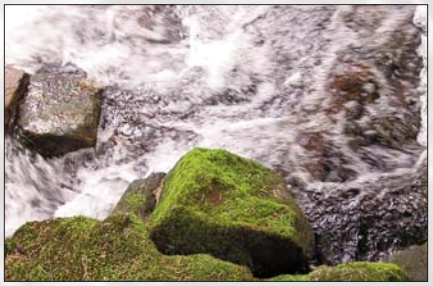
The State of the Watershed Report is available online at: www.roaringfork.org/watershedplan

1. Introduction

The State of the Roaring Fork Watershed Report is the result of a growing awareness of the interconnectedness of the watershed's parts. It is becoming more apparent how actions upstream affect conditions downstream, and how large issues such as increased water development in the West, drought, climate change, population growth, and rapidly changing land uses present serious implications for the watershed as a whole. While environmental concerns have been jurisdictionally focused in the past, the strengthening commitment across towns, counties, resource agencies, interest groups, and citizens to a collaborative process for addressing water issues has energized the Roaring Fork Watershed Plan process of which this report is the first phase. Additionally, interests throughout the watershed are gaining a better understanding of the values provided by the watershed's environmental attributes, ranging from water-based outdoor recreation activities and their associated economic benefits to the ecosystem services supported by properly functioning streams and their habitats.

The context of the report is grounded in a "watershed" perspective, a perspective which also defines the collaborative effort of the public, non-profit, and private sectors to initiate the Roaring Fork Watershed Plan. A watershed is defined as the landscape drained by a stream and its tributaries. The Roaring Fork River's watershed extends from the river's headwaters near Independence Pass to its confluence with the Colorado River at Glenwood Springs, 70 miles downstream. The river flows through Aspen and joins the Fryingpan River in Basalt and the Crystal River just downstream of Carbondale. The Roaring Fork Watershed (1,453 square miles) is located in Pitkin, Eagle, Garfield, and a small portion of Gunnison counties, in west-central Colorado. It comprises an area of high mountainous terrain and deep intervening valleys, with altitudes ranging from 14,235 feet to 5,717 feet. In addition to its diverse governing entities, the watershed's land uses cross various management boundaries. Although 76 percent of the watershed is federally managed, the percent of public land within 150 feet of streams is only 32 percent, indicating that a majority of the watershed's riparian corridors are in private or local government ownership. The Roaring Fork River is the second largest tributary of the Colorado River in the state, yielding an average of almost one million acre-feet per year.

The purpose of this report is to summarize existing studies and information in order to present a comprehensive understanding of the watershed's natural and cultural attributes as well as issues and challenges that bear further scrutiny within Phase II of the Watershed Plan process. The following executive summary offers an overview of the water-focused topics covered within the main report, starting with regional water management policies and activities that influence past and future development of the watershed's resources. This executive summary, which mirrors the sequence of the main report, then covers the watershed's physical and biological components of water quantity and quality, and riparian and aquatic ecosystems, along with key findings on the condition of these resources in each of nine sub-watersheds. With the aim of allowing readers to access whatever level of information most interests them, the main report is accompanied by an exhaustive complement of appendices and references for those seeking more in-depth information on a particular topic and/or the original studies.



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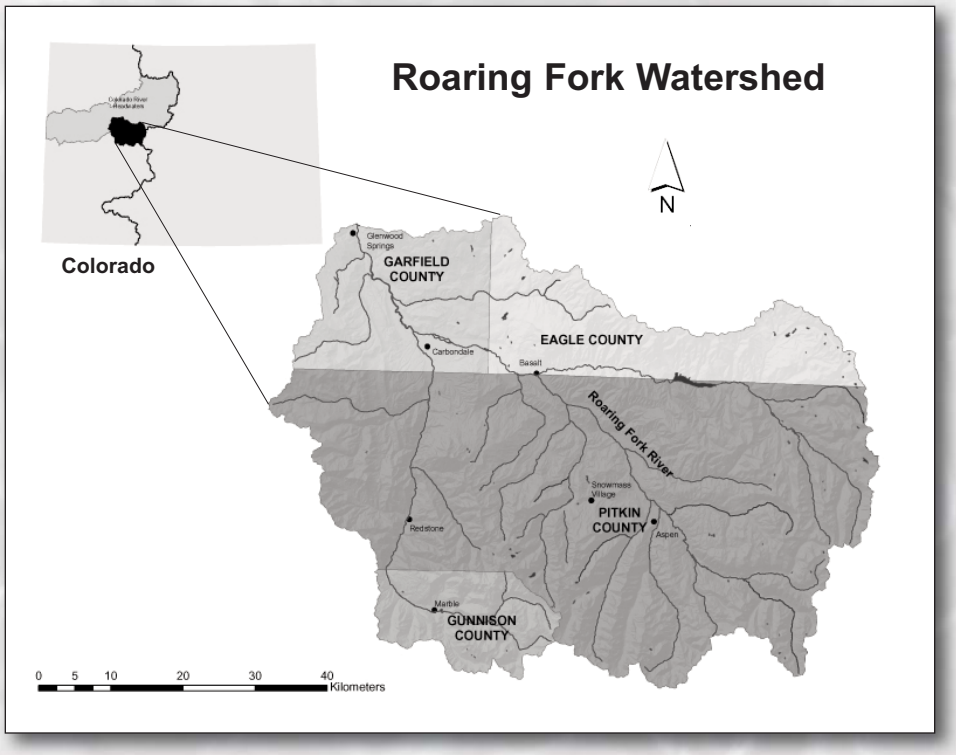
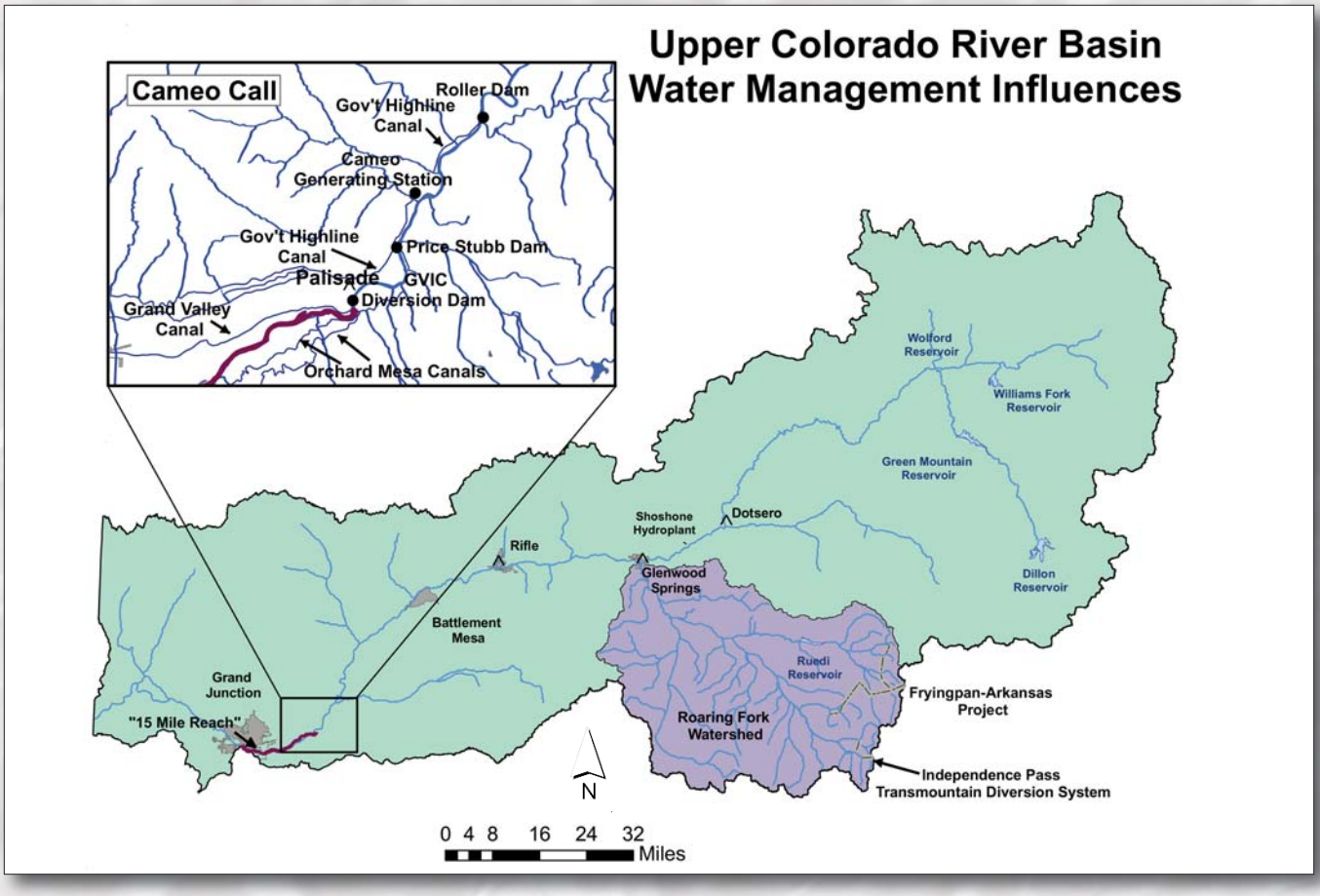


2. Regional Water Management

The adage "everything is connected to everything else" is often called the "first law of ecology," and could also be thought of as the "first law of water management" in Colorado. During the last decade, Colorado has seen rapidly increasing demands placed on water by both traditional consumptive uses and, more recently, by non-consumptive uses (recreational and environmental). By the year 2030, Colorado's population is expected to grow to about 7.1 million people from the current estimate of 4.5 million. This population growth, together with the recent drought (1999-2004) and global climate change, raises serious concerns about water supplies that Colorado has available to meet the needs of its citizens and the environment.

Water use and stream flows in the Roaring Fork Watershed are affected by transmountain diversions, water rights both within the watershed and the broader Upper Colorado River Basin, multi-state river compacts, and pressure by many interests to develop water supplies for future growth and development. What happens in the Roaring Fork Watershed has a significant impact on water management in the region and in the state, and vice versa.

Water distribution and management in the watershed is influenced primarily by Colorado's Prior Appropriation Doctrine, which determines timing and allocations of water rights. Other important factors include water management agreements like the Colorado River Compact, and planning initiatives and policies including the Colorado Interbasin Compact negotiation process, Endangered Species Act, and Wild and Scenic Rivers Act. Finally, structural projects play a key role in the watershed, with the Fryingpan-Arkansas Project and Independence Pass Transmountain Diversion System directly affecting water availability and stream flows. Looking to the future, the prospective development of conditional water rights, uncertainty surrounding the Colorado River Compact, additional water demands, and structural project proposals such as the Ruedi Pumpback, Colorado River Return Project, and Preferred Storage Options Plan are some of the issues with potential implications for water availability and management in the Roaring Fork Watershed.



3. Water Topic Overview

Within the Roaring Fork Watershed, the topics of water quantity, water quality, and riparian and instream areas are of extreme interest from both a human and environmental perspective. Their importance can be demonstrated by the fact that they each have been targeted over the past several years by well-supported initiatives including the Stream Flow Survey Project (Clarke, 2006), Water Quality Retrospective Study (U.S. Geological Survey), Stream Health Initiative (Malone and Emerick, 2007), Measures of Conservation Success (The Nature Conservancy, 2008), the Hydrologic Systems Analysis studies carried out in Pitkin County (Kolm and van der Heijde, 2006 and Kolm et al., 2007), and Climate Change and Aspen: An Assessment of Climate Change Impacts and Potential Responses (Aspen Global Change Institute, 2006). These data sources, along with other available information, provide a detailed view of the condition of water quantity and quality, and riparian and instream areas throughout much of the Roaring Fork Watershed. The following pages examine each topic more specifically and are followed in Section 4 by key findings for each of the nine sub-watersheds that make up the overall watershed.

3.1 Surface and Groundwater Quantity

Major consequences can result from not having enough water in a stream. These consequences are often highly visible, such as water rights not being met, a dewatered stream reach, or, in extreme cases, dying fish. Flood flows that exceed streambed capacity can also have noticeable consequences, such as threats to human safety and property. These flows also have benefits, because they maintain healthy creeks and riparian areas, recharge the groundwater that contributes to stream baseflow, and provide water for wells. Snowpack in Colorado provides approximately 75 percent of streamflow (http://waterknowledge.colostate.edu/). Most of Colorado's snow falls on the state's western mountain ranges, while most of the state's human population and agricultural production occurs on the semi-arid East Slope. Many West Slope headwater streams have been diverted to support these East Slope consumptive needs.

The Roaring Fork Watershed is one of Colorado's important headwater areas, receiving on its high mountains large amounts of snow that is then released during spring and summer into streams and groundwater. Established water uses within the watershed include consumptive domestic, industrial, and agricultural uses. In addition, hydropower production occurs in the watershed, most notably below Ruedi Dam, and non-consumptive uses of water are becoming better understood and valued, specifically in the form of flowing streams for streamside and aquatic ecosystem support, recreational activities (angling and boating draw many tourists to the area), and ecosystem services.

Various data sources help paint a picture of water availability and use in the watershed. These range from stream gage, water rights and diversion, instream flow, and stream modeling data to climate station, flood mapping, and non-consumptive use information. However, data are not available for all streams in the watershed and are not always available for establishing baseline conditions and detecting trends. Also, a significant gap exist for much of the watershed in information about groundwater hydrology. Finally, in addition to gaps in data, there is a limitation in the scientific community's understanding of the complex interaction between individual flow components, inter-annual variation, and physical alterations to the channel and riparian areas. These factors, together with inherent differences among streams, make relating flow to ecological and geomorphological processes a difficult task.

Factors affecting water quantity in the watershed include transmountain diversions, directly reducing water availability for both consumptive (surface and groundwater) and non-consumptive uses; inbasin diversions, which can impact local stream flows; downstream calls that can lessen the amount of water available for local diversions; and groundwater well pumping, which can deplete groundwater tables and/or the amount of water available to replenish surface waterways. In addition, perhaps most importantly, drought occurrences and climate change represent major influences on water availability, as they determine precipitation amount and flow regime patterns. Pages 14-31 contain specific key findings about water quantity conditions for the nine sub-watersheds.

3.2 Water Quality

In addition to the quantity of water available to support various uses, the quality of the water is a critical parameter when evaluating the health of water supplies and ecosystems. The Clean Water Act (CWA), administered by the U.S. Environmental Protection Agency, represents the cornerstone of surface water-quality protection in the United States. The broad goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The Colorado Department of Public Health and Environment (CDPHE) is the state agency in charge of water-quality protection, including surface and groundwater monitoring, protection, and restoration. It regulates the discharge of pollutants into the state's surface and ground waters and enforces the Colorado Primary Drinking Water Regulations.

Colorado's water-quality protection framework has three main components:

- Use classifications
- Water-quality standards
- Anti-degradation provisions

The CDPHE's Water Quality Control Commission adopts use classifications for each current or future use to be protected based on how the water is currently used and what beneficial uses are desired in the future. To protect these uses the state sets numerical and narrative water-quality standards. The primary purpose of anti-degradation provisions is to protect current water quality, especially where that quality is better than is necessary to protect a water body's classified uses.

Although the Roaring Fork Watershed is a headwater and thus is not impacted by upstream water uses, its water quality is susceptible to pollution sources originating within the watershed, especially stormwater runoff and sediment loading from changing land use patterns, heavy metal infiltration from geologic sources and historic mining disturbances, and changes in water chemistry (for example, water temperature and dissolved oxygen concentrations) caused by lower stream flow levels. These water-quality changes have direct effects on aquatic ecosystems and can influence human uses such as drinking water.

Water quality in the Roaring Fork Watershed has been monitored for more than five decades, and many studies have been conducted on water quality and related issues by organizations that include Roaring Fork Conservancy, Colorado Department of Natural Resources, CDPHE, Colorado Division of Wildlife River Watch (Colorado River Watch), U.S. Environmental Protection Agency, U.S. Forest Service, and U.S. Geological Survey. In addition, several site- or parameter-specific studies have been done in the watershed to address various land use practices, restoration efforts, and water-quality processes.

In spite of the large body of water-quality data for the Roaring Fork Watershed, gaps in data collection exist. Many streams do not have sufficient water-quality data to assess conditions, and/or do not have stream flow data available to aid in the interpretation of water-quality data. Throughout the watershed, water-quality data are lacking for groundwater sources, microorganisms, and wastewater compounds (emerging contaminants). Additionally, it is difficult to assess water-quality concerns regarding phosphorus and suspended solids because there are no state standards for these constituents. Key water-quality findings by sub-watershed can be found on pages 14–31.

3.3 Riparian Areas

Riparian ecosystems are unique kinds of wetlands located adjacent to streams and rivers. Moisture-loving plants and periodically-flooded soils define and characterize riparian areas. In the Roaring Fork Watershed, the landscape has sharp transitions between uplands and riparian areas. Mountain uplift and volcanism followed by glaciations have sculpted a dramatic landscape with steep valleys further eroded by streams. Riparian areas have formed where gradients decrease so that streams flow outside of their channel, or where meandering creates point bars or mid-channel islands suitable for establishment of new vegetation. In this narrow area where soils and soil moisture are influenced by the adjacent stream, a distinct zone of vegetation develops.

Riparian systems have the highest species richness of all major ecosystem types in Colorado, but they cover only one to two percent of the land area (Fitzgerald et al., 1994). In addition to providing high quality wildlife

habitat and supporting biological diversity, these systems also perform numerous other critical natural functions. Riparian systems act as living filters by helping to process and take up nutrients and other constituents that can impair water quality. They enhance the structural diversity of aquatic habitat, and they also support hydrologic processes and patterns as riparian vegetation stabilizes stream channels, helps maintain natural channel shape, and facilitates infiltration of flooding flows into the ground. Finally, riparian areas provide aesthetically and naturally rich places for human use.

Data sources that help inform the condition of riparian areas throughout the watershed include the Stream Health Initiative (SHI) (Malone and Emerick, 2007), which looks at elements of riparian areas including zone width, protective cover, soil condition, vegetation quality, noxious weed occurrences, and terrestrial wildlife potential. Additional information is available for some parts of the watershed from bird surveys and Colorado Natural Heritage Program (CNHP) information. Data are lacking to assess riparian condition for some tributaries and to identify trends in condition throughout the watershed. Data on upland habitat conditions (which influence riparian systems), and distribution information for many wildlife species are also needed.

Factors within the watershed that affect the health and function of riparian areas include development activities, establishment of roads, grazing, deforestation, recreation activities, mining, and beaver eradication. Key findings related to riparian conditions can be found for each sub-watershed on pages 14-31.

3.4 Instream Areas

Streams in the Roaring Fork Watershed are dominated by montane cold headwater streams that provide high-quality water for downstream habitats and thus support a wide array of aquatic and terrestrial species. Stream systems serve as important conduits for natural materials by transporting water, nutrients, sediments, and other substances. They provide recreational opportunities for humans such as boating, fishing, wildlife viewing, and general enjoyment of streams' scenic settings, and support hydropower production and consumptive water uses like agricultural irrigation, domestic and industrial activities, and municipal drinking water.

The following physical changes usually occur as a continuum when progressing in the upstream to downstream direction:

- Stream gradient and the size of the stream's bottom material decrease;
- Nutrients become more abundant and food particle size becomes smaller;
- Colder temperatures in headwater streams become progressively warmer; and
- Aquatic wildlife richness and abundance increases in the downstream direction corresponding to changes in nutrients and biological communities.

Stream characteristics are very different at the headwaters of the Roaring Fork River from those same characteristics at its confluence with the Colorado River in Glenwood Springs.

To evaluate the status of instream areas in the watershed, the SHI provides data about channel condition (including channel alteration, riffle frequency, sinuosity), stream balance (i.e. bank stability, sediment deposition, occurrence of downcutting), aquatic wildlife potential, and information about fish and aquatic insect habitat. Additional studies include fish and aquatic habitat surveys and evaluation of channel instability. However, some spatial data is lacking because not all major streams have been assessed. Very little information is available to detect trends in the condition of instream areas. In addition, little is known about invasive species and knowledge gaps exist in understanding ecological processes governing stream systems.

Stream systems are affected by direct factors such as modification of stream channels, which often arises through development activities along streams, and changes in the stream flow regime resulting primarily from water diversions. Indirect factors influencing stream channels and habitat include modification of riparian and/or upland habitat (through activities such as urbanization or grazing), which can alter the flow regime and water-quality conditions. Pages 14-31 present key findings for instream channel and habitat condition for each of the nine sub-watersheds.

3.5 Climate Change

Global warming from greenhouse gas (GHG) emissions and land use changes affect the temperature, precipitation, and streamflow of the Roaring Fork Watershed and the greater Colorado River Basin. These physical climate changes will impact the ecosystems and socioeconomics of the Roaring Fork Watershed. A recent review of six major studies on the Colorado River finds that stream flow levels will likely be reduced due to climate change (Udall, 2007). This has major significance for resource management as water supplies are projected to decrease in the face of increasing demand. High elevation tributaries such as the Roaring Fork River provide 85 percent of the total Colorado River Basin flow (IPCC, 2008; Milly et al., 2005).

Change to the physical and biological aspects of the river system will also impact the built environment and affect how water resources are managed. Some of these effects will include altered timing and amount of water available for irrigation and groundwater recharge, stresses on municipal water supplies and other consumptive uses such as snowmaking, and greater demand from diversions and downstream calls. Overall, competition for water will increase among municipal, agricultural, recreational, industrial, and ecological uses.

It is imperative that a better understanding of how climate change will alter the hydrology, ecosystems, and socioeconomics of the Roaring Fork Watershed be incorporated in the next phase of the Watershed Plan process. The nexus of global warming, natural variability, and human population growth will put unprecedented pressure on water resources in the West in the 21st century, and sets a broader context for assessing the present state of Roaring Fork Watershed and planning for managing its future.

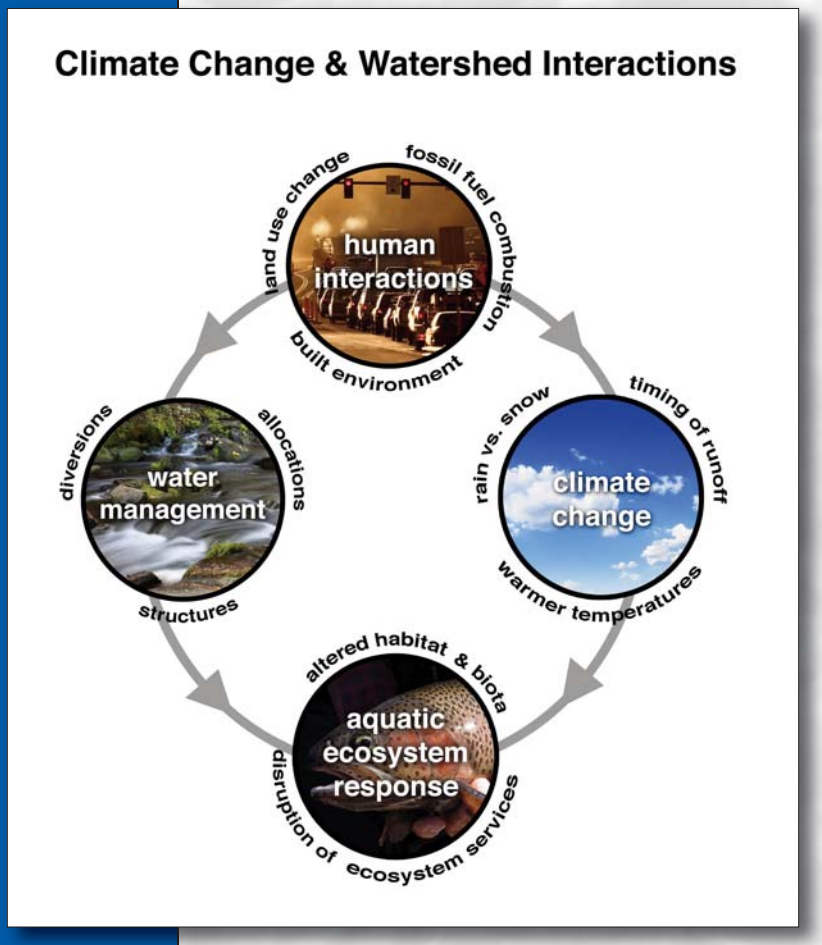
The following diagram demonstrates the interconnectedness of the watershed's various water resources and human activities, and from a larger perspective shows how climate change is influencing these interactions and outcomes.

Key direct effects of climate change projected for the Roaring Fork Watershed are:

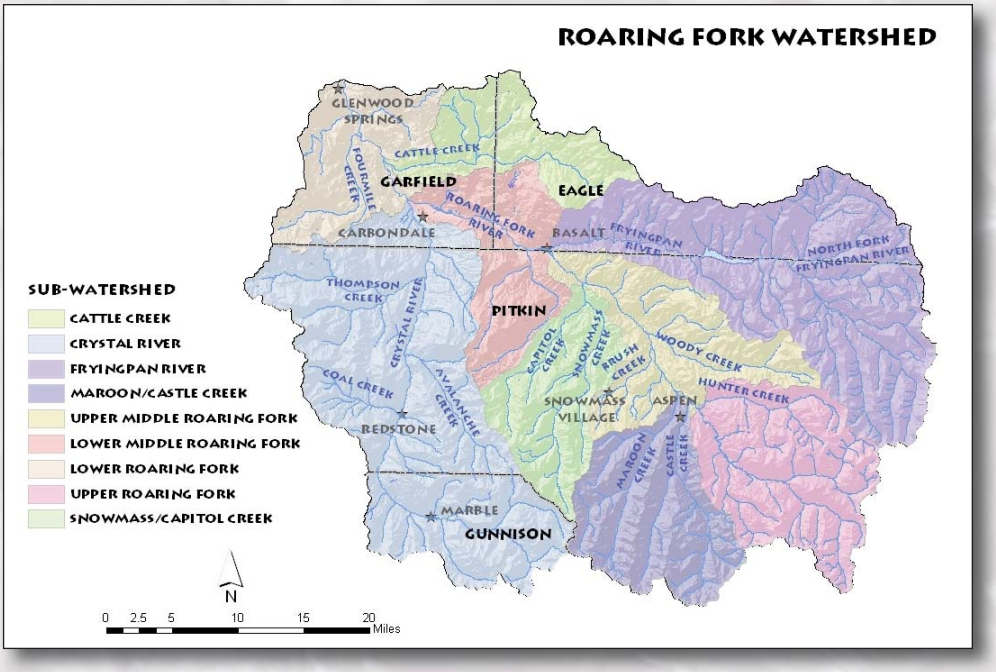
- Warmer temperatures,
- More precipitation as rain, with less as snow,
- Decreased snow cover and snowpack,
- Earlier snowmelt and runoff, and
- Decreased runoff.

These changes will drive secondary changes within the watershed, such as:

- Earlier drying of soil moisture and riparian habitats;
- Increase in evapotranspiration and water demand;
- Increase in fire risk and insect outbreaks;
- Elevational shifts in plant and animal communities and reduction or loss of alpine tundra;
- Shifts in the geographic ranges, reproductive timing, competitive interactions, and relative abundances of aquatic species;
- Potential for more extreme weather events (e.g. droughts and floods); and
- Less insulating snow cover leading to greater risk of frost exposure to roots and soil organisms.



4. Watershed Resource Discussion



The Roaring Fork Watershed is comprised of nine sub-watersheds derived from National Resource Conservation Service 10-digit hydrologic units. These sub-watersheds include the higher elevation headwaters of the upper Roaring Fork River, the Maroon-Castle and Snowmass-Capitol Creek sub-watersheds, the large tributaries of the Fryingpan and Crystal River sub-watersheds, the Cattle Creek drainage, and the lower elevation segments of the Roaring Fork River. The highest point in the watershed, at the pinnacle of the Maroon-Castle Creek Sub-watershed, is 14,235-foot Castle Peak. The lowest point is in the Lower Roaring Fork Sub-watershed where the Roaring Fork River joins the Colorado River at an elevation of 5,717 feet. The Fryingpan River Sub-watershed contains the largest number of stream miles with 279, while the Crystal River Sub-watershed has the largest area, comprising 325 square miles. The accompanying map shows the various sub-watersheds. The landscapes of these sub-watersheds differ in both their natural characteristics ranging across geology, climate, biodiversity, soils, and topography, and in their human-influenced land use characteristics. Both natural and human characteristics influence water quality and quantity as well as riparian and instream areas. Pages 10-13 provide a watershed-wide depiction of these resources, followed by key findings for each sub-watershed. An important part of the sub-watershed summaries are the maps that accompany them. The following information will help the reader better understand the symbols used in the legend for each map and chart.

Recent modeling of daily pre-developed and developed flows from 1975-2005 (CWCB and CDWR, 2007) was used to assess flow alteration. The map with the histograms on page 11 shows the magnitude of monthly flow alteration with interpretation provided on page 10. The sub-watershed maps found within pages 15-31 use symbols to portray overall flow alteration. If pre-developed flows were statistically significantly different for any of the four flow descriptors (magnitude, duration, frequency, or rate of change), the location was considered to be "flow altered." Arrows in the flow-altered symbols on the map indicate if the developed flows were lower, higher, or both higher and lower than pre-developed flows. Refer to Chapter 4 and Appendix 3.1.2 for specific information on the type and degree of flow alteration within each sub-watershed.

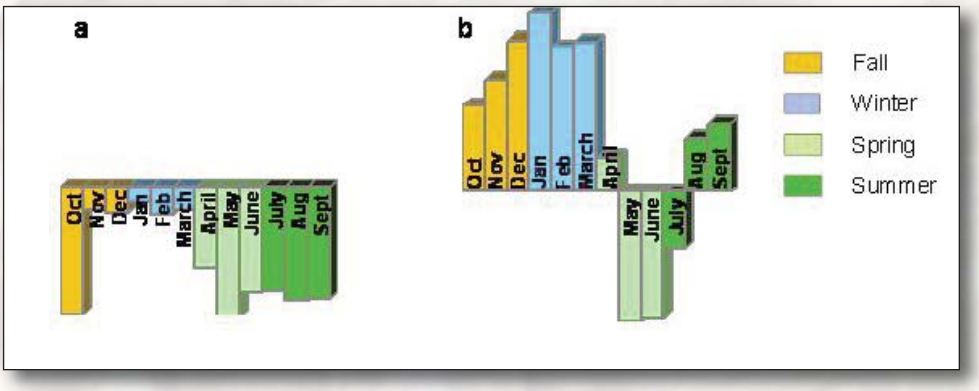
For each stream reach evaluated by the SHI (Malone and Emerick, 2007), field-based visual assessments were made of riparian, flood-prone, and upland vegetation, and of the condition of stream banks and the channel. The charts on page 13 compare riparian and instream habitat quality across the surveyed streams. The SHI assessments were used to rank the condition of the surveyed stream's left and right bank riparian and instream habitat. Five categories ranging from high quality to severely degraded are portrayed on the sub-watershed maps ("left" bank and "right" bank correspond to looking downstream). Refer to Chapter 4 and Appendix 3.3.1 for specific information on the reaches shown on these sub-watershed maps.

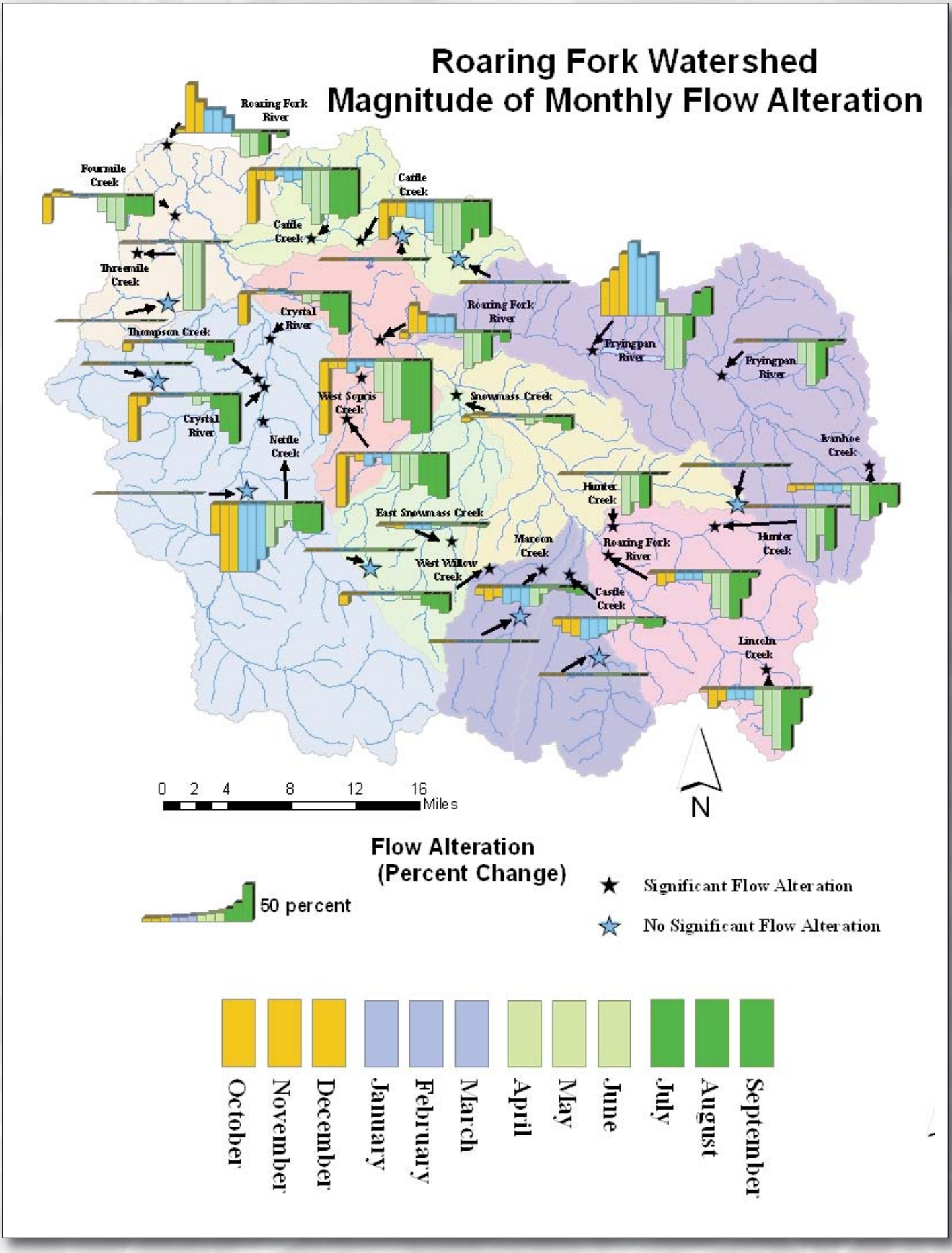
Water Quantity

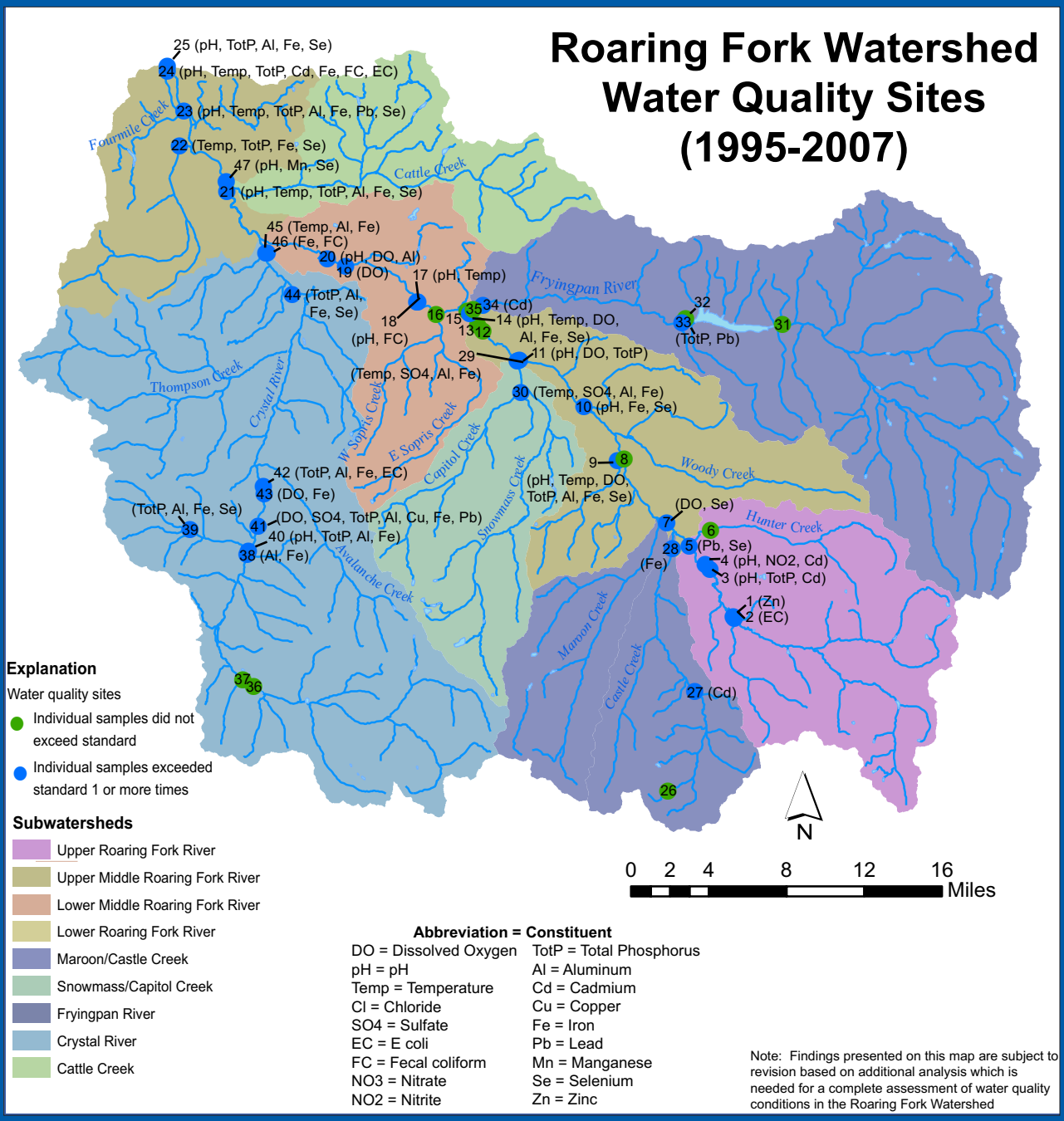
Stream flows in many reaches within the watershed are different today than they were before settlement. The degree of change in flow levels and timing of flows depends on the cause of alteration. The following is a listing of key flow alterations, comparing modeled pre-developed and developed conditions, for streams and rivers throughout the watershed:

- Transmountain diversions often reduce spring peak flows by at least 50 percent in the upper Roaring Fork and Fryingpan rivers, and Hunter and Lincoln creeks.
- A large flow reduction occurs in summer for the upper Roaring Fork River (38 percent) and Lincoln Creek (52 percent). Flows are reduced by at least 10 percent in these two streams for all other months with the exception of October.
- Two streams that are used for snowmaking, Maroon and Castle creeks, experience at least a 20 percent flow reduction in the late fall, winter, and early spring.
- Due to Ruedi Reservoir releases, developed flows for both the lower Fryingpan and lower Roaring Fork rivers are higher in fall and winter and lower in spring and early summer compared with pre-developed flows.
- Flow reductions ranging from 46 to 72 percent occur in the lower Crystal River from August to October.
- Spring peak flows and summer and early fall flows are reduced by at least 20 percent in West Sopris, lower Cattle, and Fourmile creeks.
- West Willow and lower Thompson creeks show a reduction of approximately 20 percent in August and September.
- Water from upper Threemile Creek is diverted out of the watershed, dewatering the creek in May and June.
- There is a year-round flow reduction of at least 20 percent for both Nettle Creek and Cattle Creek above the confluence with Coulter Creek.

The map on page 11 shows the magnitude of monthly flow alteration which is represented by a histogram for each node. These two example histograms show how to interpret these data. In Histogram a, developed flows are lower than predeveloped flows throughout the year, with the greatest percent flow alteration in the spring, summer, and early fall (April-October). In Histogram b, developed flows are higher than predeveloped flows in the late summer, fall, winter, and early spring (August-April), and are lower during peak runoff months (May, June, and July).



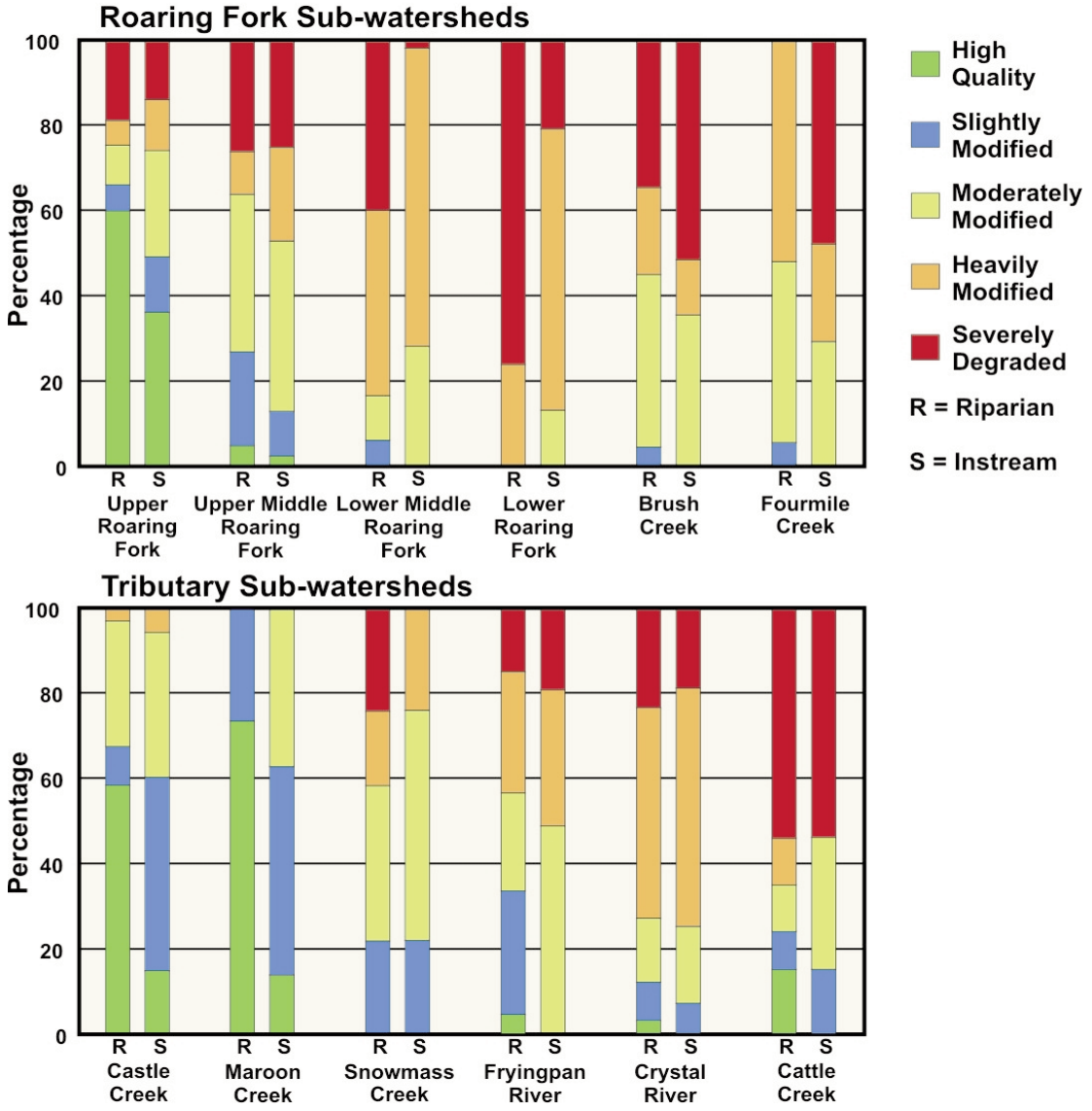

Roaring Fork Watershed
Magnitude of Monthly Flow Alteration
Roaring Fork River
Fourmile Creek
Cattle Creek
Cattle Creek
Threemile Creek
Crystal River
Thompson Creek
Roaring Fork River
Fryingpan River
Fryingpan River
West Sopris Creek
Snowmass Creek
Crystal River
Ivanhoe Creek
Hunter Creek
Hunter Creek
East Snowmass Creek
Maroon Creek
Roaring Fork River
West Willow Creek
Castle Creek
Lincoln Creek
0 2 4 8 12 16
Miles
N
Flow Alteration
(Percent Change)
50 percent
Significant Flow Alteration
No Significant Flow Alteration
October
November
December
January
February
March
April
May
June
July
August
September



The above map shows the water-quality sites discussed in the State of the Watershed Report. The map also shows at each site if a constituent exceeded either State or Federal standards one or more times. Only constituents that have a State or Federal standard are shown on the above map.

Sites summarized here in the report represent sites with more than five samples collected since 1995. Water quality constituents analyzed included field parameters, major ion data, nutrient data, trace elements, microorganism data, and suspended sediment data. Of the constituents that frequently exceeded water quality standards in the above map, they include the following: pH, temperature, total phosphorus, total recoverable iron, and selenium. Further analysis would be needed to determine the importance of these exceedances.

Riparian and Instream Habitat Quality



The Stream Health Initiative (SHI) assessed riparian and stream quality for 185 stream miles.

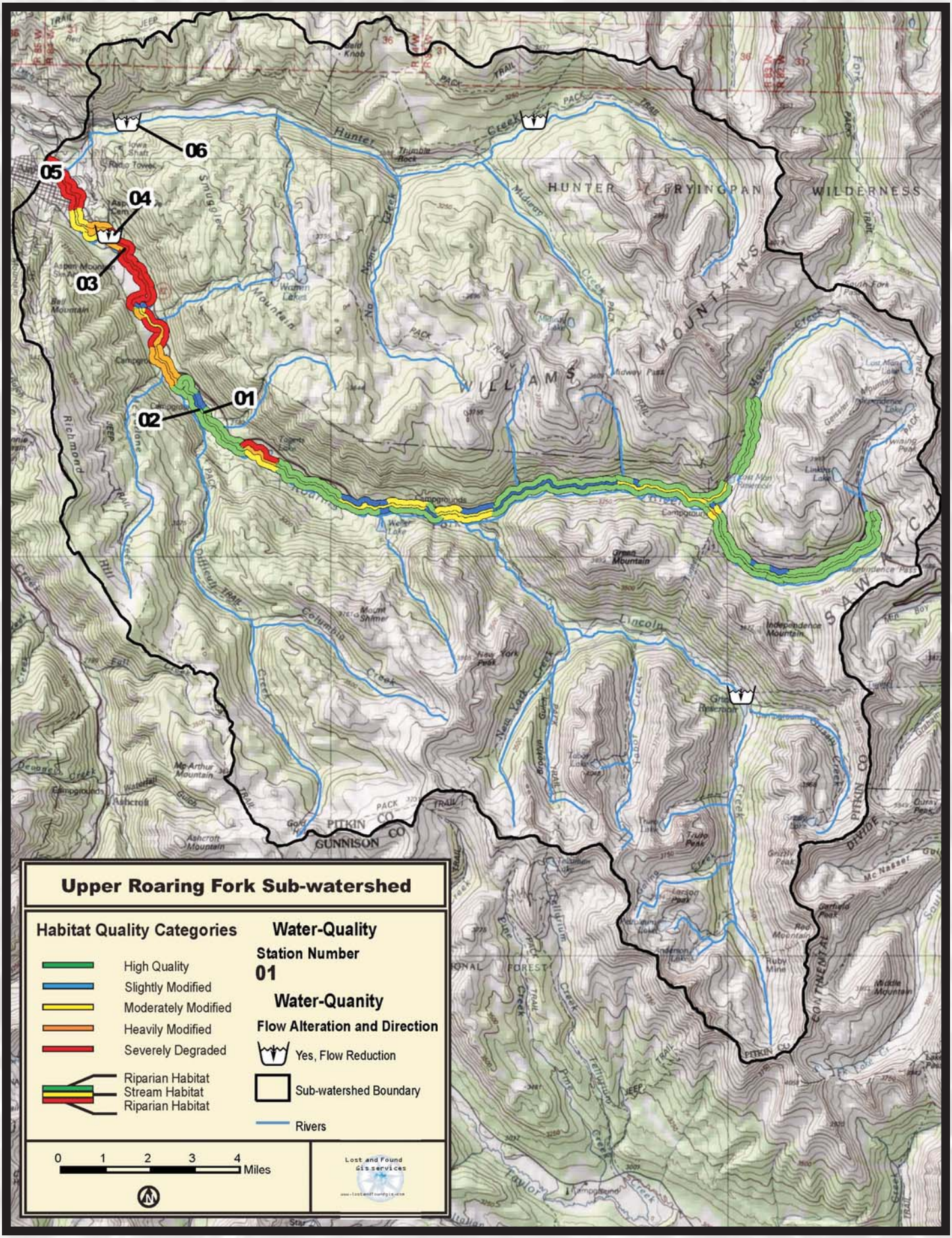
- Half of the upper Roaring Fork River's instream habitat and 34 percent of the riparian habitat quality ranges from moderately modified to severely degraded.
- Riparian habitat quality along the Roaring Fork River decreased in the upstream to downstream direction, ranging from 60 percent of the riparian zone with high quality in the upper Roaring Fork River to no high quality and more than 75 percent severely degraded habitat in the lower Roaring Fork River.
- Stream habitat follows a similar, but less extreme pattern, ranging from 36 percent high quality instream habitat in the upper Roaring Fork River to no high or slightly modified quality habitat and just above 20 percent severely degraded habitat in the lower Roaring Fork River.
- Of the surveyed tributary streams, Castle and Maroon creeks have the highest percentages of high and slightly modified quality riparian and instream habitats.
- At least half of the riparian and instream habitats for Brush, Fourmile, and Cattle creeks and the Crystal River are heavily modified or severely degraded.
- The highest percentage of riparian and instream habitat quality type in Snowmass Creek is moderately modified (36 percent and 54 percent, respectively).
- On the Fryingpan River, more than 30 percent of the riparian habitat is high quality or slightly modified, but almost 50 percent of the instream habitat is moderately modified and the rest is heavily modified or severely degraded.

4.1 Upper Roaring Fork Sub-watershed

The Upper Roaring Fork Sub-watershed, which extends from the Continental Divide downstream to Aspen, is surrounded by the Sawatch Range and the Elk Mountains with several peaks rising above 12,000 feet (Twining, Grizzly, Truro, and New York peaks, and Green and Independence mountains). Numerous small, glacial lakes are found in the headwaters, including Independence Lake at an elevation of 12,490 feet where the Roaring Fork River begins. The sub-watershed's ecological setting is influenced by the valley's directional trend and a stair-stepped valley floor. Stream, riparian, and upland environments are dominated by natural processes in the uppermost part of the sub-watershed with increasing development closer to Aspen and an urban setting within Aspen. Highway 82, recently designated as a Scenic Byway from Aspen to Twin Lakes, is a significant landscape feature, cutting a route down the valley from Independence Pass. The Independence Pass Transmountain Diversion System (IPTDS) has a significant influence on water resources in the sub-watershed. The two ecoregions in this sub-watershed are the Alpine Zone and Crystalline Subalpine Forests.

Key Findings

- The IPTDS affects all of the major headwater streams except Difficult Creek. The upper Roaring Fork River's hydrologic regime – including flow magnitude, duration, and inter-annual variation – has been dramatically changed, with an average of 37 percent of the sub-watershed's yield diverted to the East Slope annually.
- The cumulative impacts of the Fryingpan-Arkansas Project and inbasin diversions on Hunter Creek result in lower flows in May, June, and July. However, bypass requirements for the Project and Colorado Water Conservation Board (CWCB) instream flow rights (ISF) lessen flow alteration in this basin.
- CWCB ISF on Lincoln Creek, the upper Roaring Fork River, and Hunter Creek, often are not met, depending on the season, because they are junior to the Twin Lakes Reservoir and Canal Company's water rights and/or those of local inbasin diversions.
- Shallow subsurface flow is one of the most significant components of runoff in the sub-watershed, and is an important part of North Star's hydrologic system.
- There are seven direct-flow conditional water rights greater than 10 cubic feet per second in this sub-watershed.
- With respect to water quality, compared with current state and national water-quality standards, Hunter Creek and the Roaring Fork River continue to have good water quality suitable for all uses.
- More than 25 percent of the surveyed section of the Roaring Fork River within the sub-watershed is impacted by trails and development, and on 23 percent weeds are common to abundant.
- Across the areas surveyed, there is high-quality riparian habitat condition along 55 percent of the right bank and 65 percent of the left bank. Riparian wildlife potential is rated optimal in 56 percent of the riparian area, suboptimal in 19 percent, marginal in 19 percent, and poor in 5 percent.
- In general, wildlife potential in riparian areas is high in headwater reaches and decreases in the downstream direction with increased habitat alteration and human activity.
- Several CNHP elements, species designated sensitive by the U.S. Forest Service, and Audubon watch-list bird species are frequently found in stream reaches in the upper sub-watershed.
- CNHP has identified the Roaring Fork River corridor from the headwaters through North Star Nature Preserve as a Potential Conservation Area (PCA). The SHI identified seven Conservation Areas of Concern along the Roaring Fork River and on Lost Man Creek. CNHP identified five other riparian/instream PCAs in this sub-watershed: Lost Man Creek, New York Creek, the Grottos, Hunter Creek, and Grizzly Creek.
- For those areas surveyed, instream habitat quality, as measured by the ability of the stream to sustain aquatic wildlife, has diminished over much of the sub-watershed: 36 percent of instream habitat is high quality, 13 percent slightly modified, 25 percent moderately modified, 12 percent heavily modified, and 14 percent severely degraded.
- Riparian and instream data are not available for all headwater streams that are part of the IPTDS; however, two stream reaches surveyed by the SHI are directly affected by the IPTDS, with moderate modification of instream habitat resulting from stream dewatering. These reaches include several miles of the Roaring Fork River below the IPTDS dam and Lost Man Creek below the Lost Man Reservoir dam.
- The North Star Nature Preserve provides essential breeding habitat for a large diversity of native wildlife (including birds, leading to its classification by Audubon as an Important Bird Area), an important groundwater hydrologic system, and a popular location for outdoor recreation activities.
- The James H. Smith open space property provides an important example of historic channel conditions with optimal sinuosity, intact native riparian vegetation, stable stream banks, and resulting healthy riparian and aquatic habitat. This reach provides an important contrast to the rest of the lower part of the sub-watershed, which generally has been degraded through development activities.
- Boreal toads have been documented in several locations in this sub-watershed, with one known breeding population.
- Five streams in the sub-watershed contain native Colorado River cutthroat trout.


06
05
04
03
02
01
HUNTER
FRYINGPAN
WILDERNESS
WILLIAMS
MOUNTAINS
SAWATCH
Upper Roaring Fork Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
01
Water-Quanity
Flow Alteration and Direction
Yes, Flow Reduction
Sub-watershed Boundary
Rivers
0 1 2 3 4 Miles
Lost and Found GIS services
PITKIN CO
GUNNISON

4.2 Upper Middle Roaring Fork Sub-watershed

The Upper Middle Roaring Fork Sub-watershed covers the area from the Roaring Fork River's confluence with Hunter Creek to its confluence with the Fryingpan River. The Roaring Fork River flows through distinct scenic canyons in this sub-watershed, including along Red Butte, Shale Bluffs, and Snowmass Canyon. Ecoregions range from Foothill Shrublands to Crystalline Subalpine Forests. The western portion of Aspen, including Buttermilk Ski Area and the airport, is located within this sub-watershed, as is Snowmass Village, Snowmass Ski Area, the southeastern outskirts of Basalt, and the rural enclave of Woody Creek. State Highway 82 receives major use in this sub-watershed as people commute from Basalt and further down valley to Aspen. The highway affects the river corridor through road improvement and maintenance activities. The sub-watershed is subject to water quantity issues due to transmountain diversion influences in the headwaters and several large agricultural diversions near Basalt. In addition, the urbanized areas of Aspen and Snowmass Village create water-quality issues for the stretch of the Roaring Fork River in this sub-watershed, which is located fairly high in the watershed and thus has less dilution potential than downstream reaches.

Key Findings

The following refer to the overall sub-watershed:

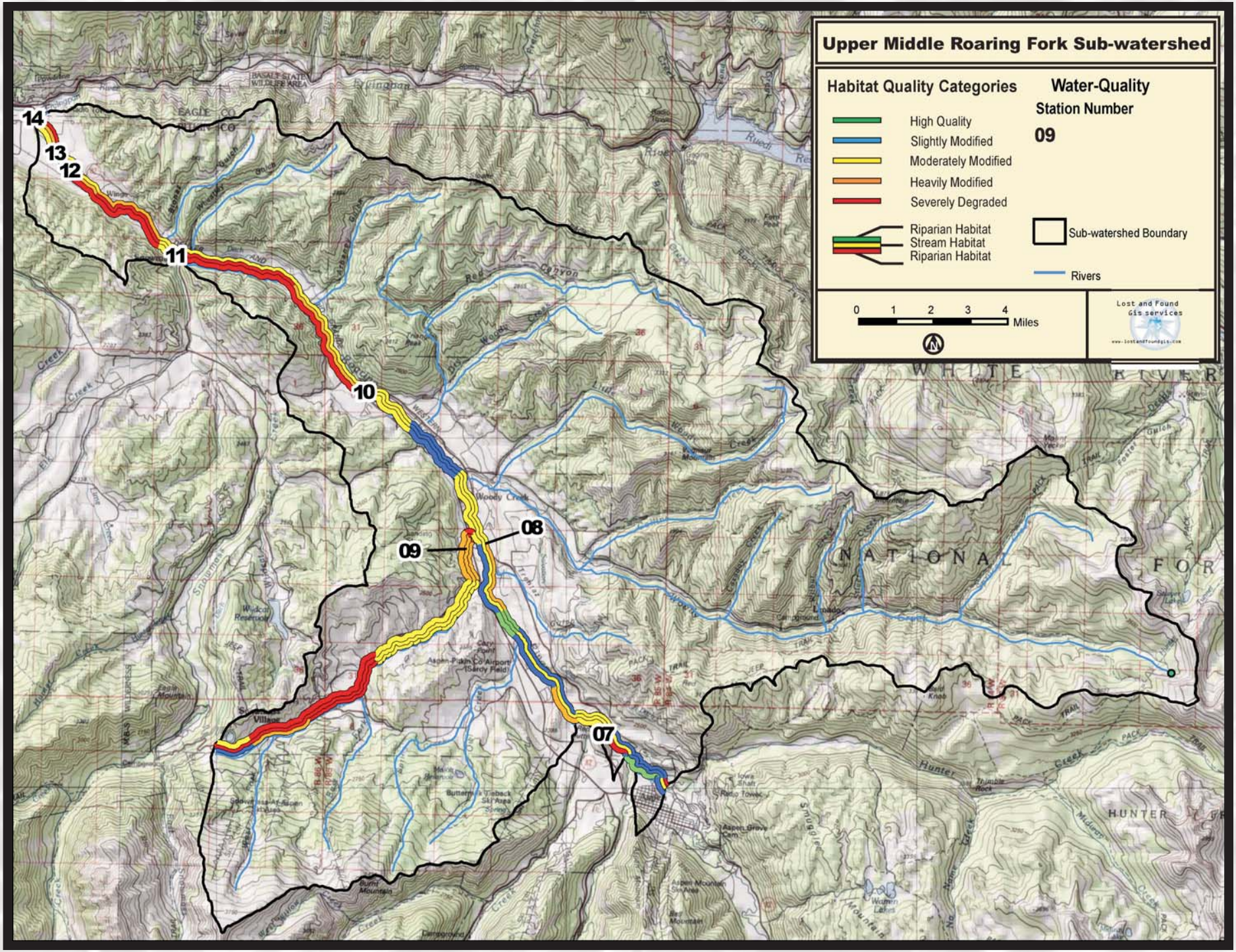
- Woody, Little Woody, and Collins creeks are often dried up downstream of large diversion structures in the summer and fall, disconnecting them from the Roaring Fork River.
- The sub-watershed contains local permeable groundwater systems that can be influenced by surface and/or other groundwater sources. The groundwater in some areas of the sub-watershed is vulnerable to pollution and partially recharged from irrigation return flows.
- There are three direct-flow conditional water rights greater than 10 cubic feet per second and one conditional storage right greater than 1,000 acre-feet in the sub-watershed.
- CNHP identified four riparian areas as Potential Conservation Areas: Roaring Fork River at Brush Creek, the Roaring Fork at Old Snowmass, Woody Creek at Horseshoe Draw, and the Woody Creek Headwaters.
- The sub-watershed has several SHI Conservation Areas of Concern with riparian and instream habitats that support high terrestrial and aquatic wildlife potential.

The following refer to the Roaring Fork River:

- The CWCB instream flow right on the Roaring Fork River between the confluences with Maroon Creek and the Fryingpan River is met throughout the year in the upper section (measured at the Roaring Fork River below Maroon Creek gage). The new stream gage located on the Roaring Fork River above Basalt will help administer this right and determine how often it is met in the lower section.
- A number of pH results on the Roaring Fork River below Brush Creek were either below or above water-quality standards in winter and spring.
- Total phosphorus exceeded water-quality standards on more than one occasion at the Roaring Fork River at the Snowmass Bridge site. Elevated concentrations of phosphorus could be attributed to a combination of anthropogenic (wastewater treatment plant discharges) and natural sources.
- Thirty-two percent of the Roaring Fork River segment's riparian and instream habitat is impacted by development, 24 percent is affected by trails, and almost 50 percent of the segment has a common to abundant presence of weeds.
- On the Roaring Fork segment, less than 10 percent of the riparian habitat is high quality due to impacts from highway construction, recreational trails, and residential, commercial, and agricultural development. On the left bank, 44 percent of the habitat is severely degraded.
- Breeding bird surveys conducted on the Roaring Fork River above Brush Creek in riparian and adjacent upland habitat identified numerous breeding bird species, including some species of conservation concern.
- Fifty-five percent of the Roaring Fork segment's instream habitat is either heavily modified or severely degraded.
- Although significant channel alteration and riparian degradation has occurred along the Roaring Fork mainstem from urbanization and highway construction, the river still maintains a robust population of brown trout that is popular with anglers. Non-native, naturally reproducing rainbow trout populations have been severely affected by whirling disease.

The following refer to Brush Creek:

- There were frequent observations of pH exceeding the water-quality standard on Brush Creek. These pH levels could be associated with low flow conditions.
- Total phosphorus exceeded water-quality standards on more than one occasion at the Brush Creek site. Elevated concentrations of phosphorus could be attributed to a combination of anthropogenic (wastewater treatment plant discharges) and natural sources.
- Thirty-eight percent of the surveyed Brush Creek segment's riparian and instream habitat is impacted by development, and almost the entire segment has a common to abundant presence of weeds.
- Brush Creek's riparian corridor has significant amounts of severely degraded habitat – 27 percent of the right bank and 42 percent of the left bank.
- Much of the Brush Creek segment's stream channel has been altered through straightening, moving, riprapping, and location into culverts. As a result, instream habitat is severely degraded in 51 percent of the segment.
- Beaver activity has improved instream habitat in some areas. Beaver dams have created deep pools where sediment drops out of the water column. These pools also provide excellent fish habitat and foraging habitat for mink, great blue herons, and waterfowl.

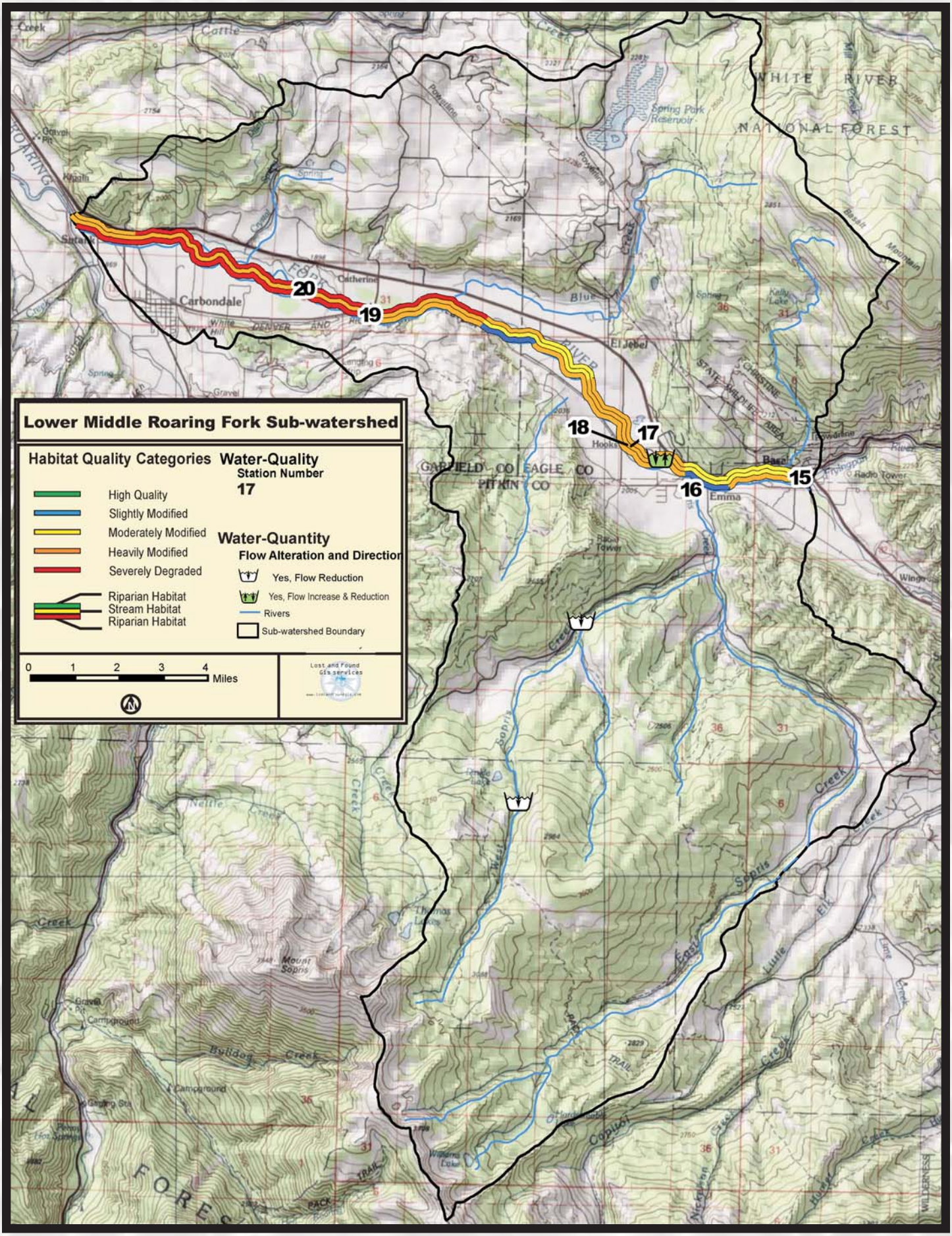

Upper Middle Roaring Fork Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
09
Sub-watershed Boundary
Rivers
0 1 2 3 4
Miles
Lost and Found
Gis services
14
13
12
11
10
09
08
07

4.3 Lower Middle Roaring Fork Sub-watershed

The Lower Middle Roaring Fork Sub-watershed extends from the confluence of the Fryingpan River to the confluence of the Crystal River. Its ecoregions are primarily Foothill Shrublands, with some Sedimentary Mid-elevation Forests and Sedimentary Subalpine Forests. The town of Basalt, which is experiencing a large increase in population and development, is the largest community within the sub-watershed. It has two distinct sections – the old town, located where the Fryingpan River joins the Roaring Fork, and a newly developing area a few miles down valley that includes part of El Jebel. Additional residential areas in the sub-watershed include Emma, The Ranch at Roaring Fork, and parts of both Missouri Heights and the town of Carbondale. This sub-watershed has the challenging circumstance of falling within three county jurisdictions, making collaborative efforts particularly important. A changing landscape from rural to more developed land uses represents a key issue for this sub-watershed, especially in relation to protection of riparian habitat and water quality.

Key Findings

- Compared with pre-developed flow patterns, the lower middle segment of the Roaring Fork River has a reduction in summer-month flows (May through July) and the number of small floods.
- Reduced flows occur in West Sopris Creek from April to October.
- CWCB instream flows are met in the sub-watershed's stretch of the Roaring Fork River throughout the year.
- Ruedi Reservoir releases increase late summer, fall, and winter flows, moderate water temperatures, and enhance fishing opportunities in the lower Roaring Fork River.
- There are two direct-flow conditional water rights greater than 10 cubic feet per second in the sub-watershed.
- Compared with current state and national water-quality standards, Sopris Creek has good water quality suitable for all uses.
- The sub-watershed generally has good water quality. pH was observed to exceed water-quality standards on the mainstem of the Roaring Fork River, specifically in observations at The Ranch at Roaring Fork and Roaring Fork at Emma. Further analysis would be needed to understand the significance of these exceedances
- More than 50 percent of the Roaring Fork River's riparian and instream habitats in this sub-watershed has been directly impacted by developed land use activities and the spread of weeds.
- Due to impacts of livestock grazing, transportation corridors, and recreational and residential development, no high-quality riparian habitat was found in the surveyed parts of this sub-watershed. On the right bank, 78 percent of the riparian corridor is classified as either severely degraded or heavily modified, and 88 percent of the left bank is so classified.
- Olive-sided and cordilleran flycatcher, osprey, great blue heron, American dipper, and a wintering bald eagle population represent important species identified in high-quality riparian areas in this sub-watershed.
- Throughout much of the sub-watershed, lack of sufficient flooding flows has resulted in a decline in cottonwood regeneration and, in combination with drying soils, has enabled the invasion of plants from adjacent upland communities. Patches of healthy native riparian habitat can be found along the Roaring Fork River near El Jebel.
- CNHP identified two riparian Potential Conservation Areas based on their biodiversity significance: The Ranch at Roaring Fork, considered one of the largest good-condition riparian areas in the entire watershed; and several reaches near El Jebel that include a great blue heron nesting colony and a globally vulnerable riparian plant community. The SHI identified four Conservation Areas of Concern.
- Spring Park Reservoir has been designated as an Important Bird Area by Audubon Colorado.
- Seventy percent of the stream channel assessed in this sub-watershed has been heavily modified because of hydrologic alteration and the effects of agricultural, residential, and commercial development within the riparian and flood plain zones. Higher-quality aquatic habitat is found in those areas with intact riparian habitat and channel structure.
- The longest Gold Medal Fishery in the state occurs from Ruedi Dam to Glenwood Springs, including the Roaring Fork River segment in the sub-watershed. It is comprised mainly of brown trout. Brown trout have replaced rainbow trout because they are not susceptible to whirling disease.


Lower Middle Roaring Fork Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
17
Water-Quantity
Flow Alteration and Direction
Yes, Flow Reduction
Yes, Flow Increase & Reduction
Rivers
Sub-watershed Boundary
0 1 2 3 4 Miles
Lost and Found GIS services
20
19
18
17
16
15
Carbondale
El Jebel
Emma
Basalt
Spring Park Reservoir
WHITE RIVER NATIONAL FOREST
GARFIELD CO
EAGLE CO
PITKIN CO
Mount Sopris
Thomas Lakes
Willow Lake
Wilderness

4.4 Lower Roaring Fork Sub-watershed

The Lower Roaring Fork Sub-watershed extends from the Roaring Fork River's confluence with the Crystal River to its confluence with the Colorado River. Its elevation ranges from 5,717 to more than 10,000 feet, covering Foothill Shrublands, Sedimentary Mid-elevation Forests, and some Sedimentary Subalpine Forest ecoregions. It includes the wide river bottomland and terraces in the lower part of the Roaring Fork Watershed. A significant portion of the land adjacent to the river has existing or planned residential development. Golf courses and active or reclaimed gravel mining operations are also located on the terraces that parallel the river's course. Historically, the valley bottomlands were irrigated for livestock pasture and hay crops. The sub-watershed also includes the watershed's largest municipality, Glenwood Springs, situated in a narrow strip of the lower Roaring Fork Valley. Hot springs, a mild climate, and access to many surrounding attractions including Sunlight Mountain Resort, have drawn visitors to Glenwood Springs for well over a century. Given the sub-watershed's population growth and land use development, the most immediate water resource issues are the effects of development on the availability and quality of water, and on riparian and instream habitat.

Key Findings

The following refer to the overall sub-watershed:

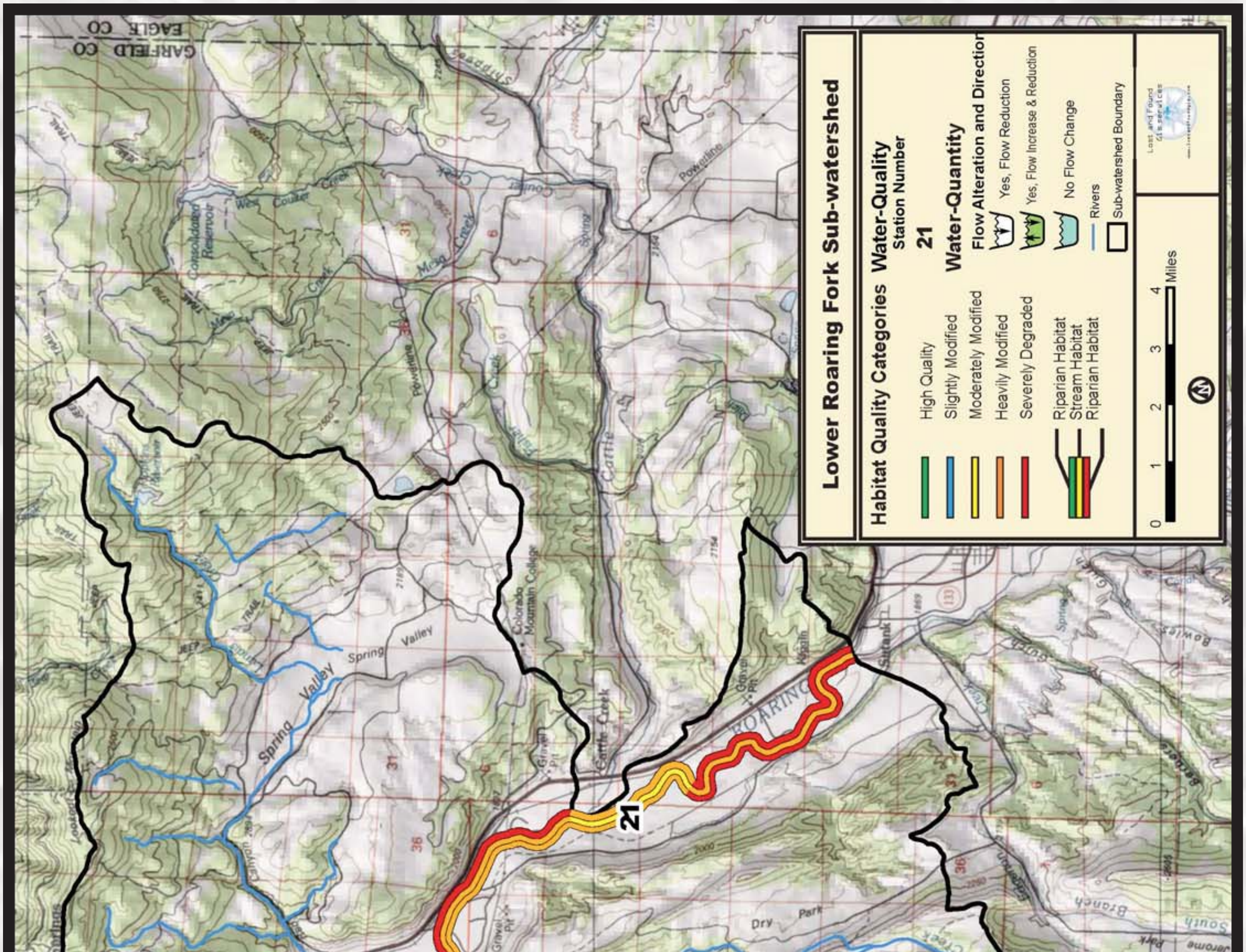
- No designated CWCB instream flow reaches are in this sub-watershed.
- The sub-watershed contains three direct-flow conditional water rights greater than 10 cubic feet per second.

The following refer to the lower Roaring Fork River:

- Compared with pre-developed flows, the frequency of small floods has been reduced and base flows have increased in the lower Roaring Fork River.
- Ruedi Reservoir releases increase late summer, fall, and winter stream flows, moderate water temperatures, and enhance fishing opportunities in the lower Roaring Fork River.
- Total recoverable iron exceeded water-quality standards, with exceedances of chronic Table Value Standards at all four monitoring sites on the Roaring Fork River.
- Selenium, total phosphorus, water temperature, and pH exceeded water-quality standards on more than one occasion. All four sites on the Roaring Fork River had total phosphorus exceedances. Elevated phosphorus concentrations could be related to naturally occurring phosphorus that enters the river during spring runoff.
- Microorganism data results showed exceedances for fecal coliform and *E. coli* at Site 24 (Roaring Fork River at Glenwood Springs) three different times from 1995 to 2000. No exceedances occurred after August 2000. Sampling was discontinued in October, 2003.
- More than 75 percent of the Roaring Fork River's riparian and instream habitat in this sub-watershed has been directly impacted by developed land use activities and the related spread of weeds.
- All riparian habitat on the right bank and 78 percent on the left bank is severely degraded. The remaining 22 percent on the left bank is heavily modified.
- The native cottonwood woodlands that historically lined the riverbanks are dying and not being replaced because of channel downcutting, riprap, and flow alteration. Upland plant species have invaded these riparian habitats.
- Small areas of riparian wetlands have been protected in some locations and provide habitat for wildlife and bird species.
- The SHI identified several Conservation Areas of Concern (CAC) including riparian wetlands in the Aspen Glen area, the Cattle Creek confluence area, and trout-spawning areas at the confluences of Fourmile and Threemile creeks.
- No high quality or slightly modified instream habitat exists; 13 percent is moderately modified, 66 percent heavily modified, and 21 percent severely degraded.
- The brown trout is the dominant trout in the lower Roaring Fork River. The longest Gold Medal Fishery in the state occurs from Ruedi Dam to Glenwood Springs, including the lower Roaring Fork River.

The following refer to Fourmile Creek:

- Reduced flows occur in Fourmile Creek from April through October due to irrigation diversions, and from November through March from hydropower diversions.
- Total recoverable iron exceeded water-quality standards, with observed exceedances of chronic Table Value Standards.
- Selenium, total phosphorus, water temperature, and pH exceeded water-quality standards on occasion.
- Fourmile Creek had two temperature values at the 20°C (68°F) standard in July of 2003 and 2006.
- Fifty-nine percent of Fourmile Creek's surveyed riparian and instream habitat has been impacted by developed land use activities and 71 percent by the spread of weeds.
- No high quality riparian habitat exists on either bank. On the left bank, 100 percent is moderately or heavily modified, as is 89 percent of the right bank.
- Cumulative grazing and development impacts have resulted in moderate modification to 29 percent of the instream habitat, heavy modification to 23 percent, and severe degradation to 48 percent.
- Aquatic wildlife is limited over the majority of the segment. Only one American dipper was observed in the drainage, indicating impaired aquatic habitat.
- Brook trout is the main salmonid in upper Fourmile Creek, while brown trout dominate lower Fourmile Creek. Fourmile and Threemile creeks are important tributaries for brown trout spawning.
- The SHI identified three contiguous reaches as CACs with important wildlife value. The CNHP designated the upland and riparian habitat in the area near Sunlight Mountain Resort as a Potential Conservation Area.


Lower Roaring Fork Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
21
Water-Quantity
Flow Alteration and Direction
Yes, Flow Reduction
Yes, Flow Increase & Reduction
No Flow Change
Rivers
Sub-watershed Boundary
0 1 2 3 4 Miles
21
22
23
24
25
Spring Valley
Dry Park
Colorado Mountain College
GARFIELD CO
EAGLE CO

4.5 Maroon/Castle Creek Sub-watershed

The Maroon/Castle Creek Sub-watershed has many spectacular mountain peaks, including several that exceed 14,000 feet. Three "fourteeners" are found in the headwaters of Maroon Creek (North Maroon, Maroon, and Pyramid peaks), and two in the headwaters of Castle Creek (Castle and Conundrum peaks). The Maroon Bells represent what is arguably one of the most-photographed natural features in the country, and draw more than 200,000 visitors annually. The sub-watershed's primary ecoregions are Sedimentary Subalpine Forests and Alpine Zone. The old silver mining town of Ashcroft in upper Castle Creek is now a ghost town. Land use within the lower parts of the Maroon and Castle creek drainages is primarily residential with a majority of the sub-watershed composed of public lands, including wilderness. Given the sub-watershed's generally pristine character, an important issue for preserving its overall hydrologic and ecologic integrity is adequate stream flows in the lower creeks – flows that are affected by local diversions.

Eliza Hotchkiss

Key Findings

The following refer to the overall sub-watershed:

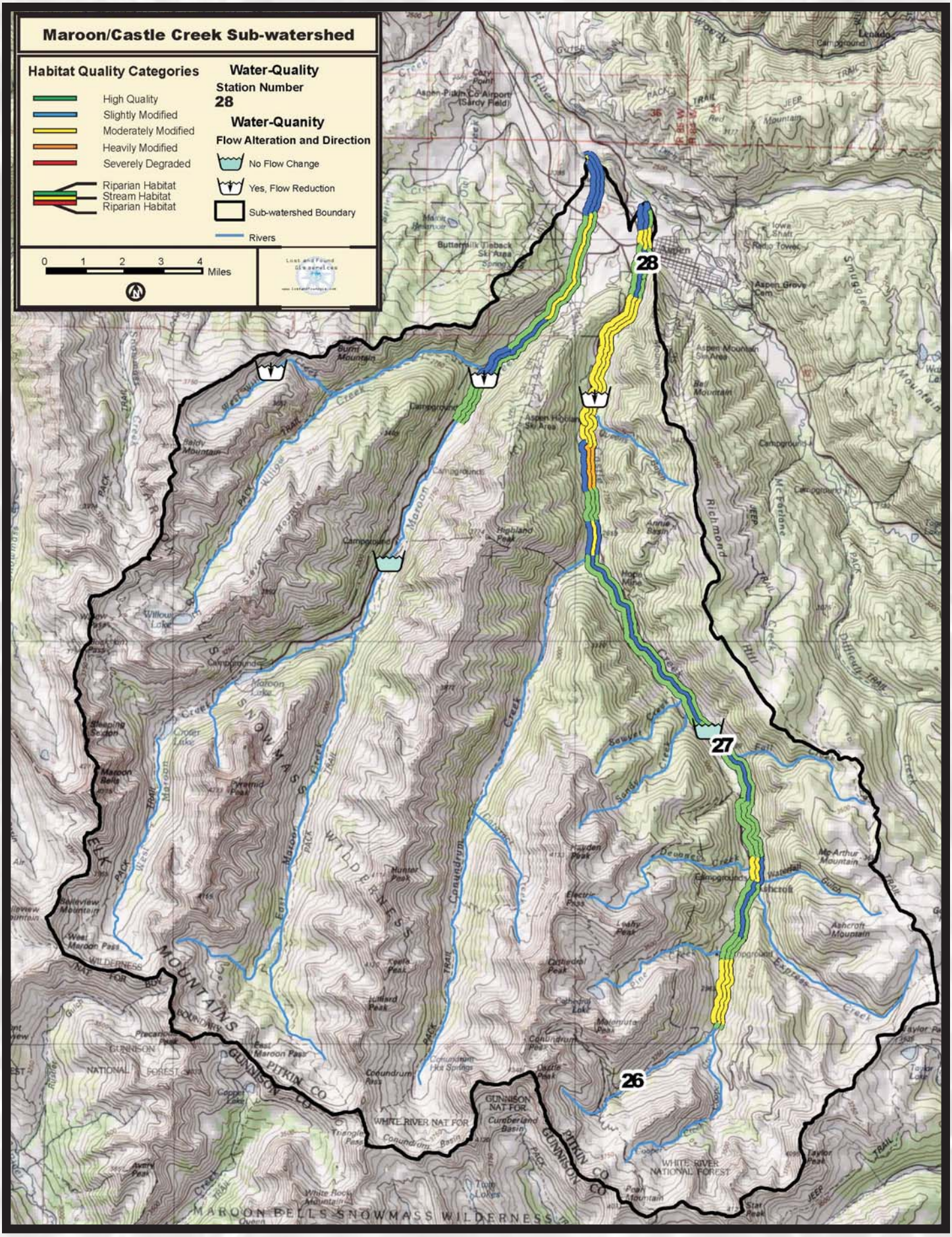
- Through proactive conservation measures, Aspen has reduced its municipal water use by 48 percent since 1993 (affecting both Maroon and Castle creeks, sources for the city's water supply).
- The sub-watershed has one direct-flow conditional water right greater than 10 cubic feet per second and two conditional storage rights greater than 1,000 acre-feet.
- Based on existing water-quality standards, the sub-watershed has overall good water quality.
- Two breeding populations of boreal toad have been documented in the sub-watershed. CNHP identified one of these areas as a Potential Conservation Area (PCA) - Conundrum Creek.

The following refer to the Maroon Creek drainage:

- Compared to pre-developed flow patterns on lower Maroon Creek, there has been a 15-20 percent flow reduction from October to April.
- A significant flow reduction was seen on Willow Creek in September when compared with pre-developed flows.
- In the surveyed section of Maroon Creek, recreation activities (including trails) represent the greatest cause of impacts and threats to riparian and instream habitat, affecting 34 percent of the surveyed area. Development, flow alteration, and weeds also impact or threaten the stream corridor.
- Because much of the riparian corridor is not developed, it is generally characterized as high quality, with some areas that are slightly modified.
- No heavily modified or severely degraded instream habitat was found in the surveyed section of Maroon Creek; 14 percent is high quality, 49 percent slightly modified, and 37 percent moderately modified.
- CNHP identified Maroon-Castle Creek and East and West Maroon Creeks as PCAs.
- The SHI identified a Conservation Area of Concern (CAC) in the lowest reach on Maroon Creek.
- Breeding bird surveys showed high species diversity, indicating high-quality habitat, and also documented several species of concern, including Northern goshawk, olive-sided and cordilleran flycatcher, and MacGillivray's warbler.
- Aquatic wildlife habitat is optimal on 48 percent of the stream and suboptimal on 52 percent.

The following refer to Castle Creek drainage:

- Compared with pre-developed flow patterns, flows in lower Castle Creek were significantly reduced by 20-30 percent from November to March.
- Within the surveyed section of Castle Creek, the greatest factor impacting or threatening riparian and instream habitat is flow alteration (affecting 24 percent of the surveyed stream corridor). Trails, roads, and development each impact or threaten from 12 to 18 percent of the stream corridor's habitat.
- High-quality riparian habitat is found on approximately 60 percent of both the left and right banks in the surveyed sections of the creek. Because of development activities along the lower creek, more than a quarter of the riparian habitat has been moderately modified on both the right and left banks.
- For the surveyed reaches, most of the instream habitat in the upper creek is in sustainable condition. It becomes progressively modified and degraded going downstream. Overall, 15 percent of instream habitat is high quality, 47 percent slightly modified, 33 percent moderately modified, and 5 percent heavily modified. Castle Creek has no severely degraded instream habitat.
- Wildlife potential is high in the uppermost reaches of Castle Creek. Neotropical migrant songbirds find high-quality breeding habitat in these undeveloped reaches.
- CNHP has identified one PCA on Castle Creek.
- The SHI identified one CAC as a good example of a narrowleaf cottonwood/blue spruce/thinleaf alder forest community (ranked as vulnerable by CNHP).
- Aquatic wildlife potential is optimal on 63 percent of Castle Creek and suboptimal on 37 percent.
- Brook trout is the dominant trout species (making up 75 percent of salmonid numbers) on Castle Creek, with rainbow trout making up the remaining 25 percent.


Maroon/Castle Creek Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
28
Water-Quanity
Flow Alteration and Direction
No Flow Change
Yes, Flow Reduction
Sub-watershed Boundary
Rivers
0 1 2 3 4
Miles
28
27
26
Aspen
Snowmass Creek
Maroon Creek
Castle Creek
Richmond Ridge
Conundrum Creek
Maroon Bells Snowmass Wilderness
Gunnison National Forest
White River National Forest
Pitkin Co
Gunnison Co

4.6 Snowmass/Capitol Creek Sub-watershed

Snowmass Creek and Capitol Creek together drain a portion of the Elk Mountains in the south-central part of the Roaring Fork Watershed. The 100-square mile Snowmass/Capitol Creek Sub-watershed contains public land, most of which is designated wilderness, along with rural residential and agricultural land uses. This sub-watershed contains an area known as "Old Snowmass," primarily a collection of residences that spreads out along the lower Snowmass Creek valley from State Highway 82. The sub-watershed's ecoregions include Alpine Zone, Sedimentary Subalpine Forests, Sedimentary Mid-elevation Forests, and Foothill Shrublands. Since the 1970s there has been a debate about the diversions of water from East Snowmass Creek and Snowmass Creek for use in the Brush Creek drainage (where the Town of Snowmass Village is located), and the effects of such diversions on the creek's aquatic ecosystem.

Key Findings

• The greatest flow reduction on East Snowmass Creek occurs in August and September due to transbasin and inbasin diversions. A dewatered creek has been observed at times.

• On Capitol Creek, severe flow shortages in the late summer and early fall are rare because of irrigation return flow, springs, and voluntary agreements between water - right holders.

• Compared with pre-developed flow patterns, the greatest reduction in flows on lower Snowmass Creek occurred in May (10 percent) and September (19 percent).

• An innovative multi-stage CWCB instream flow right on Snowmass Creek takes into account natural year-to-year variability in stream flows.

• There are two direct-flow conditional water rights greater than 10 cubic feet per second in this sub-watershed.

• There is indication of the presence of local groundwater sources within the sub-watershed. These sources appear to be shallow and potentially vulnerable to contamination.

• The following trace elements sampled in both Snowmass and Capitol creeks exceeded chronic water-quality standards on occasion:

~Total recoverable iron,

~Selenium (most likely related to irrigation of land underlain by Mancos Shale),

~Total recoverable aluminum, which often had high concentrations (> 750 µg/L), and

~Sulfate and hardness concentrations were elevated compared to other sub-watersheds, but were generally consistent with expected conditions for streams that drain areas underlain by Mancos Shale.

• In the surveyed section of Snowmass Creek, the greatest factors impacting and threatening riparian and instream habitat sustainability are flow reduction (affecting 83 percent of habitat) and development (residential, agricultural, recreational, and commercial – affecting 48 percent). Weeds are also prevalent, affecting 23 percent of the left bank and 34 percent of the right bank.

• For reaches surveyed in Snowmass Creek, past and present land use activities have influenced riparian habitat quality. No high quality reaches were found. On the left bank, 22 percent of riparian habitat is slightly modified, 31 percent moderately modified, 23 percent heavily modified, and 24 percent severely degraded; on the right bank 22 percent of riparian habitat is slightly modified, 42 percent moderately modified, 12 percent heavily modified, and 24 percent severely degraded.

• CNHP identified three Potential Conservation Areas (PCAs) in the sub-watershed. One PCA is at the base of Eagle Mountain and was identified because of the presence of a great blue heron nesting colony. The other two are located on East Snowmass Creek and Snowmass Creek at Snowmass Peak. All were assigned a rank of B3 ("high" biodiversity significance).

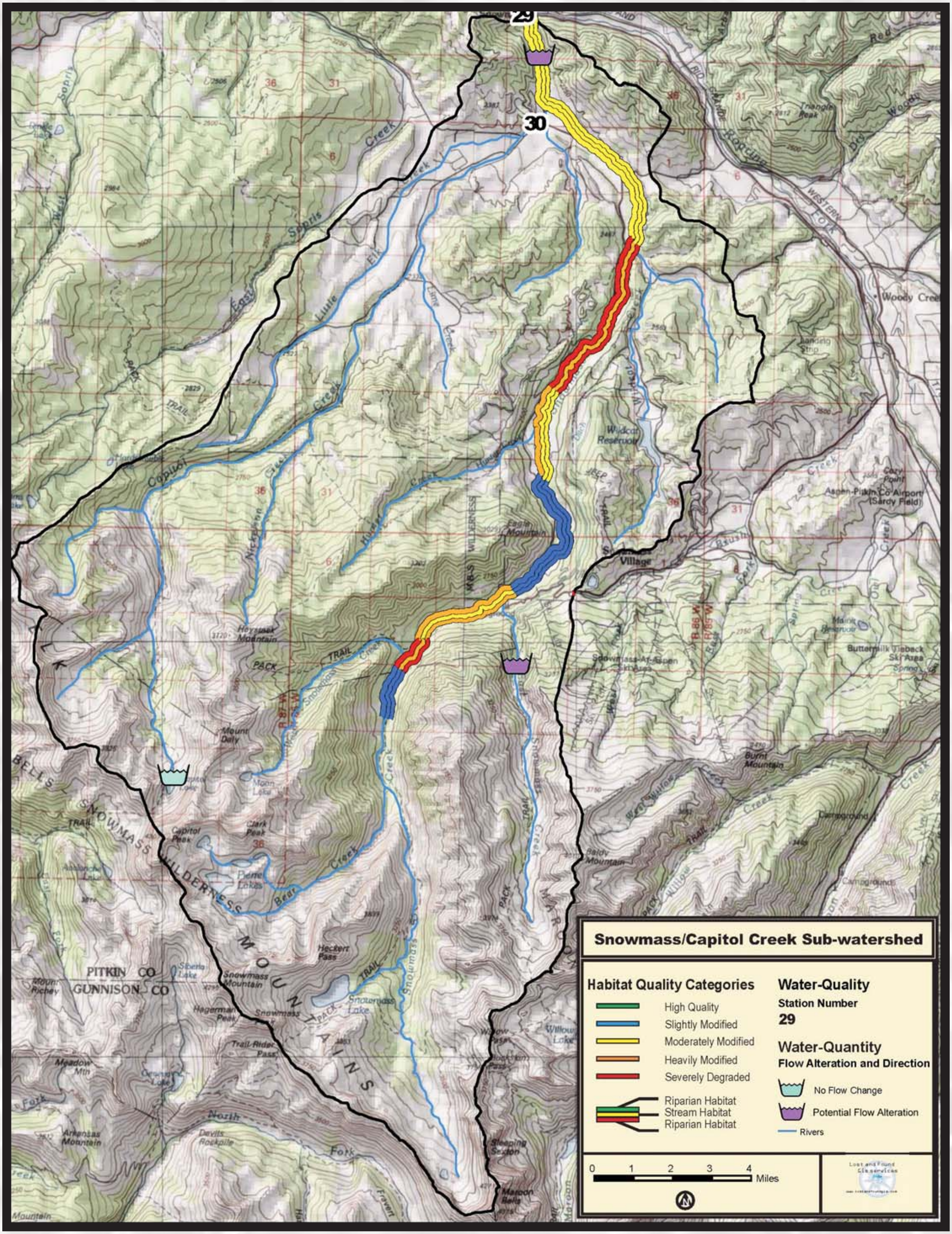
• In lower Snowmass Creek observed vulnerable or indicator bird species included Northern pygmy owl (CNHP watch-list species), American dipper, and MacGillivray's warbler.

• Overall, riparian and aquatic wildlife potential is suboptimal on a majority of the surveyed section of Snowmass Creek.

• No high quality or severely degraded stream reaches exist in the assessment area, with 22 percent of instream habitat slightly modified, 54 percent moderately modified, and 24 percent heavily modified. Causes of modification include historic and current agricultural activities, residential development, reduced beaver activity, and stream diversions.

• The question of whether existing and future winter diversions affect fish populations and aquatic habitat in Snowmass Creek has been studied and debated for more than 30 years and has yet to be resolved. However, flow and fishery monitoring is ongoing to inform this debate.

• The sub-watershed contains two conservation populations of Colorado River cutthroat trout and a breeding population of boreal toads.

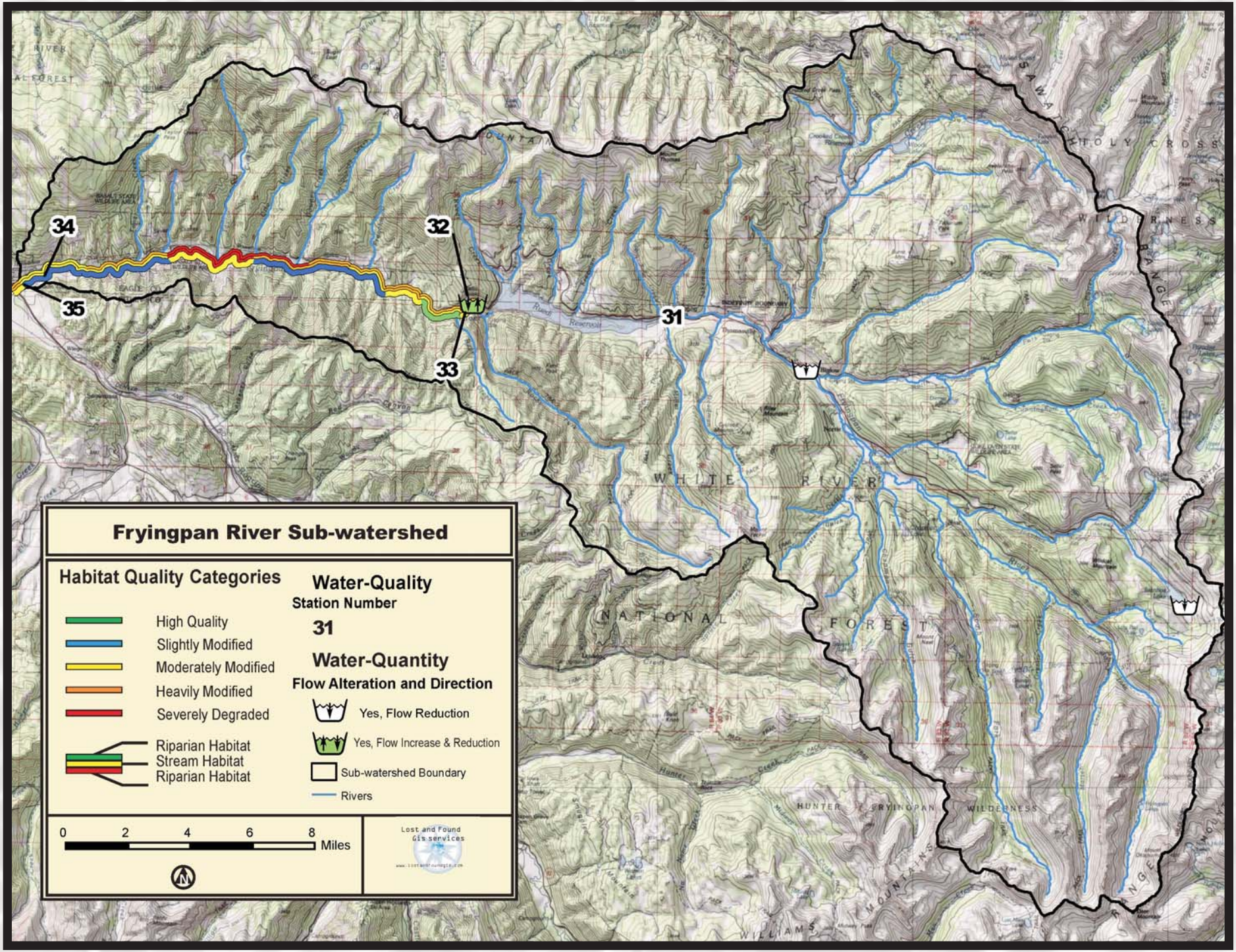

Snowmass/Capitol Creek Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
29
Water-Quantity
Flow Alteration and Direction
No Flow Change
Potential Flow Alteration
Rivers
0 1 2 3 4 Miles
29
30
PITKIN CO
GUNNISON CO
SNOWMASS WILDERNESS
Capitol
Snowmass
Wildcat Reservoir
Village
Aspen-Pitkin Co Airport (Sardy Field)

4.7 Fryingpan River Sub-watershed

The headwaters of the Fryingpan River Sub-watershed drain westward from the Continental Divide into the Fryingpan River, which meets the Roaring Fork River at Basalt. The Colorado Midland Railroad, which passed under the Continental Divide through the Hagerman Tunnel, operated in the Fryingpan River Valley from 1887 until 1918. It linked Colorado Springs and Leadville with the Roaring Fork Valley. The Fryingpan-Arkansas (Fry-Ark) Project, constructed in the 1960s, is a large transmountain diversion project whose infrastructure is evident throughout the sub-watershed's headwaters in the form of diversion tunnels and Ruedi Reservoir, which was built to compensate the West Slope for the Fry-Ark Project's water depletions. The small communities of Meredith and Thomasville lie in the upper sub-watershed, and a number of homes ring the perimeter of Ruedi Reservoir. The Fryingpan River valley serves as a popular destination for outdoor recreation including reservoir-based activities, camping, angling (including ice-fishing), hunting, snowmobiling, bicycling, and hiking. Ecoregions in the sub-watershed include Alpine Zone, Crystalline Subalpine Forests, Sedimentary Subalpine Forests, and Sedimentary Mid-elevation Forests in the lower elevations around and above Basalt. One of the largest issues in this sub-watershed has been how management of Ruedi Reservoir affects streamflows, the aquatic ecosystem, and angling activities in the lower Fryingpan River.

Key Findings

- Most of the sub-watershed's major headwater streams are strongly influenced by the transmountain diversions related to the Fry-Ark Project. The upper Fryingpan River's hydrologic regime – including flow magnitude, duration, and inter-annual variation – has been dramatically changed, with an average of 41 percent of the sub-watershed's yield diverted to the East Slope annually.
- Flows are significantly altered below Ruedi Reservoir in each month with the exception of April. From August to April developed flows are higher than pre-developed flows due to reservoir releases. During the peak flow months of May through July, developed flows are significantly less than pre-developed flows as water is diverted by the Fry-Ark Project or held in the reservoir for release later in the season. There is also a reduction in small and large floods.
- Ruedi Reservoir releases increase late summer, fall, and winter flows, moderate water temperatures, and enhance fishing opportunities in the lower Fryingpan River.
- In addition to the conditional water rights associated with the Fry-Ark Project, there are two direct-flow conditional water rights greater than 10 cubic feet per second and three conditional storage rights greater than 1,000 acre-feet in this sub-watershed.
- Compared with current state and national water-quality standards and previous studies, the Fryingpan River continues to have good water quality suitable for all uses.
- Impacts and threats to riparian and instream habitat sustainability below Ruedi Reservoir include trails and related disturbance (25 percent); roadcuts, bridges, and culverts (37 percent); development (12 percent); weeds (48 percent on the left bank and 89 percent on the right bank); and flow alteration (76 percent).
- Riparian habitat quality has been modified over a majority of the Fryingpan River below Ruedi Reservoir. On the left bank, 9 percent of riparian habitat is high quality, 58 percent slightly modified, 33 percent moderately modified, and no heavily modified or severely degraded habitat was found. The right bank has no high quality or slightly modified riparian habitat, with 13 percent moderately modified, 57 percent heavily modified, and 30 percent severely degraded.
- SHI breeding bird surveys indicated the presence of a greater diversity of human-sensitive and vulnerable bird species in higher quality habitats compared to disturbed or developed reaches. Vulnerable species (CNHP or Audubon watch-list) observed included willow flycatcher, olive-sided flycatcher, and Northern goshawk; human-sensitive species included Western tanager, Swainson's thrush, and MacGillivray's warbler.
- Instream habitat in the lower Fryingpan River has been altered by the cumulative impacts of modifications to stream flow and riparian habitat, with no high quality instream habitat found in the assessment area. Forty-nine percent of instream habitat is moderately modified, 32 percent heavily modified, and 19 percent severely degraded.
- Upstream of Ruedi Reservoir brown and brook trout are the dominant trout species. Four isolated populations of Colorado River cutthroat trout have been observed in headwater streams.
- The longest Gold Medal Fishery in the state occurs from Ruedi Dam to Glenwood Spings, including the lower Fryingpan River. It is mainly comprised of brown trout.
- There is one known boreal toad breeding population in the sub-watershed.
- CNHP identified three Potential Conservation Areas (PCA) for riparian biodiversity attributes, and five PCAs that contain important instream biodiversity values. The SHI identified two Conservation Areas of Concern in the lower Fryingpan River.
- The Seven Castles Creek area in the lower Fryingpan River Valley has been identified by the Roaring Fork and Fryingpan Rivers Multi-Objective Study (BRW, Inc. et al., 1999) as a major debris flow site that delivers high sediment loads to the river. It experienced a significant debris flow event in the summer of 2007.

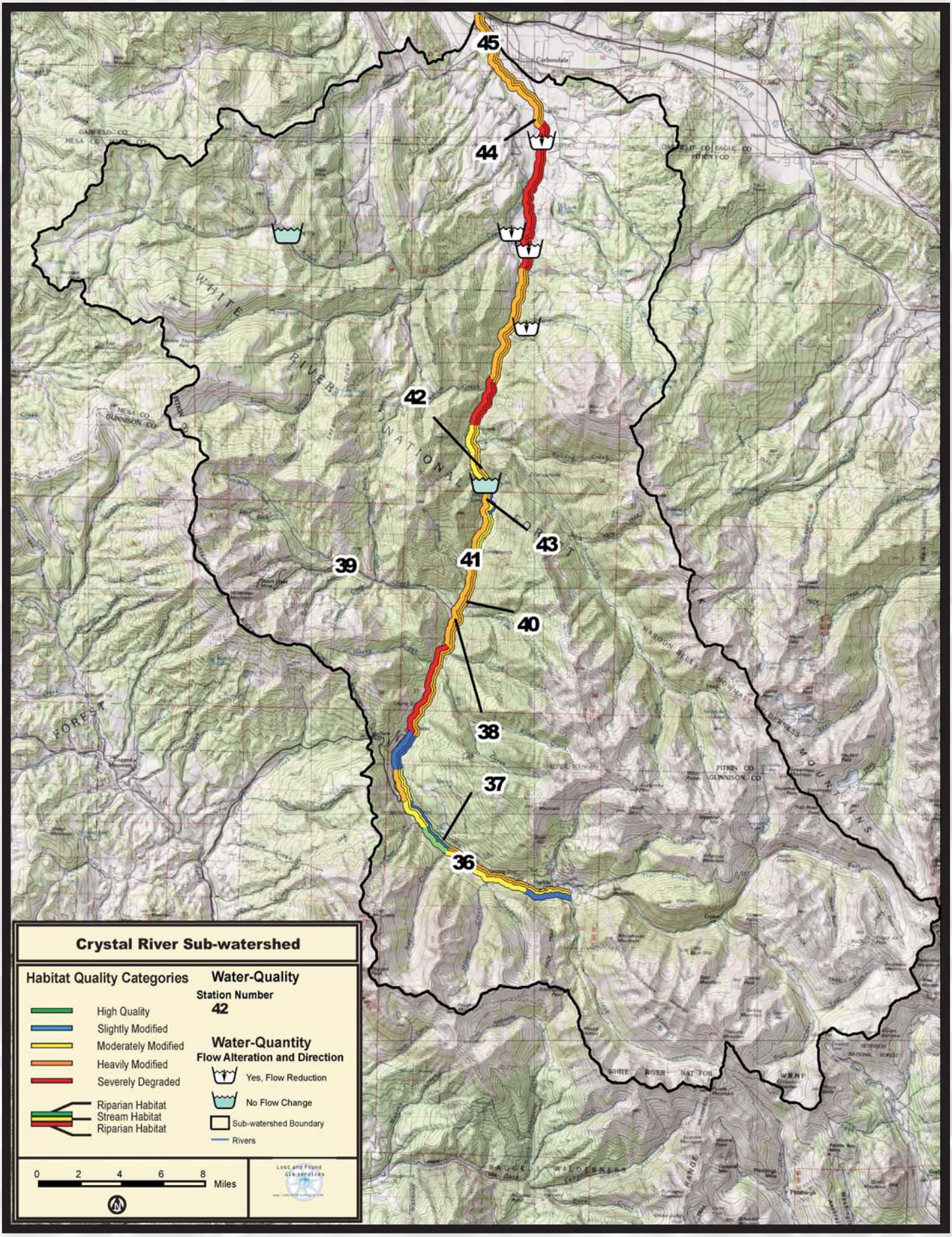

Fryingpan River Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
31
Water-Quantity
Flow Alteration and Direction
Yes, Flow Reduction
Yes, Flow Increase & Reduction
Sub-watershed Boundary
Rivers
0 2 4 6 8 Miles
Lost and Found Gis services
34
32
35
33
31
WHITE RIVER
NATIONAL FOREST
HUNTER FRYINGPAN WILDERNESS
WILDERNESS

4.8 Crystal River Sub-watershed

The Crystal River Sub-watershed is in the southwestern part of the Roaring Fork Watershed. It is the largest sub-watershed and extends from peaks in the Elk Mountain Range to Carbondale, where the Crystal River joins the Roaring Fork River. Ecoregions in this sub-watershed are the Alpine Zone in the headwaters, a large extent of Sedimentary Subalpine Forests, a short band of Sedimentary Mid-elevation Forests, and Foothill Shrublands in the lower reaches. Extensive areas of sedimentary rock formations significantly influence the sub-watershed's landscape, vegetation patterns, and streams and rivers. The sub-watershed is known for its mining history. The Mid-Continent Resources Coal Mine operated in Coal Creek basin, and historic coke ovens can still be seen at Redstone, along with Redstone Castle, all originally developed by Charles Osgood. Marble mining continues at the Yule quarry near Marble, and a historic water-driven ore-processing mill is at the old townsite of Crystal. The main valley is accessed by State Highway 133, a designated Scenic Byway, from Carbondale over McClure Pass (9,500 feet) to the North Fork of the Gunnison Basin and its communities of Paonia and Hotchkiss. The Crystal River is one of the few rivers on Colorado's West Slope not affected by dams or transmountain diversions.

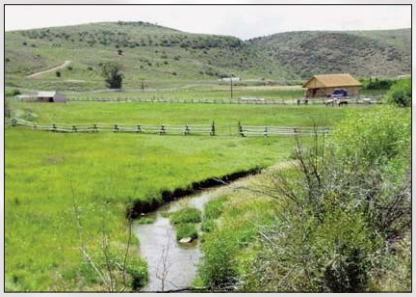
Key Findings

- Reductions in late summer/fall stream flows in the lower Crystal River and Thompson Creek are due to agricultural and municipal diversions.
- A 2003 study by Grand River Consulting that combined historic real and simulated data estimated that 27 percent of the years between 1955 and 2000 would have had an irrigation shortage in August at the confluence of the Crystal and Roaring Fork rivers. It was estimated that an irrigation shortage would have occurred in 22 percent of the years in September and 18 percent of the years in October.
- Nettle Creek, the municipal water supply for Carbondale, showed significant flow alteration for most of the year. Peak flows in May and June were not significantly altered.
- Based on combined historic real and simulated data, Grand River Consulting (2003) estimated that 66 percent of the years between 1955 and 2000 would have had stream flows below the presently-established CWCB instream flow rights (ISF) in the month of August at the confluence of the Crystal and Roaring Fork rivers. It is estimated that an ISF shortage would have occurred in 75 percent of the years in September and 44 percent of the years in October.
- Eight direct-flow conditional water rights greater than 10 cubic feet per second and six conditional storage rights greater than 1,000 acre-feet are in this sub-watershed.
- The following constituents exceeded water-quality standards on several occasions at sites on the Crystal River and Coal Creek:
  ~ Total phosphorus (with exceedances on Coal Creek and the lower Crystal River),
  ~ Dissolved oxygen at Crystal River at Penny Hot Springs,
  ~ Total recoverable iron (the major source is in the Coal Creek drainage where a historic coal mine is a point source of iron and sediment),
  ~ Selenium (a major source is Mancos Shale),
  ~ Total recoverable aluminum (which often had high concentrations in the lower Crystal River, exceeding 750 µg/l),
  ~ Coal Creek contributes to the higher suspended solid concentrations found downstream of its confluence with the Crystal River. Coal Creek is on the state's (CDPHE) monitoring and evaluation list for sediment.
- Throughout much of its surveyed length, the Crystal River has been channelized. Roadcuts have resulted in the removal and degradation of streambank vegetation and habitat loss on 27 percent of the segment. Agricultural and residential development in the riparian zone has impacted 39 percent of native riparian habitat. Weeds impact more than 50 percent of the surveyed reaches.
- Both historic and recent land uses have altered the condition of riparian habitat. Riparian habitat on both banks is heavily modified or severely degraded on more than 70 percent of the surveyed reaches.
- Along much of the surveyed segment, native cottonwood woodlands that historically lined the river banks are dying and not being replaced. Nesting by Lewis's woodpecker, a species of concern, has been documented in a few of those sites where cottonwood stands remain.
- CNHP has identified nine Potential Conservation Areas in the sub-watershed including Lost Trail Creek, Big Kline Creek, East Creek, Avalanche Creek, Middle Thompson Creek, Crystal River at Potato Bill, and Sutank. The SHI identified seven Conservation Areas of Concern.
- Vegetation degradation, channelization, and flow reduction have impacted instream habitat quality. No high quality instream habitat is present in the assessment area with 7 percent slightly modified, 18 percent moderately modified, 56 percent heavily modified, and 19 percent severely degraded.
- In general, brown trout are found in the lower reaches of the sub-watershed, mixed stocks of brook trout and brown trout in middle reaches, and brook trout in the upper reaches. Whirling disease is present in the Crystal River, causing limited natural reproduction of rainbow trout.
- Six tributary streams within the sub-watershed have populations of Colorado River cutthroat trout (CRCT) and some of these fish migrate into the main river. These CRCT populations are generally isolated from non-native trout populations by natural barriers.


45
44
42
43
41
39
40
38
37
36
Crystal River Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
42
Water-Quantity
Flow Alteration and Direction
Yes, Flow Reduction
No Flow Change
Sub-watershed Boundary
Rivers
0 2 4 6 8
Miles

4.9 Cattle Creek Sub-watershed

The Cattle Creek Sub-watershed is located in the northwest part of the overall watershed, where Cattle Creek's headwaters are fed by Basalt Mountain. The area, including much of what is known as Missouri Heights, has been dominated by agricultural ranching for generations, a practice steadily being replaced by residential development, including large-lot "ranchettes."



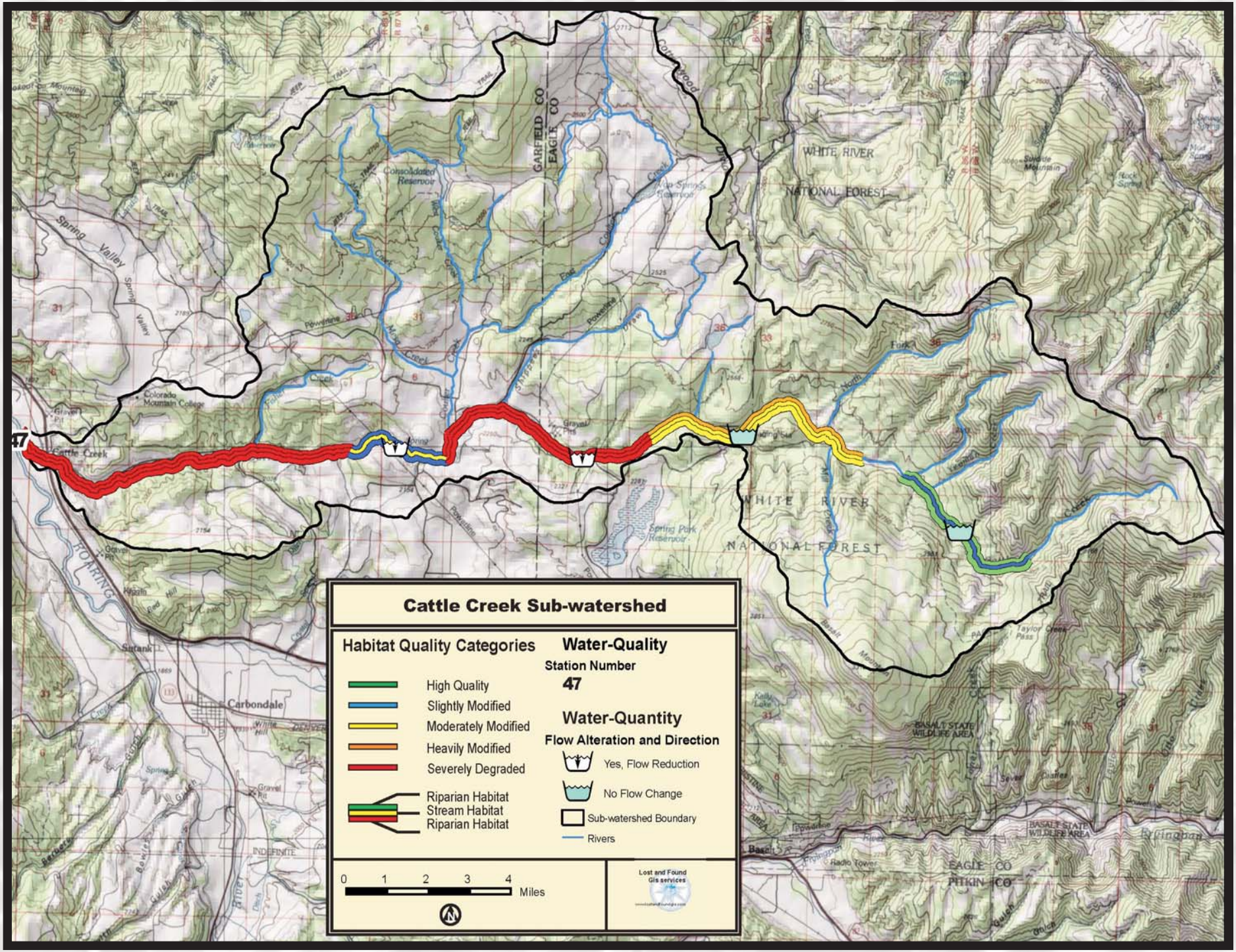
Pronounced commercial/industrial activities lie along Cattle Creek before its confluence with the Roaring Fork River. The sub-watershed is dominated by the Foothill Shrublands Ecoregion, with some Sedimentary Mid-elevation Forests and Sedimentary Subalpine Forests Ecoregions at higher elevations. The effect of land use activities directly adjacent to Cattle Creek, including grazing and development, represent an important issue for water quality and riparian and instream habitat health.

Key Findings

- Although primarily used for agriculture, year-round diversions from Cattle Creek to Spring Park Reservoir contribute to year-round flow alteration. Flows are most greatly affected from March through October. Overall, Cattle Creek has more extreme low flow conditions and fewer occurrences of high flows and associated floods when compared with its natural, undiverted flow regime.
- For the one water-quality monitoring site at the mouth of Cattle Creek, selenium frequently exceeded the chronic standard (the likely source is Mancos Shale within the sub-watershed).

- Native riparian habitat in the surveyed part of Cattle Creek has been altered by ranching and irrigated agriculture, rural development, and the more recent trend of urban development. Riparian habitat quality has been reduced in a majority of the surveyed area. On the right bank, 15 percent of riparian habitat is high quality, 9 percent slightly modified, 21 percent heavily modified, and 55 percent severely degraded. On the left bank, 15 percent is high quality, 9 percent slightly modified, 22 percent moderately modified, and 54 percent severely degraded.
- All riparian and instream habitat on the surveyed segment is threatened or impacted by weeds, and most of it is affected by reduced flows and development activities.
- A rich and abundant community of Neotropical migrant songbirds breeds in the headwaters region, indicating high quality habitat. Notable bird species observed in the upper surveyed reach include Northern goshawk (CNHP watch-list species), Swainson's hawk, golden eagle, great blue heron (CNHP watch-list species), willow flycatcher, and golden-crowned kinglet.
- There is one CNHP Potential Conservation Area, which supports globally vulnerable plant communities in its riparian area and surrounding upland.
- Two Conservation Areas of Concern were identified by the SHI in the sub-watershed.

- Instream habitat quality is reduced over the entire surveyed segment with no high quality habitat, 15 percent slightly modified, 31 percent moderately modified, and 54 percent severely degraded.
- In Cattle Creek, beavers are an integral part of healthy riparian and instream habitat. In those few areas where beaver remain active, riparian and instream functions, including the support of diverse wildlife communities, are preserved.
- Brown trout dominate the lower reaches and are co-dominant with brook trout throughout the rest of the sub-watershed.
- Headwater reaches of the sub-watershed, above the SHI surveyed segment, are in good condition and contain two populations of Colorado River cutthroat trout.


Cattle Creek Sub-watershed
Habitat Quality Categories
High Quality
Slightly Modified
Moderately Modified
Heavily Modified
Severely Degraded
Riparian Habitat
Stream Habitat
Riparian Habitat
Water-Quality
Station Number
47
Water-Quantity
Flow Alteration and Direction
Yes, Flow Reduction
No Flow Change
Sub-watershed Boundary
Rivers
0 1 2 3 4
Miles
Lost and Found Gis services
47
Cattle Creek
Carbondale
Colorado Mountain College
Consolidated Reservoir
Spring Park Reservoir
WHITE RIVER NATIONAL FOREST
BASALT STATE WILDLIFE AREA
GARFIELD CO
EAGLE CO
PITKIN CO

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