UPPER GUNNISON RIVER
WATER CONSERVANCY DISTRICT

UPPER GUNNISON RIVER BASIN
WATERSHED ASSESSMENT AND MANAGEMENT PLANNING – PHASE I

Ohio Creek, East River, and the Lake Fork of the Gunnison River Basins

Final Report

DECEMBER 31, 2019

Prepared for Colorado Water Conservation Board

The Value of Water in the Upper Gunnison River Basin

In addition to being the foundation for all land-based life,
we value water as the foundation and lifeblood for
the ecological and economic qualities that we treasure:

The forests that hold the mountains together against erosion;

The streams and rivers and the life they contain,
and the spiritual, aesthetic and recreational gifts they provide;

The utility and beauty of the water and land together
when reunited for high-country pasturage agriculture;

The snow that accumulates as a natural reservoir of water
and also affords much recreational joy;

The too-taken-for-granted quality of the water we drink;

The food and the other agricultural and ecological services
the water supports, here and in the distant farms and cities
served by the water once it moves on from our valleys,
all of which enable our lives here.

This plan is prepared to help preserve these values in the Upper Gunnison River Basin in a time of increasing human population and permanently reduced water supplies.

Nada sin aqua

List of Coordinators and Consultants:

Jesse Kruthaupt – Trout Unlimited – Ohio Creek Coordinator

Julie Nania – High Country Conservation Advocates - East River Coordinator

Camille Richard – Lake Fork Valley Conservancy - Lake Fork of the Gunnison River Coordinator

Wilson Water Group

Alpine Environmental Consulting

Table of Contents

List of Acronyms and Definitions

The following acronyms and definitions are used frequently in this Report:

303(d) List	Colorado List of Impaired Waters
µg/L	Micrograms per liter
BMPs	Best management practices
CCWC	Coal Creek Watershed Coalition
CDPHE	Colorado Department of Public Health and Environment
CDSS	Colorado Decision Support System
CNHP	Colorado Natural Heritage Program
CoAgMet	Colorado Agricultural Meteorological Network
CPW	Colorado Parks and Wildlife
CU	Consumptive Use
CWA	Clean Water Act
CWCB	Colorado Water Conservation Board
CWP	Colorado's Water Plan
District	Upper Gunnison River Water Conservancy District
DRMS	Division of Reclamation, Mining, and Safety
DWR	Colorado Division of Water Resources
EPA	Environmental Protection Agency
GBIP	Gunnison Basin Implementation Plan
HCCA	High County Conservation Advocates
M&E List	Colorado Monitoring and Evaluation List
MEMC	Mt. Emmons Mining Company
MLP WTP	Meridian Lake Park Water Treatment Plant
MMI	Macroinvertebrate Multimetric Index
NWS Coop	National Weather Service Cooperative Observer Station
OHV	Off Highway Vehicles
PCA	Potential Conservation Areas
RMBL	Rocky Mountain Biological Laboratory
StateCU	CDSS Consumptive Use Model
StateMOD	CDSS Water Rights Allocation Model
SUP	standup paddle boarding
SWSI	Statewide Water Supply Initiative
UGRWCD	Upper Gunnison River Water Conservancy District
USFS	US Forest Service
USGS	US Geological Survey
WMP	Watershed Management Plan
WMPC	Watershed Management Planning Committee
WQCD	Water Quality Control Division
WTP	Water Treatment Plant
WWTF	Wastewater Treatment Facility

Definitions

As used in this Report, these terms are defined as follows:

"Domestic use" includes the use of water for household, municipal, and industrial purposes.

"Pasture grass" is forage grown in irrigated meadows that is mowed for livestock feed (haying) or grazed.

"Watershed Management Planning Committee" is a committee formally sanctioned by the Board of Directors of the Upper Gunnison River Water Conservancy District consisting of Board members, District staff, consultants, and interested stakeholders. The Committee is chaired by a member of the Board.

Executive Summary

This document is a report prepared under the direction of the Watershed Management Planning Committee (WMPC) of the Upper Gunnison River Water Conservancy District (District) on the first phase of a watershed management planning process in the Upper Gunnison River Basin. The Watershed Management Plan (WMP) is intended to improve water security for all water uses in the Upper Gunnison Basin, by protecting existing uses, meeting user shortages, and maintaining healthy riverine ecosystems in the face of future demands and climate uncertainty, as laid out in Colorado's Water Plan (CWP) and the Gunnison Basin Roundtable's Basin Implementation Plan (GBIP). At the conclusion of the multi-year process, a long-term management plan will be developed locally for the Upper Gunnison Basin as directed by CWP. In this Report, baseline and future needs assessment information has been compiled, identifying the complex interaction between agricultural, domestic, recreational, and environmental uses of water.

For planning purposes, the WMPC has divided the Upper Gunnison River Basin into seven smaller Basins as depicted in Figure 1-1, because each has unique natural and cultural characteristics. This Report addresses three of those seven: Ohio Creek, East River, and Lake Fork of the Gunnison River (Phase I Basins). For each of the Phase I Basins, the WMPC employed a basin coordinator who performed or supervised the field work and stakeholder participation that provided the basis for the assessments and who is principal author of the Report for that basin. Technical input was provided by consultants.

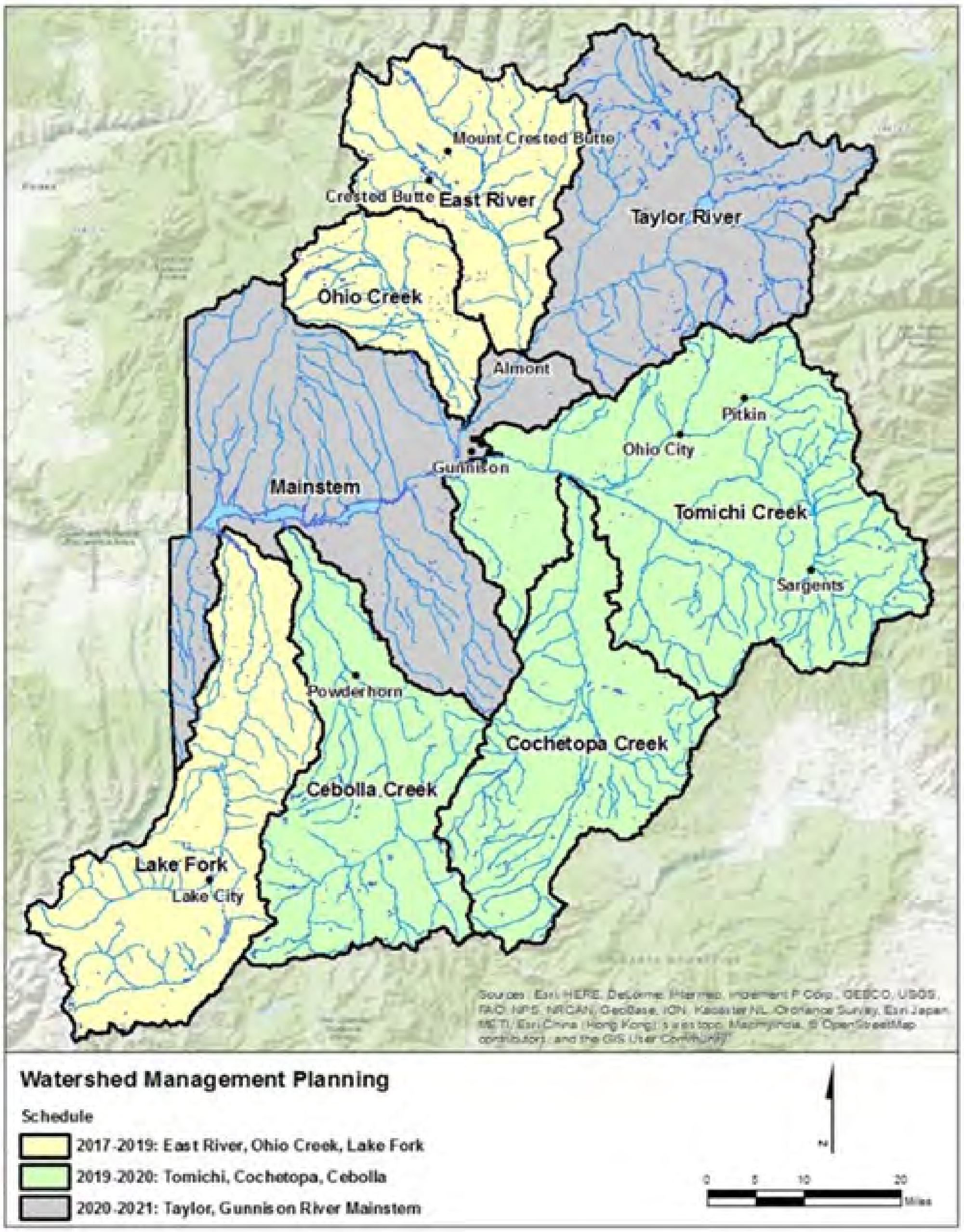


Figure 1-1: Upper Gunnison River Sub-Basins

The introduction in Chapter 1 provides the background and purpose for the Report and a description of the tasks completed by the consultants and basin coordinators.

Chapter 2 provides the legal and regulatory framework for the Report. Chapter 3 identifies environmental issues common to all of the Phase I Basins.

Chapter 4 describes stakeholder engagement in the assessment and planning process.

Chapters 5 through 7 address the Phase I Basins, beginning with an analysis of basin-wide characteristics, including geography and principal land and water uses, to provide a foundation for the data collection and needs assessments that follow. The primary objective of the initial sections of each chapter is to provide a summary of existing water use within the basin, including irrigation, domestic, environmental, and recreational uses, and identify the major challenges for water users.

To understand Basin characteristics, quantify existing water use, and develop a planning model to investigate options to meet stakeholder concerns, the following data assessment was conducted and reported for each of the Phase I Basins:

- Streamflow measurements
- Climate data
- Irrigated acreage
- Water rights
- Diversion records
- Irrigation practices
- Return flow parameters

Beginning with Section 5 in each Chapter, distinct stream reaches within the basin are assessed according to their unique characteristics and issues. The approach to investigating consumptive water needs, environmental and water quality needs, and recreational needs were tailored for each reach. The Report describes the approach to assessing current uses and identifying needs for agricultural, domestic, environmental, and recreational water use. The Colorado Water Conservation Board (CWCB) and the Colorado Division of Water Resources (DWR) have developed and updated the Colorado Decision Support System (CDSS) to aid in water resources planning. These data are accessed through the HydroBase data base maintained by DWR. The data assessment was not only used to understand basin characteristics, it was also used to enhance the CDSS consumptive use model (StateCU) and water rights allocation model (StateMod). StateCU is used to understand the existing crop demands, consumptive use, and shortages outlined in each Chapter. As discussed in more detail in Appendix A, diversion records in the Basin lack the accuracy necessary for model input. Due to this limitation, StateMod was used in a comparative fashion, to understand expected changes in streamflow and existing consumptive use due to proposed projects and operations. The environmental assessment includes stream and riparian characteristics, aquatic life, water quality, existing instream flow water rights, flow limited areas, and environmental flow goals.

Chapter 8 of the Report identifies potential demonstration projects in each Phase I Basin, Chapter 9 describes options for improved water use efficiency.

Chapter 1
Introduction

Governor John Hickenlooper initiated Colorado's Water Plan when a Statewide Water Supply Initiative (SWSI) indicated that by mid-century there will be a gap between projected water demand and the known water supply if no action is taken. The gap is the result of two assumptions: by 2050, the state's population is projected to increase by up to 40 percent - mostly in Colorado's metropolitan regions (23 percent in the Upper Gunnison River Basin); and in the same period, the water supply is projected to diminish due to climate change - a permanent reduction of as much as 20 percent from 20th-century averages.

The Colorado River is the major water provider for 40 million people and 5 million acres of irrigated agriculture. The Gunnison River is a major tributary, contributing on average one- sixth of the Colorado River Basin's total annual flow. It is the largest river in Colorado whose Basin lies entirely within the state. The headwaters in the Upper Gunnison River Basin include seven major tributaries: Ohio Creek, East River, Taylor River, Tomichi Creek, Cochetopa Creek, Cebolla Creek, and the Lake Fork of the Gunnison River. In addition, the Basin includes approximately twenty miles of the Gunnison River main stem that extends from Almont to Blue Mesa Reservoir.

The Upper Gunnison River Water Conservancy District is geographically defined by the Upper Gunnison River Basin and includes most of Gunnison County and parts of Hinsdale and Saguache Counties. Approximately 82 percent of the lands located within the District are federal public lands administered by the U. S. D. A. Forest Service (USFS), Bureau of Land Management (BLM), and National Park Service (NPS). Based on 2010 United States Census data, the total population of the District (including seasonal residents) is estimated to be 19,416, a 1.91 percent increase from the 2000 Census. Agriculture accounts for over 97 percent of the current water diversions in the District and is a significant producer of economic revenue. Although some hay is sold, over 75 percent of the hay grown in the District is used by ranchers for winter feeding of their own livestock. Over 90 percent of the hay production in the District is dependent upon irrigation. The total amount of irrigated acreage in the District is approximately 60,000 acres. The Upper Gunnison River Basin is noted for its fishing, boating, skiing, hunting, camping, scenery, and general recreational uses. The District is home to traditional industrial uses such as mining, geothermal, and hydropower energy production. Popular water-based recreation activities include rafting, kayaking, boating, standup paddle boarding, stream and reservoir fishing and skiing. All of those activities contribute significantly to the Distict's's economy. The District also contains numerous ecological communities that require a certain quantity and quality of flowing water to sustain healthy ecosystem functions.

The District's *Upper Gunnison River Watershed Assessment and Stream Management Plan* is intended to improve water security for all water uses in the Upper Gunnison River Basin, by protecting existing uses, meeting user shortages, and maintaining healthy riverine ecosystems in the face of future demands and climate uncertainty, consistent with the GBIP and CWP. Baseline and future needs assessment information will be compiled from the seven tributary sub-basins and the main stem, resulting in a comprehensive watershed management plan for the Upper Gunnison River Basin that recognizes the complex interactions between agricultural, domestic, and recreational uses of water and the environment.

Work that has been completed in Phase I under the direction of the WMPC includes assessment and planning tasks in three of the seven sub-basins of the Upper Gunnison Basin: Ohio Creek, East River, and the Lake Fork of the Gunnison River (Phase I Basins).

Stakeholder outreach. Stakeholder engagement is key to successful watershed management and was therefore the first and most essential task. Outreach was initiated with public meetings in Gunnison and Lake City introducing the assessment and management purpose and process. Both meetings were well attended. Thereafter, basin coordinators distributed paper and electronic surveys and conducted basin stakeholder meetings. These were followed up with targeted in-person interviews with key stakeholders to discuss basin issues, information gaps, and potential pilot projects.

Basin mapping and data compilation. Consultants constructed a detailed map of each Phase I Basin and compiled existing information about water usage and health of basin ecosystems. Included is a description of irrigation practices, water rights, diversion records, irrigated acreage and areas where shortages occur. Areas with significant human concentrations (incorporated towns and cities, unincorporated communities with organized water and sanitation districts, Planned Unit Developments and legal subdivisions, educational facilities, unofficial settlements (with five or more structures) and industrial areas and activities were identified. Areas with individual recreational use (whitewater boating, flatwater boating, standup paddle boarding, fishing, swimming) and areas with significant environmental concerns (instream flow problems, fishery concerns, riparian degradation, water quality concerns) were also identified. Data and information gaps in consumptive and non-consumptive uses were identified for all areas.

Needs assessments. Each Phase I Basin was divided into reaches defined by their unique characteristics and issues. The approach to investigating consumptive water needs, environmental and water quality needs, and recreational needs were tailored for each reach. The report summarizes the characteristics of each reach, issues identified by stakeholders and consultants, and the assessments performed to further understand specific needs.

Identification of Potential Projects, Programs and Activities for Improved Water Use Efficiency
As part of the stakeholder process, potential projects, best management practices (BMPs), monitoring, modeling and studies were identified for consideration in the Phase I Basins. Chapter 8 identifies potential demonstration projects to test concepts and educate stakeholders about implementation of the WMP. Chapter 9 introduces options for increased water use efficiency. These efforts will be refined as more information and data become available; however, the implementation program strategy generally includes the following components:

- Conducting monitoring, modeling, and studies to support feasibility of potential projects and refine proposed actions.

- Evaluating cost/benefit of each proposed activity.
- Implementing projects that complement the District's Mission and Vision.
- Conducting ongoing outreach to stakeholders to increase awareness of water issues, the watershed planning process, and collaboration opportunities.

Chapter 2
The Legal and Regulatory Framework

Section 1. Colorado Water Law

1.1 The Legal Framework

The legal framework for water management planning is defined by Colorado water law, which is founded on the prior appropriation doctrine (first in time, first in right). The Colorado Constitution declares that the waters of the state are the property of the public, subject to appropriation[1], guarantees the right to divert unappropriated waters, and provides that priority of appropriation gives the better right.[2] Water users with earlier water rights decrees (senior rights) have better rights in times of short supply, and can fill their needs before others with later rights (junior rights) can begin to use water.

A water right is defined as "a right to use in accordance with its priority a certain portion of the waters of the state by reason of the appropriation of the same."[3] A water right is created by an appropriation: the diversion of water from the natural stream and application to a beneficial use. "Beneficial use" is the use of that amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the appropriation is lawfully made.[4] In addition, there are recognized beneficial uses that qualify as diversions by "controlling water in the natural course", such as instream flow rights that can be appropriated or acquired by the CWCB for preservation or improvement of the natural environment.[5] Before initiating a water rights filing for an instream flow right, the CWCB must determine that the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made; that there is a natural environment that can be preserved to a reasonable degree with the water right, if granted; and that such environment can exist without material injury to water rights.[6] (See Section 1.2 below.) Certain governmental entities can appropriate recreational in-channel diversion water rights by placing control structures in the natural stream channel that create a reasonable recreational experience.[7] Impoundment of water for storage is also recognized as a beneficial use.[8]

[1] Colo. Const. Art. XVI, Section 5.
[2] Colo. Const. Art. XVI, Section 6.
[3] § 37-92-103(12), Colorado Revised Statutes.
[4] § 37-92-103(4), Colorado Revised Statutes
[5] §§ 37-92-102(3), 37-92-102(4), 37-92-103-4(c), Colorado Revised Statutes.
[6] § 37-92-102(3(c), Colorado Revised Statutes
[7] §§ 37-92-102(5)(6); 37-92-103(4)(7)(10.3); 37-92-305(13)-(16), Colorado Revised Statutes.
[8] § 37-92-103 (4)(a), Colorado Revised Statutes

To protect a water right, it must be adjudicated in the water court. "Adjudication of a water right results in a decree that confirms the priority date of the water right, its source of supply, amount, point of diversion, type and place of use and includes conditions to protect against injury to other water rights."[9] Once adjudicated, a water right can be administered by the State Engineer; the Division Engineer and Water Commissioners on the local level. Administration occurs when a senior water right is not receiving the full amount of its decree, and the owner of that right places a "call" on the stream. The call directs the water commissioner to shut down diversions by upstream junior water rights so that the senior right can be satisfied. An irrigator is required to dry up the stream in order to place a call.

Instream flow rights are administered under the priority system just as other water rights. Because they were not authorized until 1973, most appropriated instream flow rights are junior in priority to irrigation rights in the Upper Gunnison Basin.

Two factors may limit the supply of water to a user: 1) There is not enough water physically present in the stream to accomplish the user's desired diversion or in-channel use, or 2) the water is physically present in the stream, but the user is prevented from diverting water by a call from a downstream senior right.

The extent of calls in the UGRWCD varies from basin-wide to internal. A basin-wide call originates from a senior right on the mainstem of the Gunnison River downstream of Blue Mesa Reservoir and impacts all junior users in the District on a basin-wide basis. Downstream water rights with the potential to place a basin-wide, or external, call and curtail private diversions throughout the District are the water rights for the Gunnison Tunnel and Redlands Power Canal. The federal reserved water right for the Black Canyon of the Gunnison National Park and the water rights for the Aspinall Unit are subordinated to water uses in the Upper Gunnison Basin up to 40,000 acre-feet of annual depletions.[10]

Internal calls typically originate from a senior right on one tributary of a stream and have an impact only on junior users on that tributary. These calls do not affect the water supply or water rights administration status of other tributaries.

In general, water rights and water uses where there is no consumptive use and the water remains in the natural stream are not subject to being curtailed due to a downstream senior call because they do not reduce the amount of water that is available to the calling right. However, calls placed during the spring which prevent storage may have an impact on the water available to the stream for fishery, wildlife and recreational purposes during late summer and fall.

---

[9] Citizen's Guide to Colorado Water Law 6 (2009), Water Education Colorado.

[10] *Agreement for the Administration of Water Pursuant to the Subordination of Wayne N. Aspinall Unit Water Rights Within the Upper Gunnison River Basin* dated June 1, 2000, Contract No. 00-WC-40-6590; Case No. 03CW263, Water Division 4; Case No. 01CW05, Water Division 4.

More detailed discussion of Colorado water law is available from the following sources:

Citizen's Guide to Colorado Water Law, written by former Colorado Supreme Court Justice Gregory Hobbs, published by Water Education Colorado. available at:

https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorado-water-law/

Colorado Water Law for Non-Lawyers, P. Andrew Jones and Tom Cech, published by University Press of Colorado, available from Amazon.

1.2 Colorado's Instream Flow Program

Colorado has a well-established instream flow and natural lake level program. Since 1973, the CWCB has appropriated instream flow water rights on more than 1,500 stream segments covering more than 8,500 miles of stream and 477 natural lakes.[11]

Each January, the CWCB holds a workshop to request recommendations for streams and lakes to be protected. Instream flow recommendations may be proposed by any interested person. CWCB Staff collaborates with state and federal agencies and other interested persons to plan and coordinate collection of field data necessary for development of instream flow recommendations. The timeline for processing new instream flow appropriations is typically about two years, unless the appropriation is contested.[12]

The R2CROSS tool is one of the standard techniques employed by state and federal agencies to model instream hydraulic parameters and develop instream flow recommendations in Colorado. Standardized field and office procedures have been developed to help ensure that final instream flow recommendations meet statutory guidelines and are consistent. The standard field procedures that were established concern selection of transect sites and collection of hydraulic and biologic data. Standard office procedures have been established for determining biological instream flow recommendations using output from R2CROSS and for analyzing water availability.[13]

---

[11] Colorado Water Conservation Board, http://cwcb.state.co.us/environment/instream-flow-program/Pages/main.aspx, last accessed December 1, 2019.

[12] See: *Rules Concerning the Colorado Instream Flow and Natural Lake Level Program*. 2 CCR 408-2.

[13] Colorado Water Conservation Board, *Development of Instream Flow Recommendations in Colorado Using R2CROSS* (1996), p. 2, https://dnrweblink.state.co.us/cwcb/0/doc/158688/Electronic.aspx?searchid=e14efb21-664b-47ed-92fc-fe9be91dbda8, last accessed December 1, 2019.

Biologic sampling is conducted to document the existence of a natural environment. Coldwater fish species, particularly salmonids, have been used to indicate the existence of such a natural environment in the majority of the CWCB's instream flow appropriations to date.[14]

Following the field survey, raw data is entered into an Excel Macro that calculates a flow recommendation based on three criteria: average water depth, average water velocity, and the percent wetted perimeter (R2CROSS criteria). The R2CROSS model output is used to create initial recommendations for winter and summer minimum flow rates, based upon meeting the specific criteria. R2CROSS model output represents the minimum flow required to preserve the natural environment to a reasonable degree.

The CWCB relies upon the biologic expertise of the cooperating agencies to interpret the output from R2CROSS and develop an initial, biologic instream flow recommendation. This initial recommendation is designed to address the unique biologic requirements of each stream without regard to water availability. After receiving the cooperating agencies' biologic recommendation, the CWCB staff evaluates stream hydrology to determine whether water is physically available for an instream flow appropriation.[15]

A detailed site-specific water availability analysis that considers both existing water rights and physical flows is used to determine whether water is available for appropriation of the instream flow water right. Water availability typically is assessed using median hydrology. There are instances where the initial instream flow recommendations are revised based on the results of the water availability analysis. Following the water availability analysis, the revised instream flow rates are provided to the party that recommended the appropriation for additional review. Water right owners near the proposed instream flow reach are given an opportunity to comment on the instream flow proposal.

The CWCB is also authorized by statute to acquire water, water rights, or interests in water for instream flow purposes by following the procedure described in the Instream Flow Rules.[16]

Section 2. Regulation of Water Quality

Water quality standards are the foundation of the water quality-based pollution control program mandated by the federal Clean Water Act (CWA)[17]. These standards define goals for a

---

[14] *Id.*, p. 5.
[15] *Id.*, p. 10.
[16] "The Board may acquire, by grant, purchase, donation, bequest, devise, lease, exchange, or other contractual agreement, from or with any Person, including any governmental entity, such water, water rights, or interests in water that are not on the Division Engineer's abandonment list in such amounts as the Board determines are appropriate for stream flows or for natural surface water levels or volumes for natural lakes to preserve or improve the natural environment to a reasonable degree." Rule 6a., *Rules Concerning the Colorado Instream Flow and Natural Lake Level Program,* 2 CCR 408-2.
[17] 33 U.S.C. §1251 *et seq*. (1972)

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[18] were used to support this water quality analysis.

Regulation 31 describes a set of designated uses for Colorado's waters and defines the water quality conditions generally necessary to attain and maintain each designated 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 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 areas that share similar characteristics, uses, and other features. These segments are assigned designated uses and numeric water quality standards that must be met in order to protect those uses. 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.

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. 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

[18] Regulation No. 31 - *The Basic Standards and Methodologies for Surface Water*, 5 CCR 1002-31; Regulation No. 35 - *Classifications and Numeric Standards for Gunnison and Lower Dolores River Basins*, 5 CCR 1002-35; Regulation No. 93 - *Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation List,* 5 CCR 1002-93.

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”.

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 2020 however, the Gunnison Basin will not be the focal point of the 303(d) List until the 2022 update.

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 version of the 303(d) and M&E List used in this assessment was effective on March 2, 2018.[19]

[19] Regulation No. 93, *id.*

Chapter 3
Environmental Issues

Several environmental characteristics were assessed and summarized based on information collected from existing studies, stakeholder feedback, and field assessments. The following issues occurred commonly in all of the Phase I Basins.

1.1 Stream and Riparian Characteristics

The current condition of a stream and the adjacent riparian areas reflect the action of both natural processes and human activity. Stream and riparian characteristics provide important context to understand stream stability and watershed function. This assessment included a cursory review of channel and landscape form, debris supply, floodplain connectivity, stream stability, and physical structure. The objective of this portion of the assessment was to preliminarily evaluate issues identified by stakeholders and to support field assessment locations.

1.2 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 and invertebrates, also called macroinvertebrates, 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.

Diversions are the most common and severe stressor to aquatic life within a watershed. When diversions account for a considerable portion of the stream flow, the following issues tend to affect aquatic life:

- Many diversion structures prevent fish passage. During high flows, the velocities near diversion structures can be too swift to allow for upstream passage. During low flow periods, the diversion structure may dry up or nearly dry up down-gradient sections of the stream. As noted previously, to place a water right call, a water user must dry up the stream.

- Reductions in natural flows alter natural sediment transport regimes. Over time, this may alter the channel form, habitat types, and bed materials available to aquatic life.

- Reductions in natural flows may alter water temperatures. Increased temperatures reduce dissolved oxygen concentrations and may alter additional water quality characteristics (e.g. metals solubility).

- Return flows from irrigated parcels can support late season stream flows. The duration that return flows support stream flows is subject to the reach characteristics, including the stream, riparian area, and irrigated parcels and the irrigation practices employed in that area. Generally, about 50 percent of the water diverted that is not consumed by vegetation returns to the stream in four days or less; an additional 35 percent returns within approximately 60 days. The physical and chemical characteristics of return flows are difficult to measure, as a portion returns through the shallow alluvium. Return flows may accumulate nonpoint source pollutants, like nitrogen or phosphorus, that may reduce the quality of water in the stream. In addition, return flows may alter stream temperatures.

1.3 Water Quality

The assessment process identified various water quality issues, ranging from heavy metal loading to increased concern over *E. coli* concentrations and nutrient loading. Water quality was examined by reviewing Colorado's 303(d) list for impaired waters, assessment files compiled by the WQCD, and data included in the national water quality portal. Data was reviewed from 2000 to present to determine if reaches were meeting both chronic and acute water quality standards.

For instance, the water supply standard for arsenic is a two-part standard. The first criterion is a human-health standard of 0.02 µg/L. The second criterion is a maximum contaminant level, developed through the federal Safe Drinking Water Act. The maximum contaminant level is the acceptable level of a substance in public water supplies and accounts for treatability and laboratory detection limits. The maximum contaminant level for arsenic is 10 µg/L. In practice, this means that raw source waters for public drinking water systems are not classified as impaired unless arsenic concentrations exceed 10 µg/L. There was insufficient data available to review certain water quality components, including nutrient loading.

1.4 Water Temperature

Water temperature provides a critical role in regulating the physical and chemical characteristics of streams. As water temperature increases, dissolved oxygen concentrations decrease. Aquatic organisms require adequate dissolved oxygen to survive. Likewise, warm waters are more effective solvents than cold waters; which can increase the concentrations of metals, salts, and other constituents.

The stream temperature standards, which are applied to protect fish and other aquatic organisms, require continuous temperature data collection (e.g. the standard is not typically evaluated using a single temperature measurement). The chronic standard, which assesses "long-term" stress to fish, is based on the mean weekly average temperature. The acute standard is based on the daily maximum, which is the highest two-hour average water temperature recorded during a given 24-hour period.

1.5 Flow Limited Areas

Streamflow quantity and timing are critical components of water supply, water quality, and the ecological integrity of river systems. Indeed, streamflow, which is strongly correlated with many critical physicochemical characteristics of rivers, such as water temperature, channel geomorphology, and habitat diversity, can be considered a “master variable” that limits the distribution and abundance of riverine species. [20]

One purpose for the assessment described in this Report is to identify current flow conditions in the rivers and streams in the basin. For this purpose, the Basin Coordinators used stakeholder input and records of administrative calls to identify locations where diversions either dried up the stream or significantly reduced the flow (“near dry up” indicates at least a 50 percent reduction). Under Colorado law, an irrigator is required to dry up the stream in order to place a call to satisfy a decreed senior water right (see Section 1.1 above), so a “dry up” identified in this Report may be a function of normal water rights administration. Under current law, there is no alternative for the irrigator. Where dry up occurs as a result of physical water availability, or near dry up occurs, it is possible that there are options for water use efficiency that could reduce the impact on the stream without affecting irrigation. Those options will be evaluated in future phases of the planning process, Examples being tested are described in Chapter 8.

1.6 Environmental Flow Goals

The WMPC uses the term “environmental flow goals” to refer to stream flow goals in excess of existing or potential instream flow water rights. Preliminary environmental flow goals were developed, or recommended, on selected reaches based on the uses and priorities specific to the reach. Over time, the WMPC plans to create tiered environmental flow goals on selected reaches. This work will occur in subsequent phases of the planning process and will include ample stakeholder outreach.

[20] Poff, L. et al (1997). *The Natural Flow Regime.* Stomberg BioScience, Vol. 47, No. 11, pgs. 769-784.

Chapter 4
Stakeholder Engagement

Stakeholder engagement is key to successful watershed management from the beginning of the assessment and planning process. This task runs concurrent with other tasks because stakeholder input was sought for all aspects of the project, from data gathering to planning and implementation.

The primary objectives of this task are twofold. The first objective is to identify different stakeholders' perception of water user and watershed health needs under current conditions; the second is to identify needs they perceive based upon projected changes in the future.

At the beginning of the process, Basin Coordinators for each of the Phase I Basins were identified based upon their expertise as it relates to stakeholders and needs in these Basins. Once the Coordinators were identified, each worked on preparing a preliminary list of stakeholders, and contacts were made. As part of the initial contacts, the WMPC developed a survey regarding the values and perceptions about water use, environmental and recreational conditions. The standard survey is reproduced below.

Upper Gunnison Watershed Planning Questionnaire

The mission of the Watershed Management Planning Committee (WMPC) is to help protect existing water uses and watershed health in the Upper Gunnison Basin in the face of pressure from increased water demands and permanent reductions in water supply.

Your responses to these questions will help the Upper Gunnison River Water Conservancy District and its partners to develop a Watershed Management Plan to prioritize the projects or programs that will protect existing uses and improve watershed health through 2050. We want to hear your ideas on how water resource uses could be managed to protect existing uses and to improve local watershed health. We want to hear your concerns about how growth and climate changes might impact local water resources. Please skip questions that are not relevant to you.

NAME (Optional): ____

CONTACT INFORMATION: ____________________________________

____

Please let us know if we can contact you for an interview regarding your responses to the questionnaire. Yes _____ No _____

Please mark all that apply:

Full time resident	___	Landowner	___
Part-time resident	___	Size of Property	___________
Local Business Owner	___	Water rights (categories)	___________
Public service (government, non-profit, etc.)	___	Choose not to answer	___

1. **What type of water use categories would you, your property, or your business best be associated with? (Select all that apply)**

Agricultural	_____	Recreation (boating–commercial)	_____
Industrial	_____	Recreation (boating–personal)	_____
Recreation (fishing-commercial)	_____	Domestic (central water system)	_____
Recreation (fishing-personal)	_____	Domestic (individual well)	_____

2. **What information would you like to have about your watershed?**

3. **Do you have any planning or legal concerns about your watershed?**

4. **Do you have any concerns related to the following topics: yes/no/uncertain (if yes, please explain)**

   - **Low flows**
   - **Riparian degradation (erosion, bank stability, etc.)**
   - **Irrigation shortages**
   - **Recreation access**
   - **Fish habitat**
   - **Other (Some examples are water infrastructure needs, water quality, stream temperature, etc.)**

5. **Do you have recommendations for projects or actions that could help improve water use for your property or business (i.e. a diversion structure reconstruction, riparian restoration, an efficiency project)?**

6. **Do you have recommended projects or programs that will help improve water use for your watershed?**

7. **Do you have recommended projects or programs that could help improve water quality?**

8. **What could be done, if anything, to improve recreational opportunities in the area (quality, use, and/or safety)?**

9. **Have you experienced or are you aware of conflicts between water users?**

10. **What could be done to improve irrigation infrastructure in the watershed?**

11. **What is your biggest concern about the future of water uses in your watershed (i.e. irrigation shortages, downstream calls, riparian health late season flows, Big River Issues i.e. Colorado River issues)?**

12. **Are there additional objectives or issues that you would like to see addressed in the attached watershed assessment framework?**

The stakeholder issues identified by the surveys are depicted below.

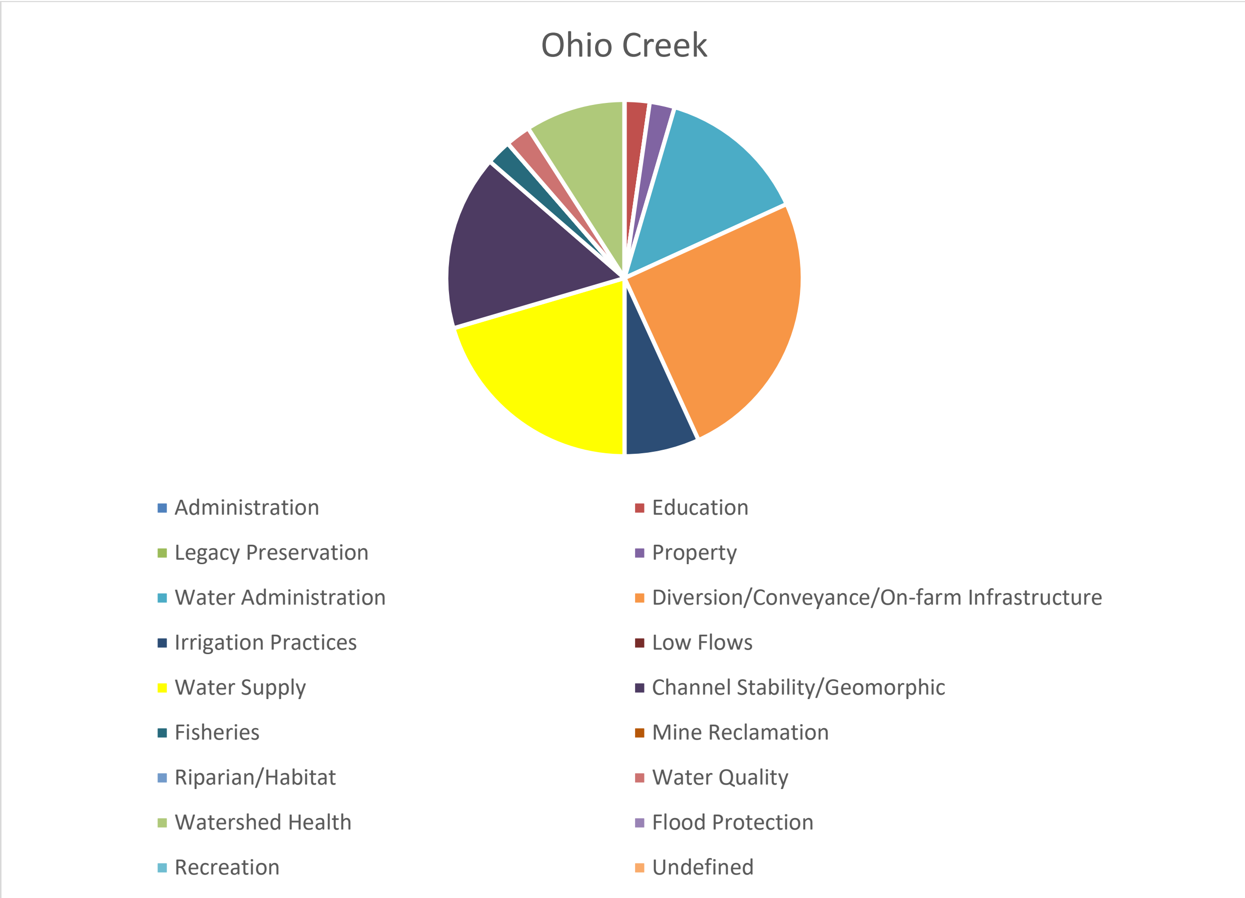


Figure 4-1: Ohio Creek Stakeholder Identified Issues

Figure 4-2: East River Stakeholder Identified Issues

Figure 4-3: Lake Fork Stakeholder Identified Issues

Based on the results of these surveys received in each of the Phase I Basins, the Basin Coordinators and District staff continued conversations with targeted groups and individuals regarding Basin issues, information gaps, potential pilot projects, and possible long-term solutions. This enabled the Basin Coordinators to build and maintain relationships with stakeholders. Contact will continue throughout the planning process. While stakeholder involvement for regularly scheduled committee meetings has been less than desirable, one-on-one contact with the Basin Coordinators has provided significant input, particularly in areas of pilot project development and the establishment of stakeholder groups throughout the Phase I Basins.

Chapter 5
The Ohio Creek Basin

Section 1. Basin Characteristics

Ohio Creek is a tributary to the Gunnison River flowing southeast through a valley of irrigated mountain meadows and productive ranches. Ohio Creek originates near Ohio Pass and is fed by major tributaries including Castle Creek, Mill Creek, Carbon Creek, and Pass Creek until it joins the Gunnison River near the city of Gunnison. During the last several decades the Ohio Creek Basin has seen an increase in residential development and a surge of new property owners attracted by the agricultural and recreational attributes of this mountain valley.

Irrigation for pasture grass production is the primary water use with 11,680 irrigated acres served by water diverted from Ohio Creek and its tributaries. Virtually all of the land in the valley bottoms is privately owned, with the exception of a small parcel owned by the Colorado State Land Board. Access to Ohio Creek for angling, and other water related recreational activities for the public is restricted to headwater areas, at elevations generally greater than 9,000 feet, on lands managed by the USFS.

Seven "multi-generational" ranch families remain in the Ohio Creek Basin and continue to manage large parcels for agricultural production. Production of high-quality hay and pasture for cattle is the foundation of these operations. A small portion of hay produced in Ohio Creek is exported from the Gunnison Basin.

Amenity ranches, which include a mixture of homes and ranchland, make up a large proportion of the Ohio Creek Basin. These properties are in agricultural production and often leased for cattle grazing or contract haying by local producers. These properties provide tax revenue and a variety of jobs including construction, maintenance, and management that benefit the greater Gunnison economy. In many cases, the amenity ranches manage the fishery for private angling.

The remaining land, primarily located on lower Ohio Creek, has been split into smaller "residential" sized parcels owned by individuals or entities. Irrigation for pasture grass production is still a primary water use in this area, but emphasis is feed for horses more so than cattle. Household wells, which are used throughout the Basin, account for a small percentage of total water use.

Further development in the Ohio Creek watershed is limited due to the number of properties with existing conservation easements. A total of 13,770 acres are protected in conservation easements held by Colorado Open Lands or Colorado Cattleman's Land Trust. These easements protect a variety of values important to the community including agricultural use, wildlife habitat, and open space. Development in lower Ohio Creek has been restricted by the presence of a CWCB instream flow water right, which limits the availability of new wells. There currently is no augmentation plan able to address this limitation.

While irrigation is the primary water use in the Ohio Creek Basin, approximately 19 stream miles are actively managed for angling by property owners and their guests.

Variable water supply is the most challenging issue for water users on Ohio Creek and lack of storage exacerbates this issue particularly during below average water years. Balancing solutions to reduce water shortages with the benefits of surface and groundwater flow patterns is a challenging task for future water management on Ohio Creek. Several stakeholders stressed that these patterns need to be accounted for if any changes in irrigation practices are made.

The primary objective of this section is to provide a summary of existing water use within the Ohio Creek Basin, including irrigation, domestic, environmental, and recreational. A major task for the WMPC was to review and assess the available information, update and refine the information, identify data gaps, and recommend future data collection efforts. The information collected as part of the data inventory process served as a key component to both identifying needs in the Ohio Creek Basin and to improve modeling tools being used to assess these needs.

Figure 1-1 shows the Ohio Creek Basin boundaries, highways and local roads, active streamflow gages, and public/managed land designation. Approximately 70 percent of the land within the watershed boundary is public. A significant portion of the private land occurs on the floor of the Ohio Creek Basin and is primarily used for cattle operations and rural subdivisions.

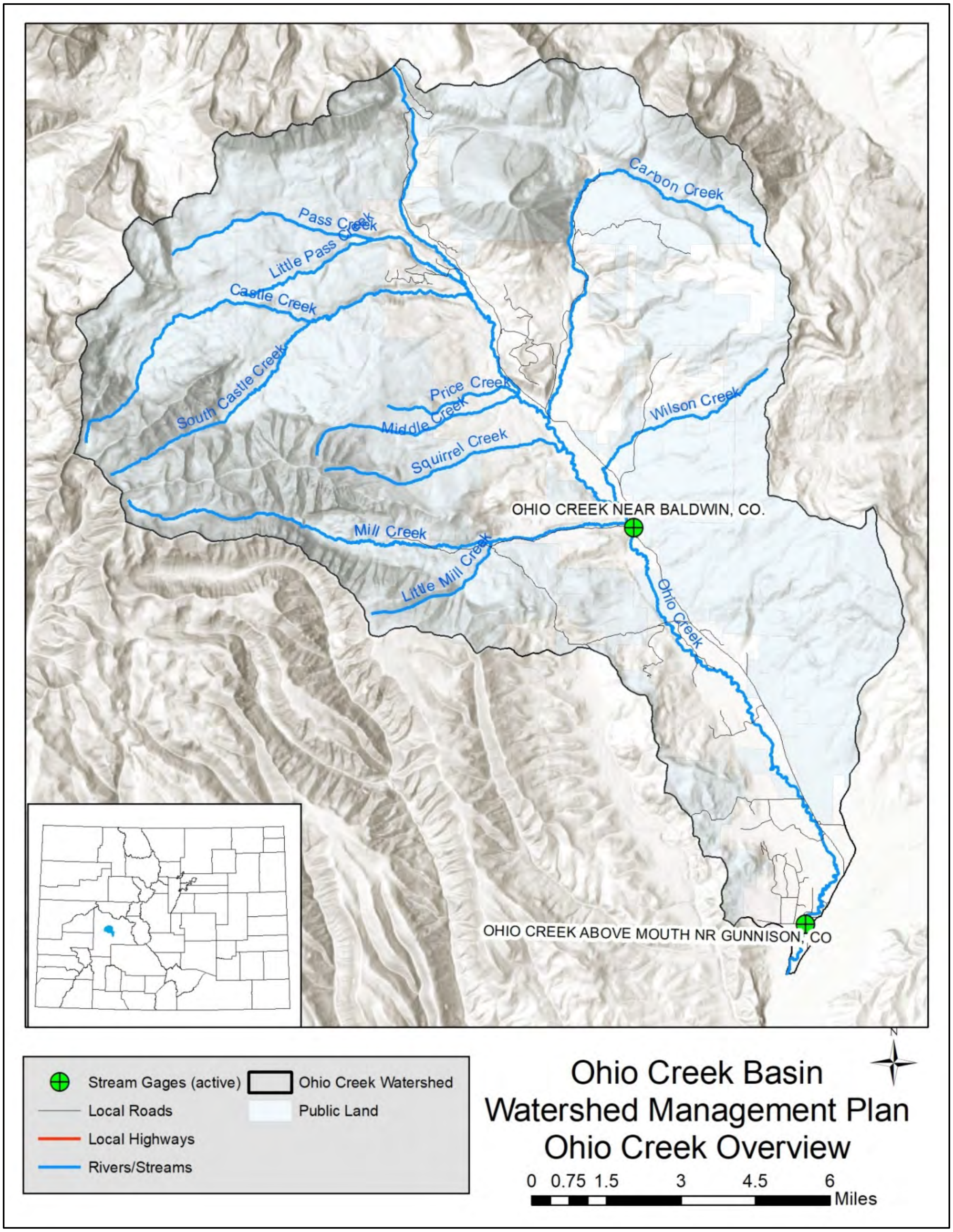


Figure 1-1: Ohio Creek Basin Overview Map

Section 2. Data Assessment

2.1 Streamflow Measurements

There are two stream gages currently measuring streamflow in the Ohio Creek Basin, both with a relatively short period of record. The ‘Ohio Creek above the Mouth near Gunnison’ gage has been active since 1999 and the ‘Ohio Creek near Baldwin’ gage was re-installed by United States Geological Survey (USGS) in 2019 near the confluence of Mill Creek to assist with water administration and watershed management. In addition, there are four inactive gages that were used to assess streamflow over a longer period. Table 2-1 summarizes the drainage area, period of record, and average annual flow for both the active and inactive stream gages. Figure 1-1 includes the location of the active gages.

Table 2-1: Summary of Active and Inactive Stream Gages in the Ohio Creek Basin

Stream Gage Name	Gage ID	Status	Drainage Area (Sq. Mi.)	Period of Record	Average Annual Flow (Acre-Feet)
Castle Creek nr Baldwin	09113000	Inactive	20.3	1945-1950	23,900
Castle Creek ab Mouth nr Baldwin	09113100	Inactive	22.4	1993-1998	27,200
Ohio Creek at Baldwin	09113300	Inactive	47.2	1959-1970	33,700
Ohio Creek nr Baldwin	09113500	Active	121	1940-1950 1959-1971 1980-1981 2019-Present	65,800
Ohio Creek ab Mouth nr Gunnison	09113980	Active	163	1999-Present	49,100
Ohio Creek nr Gunnison	09114000	Inactive	167	1945-1950	73,800

The streamflow in Ohio Creek Basin during runoff is highly variable and largely dependent upon snowpack. During the irrigation season, the streamflow at the Ohio Creek above Mouth near Gunnison gage is significantly impacted by upstream irrigation use. Irrigation return flows from about 500 acres are not represented in the streamflow measurements as they accrue to Ohio Creek below the gage. Figure 2-2 shows daily flow for 2005 through 2017, a recent period that is representative of the range of streamflow in the Basin. The following observations can be made based on the figure:

- This period includes wet years of 2008, 2011, and 2015; and one of the driest years on record, 2012. The difference in annual stream flow between 2012 and 2008 is more than 69,000 acre-feet (acre-feet) at the Ohio Creek above the Mouth near Gunnison.
- Annual streamflow in 2012 was less than 20 percent of the 2008 annual streamflow.
- Annual streamflow volumes were similar in 2008, 2011, and 2017. In 2017, an early runoff occurred, resulting in the highest March and April flows on record at that gage.

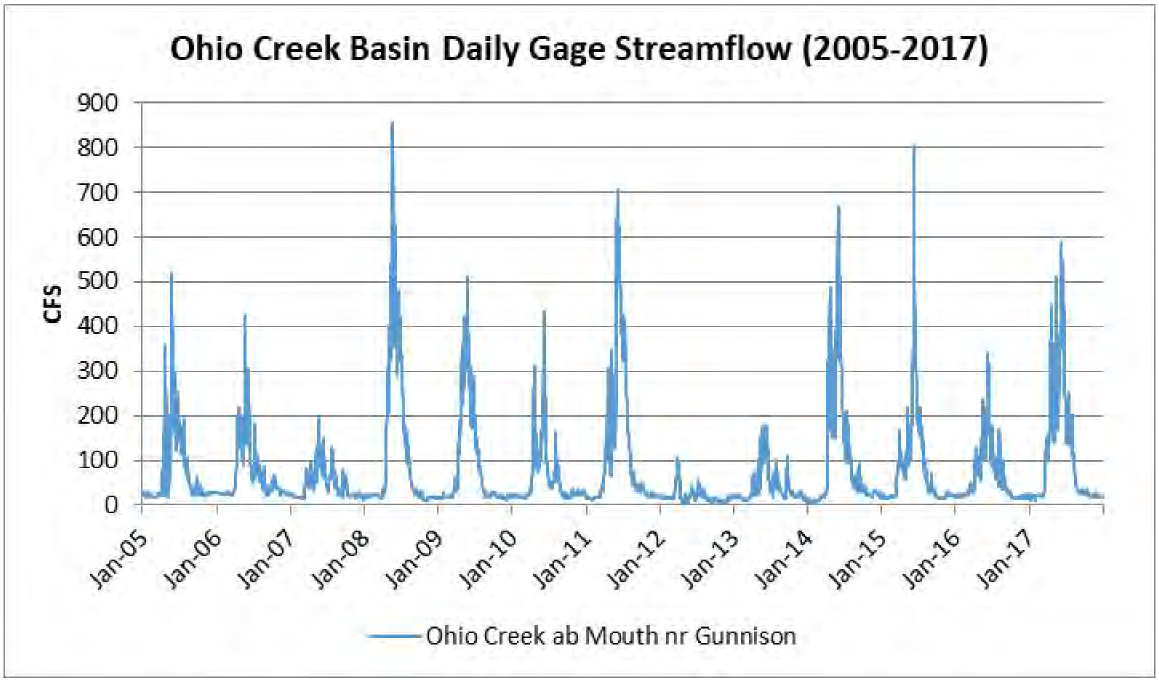


Figure 2-2: Ohio Creek Basin Streamflow (2005-2017)

Figure 2-3 shows the historical annual streamflow volume for the available period 1999 through 2017, along with the 10-year running average for the Ohio Creek at Mouth near Gunnison gage. As shown, streamflow varies widely during the period. The 10-year running average has gradually increased as dry years in the early 2000s dropped out of the 10-year running average.

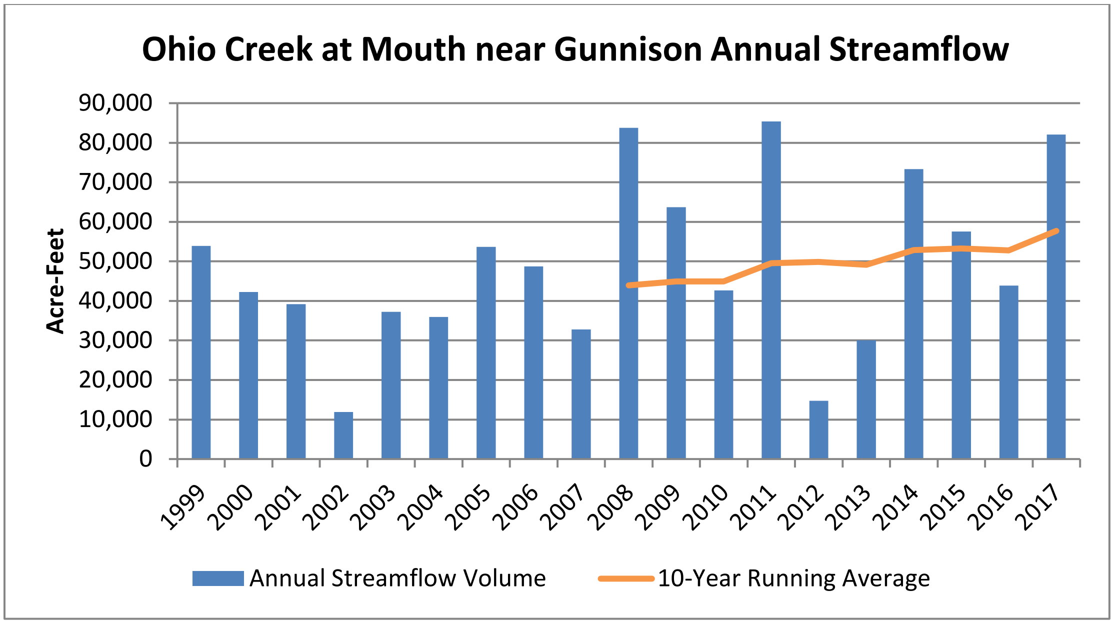


Figure 2-3: Ohio Creek at Mouth Annual Streamflow (1999-2017)

Figure 2-4 shows the average monthly flow at the Ohio Creek above Mouth gage over the 1998 through 2017 period. Water from snowmelt runoff in May, June, and July accounts for nearly 70 percent of the annual streamflow.

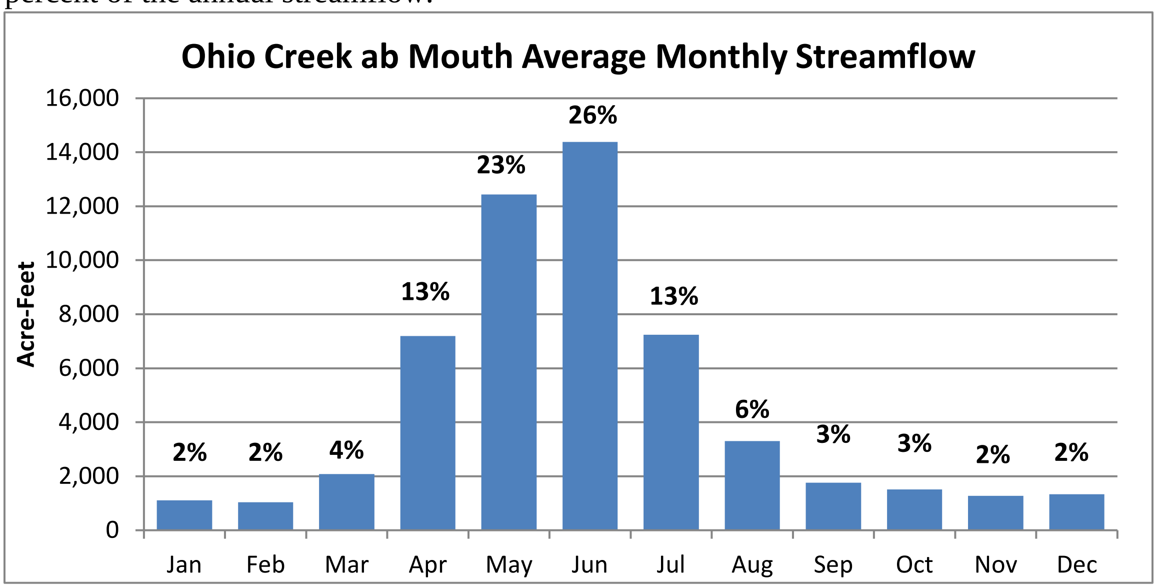


Figure 2-4: Ohio Creek above Mouth near Gunnison Average Monthly Streamflow (1998-2017)

2.2 Climate Data

Crop irrigation demands are dependent on weather during the irrigation season, with temperature being the primary driver. Figure 2-5 highlights the variability of average irrigation season temperature (May through September) at the long-term National Weather Service Cooperative Observer (NWS Coop) station in Gunnison. The Gunnison NWS gage and the Crested Butte NWS gage are both used to estimate climate-driven crop demands in the Ohio Creek Basin. The 10-year running average temperature increased during the 1980s but does not show a clear trend toward higher irrigation season temperatures in recent years.

A Colorado Agricultural Meteorological Network (CoAgMet) climate station, operated through Colorado State University, was installed on agricultural land in the lower Ohio Creek Basin in 2016. Unlike National Weather Service stations, this station measures additional information important to understanding crop demands, including solar radiation, vapor pressure, and wind speed. This station will be important to understanding crop demands into the future.

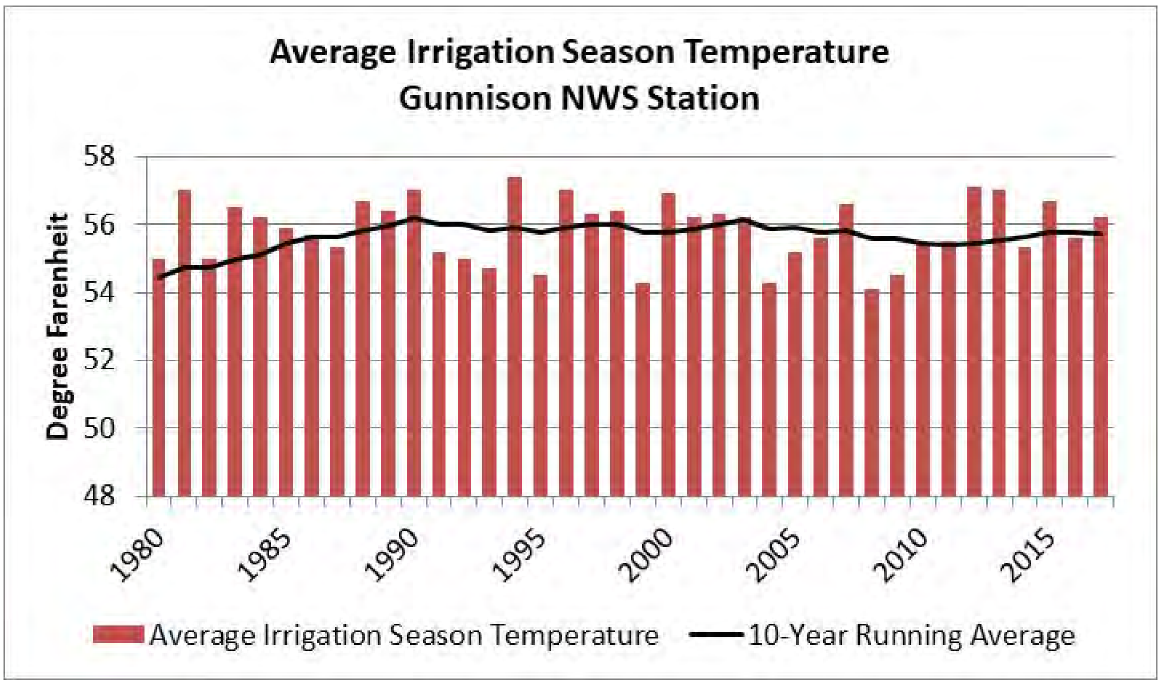


Figure 2-5: Average Irrigation Season Temperature at Gunnison (1980-2017)

Soil saturation from snowmelt during the spring and precipitation during the irrigation season reduces the amount of water required from irrigation diversions to meet crop demands. Figure 2-6 highlights the variability of total irrigation season precipitation (May through September) at the long-term NWS Coop station in Gunnison from 1980 to 2017. The total irrigation season precipitation varies from a high of nine inches in 1981 to less than three inches in 1980 and

2002. Precipitation in Crested Butte is generally greater every month than at the Gunnison NWS station, and is used in combination with the Gunnison station to better represent climate conditions in the upper reaches of the Ohio Creek Basin.

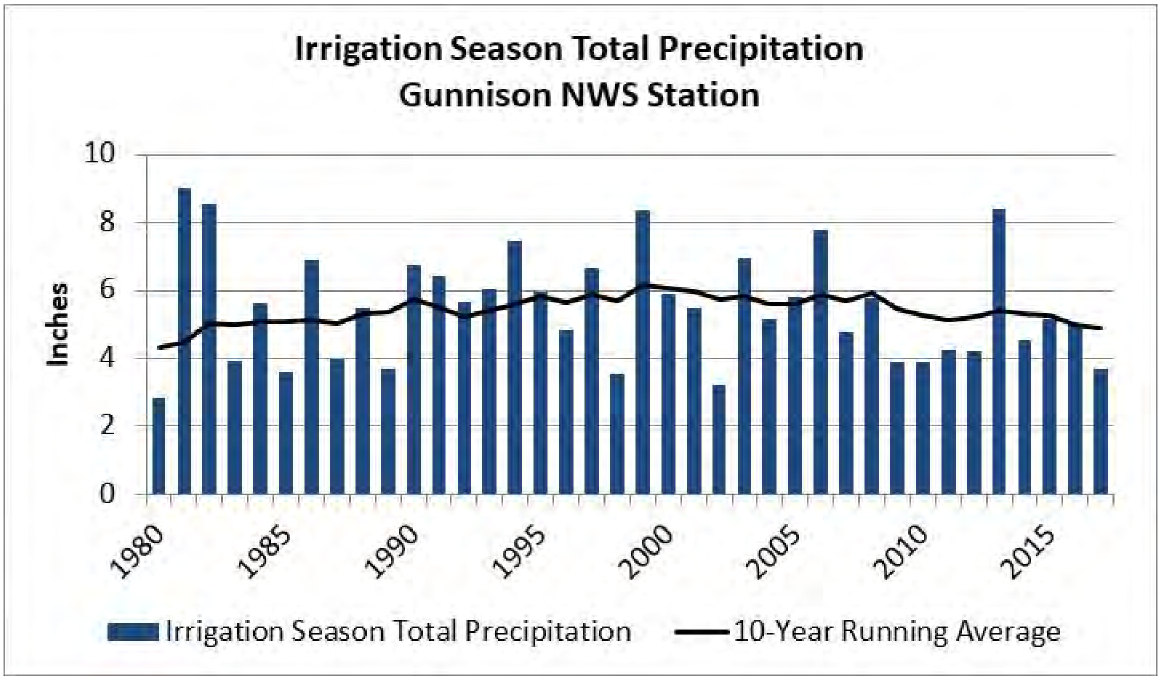


Figure 2-6: Total Irrigation Season Precipitation at Gunnison (1980-2017)

2.3 Irrigated Acreage

The majority of consumptive water use in the Upper Gunnison River Basin is for irrigation of pasture grass; therefore, it is essential to accurately represent the irrigated acreage and associated irrigation demand. CWCB developed irrigated acreage snapshots for the Gunnison River Basin for 1993, 2005, 2010, and 2015 as a key component of the CDSS. The data sets include acreage, crop type, and associated irrigation ditch. The WMP assessment determined that the acreage was appropriately represented, but the association between acreage and the supply ditch was not detailed enough to accurately tie the acreage to diversions and associated water rights. Through discussions with CWCB and DWR, they recognized that the irrigated acreage assessment needed to be refined to represent each ditch discreetly.

During this assessment, consultants worked with local water commissioners and water users to more accurately tie irrigated acreage to source ditch and associated water rights. This was a major effort and resulted in a more accurate representation of irrigation demands for each active ditch in the Upper Gunnison River Basin. This information was provided to the state, and consultants continue to work with CWCB to make the corresponding updates to the historical

GIS snapshot coverages (2010, 2005, and 1993) for inclusion in the State's records. Each of the updated coverages will be made available on the CDSS website.

The total irrigated acreage in the Ohio Creek Basin as of 2015 is approximately 11,680 acres. Based on review of aerial photos, and discussion with local water experts, there has been a reduction of around 300 irrigated acres near the confluence with the Gunnison River since the early 1990s to accommodate the residential development around Gunnison.

2.4 Water Rights

DWR created unique identifiers for each of the decreed points of diversion. DWR developed the official water rights tabulation, based on water court decrees, and assigned each water right to the associated ditch. The water rights assignments in HydroBase are believed to be accurate and appropriate for use in the WMP efforts.

The Ohio Creek Basin has minimal existing storage, just under 350 acre-feet of absolute storage rights. More than half of the absolute storage rights are CWCB rights to maintain minimum natural lake levels. The other absolute storage rights are primarily for recreation, stock, and wildlife.

Figure 2-7 presents the cumulative absolute direct flow water rights in the Ohio Creek Basin, highlighting major Basin adjudication dates and key water rights. The DWR Administration Number indicates the water right priorities based on both appropriation date and adjudication date and is used by DWR for administration throughout the state. As discussed in Section 1.1 of Chapter 2, and shown in the figure, Aspinall Unit water rights are subordinated to current and future Upper Gunnison River Basin water rights junior to the Aspinall Unit water rights up to 40,000 acre-feet of annual depletions.

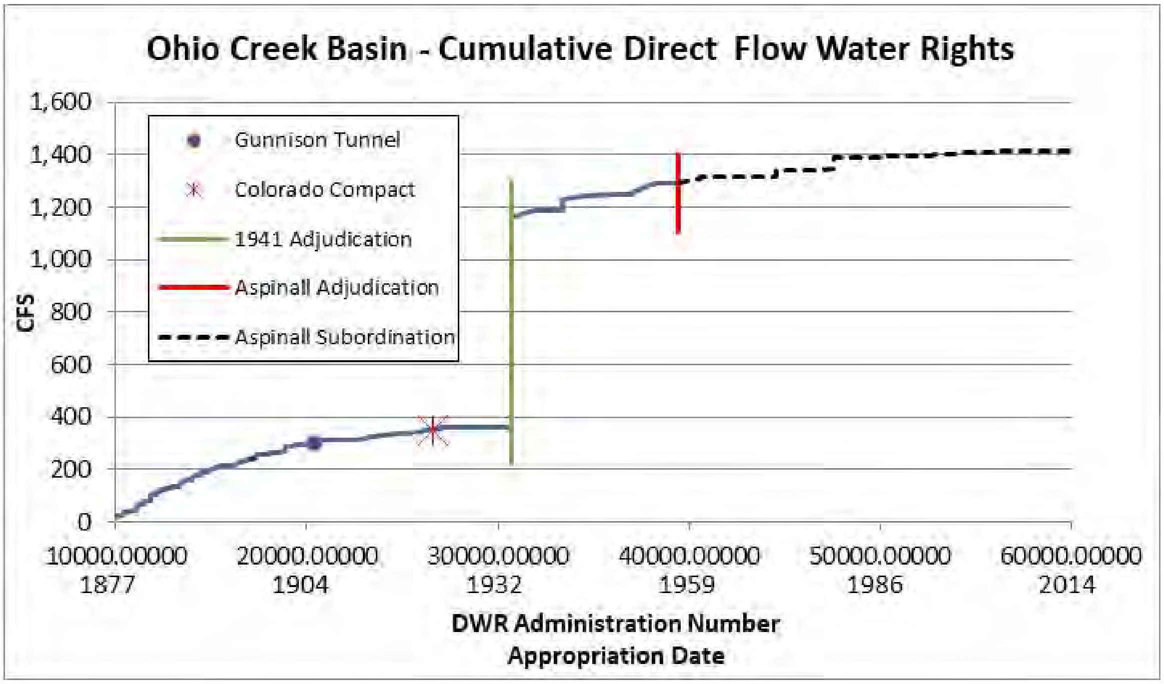


Figure 2-7: Ohio Creek Basin Cumulative Direct Flow Water Rights

There are conditional direct flow water rights totaling 47 cfs in the Ohio Creek Basin. Four conditional water rights account for 45 cfs of the total decreed rate: Eilbrecht-Mill Creek Ditch has a conditional right of 26 cfs for irrigation and Carbon Creek Intake has a conditional right for 10 cfs for irrigation, industrial, fire and domestic uses. The other two larger conditional rights are for the Goddard North Braid Ditch and the Goddard South Braid Ditch, both for recreational and fishery use. Most of the remaining conditional water rights are for domestic use, with rates of less than 0.01 cfs. Conditional storage rights total 1,236 acre-feet in the Ohio Creek Basin. The Mill Water Reservoir conditional storage right is for 1,000 acre-feet for irrigation, industrial, fire, and domestic uses. Two other conditional reservoir rights include irrigation use (Thornton Reservoir No. 1 and Buffington Reservoir). The remaining conditional rights are for stock, fish and wildlife, and augmentation.

The Ohio Creek Basin includes eight decreed instream flow water rights, summarized in Table 2-2 and shown in Figure 2-8. These rights are junior to most of the irrigation rights in the Basin. The instream flow rights in the Ohio Creek Basin were all appropriated in 1980. The instream flow water rights are discussed further in subsection 4.3.5 below.

Table 2-2: Existing Instream Flow Water Rights in the Ohio Creek Basin

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Decreed Flow Rate (cfs)
Carbon Creek	Headwaters of Carbon Creek	Confluence of Ohio Creek	3/17/1980	9.3	3
Castle Creek	Confluence of North and South Castle Creeks	Headgate at Acme Ditch	3/17/1980	3.1	7
Mill Creek	Headwaters of Mill Creek	Forest Service Boundary	3/17/1980	7.5	5
North Castle Creek	Headwaters of Castle Creek	Confluence of South Castle Creek	3/17/1980	6	4
Ohio Creek – Segment 1	Headwaters of Ohio Creek	Confluence of Castle Creek	3/17/1980	5.2	3
Ohio Creek – Segment 2	Confluence of Castle Creek	Confluence of Mill Creek	3/17/1980	6.9	10
Ohio Creek – Segment 3	Confluence of Mill Creek	Confluence of Gunnison River	3/17/1980	13.4	12
Pass Creek	Headwaters of Pass Creek	Confluence of Ohio Creek	3/17/1980	6.8	3

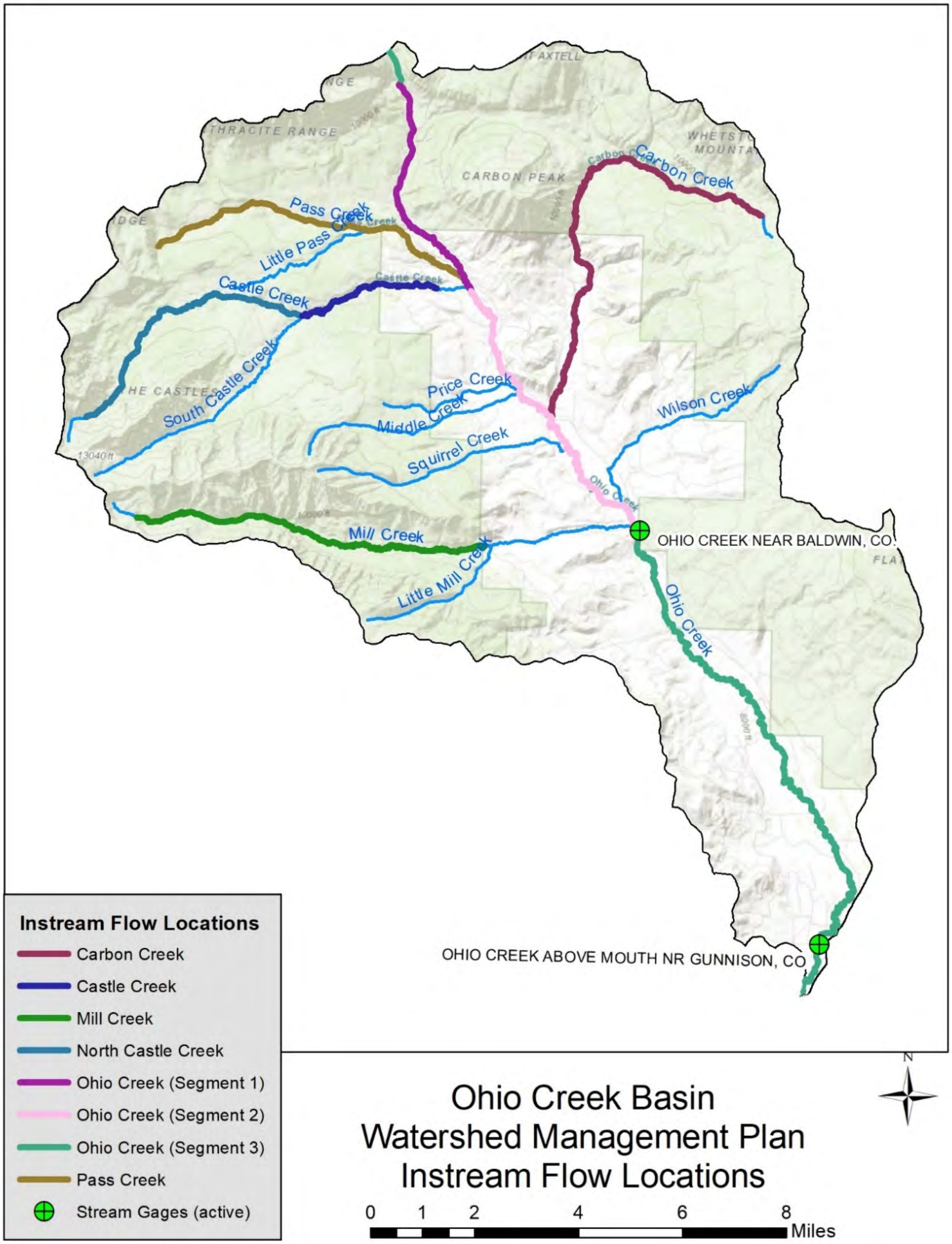


Figure 2-8: Instream Flow Reaches in the Ohio Creek Basin

CWCB also has storage rights to protect minimum water levels in six natural lakes in the Ohio Creek Basin, totaling 228 acre-feet. The six natural lakes are high in the watershed, above other water uses.

2.5 Diversion Records

The water commissioner is responsible for recording diversions for over 250 ditches that divert water for irrigation in Water District 59, of which 100 have irrigated acreage assigned in the Ohio Creek Basin. Many of the ditch headgates are challenging to access and require a significant amount of time to visit. There are no diversions with continuous recorders, so diversion records are either provided by the water user annually or, most commonly, are "spot-diversions" reported when the water commissioner visits the headgate and records the amount of water diverted on that day.

DWR uses the "fill-forward" approach where the spot-diversion record is repeated for each day until the water commissioner visits the headgate and reports an updated diversion rate. Based on the review of diversion records and discussions with the water commissioner, it is common for the water commissioner to visit each headgate only once per month during the irrigation season. Note that although this is typical of most water districts in western Colorado, diversion records do not reflect changes in daily streamflow. In addition, daily variation in flows, most notably during runoff or following large precipitation events, can cause diversion rates to change throughout the day, which can only be captured with continuous diversion loggers which are not currently used in the Basin. Figure 2-9 provides example diversions in the Ohio Creek Basin for 2011 and 2012 where the fill-forward approach was used by DWR. In many cases, the irrigation start and stop dates are estimated by the water commissioner rather than reported by the water users. In addition, the diversion records do not include information about operational practices, for example reducing diversions to allow fields to dry before haying. These data gaps influence the results of both StateCU and StateMod.

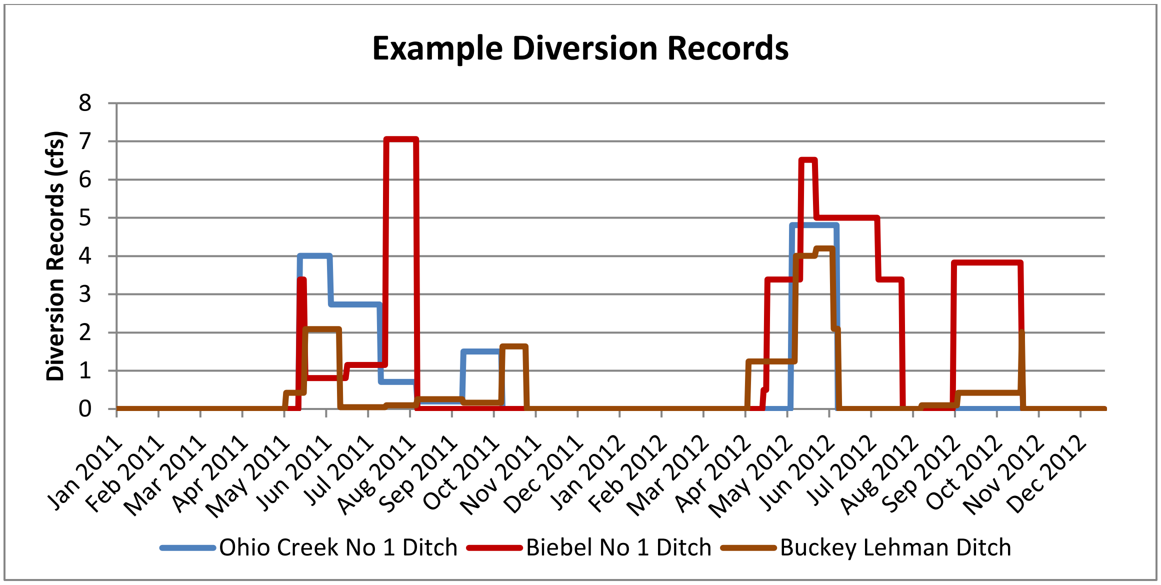


Figure 2-9: Example of the Fill-Forward Approach for Reporting Diversions

According to information provided by the water commissioner, 95 percent of the diversions in the Ohio Creek Basin have Parshall flumes or other flow control measurement devices that allow both the water commissioner and water users to quickly record diversions. For diversions without measurement devices, the water commissioner either estimates flow using the “chip-test” approach by estimating velocity and depth to determine flow rate, or simply provides a “water taken but no data available” comment in the official record.

Based on the review of diversion records, discussions with the water commissioner, and feedback from the Division 4 Engineer, the most effective way to improve diversion records is to encourage irrigators to install or maintain an accurate flow measuring device and document their use on a daily or weekly basis. Specifically, they can report dates when they start and stop irrigating each year and provide flume measurements when diversions increase or decrease. Keeping accurate diversions records and providing those records to the water commissioner is the best way for irrigators to protect their water rights.

Despite their limitations, the diversion records maintained by DWR are the most comprehensive source of data for agricultural water use. There are 108 active ditches in the Ohio Creek Basin and, as noted above, 100 of those ditches have been associated with specific irrigated acreage. From 2008 to 2017, diversions for irrigation totaled an average of 65,700 acre-feet per year. Similar to streamflow, annual diversions are variable, as shown in Figure 2-10. On average, diversions in the Ohio Creek Basin are 40 percent greater than the streamflow measured at Ohio Creek at Mouth gage, highlighting the magnitude of irrigation in the Basin.

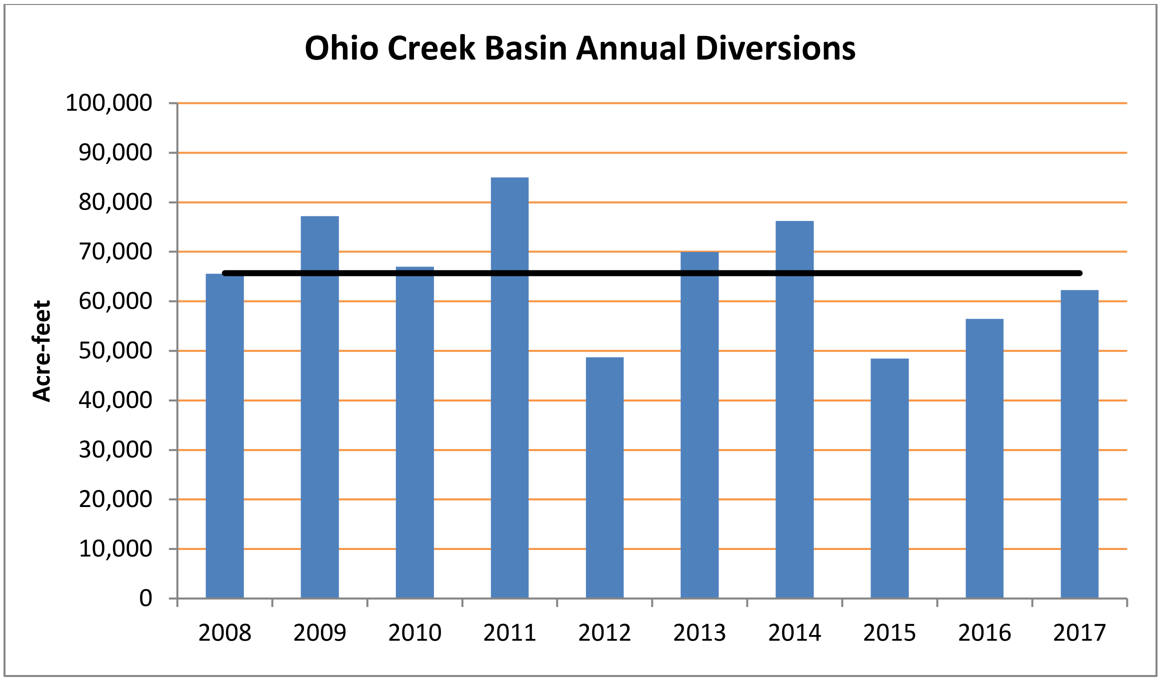


Figure 2-10: Annual Ohio Creek Basin Diversions

Figure 2-11 shows total monthly diversions for a representative average (2010), wet (2011), and dry (2012) hydrologic year in the Ohio Creek Basin. As shown, the amount of water available for irrigation is greater in the representative wet year (2011) and higher diversions continue through July, compared to the representative average year (2010) where diversions drop off after the peak runoff in June. The peak runoff flows in the Ohio Creek Basin shifts to May in drier years, and irrigation diversions occur earlier to capture the reduced available flow, as shown for the representative dry year (2012).

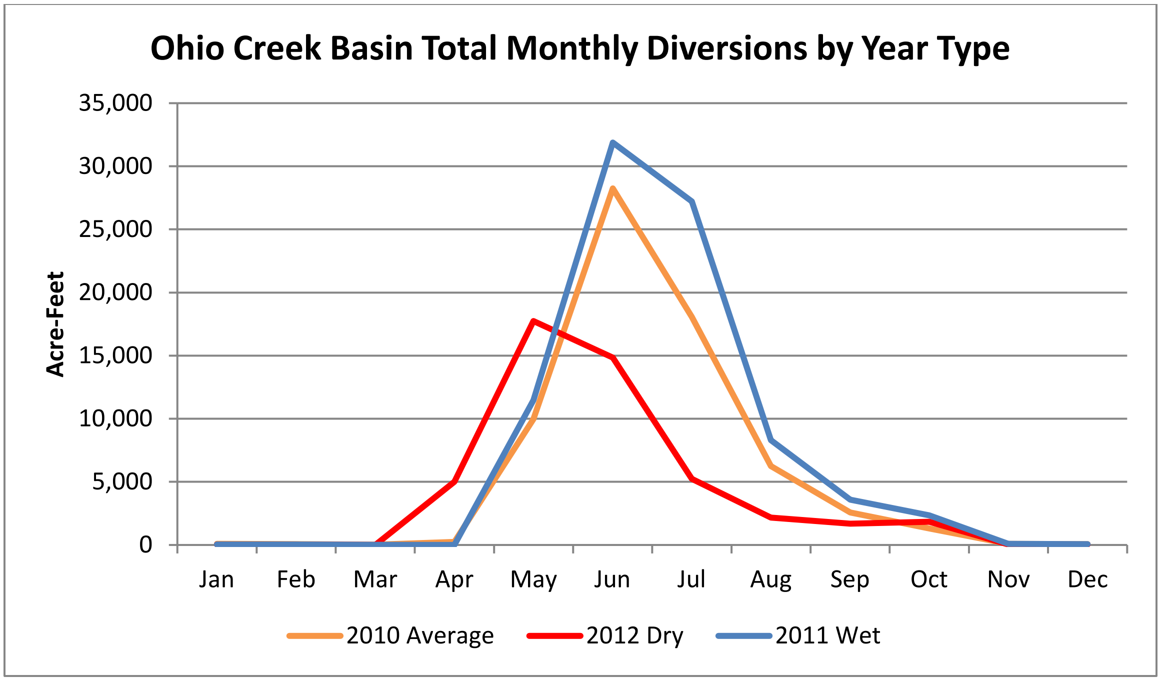


Figure 2-11: Monthly Ohio Creek Diversion for Representative Years

Figure 2-12 shows the location and magnitude of average annual diversions in the Ohio Creek Basin. About half of the ditches divert less than 400 acre-feet per year.

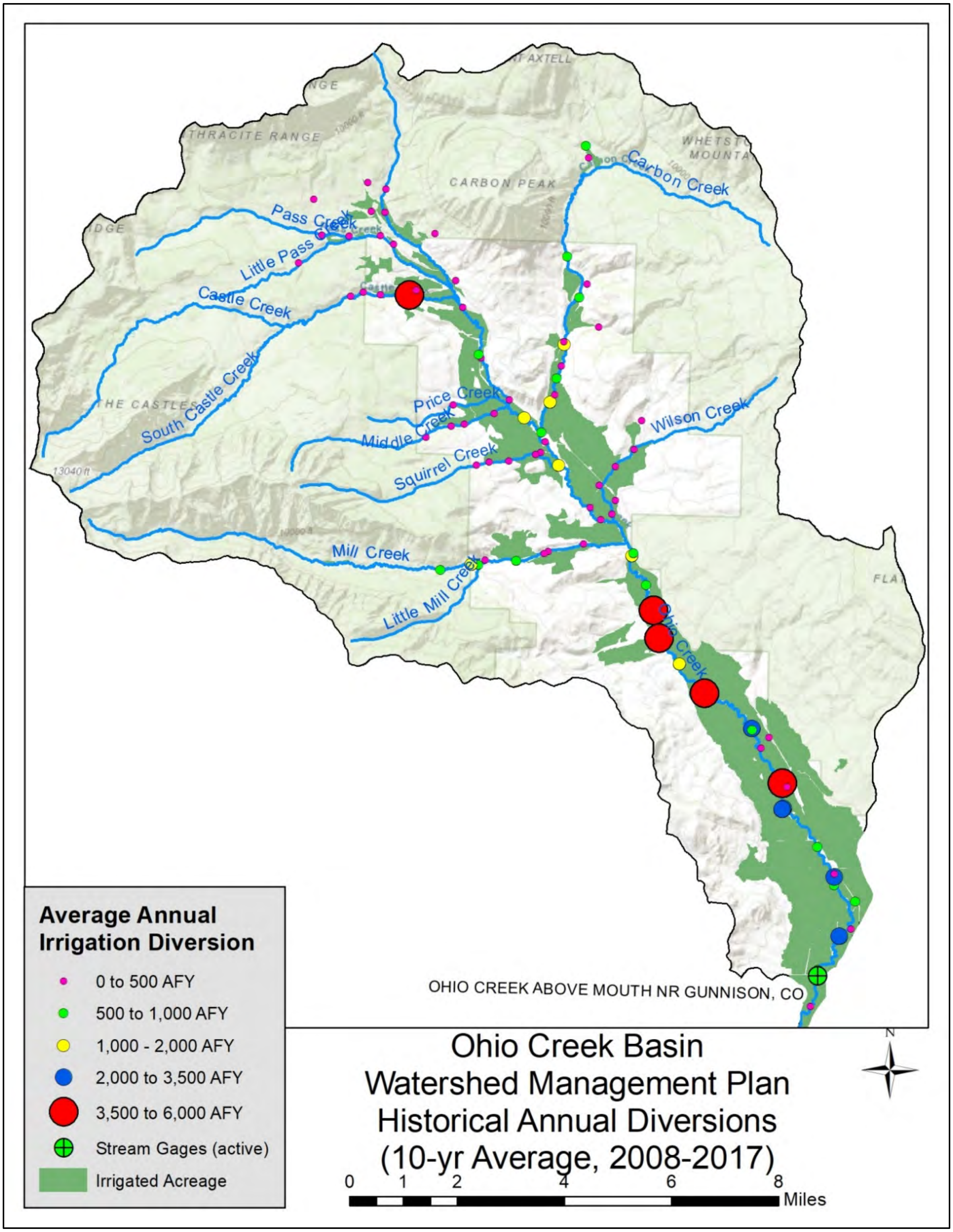

Average Annual Irrigation Diversion
0 to 500 AFY
500 to 1,000 AFY
1,000 - 2,000 AFY
2,000 to 3,500 AFY
3,500 to 6,000 AFY
Stream Gages (active)
Irrigated Acreage
Ohio Creek Basin
Watershed Management Plan
Historical Annual Diversions
(10-yr Average, 2008-2017)
0 1 2 4 6 8 Miles
N
OHIO CREEK ABOVE MOUTH NR GUNNISON, CO
Pass Creek
Little Pass Creek
Castle Creek
South Castle Creek
Carbon Creek
Price Creek
Middle Creek
Squirrel Creek
Wilson Creek
Mill Creek
Little Mill Creek
Ohio Creek
CARBON PEAK
THE CASTLES
13040 ft

Figure 2-12: Average Annual Historical Irrigation Diversions (2008-2017)

2.6 Irrigation Practices

Given the difficulty in obtaining accurate diversion records, it is especially important to understand local and ditch-specific irrigation practices to help inform planning efforts. Interviews with several of the larger ranch owners and operators in the Ohio Creek Basin and with the water commissioner were conducted to gain a better understanding of irrigation practices. In addition to general information regarding irrigation methods and haying and grazing operations; important information was gathered regarding return flows and operations during dry years.

As noted above, pasture grass is grown on all irrigated acreage in the watershed. Water is applied using flood irrigation techniques. Many of the diversions require annual maintenance and are re-worked each irrigation season. Depending on spring temperatures, irrigators begin applying water to their fields between May 1 and June 10, with irrigation generally beginning earlier in the lower portions of the watershed. Irrigators generally get one hay cutting each summer beginning in late July or early August. For the larger ditches, irrigation does not completely cease prior to cutting, but is reduced as fields are dried up and cut in rotation. It generally takes two to three weeks to dry out, so diversions are reduced in the first or second week in July. After cutting, if water is still available, irrigation continues until end of October when cattle are brought back from higher elevation areas to graze.

There are several ditches in the Ohio Creek Basin where irrigation surface return flows accrue to down-gradient ditches. Typically, irrigation surface return flows accrue directly to local drainages or streams. For example, the Teachout Ditch diverts water from Ohio Creek and a portion of the surface runoff from the irrigated fields flows directly into the Gooseberry Mesa Irrigation Ditch, where the surface runoff comingles with river diversions in the Gooseberry Mesa Irrigation Ditch. As this source of supply is not measured through the headgate, the total amount of water available for irrigation was underestimated, resulting in increased irrigation shortage estimates. During the assessment, StateCU and the water rights allocation model StateMod were updated to reflect this irrigation practice where it occurs. The additional irrigation supply delivered through surface irrigation returns and recaptured in down-gradient ditches is estimated to be an average of 8,000 acre-feet per year for the 10-year period from 2008 to 2017, or about 11 percent of the average annual total irrigation supply.

Historical diversion records indicate that in many years senior water right holders were not able to get a full supply; however, even though they could have placed calls to curtail junior users they chose not to. Information from interviews with water users and the water commissioner indicate that there was an historical “gentlemen’s agreement” in some areas of the Basin where senior water users diverted water in rotation with junior water users to share in the limited supply. Even the largest senior downstream ditch, the Gunnison Tunnel, has not placed a call during the irrigation season in recent dry years. Rather than call out upstream junior rights, the Uncompahgre Valley Water Users Association chose to use storage from Taylor Park Reservoir to supplement Tunnel diversions (recent examples include 2012 and 2018). This information is critical in understanding why StateMod, which operates based on strict priority, showed calls placed by senior water rights during drier years.

2.7 Return Flow Parameters

Water that returns to streams and rivers after it has been put to use is called a return flow. When irrigating pastures, for example, some water will typically flow off the land, referred to as tail water, and return to a waterway. Representing return flow quantities, locations, and timing are critical for investigating the changes to river flows and water availability at downstream locations. Many of the opportunities to improve watershed health include changes in irrigation use, including efficiency improvements. It is important to accurately represent return flow parameters in StateMod to understand comparative changes to streamflow, and potential impacts to downstream water right holders.

Section 3. Water Use Assessment

For this report, the Ohio Creek Basin was divided into six reaches because each has unique characteristics and issues. The approach to investigating agricultural, domestic, environmental, and recreational uses was tailored for each reach. Figure 3-13 shows the reaches. Table 3-3 summarizes general characteristics of each reach and the issues identified by stakeholders. Detailed assessments of the reaches are contained in Sections 5 through 10 of this Chapter.

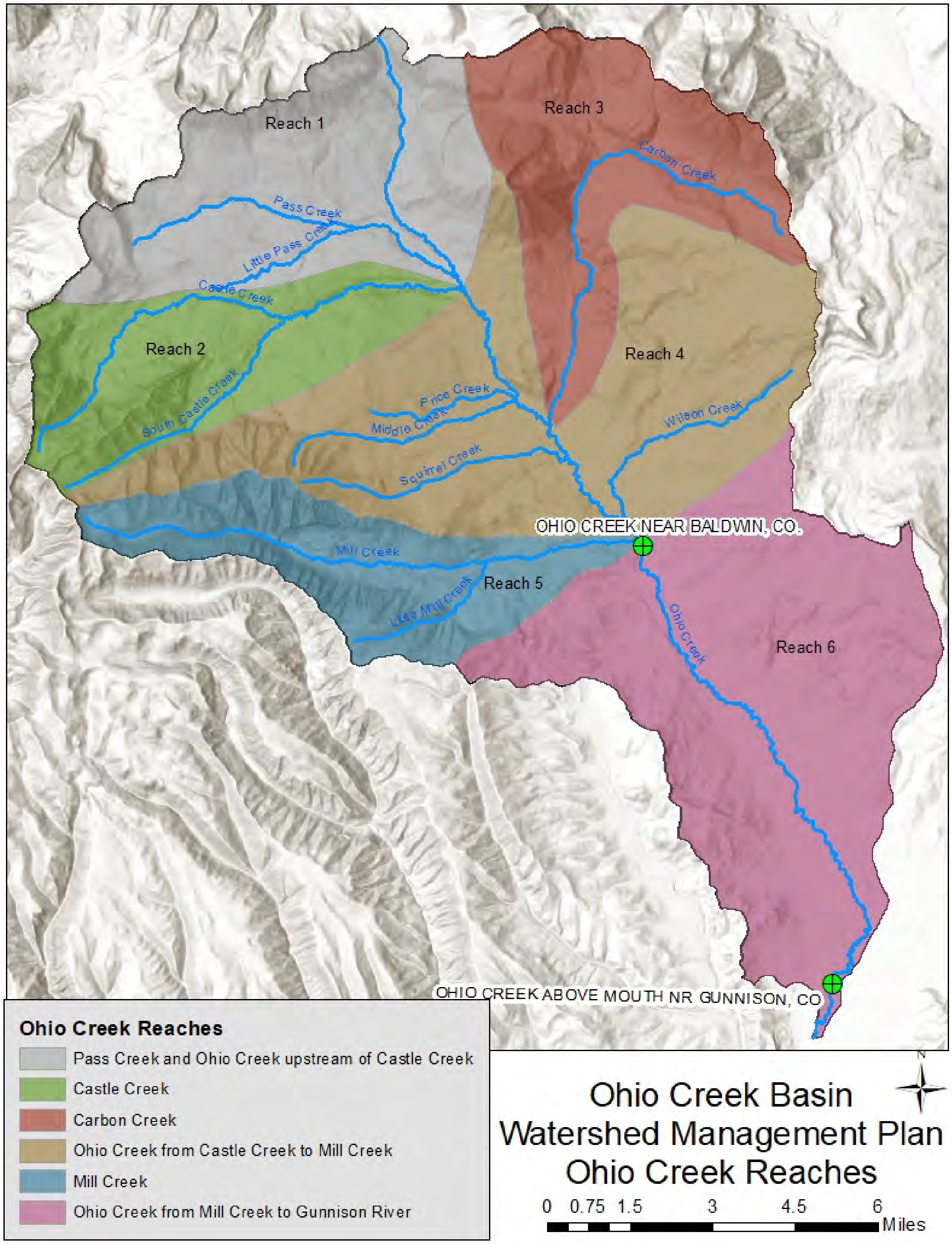


Figure 3-13: Ohio Creek Watershed Reaches

Table 3-3. Reaches, general characteristics, and stakeholder issues in the Ohio Creek Basin (continued on following page).

Reach	***General Characteristics***	***Stakeholder Identified Issues***
Pass Creek and Ohio Creek upstream of Castle Creek	Pass Creek and upper Ohio Creek provides 10-15 percent of the Ohio Creek annual streamflow. Deeded land in this area consists of Wilderness Streams Subdivision, Evans Ranch, and several smaller parcels. The headwaters are public land managed by USFS. These headwater streams consist of beaver complexes, alpine lakes, and forests which provide high environmental and recreation values. Livestock grazing on public and private land is also an important use in this area.	• Downstream calls • Irrigation shortages • Riparian degradation • Erosion and bank stability • Water quality- data gap • Pond administration/inventory • Water supply • Aging irrigation infrastructure • Ditch maintenance
Castle Creek	Castle Creek provides 35-45 percent of the Ohio Creek annual streamflow and originates on north facing slopes in the West Elk Wilderness. Upper Castle is public land managed by USFS and provides important environmental and recreational values for hunting, hiking, angling, and horseback riding. Livestock grazing on public lands is also an important use in upper Castle creek. Castle Creek provides water to eight ditches upstream of its confluence with Ohio Creek.	• Water supply - late season and drought year shortages, especially for the Acme Ditch. • Water supply - low streamflows in Castle Creek below the Acme Ditch • Erosion and bank stability issues • Aging infrastructure on several small reservoirs
Carbon Creek	Carbon Creek provides 10 percent of Ohio Creek's annual streamflow. This area is a mixture of private land and public land managed by the USFS and the Colorado State Land Board. Carbon Creek also drains the northeast and east side of Carbon Peak. Carbon Creek has a healthy brook trout fishery and a two-mile segment on USFS land is a popular site for anglers. Forested areas, springs, beaver complexes, and wetlands help support base flows. Big game habitat and livestock grazing are important uses in this area.	• Water supply - late season and drought year shortages to instream flows and irrigation • Water quality - data gap • Erosion and bank stability • Irrigation infrastructure
Ohio Creek from Castle Creek to Mill Creek	This reach of Ohio Creek is 100 percent privately owned. In addition to Carbon Creek, several smaller tributaries like Price, Squirrel, and Wilson creeks provide modest contributions to Ohio Creek. The area consists of three large ranches that are primarily managed for hay production, livestock grazing, and wildlife habitat. Private angling is also	• Trespassing near confluence of Mill Creek • Campbell Ditch maintenance • Erosion and bank stability • Diversion instability and operation issues

	an identified use in this segment. There are 28 irrigation diversions on this reach irrigating over 1,400 acres.	
Mill Creek	Mill Creek provides 20-30 percent of the annual streamflow in Ohio Creek. This area is private land to about three miles above the confluence with Ohio Creek; upstream reaches are public lands managed by the USFS. Mill Creek has a healthy brook trout fishery. The USFS land is frequented by hikers, hunters, and anglers. Forested areas, springs, beaver complexes, and wetlands help support base flows. Big Game habitat and livestock grazing are important uses in this area.	• Cunningham Reservoir restoration • Cunningham Ditch maintenance
Ohio Creek from Mill Creek to Gunnison River	This reach of Ohio Creek is nearly 100 percent privately owned. The primary water use is for irrigation, with 29 irrigation structures irrigating over 6,000 acres of pasture grass. Some ranches and property owners manage resources to enhance Ohio Creek as a fishery for private angling. During the irrigation season, water diverted from the Gunnison River can help to bolster streamflows on the lower two miles of Ohio Creek. Residential water use for households and small acreages make up a larger proportion of use on lower Ohio Creek than other reaches.	• Water supply- irrigation and instream flow shortages • Diversion instability and operation (multiple sites) • Water administration • Erosion and channel stability (multiple sites) • Over-irrigation (flooding on residential properties) • Education (private property and water rights) • Ditch maintenance (multiple sites) • Watershed health - wetland restoration to store water • Water distribution (multiple sites) • Maintenance of groundwater levels and historic return flow patterns • Restriction on future development due to senior irrigation rights and CWCB Instream Flow right, combined with lack of suitable augmentation water source

Section 4. Assessing Current Uses

Physical water availability within a watershed varies by year and throughout the year. Water may not be physically available to provide a full supply to meet all water demands in every year. Interactions between decreed water rights, diversions, and return flows add further complexity.

4.1 Agricultural Water Use

Understanding existing uses and assessing future needs for each water use category requires an understanding of hydrologic variability both throughout the year and for different hydrologic year types. This assessment uses recent years to characterize representative year types. 2012 was selected as the representative dry year. 2010 was selected as the representative average year. 2011 was selected as the representative wet year.

Irrigation is the largest water use in the Ohio Creek Basin. Pasture grass is the primary crop grown in the Basin. This high-quality forage supports local cattle operations and in some cases is exported from the valley. Seven multi-generation ranches are still in operation in the Ohio Creek Basin. Because agriculture is the major consumptive use of water in the Ohio Creek Basin, options to decrease agricultural shortages or provide water for other uses will likely necessitate changes in current irrigation use or irrigation practices. Therefore, significant detail is provided on diversions, consumptive use, and return flows of agricultural water to facilitate options to address stakeholder identified issues in each reach.

Consumptive use analyses compare expected crop water demand to actual crop water use to identify consumptive use shortages. Consumptive use analyses also estimate permanent depletions to the river attributed to crop consumptive use, and temporary depletions to the river which are caused by conveyance and irrigation application inefficiencies. Conveyance loss is water that infiltrates into the soil in route to the field. Conveyance losses return to the river, generally within a few days or few weeks of diversion. Application losses are the portion of water applied to an irrigated field that returns to the river through surface runoff or infiltrates beyond the crop root zone and lags back the river.

First, StateCU estimates crop demand – the amount of water crops could use if provided a full irrigation supply – based on monthly climate data and irrigated acreage. Although temperature is the primary driver of crop demands, non-irrigation supplies available from winter snowmelt saturating the soil during late spring and irrigation season precipitation reduce the amount of supply required from irrigation. Next, StateCU uses diversion records and estimated conveyance and application efficiencies to determine the actual (supply-limited) crop consumptive use and associated shortages. Consumptive use shortages occur when the crop demand is greater than the crop consumptive use. Diversion records limit the reliability of the consumptive use analysis, because often a single instantaneous diversion rate is reported for up to a 30-day period; and the records do not report actual start and stop dates. Despite their limitations, the diversion records are the accepted standard and are the best available information for agricultural water use.

Conveyance efficiencies vary based on soil permeability and ditch length and have been estimated for each ditch in the Ohio Creek Basin. In the Ohio Creek Basin, conveyance efficiencies range from 75 to 90 percent depending on ditch length. Flood irrigation application efficiency can be locally estimated based on soil types, soil thickness, field topography, and underlying geology. Where relatively shallow soils formed on gravel deposits the irrigation application efficiency is low due to rapid infiltration rates and limited water storage within the soil profile. Based on information from water rights decrees and soil reports, a maximum application efficiency of 45 percent was used in the Ohio Creek Basin.

The estimated annual diversions often exceed the annual crop demands by a large margin. This is due to the cobbly and porous soils and is consistent with amount of water allocated to the irrigated parcel (i.e. the duty of water) in the 1941 district court case (CA2021) for water rights decreed in the Ohio Creek Basin. The decree states, “the soil is very porous and open, consisting of a deposit of loam on the surface of variable thickness generally from eight to eighteen inches, with a base consisting of coarse granite, sand, gravel, and boulders, underlaid with materials of a firmer and more permanent nature; that by reason of the above character and formation of the soil water applied thereto percolates through the soil rapidly, making it necessary to raise the water table a very considerable distance before any adequate irrigation can be begun or maintained.” The decree further declares “not less than two cubic feet of water per second of time, and in some portions of the district five and five and a half cubic feet of water per second of time are required for each forty acres in order to grow and mature a valuable crop thereon.” As indicated, the soil profile requires a duty of water from 1 cfs per 8 acres to 1 cfs per 20 acres, compared to other areas in Colorado where the duty of water is more often between 1 cfs per 40 acres and 1 cfs per 80 acres. The soils in the Ohio Creek Basin require up to five times more water than some other areas in the state.

The amount of water diverted at the headgate is not all available to meet crop demands. The amount available to the crop is the diverted water less ditch conveyance loss and irrigation application losses. For example, if 100 acre-feet is diverted and the conveyance loss is 20 percent, only 80 acre-feet is available at the ranch turnout. The maximum flood application efficiency, based on the porous nature of the soil, is 45 percent; therefore, of the 100 acre-feet diverted in this example, only 36 acre-feet (80 acre-feet x 45 percent) is available to meet crop demands. As noted, the accuracy of the crop consumptive use estimate is highly dependent on the accuracy of diversion records.

Excess water applied to the fields during flood irrigation returns to the river over time. Based on irrigation surface runoff, aquifer characteristics, and the location of the irrigated parcels, over 50 percent of diversions not consumed by crops are estimated to return to the river within four days of application, with over 85 percent returning within two months of application. The remaining 15 percent returns over the following three to six-month period. Due to cobbly and porous soils, the soil zone does not store significant water, unlike other areas of Colorado where a significant amount of water can be stored in the soil root zone. Return flow locations are estimated based on ditch alignment, irrigated acreage location, topography, and proximity to local drainages and tributaries.

Figure 4-14 shows the annual variability of agricultural water use for the period 1998 through 2017. The results are for the Ohio Creek Basin, but each ditch was represented individually in the consumptive use analysis. Average annual consumptive use from irrigation for 1998 through 2017 is just under 16,700 acre-feet, varying from a low of 13,200 in the extremely dry summer of 2002 to just over 19,000 acre-feet in hot, high-runoff year of 2007.

Irrigation water rights in the Basin exceed natural (un-depleted) flow in most months. As noted above, the soil and aquifer characteristics require that a significant amount of water be diverted above what is consumed by the crops. The excess diverted water returns to the river and is re-diverted by downstream ditches.

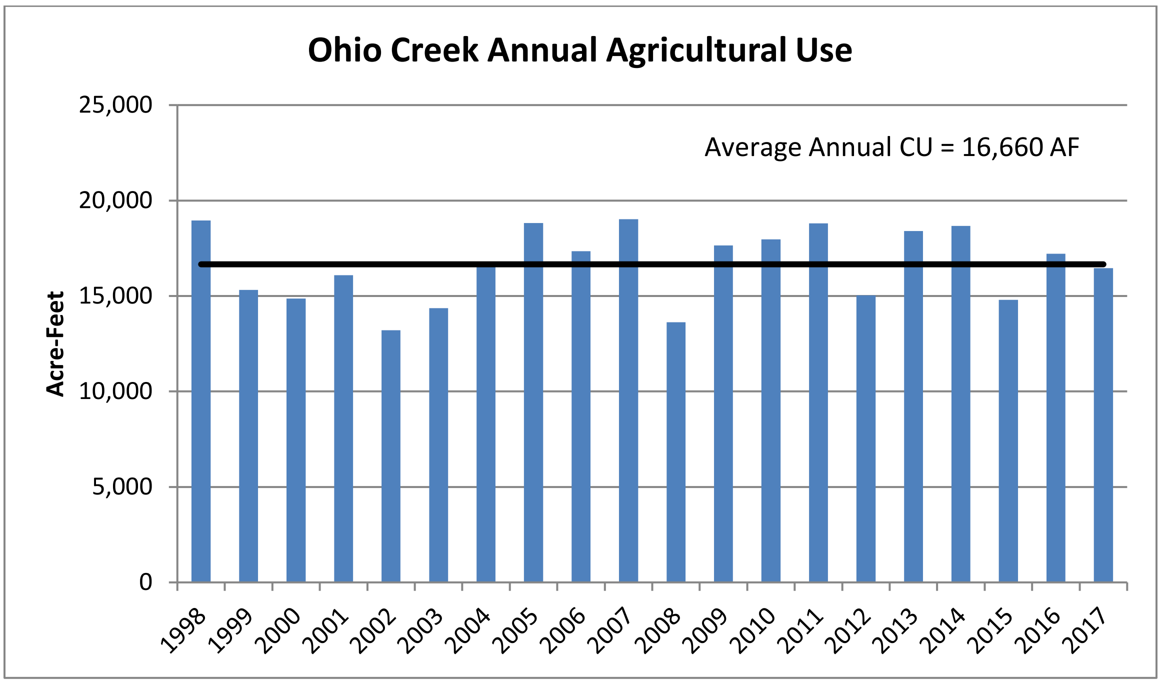


Figure 4-14: Annual Ohio Creek Basin Agricultural Water Use (1998-2017)

Shortages to consumptive crop demands occur when the amount of water available to the irrigated fields is not enough to satisfy the full crop demands. Ohio Creek has a hydrograph dominated by snowmelt resulting in a supply of river water that is higher during the spring runoff and then decreases as the snowmelt runoff decreases. This leads to agricultural shortages during the late irrigation season and, in drought years throughout the irrigation season. Detailed results of the agricultural water use are presented by reach in Sections 5 through 10 of this Chapter. In many cases, ditches divert water within a reach to irrigate lands physically located in a downstream reach. Because the stream depletion occurs at the point of diversion, the consumptive use and associated shortages are reported based within the reach where the diversions occur.

4.2 Domestic Water Use

Currently, there are no municipal or industrial water uses in the Ohio Creek Basin. Household use within the Basin relies on groundwater primarily from exempt well permits. There are 237 active wells in the lower Ohio Creek area. These household wells do not significantly impact streamflows in Ohio Creek.

Prior plans for the Keystone molybdenum mine have included operations and facilities within the Ohio Creek Basin. Currently, there are no applications to develop the mine.

4.3 Environmental Water Use

The following subsections discuss Basin-wide environmental use. Sections 5 through 10 in this Chapter provide more detail on the assessment of environmental uses and needs within the six defined reaches.

4.3.1 Aquatic Life

Macroinvertebrates were identified as a data gap and a priority for selected landowners that manage a considerable portion of Ohio Creek located on private lands. During the summer of 2017, macroinvertebrate samples were collected from three locations on the Eagle Ridge Ranch, which is located in the Ohio Creek reach from Mill Creek to the Gunnison River.

Perennial streams within the Ohio Creek Basin would typically be expected to provide high-quality aquatic habitats.

4.3.2 Water Quality

In the Ohio Creek Watershed, the numeric standards associated with aquatic life (most metals), recreation (*E. coli*) or water supply (arsenic, iron) are typically the lowest and are therefore applied as the numeric standard for many parameters.

Ohio Creek and its tributaries are generally expected to be suitable habitat for all the cold-water biota used to develop the aquatic life standards.

Relative to the Lake Fork and East River Basins, the Ohio Creek Basin lacks water quality data. However, a query of the National Water Quality Monitoring Portal provided 8,975 results from 33 sample locations. Samples were collected by USGS and the Colorado Department of Public Health and Environment (CDPHE). Unless otherwise noted, the water quality analysis included samples collected between 2000 and 2019. On some reaches it was necessary to use older water quality data because very limited water quality data has been collected in the Ohio Creek Watershed.

The entire mainstem of Ohio Creek is potentially impaired for *E. coli*. The *E. coli* standard is applied to protect recreational users from illness, due to ingesting incidental quantities of water. Laborers that work irrigation ditches may also face similar exposure as recreational users. A rolling 60-day geometric mean is used to evaluate the standard. To date, *E. coli* samples have not been collected frequently enough to calculate a 60-day geometric mean. But individual samples have been well over the standard, which is why the mainstem of Ohio Creek is listed as potentially impaired. Additional sample collection is recommended to characterize *E. coli* concentrations at the frequency needed to properly evaluate the standard.

4.3.3 Water Temperature

All the streams in the Ohio Creek Watershed are classified as Cold Class 1 which applies the most stringent temperature standards to protect cutthroat, rainbow, brown, and brook trout.

4.3.4 Existing Instream Flow Water Rights

As part of this assessment, existing instream flow water rights were reviewed. During the review, the consultants evaluated original cross-section data, field notes, and R2CROSS model output. Unfortunately, due to their age, some instream flow segments in the Ohio Creek Basin lacked some of the components included in the original proposal. Nevertheless, the review provided useful insights related to the existing instream flow water rights. In many cases, the existing instream flow water rights in the Ohio Creek watershed do not fully meet the physical criteria necessary to preserve the natural environment. This assessment provides recommendations to re-evaluate the existing instream flow water rights.

Sections 5 through 10 in this Chapter include summaries of existing instream flow water rights and recommendations where it may be suitable to appropriate a new instream flow water right or enlarge the existing instream flow with a new junior instream flow appropriation or an acquisition. Additional field work is likely needed for any future instream flow proposals. Six R2CROSS surveys were completed during this assessment, as shown in Figure 4-15, and the results are presented in the respective reach sections.

4.3.5 Flow Limited Areas

Stakeholder knowledge and water rights calls were used to identify dry up locations.

4.3.6 Environmental Flow Goals

Recommendations related to existing and potential instream flows are presented in this section.

Figure 4-15 shows the field assessment locations in the Ohio Creek Basin. R2CROSS assessments and pebble counts were completed at six locations. Macroinvertebrate samples were collected from three locations. Ditch losses were estimated based on six measurements collected from two ditches.

Figure 4-15: Field Assessment Locations in the Ohio Creek Basin

4.4 Recreational Water Use

Generally, the mainstem of Ohio Creek is not large enough to support rafting, kayaking, or standup paddle boarding (SUP) except during runoff in above average years, and the land surrounding the mainstem of Ohio Creek is privately owned. Tributaries to Ohio Creek located on public lands are too narrow and shallow to support rafting, kayaking, or SUP. Due to these factors a formal floating recreational water use survey was not completed in the Ohio Creek Basin.

Hunting, angling, camping, hiking, and horseback riding are the most prevalent recreational uses in the Ohio Creek Basin. These uses occur on both public lands in the headwaters and tributaries and on private lands along the mainstem of Ohio Creek. Many landowners on the mainstem of Ohio Creek enjoy walk and wade angling and several properties are managed to benefit aquatic life and angling.

Input for recreational needs was gathered from general stakeholder surveys, which focus on infrastructure issues rather than topics related to floating the river, and interviews with landowners and ranch managers in the Ohio Creek Basin. Public input on recreational water use in the headwater areas was not a priority in this assessment.

4.5 Needs for each Reach; Issues Identified

For each reach, this section summarizes the issues most frequently identified by stakeholders and the consultants during the assessment process. This material will be a central component of the next phase of WMP, where potential options and best management practices will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Section 5. Reach 1 - Pass Creek and Ohio Creek Upstream of Castle Creek

Privately owned land in this reach includes Wilderness Streams Subdivision, Evans Ranch, and several smaller parcels. The USFS manages the public land in the upper portions of the reach. A considerable portion of this reach is in the West Elk Wilderness.

Pass Creek and Upper Ohio Creek provide an estimated 25 percent of the annual stream flow in Ohio Creek. Low flows generally occur from September to March. As spring approaches stream flow increases. Peak flows typically occur in May or June and taper off as the snowpack declines. In general, stream flow in smaller tributaries is more readily increased by intense precipitation events (Hornberger et al., 1998). There are no water supply reservoirs on the reach.

Pass Creek, the headwaters of Ohio Creek, and their tributaries feature large, minimally disturbed beaver complexes, alpine lakes, and forests. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses.

Residents and guests of Wilderness Streams frequently fish Pass Creek, upper Ohio Creek, and two privately-owned ponds. Livestock grazing on public lands and private land is also an important use in this reach. Currently, all irrigated meadows in this reach are used for grazing.

5.1 Agricultural Water Use

There are 13 active irrigation diversions in Pass Creek and Ohio Creek upstream of Castle Creek, serving approximately 500 acres of flood irrigated pasture grass. Table 5-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 5-1: Agricultural Water Use Statistics Pass Creek and Ohio Creek upstream of Castle Creek

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	13	n/a
Irrigated Acreage	501 acres	n/a
Water Rights	68.675 cfs	n/a
Diversions	3,400 acre-feet	1,380 – 7,450 acre-feet
Crop Demand	910 acre-feet	730 – 1,090 acre-feet
Crop CU	690 acre-feet	440 - 890 acre-feet
Shortage/Need	220 acre-feet	200 - 290 acre-feet
Percent Shortage	24%	6% - 52%

Figure 5-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. All the ditches are unlined, and each ditch is estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from this reach, estimated to be an average of 2,710 acre-feet per year from 1998 to 2017, accrue to Ohio Creek above the confluence with Castle Creek.

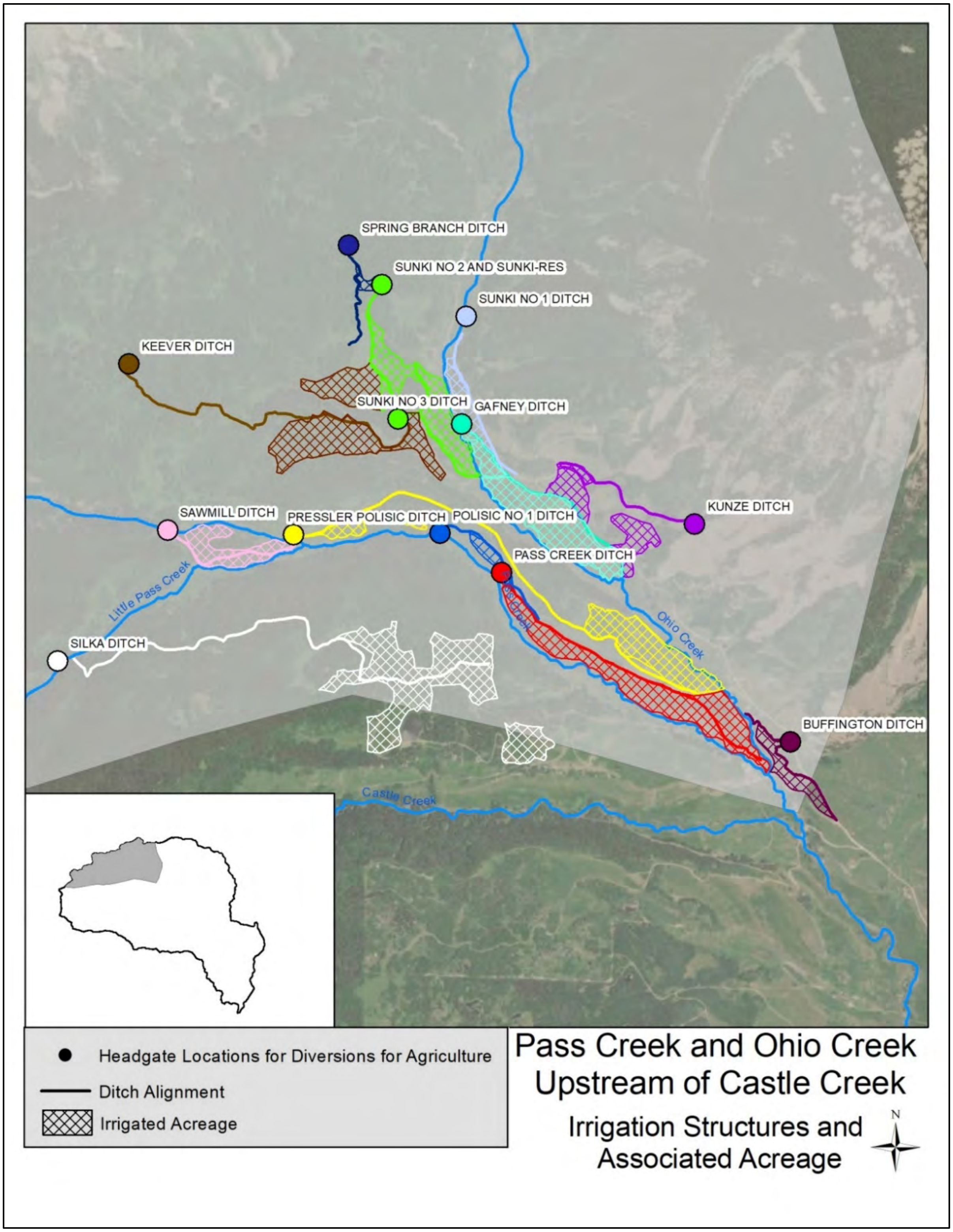
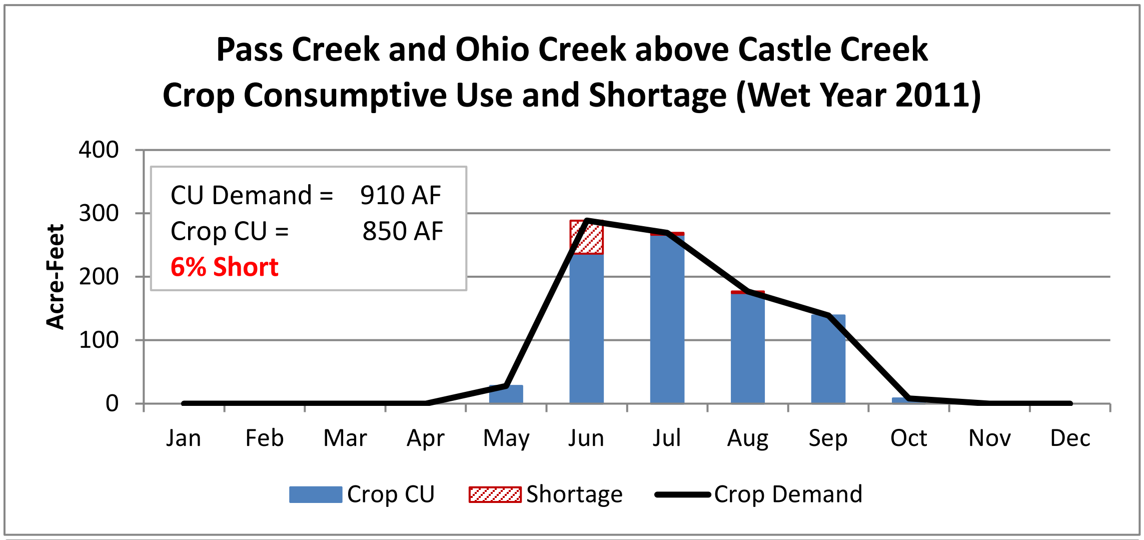
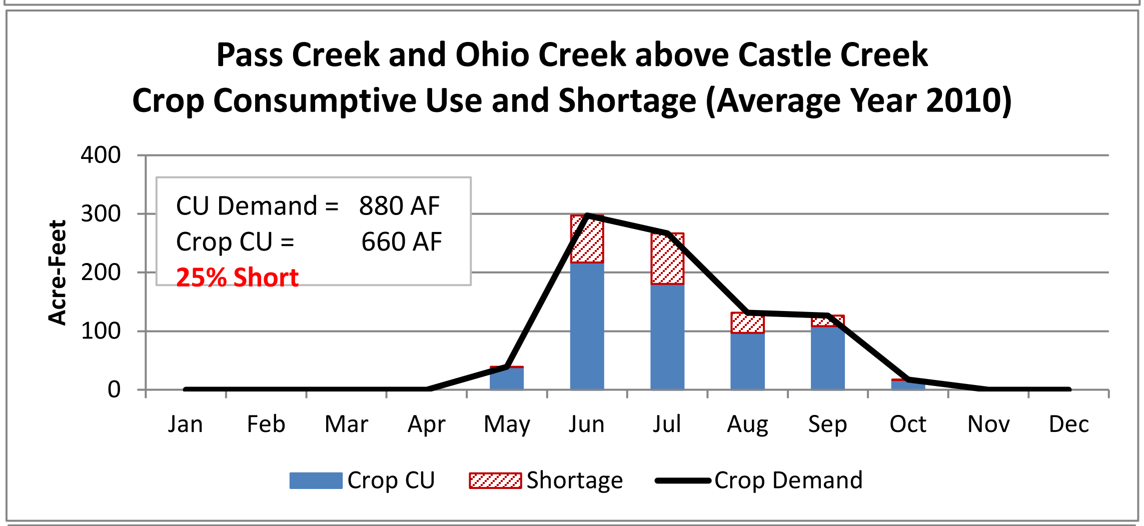


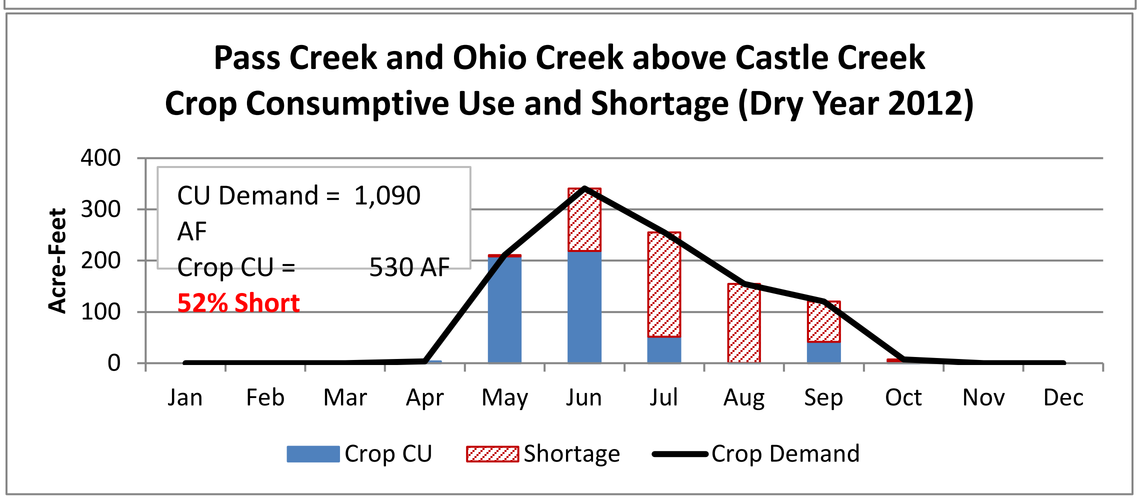
Figure 5-6: Pass Creek and Ohio Creek upstream of Castle Creek, Irrigation Structures and Acreage

Figure 5-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, shortages in this reach occurred every month during the irrigation season for the representative average year and were largest in the representative dry year. This reach sits at elevations greater than 9,000 ft in an area that experiences significant snowfall during wet and average years. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, except in very dry years, crop demand from an irrigation supply is minimal and limited diversions were recorded. The decrease in runoff during average and dry years results in increased physical flow shortages in the late irrigation season.

Figure 5-5: Pass Creek and Ohio Creek upstream of Castle Creek Reach
Crop Consumptive Use and Estimated Shortage







5.2 Domestic Water Use

Stakeholders identified water quality in household wells as a top concern for this reach. Approximately, 30 homes rely on water from wells or springs and use on-site wastewater treatment systems.

The Ohio Pass Spring, located immediately adjacent to Ohio Creek Pass Road, is a popular spring where locals and visitors collect drinking water. USGS sampled the Ohio Pass Spring in August 1978. The sample analysis included a relatively broad suite of analytes and concentrations were generally low. However, because there is only a single sample result that is nearly 40 years old, additional sample collection should occur. Very limited data collection has occurred to characterize groundwater and spring water quality.

5.3 Environmental Water Use and Needs

5.3.1 Stream and Riparian Characteristics

The headwaters of Pass Creek form below the east and north facing slopes of Storm Mountain at nearly 10,000 feet. The headwaters of Ohio Creek flow adjacent to the summit of Ohio Creek Pass Road. Pass Creek, Ohio Creek, and their tributaries drain portions of Swampy Pass and the Anthracite Range. Slopes are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. The streams, which are both intermittent and perennial, are steep entrenched channels that may be scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages.

Below the alpine peaks, the watershed is a mixture of forest and meadows, with generally robust riparian corridors. There are at least four large beaver complexes on upper Ohio and Pass Creek that support approximately 120 acres of wetlands and an additional 60-80 acres of wetlands that are not specifically associated with beaver activity. These wetlands also provide wildlife habitat, fishery habitat, filter sediment, and store water providing base flows after snowmelt and runoff subsides. The width of the riparian corridors adjacent to Pass and Ohio Creeks is generally much narrower where irrigated parcels are adjacent to the creek.

5.3.2 Aquatic Life

Upper Ohio Creek, Pass Creek, and their larger tributaries support aquatic life including brook trout. Data to further characterize aquatic life were not identified during this assessment.

5.3.3 Water Quality

In 2018 the headwaters of Pass Creek and other tributaries to Ohio Creek located in wilderness areas within the Upper Gunnison River Basin were listed as impaired for total recoverable arsenic for the water supply use. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use as shown in Table 5-2 and Figure 5-3. Tributaries within wilderness areas in the Ohio Creek Sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries.

An *E. coli* sample collected by the WQCD in September 2014 suggests that Ohio Creek may be impaired for the recreational use standard (Table 5-2). Additional data collection is recommended to determine the impairment status.

Four of six samples collected by the WQCD in 2014 and 2015 from Ohio Creek downstream of Ohio Pass Road detected dissolved arsenic and total arsenic [21] concentrations ranged from 1 to 3.8 µg/L in five of six samples.

The Swampy Pass Trailhead was outfitted in 2012 with a permanent vault toilet to mitigate water quality impacts to Ohio Creek from visitors using the trailhead and the Ohio Pass Scenic Byway.

Table 5-2: Impaired and potentially impaired stream reaches in the Pass Creek and Ohio Creek upstream of Castle Creek reach.

Listed Portion of Stream	Affected Uses	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
All tributaries to the Gunnison River, including wetlands, within the West Elk Wilderness Areas, excluding Stewart Creek	Water Supply Use	Dissolved Iron	NA	NA
		NA	Total Arsenic	High
Mainstem of Ohio Creek upstream of County Road 7	Recreational Use	*E.coli*	NA	NA

[21] The water supply standard is based on total recoverable arsenic concentrations. Due to a lack of total recoverable arsenic data, and the existing results for dissolved and total arsenic, it is reasonable to recommend additional sample collection.

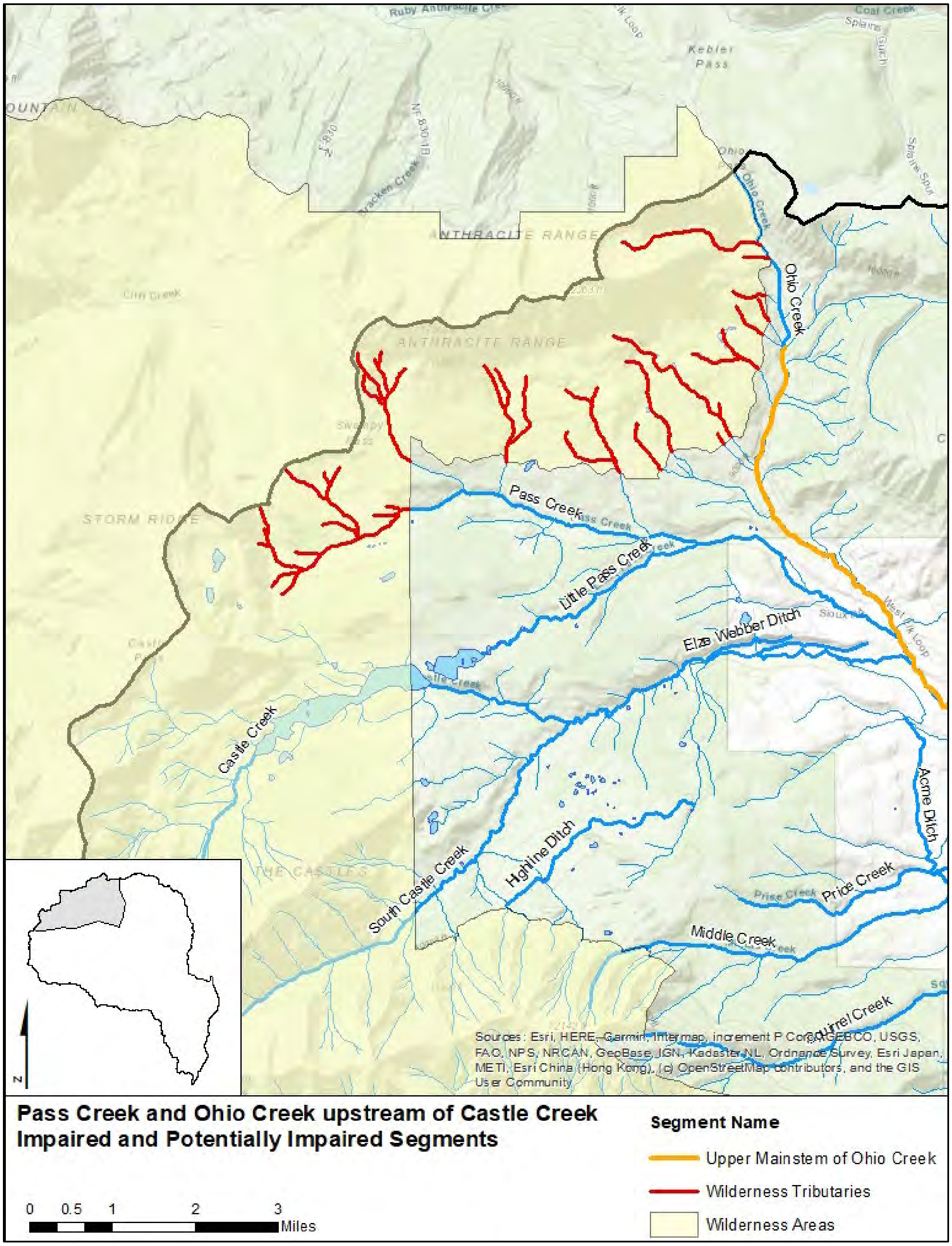


Figure 5-6: Impaired and potentially impaired stream reaches in the Pass Creek and Ohio Creek upstream of Castle Creek reach

5.3.4 Water Temperature

Continuous water temperature measurements are not known to have occurred in this reach, which is a data gap.

5.3.5 Existing Instream Flow Water Rights

Both Pass Creek and Ohio Creek have instream flow water rights of 3 cfs year-round as shown in Figure 5-4. The instream flow proposals were developed by CWCB and CPW staff in 1980.

An initial review of the average monthly flows suggests that the summer instream flow rates for both Pass Creek and Ohio Creek could be enlarged.

In 2018 an R2CROSS assessment was completed in Ohio Creek immediately upstream of the confluence with Castle Creek. The R2CROSS output identified minimum flow rates of 5 and 6.5 cfs for winter and summer, respectively.

Ohio Creek immediately upstream of the confluence with Castle Creek during the field assessment in October 2018

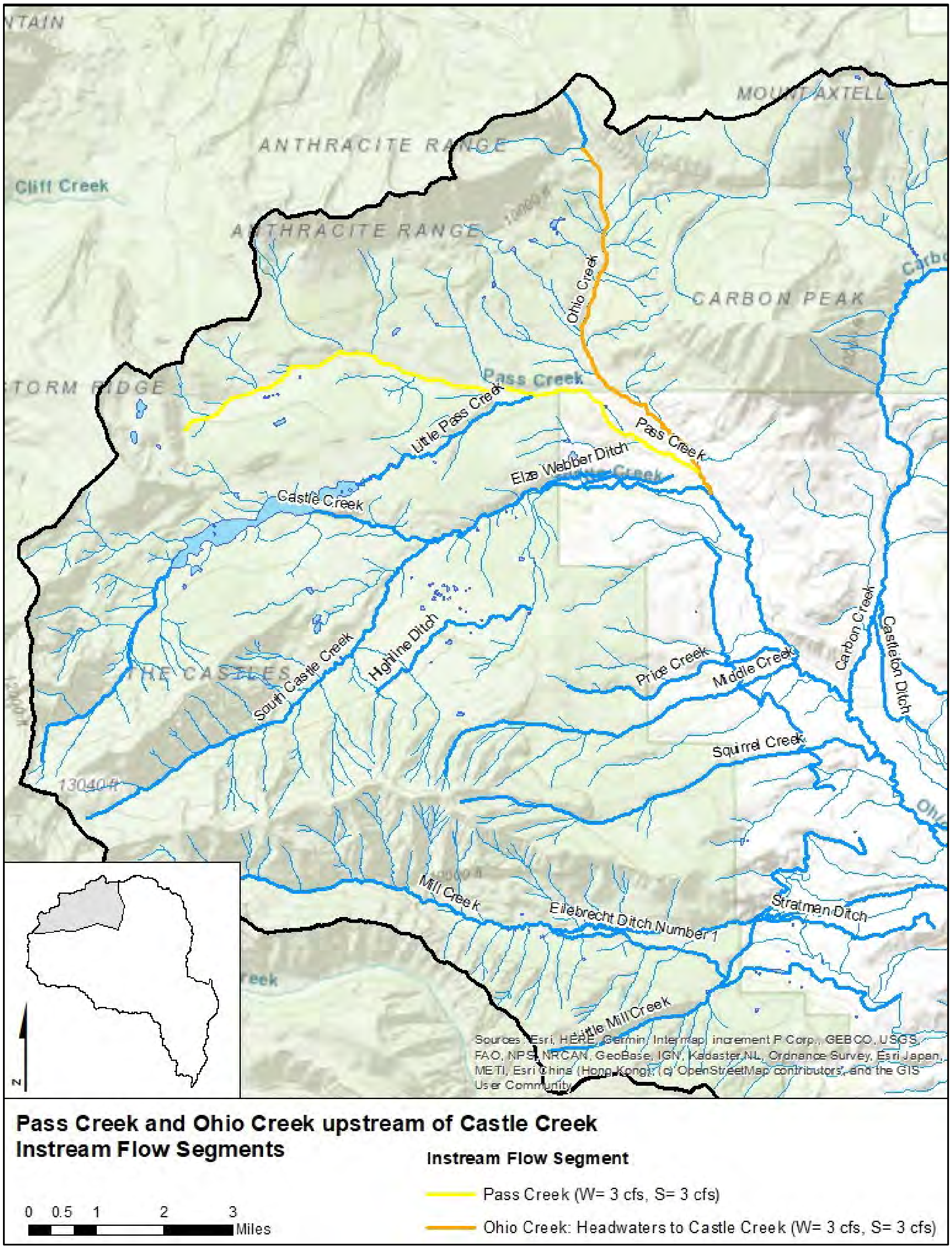


Figure 5-7: Instream flow water rights in the Pass Creek and Ohio Creek upstream of Castle Creek Reach

5.3.6 Flow Limited Areas

Flows in upper Ohio Creek, upper Pass Creek, and upper Little Pass Creek are natural. Diversions from these streams do not occur until the lower reaches of each creek where the valley form allows for irrigation.

There are four diversion structures located on the last 3.5 miles of Pass Creek. There are two diversion structures on Ohio Creek in this reach. The water rights for these diversions are large enough to alter the natural hydrology of the stream. The degree of flow alteration in this reach has not been characterized.

5.3.7 Environmental Flow Goals

Voluntary environmental flow goals have not been identified as a priority for this reach.

5.4 Recreational Water Use

Recreational uses on Pass Creek and upper Ohio Creek include angling, hunting, hiking, backpacking, horseback riding, and dispersed camping. For the public, these uses are limited to areas upstream of private land. Property owners in the Wilderness Streams Subdivision utilize the streams and riparian areas on private property for similar purposes with angling the predominate recreational water use.

5.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Potential for elevated arsenic concentrations due to the local geology in household wells within and downgradient of Ohio Creek.

Issue: Erosion and channel stability within Wilderness Streams.

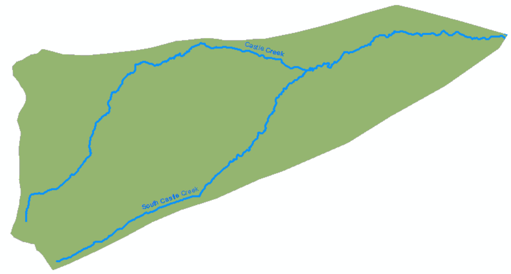
Issue: Irrigation infrastructure and irrigation water distribution at both the Wilderness Streams Subdivision and Evans Ranch.

Issue: Water storage, including small reservoirs and wetland restoration were identified as priorities in this reach.

Issue: Instream flow rates for Pass Creek and/or Ohio Creek.

Issue: Potential instream flow on Little Pass Creek.

Section 6. Reach 2 - Castle Creek



Privately owned land is concentrated on the lower portion of the reach and includes Wilderness Streams Subdivision, Castle Creek Ranch, and several smaller parcels. The headwaters of Castle Creek are on land managed by the USFS and a considerable portion is part of the West Elk Wilderness.

Castle Creek provides approximately 35 percent of the annual stream flow in the Ohio Creek watershed. Like other snow melt driven systems, streamflows increase in the early spring as snow melt begins. Peak flows typically occur in May or June and taper off as the snowpack declines. In general, streamflows in smaller tributaries are more readily increased by intense precipitation events. Low flows generally occur from September to March.

The headwaters of Castle Creek tributaries feature large, minimally disturbed beaver complexes, alpine lakes, and forests. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate flood flows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses.

En route to Ohio Creek, lower Castle Creek flows through privately owned irrigated lands. The Acme Ditch diverts a substantial portion of water from Castle Creek to irrigate over 800 acres of pasture grass located downstream in the Ohio Creek to Mill Creek reach. The Acme Ditch can experience water shortages during drought years and during late summer months. Consequently, streamflows downstream of the Acme Ditch also experience shortages during these periods. There are two small reservoirs within the reach that store water for irrigation.

6.1 Agricultural Water Use

There are eight active irrigation diversions in Castle Creek, serving approximately 1,165 acres of flood irrigated pasture grass. Table 6-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 6-1: Agricultural Water Use Statistics– Castle Creek

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	8	n/a
Irrigated Acreage	1,165 acres	n/a
Water Rights	146.956 cfs	n/a
Diversions	4,110 acre-feet	1,680 – 8,350 acre-feet
Crop Demand	1,630 acre-feet	1,080 – 2,190 acre-feet
Crop CU	1,440 acre-feet	960 – 1,930 acre-feet
Shortage/Need	190 acre-feet	260 - 120 acre-feet
Percent Shortage	12%	0% - 47%

Figure 6-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. Although the Acme Ditch diverts within the reach, the associated irrigated acreage is located in the Ohio Creek from Castle Creek to Mill Creek reach. All of the ditches are unlined and are estimated to lose approximately 10 percent during transit; Acme Ditch is estimated to lose 20 percent of diverted water during delivery to the irrigated fields.

According to the CDWR, the Castle Peak Feeder Ditch and Castle Peak Feeder Ditch No. 2 are active ditches with absolute water rights; however, there are no recorded diversions. They are believed to provide supplemental water to the fields irrigated by the Highline Ditch. The diversion locations shown are spotted from the legal description in water right decrees.

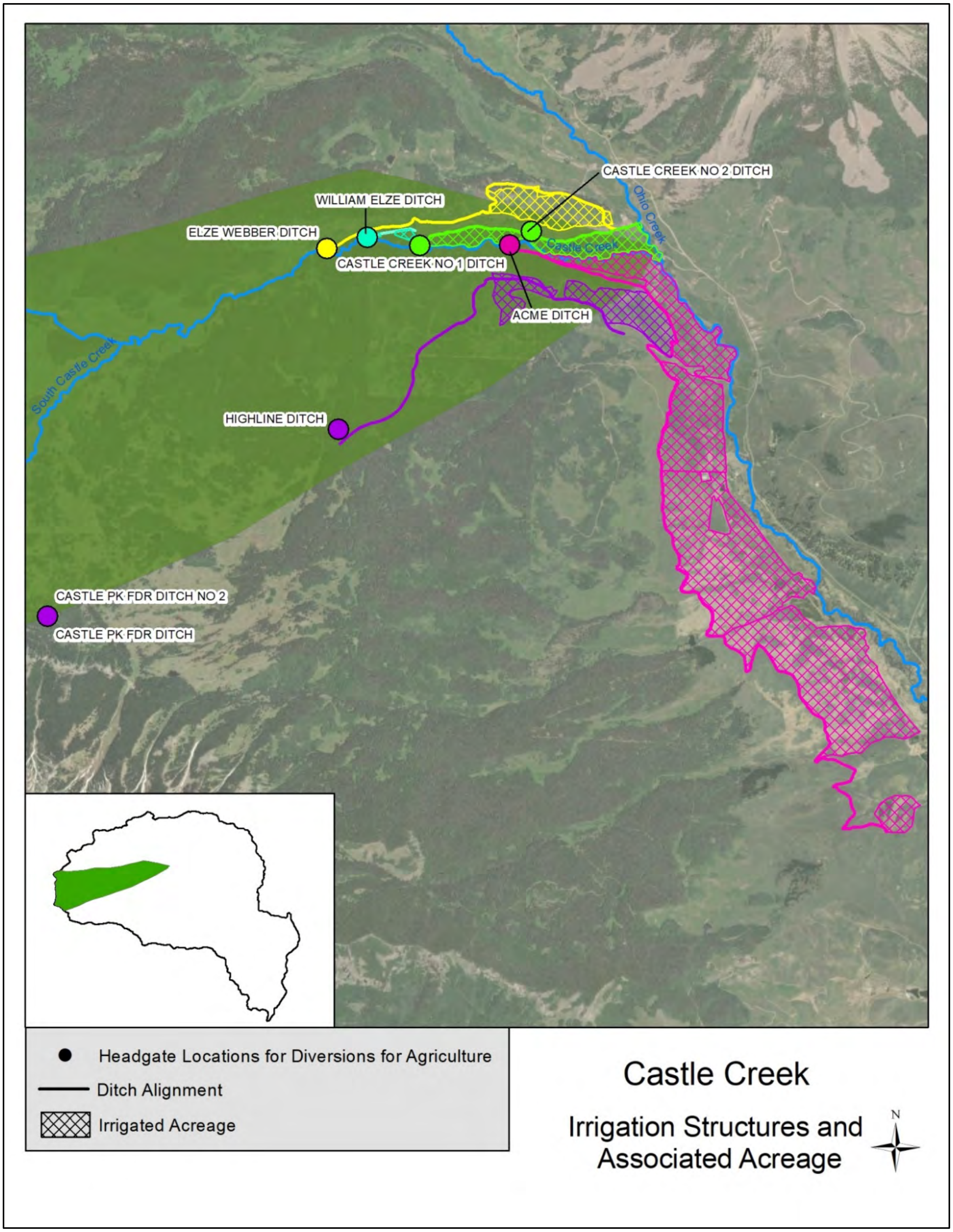


Figure 6-1: Castle Creek irrigation structures and acreage

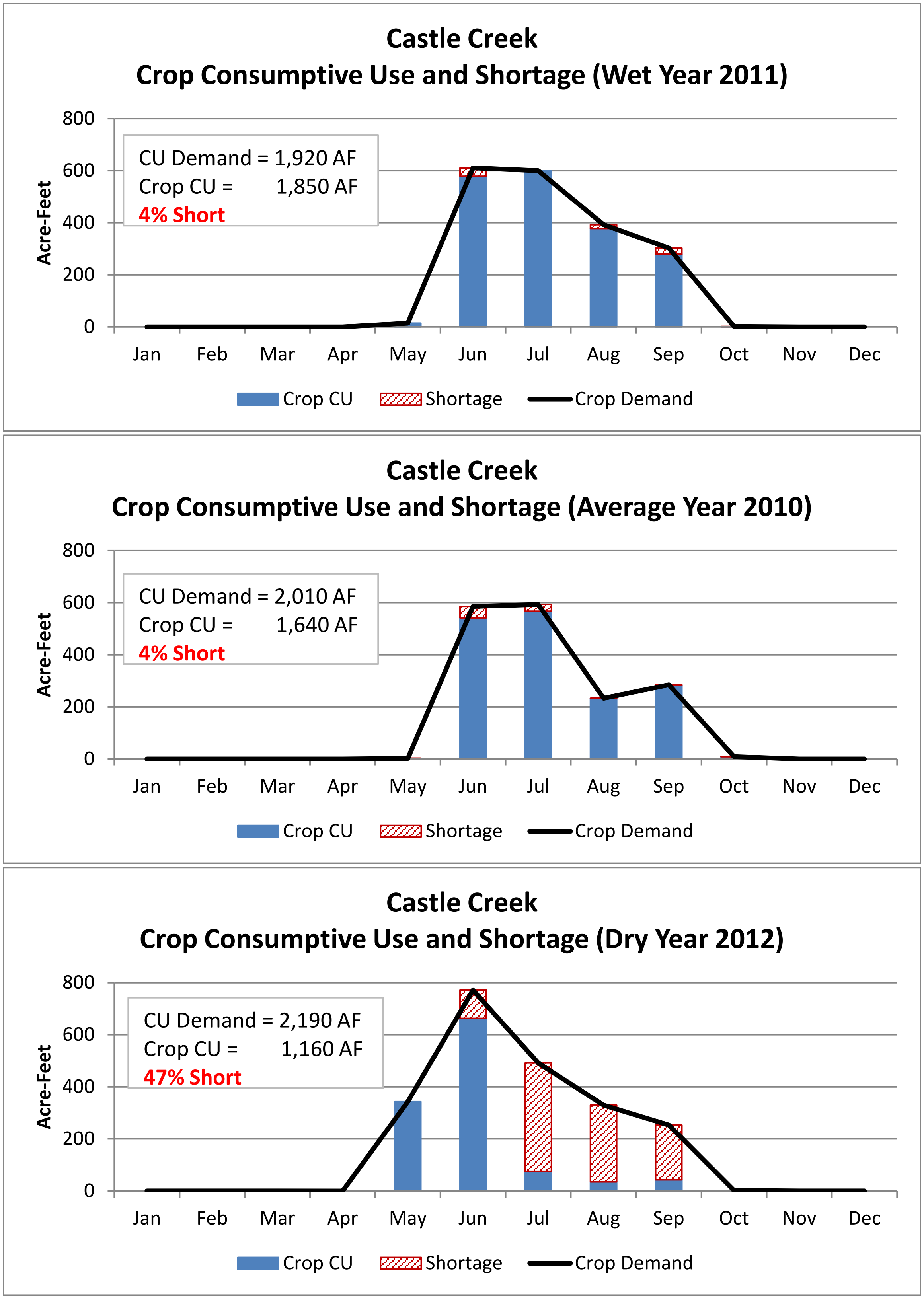
Table 6-2 shows the estimated percentage of water that returns to Castle Creek and to downstream reaches.

Table 6-2: Agricultural Return Flow Locations – Castle Creek

Return Flow Location	**% of Total Return Flows**	**1998-2017 Average Annual Return Flows (Acre-Feet)**
Castle Creek	20%	530
Ohio Creek from Castle Creek to Mill Creek	80%	2,140

Figure 6-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, minor shortages in this reach occurred during the irrigation season for the representative wet and average years, and shortages were significant in the representative dry year. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, crop demand from an irrigation supply is minimal and limited diversions were recorded. The decrease in runoff during dry years results in physical flow shortages in the late irrigation season. Price Creek and Middle Price Creek flow into the Acme ditch. These contributions can decrease diversions at the head gate in the early spring period; particularly in wet years when excess flows could breach the ditch and diversions at the headgate are reduced to eliminate the risk.

Figure 6-2: Castle Creek Crop Consumptive Use and Estimated Shortage



6.2 Domestic Water Use

Approximately 40 homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

6.3 Environmental Water Use and Needs

6.3.1 Stream and Riparian Characteristics

The headwaters of North Castle Creek form in the north facing basin below West Elk Peak (13,040 feet) at over 12,000 feet in the West Elk Wilderness. The headwaters of South Castle Creek form in an east facing basin below West Elk Peak. The Castles ridgeline separates the north and south forks of Castle Creek. Slopes are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. In wet years, snow may be present until August in sheltered areas. In this area, streams are both intermittent and perennial, and most channels are steep and entrenched and may be scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel the drainages.

The confluence of Castle Creek and Ohio Creek following a large and intense precipitation event in the headwaters of Castle Creek in October 2018. The water in Castle Creek is sediment laden due to erosion and sediment transport following the storm.

Below the alpine basins, the headwaters of Castle Creek and its tributaries feature large, minimally disturbed beaver complexes, which total over 190 acres in size, small lakes, and forests. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses.

6.3.2 Aquatic Life

The Castle Creek watershed supports a healthy wild trout fishery that includes brook trout, brown trout, and rainbow trout. Data to further characterize aquatic life were not identified during this assessment.

6.3.3 Water Quality

In 2018, the portion of Castle Creek in the West Elk Wilderness was listed as impaired for total recoverable arsenic for the water supply use. Table 6-3 and Figure 6-3 show information about the wilderness tributaries which were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the Ohio Creek Sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries. Water quality samples are not known to have been collected in the Castle Creek Watershed.

Table 6-3: Impaired and potentially impaired stream reaches in the Castle Creek reach.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
All tributaries to the Gunnison River, including wetlands, within the West Elk Wilderness Areas, excluding Stewart Creek.	Water Supply Use	Dissolved Iron	NA	NA
		NA	Total Arsenic	High

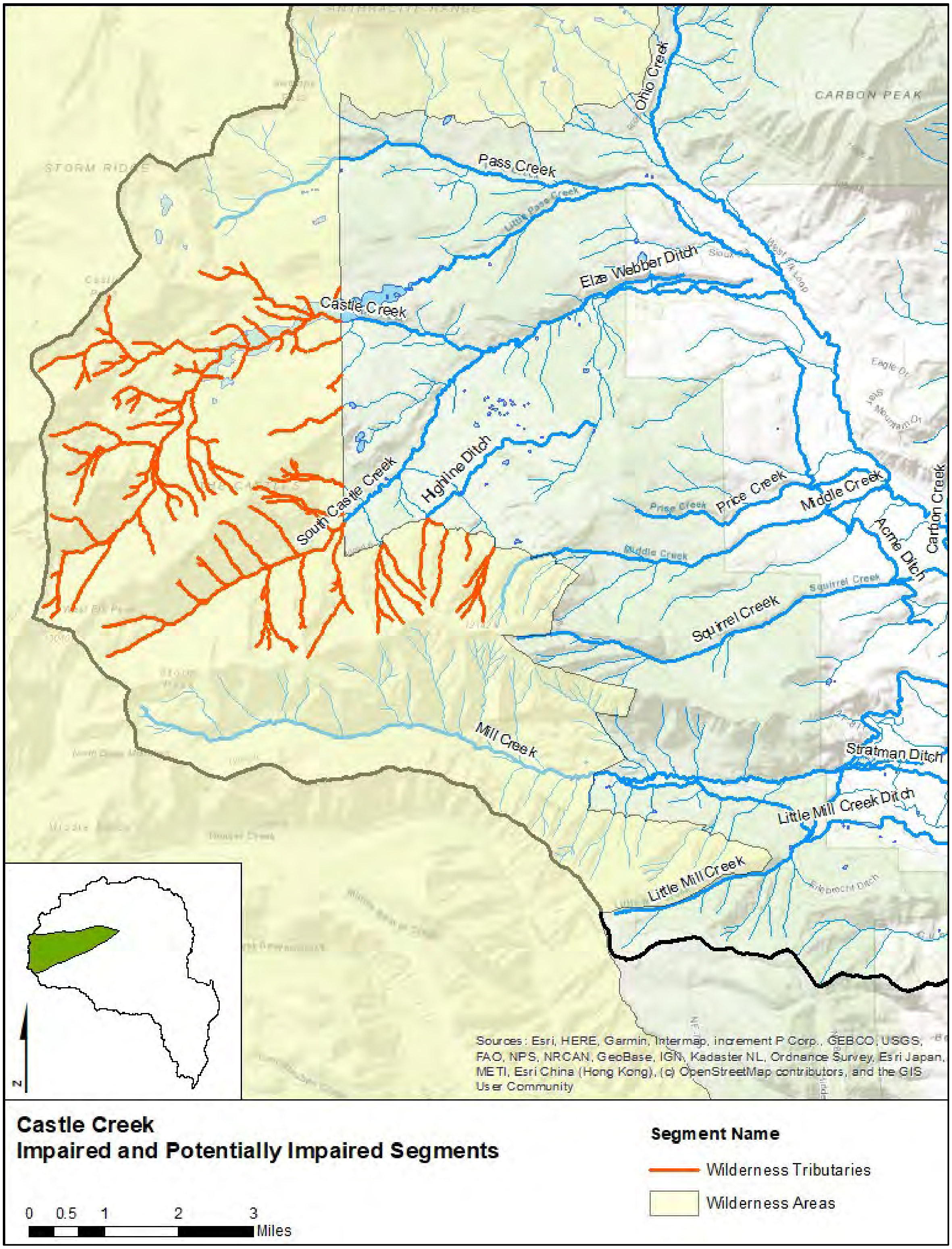


Figure 6-3: Impaired and potentially impaired reaches in the Castle Creek reach

6.3.4 Water Temperature

Continuous water temperature measurements are not known to have occurred on this reach and are currently a data gap.

6.3.5 Existing Instream Flow Water Rights

North Castle Creek from the headwaters to the confluence with South Castle Creek has a year-round instream flow water right of 4 cfs as shown in Figure 6-4. Castle Creek from the confluence of North and South Castle creeks to the Acme Ditch has a year-round instream flow water right of 7 cfs. The instream flow proposals were developed by CWCB and CPW staff in 1980. The original proposal documents were not available during this assessment.

Based on the original water availability analysis, 7 cfs was not available at a regular frequency in Castle Creek downstream of the Acme Ditch. Trout Unlimited monitoring data indicates that late season flows on Castle Creek can be less than 12 cfs upstream of the Acme Ditch diversion. However, monthly average flows measured in Castle Creek at the historic gage ranged from a high of 147 cfs in June to a low of 14 cfs in September during the six years the gage was operated (1992-1998).

South Castle Creek forms in the headwaters of the West Elk Wilderness and flows into Castle Creek on lands owned by the USFS. South Castle Creek does not have an instream flow water right.

An R2CROSS assessment was completed in Castle Creek near the confluence with Ohio Creek. Site selection was difficult due to low flow conditions and channel form. The data collected did not meet the quality control criteria for this assessment.

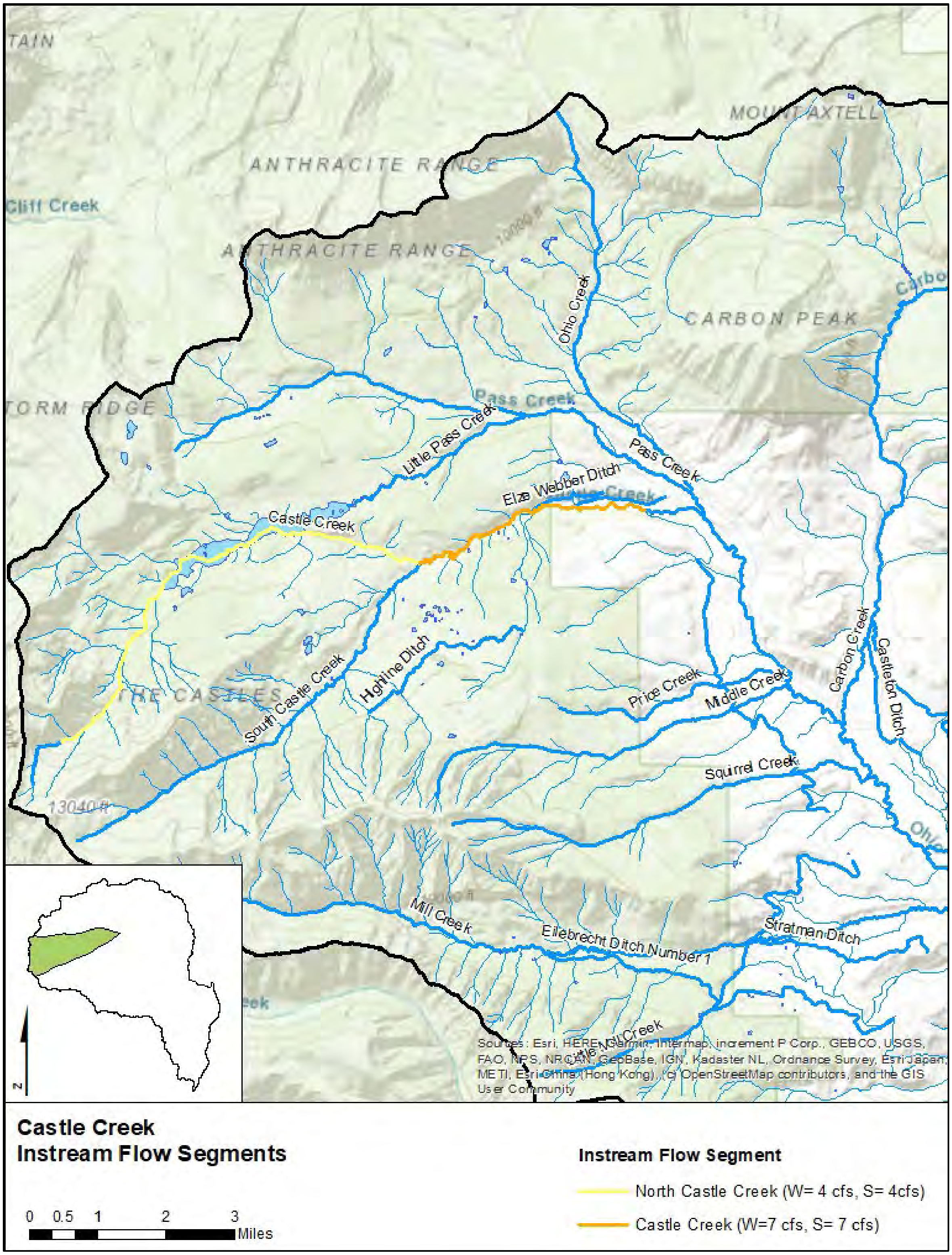


Figure 6-4: Instream flow water rights in the Castle Creek reach

6.3.6 Flow Limited Areas

From 1992 to 1998 USGS operated a gage on Castle Creek near the confluence with Ohio Creek (USGS gage #09113100). The gage was located downstream of several diversions from Castle Creek, but upstream of the Acme Ditch. Irrigation season flows in Castle Creek ranged from about 11 cfs in October to 147 cfs in June. Trout Unlimited monitoring data indicates that late season flows on Castle Creek can be less than 10 cfs upstream of the Acme Ditch diversion.

Late in the irrigation season diversions upstream of the gage account for a substantial portion of the natural stream flow, particularly in dry years. Thus, the last mile of Castle Creek below the Acme Ditch diversion to the confluence with Ohio Creek is classified as flow limited.

The Acme Ditch diverts a substantial portion of water from Castle Creek. The Acme Ditch diversion records indicate the maximum diversion since 1975 was 60 cfs, and in most years they divert a maximum of around 30 cfs during the runoff and significantly less by mid-July. The Acme Ditch can experience water shortages, due to a lack of physical availability, during drought years and during the late summer months of average years. During these periods, Castle Creek downstream of the Acme Ditch may lack the stream flow needed to fully support aquatic life. Water users work to prevent total dry up at this point through coordinated management, but there are times when maintaining some bypass flow is challenging due to a lack of water supply. The final mile of Castle Creek upstream of Ohio Creek is impacted by this flow limitation; return flows may increase stream flows approximately 0.5 miles downstream.

6.3.7 Environmental Flow Goals

South Castle Creek drains an area similar in size to North Castle Creek and supports expansive wetlands, riparian vegetation, and robust aquatic life. There is not an instream flow on this tributary.

While specific voluntary environmental flow goals have not been established for this reach, efforts to improve flows in lower Castle Creek have taken place and there is continued interest from some stakeholders to improve flows in lower Castle Creek during critical low flow periods, which would also benefit Ohio Creek downstream from the confluence with Castle Creek.

6.4 Recreational Water Use and Needs

Primary recreational uses on Castle Creek include angling, hunting, hiking, backpacking, horseback riding, and camping. These uses are limited to areas upstream of private land for the public. Property owners utilize the streams and riparian areas on private property for similar purposes, with angling being the primary recreational water use on private lands.

6.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality sampling for household wells.

Issue: Irrigation water distribution, aging infrastructure, bank stability, and water supply.

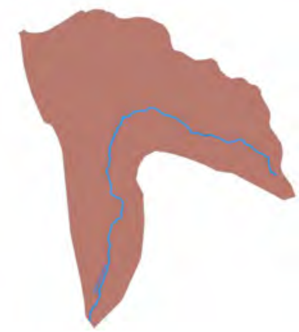
Issue: Small reservoir storage, including maintenance and enlargement of Silka Reservoir and an additional storage site in Berry Gulch.

Issue: Potential instream flow water right on South Castle Creek.

Issue: Potential to increase summer instream flow rates for North Castle Creek and Castle Creek.

Issue: Potential opportunities to maintain flow in Castle Creek downstream of the Acme Ditch.

Section 7. Reach 3 - Carbon Creek



The headwaters of Carbon Creek form on the south side of Whetstone Mountain. The headwaters are public lands managed by the USFS and Colorado State land board. The middle and lower portions of the Carbon Creek Watershed are privately owned, and parcel sizes vary from large ranches to moderately sized residential lots.

Carbon Creek provides approximately 15 percent the annual stream flow in Ohio Creek. The headwaters of Carbon Creek drain primarily west and south facing slopes which melt off earlier than Castle and Mill Creek.

Carbon Creek and its tributaries feature large, minimally disturbed wetlands and beaver complexes. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses. Big game habitat and livestock grazing are important uses in this area.

Several ditches on Carbon Creek carry water across steep hill sides of talus which creates extremely high conveyance losses. This is particularly challenging for water users during low flow periods because “carriage” water is simply not available to make up for the high transit loss. During drought years diversions will result in segments of channel dry up.

7.1 Agricultural Water Use

There are 13 active irrigation diversions in Carbon Creek, serving approximately 1,080 acres of flood irrigated pasture grass. Table 7-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates for the thirteen ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 7-1: Agricultural water use statistics – Carbon Creek

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	13	n/a
Irrigated Acreage	1,078 acres	n/a
Water Rights	111.7 cfs	n/a
Diversions	5,190 acre-feet	2,230 – 9,430 acre-feet
Crop Demand	1,900 acre-feet	1,480 – 2,280 acre-feet
Crop CU	1,430 acre-feet	890 – 1,880 acre-feet
Shortage/Need	470 acre-feet	400 - 590 acre-feet
Percent Shortage	25%	4% - 61%

Figure 7-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions through the Kubler Ditch, Cabin Ditch, and Weinert-Owens Creek Ditch comingle to serve some common acreage. Likewise, the Hope Resich Ditch, Bourne Ditch, and Mount Carbon Ditch also comingle to serve common acreage. All of the ditches are unlined, the longer ditches, including the Hope Resich Ditch, Smith Ditch, and Carbon Ditch, are estimated to lose 25 percent of diverted water during delivery to the irrigated fields. The other ditches in the reach are estimated to lose 20 percent during delivery.

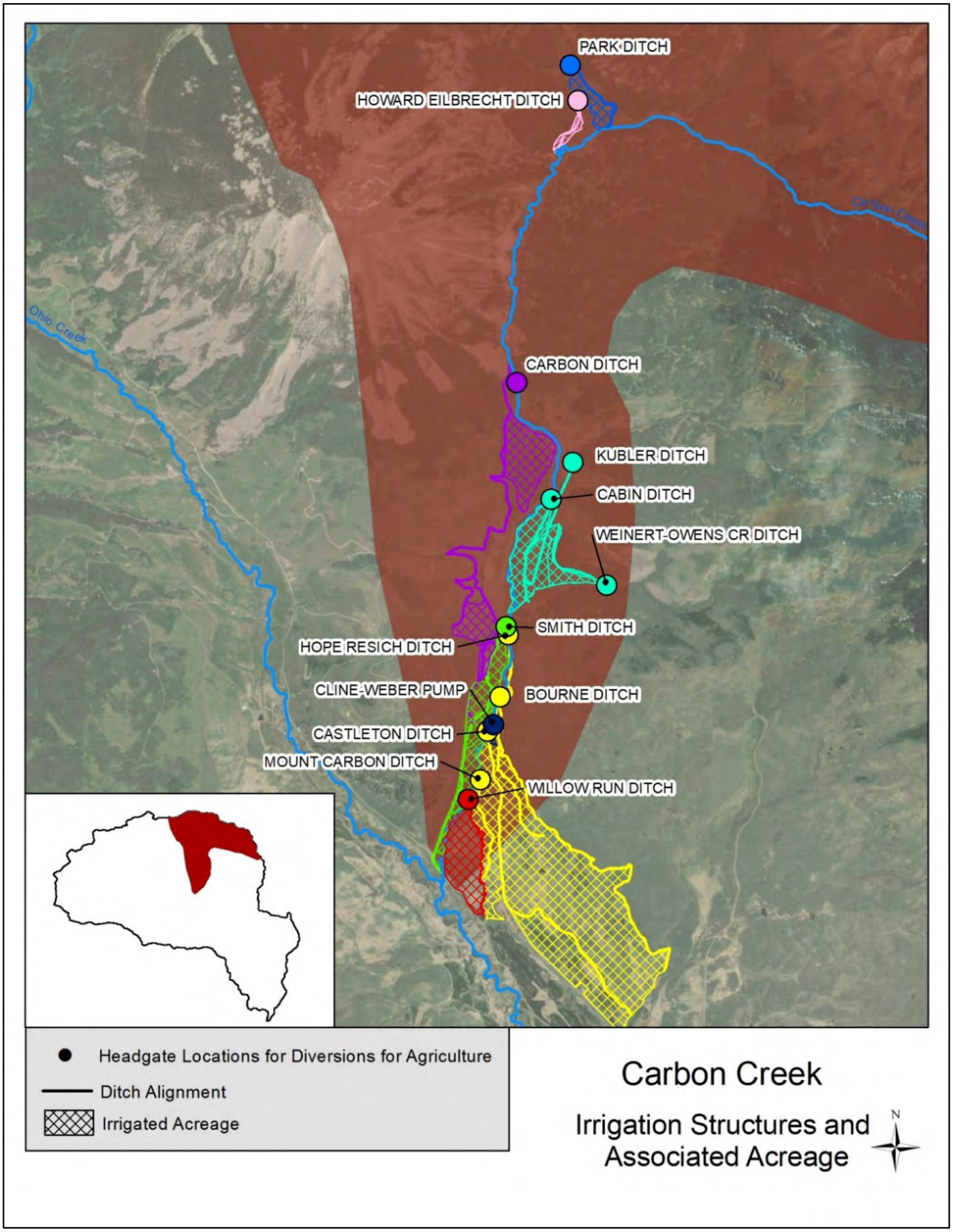


Figure 7-1: Carbon Creek irrigation structures and acreage

Table 7-2 shows the estimated percentage of water that returns to Carbon Creek and to downstream reaches.

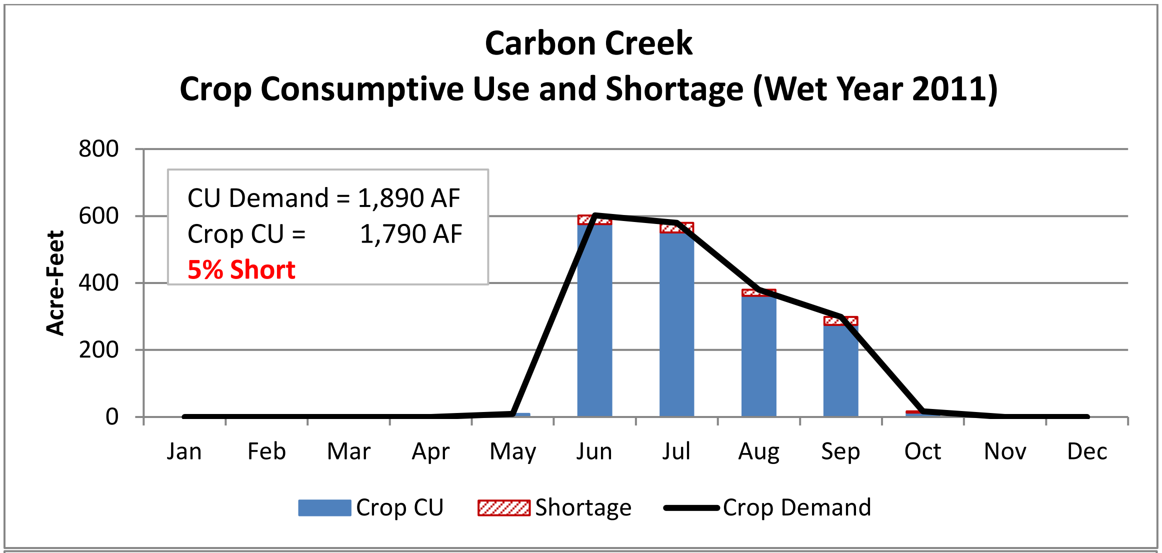
Table 7-2: Agricultural Return Flow Locations – Carbon Creek

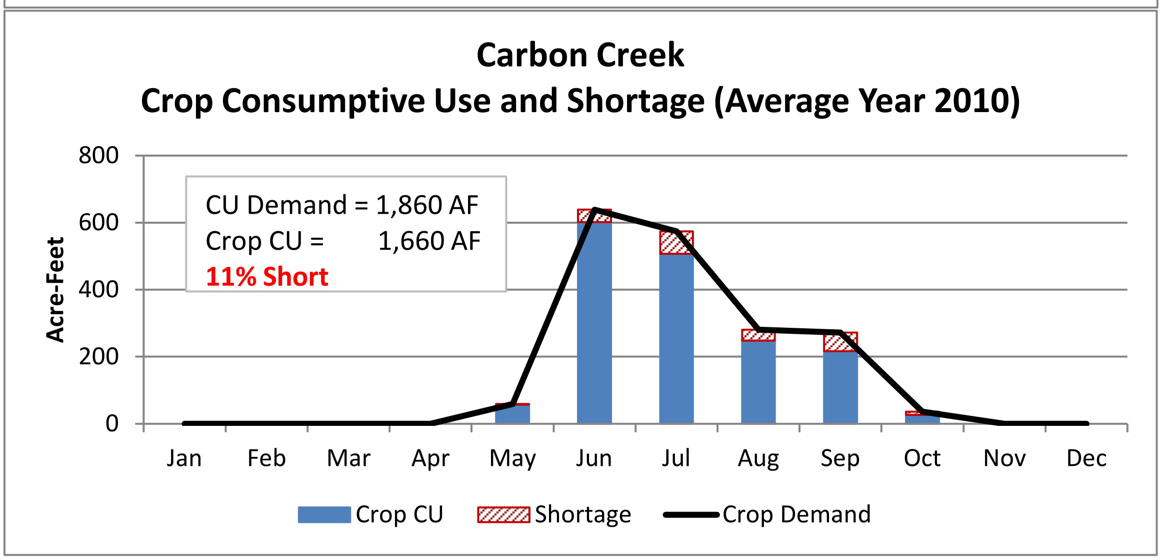
Return Flow Location	% of Total Return Flows	1998-2017 Ave Annual Return Flows (Acre-Feet)
Carbon Creek	40%	1,500
Ohio Creek from Castle Creek to Mill Creek	60%	2,260

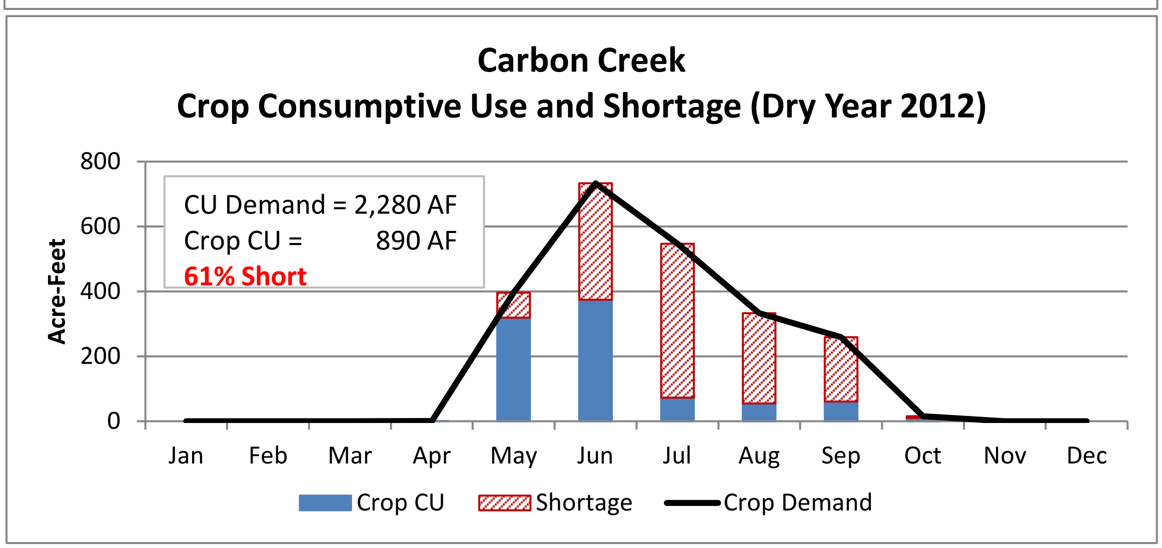
Figure 7-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, there were minimal shortages in the representative wet year. Minor shortages occurred in this reach every month during the irrigation season for the representative average year, and shortages were significant in the representative dry year. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, crop demand from an irrigation supply is minimal and limited diversions were recorded.

Monthly average natural flows in Carbon Creek at the mouth range from 109 cfs in June to 8 cfs in October. Even though physical water supply is much less than the cumulative water rights on the reach for most of the irrigation season, crop demands can generally be met in wet and average years with available supply.

Figure 7-2: Carbon Creek Crop Consumptive Use and Estimated Shortage







7.2 Domestic Water Use

A handful of homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

7.3 Environmental Water Use

7.3.1 Stream and Riparian Characteristics

The headwaters of Carbon Creek form below the northwest ridge of Red Mountain (11,660 feet) at about 10,500 feet. Carbon Creek quickly accumulate water as the stream flows west past small lakes, wetlands and tributaries that drain the south facing slopes of Whetstone Mountain, the southeast facing slopes of Mount Axtell, and the northern end of Red Mountain. At the foot of Carbon Peak, Carbon Creek turns south toward its confluence with Ohio Creek.

The portions of these mountains above tree line are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. In wet years, snow may be present until August in sheltered areas. In this area, steams are both intermittent and perennial, and most channels are steep and entrenched, and may be scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events, these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages.

Below the alpine basins, the headwaters of Carbon Creek and its tributaries feature large, minimally disturbed wetlands and beaver complexes. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses.

South of Carbon Peak, the valley widens, and the final four miles of the Carbon Creek Valley supports irrigated pasture grass. The riparian corridor narrows considerably likely due to reduced flows, vegetation removal, and in some areas channel incision. Although agricultural use has changed the character and overall size of the riparian area, many natural watershed functions are still relatively intact. Road 737 has an undersized bridge that crosses Carbon Creek; there is evidence of channel stability issues and armoring in this area.

7.3.2 Aquatic Life

Carbon Creek has a healthy cold-water trout fishery, including brook and brown trout, and a two-mile segment located on USFS lands is a popular site for campers and anglers. Forested areas, springs, beaver complexes, and wetlands help support base flows and create high quality aquatic and riparian habitat. Data to further characterize aquatic life were not identified during this assessment.

7.3.3 Water Quality

Water quality data has not been collected in the Carbon Creek Watershed since the late 1970s when USGS completed collection of a handful of samples as part of a regional study. In the only sample collected from Carbon Creek, the dissolved arsenic concentration was 5 µg/L in the lower portion of Carbon Creek. The human-health criterion for total recoverable arsenic is 0.02 µg/L.

Additional data exists for Carbon Creek and its tributaries, collected by various owners of the Keystone Mine and the Water Quality Control Division, but were not evaluated in this assessment as the data are over 30 years old and detection limits for many metals have decreased dramatically in the past 30 years.

As recently as 2010, the Keystone Mine Operations plan included tailings storage facilities in the headwaters of the Carbon Creek drainage.

7.3.4 Water Temperature

Continuous water temperature measurements are not known to have occurred on this reach. This is currently a data gap.

7.3.5 Existing Instream Flow Water Rights

Carbon Creek from the headwaters to the confluence with Ohio Creek has a year-round instream flow water right of 3 cfs as shown in Figure 7-3. The instream flow proposals were developed by CWCB and CPW staff in 1980. There are dry up points below the larger or more senior ditches on Carbon Creek during below average water years, which prevents an increase to the existing instream flow water right, due to a lack of physically and legally available water.

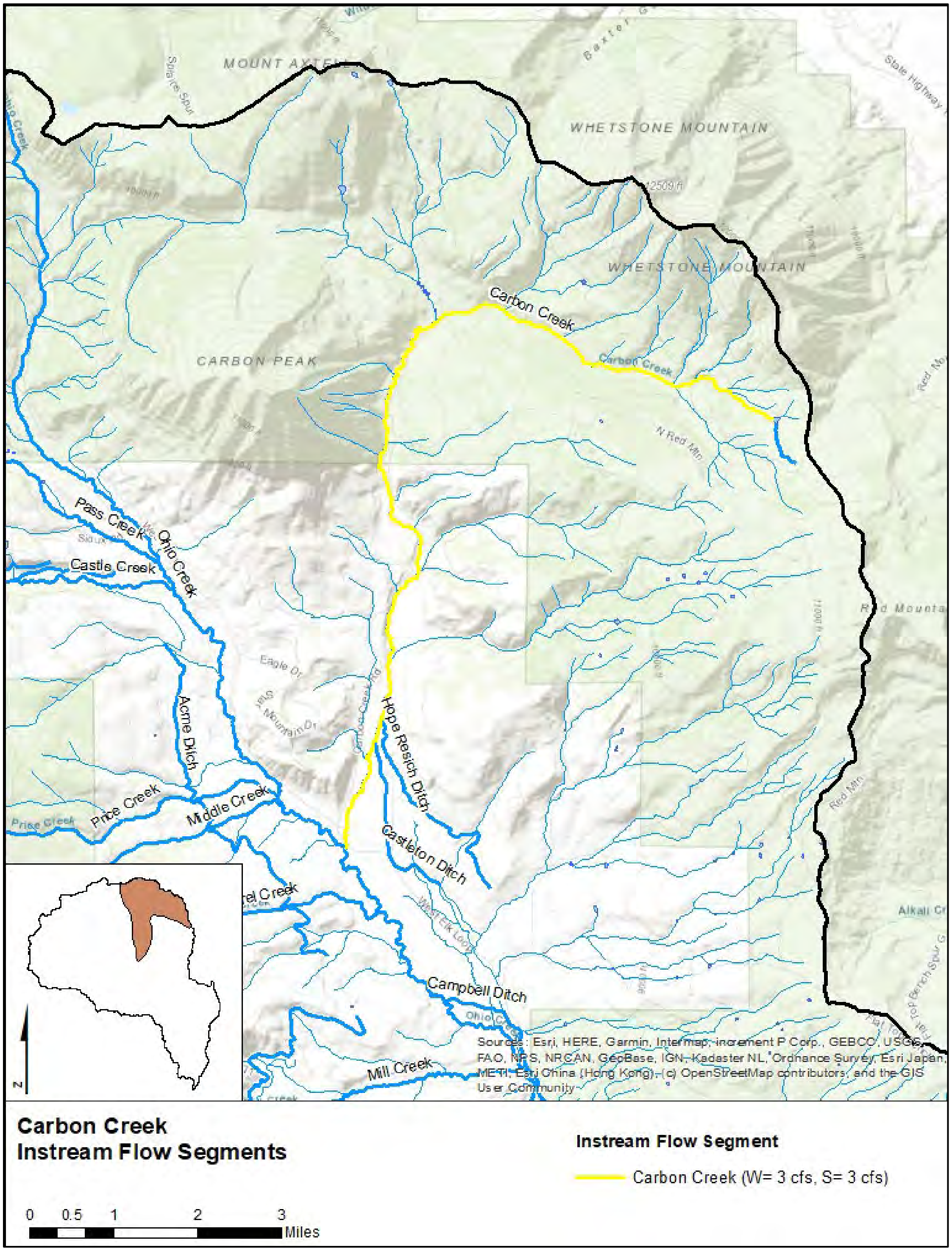


Figure 7-3: Carbon Creek instream flow water right

7.3.6 Flow Limited Areas

There are dry up points below the larger or more senior ditches on Carbon Creek during below average water years. Administrative calls were placed on two Carbon Creek ditches in 2018, and one ditch called in 2012.

7.3.7 Environmental Flow Goals

Voluntary environmental flow goals have not been identified as a priority for this reach.

7.4 Recreational Water Use

Recreational uses on Carbon Creek include angling, hunting, hiking, backpacking, and horseback riding. For the public, these uses are limited to USFS land. However, property owners utilize the streams and riparian areas on private property for similar purposes with angling being the primary recreational water use.

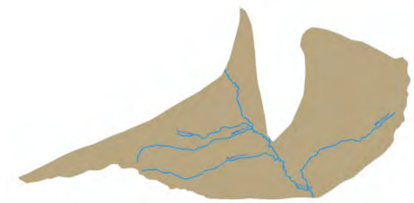
7.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Potential for elevated arsenic concentrations due to the local geology for household wells within and downgradient of Carbon Creek.

Issue: Diversion structures, irrigation water distribution, aging infrastructure, bank stability, and water supply.

Section 8. Reach 4 - Ohio Creek from Castle Creek to Mill Creek



The USFS service owns and manages the upper reaches of the relatively small creeks and unnamed tributaries that flow into the Ohio Creek Basin. Land within the Ohio Creek Basin is all privately owned. The area consists of four large ranches that are primarily managed for hay production, livestock grazing, and wildlife habitat. Grazing, on both private and publics lands, and wildlife habitat are important land uses within this reach.

Several small tributaries drain the West Elks, including Price, Middle, and Squirrel creeks; Wilson Creek and other unnamed tributaries drain the west side of Red Mountain. Flows from many of these tributaries are used for irrigation and in some cases provide topography suitable for new small reservoirs.

About 20 percent of the irrigated land in this reach is served by Acme and Castleton Ditches that divert water from Castle Creek, and the Hope Resich and Bourne Ditches that divert water from Carbon Creek.

The valley is constricted near the confluence of Mill Creek. The constriction may direct surface and groundwater return flows back to the channel in this reach. Several stakeholders noted that early season flood irrigation on this reach provides for improved flows for downstream uses later in the season.

8.1 Agricultural Water Use

There are 28 active irrigation diversions on Ohio Creek and the tributaries between Castle Creek and Mill Creek reach, serving approximately 1,500 acres of flood irrigated pasture grass. Table 8-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates for the twenty-eight ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 8-1: Agricultural Water Use Statistics – Ohio Creek from Castle Creek to Mill Creek

Reach Statistics	1998-2017 Average	1998 to 2017 Range
Number of Irrigation Structures	28	n/a
Irrigated Acreage	1,402 acres	n/a
Water Rights	179.77 cfs	n/a
Diversions	9,060 acre-feet	4,120 – 12,240 acre-feet
Crop Demand	2,570 acre-feet	2,000 – 3,100 acre-feet
Crop CU	1,760 acre-feet	1,170 – 2,130 acre-feet
Shortage/Need	810 acre-feet	970 - 830 acre-feet
Percent Shortage	32%	17% - 57%

Figure 8-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions for the Campbell Ditch E and W Branch are measured together and serve common lands located in the downstream reach. All of the ditches are unlined and are estimated to lose between 10 percent and 25 percent of diverted water during delivery to the irrigated fields, depending on ditch length.

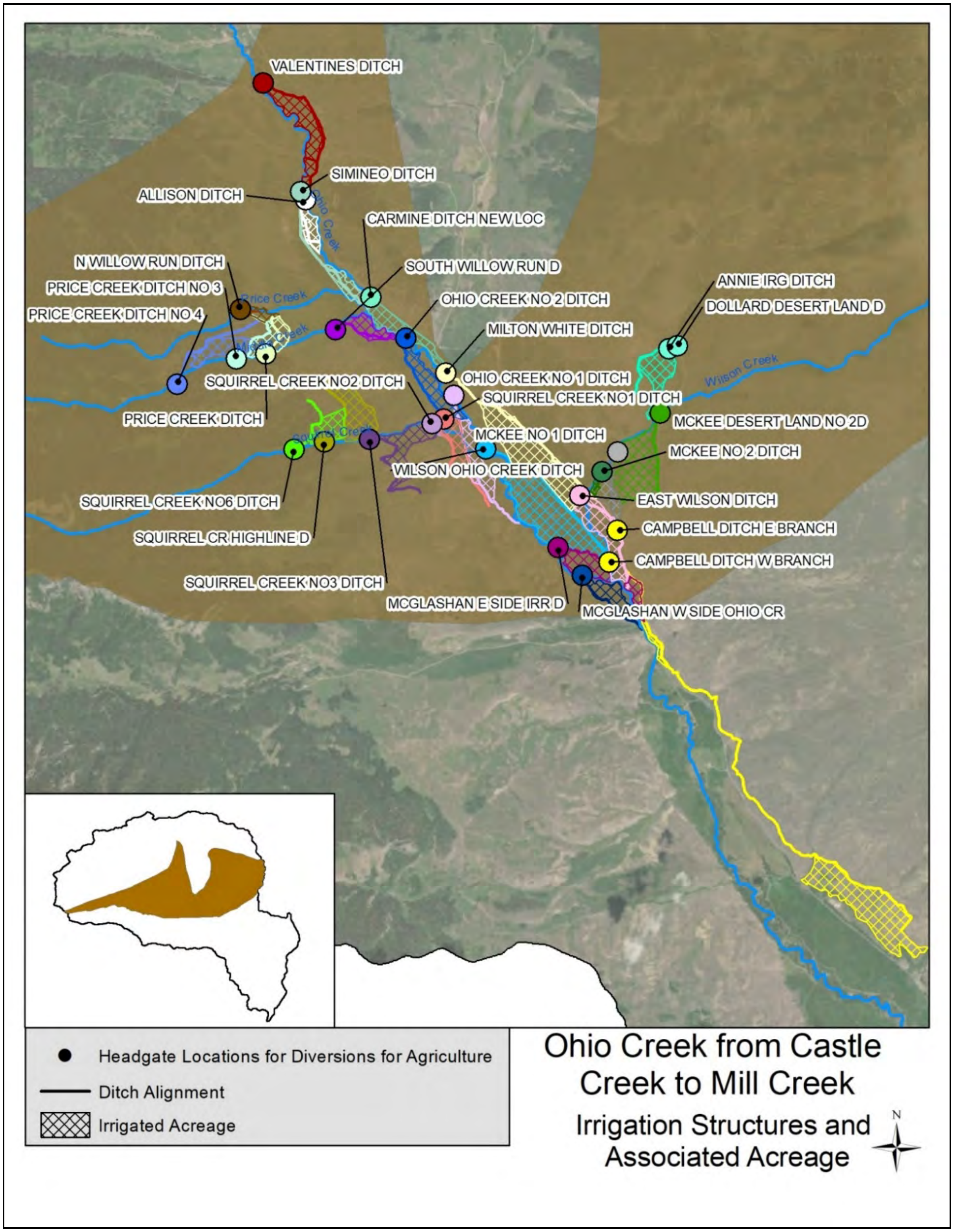


Figure 8-1: Ohio Creek from Castle Creek to Mill Creek irrigation structures and acreage

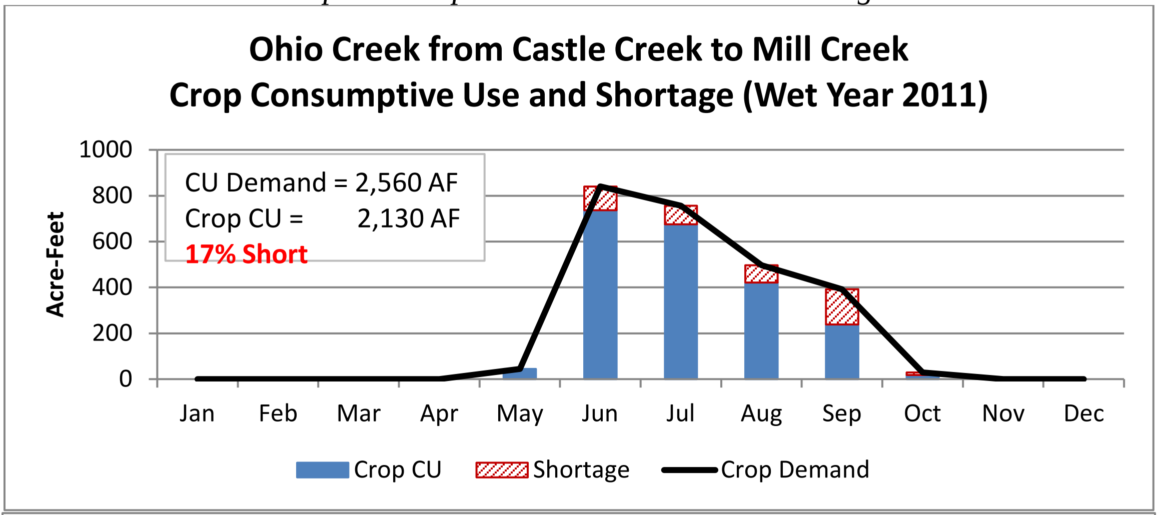
Table 8-2 shows the estimated percentage of water that returns within the reach and to downstream reaches.

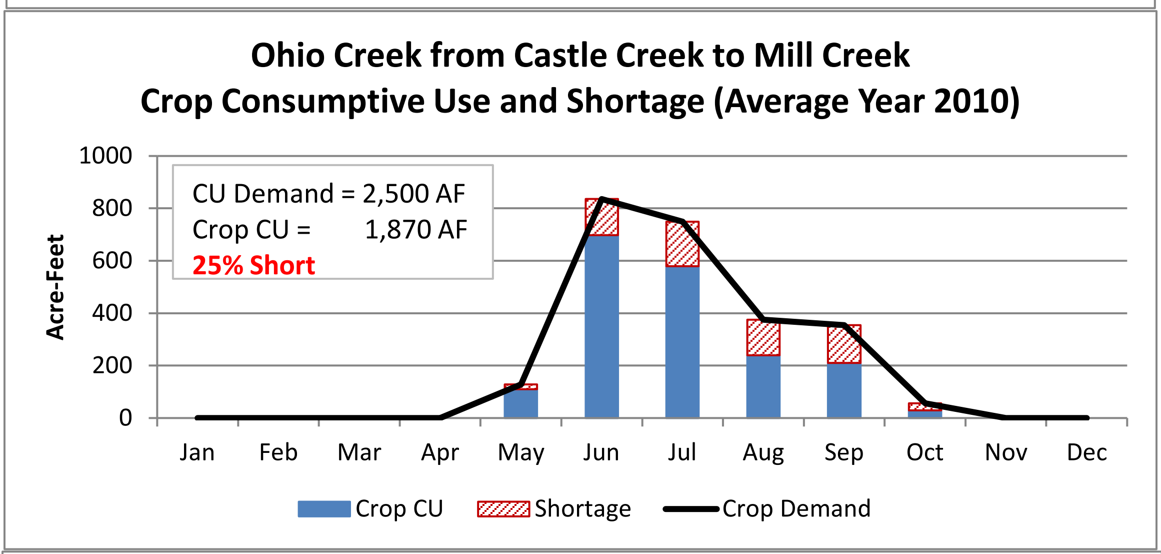
Table 8-2: Agricultural Return Flow Locations – Ohio Creek from Castle Creek to Mill Creek.

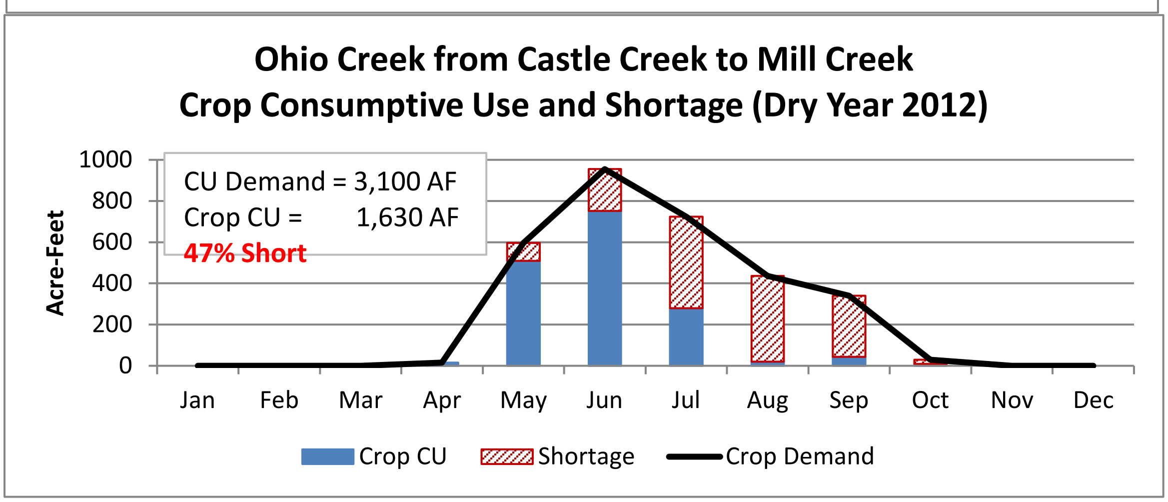
Return Flow Location	% of Total Return Flows	1998-2017 Ave Annual Return Flows (Acre-Feet)
Ohio Creek from Castle Creek to Mill Creek	95%	6,930
Ohio Creek from Mill Creek to Gunnison River	5%	370

Figure 8-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were shortages every year during the analysis period and, as shown, shortages were largest in the representative dry year. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, crop demand from an irrigation supply is minimal and limited diversions were recorded. Although mainstem Ohio Creek ditches experience shortages in average and wet years, shortages are greater on the smaller tributaries to Ohio Creek in this reach.

Figure 8-2: Ohio Creek from Castle Creek to Mill Creek
Crop Consumptive Use and Estimated Shortage







8.2 Domestic Water Use

Approximately 20 homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

8.3 Environmental Water Use

8.3.1 Stream and Riparian Characteristics

Prior to human settlement, the Ohio Creek Basin likely supported a broad riparian area littered with large beaver complexes, multi-threaded channels, and a wide variety habitat types as evidenced by the terrace structure throughout the valley and multiple relic channels.

Today, the Ohio Creek Basin is a bucolic and productive agricultural area. The riparian corridor has narrowed considerably but persists in some form throughout the reach. The size of the riparian corridor has decreased due to reduced flows, altered ground and surface water hydrology, vegetation removal, and in some areas channel incision.

Although agricultural use has changed the character and overall size of the riparian area, natural watershed functions are still relatively intact. In recent years, channel stabilization and habitat improvements have been completed on several properties on the upper two-thirds of the reach.

8.3.2 Aquatic Life

Ohio Creek between Castle and Mill creeks has a healthy cold-water trout fishery, including brook and brown trout. Data to further characterize aquatic life were not identified during this assessment.

8.3.3 Water Quality

An *E. coli* sample collected by the WQCD in September 2014 suggests that Ohio Creek may be impaired for the recreational use standard (Table 8-3 and Figure 8-3). Additional data collection will be required to determine the impairment status.

Five of six samples collected by the WQCD in 2014 and 2015 from Ohio Creek downstream of Ohio Pass Road detected total arsenic and concentrations ranged from 1 to 3.8 µg/L.

In 2018 the headwaters of Middle Creek located in wilderness areas within the Upper Gunnison River Basin were listed as impaired for total recoverable arsenic for the water supply use. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the Ohio Creek Sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries.

Table 8-3: Impaired and potentially impaired stream reaches in the Ohio Creek from Castle Creek to Mill Creek reach.

<table>
<tr><th>Listed Portion of Stream</th><th>Affected Use</th><th>Potentially Impaired Analyte (M&E List)</th><th>Impaired Analyte (303(d) List)</th><th>Impairment Priority</th></tr>
<tr><td rowspan="2">All tributaries to the Gunnison River, including wetlands, within the West Elk Wilderness Areas, excluding Stewart Creek</td><td rowspan="2">Water Supply Use</td><td>Dissolved Iron</td><td>NA</td><td>NA</td></tr>
<tr><td>NA</td><td>Total Arsenic</td><td>High</td></tr>
<tr><td rowspan="2">Mainstem of Ohio Creek upstream, of County Road 7</td><td>Recreational Use</td><td>E. coli</td><td>NA</td><td>NA</td></tr>
<tr><td>Water Supply Use</td><td>NA</td><td>Total Arsenic</td><td>High</td></tr>
</table>

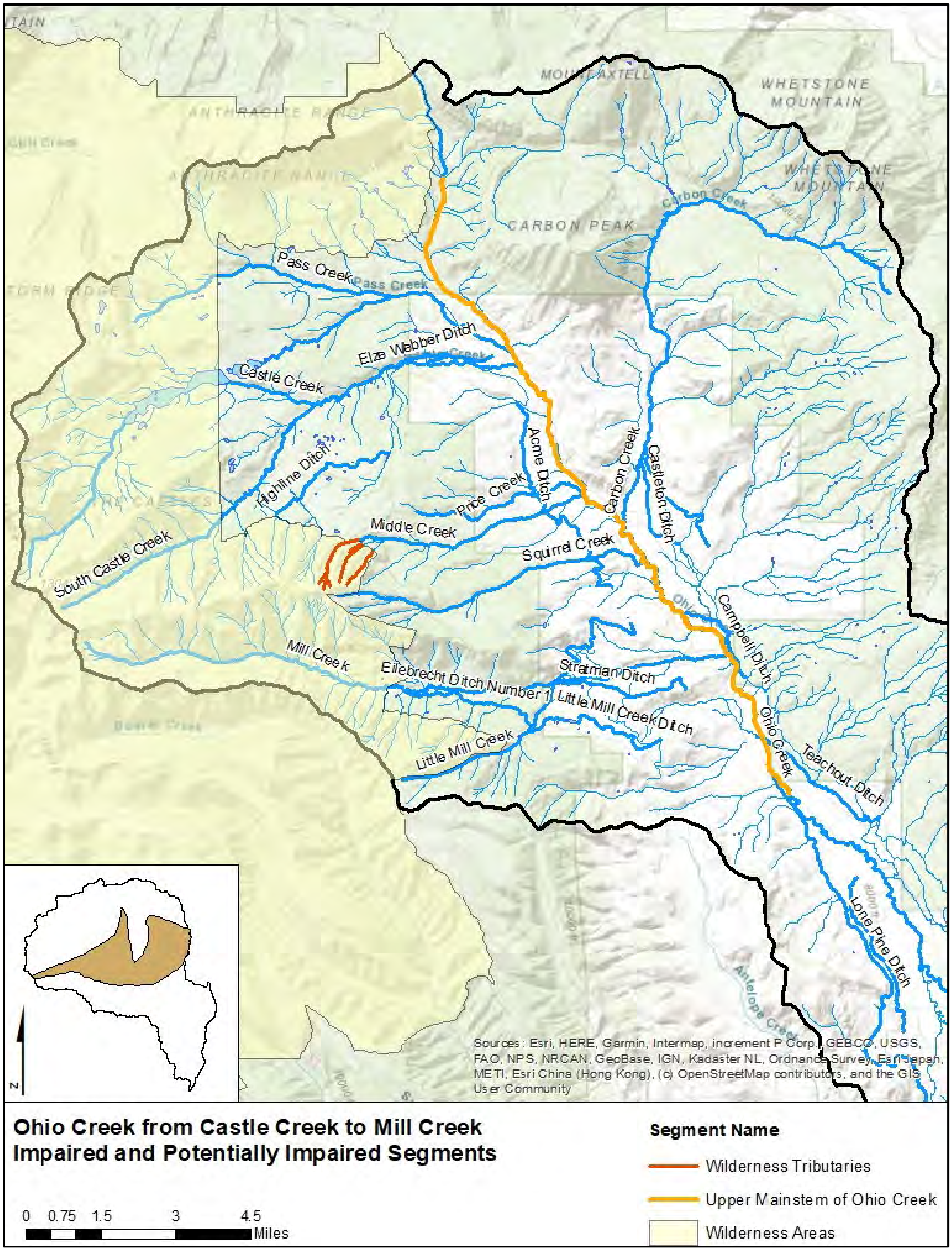


Figure 8-3: Impaired and potentially impaired stream reaches in the Ohio Creek from Castle Creek to Mill Creek reach

8.3.4 Water Temperature

Trout Unlimited has collected temperature data from Ohio Creek approximately seven miles downstream of the confluence with Mill Creek. The temperature data from downstream may provide some insights to stream temperatures within this reach.

8.3.5 Existing Instream Flow Water Rights

Ohio Creek from Castle Creek to Mill Creek has a year-round instream flow water right of 10 cfs as shown on Figure 8-4. The instream flow proposals were developed by CWCB and CPW staff in 1980.

An R2CROSS assessment was completed on October 16, 2018 in Ohio Creek downstream of the confluence with Castle Creek. During the assessment stream flow was 11.7 cfs. The preliminary R2CROSS output calculated a summer flow rate of 16 cfs; the winter rate was slightly lower than the existing instream flow rate.

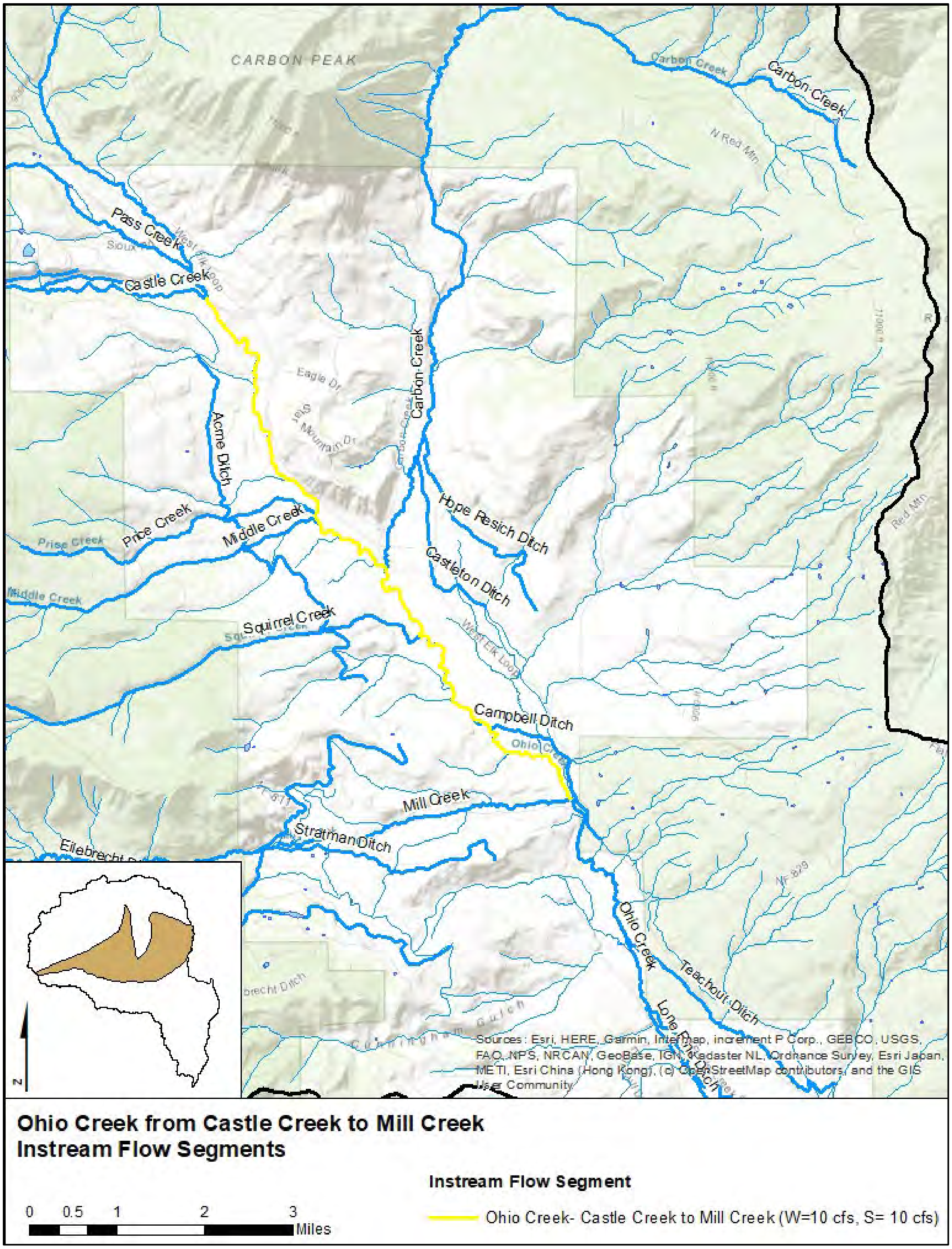


Figure 8-4: Instream flow water right on Ohio Creek from Castle Creek to Mill Creek reach

8.3.6 Flow Limited Areas

Although substantial diversions occur upstream of and within this reach, there are not any known dry up points.

8.3.7 Environmental Flow Goals

To date, voluntary environmental flow goals have not been identified as a priority for this reach. In the future, flow data from the newly reactivated gage, Ohio Creek near Baldwin (USGS 09113500), and a pressure transducer in the mouth of Mill Creek could be used to assess instream flow attainment rates for Ohio Creek from Castle Creek to Mill Creek.

8.4 Recreational Water Use

Recreational uses on Ohio Creek from Castle Creek to Mill Creek include angling and hunting by private landowners and their guests. Recreational use by the general public is limited to the upper reaches of tributary streams in the West Elks and Red Mountain and includes hunting, hiking, backpacking, and horseback riding.

8.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Potential risks to household well quality posed by arsenic and *E. coli*.

Issue: Potential stability and habitat improvement projects on the lower third of Ohio Creek on this reach.

Issue: Diversion structures, irrigation water distribution, aging infrastructure, bank stability, and water supply.

Issue: Wet meadow restoration: Several small tributaries drain the West Elks, including Price, Middle, and Squirrel creeks; Wilson Creek and other unnamed tributaries drain Red Mountain. Most areas provide excellent wildlife habitat and livestock grazing, but some areas could benefit from restoration to improve hydrologic function and water retention, reduce erosion and improve habitat quality.

Issue: Potential to enlarge summer instream flow rate for Ohio Creek from Castle Creek to Mill Creek.

Issue: Potential for small-scale water storage.

Section 9. Reach 5 - Mill Creek

The headwaters of Mill Creek form in the West Elk Wilderness. The wilderness and adjacent public lands are managed by the USFS, except for small privately-owned inholdings. As Mill Creek flows east toward Ohio Creek, privately owned lands become more common. Land adjacent to the last three miles of stream are privately owned and used for livestock grazing and hay production. Big game habitat and livestock grazing are important uses in the Mill Creek drainage.

Upper Mill Creek supports several springs and beaver complexes that support late season flows and provide excellent aquatic and terrestrial habitat. Mill Creek provides 20 percent of the annual streamflows in Ohio Creek.

9.1 Agricultural Water Use

There are nine active irrigation diversions in Mill Creek, serving approximately 1,146 acres of flood irrigated pasture grass. Table 9-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates for the nine ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 9-1: Agricultural water use statistics – Mill Creek.

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	9	n/a
Irrigated Acreage	1,146 acres	n/a
Water Rights	114 cfs	n/a
Diversions	4,230 acre-feet	2,440 – 6,920 acre-feet
Crop Demand	2,040 acre-feet	1,630 – 2,370 acre-feet
Crop CU	1,530 acre-feet	980 – 1,850 acre-feet
Shortage/Need	510 acre-feet	520 - 650 acre-feet
Percent Shortage	25%	2% - 45%

Figure 9-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions for several ditches comingle to serve common lands north of Mill Creek. Note that one ditch, irrigating in the upper reaches of Mill Creek is not shown on the figure. Although Cunningham Ditch diverts from Mill Creek, the irrigated land is in the downstream reach. Water is diverted from Mill Creek to Cunningham Gulch for delivery to the irrigated lands. Similarly, Smelser Ditch diverts from Mill Creek then releases water into a small drainage for delivery to the irrigated lands. All the ditches are unlined and are estimated to lose between 10 percent and 25 percent of diverted water during delivery to the irrigated fields, depending on ditch length.

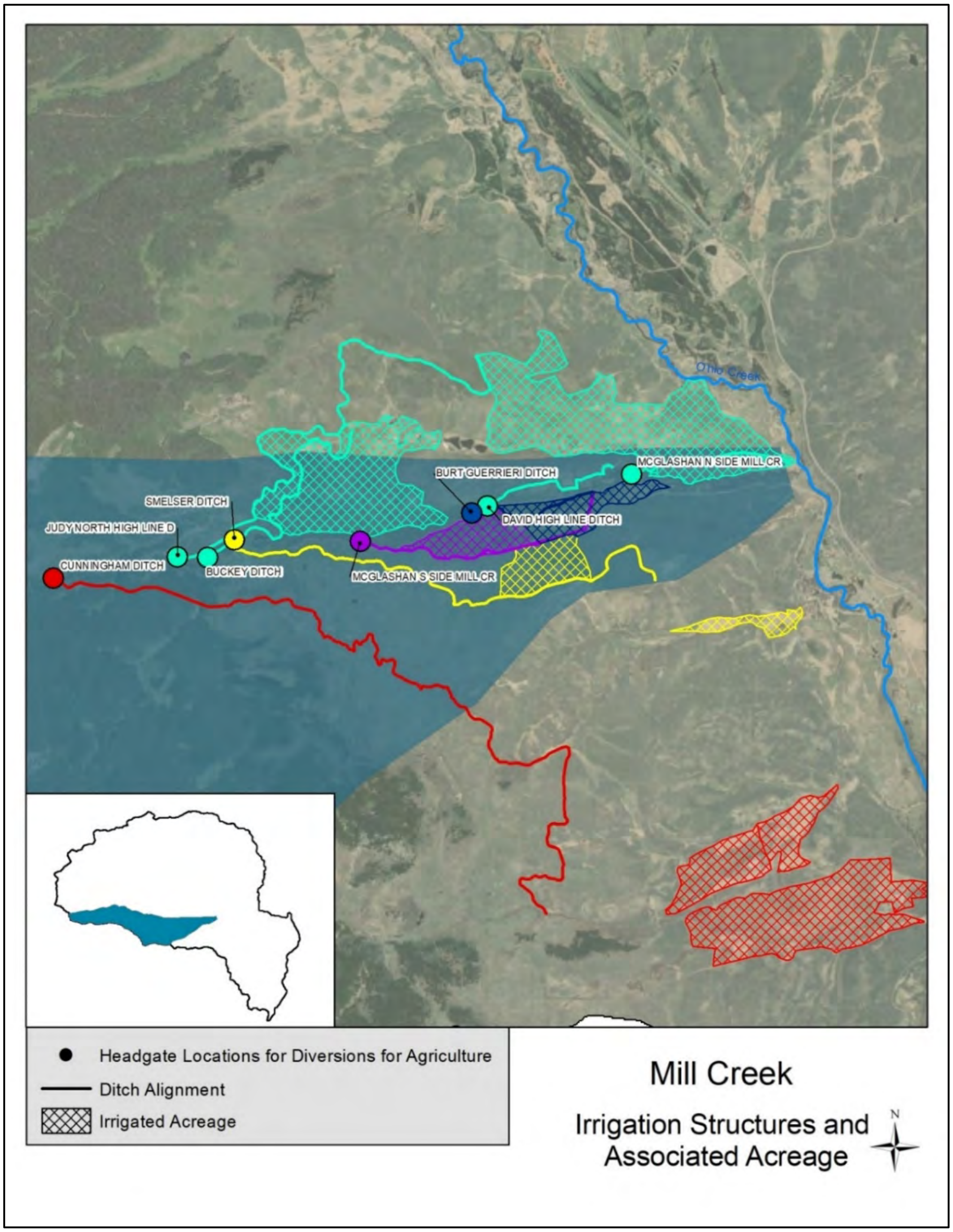


Figure 9-1: Mill Creek irrigation structures and acreage

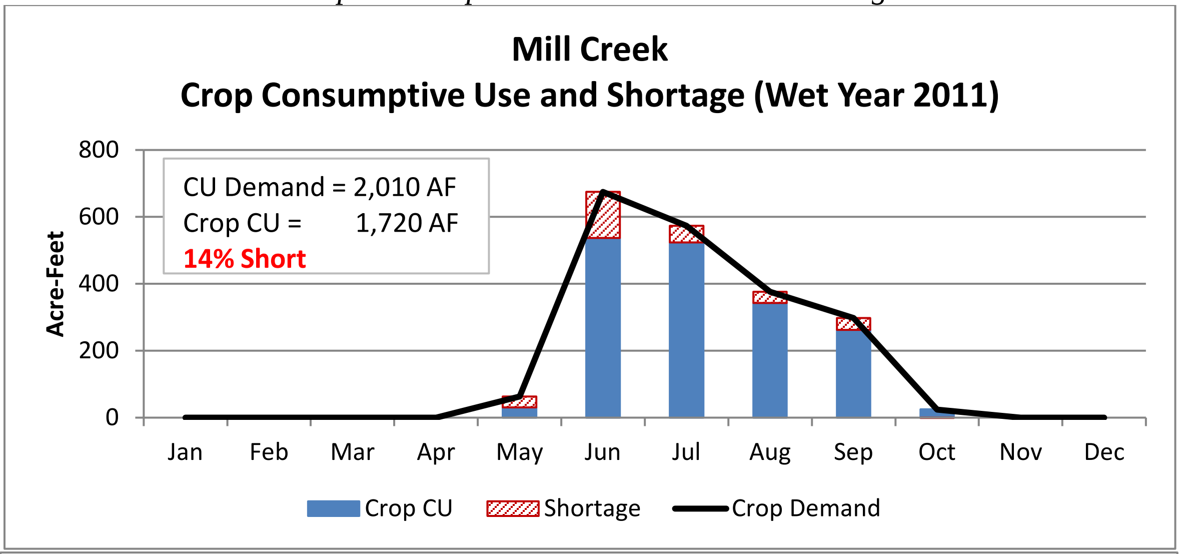
Table 9-2 shows the estimated percentage of water that returns to Mill Creek and to downstream reaches.

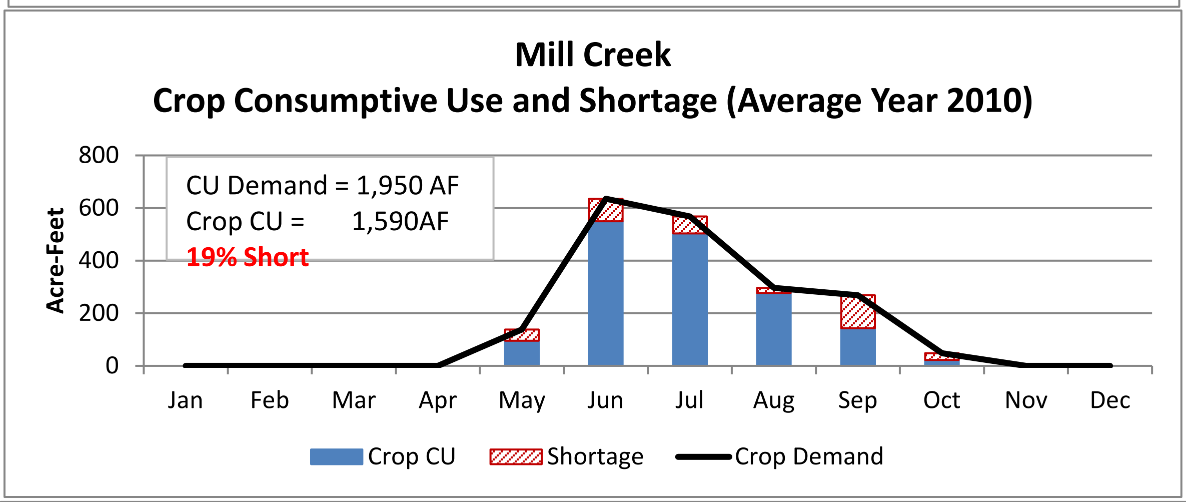
Table 9-2. Agricultural return flow locations –Mill Creek.

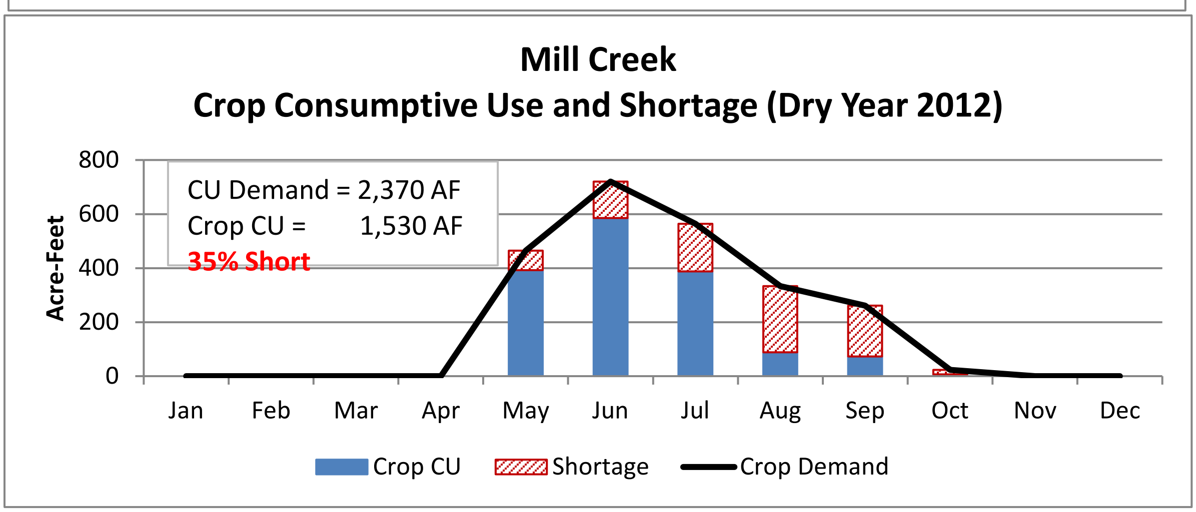
Return Flow Location	% of Total Return Flows	1998-2017 Average Annual Return Flows (Acre-Feet)
Mill Creek	**70%**	**1,890**
Ohio Creek from Mill Creek to Gunnison River	**30%**	**810**

Figure 9-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were shortages every year during the analysis period and, as shown, shortages were largest in the representative dry year. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, crop demand from an irrigation supply is minimal and limited diversions were recorded.

Figure 9-2: Ohio Creek from Castle Creek to Mill Creek
Crop Consumptive Use and Estimated Shortage







9.2 Domestic Water Use

A handful of homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality. Like other reaches in the Ohio Creek watershed, arsenic concentrations present a potential risk to drinking water uses (see water quality section below).

9.3 Environmental Water Use

9.3.1 Stream and Riparian Characteristics

The headwaters of Mill Creek form in the east facing basin below North Baldy Mountain and Storm Pass at over 12,000 feet in the West Elk Wilderness. Mill Creek flows east toward the Ohio Creek Valley. The upper reaches of Mill Creek and its tributaries drain steep talus covered slopes or a thin veneer of soil and sensitive alpine tundra vegetation. In wet years, snow may be present until August in sheltered areas. In this area, streams are both intermittent and perennial, and most channels are steep and entrenched, and may be scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events, these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages.

As the Mill Creek Basin widens, large minimally disturbed beaver complexes and wetlands become more common. These features increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses. Small canyons also exist in the upper and middle sections of Mill Creek.

Irrigation diversions begin where the Mill Creek Basin reaches the margin of the Ohio Creek Valley. The size and complexity of the riparian area tends to decrease as Mill Creek flows toward Ohio Creek, yet the riparian corridor is in reasonably good condition, with only a few areas with evidence of sediment imbalance or stability issues.

9.3.2 Aquatic Life

Mill Creek has a healthy trout fishery, including brook and brown trout. In August 2013 WQCD staff collected a macroinvertebrate sample from Mill Creek at the Mill-Castle Campground. The species composition and diversity of the macroinvertebrate sample attained the criteria for aquatic life use.

9.3.3 Water Quality

In 2014 and 2015, WQCD staff collected 11 water quality samples from Mill Creek at the Mill-Castle Campground. Aside from, total recoverable arsenic, the samples indicated good to excellent water quality. Total recoverable arsenic was detected in 10 of 11 samples and ranged from 0.32 to 3.6 µg/L. These results exceed the human-health criterion for the water supply standard (0.02 µg/L).

In 2018, the headwaters of Mill Creek located in wilderness areas within the Upper Gunnison River Basin were listed as impaired for total recoverable arsenic for the water supply use, as shown in Table 9-2 and Figure 9-3. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the Ohio Creek Sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries.

Table 9-2: Impaired and potentially impaired stream reaches in the Mill Creek reach.

<table>
<tr><th>Listed Portion of Stream</th><th>Affected Use</th><th>Potentially Impaired Analyte (M&E List)</th><th>Impaired Analyte (303 (d) List)</th><th>Impairment Priority</th></tr>
<tr><td rowspan="2">All tributaries to the Gunnison River, including wetlands, within the West Elk Wilderness Areas, excluding Stewart Creek.</td><td rowspan="2">Water Supply Use</td><td>Dissolved Iron</td><td>NA</td><td>NA</td></tr>
<tr><td>NA</td><td>Total Arsenic</td><td>High</td></tr>
</table>

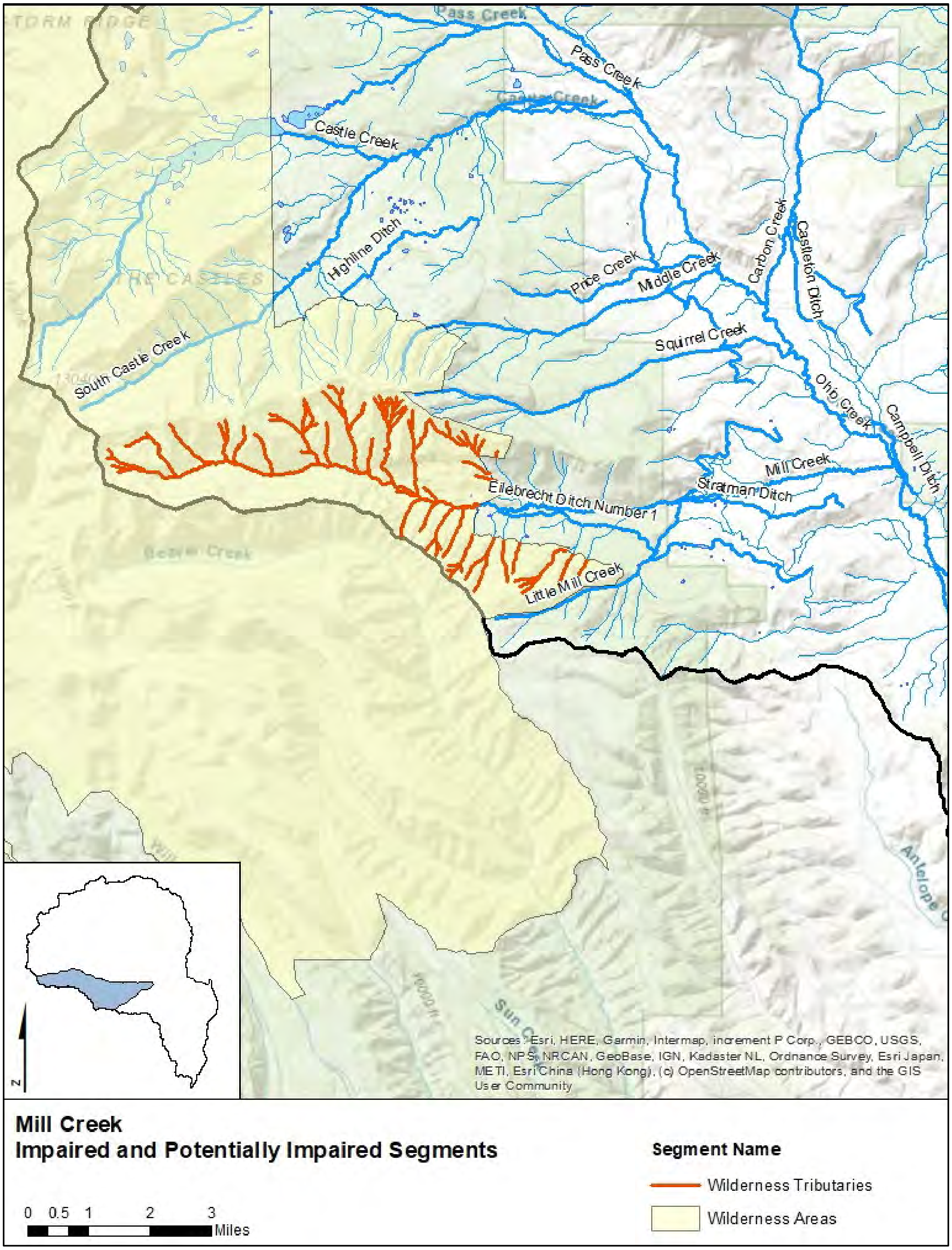


Figure 9-3: Impaired and potentially impaired stream reaches in the Mill Creek reach

9.3.4 Water Temperature

Continuous water temperature measurements are not known to have occurred on this reach. This is currently a data gap.

9.3.5 Existing Instream Flow Water Rights

Mill Creek from the headwaters to the Forest Service boundary on County Road 727 has a year-round instream flow water right of 5 cfs as shown in Figure 9-4. The instream flow proposals were developed by CWCB and CPW staff in 1980. The original proposal documents were not available during this assessment.

Figure 9-4: Instream flow water right for Mill Creek

9.3.6 Flow Limited Areas

Although substantial diversions occur upstream in this reach, there are not any known dry up points.

9.3.7 Environmental Flow Goals

The existing instream flow for Mill Creek provides a summer flow rate that appears more adequate than other reaches in the Ohio Creek sub-basin. Therefore, changes to the instream flow rate are not currently a priority.

Voluntary environmental flow goals have not been identified as a priority for this reach.

9.4 Recreational Water Use

The majority of recreational uses by the general public are limited to USFS land. However, property owners utilize the streams and riparian areas on private property for hunting and in some cases angling.

There is a large parking area near the forest service boundary and a more primitive parking area at the wilderness boundary. The area sees significant traffic from recreational uses including angling, hunting, hiking, backpacking, horseback riding. Dispersed camp sites can be found near the road between the USFS boundary and wilderness boundary.

9.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Potential risks to water quality for household wells posed by arsenic and *E. coli*.

Issue: Cunningham Ditch maintenance and Cunningham Reservoir improvements.

Issue: Potential for additional infrastructure to support recreational uses, including permanent toilets.

Section 10. Reach 6 - Ohio Creek from Mill Creek to the Gunnison River

This reach of Ohio Creek is almost all privately owned. The primary water use is irrigation for livestock grazing and hay production. However, nearly all the properties located on the stream channel manage Ohio Creek as a trout fishery for private angling.

The most challenging issue on this segment is water supply, leading to both irrigation shortages and instream flow shortages. Dry up and near dry up below diversions is common during below average years.

Three large ditches divert water from the upper end of this reach and distribute water on a similar contour to the east and west of the channel. These ditches provide primary or supplemental irrigation for much of the acreage in this segment of Ohio Creek. During low flow periods, flows in Ohio Creek directly downstream of these ditches can be negatively impacted.

Lands on the lower end of this reach are subdivided into smaller parcels (35 acre or less) with water rights in shared ditches. Due to the number of owners associated with the shared ditches, it is often more difficult to coordinate operations. Stakeholders noted that increased coordination for flood irrigation, management and maintenance of infrastructure, and education are a priority in this area. Education needs identified to date include water rights, ditch management, and appropriate irrigation rates.

Calling rights are located on this reach. The current owners of the calling rights would prefer not to call and suggested coordinated irrigation management to meet their demands rather than placing a call. Continuing irrigation practices that maintain historic flow patterns is important to stakeholders to assure existing uses are protected. To help address these concerns and better characterize flows within this reach, the UGRWCD partnered with USGS to reactivate an historic gage in Ohio Creek downstream of Mill Creek (USGS-09113500).

10.1 Agricultural Water Use

There are 29 active irrigation diversions in Ohio Creek from Mill Creek to Gunnison River reach, serving approximately 6,384 acres of flood irrigated pasture grass. Table 10-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates for the twenty-nine ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 10-1: Agricultural water use statistics – Ohio Creek from Mill Creek to Gunnison River.

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	29	n/a
Irrigated Acreage	6,384 acres	n/a
Water Rights	497.414 cfs	n/a
Diversions	36,390 acre-feet	16,930 – 48,060 acre-feet
Crop Demand	12,040 acre-feet	9,620 – 13,840 acre-feet
Crop CU	9,450 acre-feet	6,240 – 11,290 acre-feet
Shortage/Need	2,590 acre-feet	2,550 – 3,380 acre-feet
Percent Shortage	22%	7% - 53%

Figure 10-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. Towards the lower end of Ohio Creek, many of the ditches comingle. Lands with multiple sources are shown in the blue hatch. There are approximately 1,700 acres in the lower portion of the reach that are irrigated from ditches diverting from the Gunnison River (not shown).

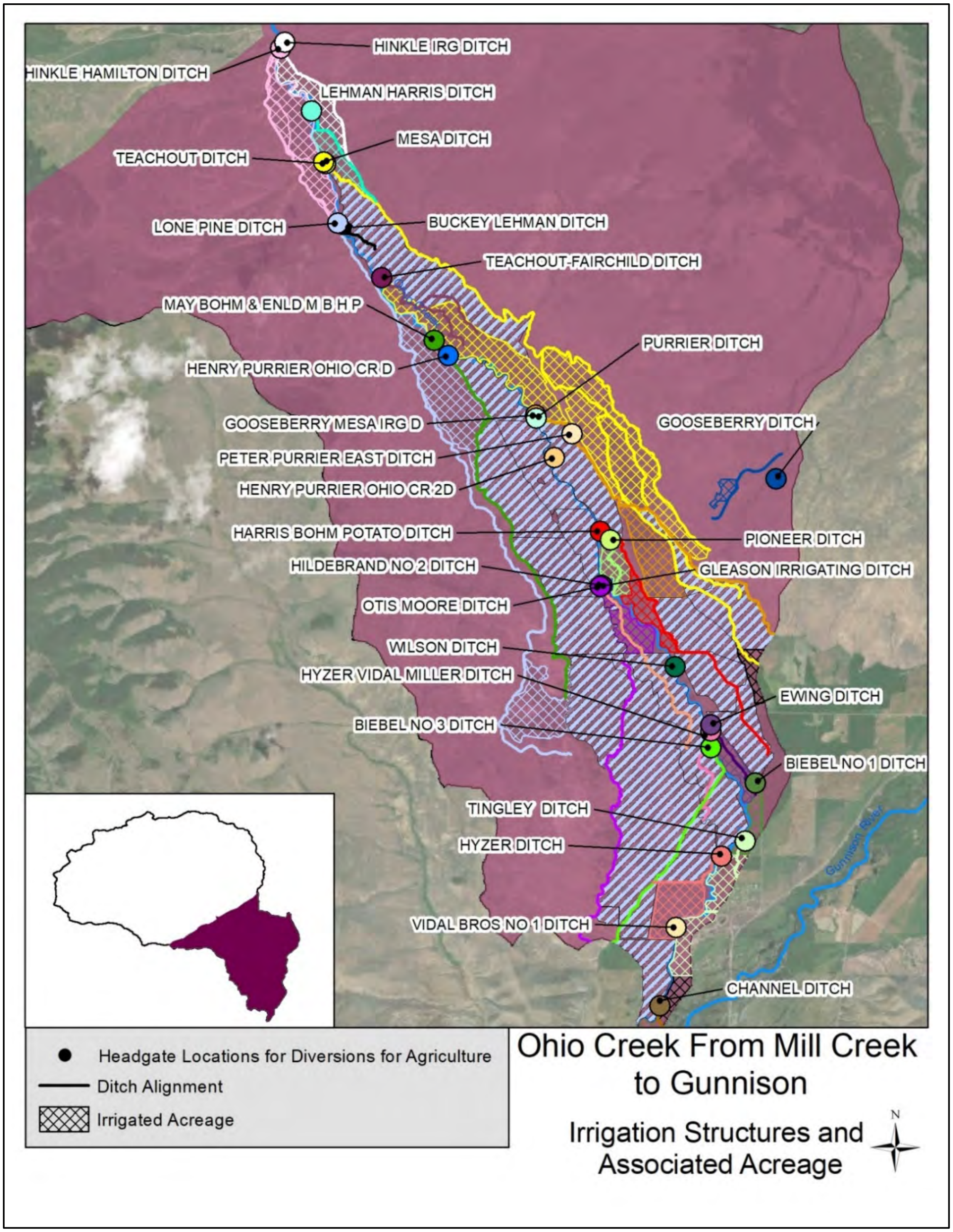
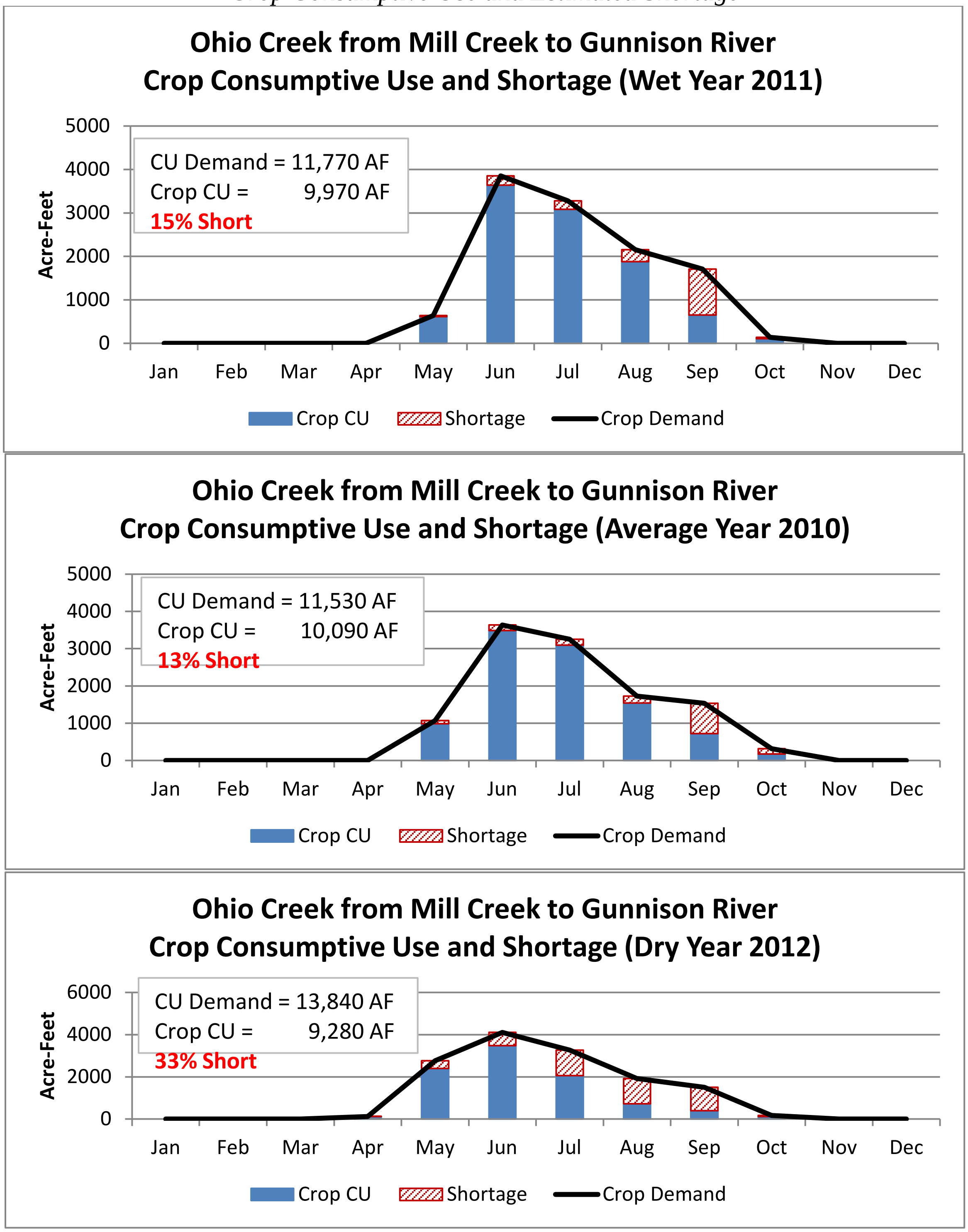


Figure 10-1: Ohio Creek from Mill Creek to Gunnison River irrigation structures and acreage (blue hatched areas indicate that the parcel is irrigated with water from both Ohio Creek and the Gunnison River)

Return flows from irrigation in this reach primarily accrue to Ohio Creek above the confluence with the Gunnison River. In addition, approximately 4,900 acre-feet per year for 1998 to 2017 period of return flows from irrigation and from diversions off the Gunnison River, including the Gunnison River-Ohio Creek Irrigation Ditch and the Gunnison & Ohio Creek Canal, return to Ohio Creek above the Ohio Creek at Mouth near Gunnison gage. These return flows provide water to the lower senior Ohio Creek ditches, including the Hyzer Vidal Miller Ditch, which helps reduce the frequency of administrative calls.

Figure 10-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were shortages every year and every month during the analysis period and, as shown, shortages were largest in the representative dry year. Shortages during the representative wet year are shown to be slightly more than average year. These shortages are likely due to operational influences and not water supply.

Figure 10-2: Ohio Creek from Mill Creek to Gunnison River
Crop Consumptive Use and Estimated Shortage



10.2 Domestic Water Use

There are 237 homes within the reach rely on water from wells or springs. Homes located in the subdivisions near Highway 135 use centralized wastewater collection systems. Homes outside of that area rely on-site wastewater treatment systems. Additional homes are likely to be built in the future but are limited by the lack of suitable augmentation water. Very limited data collection has occurred to characterize groundwater and spring water quality.

10.3 Environmental Water Use

10.3.1 Stream and Riparian Characteristics

Prior to human settlement, the Ohio Creek Valley likely supported a broad riparian area littered with large beaver complexes, multi-threaded channels, and a wide variety habitat types as evidenced by the terrace structure throughout the valley and multiple relic channels.

Today, the Ohio Creek Valley is a pastoral and productive agricultural valley. The riparian corridor has narrowed considerably but persists in some form throughout this reach. The size of the riparian corridor has decreased due to reduced flows, altered ground and surface water hydrology, vegetation removal, and in some areas channel incision and instability.

Although, agricultural use has changed the character and overall size of the riparian area, natural watershed functions are still relatively intact. In recent years, channel stabilization and habitat improvements have been completed that used varying degrees of ecologically based design. As with channel instability, there are isolated segments where revegetation within the riparian corridor would be helpful. Projects at these sites could overlap with channel stabilization work.

Ohio Creek downstream of Anchorman Bridge. Note the recent in-channel work including mechanically placed boulders. The channel form provides relatively good floodplain connectivity and the left bank in the photo is beginning to support willows in response.

10.3.2 Aquatic Life

Ohio Creek from Mill Creek to the Gunnison River has a cold-water trout fishery that includes brook, brown and rainbow trout. Macroinvertebrates were identified as a data gap early in the assessment process.

In 2017 macroinvertebrate samples were collected from Ohio Creek at three locations on the Eagle Ridge Ranch. The species composition, diversity, and evenness in all three samples met and exceeded the state's criteria for aquatic life use. In fact, all three waters readily met the criteria for "high scoring waters" which is the best possible designation.

The sample collected immediately downstream of County Road 7 had the highest overall score. The sample collected near the downstream (south) end of Eagle Ridge Ranch had the second highest score. The sample collected in the middle scored the lowest. The total number of macroinvertebrates collected from each location varied by nine individuals and the metrics were very similar. Any distinctions between the sites appear minor and causal factors could not be identified from this set of samples.

10.3.3 Water Quality

From December 2003 to November 2006, USGS sampled Ohio Creek downstream of Mill Creek (USGS-09113500). Four of 15 *E. coli* concentrations were greater than the primary contact standard for recreation. This information is shown in Table 10-2 and Figure 10-3.

From 2010 to 2015, USGS sampled Ohio Creek near Gunnison (USGS-09113980) every other month for a total of 29 samples. *E. coli* concentrations ranged from <1 to 260 col/100 mL and eight individual results were greater than the primary contact standard for recreation.

To date, *E. coli* samples have not been collected frequently enough to calculate a 60-day geometric mean, but individual samples have been well over the standard which is why the mainstem of Ohio Creek is listed as potentially impaired. Additional sample collection is recommended to characterize *E. coli* concentrations at the frequency needed to properly evaluate the standard.

To date, total recoverable arsenic has not been measured in this reach. A limited number of total arsenic results suggest that arsenic concentrations may also be problematic in this portion of Ohio Creek.

Table 10-2: Impaired and potentially impaired stream reaches in Ohio Creek from Mill Creek to the Gunnison River.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of Ohio Creek upstream of County Road 7	Recreational Use	*E.coli*	NA	NA
	Water Supply Use	NA	Total Arsenic	High
Mainstem of Ohio Creek downstream of County Road 7 to the confluence with the Gunnison River	Recreational Use	*E.coli*	NA	NA

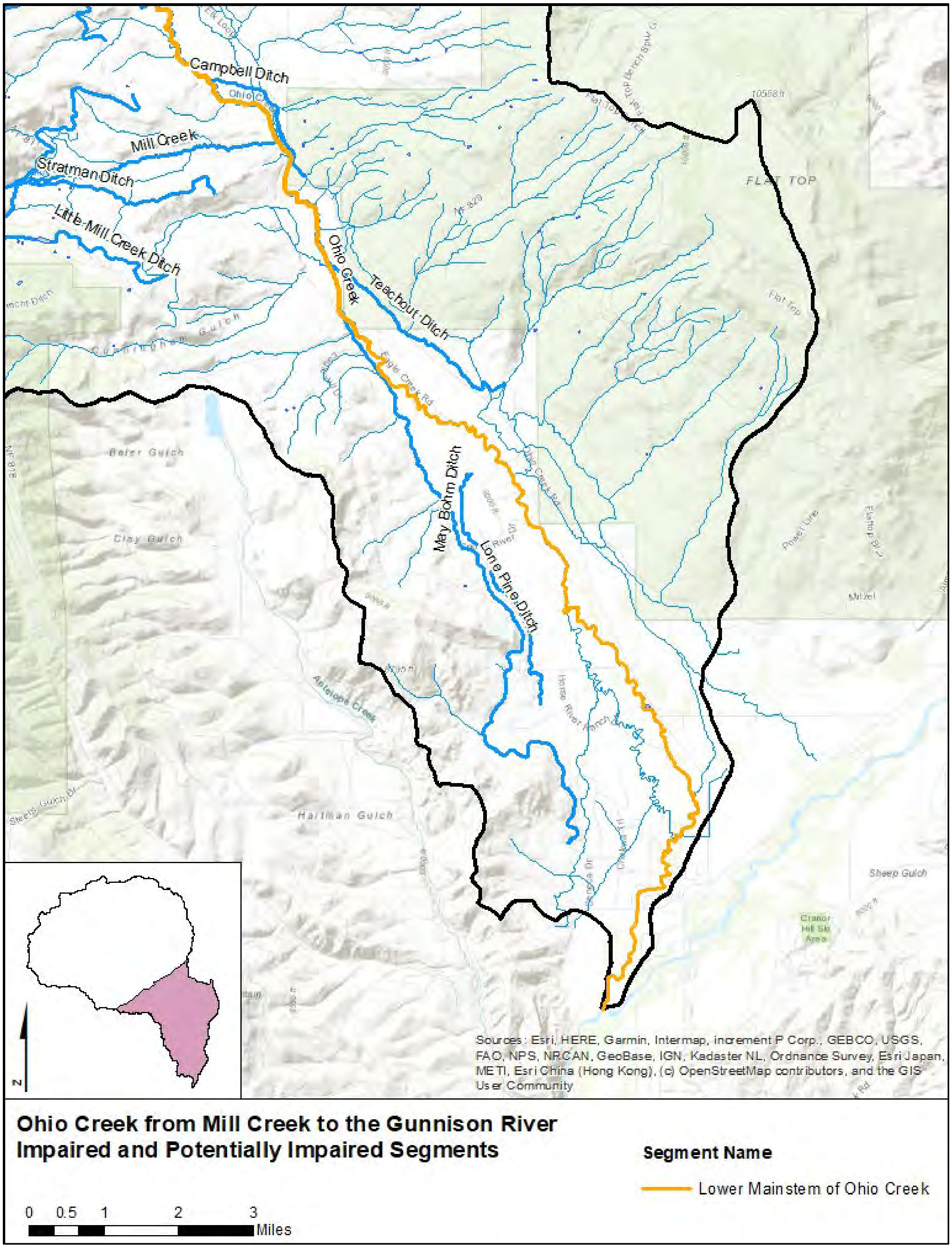


Figure 10-3: Impaired and potentially impaired stream reaches in Ohio Creek from Mill Creek to the Gunnison River

10.3.4 Water Temperature

In 2012, the WQCC adopted site-specific temperature standards for Ohio Creek downstream of County Road 7. The site-specific standards maintained the cold class 1 use, which protects brook trout and other thermally sensitive species known to occur on the reach but extended the duration of the summer standard from September 30 to November 15 as shown in Table 10-3.

Table 10-3: Temperature standards applied to Ohio Creek downstream of County Road 7. WAT= weekly average temperature. DM= 2-hour daily maximum.

Season	Degrees Celsius		Degrees Fahrenheit	
	Chronic (WAT)	Acute (DM)	Chronic (WAT)	Acute (DM)
Summer standard: April 16 to November 15	17.0	21.7	62.6	71.0
Winter standard: November 16 to April 15	9.0	13.0	42.8	55.4

Trout Unlimited installed a continuous temperature sensor in Ohio Creek just over one mile upstream of County Road 818. Water temperatures were measured during the summers of 2014, 2015, and 2017. As expected, stream temperatures attained the standards in 2017 which was an above average flow year.

On August 3, 2014 the daily maximum temperature narrowly exceeded the temperature standard by 0.1-degree C. On August 16, 2015 the daily maximum temperature exceeded the temperature standard by 1.2 degrees C. Exceedances of the acute standard can result in mortality to aquatic life.

The weekly average temperatures, which are calculated on a rolling basis, were exceeded from August 16 to August 18, 2015. Prolonged exceedances of the chronic standard can result in increased mortality, increased disease, and reduced reproduction of aquatic life. Relatively speaking, 2015 was an average year. The available temperature data suggest that stream temperatures may be a persistent problem in average and below average water years. Additional data collection is recommended to better characterize the duration and magnitude of temperature issues in Ohio Creek.

10.3.5 Existing Instream Flow Water Rights

Ohio Creek from Mill Creek to the Gunnison River has a year-round instream flow water right of 12 cfs as shown in Figure 10-4. The instream flow proposals were developed by CWCB and CPW staff, using multiple cross-sections in 1980.

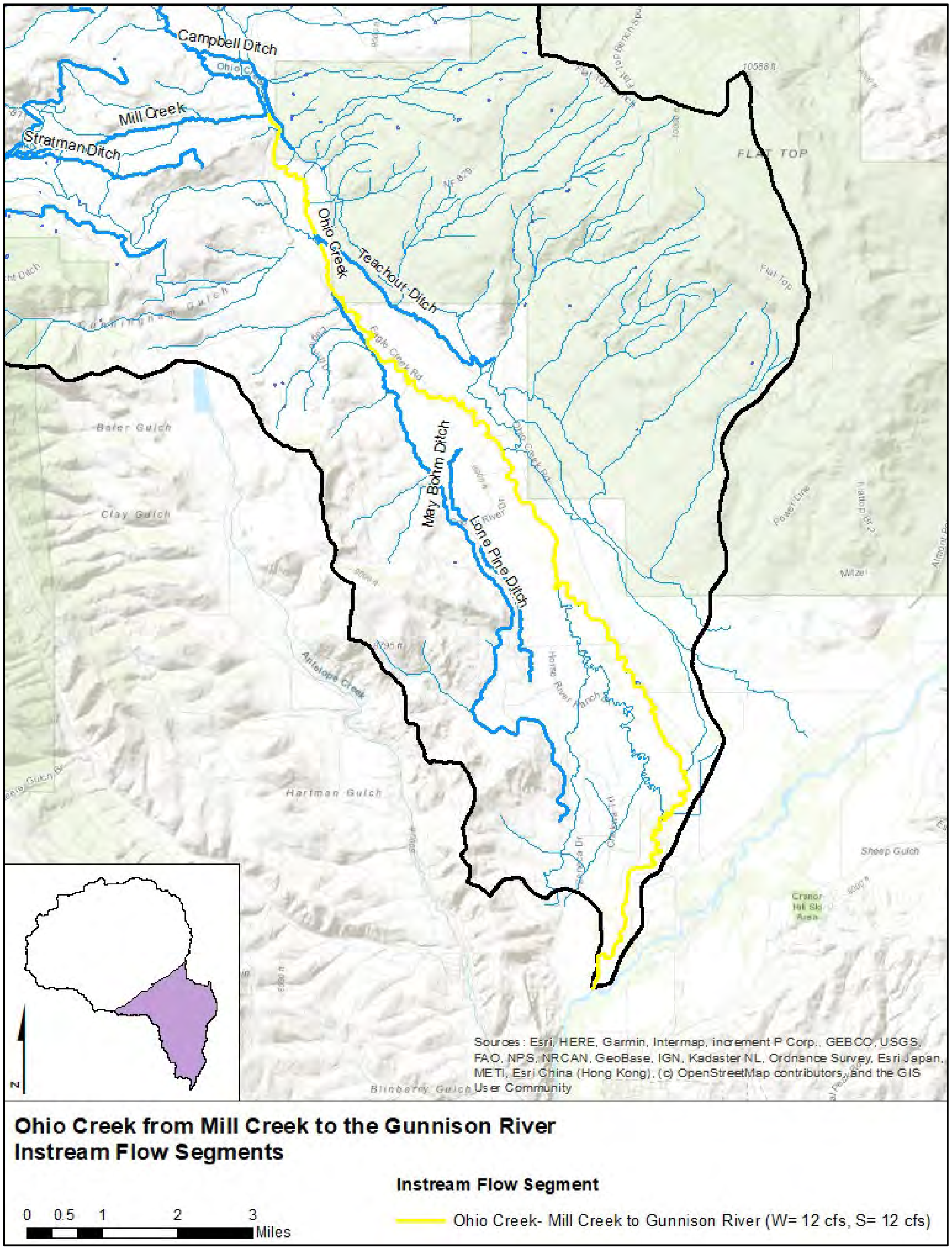


Figure 10-4: Instream flow water right for Ohio Creek from Mill Creek to the Gunnison River

Flow data from the Ohio Creek near Gunnison gage was used to evaluate how often instream flow rates wet met for three recent years that are generally representative of the range of conditions in Ohio Creek. The instream flow was met 100 percent of the time in 2010 which is considered an average year as shown in Table 24. The instream flow was met 99 percent of the time in 2011 which is classified as a wet year.

In 2012, a dry year, the instream flow was met 70 percent of the time on an annual basis. Table 10-4 shows return flows from fields irrigated with water from the Gunnison River increases the amount of time the instream flow rate is met during in low flow years, which in 2012 ranged from a low of 23 percent to a maximum of 100 percent.

Table 10-4: Percent of days when the average daily flow in Ohio Creek near Gunnison was greater than the instream flow rate of 12 cfs.

Year	**Month**												**Year Round**
	Jan	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	
2010 (average)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2011 (wet)	100%	93%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%
2012 (dry)	100%	100%	100%	53%	58%	93%	100%	81%	23%	35%	3%	90%	70%

10.3.6 Flow Limited Areas

The most challenging issue on this segment is water supply, leading to both irrigation shortages and instream flow shortages- particularly downstream of the larger diversions before returns flows accrue to Ohio Creek from diversions from both Ohio Creek and the Gunnison River. The majority of these return flows reach Ohio Creek downstream of the Hyzer Vidal Miller ditch diversion, a calling right on the Ohio Creek. Dry up and near dry up below diversions is common during below average years.

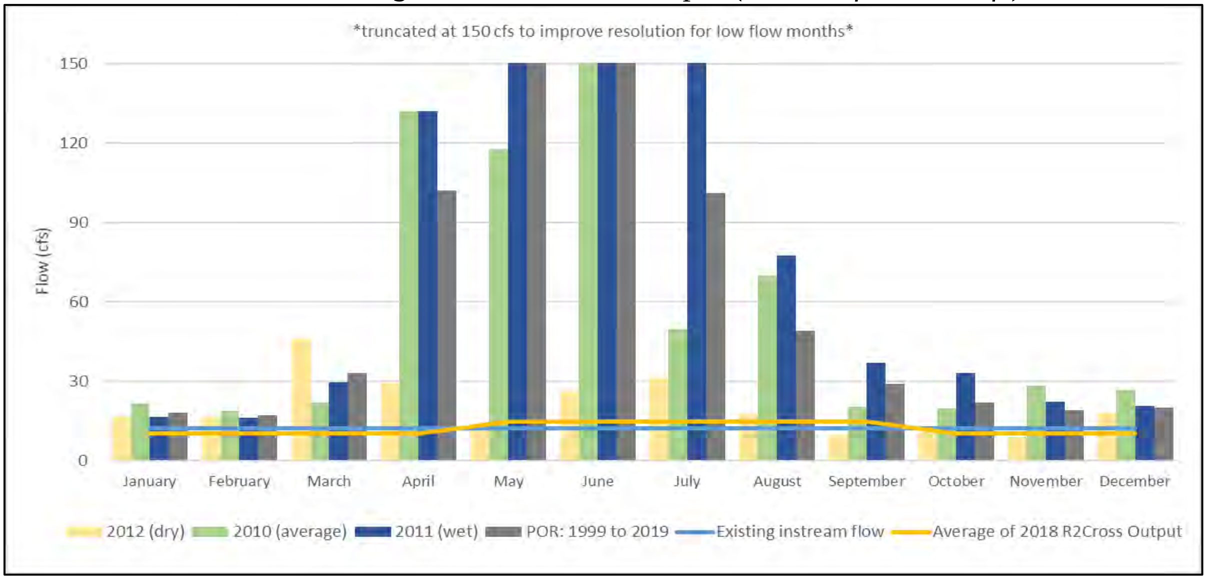
Large ditches divert water from the upper end of this reach and distribute water on a similar contour to the east and west of the channel. These ditches provide primary or supplemental irrigation for much of the acreage in this segment of Ohio Creek. During low flow periods flows in Ohio Creek directly downstream these ditches can be negatively impacted.

10.3.7 Environmental Flow Goals

Multiple landowners within this nine-mile reach of Ohio Creek manage their properties to support the fishery and create an improved angling experience. Macroinvertebrate and fish data suggest the aquatic community is very robust in select areas and present throughout Ohio Creek between Mill Creek and the Gunnison River.

The 2018 R2CROSS assessments suggest that the summer instream flow rate could potentially be increased to 15 cfs. Figure 10-5 shows the average monthly flows for recent dry, average, and wet years which suggest that water is physically available in the portion of Ohio Creek near Gunnison. However, dry ups occur on other portions of the reach. Therefore, there may not be legally available water to increase the summer instream flow water right.

Figure 10-5: Average monthly flows for Ohio Creek for representative years types, and on average (1999-2019) versus the existing instream flow rate (12 cfs year-round) and the average 2018 R2CROSS output (W= 10 cfs, S= 15 cfs).



10.4 Recreational Water Use and Needs

Recreational uses on Ohio Creek from Mill Creek to the confluence with the Gunnison River include angling and enjoyment of riparian aesthetics by private landowners and their guests. There are nine miles of stream on properties that manage specifically for angling and a productive fishery. There is no recreational use by the public on this reach.

10.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Continuing irrigation practices that maintain historic flow patterns.

Issue: Diversion structure stability and operation, along with bank stability.

Issue: Channel stability and riparian restoration in isolated areas that can be improved with modest channel modifications or restoration projects.

Issue: Education and outreach regarding increased coordination for flood irrigation, management and maintenance of infrastructure, water rights, ditch management and ownership, and appropriate irrigation rates.

Issue: USGS analysis for total recoverable arsenic in samples collected from Ohio Creek above mouth near Gunnison (USGS-09113980).

Chapter 6
The East River Basin

Section 1. Basin Characteristics

The East River is made up of a diverse community of water users including ranchers that irrigate pasture grass, popular tourist towns, an important trout fishery, boating enthusiasts, and a major ski area. It is host to multiple municipal water providers that serve the towns of Mt. Crested Butte, Crested Butte and Crested Butte South as well as a number of smaller providers. Crested Butte Mountain Resort is a major economic driver in the valley and draws water from the East River for snowmaking. Wildlife, watershed views, and ecosystem services are sustained by water flowing in creeks and support vibrant angling and stand-up paddle board businesses. In addition to hosting a range of uses, the East River Basin faces diverse challenges presented by a legacy of mining and impaired streams, a growing population, and competing water uses. Finding collaborative ways to protect these uses while improving watershed health is the goal of the Upper Gunnison River Water Conservancy District's watershed management planning process.

The primary objective of this section is to provide a summary of existing water use within the East River Basin, including irrigation, municipal, industrial, instream flow, and recreational water uses. A major task for the WMPC was to review and assess the available information; update and refine the information; identify data gaps; and recommend future data collection efforts. The information collected as part of the data inventory process served as a key component to both identify needs in the East River Basin and to improve modeling tools being used to assess these needs.

Figure 1-1 shows the East River Basin boundaries, highways and local roads, active streamflow gages, and public/managed land designation. Approximately 80 percent of the land within the Basin boundary is public. A significant portion of the private land generally follows the East River and other tributaries and includes irrigated acreage, the towns of Crested Butte and Mt. Crested Butte, and other municipal subdivisions.

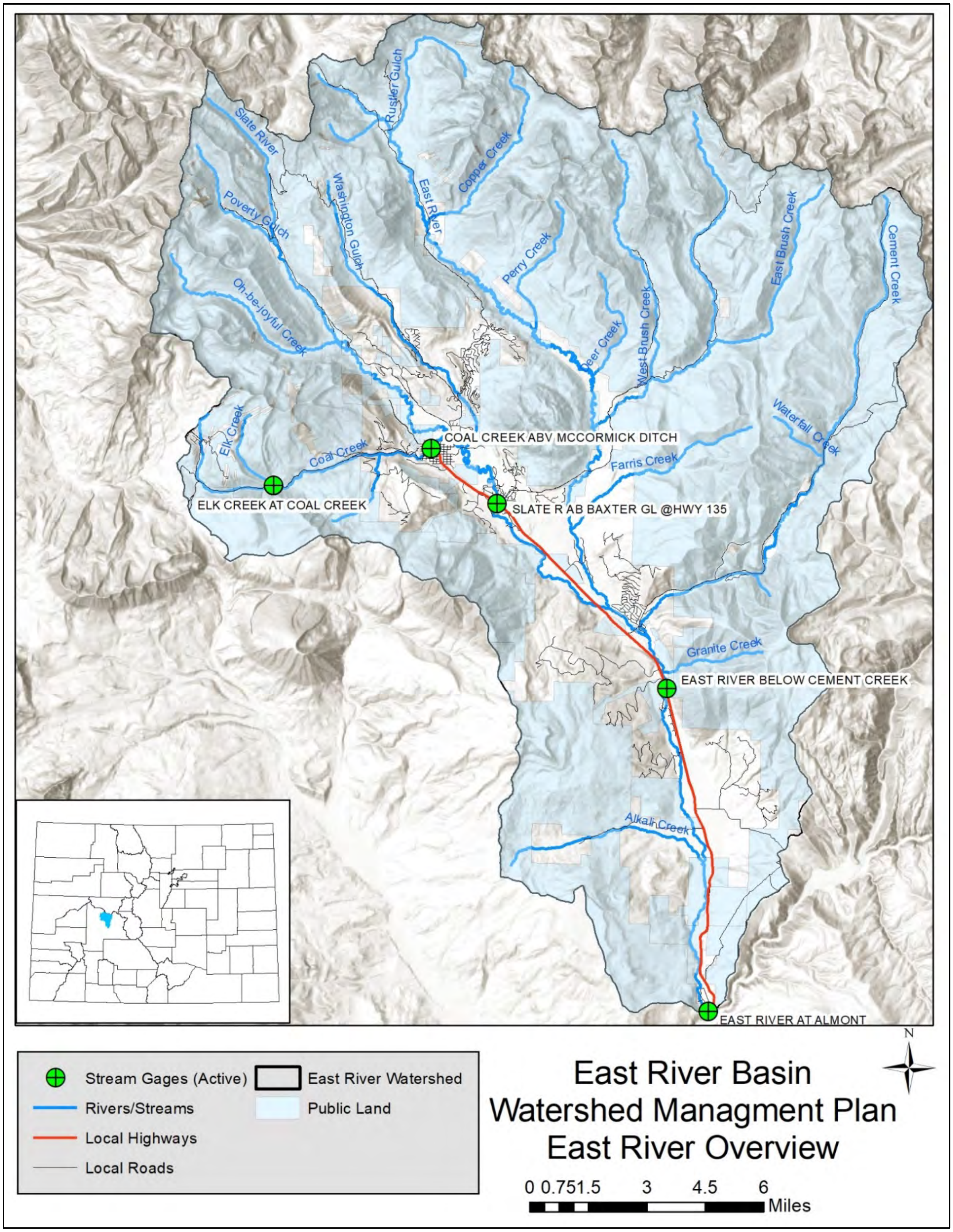


Figure 1-1: East River Basin Overview Map

Section 2. Data Assessment

2.1 Streamflow Measurements

There are five stream gages currently measuring streamflow in the East River Basin. In addition, there are four inactive gages that were used to assess streamflow over a longer period. Table 2-1 summarizes the drainage area, period of record, and average annual flow for both the active and inactive stream gages. Figure 1-1 includes the location of the five active gages. With the addition of the gages on Coal Creek and Elk Creek, the spatial coverage in the Basin is adequate for modeling and planning efforts. In addition, DWR did not identify additional gages that would help with water rights administration. CWCB has considered installing a gage in the East River at the Alkali River bridge (CR 749) to monitor flow and allow administration of the instream flow water right. In 2016, the Department of Energy installed a gage on the East River upstream of the pumphouse to support on-going scientific research; streamflow from this gage should be used in future planning efforts.

Table 2-1: Summary of Active and Inactive Stream Gages in the East River Basin

Stream Gage Name	Gage ID	Status	Drainage Area (Sq. Mi.)	Period of Record	Average Annual Flow (Acre-Feet)
Elk Creek at Coal Creek ab Crested Butte (operates seasonally from Apr 1 to Nov 15)	09110990	Active	8.65	2017-Present	890*
Coal Creek nr Crested Butte	09111000	Inactive	8.7	1942-1946	12,100
Coal Creek ab McCormick Ditch (operates seasonally from Apr 1 to Oct 31)	09111250	Active	20.4	2015-Present	19,100*
Slate River nr Crested Butte	09111500	Inactive	68.9	1941-1951 1994-2006	97,350
Slate River ab Baxter Gulch	38510610657 1000	Active	73.4	2007-Present	99,000
East River nr Crested Butte	09110500	Inactive	90.3	1940-1951	96,500
Cement Creek nr Crested Butte	09112000	Inactive	32.9	1911-1913 1941-1951	26,500
East River bl Cement Creek	09112200	Active	239.0	1964-1972 1980-1981 1994-Present	233,400
East River at Almont	09112500	Active	289.0	1911-1922 1935-Present	240,700

**Average Annual Flow does not include winter months*

The streamflow in the East River Basin is highly variable depending on snowpack. Figure 2-2 shows daily flow from 2005 to 2017, a recent period that is representative of the range of streamflow in the basin, for two gages on the East River mainstem. Similarly, Figure 2-3 shows daily flow from 2007 to 2017 at two active gages in the Slate River Basin, and the inactive Slate River near Crested Butte gage. The following observations can be made based on the figures:

- The runoff pattern and peak flow months are similar for these four locations
- This period includes one of the wettest years on record, 2011, followed by one of the driest years on record, 2012. The difference in annual stream flow between the two years is more than 200,000 acre-feet at the East River at Almont gage
- Annual streamflow in 2012 was less than 30 percent of the 2011 annual streamflow at the three gages active at that time (Slate River above Baxter Gulch, East River below Cement Creek, and East River at Almont)

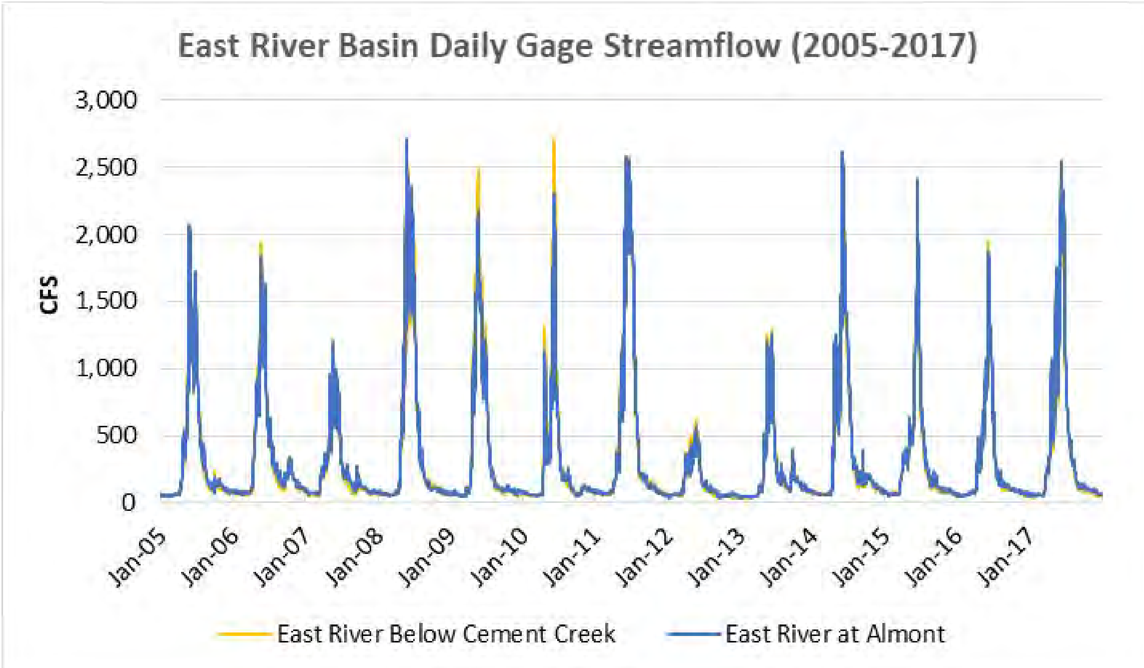


Figure 2-2: East River Basin Streamflow (2005-2017)

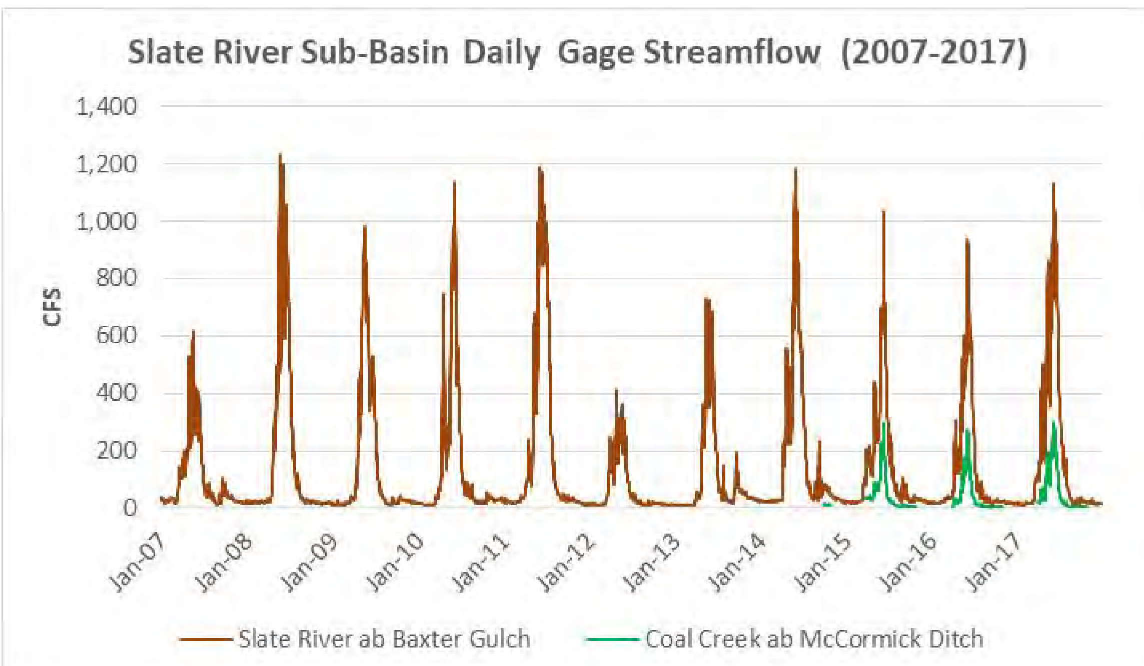


Figure 2-3: Slate River Basin Streamflow (2007-2017)

Figure 2-4 shows the historical annual streamflow volume from 1935 to 2017, along with the 10-year running average. As shown, streamflow varies wildly during over the period. Although the 10-year running average is also highly variable, the 10-year running average does not indicate a long-term trend towards lower streamflow.

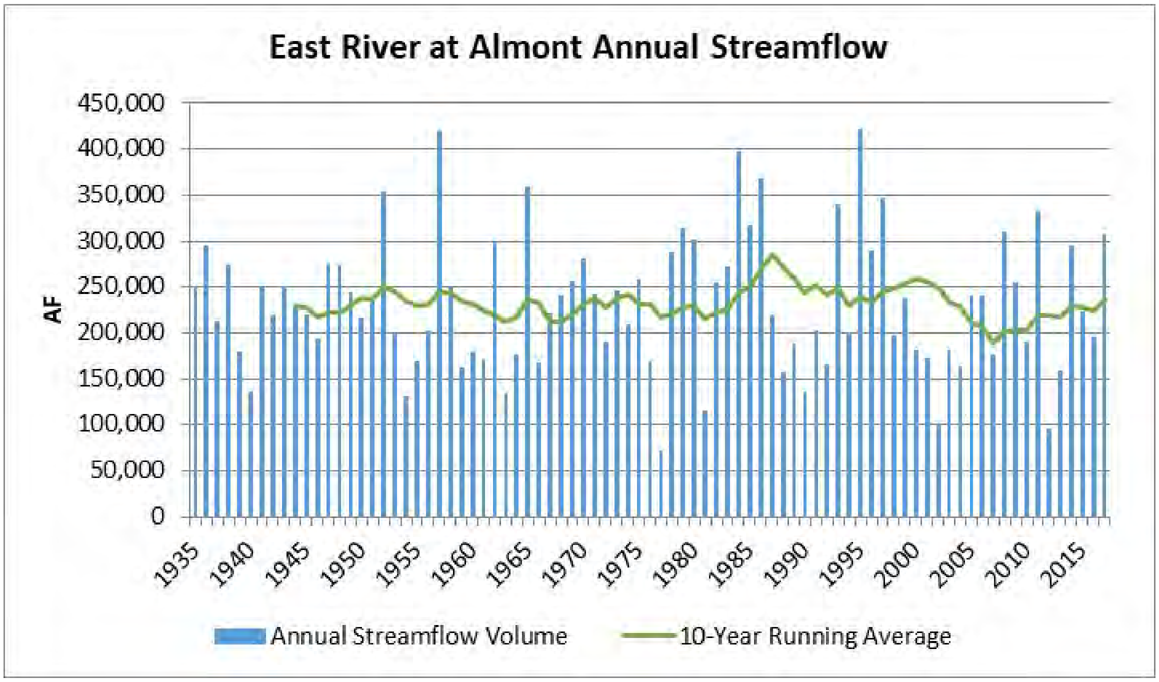


Figure 2-4: East River at Almont Annual Streamflow (1935-2017) in acre-feet (acre-feet)

Figure 2-5 shows the average monthly flow at the East River Almont at gage from 1998 to 2017. Water from snowmelt runoff in May, June, and July accounts for nearly 70 percent of the annual streamflow.

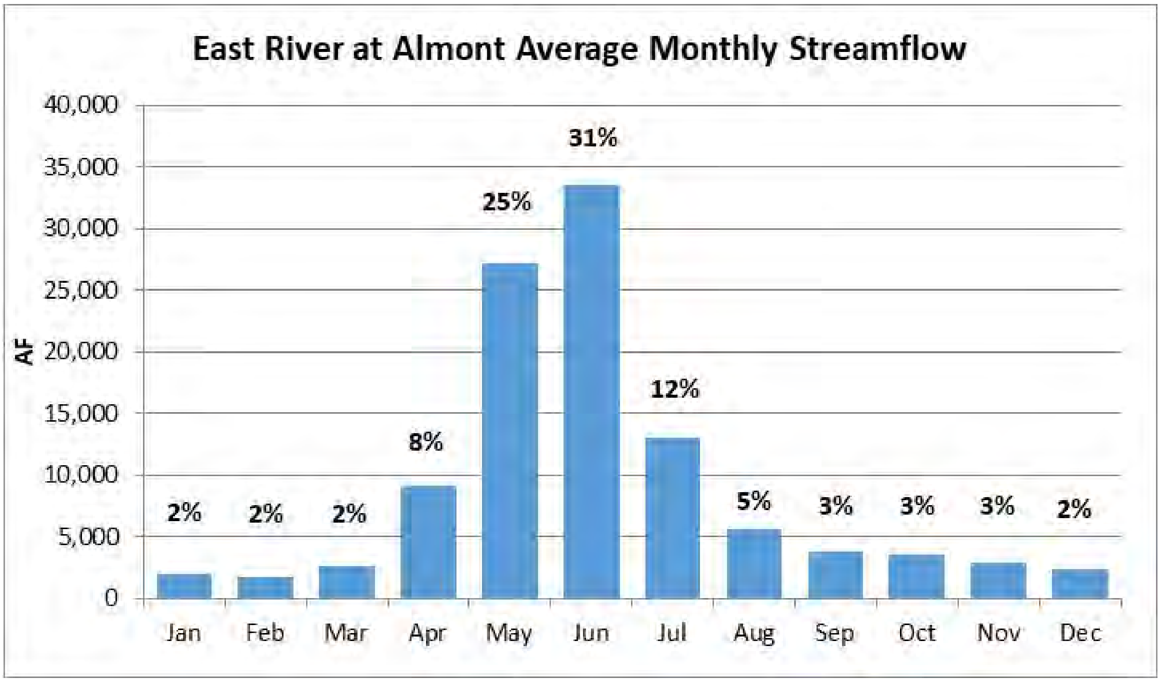


Figure 2-5: East River at Almont Average Monthly Streamflow (1998-2017)

2.2 Climate Data

Crop irrigation demands are dependent on weather during the irrigation season, with temperature being the primary driver. Figure 2-6 highlights the variability of average irrigation season temperature (May through September) at the long-term NWS Coop station in Crested Butte. Although the climate station reported high temperatures in the late 1950s and early 1960s, the 10-year running average shows a clear trend toward higher irrigation season temperatures since 1980.

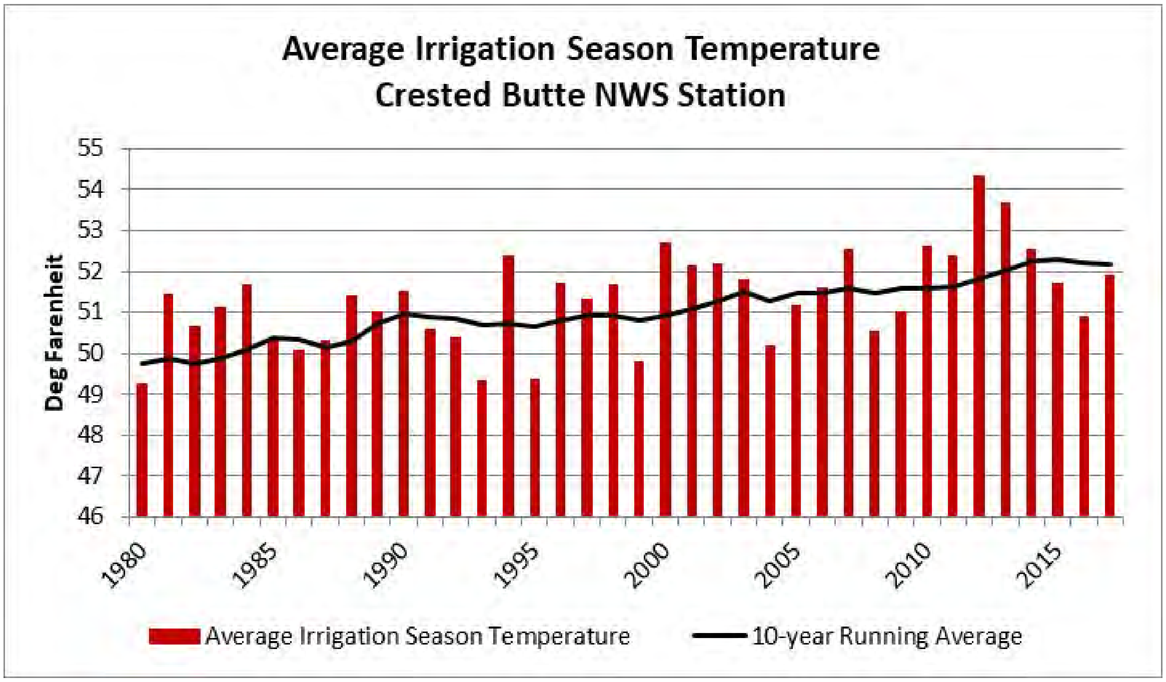


Figure 2-6: Average Irrigation Season Temperature at Crested Butte (1980-2017)

Precipitation during the irrigation season reduces the amount of water required from irrigation diversions to meet crop demands. Figure 2-7 highlights the variability of total irrigation season precipitation (May through September) at the long-term NWS Coop station in Crested Butte from 1980 to 2017. The total irrigation season precipitation varies from a high of 13 inches in 1999 to a low of 4 inches in 2011. Even though the irrigation season precipitation has been relatively high from 2013 to 2016, the 10-year average has yet to recover from the dryer summers between 2007 and 2012.

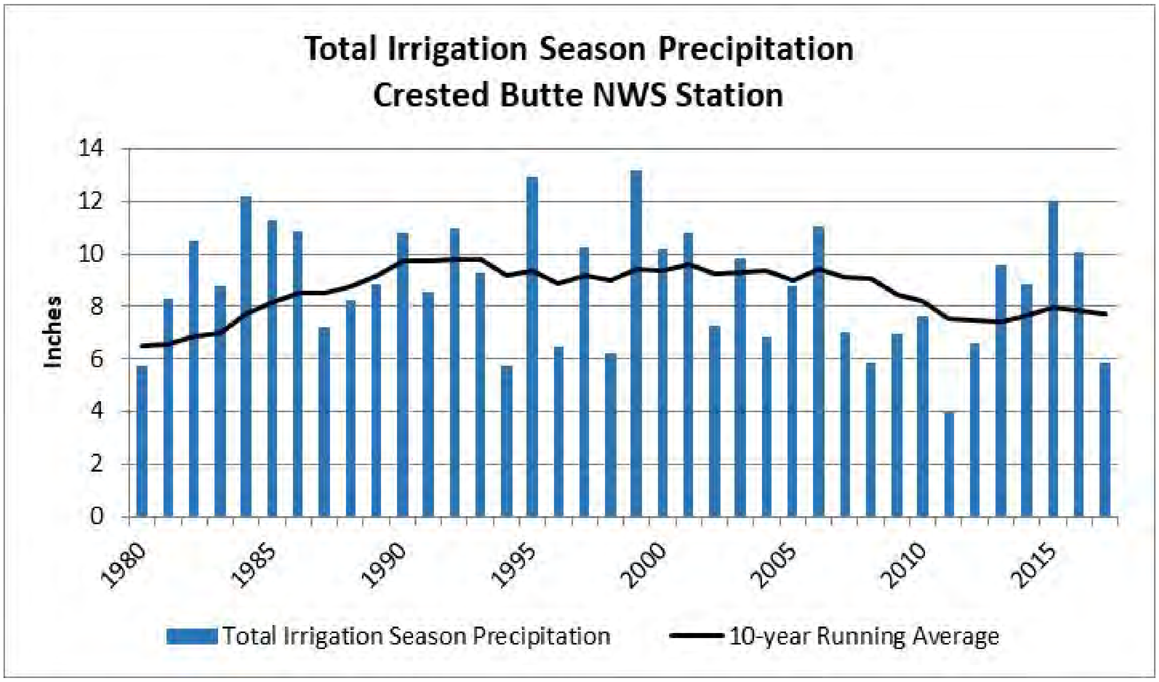


Figure 2-7: Total Irrigation Season Precipitation at Crested Butte (1980-2017)

There is very good temperature and precipitation data coverage for the East River Basin, covering an extended historical period. A CoAgMet station measuring other key climate information, including wind speed and solar radiation, was recently installed north of Gunnison. This station will provide additional information, including reference crop demands, for future planning efforts in the Basin.

2.3 Irrigated Acreage

The majority of consumptive water use in the Upper Gunnison River Basin is for irrigation of pasture grass; therefore, it is essential to accurately represent the irrigated acreage and associated irrigation demand. There is a lack of detailed information on diversion records in the Upper Gunnison Basin; this presents a serious limiting factor for understanding irrigation practices and water budgets in this basin. CWCB developed irrigated acreage snapshots for the Gunnison River Basin for 1993, 2005, 2010, and 2015 as a key component of the CDSS. The data sets include acreage, crop type, and associated river diversion ditch or canal. The WMP assessment determined that the acreage was appropriately represented, but the association between acreage and the supply ditch was not detailed enough to accurately tie the acreage to diversions and associated water rights. Through discussions with CWCB and DWR, they recognized that the irrigated acreage assessment needed to be refined and disaggregated to represent each ditch discreetly.

During this assessment, consultants worked with local water commissioners and water users to more accurately tie irrigated acreage to source ditch and associated water rights. This was a major effort and resulted in a more accurate representation of irrigation demands for each active ditch in the Upper Gunnison River Basin. This information was provided to the state, and consultants continue to work with CWCB to make the corresponding updates to the historical GIS snapshot coverages (2010, 2005, and 1993) for inclusion in the State's records. Each of the updated coverages will be made available on the CDSS website.

The total irrigated acreage in the East River Basin as of 2015 is approximately 8,060 acres. Based on review of aerial photos, and discussion with local water experts, there has been a reduction of around 500 irrigated acres south of Crested Butte, primarily in the Slate River Basin, since the early 1990s to accommodate the growing population around Crested Butte.

2.4 Water Rights

DWR created unique identifiers for each of the decreed points of diversion. DWR developed the official water rights tabulation, based on water court decrees, and assigned each water right to the associated ditch. Based on consultants' experience in the Gunnison Basin, and other Basins throughout Colorado, the water rights assignments in HydroBase are believed to be accurate and appropriate for use in the WMP efforts.

The East River Basin has minimal water storage. There is just over 4,000 acre-feet of absolute storage rights; most of the volume is to protect minimum levels in natural lakes and for stock ponds. Meridian Lake Reservoir releases water to augment wells and ponds throughout the East River Basin.

Figure 2-8 represents the cumulative absolute direct flow water rights in the East River Basin, highlighting major Basin adjudication dates and key water rights. The DWR Administration Number indicates the water right priorities based on both appropriation date and adjudication date and is used by DWR for administration throughout the state. As discussed in Section 1.1 of Chapter 2 and shown in the figure, Aspinall Unit water rights are subordinated to current and future Upper Gunnison River Basin water rights junior to the Aspinall Unit water rights up to 40,000 acre-feet of annual depletions.

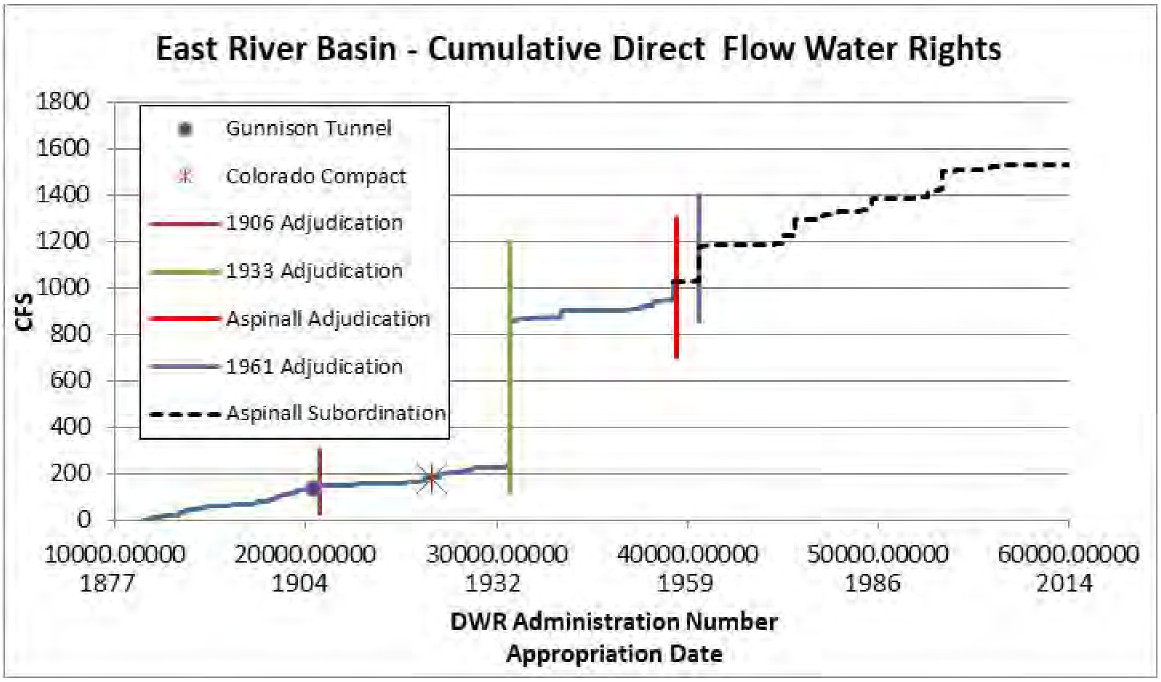


Figure 2-8: East River Basin Cumulative Direct Flow Water Rights

In addition, there are conditional direct flow water rights totaling 161 cfs in East River Basin. Most of the conditional water rights are for domestic use, with rates of less than 1 cfs. Crested Butte Mountain Resort has a 5 cfs conditional water right for snowmaking to supplement its 6 cfs absolute water right. Conditional water rights that include municipal use total 38.41 cfs. There is also a 30 cfs conditional water right filed by Mount Emmons Mining Company, with a conditional point of diversion on the Slate River upstream of Oh Be Joyful Creek. This water right is junior to other consumptive water rights; however, if it were diverted and made absolute for mining purposes, it would significantly reduce the flow in the Slate River.

The East River Basin includes 28 decreed instream flow water rights, summarized in Table 2-2 and shown in Figure 2-9. These rights are junior to most of the irrigation rights in the basin.

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Brush Creek	Confluence at M&E Brush Creek	Confluence of West Brush Creek	6/3/1982 1/24/2016	2.1	5	8
Brush Creek – Segment 1	Confluence of West Brush Creek	Headgate at Jarvis Ditch	6/3/1982	1.4	7	12
Brush Creek – Segment 2	Headgate at Jarvis Ditch	Confluence of East River	6/3/1982	0.9	7	
Cement Creek	Headwaters of Cement Creek	Confluence of East River	3/17/1980	16.1	10	
Coal Creek	Headwaters of Coal Creek	Confluence of Slate River	3/17/1980	8.8	2	
Copper Creek	Outlet Natural Lake	Confluence of East River	3/17/1980	5.9	7	
East Brush Creek	Headwaters of Brush Creek	Confluence of Middle Brush Creek	3/17/1980	6.1	5	
East River – Segment 1	Headwaters at Lake	Confluence of Copper Creek	6/3/1982	8	8	15
East River – Segment 2	Confluence of Copper Creek	Confluence of Brush Creek	6/3/1982	10.8	15	25
East River- Segment 3	Confluence of Brush Creek	Confluence of Alkali Creek	6/3/1982	13.9	10	
East River - Segment 4	Confluence of Alkali Creek	Confluence of Taylor River	6/3/1982	12.8	27	50
Farris Creek	Headwaters of Farris Creek	Headgate at Meads No. 3 Ditch	3/17/1980	3.9	0.5	
Middle Brush Creek	Headwaters of Brush Creek	Confluence of East Brush Creek	3/17/1980	9	8	
Oh Be Joyful – Increase	Confluence of Unnamed Tributary	Confluence of Slate River	1/28/2014	1.66	Summer Rate Only	14
Oh Be Joyful Creek – Segment 1	Headwaters of Outlet at Blue Lake	Confluence of Unnamed Tributary	3/17/1980	1.5	1	
Oh Be Joyful Creek – Segment 2	Confluence of Unnamed Tributary	Confluence of Slate River	3/17/1980	4.8	3	
Perry Creek	Headwaters of Perry Creek	Confluence of East River	3/17/1980	4.1	1	

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Poverty Gulch – Segment 1	Headwaters of Poverty Gulch	Confluence of Unnamed Tributary	3/17/1980	1.8	3	
Poverty Gulch – Segment 2	Confluence of Unnamed Tributary	Confluence of Slate River	3/17/1980	2.1	5	
Quigley Creek	Headwaters of Quigley Creek	Confluence of East River	3/17/1980	1.7	1	
Rustler Creek	Headwaters of Rustler Creek	Confluence of East River	5/4/1984	2.5	4.5	
Slate River – Lower	Confluence of Oh Be Joyful Creek	Confluence of Coal Creek	1/28/2014	5.63	Summer Rate Only	45
Slate River – Segment 1	Headwaters of Slate River	Confluence of Poverty Gulch	3/17/1980	4.5	5	
Slate River – Segment 2	Confluence of Poverty Gulch	Confluence of Oh Be Joyful Creek	3/17/1980	3.7	8	15
Slate River – Segment 3	Confluence of Oh Be Joyful Creek	Confluence of Coal Creek	3/17/1980	5.2	10	20
Slate River – Segment 4	Confluence of Coal Creek	Confluence of East River	3/17/1980	8.8	12	23
Slate River – Upper	Confluence of Poverty Gulch	Confluence of Oh Be Joyful Creek	1/28/2014	3.69	Summer Rate Only	30
Washington Gulch	Headwaters of Washington Gulch	Confluence of Slate River	3/17/1980	9.1	2.5	
West Brush Creek	Headwaters of West Brush Creek	Confluence of Brush Creek	3/17/1980	7	7	

Table 2-2: Existing CWCB Instream Flow Water Rights in the East River Basin

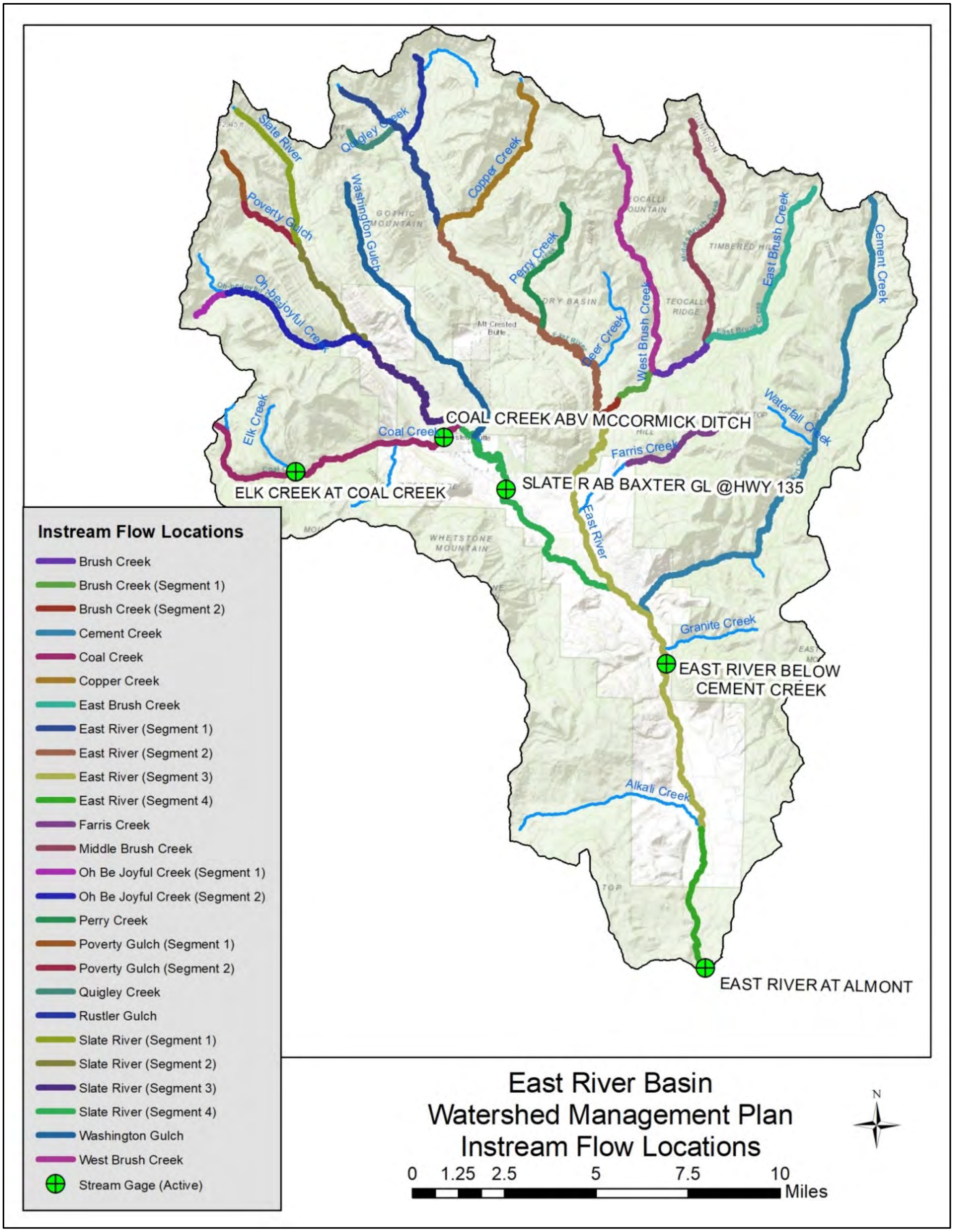


Figure 2-9: Instream Flow Reaches in the East River Basin

Figure 2-10 shows the instream flow rights along with the cumulative direct flow water rights. Most instream flow rights in the East River Basin were appropriated between 1980 and 1982. In recent years, new instream flow water appropriations have been made by the CWCB to reflect updates to the scientific methods used to determine minimum flows and to more accurately reflect changes in the natural hydrograph. Estimated shortages are discussed in the reach sections.

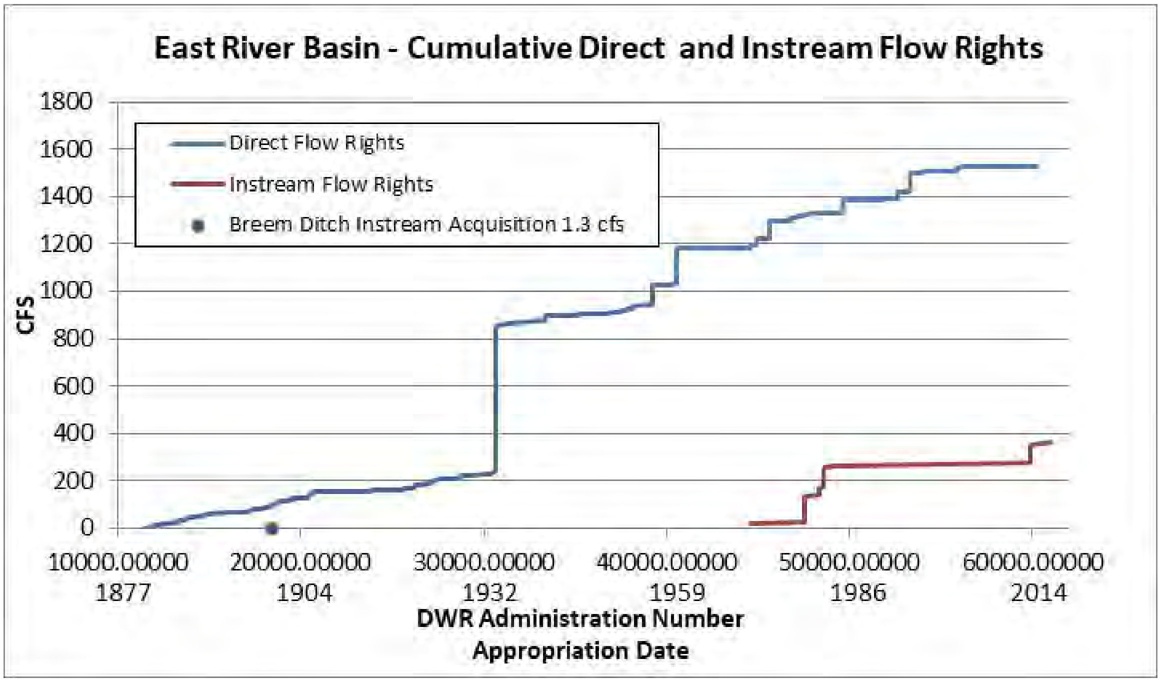


Figure 2-10: East River Basin Cumulative Direct Flow and Instream Flow Water Rights

CWCB also has storage rights to protect minimum water levels in 16 natural lakes in the East River Basin, totaling 1,272 acre-feet. All the natural lakes are high in the basin, above other water right uses.

2.5 Diversion Records

The water commissioner is responsible for recording diversions for nearly 250 ditches that divert water for irrigation in Water District 59. Many of the ditch headgates are challenging to access and require a significant amount of time to visit. There are no diversions with continuous recorders, so diversion records are either provided by the water user annually or, most commonly, are “spot-diversions” reported when the water commissioner visits the headgate and records the amount of water diverted on that day.

DWR uses the “fill-forward” approach where the spot-diversion record is repeated for each day until the water commissioner visits the headgate and reports and updated diversion rate. Based on the review of diversion records and discussions with the water commissioner, it is common for the water commissioner to visit each headgate only once per month during the irrigation season. Note that although this is typical of most water districts in western Colorado, diversion records do not mimic changes in daily streamflow. In addition, daily variation in flows, most notably during runoff or following large precipitation events, can cause diversion rates to change throughout the day, which cannot be captured even if the water commissioner visited each diversion once per day. Figure 2-11 provides example diversions in the East River Basin for 2011 and 2012 where the standard fill-forward approach was used by DWR. In many cases, the irrigation start and stop dates are estimated by the water commissioner rather than reported by the water users. In addition, the diversion records do not include information about operational practices, for example reducing diversions to allow fields to dry before haying.

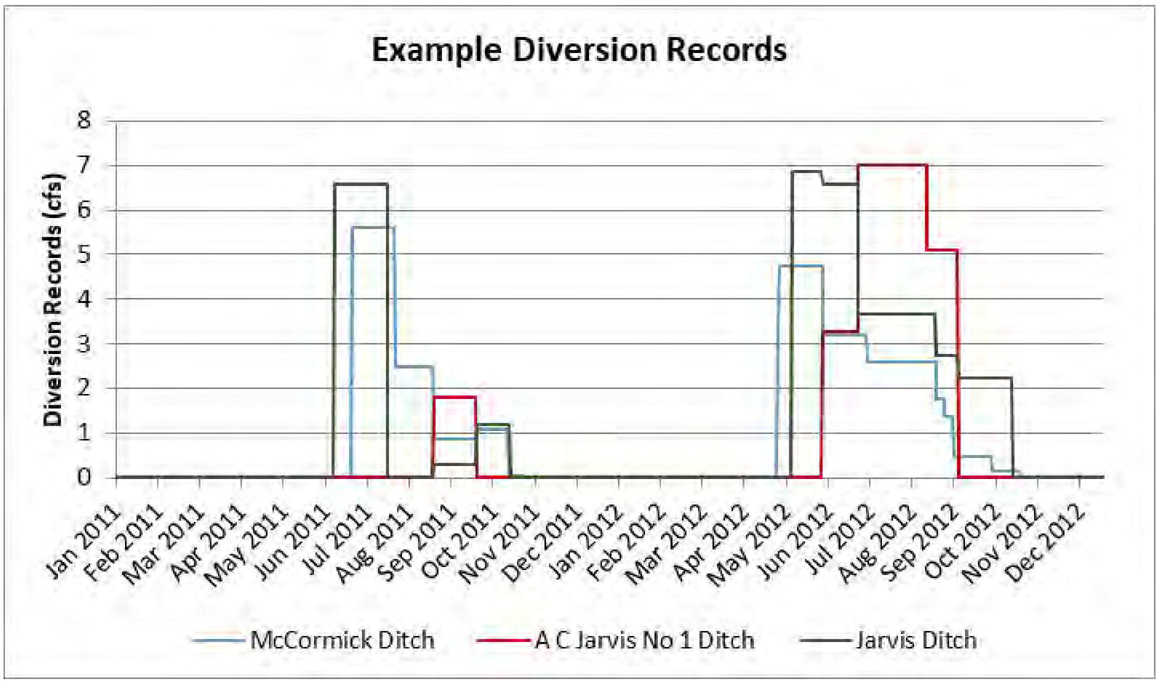


Figure 2-11: Example of the Fill-Forward Approach for Reporting Diversions

Consultants also identified the number of diversions that have Parshall Flumes or other flow control measurement devices that allow both the water commissioner and water users to quickly record diversions. Based on information from the water commissioner, about 90 percent of the diversions in Water District 59 have a measurement device. For diversions without measurement devices, the water commissioner either estimates flow for the remaining structures using the "chip-test" approach by estimating velocity and depth to determine flow rate, or simply provides a "water taken but no data available" comment in the official record.

Based on the review of diversion records, discussions with the water commissioner, and feedback from the Division 4 Engineer, the most effective way to improve diversion records is to encourage irrigators to document their use on a daily or weekly basis. Specifically, they can report dates when they start and stop irrigating each year and provide flume measurements when diversions increase or decrease with flows in the river.

Regardless of the frequency of measurements, the diversion records maintained by DWR are still the best source of data available. There are over 77 active irrigation ditches in the East River Basin. From 2008 to 2017, they diverted an average of 119,500 acre-feet per year. Similar to streamflow, annual diversions are variable, as shown in Figure 2-12.

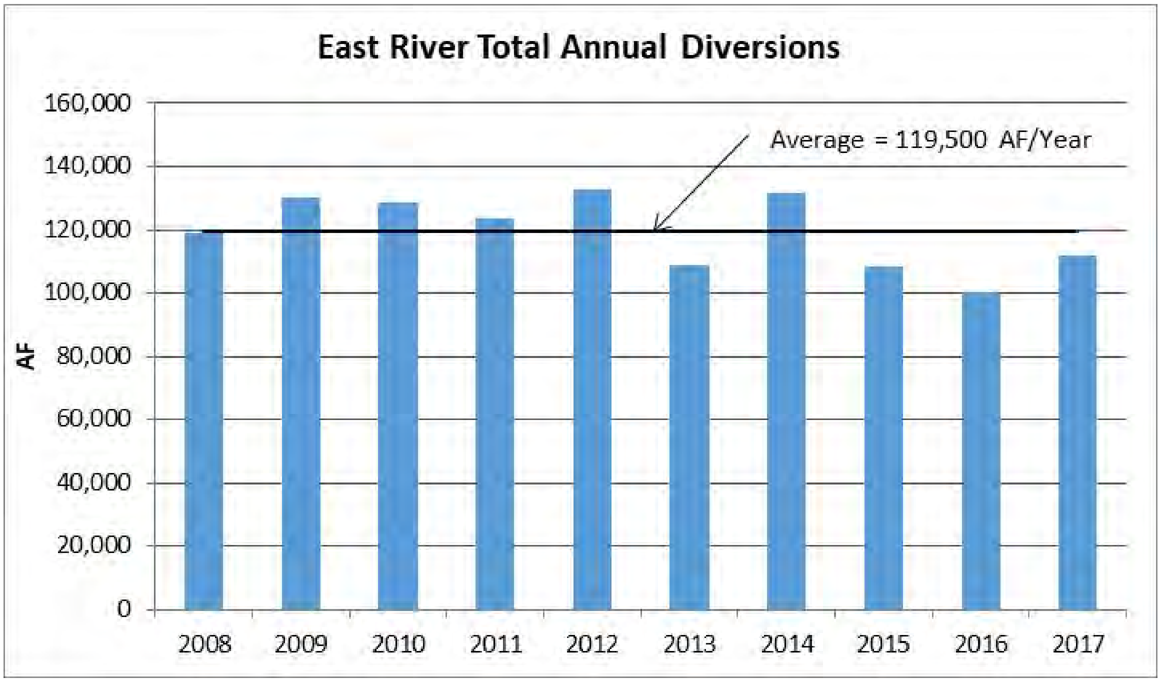


Figure 2-12: Annual East River Basin Diversions

Figure 2-13 shows total monthly diversions for a representative average (2010), wet (2011), and dry (2012) hydrologic year. As shown, the annual amount diverted is similar each year; however, diversions match the runoff pattern. In the 2012 representative dry year, a warmer spring resulted in earlier runoff and earlier diversions. Water supply dropped of significantly in July. In the 2011 representative wet year, the diversions peaked in July.

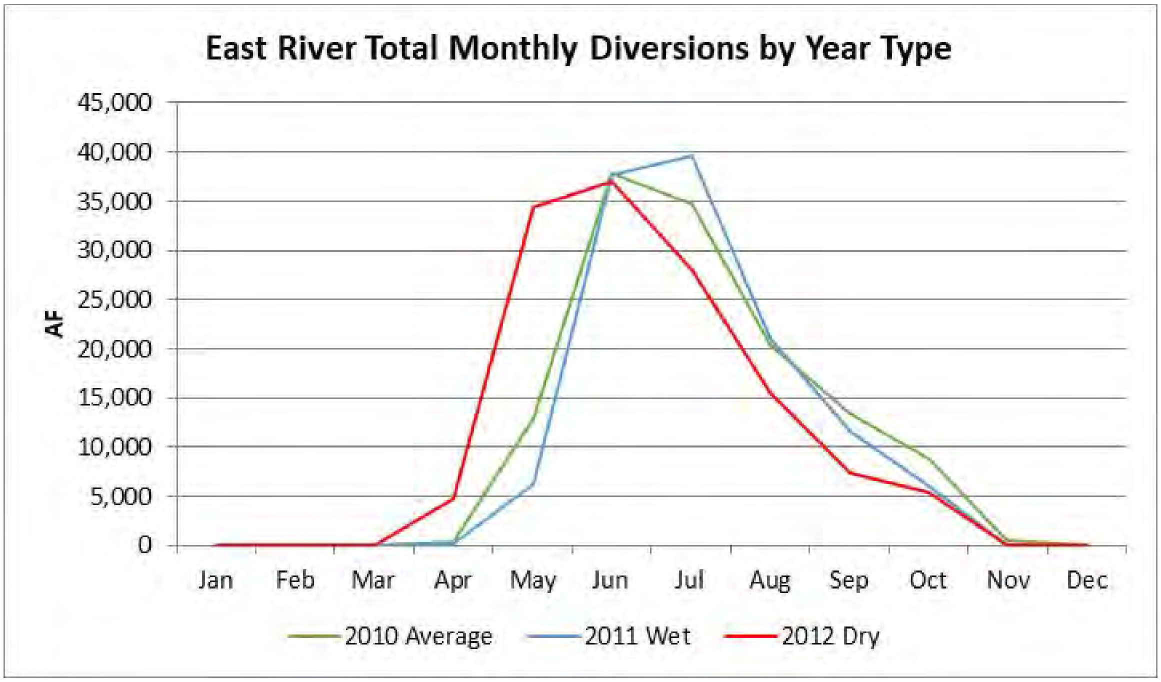


Figure 2-13: Monthly East River Basin Diversions for Representative Years

Figure 2-14 shows the location and magnitude of average annual diversions in the East River Basin. In the upper reaches, most of these ditches divert less than 1,000 acre-feet per year. Ditches tend to have larger diversions and irrigate more acreage further downstream in the basin. Average annual diversions from 2008 to 2017 average 119,500 acre-feet. The largest nine ditches deliver almost 60 percent of the total diversions (69,600 acre-feet/Year).

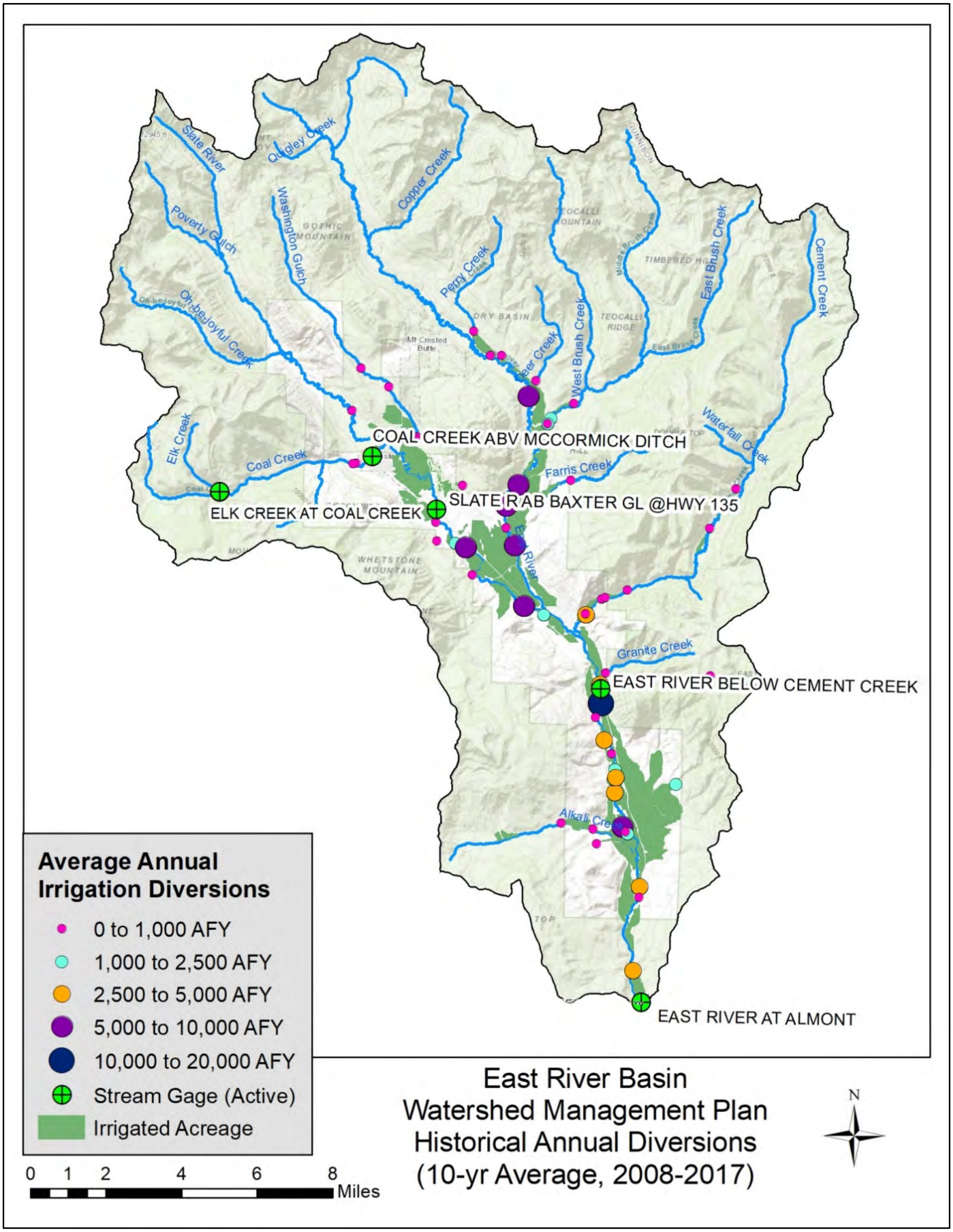


Figure 2-14: Average Annual Historical Irrigation Diversions, 2008-2017

2.6 Irrigation Practices

Given the difficulty in obtaining accurate historical diversion records, it is especially important to understand local and ditch-specific irrigation practices to help inform planning efforts. Interviews with several of the larger ranch owners and operators in the East River Basin and with the water commissioner were conducted to gain a better understanding of irrigation practices. In addition to general information regarding irrigation methods and haying and grazing operations; important information was gathered regarding return flows and operations during dry years.

As noted above, pasture grass is grown on all of the irrigated acreage in the Basin. Water is applied using flood irrigation techniques. Many of the diversions are "push-up" dams that are re-worked each irrigation season. Depending on spring temperatures, irrigators begin applying water to their fields between May 1 and June 10, with irrigation generally beginning earlier in the lower portions of the basin. Irrigators generally get one hay cutting each summer in late July or early August. For the larger ditches, irrigation does not completely cease prior to cutting, but is reduced as fields are dried up and cut in rotation. It generally takes 2 to 3 weeks to dry out, so diversions are cut-back in the first week or two of July. After cutting, if water is still available, irrigation continues until end of October when cattle are brought back from higher areas to graze.

There are several ditches in the East River Basin where irrigation surface return flows accrue to down-gradient ditches. Typically, irrigation surface return flows accrue directly to local drainages or streams. For example, the Kubiak Ditch diverts water from the East River and surface runoff from the irrigated fields flows directly into the James Watt Ditch, where the surface runoff comingles with river diversions through the James Watt Ditch. As this source of supply is not measured through the headgate, the total amount of water available for irrigation was underestimated, resulting in slightly higher irrigation shortage estimates. During the assessment, the CDSS consumptive use model (StateCU) and the water rights allocation model (StateMod) were updated to reflect this irrigation practice where it occurs. The additional irrigation supply delivered through surface irrigation returns and recapture in down-gradient ditches, is estimated to be an average of 15,700 acre-feet per year for the 10-year period from 2008 to 2017, or about 15 percent of the average annual total irrigation supply.

The official DWR record does not reflect that senior water right holders were not able to get a full supply and could have placed calls on the river in dryer years. Information from the interviews indicated that there was an historical "gentlemens' agreement" in some areas of the Basin where senior water users divert water in rotation with junior water users to share in the limited supply. Even the largest senior downstream ditch, the Gunnison Tunnel, has not placed a call during the irrigation season in recent dry years (for example 2012 and 2018). This information is critical in understanding why StateMod, which operates based on strict priority, showed calls place by senior water rights during drier years.

2.7 Return Flow Parameters

Representing return flow quantities, locations, and timing are critical for investigating the changes to river flows and water availability at downstream location. Many of the opportunities to improve watershed health include changes in irrigation use, including efficiency improvements. It is important to accurately represent return flow parameters in StateMod to understand comparative changes to streamflow, and potential impacts to downstream water right holders.

Section 3. Water Use Assessment

For this Report, the East River Basin was divided into 15 reaches because each has unique characteristics and issues. The approach to investigating agricultural, domestic, environmental, and recreational uses was tailored for each reach. Figure 3-15 shows the reaches. Table 3-3 summarizes general characteristics of each reach and the issues identified by stakeholders. Detailed assessments of the reaches are contained in Sections 5 through 19 of this Chapter.

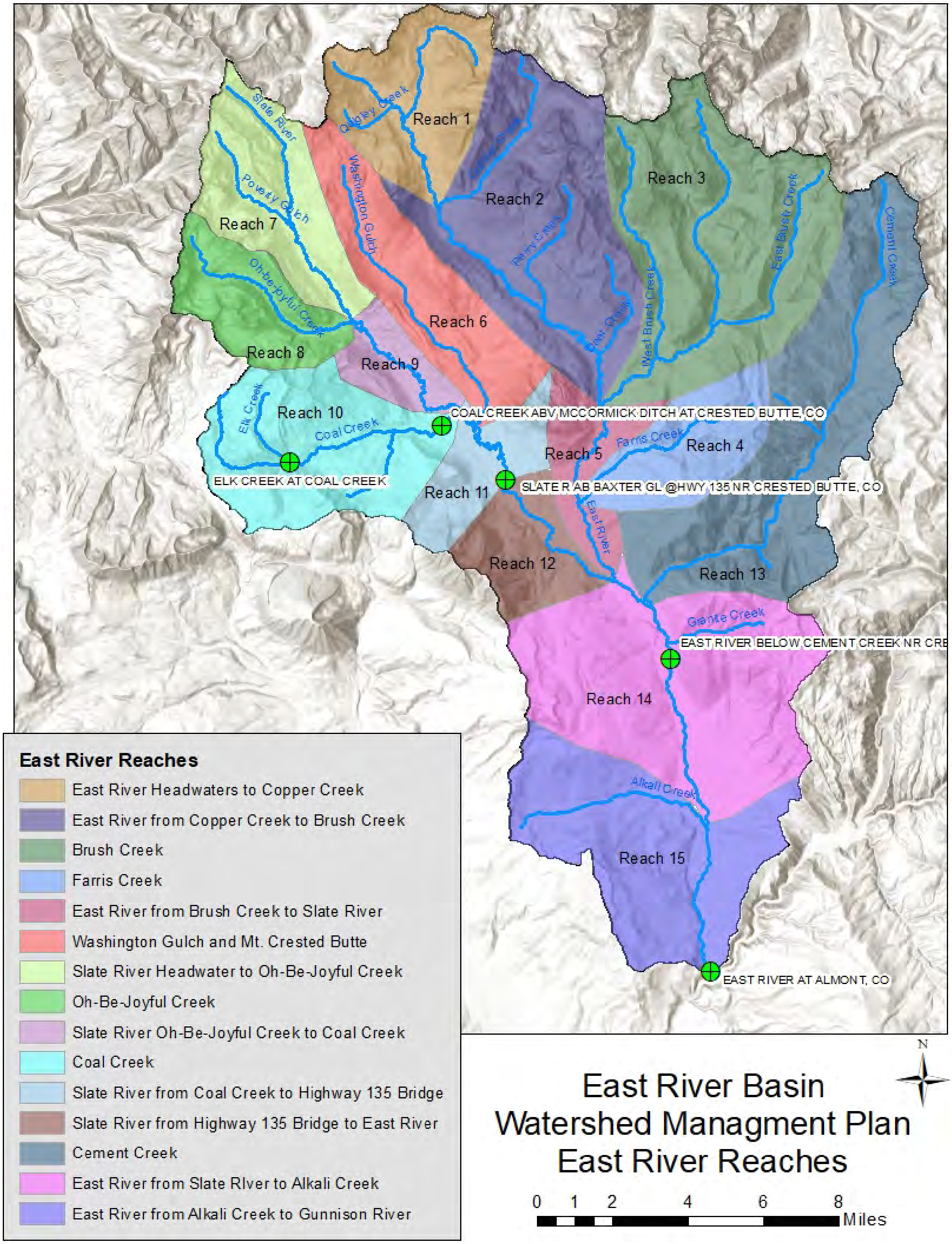


Figure 2-15: East River Reaches

Table 3-3. East River Reach Characteristics

Reach	General Characteristics	Stakeholder Identified Issues
East River Headwaters to Copper Creek	Few water uses; impacts from off-river recreation	Preserving RMBL uses
East River Copper Creek to Brush Creek	Industrial (CBMR);	Low winter flows; increased municipal demands; water supply shortages; road erosion
Brush Creek	Public lands; ranching and grazing; recreation	Water quality; water supply shortages; erosion and stream stability; riparian and habitat health
Farris Creek	Predominantly agricultural	Environmental flows
East River from Brush Creek to Slate River	Predominantly agricultural	Water quality; sedimentation; conveyance losses; water use efficiency
Washington Gulch and Mt. Crested Butte	Municipal water supply, recreation, and	Water quality; land use; stormwater management; water supply shortages; riparian health; water use efficiency
Slate River Headwaters to Oh-Be-Joyful Creek	Predominately recreational	Water quality; increased recreational uses; erosion and sedimentation; land use
Oh-Be-Joyful Creek	Wilderness reach with mining impacts	Preserve recreational access; address water quality impairments
Slate River Oh-Be-Joyful Creek to Coal Creek	High impact rec reach; mixed domestic and agricultural uses	Water quality; water supply shortages; infrastructure needs; sedimentation; riparian and habitat health
Coal Creek	Municipal water supply; mining impacted	Water supply shortages; water quality; environmental flows
Slate River from Coal Creek to Highway 135 Bridge	Municipal, domestic, recreational, agricultural, environmental	Water quality; land use; water temperature; riparian degradation; water supply shortages; environmental health
Slate River from Highway 135 Bridge to East River	Agricultural, recreational, industrial, domestic	Water quality; water temperature; infrastructure; increased recreational use; environmental flows
Cement Creek	Agricultural, recreational, domestic	Water quality for domestic wells; water supply shortages; riparian and habitat health; erosion and sedimentation; land use
East River from Slate River to Alkali Creek	Primarily agricultural	Water quality; water supply shortages; environmental flows; recreational passage issues
East River from Alkali Creek to Gunnison River	Agricultural, domestic, fish hatchery; recreational, environmental	Water quality; riparian health; environmental flows; recreation passage

Section 4. Assessing Current Uses

Physical water availability within a watershed varies by year and throughout the year. Water may not be physically available to provide a full supply to meet all water demands in every year. Interactions between decreed water rights, diversions, and return flows add further complexity.

4.1 Agricultural Water Use

Understanding existing uses and assessing future needs for each water use category requires an understanding of hydrologic variability both throughout the year and for different hydrologic year types. This assessment uses recent years to characterize representative year types. 2012 was selected as the representative dry year. 2010 was selected as the representative average year. 2011 was selected as the representative wet year.

Irrigation is the largest consumptive water use in the East River Basin. Pasture grass is the primary crop grown in the East River and supports cattle operations, many that have been in business for generations.

Consumptive use analyses compare expected crop water demand to actual crop water use to identify consumptive use shortages. Consumptive use analyses also estimate permanent depletions to the river attributed to crop consumptive use, and temporary depletions to the river which are caused by conveyance and application inefficiencies. Conveyance loss is water that infiltrates into the soil in route to the field. Conveyance losses return to the river, generally within a few days to weeks of diversion. Application losses are the portion of water applied to an irrigated field that returns to the river through surface runoff or infiltrates beyond the crop root zone and lags back the river.

StateCU was used to estimate crop consumptive use and shortages from 1998 to 2017. First, StateCU estimates crop demand – the amount of water the crops could use if provided a full irrigation supply – based on monthly climate data and irrigated acreage. Next, StateCU uses diversion records and estimated conveyance and application efficiencies to determine the actual (supply-limited) crop consumptive use and associated shortages. Consumptive use shortages occur when the crop demand is greater than the crop consumptive use. Diversion records limit the reliability of the consumptive use analysis, because often a single instantaneous diversion rate is reported for up to a 30-day period; and the records do not report actual start and stop dates. Despite their limitations, the diversion records are the best available information for agricultural water use.

As discussed in Appendix A, conveyance efficiencies vary based on soil permeability and ditch length and have been estimated for each ditch in the East River Basin. Conveyance efficiencies in the East River Basin range from 75 to 90 percent depending on ditch length. Flood irrigation application efficiency is also estimated based on soil types, soil thickness, and underlying geology. The soil profile overlays gravel deposits; therefore, application efficiency is relatively low. Based on information from decrees and soil reports, a maximum application efficiency of 45 percent was used for irrigation in the East River Basin. Actual efficiencies vary depending on water availability. Supplies to individual ditches dictate whether irrigators are operating at the maximum efficiency, with most ditches reaching maximum efficiency in the late irrigation season when supplies are more limited. When considering both conveyance and application efficiency, late season system efficiency ranges from 30 to 40 percent.

The estimated annual diversions often far exceed the annual crop demands in the East River Basin. This is due to the cobbly and porous soils and is consistent with the amount of water allocated to irrigated parcels (i.e. the duty of water) in the 1941 district court case (CA2021) for water rights decreed in the East River Basin.[22] As indicated, the soil profile requires a duty of water between 1 cfs per 8 acres and 1 cfs per 20 acres, compared to other areas in Colorado where the duty of water is more often between 1 cfs per 40 acres and 1 cfs per 80 acres, meaning the soils in the Upper Gunnison River Basin require up to five times more water than some other areas in the state. Based on current acreage and active irrigation rights, the duty of water in the East River Basin is 1 cfs per 8 acres.

Not all the water diverted at the river headgate is available to meet crop demands due to transit losses and irrigation application losses. For example, if 100 acre-feet is diverted and the conveyance loss is 20 percent, only 80 acre-feet is available when the water reaches the irrigated parcel. The maximum flood application efficiency, based on the porous nature of the soil, is 45 percent; therefore, of the 100 acre-feet diverted in this example, only 36 acre-feet (80 acre-feet x 45 percent) is available to meet crop demands. As noted, the accuracy of the crop consumptive use estimate is highly dependent on the accuracy of diversion records. Infrequent reporting of diversion rates (i.e. monthly rather than daily and inaccurate irrigation start and stop dates) limits the ability to accurately calculate consumptive use shortages. At this time, it is unclear whether existing diversion records increase or decrease modeled consumptive use shortages.

Excess water applied to the fields during flood irrigation returns to the river over time. Based on irrigation surface runoff; aquifer characteristics, and the location of the irrigated parcels over 50 percent of diversions not consumed by crops are estimated to return to the river within four days of application, with over 85 percent returning within two months of application. The remaining 15 percent returns over the following three to six-month period. Due to cobbly and porous soils, the soil zone does not store significant water, unlike other areas of Colorado where a significant amount of water can be stored in the soil root zone. Return flow locations are estimated based

---

[22] The decree states, “the soil is very porous and open, consisting of a deposit of loam on the surface of variable thickness generally from eight to eighteen inches, with a base consisting of coarse granite, sand, gravel, and boulders, underlaid with materials of a firmer and more permanent nature; that by reason of the above character and formation of the soil water applied thereto percolates through the soil rapidly, making it necessary to raise the water table a very considerable distance before any adequate irrigation can be begun or maintained.” The decree further declares “not less than two cubic feet of water per second of time, and in some portions of the district five and five and a half cubic feet of water per second of time are required for each forty acres in order to grow and mature a valuable crop thereon.”

ditch alignment, irrigated acreage location, topography, and proximity to local drainages and tributaries.

Figure 4-16 shows the annual variability of agricultural water use in the East River Basin from 1998 to 2017. The results are for the East River Basin; but each ditch was represented individually in the consumptive use analysis. Average annual consumptive use from irrigation is 12,800 acre-feet, for 1998 through 2017, varying from a low of 10,300 in the relatively cool summer of 1999 to over 14,700 acre-feet in hot summer of 2012.

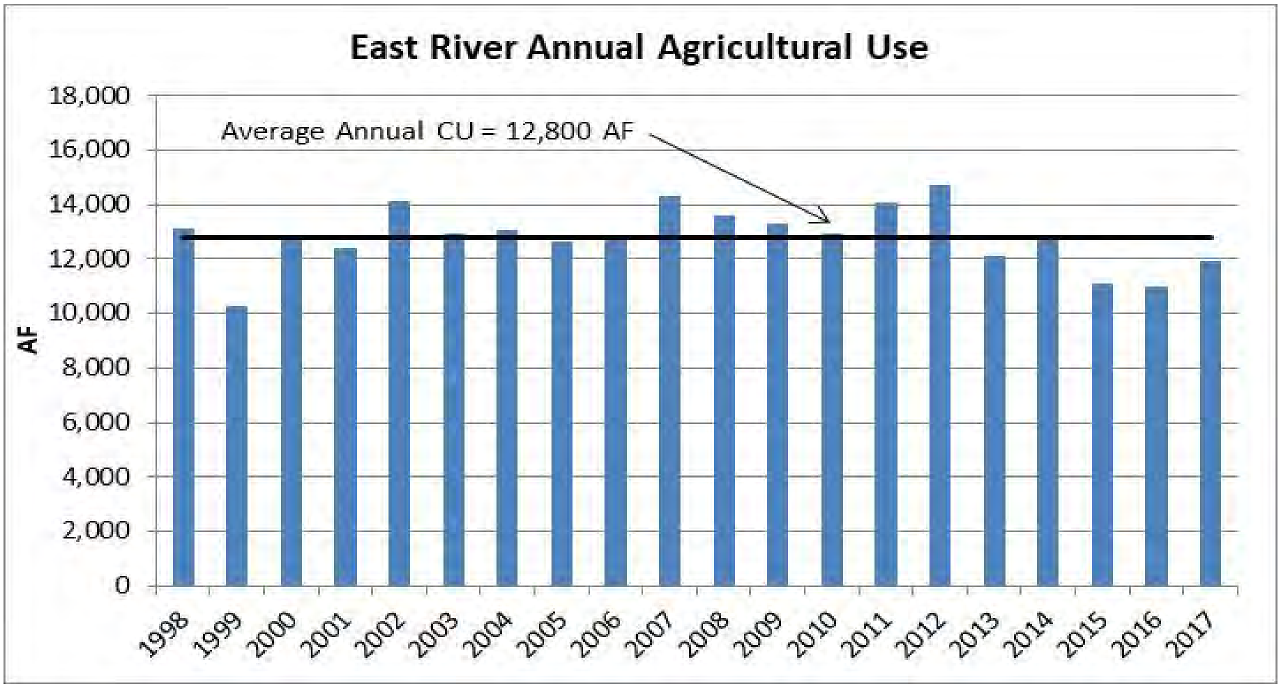


Figure 3-16: Annual East River Basin agricultural consumptive use (CU) in acre-feet (acre-feet) from 1998 to 2017

Crop water shortages occur when the amount of water delivered to the irrigated fields is less than the crop demand. Flow in the East River is driven by snowmelt. Flows are higher during spring runoff and decreases as the snowpack declines. This often leads to agricultural shortages during the late summer. Detailed analyses of agricultural water use are presented by reach in Sections 5 through 19 of this Chapter. In many cases, ditches divert water within a reach to irrigate lands located in a downstream reach. Because the stream depletion occurs at the point of diversion, the consumptive use and associated shortages are reported based on the reach where the diversions occur.

4.2 Domestic Water Use

Municipal water providers and industrial water users were interviewed as part of the stakeholder outreach process. Existing uses and potential future needs were discussed with each entity.

Detailed analyses of domestic water uses and needs are presented by reach in the reach sections of this Chapter.

Over the years, there have been several proposals to develop the molybdenum deposit beneath Mt. Emmons. Prior mine proposals have included operations and facilities within the Coal Creek, Slate River, and Ohio Creek Basins. There are substantial conditional water rights associated with the proposed mine. Currently, there are no applications to develop the mine. This assessment does not specifically address the impacts of potential mining operations on Mt. Emmons but does discuss issues related to the Keystone Mine.

4.3 Environmental Water Use

Several environmental characteristics were assessed and summarized based on information collected from existing studies, stakeholder interviews, and field assessments. The paragraphs below summarize the techniques used in the environmental water use and needs assessment.

4.3.1 Stream and Riparian Characteristics

The current condition of a stream and the adjacent riparian areas reflect the action of both natural processes and human activity. Stream and riparian characteristics provide important context to understand stream stability and watershed function. This assessment included a cursory review of channel and landscape form, debris supply, floodplain connectivity, stream stability, and physical structure. The objective of this portion of the assessment was to preliminarily evaluate issues identified by stakeholders and to support the selection of field assessment locations.

4.3.2 Aquatic Life

Perennial and intermittent streams within the East River Basin are typically expected to provide high-quality aquatic habitat, except where stressors have decreased the condition of the stream. In the East River Basin, historic abandoned mines and runoff from developed areas are examples of water quality stressors that occur in some portions of the basin.

In some portions of the East River Basin, environmental stressors overlap. The overlap may create outsized effects on the aquatic community. For example, the stress imposed by elevated zinc concentrations is exacerbated when stream temperatures are also elevated.

4.3.3 Water Quality

Aquatic life, recreation, agriculture, and water supply uses are applied to segments in the East River Basin. Each of the use classifications has specific standards for many water quality parameters. The water use classification with the most conservative criteria (e.g., lowest value) is applied as the effective standard for each parameter (e.g., temperature, nitrogen 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 East River Basin, the numeric standards associated with aquatic life (most metals), recreation (*E. coli*) or water supply (arsenic, iron) are typically the lowest and are therefore applied as the effective standard for many parameters.

4.3.4 Existing Instream Flow Water Rights

As part of this assessment, existing instream flow water rights were reviewed. During the review, the consultants evaluated original cross-section data, field notes, and R2CROSS model output. Unfortunately, due to their age, some instream flow segments in the East River Basin lacked some of the components included in the original proposal. Nevertheless, the review provided useful insights related to the existing instream flow water rights. In general, the original R2CROSS output and preliminary instream flow water rights were revised downward as a result of professional judgment and input from the local water commissioner, typically because of water availability limitations. The resulting instream flow rights are not consistent with current protocols for instream flow proposals. In many cases, the existing instream flow water rights in the East River Basin do not fully meet the physical criteria to preserve the natural environment to a reasonable degree.

In Sections 5 through 19 of this Chapter, a summary of the existing instream flow water rights is provided, as well as recommendations where it may be possible to establish a new instream flow water right or expand the existing instream flow with a new instream flow appropriation or acquisition. Additional field work is likely needed to for any future instream flow proposals. Figure 4-17 shows the field assessment locations for the East River Basin. R2CROSS assessments and pebble counts were completed at nine locations. Transit losses were estimated based on five flow measurements collected from one ditch. Further information about the R2CROSS results are presented in the respective reach sections.

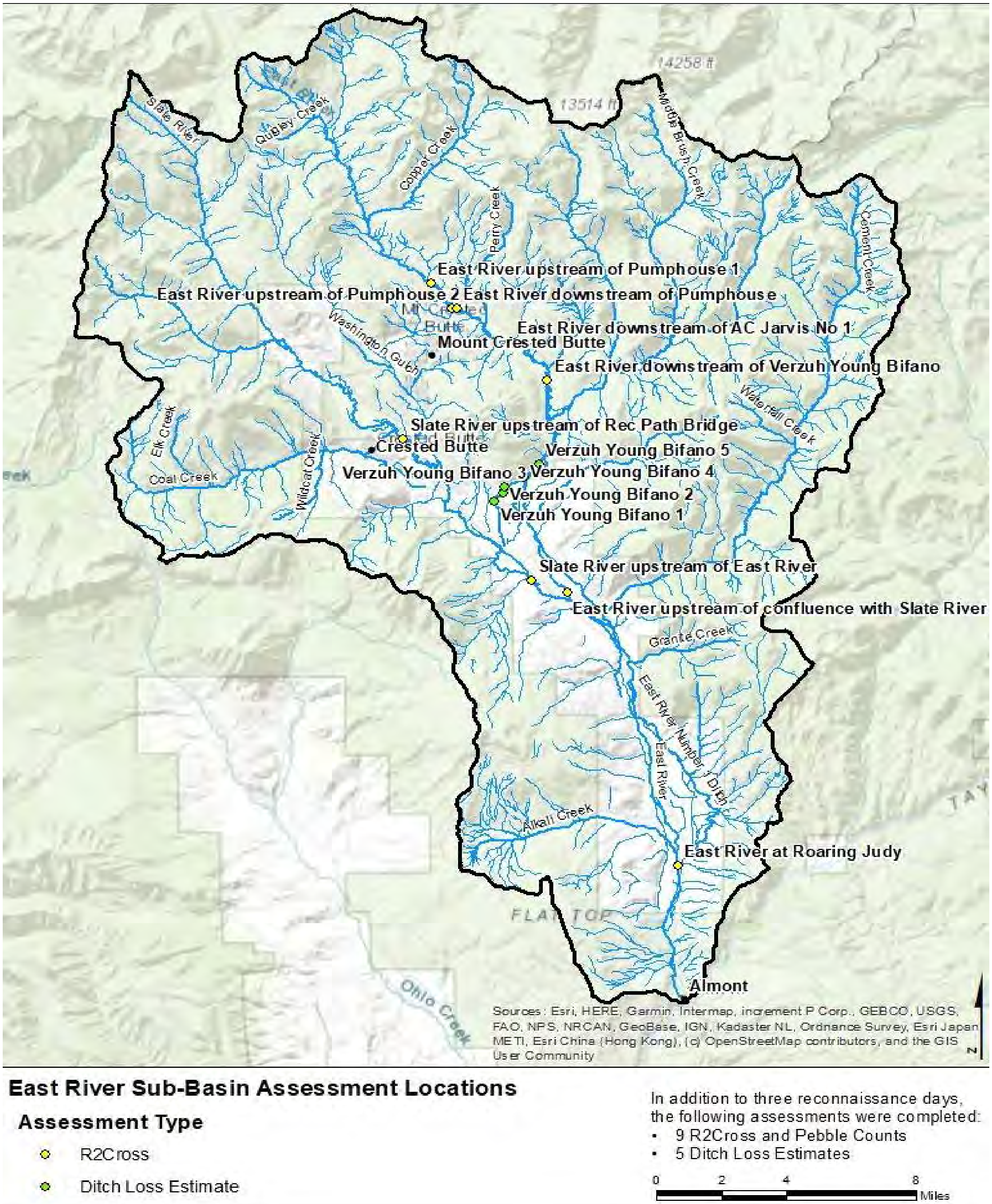


Figure 4-17: Field assessment locations in the East River Basin

4.3.5 Flow Limited Areas

Flow limited areas are identified in the reach sections that follow.

4.3.6 Environmental Flow Goals

Environmental flow goals are identified in the reach sections that follow.

4.4 Recreational Water Use

Recreation is one of the primary land uses in the East River Basin. Recreation occurs year-round and includes hiking, biking, camping, fishing, birdwatching, kayaking, rafting, Off Highway Vehicle use, Nordic skiing, backcountry skiing and snowboarding, snowmobiling, and hunting, among others. Water sports, like rafting, kayaking, standup paddle boarding, and tubing are increasingly common on larger reaches within the basin. Angling, including float fishing and wading, is also an important use in the East River Basin.

Recreation and tourism are a critical part of the local economy and culture. Water sports and angling support several businesses, including fly-fishing shops and outfitters, commercial guides, rentals, and retail stores, and jobs within the community. Due to recent increases in tourism and recreation, the community is very engaged on issues related to recreation management.

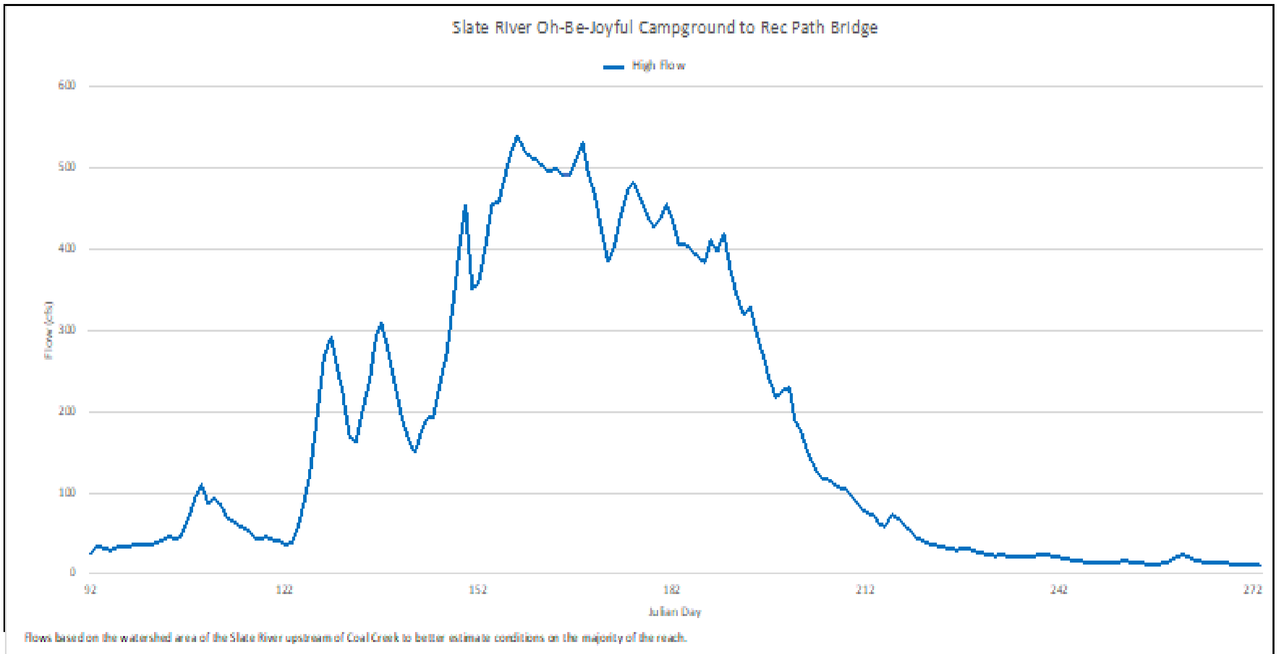
As part of this assessment the consultants surveyed recreational boaters to better understand how they enjoy rivers in the area. Figure 4-18 shows the recreational use reaches in the basin.

Ten unique surveys created for each recreational use reach in the East River Basin. To be eligible to complete a survey, the user had to confirm that they had floated the reach in the past. The criterion was used to avoid bias, particularly for Class V waters.

The four-page survey included questions related to craft type, floating experience, and infrastructure (parking, restrooms, fences, etc.). The survey included flow calendars for high and low flow years, and example of which is shown in Table 4-4. Survey respondents used the calendar to identify the week of the month when they prefer to flow the reach, and could also reference flows, if needed. For rafting and kayaking, users were asked to identify high, medium, and low flow conditions on selected reaches. This approach was preferred over asking respondents to estimate stream flows, as most users are better able to remember when they floated a reach, but the particulars of flow may be difficult to recall. Where an adequate number of surveys were gathered, the use data was correlated with average daily stream flows at the nearest downstream gage. Data related to infrastructure and other components of the survey were tabulated and are reported in the reach sections that follow.

Table 4-4. Example of flow calendar used in the recreational use surveys.

High Flow Years



Activity		April				May				June				July				August				September			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Kayak	Low Flow																								
	Medium Flow																								
	High Flow																								
Whitewater Rafting	Low Flow																								
	Medium Flow																								
	High Flow																								
Float Fishing																									
SUP and Tubing																									

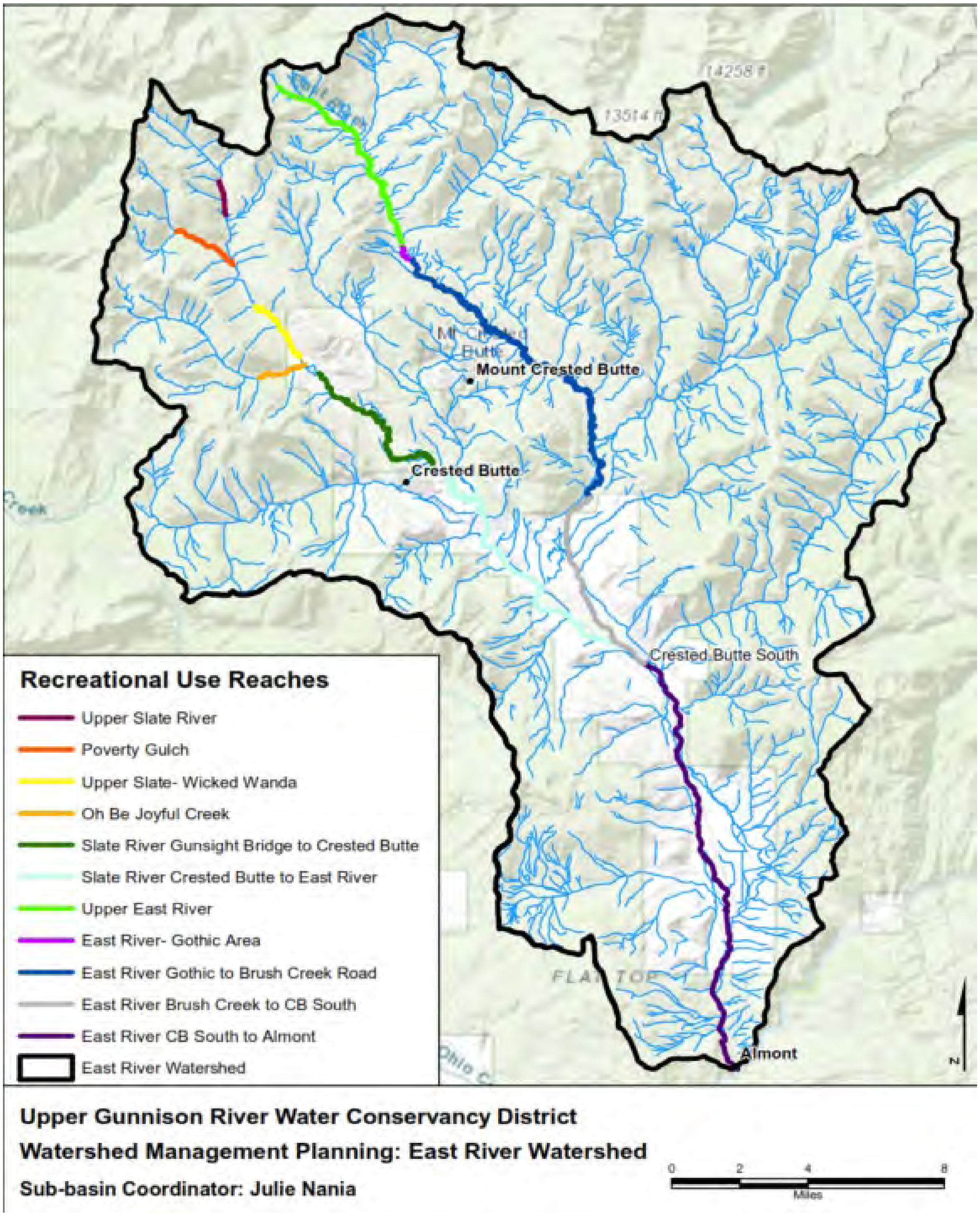


Figure 4-18: Recreational use reaches in the East River Basin

4.5 Needs for each Reach; Issues Identified

For each reach, this section summarizes the issues most frequently identified by stakeholders and the consultants during the assessment process. This material will be a central component of the next phase of WMP, where potential options and best management practices will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Section 5. Reach 1 - East River Headwaters and Copper Creek

The headwaters of the East River form below Emerald Lake near the summit of Schofield Pass. The basin boundaries are formed by iconic peaks including Gothic Mountain, Mount Baldy, Mount Bellview, Avery Peak, White Rock Mountain, and many others. The beautiful mountains attract a wide variety of recreational users throughout the year.

The headwaters of the East River include the Mexican Cut Ponds, home to a rare salamander. The Mexican Cut Ponds are protected as a research natural area by the Colorado Natural Areas Program.

A world-class research facility, Rocky Mountain Biological Laboratory (RMBL), is also located in this headwater reach. RMBL was established by a biology professor at Western Colorado College in 1928. Researchers from RMBL have been conducting studies in this basin for nearly a century. The Department of Energy (DOE) has recently initiated a large-scale multi-decade research effort to study many facets of water resources, watershed health, and ecology.

5.1 Agricultural Water Use

There are no diversions for agricultural use in this reach and no identified needs in the future.

5.2 Domestic Water Use

RMBL relies on wells to supply its scientific, educational, and residential facilities and uses on-site wastewater treatment systems.

Approximately ten homes and cabins rely on wells or springs and use on-site wastewater treatment systems. Very limited data collection has occurred to characterize groundwater and spring water quality.

There are no diversions for municipal or industrial use in this headwater reach and no identified needs in the future.

5.3 Environmental Water Use

An imposing view of Gothic Mountain, as seen from the valley floor. The exposed bedrock on Gothic Mountain and other peaks are impervious surfaces that can rapidly deliver ample amounts of water to drainages below the peak. These natural conditions make mass erosion events more likely. Photo from the RMBL archives.

5.3.1 Stream and Riparian Characteristics

Steep glaciated valleys form the headwaters of the East River. Slopes are covered with bedrock, talus or a thin veneer of soil. Vegetation communities include alpine tundra dominated by grasses and forbs, and spruce-fir forests. The streams, which are both intermittent and perennial, are steep entrenched channels that are often scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages.

Due to the steep slopes and the materials found on the slopes, hillslopes in the headwaters are naturally susceptible to mass erosion which includes landslides, earth flows, debris avalanches, debris flows, torrents, and snow avalanches. These sporadic events provide massive natural sediment sources. Evidence of recent mass erosion is very common throughout the headwaters area. Natural mass erosion events are probable throughout the headwaters area. These natural hillslope processes are an enormous source of sediment to the East River. Natural mass erosion dominates sediment supply in the headwaters. These events form the backdrop from which human impacts must be evaluated.

In a 2011 study, prepared in cooperation with Gunnison County, the USGS evaluated the probability of debris flows in the area near Marble[23]. Although the headwaters of the East **River**

[23] Stevens, M.R., Flynn, J.L., Stephens, V.C., and Verdin, K.L., 2011, Estimated probabilities, volumes, and inundation areas depths of potential post wildfire debris flows from Carbonate, Slate, Raspberry, and Milton Creeks, near Marble, Gunnison County, Colorado: U.S. Geological Survey Scientific Investigations Report 2011–5047, 30 p.

were not included in the study, the topography, mechanisms, and other factors exist in the headwaters of the East River and the general principals apply. Drought periods followed by intense rainfall increase the probability for debris flows. Wildfire, which destroys vegetation that stabilizes soil and sediment on many steep slopes, increases the probability of destructive debris flows in the years following a fire.

Willows and riparian vegetation have colonized portions of narrow stream corridors in larger headwater tributaries where sediment deposition has supported soil development. Where the valley opens near Judd Falls, large wetland complexes support a variety aquatic and wildlife habitat. These wetland complexes also attenuate flood flows and store water to support late season flows. Aside from site-scale disturbances near trails and roads, the riparian area is typically undisturbed.

5.3.2 Aquatic Life

RMBL biologists began studying aquatic life in the headwaters of the East River in 1928. The headwaters support diverse and healthy aquatic life. There is a mixed fishery of wild browns, rainbows, and cutthroats. There tend to be smaller fish in the headwaters of the East River with some deeper pools that serve as refuge for larger fish.

The Mexican Cut Ponds are home to a rare species of salamander that looks oddly like a fish and never leaves the water.

5.3.3 Water Quality

Two samples collected from the East River near RBML in July and August of 2014 by the WQCD were used to identify a potential impairment of the water supply use for total recoverable arsenic in the East River, and its tributaries from the headwaters to the confluence with the Slate River, as shown in Table 5-1 and Figure 5-1. Data collected by the DOE from the East River at the Pumphouse confirm the impairment status for total recoverable arsenic. In recent years, arsenic concentrations in the East River at the Pumphouse ranged from 0.2 to 2.0 µg/L.

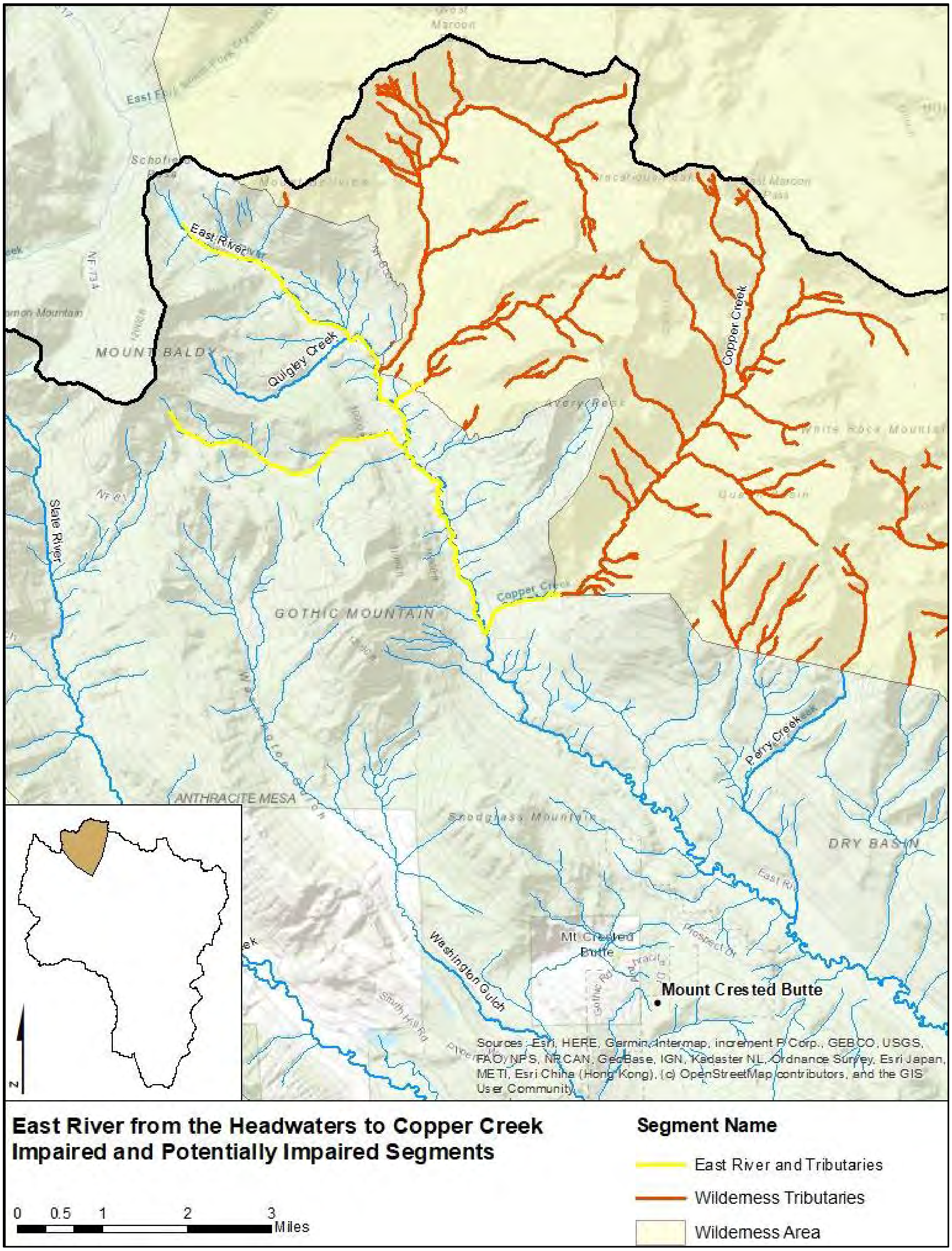
In 2018 the portions of the East River, Copper Creek, and other tributaries located in wilderness were listed as impaired for total recoverable arsenic for the water supply use. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the East River Basin share many characteristics, the listings were retained for all wilderness tributaries, also shown in Table 5-1.

Additional water quality data is collected by many researchers affiliated with the DOE's East River Basin Function Scientific Focus Area. Those data were not evaluated as part of this assessment.

Table 5-1: Impaired and potentially impaired portions of the East River from the Headwaters to Copper Creek.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
All tributaries to the Gunnison River, including all tributaries and wetlands, within the La Garita, Powderhorn, West Elk, Collegiate Peaks, Maroon Bells, Raggeds, Fossil Ridge, or Uncompahgre Wilderness Areas	Water Supply Use	Iron (Dissolved)	NA	NA
		NA	Total Arsenic	High
Mainstem of the East River, including all tributaries and wetlands, from its sources to a point immediately above the confluence with the Slate River, except for specific listings in Segment 1	Water Supply Use	Total Arsenic	NA	NA

Figure 4-1: Impaired and potentially impaired stream reaches in the East River Headwaters to Copper Creek



5.3.4 Water Temperature

A cursory review of continuous water temperature data collected by DOE researchers demonstrates that the water quality standards used to protect thermally sensitive cold-water species are attained at all monitoring locations in the headwaters of the East River.

5.3.5 Existing Instream Flows

Figure 5-2 shows that the East River from the outlet of Emerald Lake to the confluence with Copper Creek has a summer and winter instream flow right of 8 and 15 cfs, respectively. The instream flow proposals for the headwaters of the East River were developed by CWCB and CPW staff from 1979 to 1982. Professional judgement was used to establish the value of the instream flow for the East River from Emerald Lake to Copper Creek based on the R2CROSS output from the East River upstream of Perry Creek.

Quigley Creek, Rustler Gulch, and Copper Creek have year-round instream flow water rights. DOE researchers maintain six gage stations in the headwaters of the East River reach. These data could be evaluated in future assessments to better understand instream flow attainment rates in reaches with instream flow water rights. During this assessment, this task was not a priority due to a lack of water use in these reaches.

Natural Lake Levels were not evaluated during this assessment. However, it is important to note the CWCB holds natural lake level rights for the Mexican Cut Ponds to protect the unique environment and rare aquatic life.

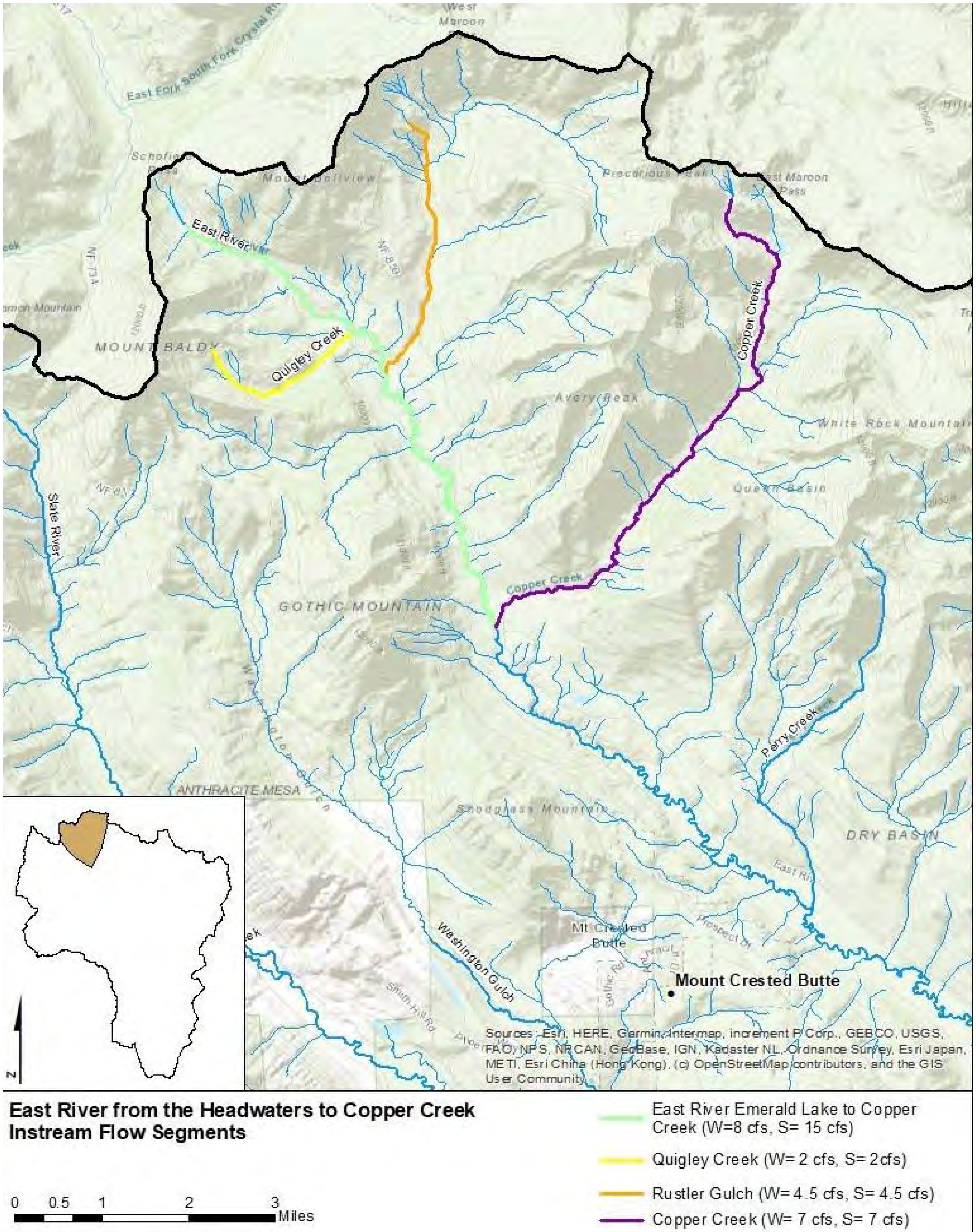


Figure 5-2: Instream flow water rights in the East River and its tributaries from the headwaters to the confluence with Copper Creek.

5.3.6 Flow-limited Areas

The headwaters of the East River and Copper Creek are snowmelt dominated systems that flow in response to natural climate and precipitation patterns. There are no diversions in this reach. Flow-limited areas were not identified.

5.3.7 Environmental Flow Goals

Stream flow in the East River from its headwaters to the confluence with Copper Creek is entirely natural. Flow in each of the tributaries is also natural. Changes in current land and water uses are not expected. Due to the natural hydrology of the reach and lack of water use, environmental flow goals are not required in the headwaters of the East River. However, flows within this reach support downstream uses and as such the current conditions should be maintained for the benefit of the natural environment in this reach and downstream water users.

5.4 Recreational Water Use

Skilled kayakers enjoy the technical challenges found in a reach of the East River upstream of Gothic, and its proximity to town. Kayakers noted that the cascades and drops and woody debris in the reach are the primary hazards. Figure 5-3 shows a summary of recreational use on the East River from the headwaters to Gothic.

Emerald Lake is a popular recreation destination, particularly for standup paddle boarding. In dry years, when other reaches of the river are too low to run, Emerald Lake and other local lakes may see increased use. Recreational use is summarized below.

Summary of Recreational Use on the East River from the Headwaters to Gothic

Reach Description: Technical two-mile reach between Judd Falls and Gothic Road Bridge. Class increases as flow increases with flow ranges from 600 at a minimum to 2,500 cfs.

Reach Information:

- Put-in: Varies, dependent upon conditions and skill. Anywhere from 1-2 miles upstream of Bridge near Gothic
- Take-out: Varies, upstream of Bridge near Gothic
- Activities: Whitewater kayaking
- Guidebook reference: Whitewater of the Southern Rockies, page 136
- Nearest downstream gage: USGS East River below Cement Creek near Crested Butte, CO

Survey Results:

- Most common craft type: Whitewater kayak
- Top two methods to decide to float: USGS Gage and observation
- Most enjoyable aspects: Technical level and proximity to town
- Top two suggestions for improvement: Create parking areas and add signs
- Top hazards: Falls and woody debris

5.5 Needs for this Reach; Issues Identified

This section summarizes the issues most frequently identified by stakeholders. This material will be a central component of the next phase of WMP, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Source water protection. The headwaters of the East River and its tributaries are the primary source of drinking water to the Town of Mt. Crested Butte. The basin is vulnerable to debris flows, mass wasting, large avalanches, and other episodic mass erosion events that can rapidly alter water quality, especially turbidity. The probability of these events increases when large precipitation events occur following wildfire, during extended droughts, or in areas with substantial forest health issues (e.g. beetle kill areas).

Issue: The Mt. Crested Butte Water and Sanitation District is concerned about mass erosion events, particularly following disturbance in the headwaters. In a typical year, small-scale mass erosion events can create operational challenges.

Issue: Water quality for household wells where sampling has not occurred.

Issue: Multiple stakeholders are concerned about off-road traffic in the headwaters of the East River Basin. This issue can be further classified in three areas:

- Some are concerned about isolated impacts in specific areas (e.g. roads to access dispersed camping site cause site-scale impacts to riparian or wet meadow vegetation and increases erosion at a local-scale).
- Some are concerned about increased recreational use (camping, hiking, fishing, etc.) and a perceived lack of management and lack of infrastructure.
- Some are concerned that traffic and roads in the headwaters of the East River may alter natural sediment transport.

Issue: DOE and RMBL publish research on the East River Basin. There is an opportunity to better incorporate research findings into the watershed management planning process and local natural resource management. This process is underway but could be improved upon.

Issue: Road erosion related to recreational access. Road shows damage related to springtime use for recreation (kayaking, backcountry skiing, or other users) when road is wet.

Section 6. Reach 2 - East River from Copper Creek to Brush Creek

This reach of the East River extends from Copper Creek to the confluence with Brush Creek. It begins where Copper Creek contributes a significant amount of flow to the East and includes several small tributaries, including Perry Creek and Deer Creek. This section of the East River has two dramatic geomorphic features: Stupid Falls, a step waterfall system, and another section that forms some of the most stunning meanders in the State of Colorado. The reach is very dynamic in nature, with substantial sediment transport largely attributed to natural processes.

There are a range of different uses on the East River between Copper Creek and Brush Creek. As in Reach 1, researchers from RMBL have been conducting studies in this basin for nearly a century, and DOE has recently initiated a large-scale multi-decade research effort to study many facets of water resources, watershed health, and ecology. Below RMBL is Stupid Falls, an extreme whitewater run occasionally descended by expert whitewater kayakers and accessible via private property.

The East River continues traveling towards Crested Butte and travels behind Crested Butte Mountain Resort. The next major water use occurs at the Pumphouse where both Mt. Crested Butte Water and Sanitation District and Crested Butte Mountain Resort withdraw water for municipal use and snowmaking, respectively. As the valley opens further, there are five agricultural diversions that irrigate pasture grass as shown in Figure 6-1.

6.1 Agricultural Water Use

There are five active irrigation diversions in the East River from Copper Creek to Brush Creek, serving approximately 490 acres of flood irrigated pasture grass. Table 6-1 shows the combined water rights, average annual and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the five ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 6-1. Agricultural water use statistics for the East River between Copper Creek and Brush Creek.

Reach Statistics	1998 to 2017 Average	1998-2018 Range
Number of Irrigation Structures	5	n/a
Irrigated Acreage	492	n/a
Water Rights	56.33	n/a
Diversions	9,040 acre-feet	4,050 – 12,230 acre-feet
Crop Demand	780 acre-feet	560 - 930 acre-feet
Crop CU	730 acre-feet	550 - 870 acre-feet
Shortage/Need	50 acre-feet	10 - 60 acre-feet
Percent Shortage	6%	0% - 27%

Figure 6-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions through the AC Jarvis No 1 Ditch, the Beitler Ditch No 1, and the Beitler Ditch No 2 comingle to serve common acreage. Although the Verzuh Young Bifano Ditch diverts within the reach, the associated irrigated acreage is located in downstream reaches. All of the ditches are unlined and are estimated to lose between 20 and 25 percent of diverted water during delivery to the irrigated fields. Conveyance losses reduce the water delivered to irrigated fields. The water lost in transit returns in subsequent days and months. Excess water applied to the fields during flood irrigation returns to the river over time. Due to cobbly and porous soils, the soil zone does not store significant water, unlike other areas of Colorado where a significant amount of water can be stored in the soil root zone from higher diversions during the runoff, and then is consumed by the crop when diversion supply is limited.

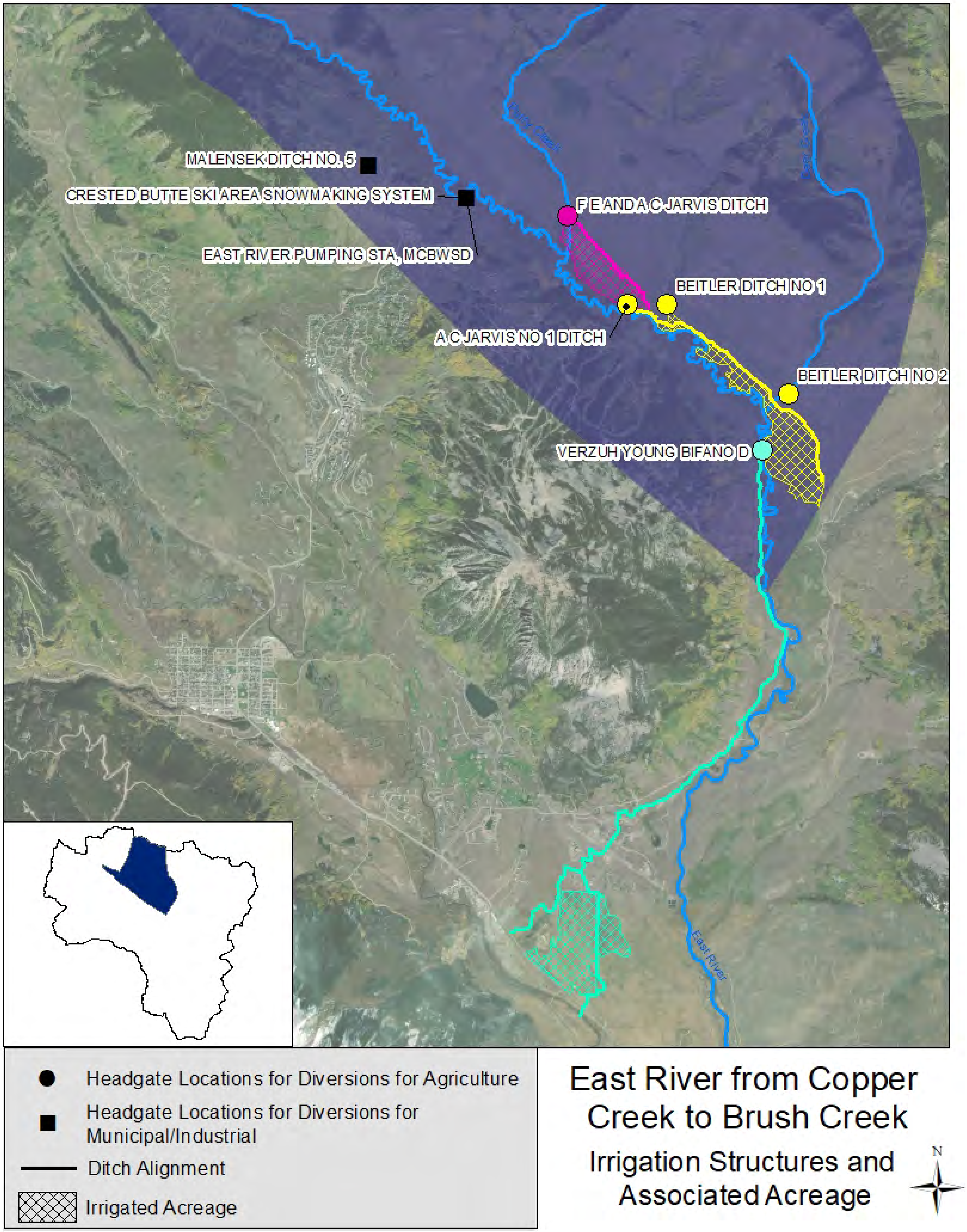


Figure 5-1: Diversion structures and acreage for the East River from Copper Creek to Brush Creek

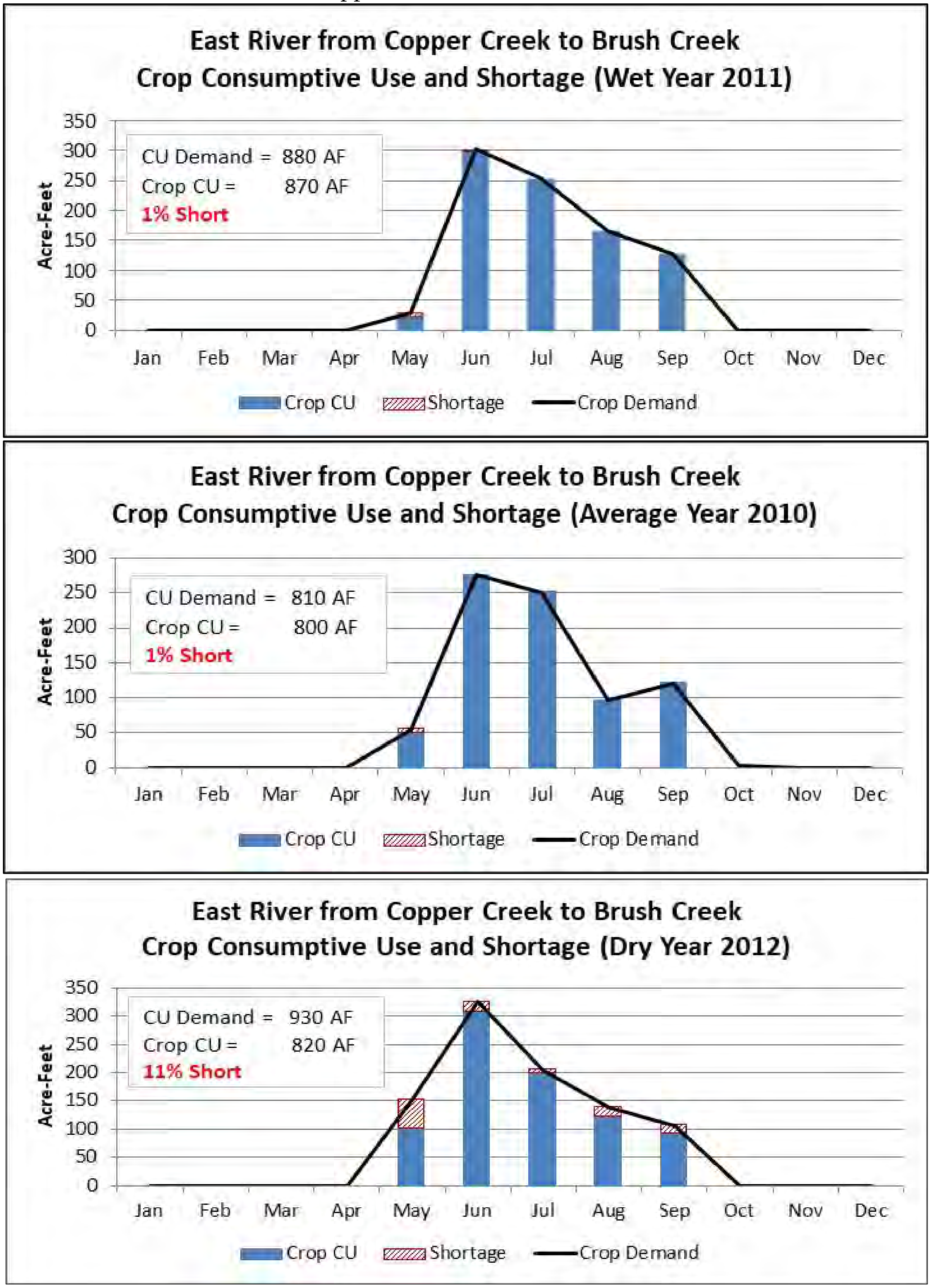
Table 6-2 shows the percentage of water that returns to the East River from Brush Creek to Copper Creek and to adjacent reaches. A significant portion of water diverted from this reach of the East River, an estimated 40%, returns to the Slate River rather than the East River.

Table 6-2: Agricultural Return Flow Locations for the East River from Copper Creek to Brush Creek

Return Flow Location	% of Total Return Flows	1998-2018 Avg Annual Return Flows (Acre-Feet)
East River from Copper Creek to Brush Creek	55%	4,570
East River from Brush Creek to Slate River	5%	410
Slate River from Highway 135 Bridge to East River	40%	3,330

Figure 6-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, there were minimal shortages during the representative wet and average years, with larger shortages in the representative dry year. Precipitation was well above average in August of the 2010 representative average year, resulting in a relatively low crop consumptive use from irrigation supplies. Crop demands were met through the summer and into the fall irrigation season during the representative average and wet years; however, during the dry year in 2012 there was not enough supply to fully meet crop demand in the late irrigation season.

Figure 6-2: Crop Consumptive Use and Shortage for the East River from Copper Creek to Brush Creek



6.2 Domestic Water Use

There are two diversions for municipal and industrial use on the East River between Copper Creek and Brush Creek. The diversions locations are shown on Figure 6-1. The East River Pump Station diverts year-round to the Mt. Crested Butte Water and Sanitation District's water treatment plant, where treated water is delivered to the Town of Mt. Crested Butte for indoor use and outdoor use to irrigate landscaped areas.

Water is diverted from the East River via culverts into a small pond. The pond has an intake to a stilling well in the pumphouse building. There are two pumps with a total capacity of approximately 650 gpm (gallons per minute) that pump water from the East River to the pre-sedimentation pond, located near the Snodgrass Trailhead.

Mt. Crested Butte Water and Sanitation District (operated independently from the Town of Mt. Crested Butte) also collects water from four springs on Crested Butte Mountain within the Washington Gulch reach. The Malensek Ditch No 5 gathers water from a spring gallery west of Schofield Pass Road and delivers water to the pre-sedimentation pond. All sources are mixed in the pre-sedimentation pond before treatment at the Mt. Crested Butte Water Treatment Plant.

Diversions from the East River increase during the high summer tourist season from June through August, and again during ski season from December through March. Diversions are lowest during spring and fall months. Mt. Crested Butte Water and Sanitation District has historically been able to meet its demands.

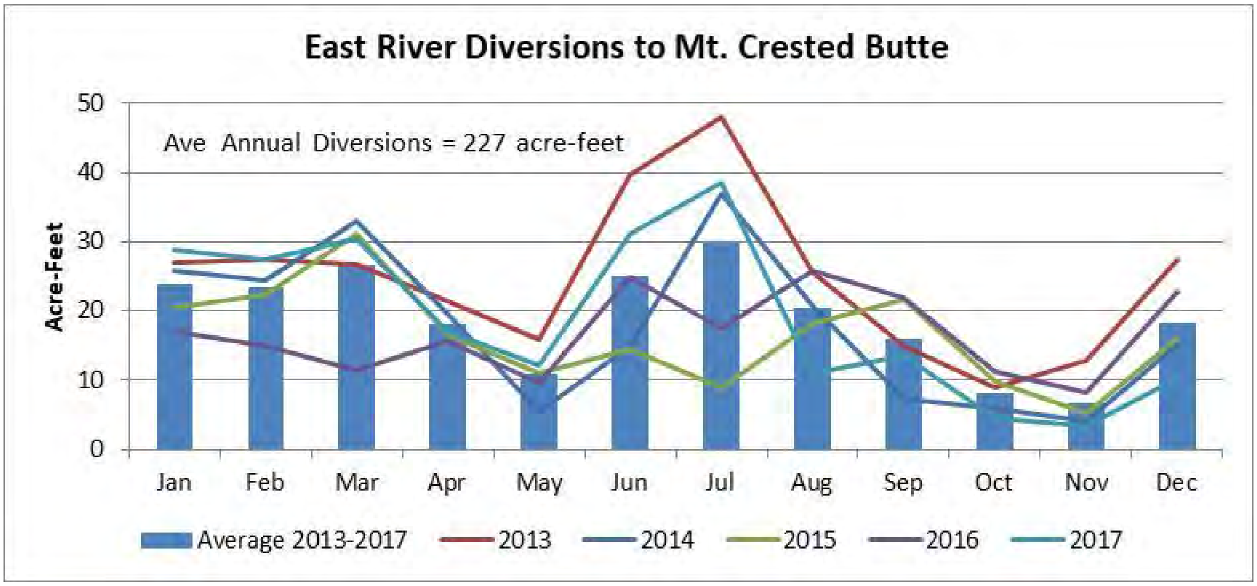


Figure 6-3: Diversions for municipal use in the Mt. Crested Butte service area. Data provided by Mt. Crested Butte Water and Sanitation District

Water used indoors is collected via the sanitary sewer system, treated, and discharged to Woods Creek, a tributary to Washington Gulch. A very small portion of the outdoor water use (e.g. irrigated landscapes in the Prospect area) may flow back to the East River reach between Copper Creek and Brush Creek. The consumptive use factor associated with diversions for indoor use averaged 25 percent based on information provided by Mt. Crested Butte Water and Sanitation District, meaning that approximately 75 percent of the water diverted for Mt. Crested Butte is returned as treated effluent to Washington Gulch via Woods Creek.

Water is also diverted from the East River at the Pumphouse for snowmaking at Crested Butte Mountain Resort (CBMR). Water is primarily diverted in November, December, and in some years January, with a 6 cfs absolute water right. CBMR also has a 5 cfs conditional water right for snowmaking.

CBMR is restricted when exercising these rights by a minimum bypass flow requirement that is a condition of its Special Use Permit. The minimum bypass flow requires that flow in the East River not fall below 7 cfs during snowmaking operations (this restriction allows drawdown to 6 cfs for up to 15 days in December[24]). Diversions can only occur if a minimum of 7 cfs (or 6 cfs for the December period) remains in the downstream reach of the East River.

---

[24] The minimum bypass flow is defined as “CBMR shall not divert more water from the East River than will permit 7.0 cfs of water to remain in the East River immediately below its point of diversion; provided, however, that during the month of December each year, CBMR shall be permitted to divert water from the East River in a quantity which will leave not less than 6.0 cfs of water remaining in said stream immediately below its point of diversion for a duration not to exceed 360 hours.” (USDA Forest Service (2018) *CBMR – Ski Area Projects Draft Environmental Impact Statement*, page 215).

A regression equation, that relates flows in the East River at Almont (USGS gage 09112500) to flows in the East River upstream of the Pumphouse[25], is used to determine how much water can be diverted each day while maintaining a compliance with the minimum bypass flow (i.e. leaving at least 7 cfs in the river).

Snowmaking diversions are typically reported on a total monthly basis in acre-feet; except for 2012. In 2012, Division of Water Resource records provide a single daily diversion rate of 11.5 cfs. Figure 6-4 shows total diversions for the period 1998 through 2016 (2017 and 2018 data are not available yet). As shown in the graph, diversions for snowmaking were highest in 2011 and 2014. Above average late fall flows and above average early snowfall allowed for additional snowmaking diversions.

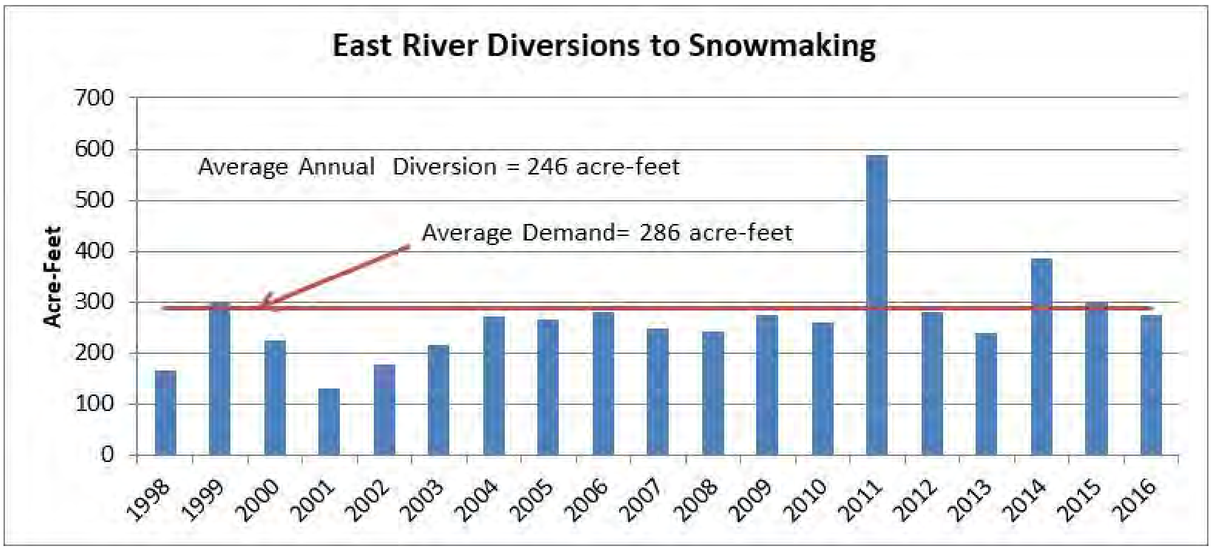


Figure 6-4: Diversions from the East River for snowmaking

In drier years, snowmaking diversions are limited due to a lack of water coupled with the need to meet the minimum bypass flow. Diversions vary depending on late fall flows and early season snowfall events. Based on an average demand of 286 acre-feet per year, recent shortages to snowmaking range from 0 to 130 acre-feet per year.

Along this reach, a handful of mostly seasonal homes rely on water from wells or springs and use on-site wastewater treatment systems. Very limited data collection has occurred to characterize groundwater and spring water quality.

[25] The regression equation was originally developed in the late 1980s. The regression equation was developed based on approximately 40 flow measurements.

6.3 Environmental Water Use

6.3.1 Stream and Riparian Characteristics

The riparian corridor adjacent to this reach of the East River is dominated by willows with extensive stands of aspen located directly upslope of a large portion of the corridor. Below Stupid Falls, the East River meanders through a broad valley and supports wetlands, relic channels, and beaver complexes. These features provide wildlife habitat, aquatic habitat, filter sediment, and store water, which provides base flows after snowmelt and runoff subsides.

The width of the riparian corridor and complexity of the channel decreases near the lower portion of the reach. These reductions are due to reduced flows, altered ground and surface water hydrology, vegetation removal, and in some areas channel incision. The lower portion of the reach remains relatively healthy.

Small tributaries within this reach, including Perry Creek and Dry Basin, support small riparian corridors on the upper reaches. Diversions located near the mouth of both Deer Creek and Dry Basin (Beitler Ditches No 1 and 2) have altered the riparian habitat of these small tributaries near the confluence with the East River.

The area provides important habitat for big game species, including calving grounds for elk. Cattle grazing is an important use within this reach.

6.3.2 Aquatic Life

There is a mixed fishery of wild browns, rainbows, and cutthroats. Most of the banks near the fishing access at Gothic are slightly undercut and hold fish seeking refuge. There tend to be smaller fish in the East River upstream of Stupid Falls, with some deep pocket pools that serve as refuge for larger fish. Downstream of Stupid Falls, fish tend to be larger.

In dry years, this reach may lack adequate overwinter habitat, such as pools, due to water removal for snowmaking operations.

6.3.3 Water Quality

Two samples collected from the East River near RBML in July and August of 2014 by the WQCD were used to identify a potential impairment of the water supply use for total recoverable arsenic in the East River and its tributaries from the headwaters to the confluence with the Slate River. Data collected by the DOE from the East River at the Pumphouse confirm the impairment status for total recoverable arsenic. In recent years, arsenic concentrations in the East River at the Pumphouse ranged from 0.2 to 2.0 µg/L.

The water supply standard for arsenic is a two-part standard. The first criterion is a human-health standard of 0.02 µg/L. The second criterion is a maximum contaminant level, developed through the federal Safe Drinking Water Act. The maximum contaminant level is the acceptable level of a substance in public water supplies and accounts for treatability and laboratory detection limits. The maximum contaminant level for arsenic is 10 µg/L. In practice, this means that raw source waters for public drinking water systems are not classified as impaired unless arsenic concentrations exceed 10 µg/L, as shown in Table 6-3 and Figure 6-5.

However, there are two water supply uses in the East River. The East River provides water for both household wells (which are generally assumed to be connected to surface water) and a public water supply system. Household wells are used at RBML (additional treatment occurs at RMBL), and wells and springs are used at residences scattered throughout the reach. Treatment practices at individual residences were not evaluated in this assessment. Mt. Crested Butte Water and Sanitation District serves as a public water supply. Because of the dual water supply uses, the East River has been listed as impaired for arsenic.

In 2018 the headwaters of Perry Creek and Dry Basin (located in wilderness) were listed as impaired for total recoverable arsenic for the water supply use. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the reach have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the Upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries. This does not necessarily mean that all wilderness reaches are impaired.

Table 6-3. Impaired and potentially impaired portions of the East River from Copper Creek to Brush Creek.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of the East River, including all tributaries and wetlands, from its sources to a point immediately above the confluence with the Slate River, except for specific listings in Segments 1	Water Supply Use	Total Arsenic	NA	NA
All tributaries to the Gunnison River, including wetlands within the La Garita, Powderhorn, West Elk, Collegiate Peaks, Maroon Bells, Raggeds, Fossil Ridge, Or Uncompahgre Wilderness Areas	Water Supply Use	Dissolved Iron	NA	NA
		NA	Total Arsenic	High

Academic researchers affiliated with DOE and RMBL continue to study water quality characteristics at multiple scales. Their research is advancing the collective understanding of watershed function and its relationship with water quality. Additional information is available at: *https://watershed.lbl.gov/about/*.

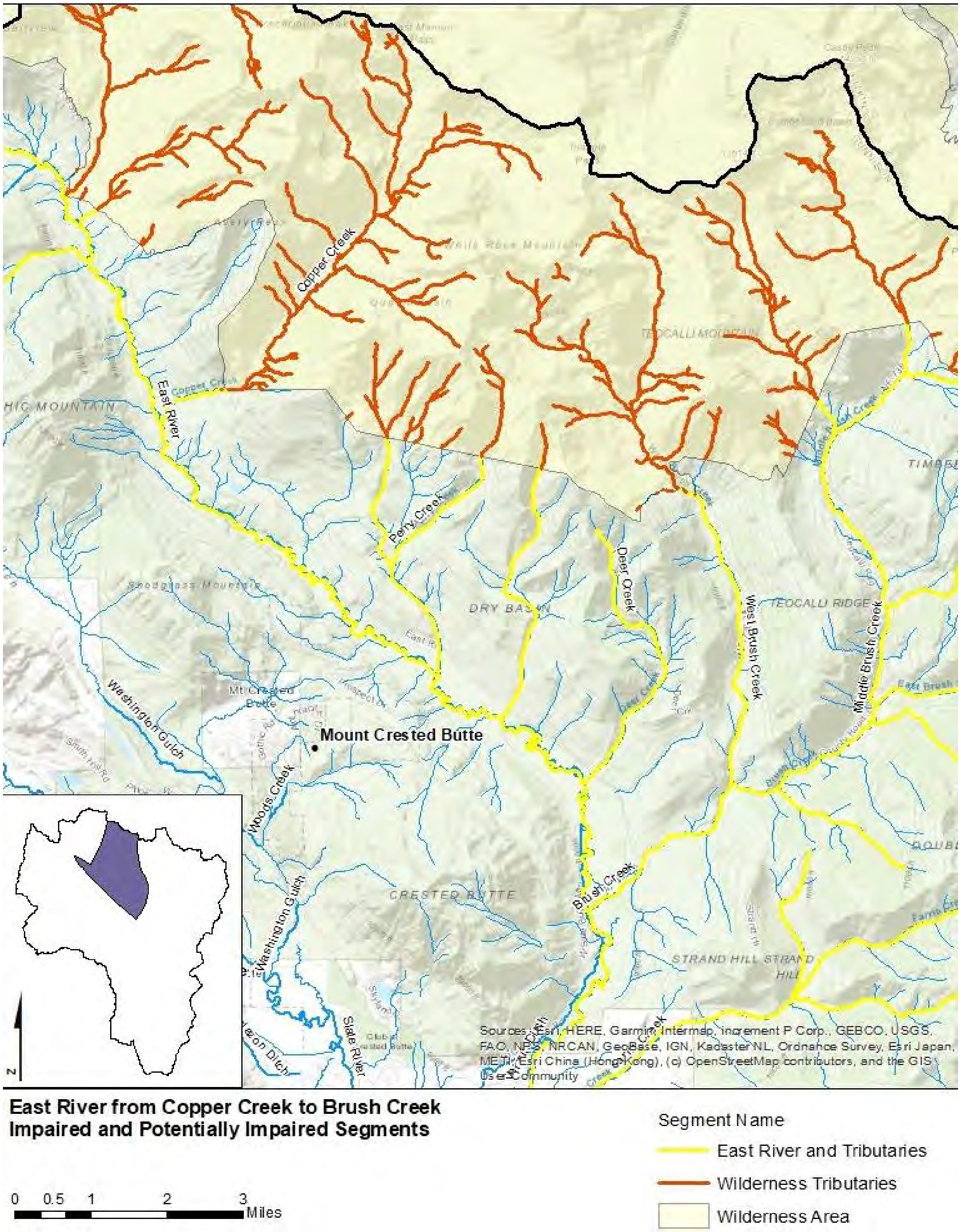
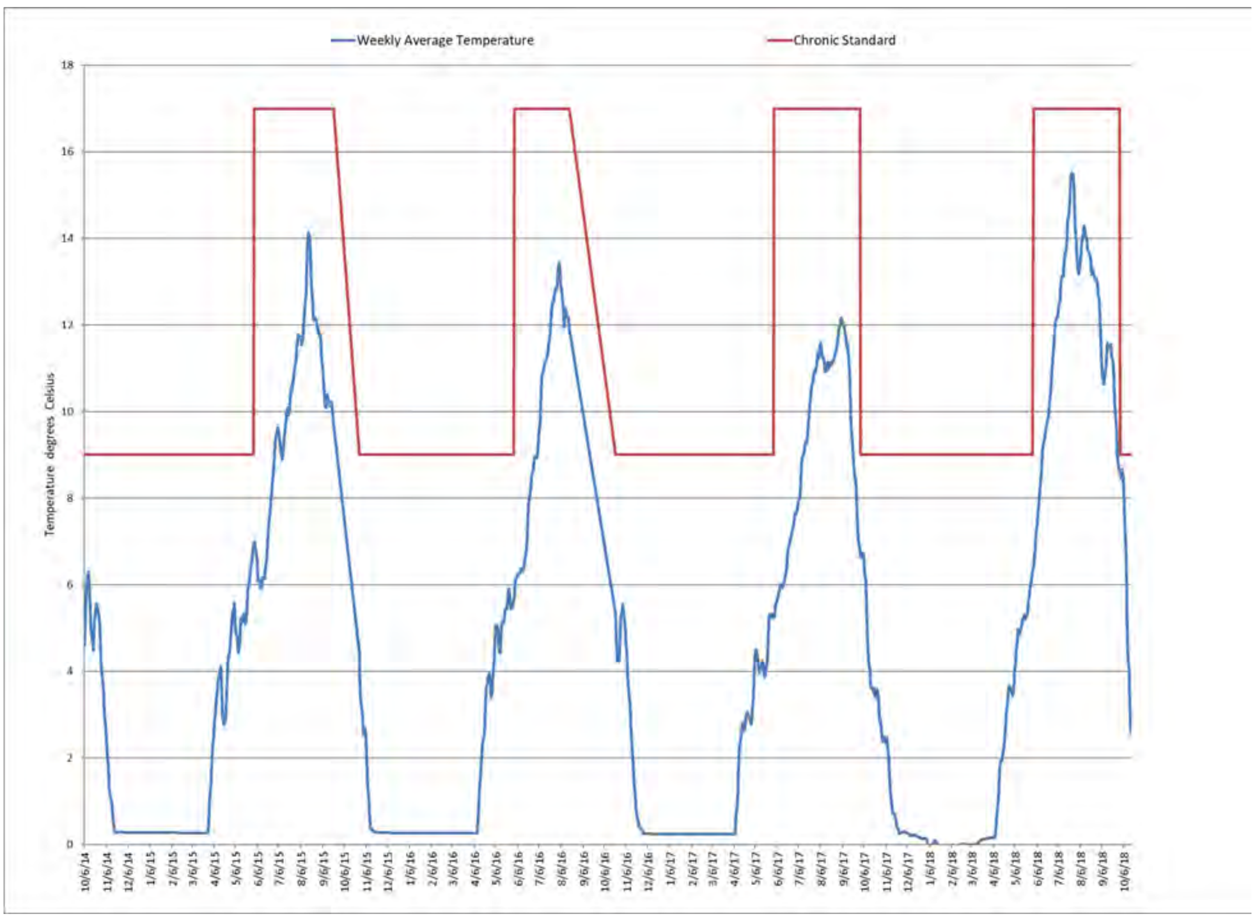


Figure 6-5: Impaired and potentially impaired stream reaches in the East River from Copper Creek to Brush Creek reach.

6.3.4 Water Temperature

Based on temperature data collected from October 2014 to October 2018 (data collection is on-going) by the DOE, weekly average temperatures in the East River upstream of the Pumphouse attained the chronic temperature standard as shown in Figure 6-6. During the late fall of 2018, weekly average temperatures in the East River approached the chronic temperature standard. This is notable because flows in the East River upstream of the Pumphouse are natural (e.g. no substantial diversions upstream of the Pumphouse). This provides two important insights. First, during low flows stream temperatures can naturally reach temperatures that may stress aquatic life. Second, as diversions remove water in downstream reaches, the thermal mass of the stream may be reduced (i.e. small volumes of water are warmed more readily than large volumes) which increases the likelihood of stream temperatures exceeding chronic or acute temperature standards. Given that continuous temperature data are a data gap in downstream reaches, temperature monitoring is recommended.

Figure 6-6: Weekly average temperatures, in degrees Celsius, from October 2014 to October 2018 in the East River upstream of the Pumphouse



6.3.5 Existing Instream Flow Water Rights

CWCB and CPW staff collaborated to develop the East River instream flow water rights in 1979 and 1980. Based on data collected approximately a quarter of a mile downstream of Perry Creek, the R2CROSS analysis produced flow recommendations of 51 and 25 cfs for summer and winter flows, respectively. CWCB staff recommended 25 and 15 cfs for summer and winter flows, respectively, where two rather than three of the hydraulic criteria were met. The ISF proposal records do not provide the specific rationale for the reduction in the ISF rates, but the reductions were most likely attributed to professional judgement regarding the R2CROSS analysis or physical availability. Legal availability was not clearly identified as an issue in the proposal.

Perry Creek has a year-round instream flow water right of 1 cfs as shown in Figure 6-7.

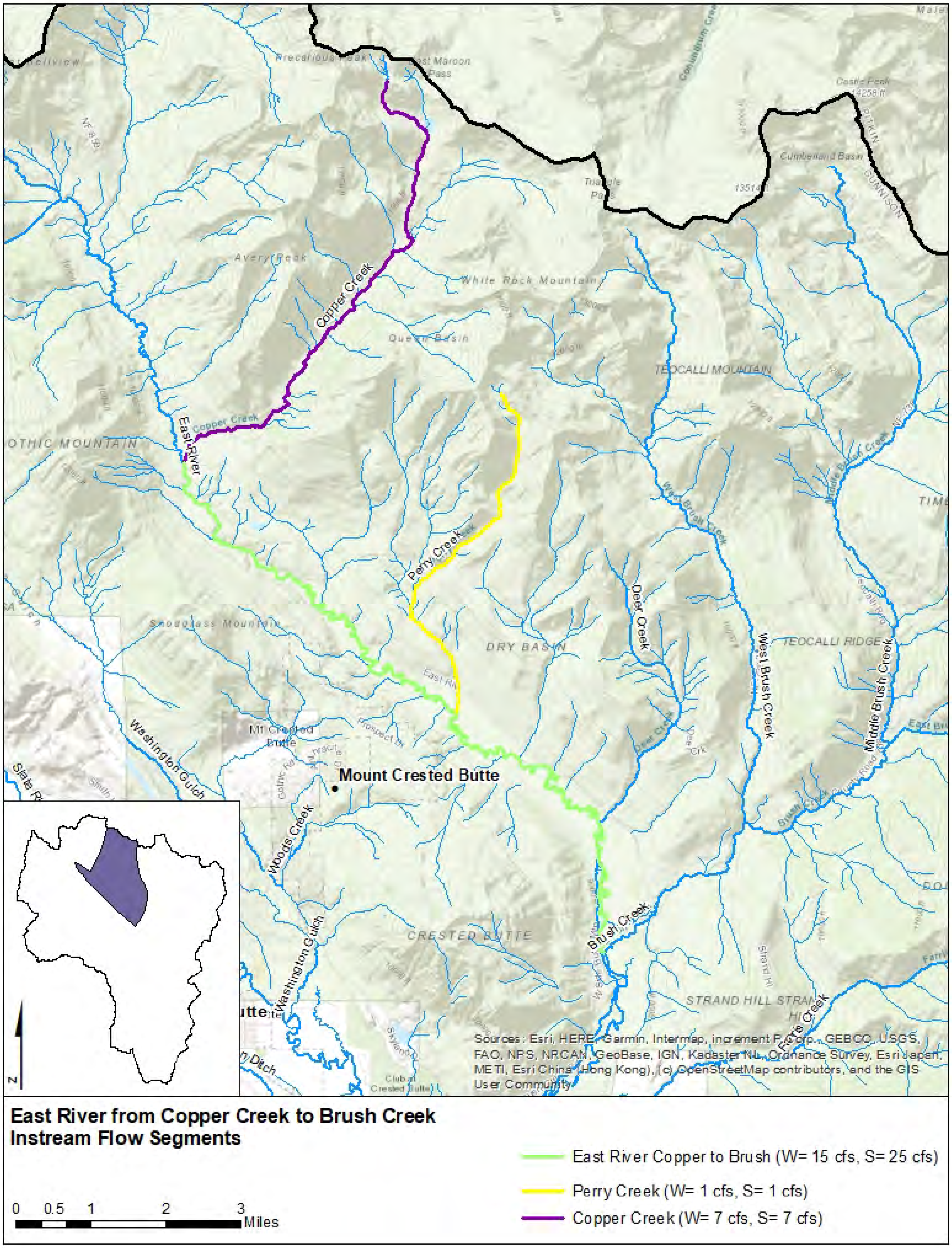


Figure 6-7: Instream flow water rights in East River from Copper Creek to Brush Creek.

In addition to the instream flow water rights on the East River from Copper Creek to Brush Creek, there is a bypass flow associated with Crested Butte Mountain Resort's pumping withdrawal on the East River for snowmaking, as discussed above and shown in Table 6-5.

Table 6-5. Summary of the minimum bypass flow, which is a term of CBMR's Special Use Permit for snowmaking.

Location	Bypass Rates	Authority	Enforcement
East River at the Pumphouse	7 cfs or 6 cfs	Included in CBMR's Special Use Permit	The bypass flow is monitored by a regression equation

6.3.6 Flow-limited Areas

The following locations were identified by stakeholders in the East River from Copper Creek to Brush Creek:

- Crested Butte Mountain Resort snowmaking system and East River Pumping Station: creates near dry up during the late fall and early winter. Stakeholders have also reported a fully frozen river downstream of the Pumphouse.
- FE and AC Jarvis Ditch: Dries up the lowest portion of Perry Creek in the latter part of the irrigation season in most years.
- AC Jarvis No 1 Ditch: In dry years it could create near dry up.
- Beitler Ditch No 1: Dries up the lowest portion of Deer Creek in the latter part of the irrigation season in most years.
- Beitler Ditch No 2: Dries up the lowest portion of Dry Basin drainage in the latter part of the irrigation season in most years.
- Verzuh Young Bifano Ditch: In dry years it could create near dry up.

6.3.7 2018 R2CROSS Analyses

Five cross-sections were completed in the East River between Copper and Brush Creek in July 2018. The R2CROSS analysis for the cross-section located closest to Perry Creek produced results very similar to the original R2CROSS recommendations and were 49 and 23 cfs for summer and winter, respectively. The average of the 2018 R2CROSS analyses generated preliminary recommendations of 30 and 17 cfs for summer and winter, respectively. Legal availability was not evaluated as part of the assessment.

The summer instream flow rate of 25 cfs was met 84 percent of the time during the four-year period of record. While the summer ISF attainment rate is strong, stream flows were measured upstream of three large diversions that divert water on the lower portion of the reach. Collectively, the water rights on those three ditches total 39 cfs. Due to the seniority of these water rights, diversions would only be limited by physical water supply and the summer ISF attainment decreases to approximately 60-65 percent based on expected diversions and return flows within the reach.

6.3.8 Environmental Flow Goals

Due to the substantial environmental value of the East River from Copper Creek to Brush Creek, environmental flow goals should be developed to protect and maintain the robust fish and macroinvertebrate community, riparian corridor, wildlife habitat, and a potentially significant groundwater recharge zone. Due to extensive water storage in wetland complexes and alluvial groundwater, particularly in the upper two-thirds of this reach, downstream reaches of the East River benefit from the existing conditions in the East River between Copper and Brush Creeks.

The existing winter instream flow rate of 15 cfs is a reasonable minimum flow. Snowmaking operations increase the number of days when flows fall below the winter ISF rate. However, natural variability also accounts for a considerable portion of the flows under the winter ISF rate. A minimum flow goal of 15 cfs is recommended to maintain late season spawning and overwinter habitat for the fish community in the East River from Copper Creek to Brush Creek. Alternative management options or projects should be evaluated to increase the winter ISF attainment frequency. A more detailed habitat survey is recommended to better characterize the distribution of pool habitat, a vital feature that increases fish survival during the winter.

At the existing summer ISF rate of 25 cfs habitat impacts are apparent. Field surveys from the drought year of 2018 found that flows at or near 25 cfs reduce water depths so that many riffles are nearly or fully impassable to mature trout, creating habitat fragmentation that may increase competition in the remaining habitat and accelerate the spread of disease. Additionally, riparian vegetation was stressed due to low flows and lower than average precipitation. Multiple seasons of drought, or permanent reductions in water supply that cause flows to frequently fall below 25 cfs would change the existing character of the East River from Copper to Brush Creek.

The outstanding criterion resulting from a Montana Method analysis is 40 cfs.[26] Based on the four-year period of record, flows in the upper portion of the reach are 40 cfs or higher for approximately 70 percent of the summer. In the lower portion of the reach, stream flows are estimated to exceed 40 cfs just over half of the time. Due to the short period of record used to

---

[26] The Montana method, also called the Tennant method, was developed by USGS hydrologists and other natural resource professionals to identify the flows necessary to sustain the biological integrity of river and riparian ecosystems. The study, conducted in the 1970s, included physical surveys of a variety of rivers in Montana, Nebraska, and Wyoming and stream flow data from hundreds of locations in 21 states. The study related a portion of the mean annual or seasonal flow to criterion (i.e. minimum, acceptable, excellent) to protect environmental flows. The primary benefit of the Montana method is that it is simple to calculate the criteria from stream gage data. The Montana method was used on a select number of reaches in the East River due to the spatial distribution of gages and existing water use practices. The Montana method criteria are specific to the stream where the criteria were developed. See: *Tennant, D.L. 1976. Instream flow regimens for fish, wildlife, recreation and related environmental resources. Fisheries 1: 6-10.*

develop this preliminary flow goal, it should be reevaluated as more data becomes available for the East River at the Pumphouse.

6.4 Recreational Water Use

Recreational use occurs in three distinct areas of the East River from Copper to Brush Creek. The upper two reaches are characterized by natural flows (all substantial diversions are downstream). Because the portion of these reaches that host significant recreational use can be characterized as having natural flow regimes (and less opportunity for impacts from new diversions) in-depth recreational flow assessments were not prioritized for this reach. Stakeholder identified issues on the Copper to Brush Creek portion of the East primarily addressed concerns about access and private property rights. Recreational use is summarized below.

The East River is renowned for having some of the best freestone fishing in the state. However, access for fishing on this reach is somewhat limited and public access for fishing is only available at the Gothic Bridge and the Pumphouse. At least one major irrigator on the reach leases out land to allow commercial fishing access.

Upper East River - Gothic Road Bridge and one mile downstream (reach ends upstream of Stupid Falls)

Uses: Whitewater kayaking

Description: Flow ranges from 600 cfs (minimum) to 2500 cfs (high) and class increases as flow increases. This ¾ mile run is mentioned in ‘Whitewater of the Southern Rockies’. Put-in is at the Gothic Road Bridge over the East River and take-out is ¾ miles downstream (page 136, *Stafford and McCutchen*, 2007).

Middle East River- Gothic Road Bridge and ¼ mile downstream (Stupid Falls)

Uses: Whitewater kayaking

Description: These falls are Class V. Stupid Falls is mentioned in ‘Whitewater of the Southern Rockies’ (page 136, *Stafford and McCutchen*, 2007) even though they are known to be on private property.

Middle East River- Gothic to confluence with Brush Creek

Uses: Whitewater kayaking, boat floating, SUP

Description: Put-in may be at Gothic Road Bridge over the East River and take-out is in Crested Butte South where the East River meets the Slate River (there are variations for put-in and take-out, e.g. put-in on Brush Creek Road). Approximately a 15-mile run.

Five surveys were completed for the reaches listed above to identify issues related to float-based recreation. While some initial flow information was collected, the basin coordinator and consulting team did not emphasize flow data collection on these recreational reaches as they appear to be at a low risk for flow alteration and have minimal user conflicts related to flow. Skilled kayakers enjoy the technical challenges found on the uppermost portion of the reach near Gothic and the proximity to town. Kayakers noted that woody debris and the cascades and drops in the reach present the primary hazards. Kayakers noted that it was common for their crafts to contact bedrock and banks while running the reach. Survey respondents also identified signage, parking, and more responsible use of the road (i.e. walk during muddy periods) as priorities to improve the recreational experience on this reach.

6.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders. This material will be a central component of the next phase of WMP, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Low winter flows below the Pumphouse that may impact fall spawning and contribute to habitat fragmentation. Pumping occasionally depletes streamflow below the winter instream flow rate and, less frequently, the required minimum bypass flow during fall spawning.

Issue: Explore Wild & Scenic eligibility for the East River meanders and RMBL scientific reach.

Issue: Mt. Crested Butte Water and Sanitation District is concerned about meeting increased demands during peak tourist times and due to growth and climate change.

Issue: Increase water efficiency of MCBWSD delivery system. This will help reduce the burden of meeting peak demands. Increased outdoor water efficiency may reduce inflow and infiltration into the collection system.

Issue: Does RMBL have adequate water supply, water treatment, and wastewater treatment infrastructure to meet projected growth? RMBL is concerned about both water supply and treatment capacity.

Issue: Crested Butte Mountain Resort has a snowmaking supply shortage.

Issue: There are a limited number of household wells on this reach. Water quality sample analysis is recommended.

Issue: Road erosion related to recreational access. Road shows damage related to springtime

Issue: Recreational access. Boaters were concerned about preserving access to the East River put-in near Deer Creek.

Section 7. Reach 3 - Brush Creek Basin

The headwaters of Brush Creek are within the Maroon Bells Wilderness Area. Castle Peak (14,258 feet) is the highest point in this basin. White Rock Mountain, Triangle Pass, Pearl Mountain, Star Peak, Crystal Peak, and Hunters Hill form the boundary of this basin and gather the snow that supports the seeps and springs that feed the headwaters of West Brush Creek, Middle Brush Creek, and East Brush Creek. The watershed of this basin is nearly 39 square miles.

Much of the basin is located on lands managed by the US Forest Service. Private lands are common in the lower portion of the Brush Creek Basin. Ranching and grazing are important uses within the Brush Creek Basin. Recreational users, including hunting outfitters, guided wilderness tours, and fly-fishing guides benefit from the high-quality habitat. In the 2019 draft wilderness proposal[27], the Gunnison Public Land Initiative recommended an additional portion of the Brush Creek Basin become wilderness, while another area was identified as a special management area.

7.1 Agricultural Water Use

There are four active irrigation diversions in the Brush Creek Basin, serving approximately 355 acres of flood irrigated pasture grass. Table 7-1 shows the combined water rights, average annual and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the basin ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 7-1: Agricultural water use statistics in Brush Creek.

Basin Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	4	n/a
Irrigated Acreage	356	n/a
Water Rights	43	n/a
Diversions	6,070 acre-feet	3,610 – 10,230 acre-feet
Crop Demand	560 acre-feet	400 - 670 acre-feet
Crop CU	500 acre-feet	370 - 600 acre-feet
Shortage/Need	60 acre-feet	30 - 70 acre-feet
Percent Shortage	11%	1% - 25%

[27] Gunnison Public Lands Initiative (2019). *Revised GPLI Proposal*. Available at: https://www.gunnisonpubliclands.org/gpli-proposal

Figure 7-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this basin. All of the ditches are unlined, and the individual ditches are estimated to lose between 10 and 20 percent of diverted water during delivery to the irrigated fields depending on ditch length.

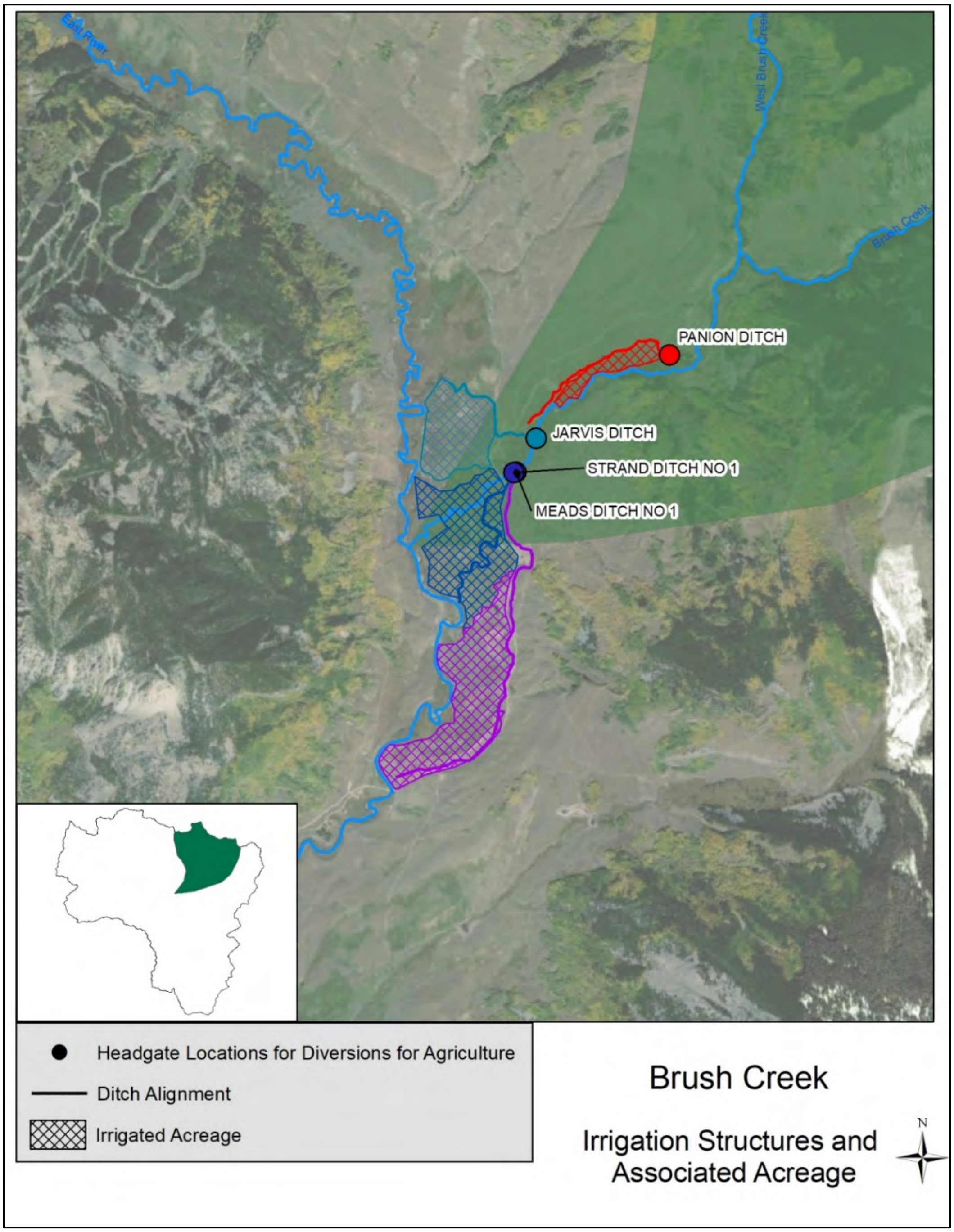


Figure 6-1: Diversion structures and acreage in Brush Creek

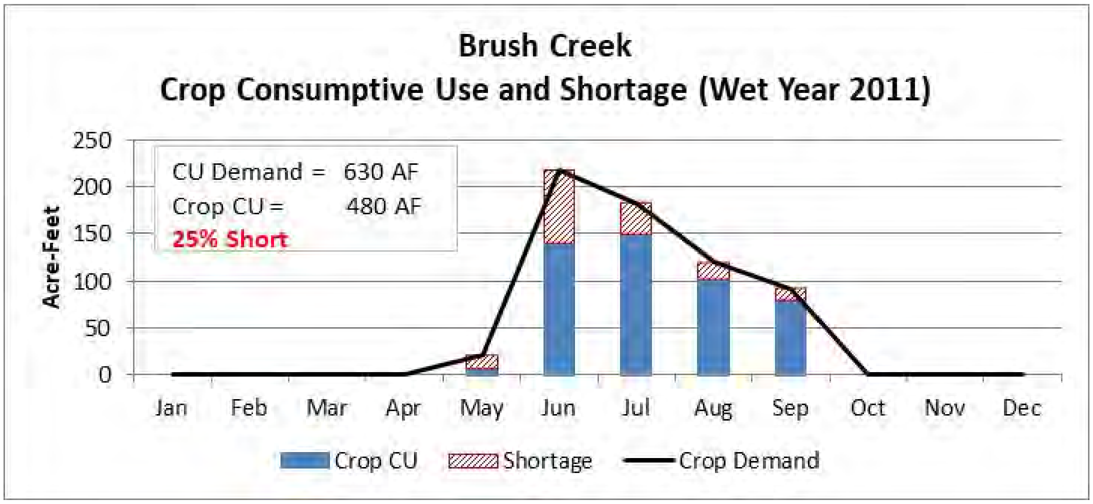
Table 7-2 shows the estimated percentage of water that returns to the Brush Creek and to adjacent basins.

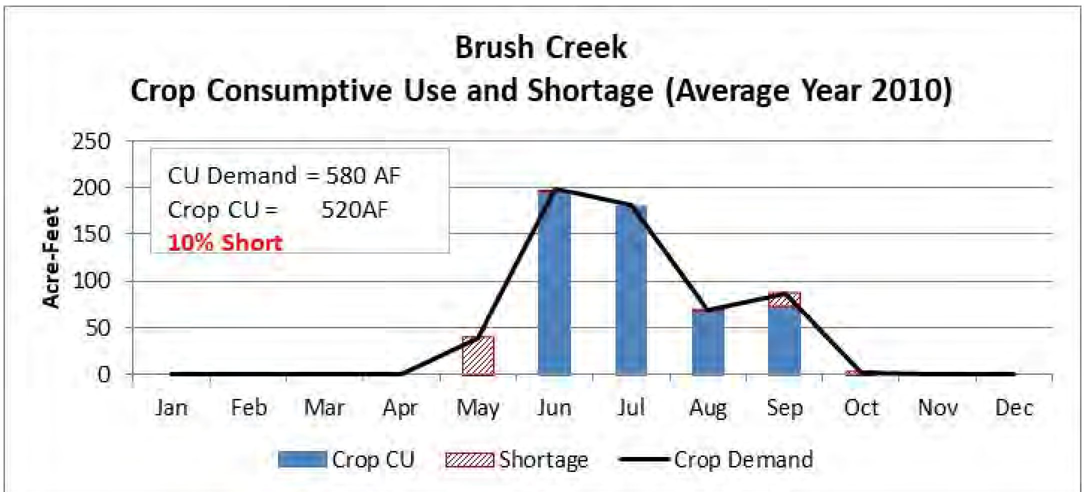
Table 7-2: Agricultural return flow locations in Brush Creek.

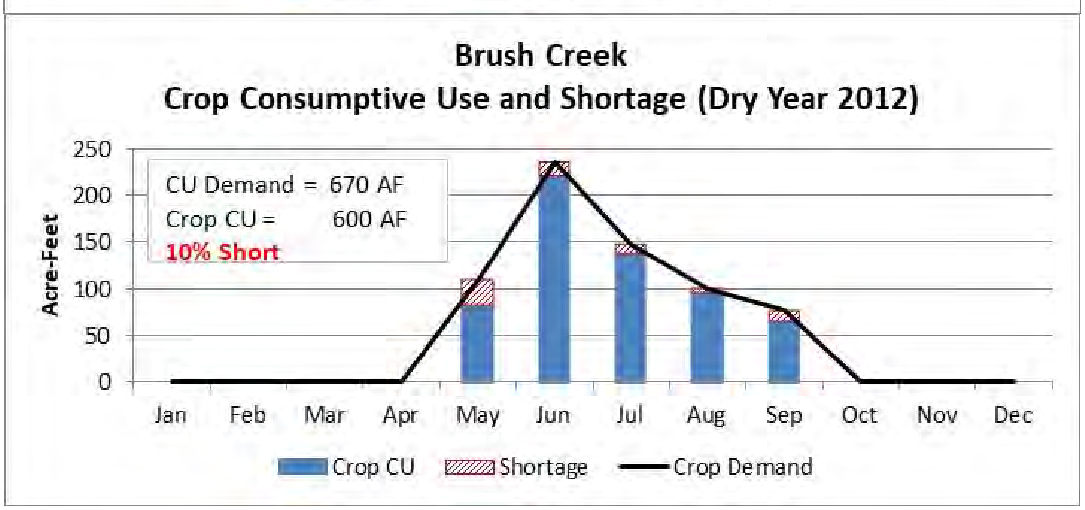
Return Flow Location	% of Total Return Flows	1998 to 2017 Avg Annual Return Flows (Acre-Feet)
Brush Creek	21%	1,170
East River from Brush Creek to Slate River	43%	2,400
East River from Copper Creek to Brush Creek	36%	2,000

Figure 7-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). Shortages were much greater in the representative wet year than most years from 1998 through 2017. None of the four ditches in the basin had reported diversion in May 2011, three of the ditches had minimal diversions in June, and one ditch reported no diversions until July. Crop demand is from an irrigation source; winter carry-over precipitation and summer weather (both temperature and precipitation) are accounted for when estimating crop demand. The two likeliest explanations for higher shortages in the representative wet year are that there was more local precipitation on Brush Creek than was measured at the nearby climate stations relied on for the analysis, or that the diversion records did not accurately reflect the amount of water applied to the crops. The analysis indicated May shortages for the three representative year types, even after accounting for soil saturation from winter precipitation. Water is generally available for diversion in May; however, in most years the four ditches do not have recorded diversion until June. Shortages were minimal from June through October in both the representative average and dry years. Above average rainfall in August of 2010 reduced the crop demand from an irrigation source.

Figure 7-2: Crop consumptive use and shortage in Brush Creek.







Domestic Water Use

There are no diversions for municipal or industrial use in the Brush Creek Basin. Future needs were not identified during this assessment.

A few homes near the confluence with the East River rely on wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

7.2 Environmental Water Use

7.2.1 Stream and Riparian Characteristics

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

Where the valley widens, the riparian corridor in the Brush Creek Basin is dominated by willows and alders. There are significant beaver complexes in each fork of Brush Creek. Spruce and aspen stands are common upslope of the riparian corridor. Lateral moraines deposited glacial till on many of the valley hillslopes and created the bench-like features found on several slopes. Lateral moraines can support small surficial aquifers that support non-riparian wetlands. Wetlands provide critical ecosystem services including water storage to support late season flows, high quality habitat for a large range of aquatic and terrestrial species, carbon storage, and generally improve overall watershed health.

Brush Creek tends to have a higher density of roads, particularly roads that frequently cross or parallel streams more than other areas of the East River Basin. Prior studies included field surveys[28] that identified multiple areas where road or trail crossings may affect stream and riparian function. The studies have also identified apparent channel instability that may be attributed to roads. Additional characterization is recommended to better understand erosion and stream stability issues and the extent to which roads and trails may contribute to altered sediment regimes.

[28] *Healthy Headwaters Assessment of the East River Watershed*. Completed in 2015 by a master's in environmental management student at Western State Colorado University.

Photo 7-1: East Brush Creek. Left photo is a view upstream and includes healthy riparian wetland. The right photo is a downstream view.

7.2.2 Aquatic Life

According to Colorado Parks and Wildlife data, Brush Creek and its tributaries contain breeding populations of brook trout, brown trout, and Colorado cutthroat trout. Due to the geology, East Brush Creek hosts a diverse system of pools and small waterfalls that may serve as protective barriers for upstream fish populations. West Brush Creek has a series of old beaver ponds that create habitat for cutthroat. Middle Brush Creek is remote and has great habitat for deer, elk and other ungulates.

The Triangle Pass area, part of the headwaters of West Brush Creek, "supports one of the best-known breeding locations for the critically imperiled boreal toad in Colorado"[29]. This habitat has been identified as a Potential Conservation Area by a survey of critical wetlands and riparian areas conducted by the Colorado Natural Heritage Program. Although once common in Colorado, the boreal toad has been declining in the past few decades. "In 1993 the boreal toad was listed as state endangered and is currently a candidate species for federal listing under the U.S. Endangered Species Act." To reproduce, the toad requires still or slowly moving water and permanent or semi-permanent water sources. Because this population is in the Maroon Bells Wilderness area, it is generally thought to be well protected. Maintaining the riparian health in

[29] Rocchio, J. et al *(2004). Survey of Critical Wetlands and Riparian Areas in Gunnison County. Colorado Department of Natural Resources.* Colorado Natural Heritage Program. Page 167. Available at http://www.cnhp.colostate.edu/download/documents/2004/Gunnison_County_Wetlands.pdf.

this area is crucial to protect this population; if use increases in the basin, it may be necessary to provide additional protections from hikers and horse packers.

7.2.3 Water Quality

Two samples collected from the East River near RBML in July and August of 2014 by the WQCD were used to identify a potential impairment of the water supply use for total recoverable arsenic in the East River, and its tributaries from the headwaters to the confluence with the Slate River. Data collected by the DOE from the East River at the Pumphouse confirm the impairment status for total recoverable arsenic. In recent years, arsenic concentrations in the East River at the Pumphouse ranged from 0.2 to 2.0 µg/L. This information is shown in Table 7-3 and Figure 7-3.

The nearest downstream public water supply is the Crested Butte South Metropolitan District. Protecting the downstream water supply use in Crested Butte South is an additional reason the water supply use is applied to this segment. Treatment practices at individual residences were not evaluated in this assessment.

In 2018 the headwaters of Brush Creek and its tributaries located in wilderness were listed as impaired for total recoverable arsenic for the water supply use. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the East River sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries.

Table 7-3: Impaired and potentially impaired portions of Brush Creek.

<table>
<tr><th>Listed Portion of Stream</th><th>Affected Use</th><th>Potentially Impaired Analyte (M&E List)</th><th>Impaired Analyte (303(d) List)</th><th>Impairment Priority</th></tr>
<tr><td>Mainstem of the East River, including all tributaries and wetlands, from its sources to a point immediately above the confluence with the Slate River, except for specific listings in Segment 1</td><td>Water Supply Use</td><td>Total Arsenic</td><td>NA</td><td>NA</td></tr>
<tr><td rowspan="2">All tributaries to the Gunnison River, including wetlands, within the La Garita, Powderhorn, West Elk, Collegiate Peaks, Maroon Bells, Raggeds, Fossil Ridge, or Uncompahgre Wilderness Areas</td><td rowspan="2">Water Supply Use</td><td>Iron (Dissolved)</td><td>NA</td><td>NA</td></tr>
<tr><td>NA</td><td>Arsenic (Total)</td><td>High</td></tr>
</table>

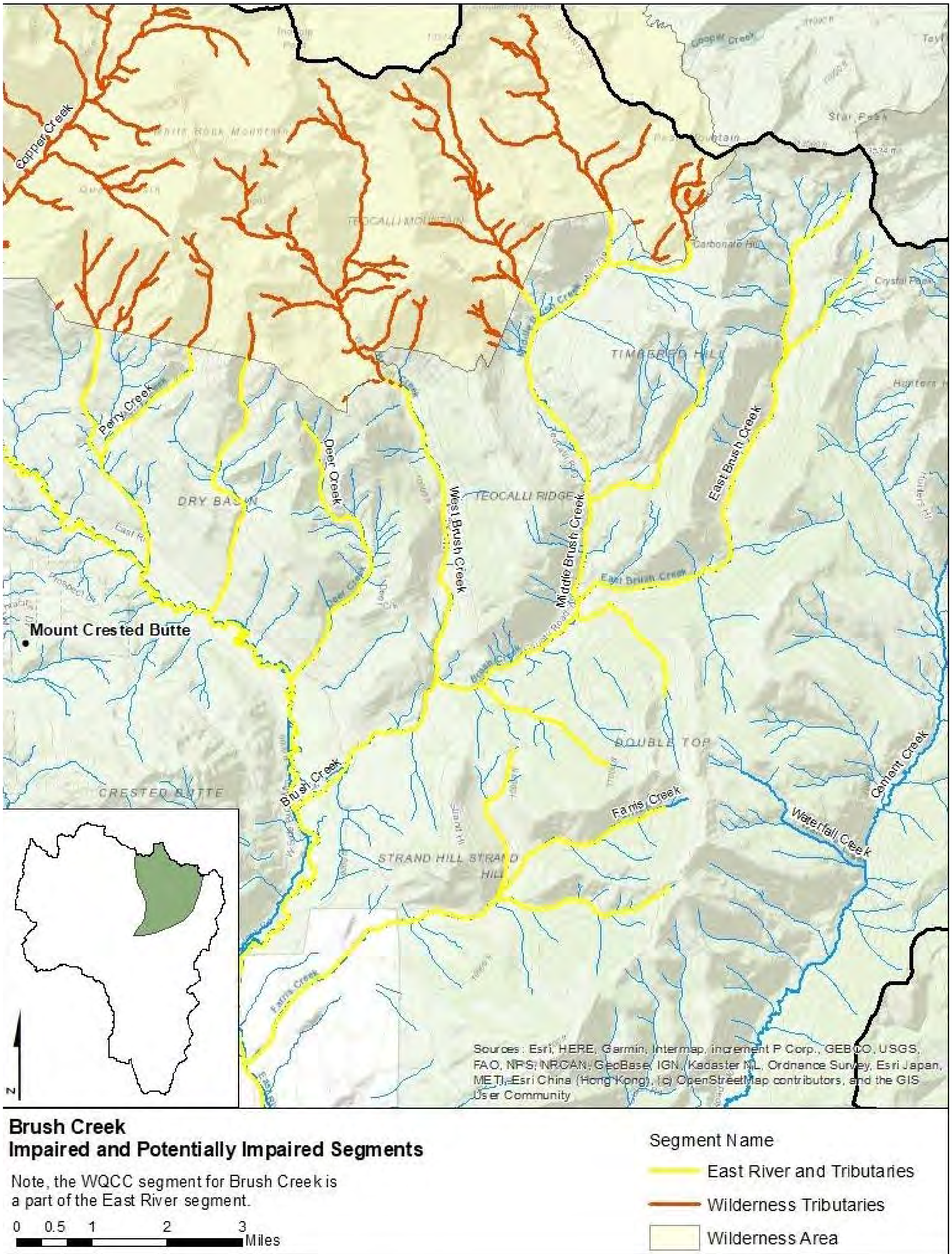


Figure 7-3: Crop consumptive use and shortage in Brush Creek

Water Temperature

Continuous water temperature measurements are not known to have been collected in this basin. Water temperature information is currently a data gap. However, due to the elevation and natural hydrology of Brush Creek and its tributaries, there is no reason to expect the temperature standards used to protect sensitive aquatic life would be exceeded in the upper portions of the basin. Temperature standards may be exceeded in flow-limited areas between the lowest Brush Creek Road crossing and the confluence with the East River.

7.2.4 Existing Instream Flows

The Brush Creek Basin has several instream flow reaches, as shown in Figure 7-4. The original instream flow proposals were developed by CPW and CWCB staff in 1979 and 1980. Initially, four segments were proposed in the Brush Creek Basin. The year-round instream flow rates for the East, Middle, and West forks of Brush Creek met two of three R2CROSS criteria and were appropriated without substantial revisions.

The proposal for Brush Creek from West Brush Creek to the East River received additional scrutiny. The original R2CROSS recommendations for the lower reach were a winter rate of 15 cfs and a summer rate of 26 cfs. The R2CROSS recommendations were reduced to address Division of Water Resources (DWR) concerns about physical and legal availability. DWR also requested that the lower terminus of the lower reach be moved upstream to the Jarvis Ditch headgate, based on legal availability during the summer irrigation season. A compromise was identified, where 7 cfs is applied as a year-round instream flow water right from the Jarvis Ditch headgate to the East River. The senior instream flow water rights of 7 and 12 cfs for winter and summer, respectively, do not provide ideal protection for aquatic life in lower Brush Creek, but given the legal constraints on their appropriation, they accomplish their statutory purpose of preserving the natural environment to a reasonable degree.

From 2015 to 2017, HCCA and American Rivers staff developed a proposal to increase the instream flow water rights in Brush Creek from the confluence with Middle and East Brush Creeks to the confluence with West Brush Creek to provide additional instream flow protections.

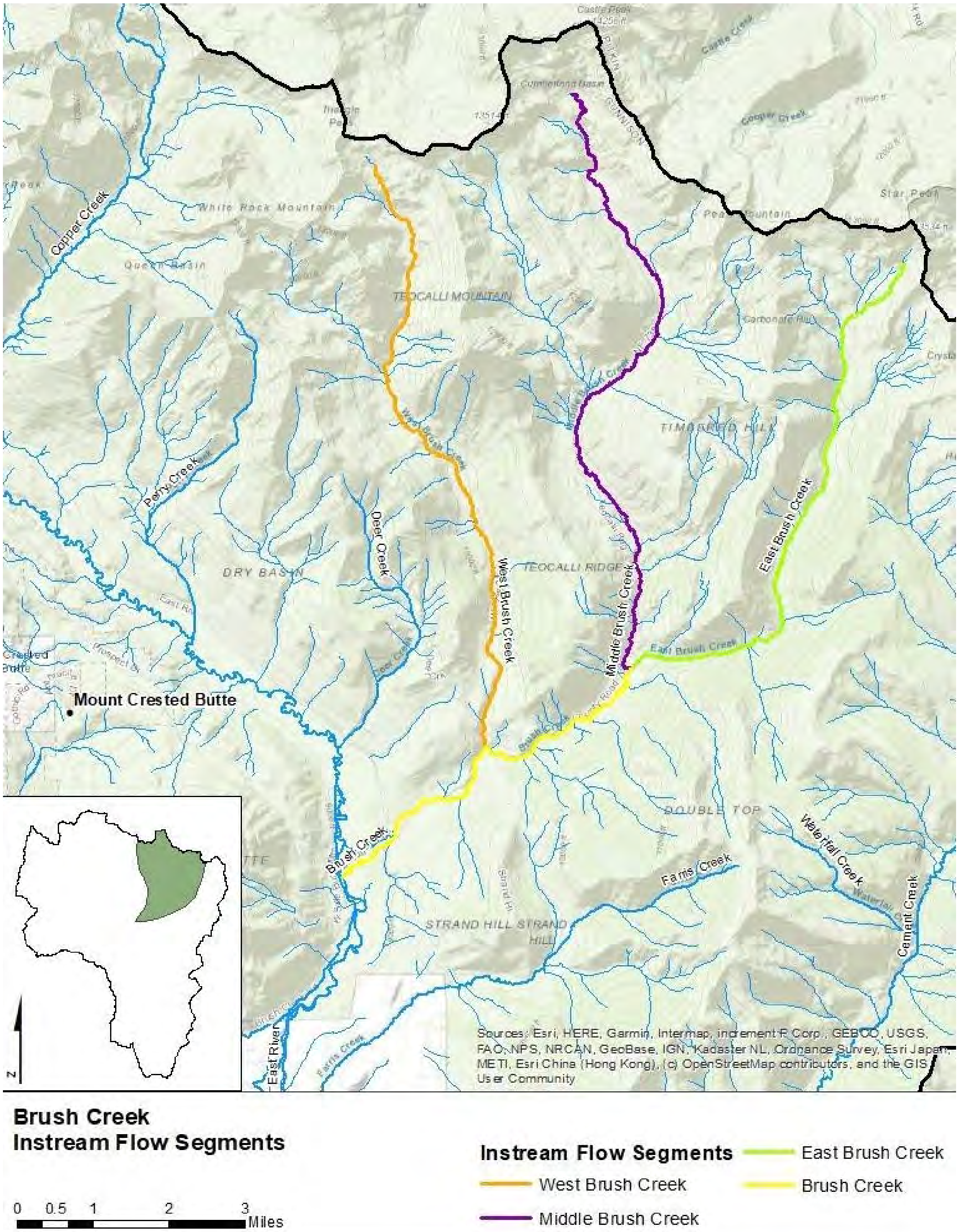


Figure 7-4: Instream flow water rights for Brush Creek and its tributaries.

7.2.5 Flow-limited Areas

The following diversions were identified by stakeholders in the Brush Creek Basin.

- Jarvis Ditch
- Strand Ditch Numbers 1 and 2
- Meads Ditch Number 1

All three of these diversions dry up the creek in most years by late in the irrigation season.

There is typically little to no water in Brush Creek at the lowest Brush Creek Road crossing by late summer.

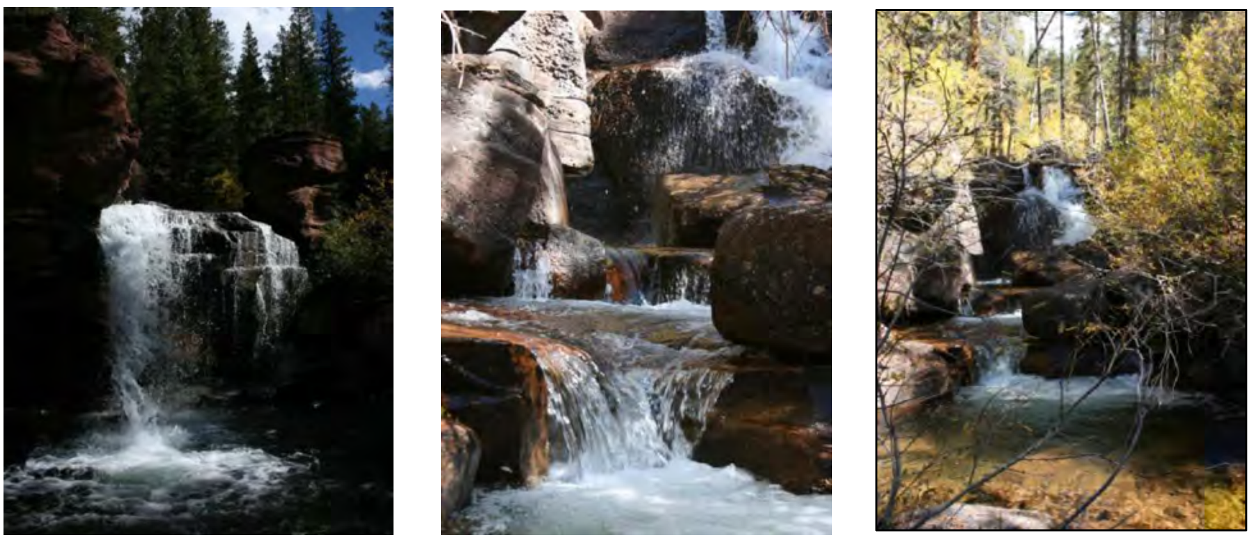


Photo 7-2. East Brush Creek above the confluence of East and Middle Brush Creek in mid-September. Notice the pools and small waterfalls which provide both high-quality habitat and breathtaking scenery.

7.2.6 Environmental Flow Goals

Streamflow in upper portions of Brush Creek is driven by natural hydrology. Near the confluence with the East River, where Brush Creek flows under Forest Road 738, water diversions remove a substantial portion of flow and dry up is common in low flow years, and in the late summer and fall of average years. Site-scale assessment of the stream and riparian habitat is recommended to further evaluate the habitat and flow needs. Outreach to local water users is recommended to assess interest and to identify voluntary measures to provide environmental flows while maintaining existing uses.

7.3 Recreational Water Use

Both East and Middle Brush Creek are popular locations for local fly-fishing companies to lead guided fly-fishing excursions. Brush Creek hosts an important recreational fishery, a healthy riverine ecosystem, and provides for irrigation of several large pastures. Brush Creek, East Brush Creek, and Middle Brush Creek also offer numerous recreational opportunities, including beautiful waterfalls that are easily accessible from hiking and single-track trails.

7.4 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders. This material will be a central component of the next phase of WMP, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality sample analysis for household wells is recommended, particularly because of the limited data collected to date and the potential for elevated arsenic concentrations due to the local geology in some areas.

Issue: Review dry-up and near dry-up locations to prioritize the next steps. The assessment identified three locations where dry-up and near dry-up occurs based on local knowledge. Additional work is needed to prioritize dry-up locations based on the frequency and duration relative to the aquatic life, flow regime, and riparian conditions in adjacent portions of the stream.

Issue: Jarvis Ditch, Strand Ditch Numbers 1 and 2, and Meads Number 1 Ditch: Begin discussion with landowner and water rights holder to identify potential strategies to improve stream flow and riparian condition near the ditch while maintaining or improving ditch diversions.

Issue: Low flows and habitat fragmentation at diversion structures in the lower portion of Brush Creek: Due to the outstanding fish habitat in both Brush Creek and the East River, additional investigation should occur to identify solutions to improve habitat connectivity. This work should occur in concert with the dry-up prioritization mentioned above.

Issue: Stakeholders and previous studies have suggested that road and trail alignments may increase erosion and stream stability issues: Additional assessment is recommended to determine the extent to which roads and trails may contribute to altered sediment regimes. The Healthy Headwaters Assessment can provide a baseline to help refine the study area and objectives.

Issue: Maintaining the riparian health in the Triangle Pass area is crucial to protecting the Boreal toad population: If use increases in the basin it may be necessary to provide additional protections from hikers and horse packers.

Section 8. Reach 4 - Farris Creek

The headwaters of Farris Creek form in a west-facing basin below Double Top at over 11,600 feet. Where Farris Creek flows around Strand Hill there is a relatively large riparian area with multiple ponds, relic channels, and beaver complexes. These wetlands appear relatively undisturbed and provide excellent habitat.

Grazing occurs throughout most of the Farris Creek Basin. Lower Farris Creek is used extensively for agriculture.

8.1 Agricultural Water Use

There are three active irrigation diversions in the Farris Creek Basin that serve approximately 550 acres of flood irrigated pasture grass. There are also two reservoirs with a conditional right, combined with a small reservoir on Grouse Creek, for a total 3,000 acre-feet decreed for irrigation and stock use; Farris Creek Reservoir and Farris Creek Reservoir No 1. Diligence on the storage right was last completed in 2012. Recent aerial photos show water has been stored under the conditional rights. Table 8-1 shows the combined water rights and crop demands. There are no measurement devices within this basin, and only one of the three ditches report diversions; therefore, it is not reasonable to estimate actual crop consumptive use and shortages. However, based on the reported diversions and user information, it is likely that the tributary ditches generally experience significant shortages in the late summer and fall.

Table 8-1: Agricultural water use statistics for Farris Creek.

Basin Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	3	n/a
Irrigated Acreage	552	n/a
Water Rights	31.075	n/a
Crop Demand	870 acre-feet	620 – 1,040 acre-feet

Figure 8-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this basin.

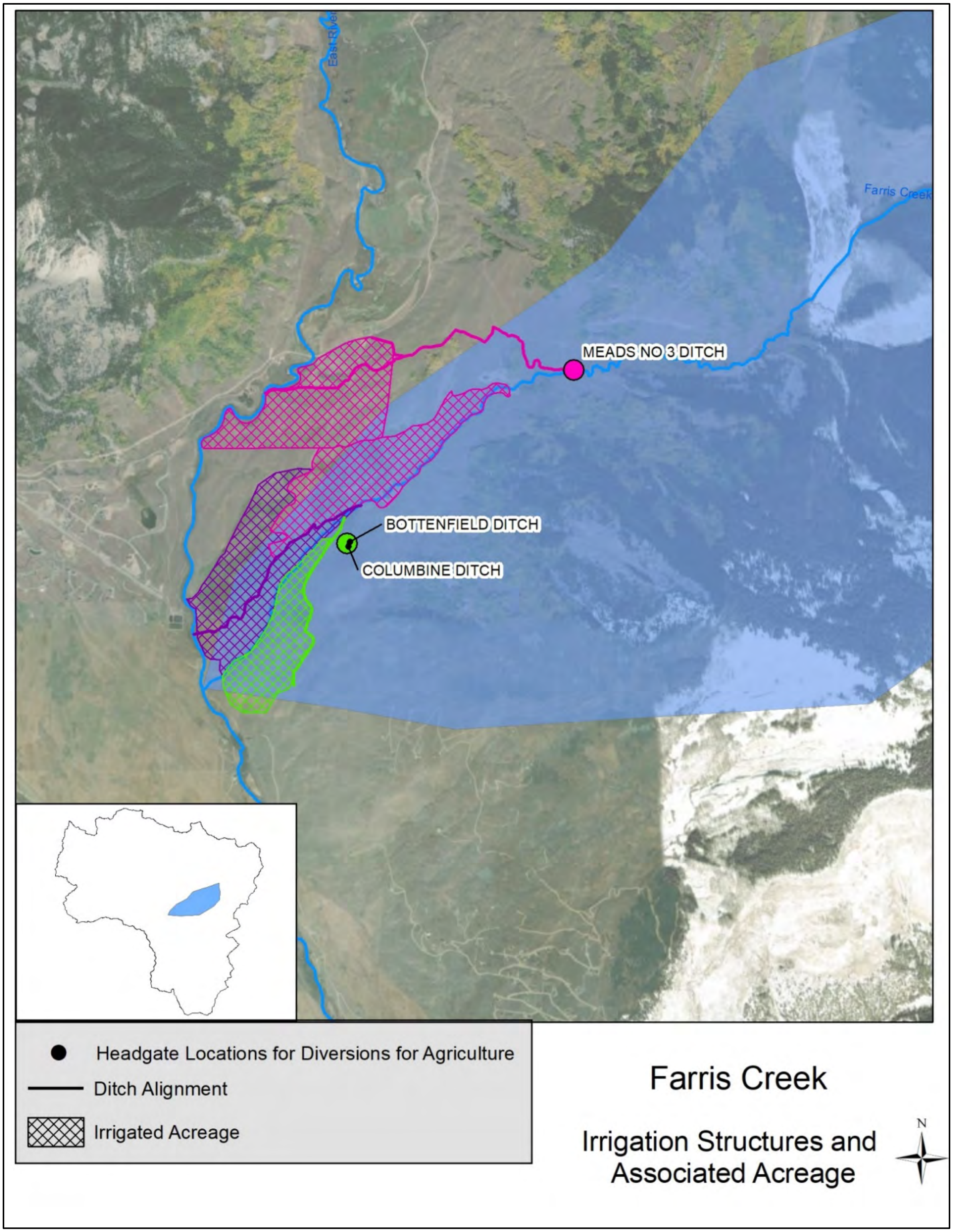


Figure 7-1: Diversion structures and irrigated acreage for Farris Creek

8.2 Domestic Water Use

There is no household, municipal, or industrial use in this basin and there are no identified needs in the future.

8.3 Environmental Water Use

8.3.1 Stream and Riparian Characteristics

The headwaters of Farris Creek form in a west-facing basin below Double Top at over 11,600 feet. There is a relatively large riparian area with multiple ponds, relic channels, and beaver complexes where Farris Creek flows around Strand Hill. These wetlands appear relatively undisturbed and provide excellent habitat.

Grazing occurs throughout most Farris Creek. Lower Farris Creek is used for agriculture. During irrigation season most of the creek is diverted to irrigate pasture grass. The riparian area is substantially smaller downstream of the Meads Ditch Number 3 diversion.

8.3.2 Aquatic Life

Based on the available habitat, the wetland complex in the middle section of Farris Creek likely supports a modest fishery. Data to further characterize aquatic life were not identified during this assessment.

8.3.3 Water Quality

Two samples collected from the East River near the Rocky Mountain Biological Laboratory in July and August of 2014 by the Water Quality Control Division were used to identify a potential impairment of the water supply use for total recoverable arsenic in the East River, and its tributaries from the headwaters to the confluence with the Slate River. Data collected by the DOE from the East River at the Pumphouse confirm the impairment status for total recoverable arsenic. In recent years, arsenic concentrations in the East River at the Pumphouse ranged from 0.2 to 2.0 µg/L.

There is not currently household, or municipal water use in Farris Creek. However, the stream is tributary to the East River which has a domestic water supply use. Therefore, the potentially impaired status was retained as shown in Table 8-2, Figure 8-2.

Table 8-2: Potential impairments in Farris Creek

Listed Portion of Stream	**Affected Use**	**Potentially Impaired Analyte (M&E List)**	**Impaired Analyte (303(d) List)**	**Impairment Priority**
Mainstem of the East River, including all tributaries and wetlands, from its sources to a point immediately above the confluence with the Slate River, except for specific listings in Segment 1.	Water Supply Use	Total Arsenic	N/A	N/A

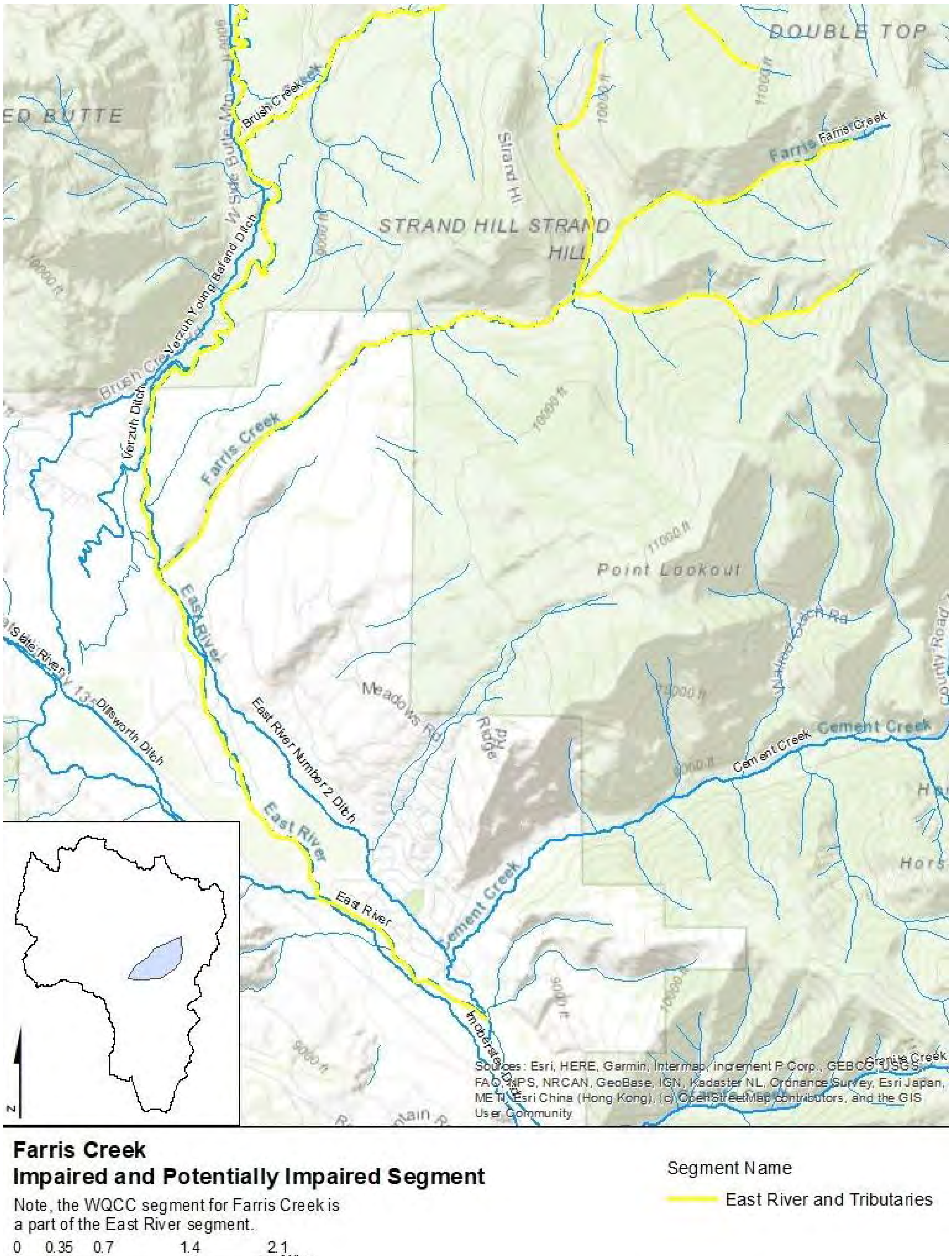


Figure 8-2: Impaired and potentially impaired stream reaches in Farris Creek

8.3.4 Water Temperature

No continuous water temperature measurements are known to have been collected in this reach. Water temperature information is currently a data gap. Addressing this data gap is not a high priority.

8.3.5 Existing Instream Flow Rights

Farris Creek from the headwaters to the Meads Number 3 Ditch headgate has a year-round instream flow water right of 3 cfs as shown in Figure 8-3. The instream flow proposals were developed by CWCB and CPW staff in 1979 and 1980. The instream flow right ends at the Meads Number 3 Ditch headgate due to a lack of physical and legal water availability.

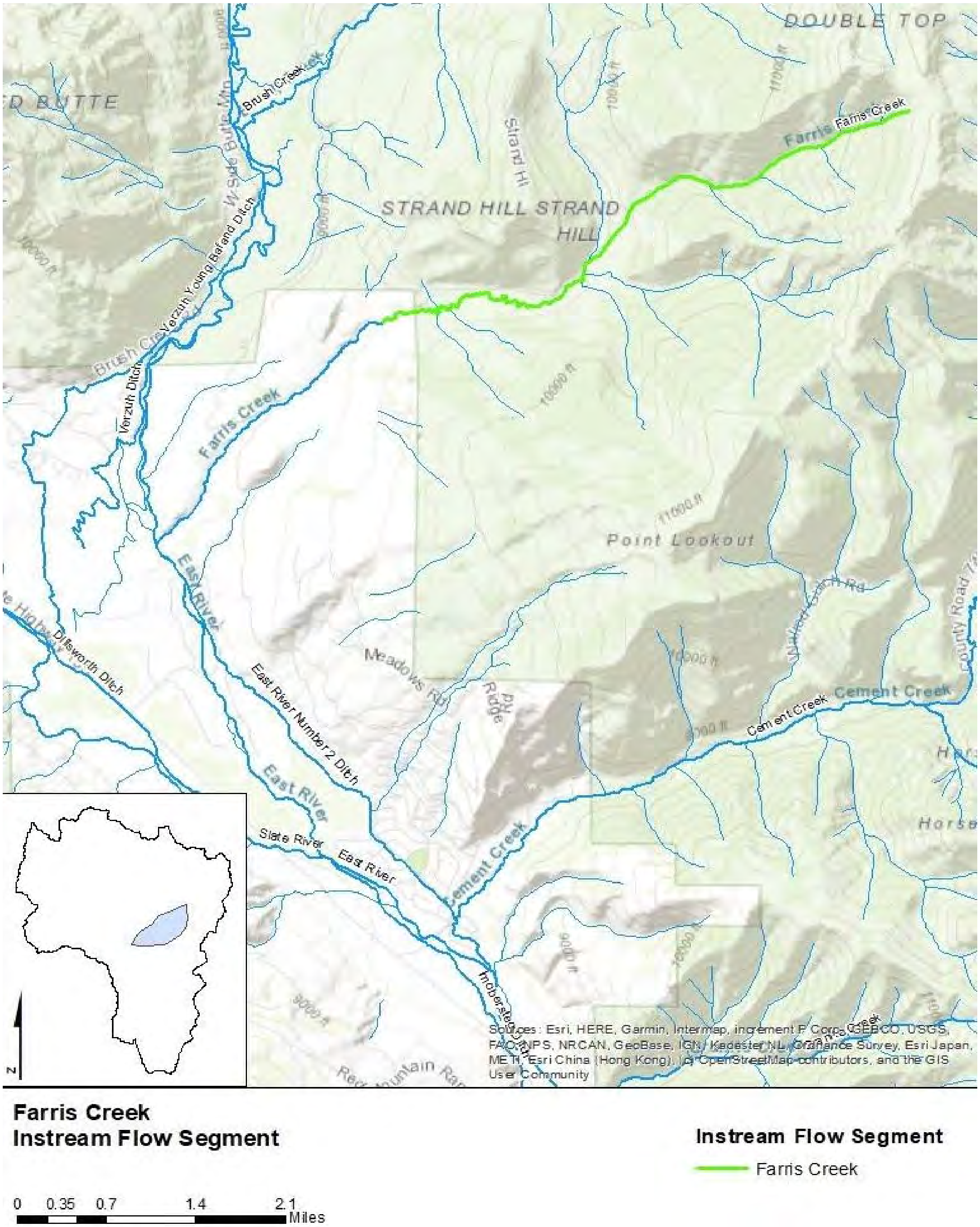


Figure 8-3: Farris Creek instream flow water right

8.3.6 Flow-limited Areas

The Meads Number 3 Ditch, alternate diversion points, and on-channel reservoirs reduce the flow in Farris Creek and dramatically alter the character of the riparian corridor. There is a lack of habitat connectivity in Farris Creek from the Meads Number 3 Ditch headgate to the East River.

8.3.7 Environmental Flow Goals

Stream flow in most of Farris Creek is driven by natural hydrology. Starting at the Meads Number 3 Ditch, water diversions remove a substantial portion of flow. Developing an environmental flow goal is not currently a priority.

8.4 Recreational Water Use and Needs

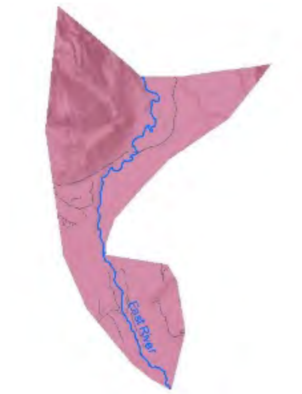
Farris Creek is not a floatable reach but there are several trails for motorized and non-motorized activity within the watershed. The trails include 409, 409.5, Farris Creek, and a small portion of the Strand Hill Trail.

8.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of WMP, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: The current instream flow ends at the Meads No. 3 Headgate. There is no minimum flow protection below this headgate.

Section 9. Reach 5 - East River from Brush Creek to Slate River



This reach of the East River begins where Brush Creek joins the East River east- southeast of Crested Butte Mountain Resort. It ends at the confluence of the East River and the Slate River near Crested Butte South. Use on this reach is primarily agricultural; irrigators divert using large ditches that serve adjacent irrigated ground. The two notable tributaries that join the East River on this segment are Brush Creek and Farris Creek.

9.1 Agricultural Water Use

There are six active irrigation diversions in the East River from Brush Creek to Slate River reach, serving approximately 715 acres of flood irrigated pasture grass. Table 9-1 shows the combined water rights, annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 9-1: Agricultural water use statistics for the East River from Brush Creek to the Slate River

Reach Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	6	n/a
Irrigated Acreage	714	n/a
Water Rights	134.141	n/a
Diversions	19,820 acre-feet	13,630 – 25,760 acre-feet
Crop Demand	1,130 acre-feet	800 – 1,350 acre-feet
Crop CU	1,110 acre-feet	800 – 1,350 acre-feet
Shortage/Need	20 acre-feet	0 - 70 acre-feet
Percent Shortage	1%	0% - 6%

Figure 9-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions through the Verzuh Ditch, the Lafayette Ditch, and McClenathan Ditch, and the Lacy Ditch Spring Headgate 1 comingle to serve common acreage. All of the ditches are unlined, and the individual ditches are estimated to lose 25 percent of diverted water during delivery to the irrigated fields. Return flows from this reach, estimated to be an average of 18,710 acre-feet per year from 1998 to 2017, accrue to the East River above the confluence with the Slate River.

Under the terms of the decree in Case W-2417, 6 cfs of the 12 cfs of senior right of 1906 has to remain in the river past the East River No. 2 Ditch headgate. Unlike typical water rights administration, this means the East River No. 2 can call out junior upstream water rights without fully drying up the river.

Figure 9-1: Diversion structures and acreage on the East River from Brush Creek to the Slate River.

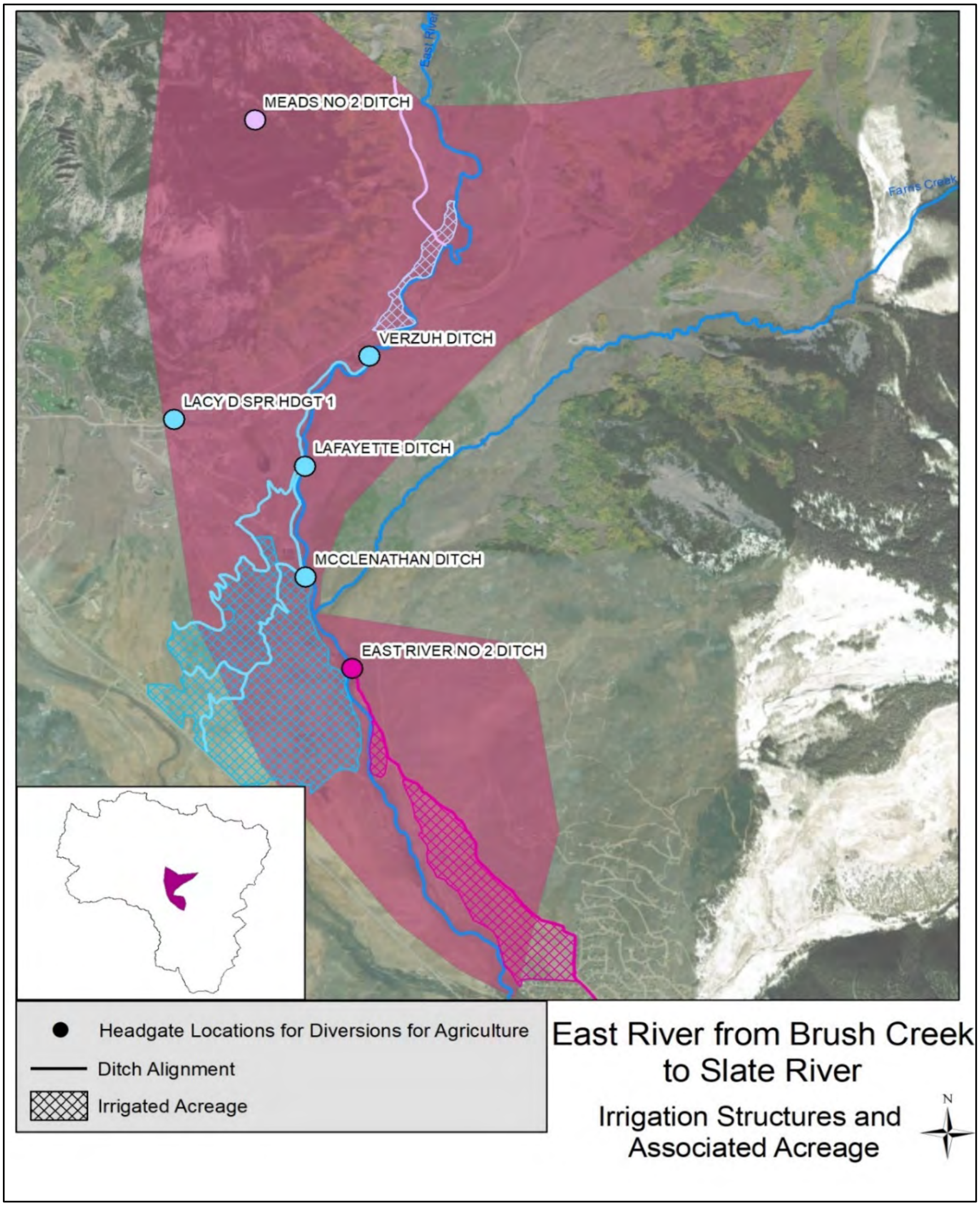
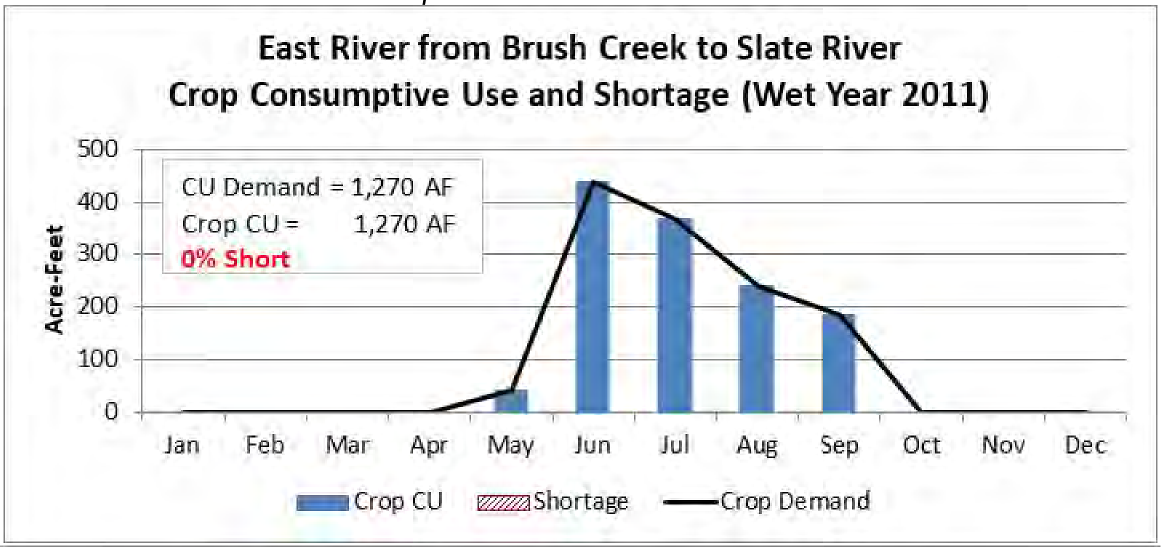
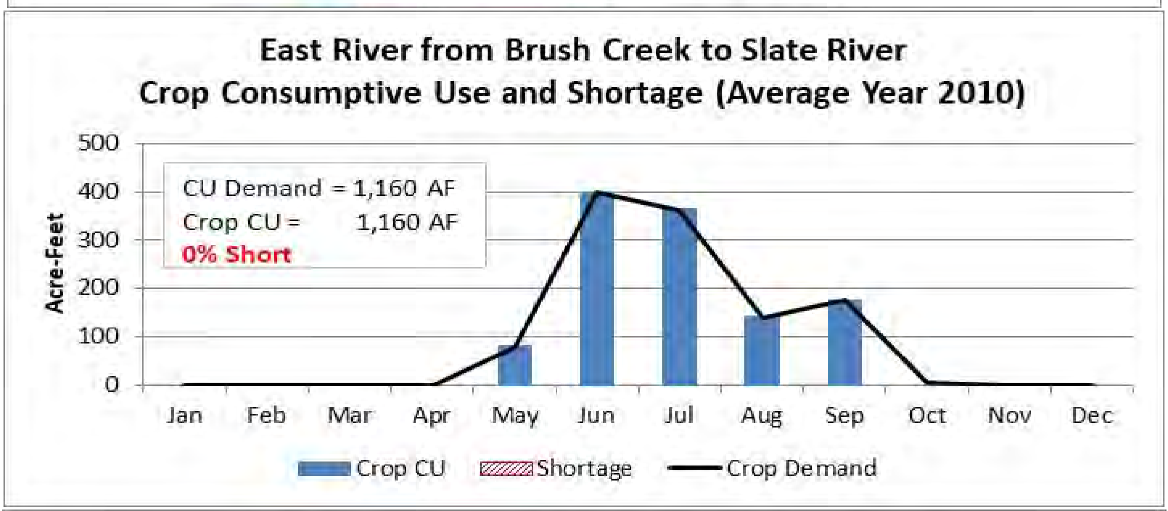


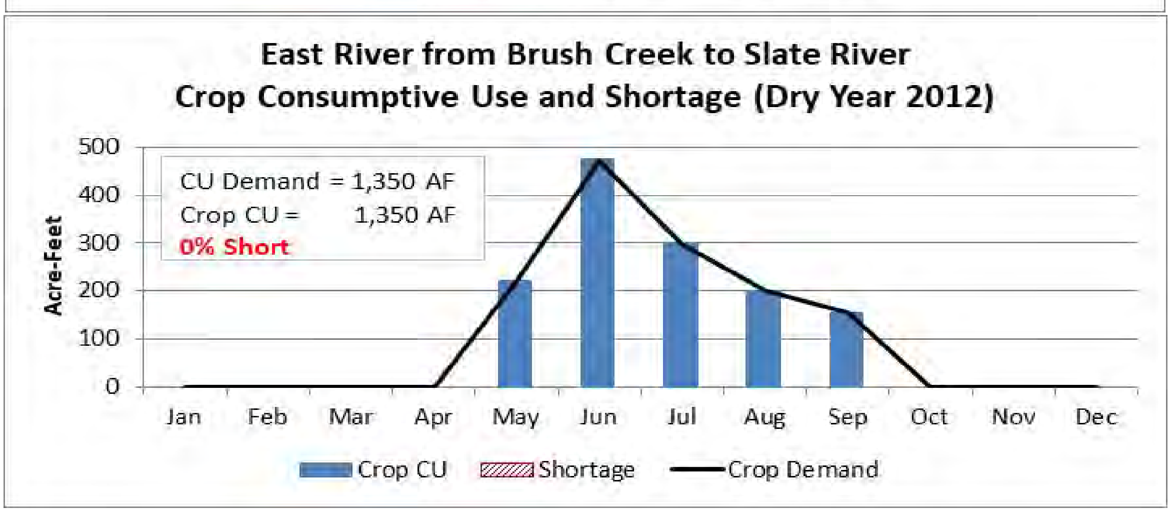
Figure 8-1: Diversion structures and acreage on the East River from Brush Creek to the Slate River

Figure 9-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). These senior water rights receive a full supply in every month of the irrigation season, even during dry hydrologic years. Above average rainfall in August of 2010 reduced the crop demand from an irrigation source.

Figure 9-2: Crop Consumptive Use and Shortage on the East River from Brush Creek to the Slate River







9.2 Domestic Water Use

Over the past several decades some of the agricultural lands south of Crested Butte have been developed for residential and commercial use. The development occurred and continues to occur at a piecemeal rate, which has created a unique configuration of municipal water and wastewater systems, and smaller centralized systems operated by individual homeowners' associations. During this assessment, the Skyland Metropolitan District (Skyland) and East River Regional Sanitation District (East River Sanitation) were interviewed. Skyland and East River Sanitation are the largest providers to the homes near the intersection of Highway 135 and Brush Creek Road, as shown in Figure 9-3. The information about municipal services is provided in the East River from Brush Creek assessment because treated wastewater effluent is discharged to the East River.

Skyland provides household water to the Skyland Subdivision but does not serve Buckhorn or other adjacent subdivisions. Skyland relies on the Decker Spring, located on the southeast side of Mount Crested Butte. Flows at the Decker Spring are dependent upon the annual snowpack. Water from the spring is pumped to a clear well and then storage tanks. Pumping is automated based on the tank's water elevation. Skyland also pumps from two wells adjacent to the Slate River. Each source is metered to report total use.

Skyland has formally changed the use of its 0.5 cfs water right in the Breem Ditch from irrigation to municipal and domestic use. Lake Grant is used as an augmentation supply and to irrigate the Club at Crested Butte Golf Course. Flow from Lake Grant is metered for both augmentation and irrigation uses.

In 2010, the Colorado Water Conservation Board and the Colorado Water Trust purchased 5.45 cfs from the Breem Ditch for instream flow use on Washington Gulch and the Slate River. This purchase was the Colorado Water Conservation Board's first purchase of water using funds from the General Assembly and the purchase price was paid in part by the CWCB and in part by the Colorado Water Trust. The Skyland Metropolitan District and local irrigators collaborated on this acquisition to provide water for Washington Gulch year-round. Importantly, after providing water to Washington Gulch for instream flow purposes, the water is also available downstream to help meet supply needs of the Skyland Metropolitan Water District.

Skyland currently serves a population of approximately 500, many of whom are second homeowners or guests at the golf course. Skyland is about 50 percent built-out and is currently working on a Master Plan. Skyland has adopted a water conservation plan, that includes several potentially beneficial measures, but the plan has not been fully implemented.

There is substantial potential for additional development in the future in both Skyland and adjacent areas. Additional development could affect the performance of the wells adjacent to the Slate River. Currently, the top management issue is that landowners want lush landscaping, lawns, and golf course fairways, plus a full Lake Grant to support aesthetics in the community.

The Buckhorn Subdivision provides drinking water to its residents. An interview with Buckhorn was not secured during the assessment period.

East River Sanitation collects and treats wastewater from the Skyland and Buckhorn Subdivisions. The treated effluent is discharged to the East River.

A portion of the domestic use in this area relies on groundwater primarily from exempt well permits. Because domestic use does not measurably impact stream flows in the East River, the quantity of domestic well water use was not explored further as part of this effort.

Approximately 20 homes rely on household wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

Figure 9-3: Major water and wastewater providers in the vicinity of Highway 135 and Brush Creek Road. This area includes portions of three reaches including the Slate River from Coal Creek to Highway 135, the Slate River from Highway 135 to the East River, and the East River from Brush Creek to the Slate River.

9.3 Environmental Water Use and Needs

9.3.1 Stream and Riparian Characteristics

Near the confluence with Brush Creek, the East River meanders through a broad valley and supports wetlands, relic channels, and beaver complexes. The width of the riparian corridor and complexity of the habitat varies based on land use and management practices in the upper portion of the reach. The valley form narrows down-gradient of Brush Creek Road. Below the constriction, the grade of the river briefly increases, which formed the deeper terrace features that persist until the confluence with the Slate River. Within this reach, the riparian corridor adjacent to the East River is generally narrower than in other portions of the watershed due to the narrower and steeper terraces.

The size of the riparian corridor has decreased somewhat due to vegetation removal, and potentially reduced flows. Cattle grazing is an important use within the reach. Grazing may impact the riparian corridor in some isolated areas. Other studies have identified minor vegetation disturbance and bank erosion attributed to grazing within the riparian area. The area provides habitat for big game species, including calving grounds for elk.

9.3.2 Aquatic Life

The East River is a high-quality fishery that includes rainbow, brown, and cutthroat trout. The uppermost portion of the reach, located on private land, is managed for angling. Data to further characterize aquatic life were not evaluated during this assessment.

9.3.3 Water Quality

The East River from Brush Creek to the Slate River is listed as potentially impaired for arsenic, see Table 9-2, Figure 9-4. Although arsenic has not been sampled in this reach the listing was retained because this reach is on the same WQCC segment and supports the same water uses.

Table 9-2: Potentially impaired stream reaches on the East River from Brush Creek to Copper Creek.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303d) List)	Impairment Priority
Mainstems of the East River, including all tributaries and wetlands, from its source to a point immediately above the confluence with the Slate River, except for specific listings in Segment 1.	Water Supply Use	Total Arsenic	NA	NA

Two samples collected from the East River near Gothic in July and August of 2014 by the WQCD were used to identify a potential impairment of the water supply use for total recoverable arsenic in the East River and its tributaries from the headwaters to the confluence with the Slate River. Data collected by the DOE from the East River at the Pumphouse confirm the impairment status for total recoverable arsenic. In recent years, arsenic concentrations in the East River at the Pumphouse ranged from 0.2 to 2.0 µg/L.

In this reach, the East River provides water for household wells (which are connected to surface waters). Household wells are used at residences scattered throughout the reach, treatment practices at individual residences were not evaluated in this assessment.

From 1995 to 2006, the USGS monitored the East River immediately upstream of the confluence with the Slate River (USGS 384950106544200). Arsenic was not analyzed at that location.

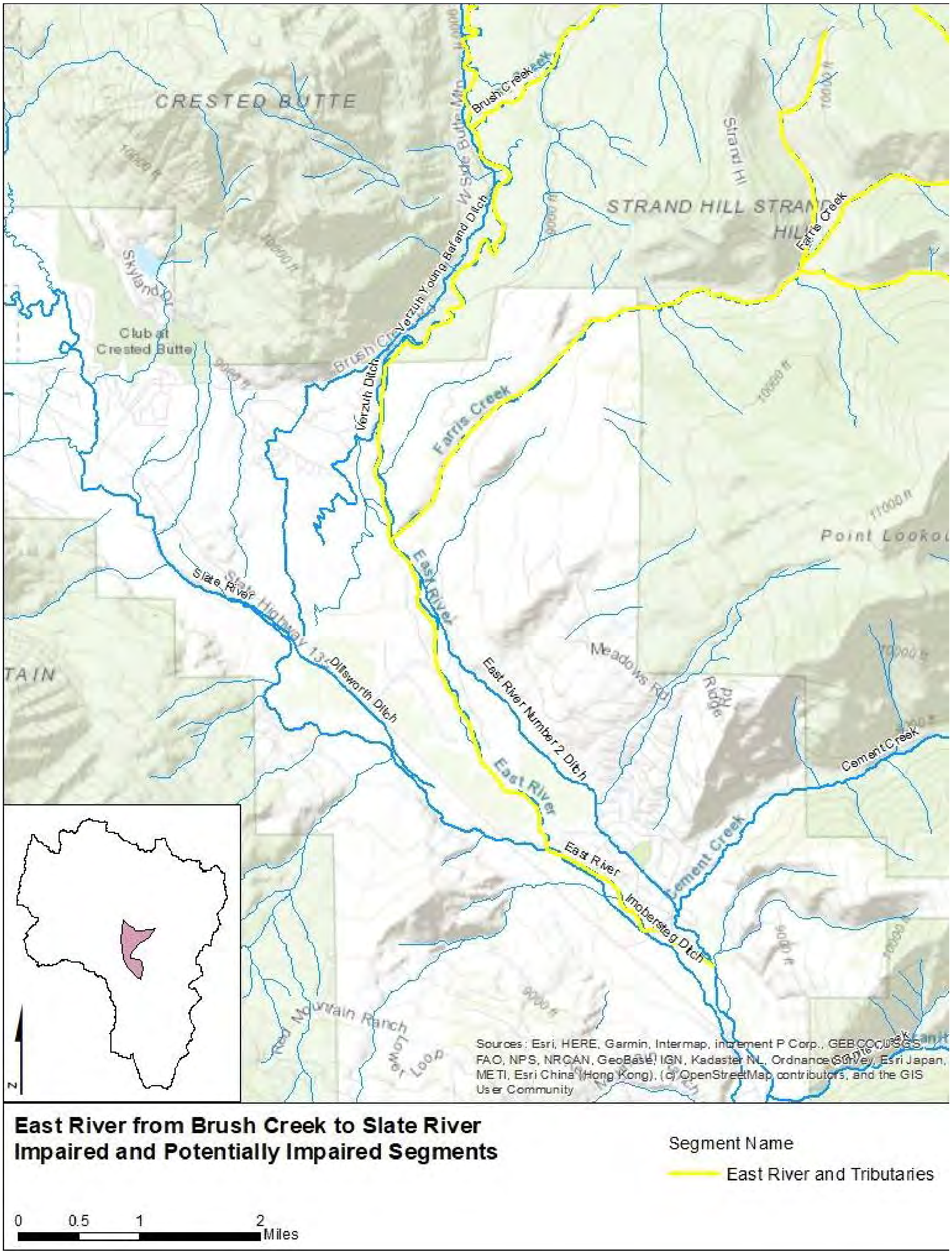


Figure 9-4: Potentially impaired stream reaches in the East River from Brush Creek to the Slate River

9.3.4 Water Temperature

Continuous water temperature measurements are not known to have been collected in this reach. Water temperature information is currently a data gap. Dry-up occurs on this reach in low flow years.

9.3.5 Existing Instream Flow Rights

Figure 9-5 shows that the East River from Brush Creek to the confluence with Alkali Creek has a year-round instream flow water right of 10 cfs. The instream flow proposals were developed by CWCB and CPW staff from 1979 to 1982. The original intent was to create two instream flow reaches - the East River from Brush Creek to the Slate River, and the East River from the Slate River to Alkali Creek. The R2CROSS output from the original cross-sections identified the minimum stream flows to meet the physical criteria were 20 and 40 cfs for winter and summer, respectively in the upper reach and 35 and 65 cfs, for winter and summer, respectively in the lower reach. The proposal was contested. The instream flow rate was reduced to 10 cfs and converted to a year-round rate. The originally proposed reaches were combined into a single reach. Further, the instream flow water right on this reach is lower than the instream flow reach on the East River upstream of Brush Creek, which is 15 and 25 cfs for summer and winter, respectively. The existing instream flow water right does not provide ideal protection for aquatic life, but given the legal constraints on its appropriation, it accomplishes its statutory purpose of preserving the natural environment to a reasonable degree.

The Crested Butte South Metropolitan District replaces well depletions with a senior changed water right for 6 cfs. The water right should be shepherded past the East River No 2 Ditch, as discussed in subsection 9.3.6 below, providing up to 6 cfs that can avoid complete dry up during the irrigation season in water short years.

On August 10, 2018 an R2CROSS assessment was completed in the East River immediately upstream of the confluence with the Slate River. The R2CROSS preliminary recommendation was 24 and 55 cfs for winter and summer, respectively. During the assessment the flow was 21.5 cfs. Despite very low flow conditions in 2018, the measured flow was near the minimum recommended stream flow of 24 cfs, which suggests that even during severe low flows, water may be physically available in this location.

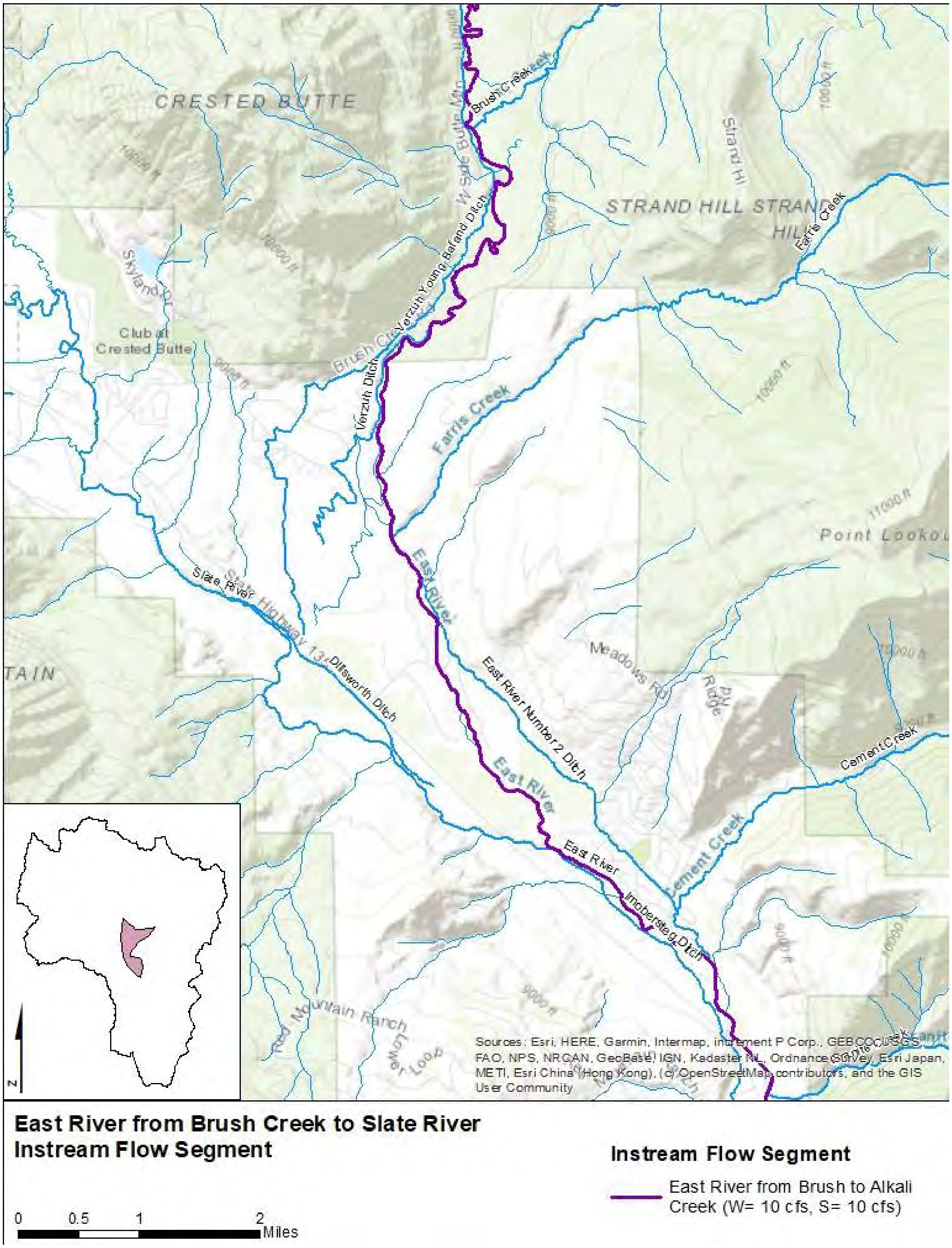


Figure 9-5: East River from Brush Creek to Alkali Creek instream flow water right

9.3.6 Flow-limited Areas

The following locations were identified by stakeholders in the East River from Brush Creek to the Slate River:

- Verzuh Ditch: A significant diversion. In dry years it could create near dry up.
- Lafayette Ditch: A significant diversion. During dry years, the Lafayette Ditch occasionally creates dry up in the East River. The dry section is a few hundred feet long. The situation also creates conflict with the downstream and senior water user at the East River No. 2 Ditch.
- East River No 2 Ditch: A portion of the East River No 2 Ditch senior water right was transferred to the Utilities Inc. Well No 1, currently used by the Crested Butte South Metropolitan District, to replace pumping impacts. Under the terms of the decree entered in Case W-2471, the East River No 2 must "allow 6.0 cfs of surface water to remain in the stream in exchange for year-round pumping priority not to exceed 2.0 cfs from the wellhead." This has only recently been administered correctly, allowing the East River No 2 Ditch to place a call while bypassing the water required to replace the well impacts. Note that although the water right transfer was to replace year-round pumping impacts, the water right can only be delivered to the reach during the irrigation season. This "mismatch" in timing of historical consumptive use credits was more common in 1975 and would not likely be approved through the water court process today.

9.3.7 Environmental Flow Goals

Based on the 2018 R2CROSS assessment and assessments from adjacent reaches, it may be possible to enlarge the rate of the summer instream flow water right. However, stakeholder observations indicate that in low flow years dry up is common downstream of both the Lafayette and East River No. 2 ditches. Data collection to better understand stream flows in flow-limited portions of the reach is recommended prior to developing an instream flow proposal or additional environmental flow goals.

9.4 Recreational Water Use

The East River from Brush Creek to the confluence with the Slate River at Crested Butte South is a 7-mile reach used for whitewater rafting and float fishing. Recreational use is summarized below.

Recreational Use Survey Summary for the East River from Brush Creek to the Slate River

Reach Description: 7-mile reach on the East River from Brush Creek to Crested Butte South.

Reach Information

- Put-in: Brush Creek Road Bridge
- Take-out: Crested Butte South Bridge
- Activities: Whitewater rafting and float fishing
- Nearest Downstream Gage: USGS East River Below Cement Creek Near Crested Butte, CO

Survey Results

- Number of survey participants: 1
- Craft types: Whitewater raft, SUP and float fishing boats
- Best method to decide to float: USGS Gages
- Most enjoyable aspect: Fishing
- Most concerning hazard: Fences
- Instances of trespassing are mainly due to: Low flows
- Top three suggestions for improvement: Restrooms, parking, and boater-friendly fences

Estimated Gage Flow Range for Recreational Use: 700 -2,000 cfs.

9.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water and wastewater practices in the vicinity of Highway 135 and Brush Creek Road. As development continues in the area, it will be important to understand the implications of a proposal's potential effect on water quantity and water quality.

Issue: Because of the limited data collected to date and the potential for elevated arsenic concentrations due to the local geology, household wells need sampling.

Issue: Effects of CBMR's expansion on downstream ditches: Irrigators within this reach noted concerns about siltation in their ditches as a result of plans to expand the ski area further into the Teocalli drainage, located on the East side of the mountain, which would reduce vegetation cover. The concerns related to long-term small-scale erosion and debris flows or similar events.

Issue: Conveyance losses. Ditches that deliver water within this reach, particularly the Verzuh Young Bifano Ditch (diverts in the upstream reach from Copper Creek to Brush Creek), traverse sections of scree and talus where transit losses are obvious. A ditch loss study was completed in early August. The ditch loss study found that the Verzuh Young Bifano lost about 9 percent as it traversed the south edge of Mount Crested Butte from Brush Creek Road through Buckhorn Subdivision, where the first lateral splits flows. It is possible that conveyance losses are larger during the spring, when the sides of the ditch, that are not silted in, contact more of the water. Conveyance losses may be higher in the portion of the ditch up-gradient from Brush Creek Road (that section was not included in the study).

Issue: Currently, the East River No. 2 Ditch lacks the infrastructure to effectively implement the minimum bypass flow, as discussed above.

Issue: Additional flow data from flow-limited areas: Based on the 2018 R2CROSS assessment and assessments from adjacent reaches, it may be possible to increase the rate of the summer instream flow water right. However, stakeholder observations indicate that in low flow years dry up is common.

Issue: Implementation of the Skyland Metropolitan District’s Water Conservation Plan.

Section 10. Reach 6 - Washington Gulch and Mt. Crested Butte

The headwaters of Washington Gulch originate near Anthracite Mesa and Mount Baldy on public lands managed by the US Forest Service. Upstream of Meridian Lake Park Reservoir, Washington Gulch is primarily accessed for recreational use. Dispersed camping occurs throughout the summer and into the fall in areas adjacent to Forest Service Road 811. Grazing also occurs in the headwaters of Washington Gulch on public and private lands.

Woods Creek drains Mt. Crested Butte and Crested Butte Mountain Resort (CBMR). Woods Creek is a heavily manipulated stream. Commercial and residential development has occurred throughout the area; as a result, much of Woods Creek is piped or directed through artificial channels.

Woods Creek joins Washington Gulch downstream of the Mt. Crested Butte Water and Sanitation District wastewater treatment facility near the upper end of the recreation path that links Mt. Crested Butte to Crested Butte.

Meridian Lake Reservoir, also known as Long Lake, is a part of this reach. Long Lake is a popular summer destination for swimming and paddle boarding.

10.1 Agricultural Water Use

There are five active irrigation diversions in the Washington Gulch and Mt. Crested Butte reach, serving approximately 325 acres of flood irrigated pasture grass. Table 10-1 shows the combined water rights, average annual and range of diversions, crop demands, actual crop consumptive, and shortage estimates for the ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 10-1: Agricultural water use statistics for Washington Gulch and Mt. Crested Butte.

Reach Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	5	n/a
Irrigated Acreage	325 acres	n/a
Water Rights	32.45 cfs	n/a
Diversions	1,850 acre-feet	900 – 3,040 acre-feet
Crop Demand	510 acre-feet	370 - 610 acre-feet
Crop CU	340 acre-feet	160 - 430 acre-feet
Shortage/Need	170 acre-feet	0 - 70 acre-feet
Percent Shortage	33%	8% - 66%

Figure 10-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. Water can be diverted through either the Willson Ditch or the Willson Ditch AP to serve the common acreage. All of the ditches are unlined, and the individual ditches are estimated to lose between 10 and 25 percent of diverted water during delivery to the irrigated fields depending on ditch length. Return flows from this reach, estimated to be an average of 1,510 acre-feet per year from 1998 to 2017, accrue to Washington Gulch near the confluence with the Slate River.

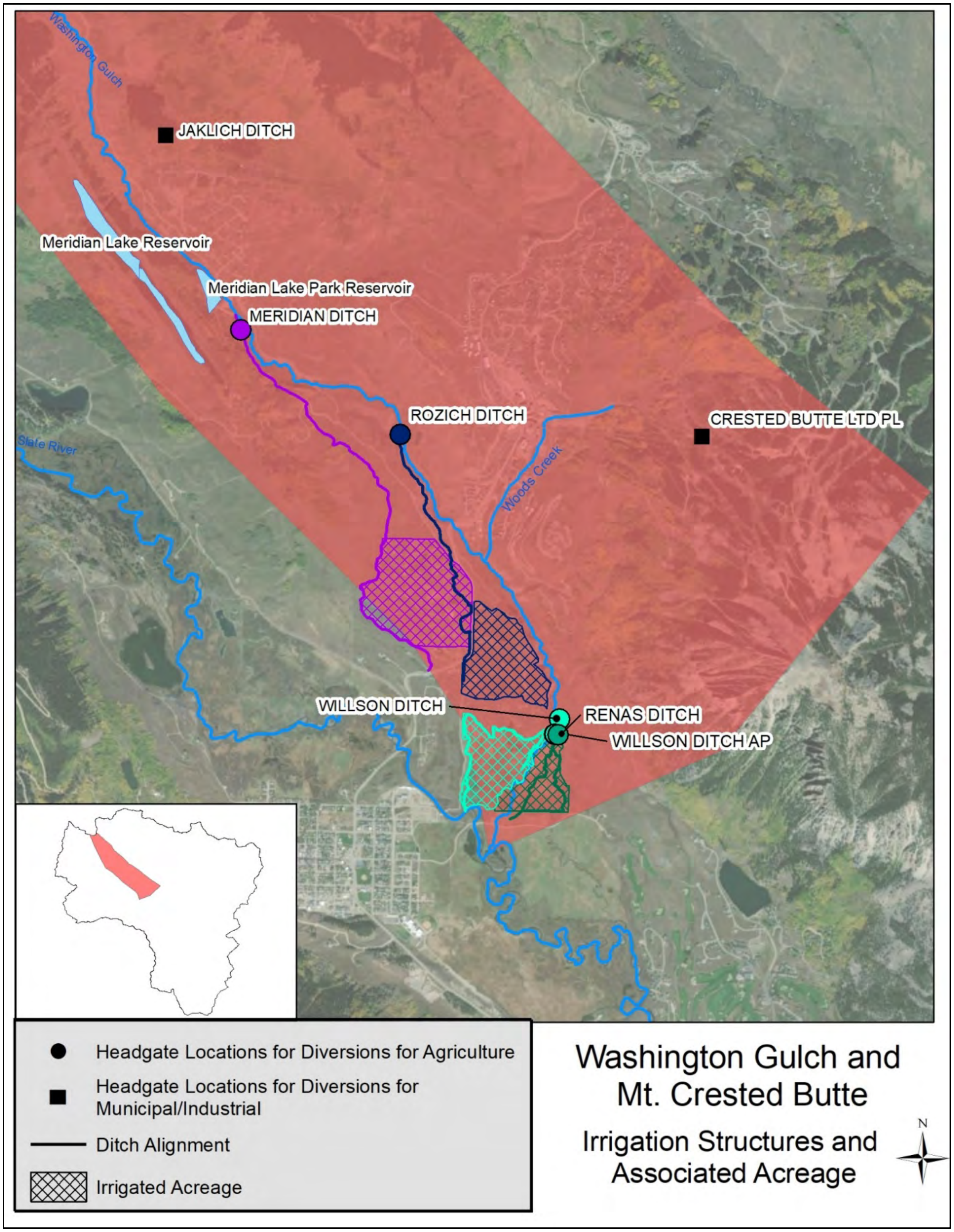
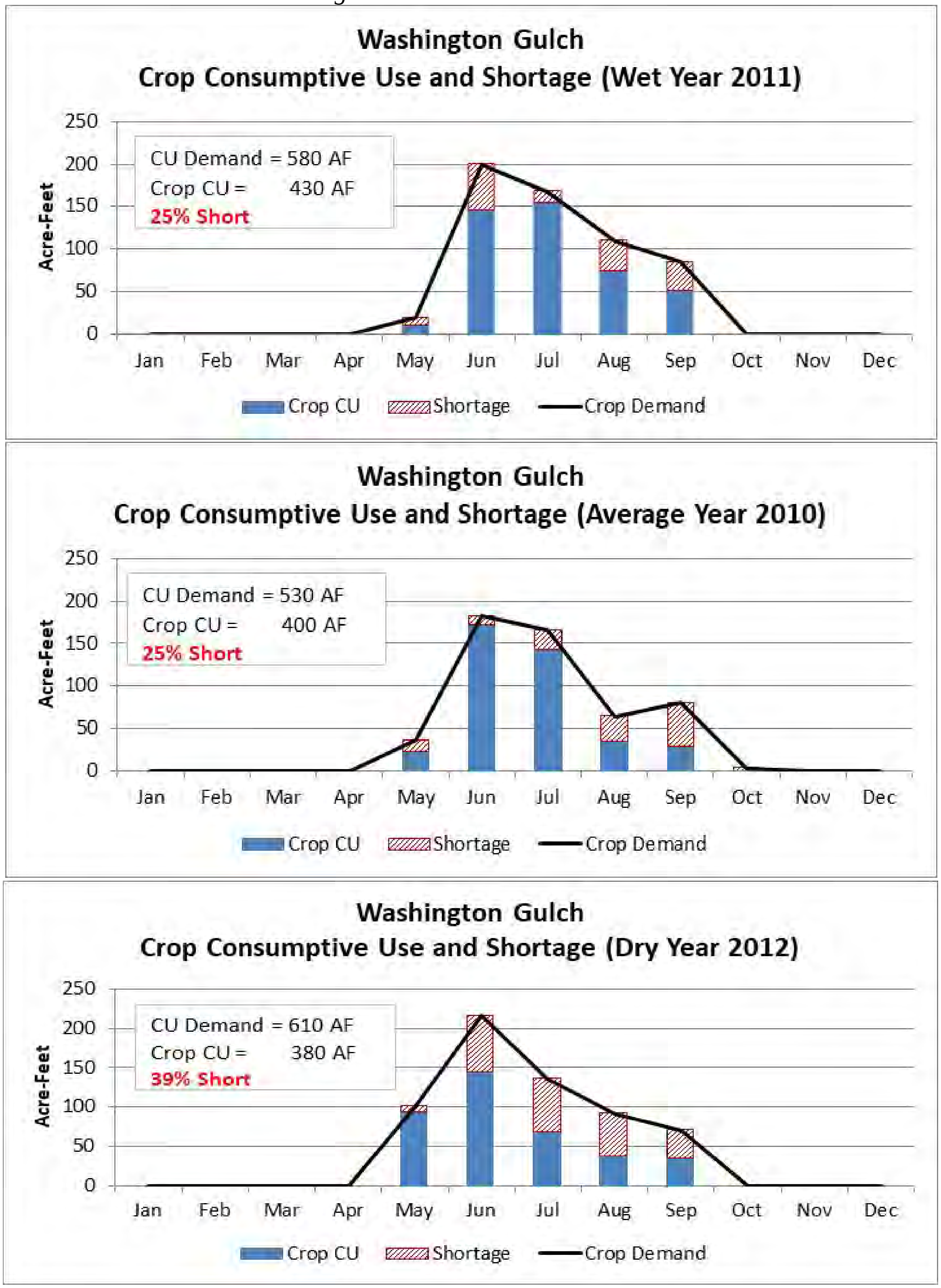


Figure 9-1: Diversion structures and acreage for Washington Gulch and Mt. Crested Butte

Figure 10-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). A significant portion of the shortages reported in Figure 10-2 are attributed to a lack of physical flow. Although there is not a streamflow gage on Washington Gulch, spot measurements indicate that, except during peak runoff, there is rarely water available after the runoff to divert the full 32.45 cfs of agricultural water rights on Washington Gulch. StreamStats reports that average streamflow ranges from a peak of 77 cfs in June to a low of 5 cfs in September. Recent monthly flow measurements in Washington Gulch downstream of Woods Creek range from approximately 2 to 15 cfs in the mid to late summer.

Figure 10-2: Crop consumptive use and shortage for Washington Gulch and Mt. Crested Butte



10.2 Domestic Water Use

The Mt. Crested Butte Water and Sanitation District (MCBWSD) operates the Meridian Lake Park water treatment plant (MLP WTP) that serves Meridian Lake Park Subdivision. The MLP WTP relies upon two raw water sources. Water is diverted from a spring gallery into the Jaklich Ditch. Water is also pumped from Meridian Lake Park Reservoir. The waters are combined and treated at the MLP WTP.

Municipal effluent is collected and delivered to the MCBWSD Wastewater Treatment Facility (WWTF). Treated effluent is discharged to Woods Creek, a tributary to Washington Gulch that drains CBMR's base area and the Town of Mt. Crested Butte.

The headwaters of Woods Creek form on CBMR property. The small creek is fed by multiple springs. Four of these springs are used as a raw source water in the Mt. Crested Butte water system. The springs are in the vicinity of the red Lady Chairlift. Recently collected water quality data indicated that the springs are generally of excellent quality.

The current discharge permit was developed in 2013 and included permit limits to meet the water quality standards applied in Woods Creek and Washington Gulch. The water quality standards are applied to protect aquatic life, agriculture, water supply, and recreational uses. In preparation for the permit renewal (originally scheduled for 2018), MCBWSD began voluntarily collecting additional water quality samples in 2016 to address data gaps to support permitting.

The Water Quality Control Division (WQCD) is currently revising the MCBWSD WWTF discharge permit. A public hearing was held in April 2019. At the hearing, members of the public expressed concerns related to *E. coli*, nutrients, and stream flows in Woods Creek and Washington Gulch. In comments to WQCD, MCBWSD requested that stream flows used in the permit be reevaluated and requested additional time to complete projects to minimize infiltration and inflow into the wastewater collection system, due to the limited construction season in Mt. Crested Butte. The WQCD has released another draft discharge permit without a defined timeline for final issuance and could remain in administrative review for some time.

Approximately eight cabins upstream of Meridian Lake Park Reservoir rely on household wells or springs and use on-site wastewater treatment systems. Homes in the Smith Hill Ranches, Glacier Lily, Saddle Ridge Ranch Estates, Three Valleys, and Moon Ridge Subdivisions rely on wells that are operated by the respective HOAs. Other homes adjacent to County roads 317 and 811 use individual wells. On-site wastewater treatments systems are used in these homes, except for Saddle Ridge Ranch where wastewater is treated at the MCBWSD WWTF.

Storage in Meridian Lake Reservoir is decreed for augmentation and is used to replace out-of-priority wells or other diversions that would otherwise be curtailed by a senior water rights call in the East River basin. The augmentation storage is owned by the UGRWCD and managed by Upper Gunnison River Water Activity Enterprise. The Enterprise has significant remaining augmentation water available. A proposed joint venture between the Enterprise and MCBWSD has the potential to increase the firm yield of the reservoir for augmentation purposes.

10.3 Environmental Water Use

10.3.1 Stream and Riparian Characteristics

The headwaters of Washington Gulch are flanked by Anthracite Mesa to the southwest and Gothic Mountain and Snodgrass Mountain to the northeast. Washington Gulch forms where a series of springs converge below the southeast face of Mount Baldy, near the old town site of Elkton. A limited number of historic mines and prospect pits occur in the headwaters of Washington Gulch. Despite having significant mining activities in the past, there is a lack of draining mine adits in the area and the impact to water quality from these historic mine features is generally understood to be minimal.

The upper reaches of Washington Gulch and its tributaries have moderately sized beaver complexes. Beaver complexes increase the volume of water stored on the landscape, support stream flows into the late summer, increase connection with the floodplain which generally helps attenuate stream flows, and support more robust riparian vegetation. While beaver activity can cause management issues associated with infrastructure, there are opportunities to mitigate culvert issues and ditch issues through tools like beaver deceivers and other management techniques.

Surface flows and groundwater from the western and southern flanks of Gothic Mountain support ponds and wetlands. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses. There are no diversions from Washington Gulch upstream of Meridian Lake Park Reservoir.

The riparian area of Washington Gulch upstream of Meridian Lake Park Reservoir is largely undisturbed, except for isolated areas where dispersed camping or grazing activities have caused minor disturbance. The parking area and trail to Long Lake (Meridian Lake) could be improved to benefit both recreational use and riparian health.

All irrigation diversion structures are located downstream of Meridian Lake Park Reservoir. In select areas County Road 811 reduces the function of Washington Gulch. Gravel applied for traction in the winter is evident within the riparian area and rills and gullies occur on the road’s fill slope. The culvert on County Road 811 appears under-sized and may alter sediment transport within the reach. However, the sediment regime is altered due to Meridian Lake Park Reservoir and to a lesser extent by beaver dams immediately upstream of the culvert.

The culvert under County Road 317 also alters sediment transport dynamics and created a large pool and minor sedimentation issues downstream of the culvert. It appears that the channel form allows energy to dissipate into adjacent wetlands. Stormwater runoff from County Road 317 has formed rills and gullies on the road's fill slope. Gravel applied for traction in the winter is evident within the riparian area.

Woods Creek, an important tributary to Washington Gulch, forms on the lower portion of CBMR. Although some stormwater best management practices are used in the area, there is room for improvement. In many areas, runoff from impervious surfaces, particularly unpaved parking areas, flows directly into the creek. Treated effluent from the MCBWSD WWTF is discharged to Woods Creek approximately 600 feet upstream of the confluence with Washington Gulch.

Washington Gulch up and downstream of the confluence with Woods Creek supports a moderately-sized beaver and wetland complex within a small canyon section. The Willson Ditch diverts water from Woods Creek where the valley widens about a mile upstream of the confluence with the Slate River. A portion of the riparian area within this reach has narrowed as a result of grazing. However, the grazing intensity has decreased in recent years.

10.3.2 Aquatic Life

Upstream of Meridian Lake Park Reservoir, Washington Gulch has a small but healthy cold-water trout fishery. Washington Gulch also supports fish near the confluence with Woods Creek, particularly in the beaver ponds. Irrigators have reported a lack of fish near the confluence with the Slate River. Macroinvertebrates occur in Washington Gulch up and downstream of Woods Creek and in Woods Creek up and downstream of the MCBWSD WWTF. Algae growth in Woods Creek downstream of the WWTF is denser than observed in other portions of the watershed. Data to further characterize aquatic life were not identified during this assessment.

10.3.3 Water Quality

Washington Gulch was listed as impaired for total recoverable arsenic for the water supply use because it is a part of the Slate River tributaries segment (COGUUG09), as shown in Table 10-3 and Figure 10-3. The data used to establish the arsenic impairment were not collected from Washington Gulch.

The East River provides water for both household wells (which are generally assumed to be connected to surface waters) and a municipal water system. Household wells are used at residences scattered throughout the reach. Treatment practices at individual residences were not evaluated in this assessment. MCBWSD provides a municipal water supply. Because of the dual water supply uses, the East River has been listed as impaired for arsenic.

Table 10-3: Impaired and potentially impaired portions of Washington Gulch.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of Washington Gulch	Aquatic Life Use	Temperature	NA	NA
		NA	Total Arsenic	High

Since 2011, the Coal Creek Watershed Coalition (CCWC) has collected a limited number of *E. coli* samples from the Slate River Watershed. In 2018 the study was expanded to include Washington Gulch immediately upstream of the confluence with the Slate River at the request of the US Forest Service. The US Forest Service wanted some baseline data that could be used to support a funding request for a permanent toilet in the upper reaches of Washington Gulch.

The 2018 study found that *E. coli* concentrations exceeded the primary contact standard in Washington Gulch immediately upstream of the confluence with the Slate River. The upstream extent of the problem is currently unknown. A review of *E. coli* concentrations measured in the MCBWSD WWTF effluent indicate the facility has maintained compliance with the discharge permit limit. Additional *E. coli* sample collection, along with flow and temperature monitoring, is currently underway. One of the study objectives is to determine the sources of *E. coli* concentrations in the Washington Gulch Watershed. One of the CCWC study objectives is to determine the sources of *E. coli* concentrations in the Washington Gulch Watershed.

A very limited number of nutrient samples have been collected from Woods Creek and Washington Gulch. To date, nitrogen and phosphorus concentrations have been below the interim standards.

An unnamed tributary that drains the southern half of Snodgrass and a small portion of Mt. Crested Butte flows into Washington Gulch approximately one-half mile upstream of where County Road 317 crosses Washington Gulch. One stakeholder speculated that this area could contribute to water quality issues in Washington Gulch.

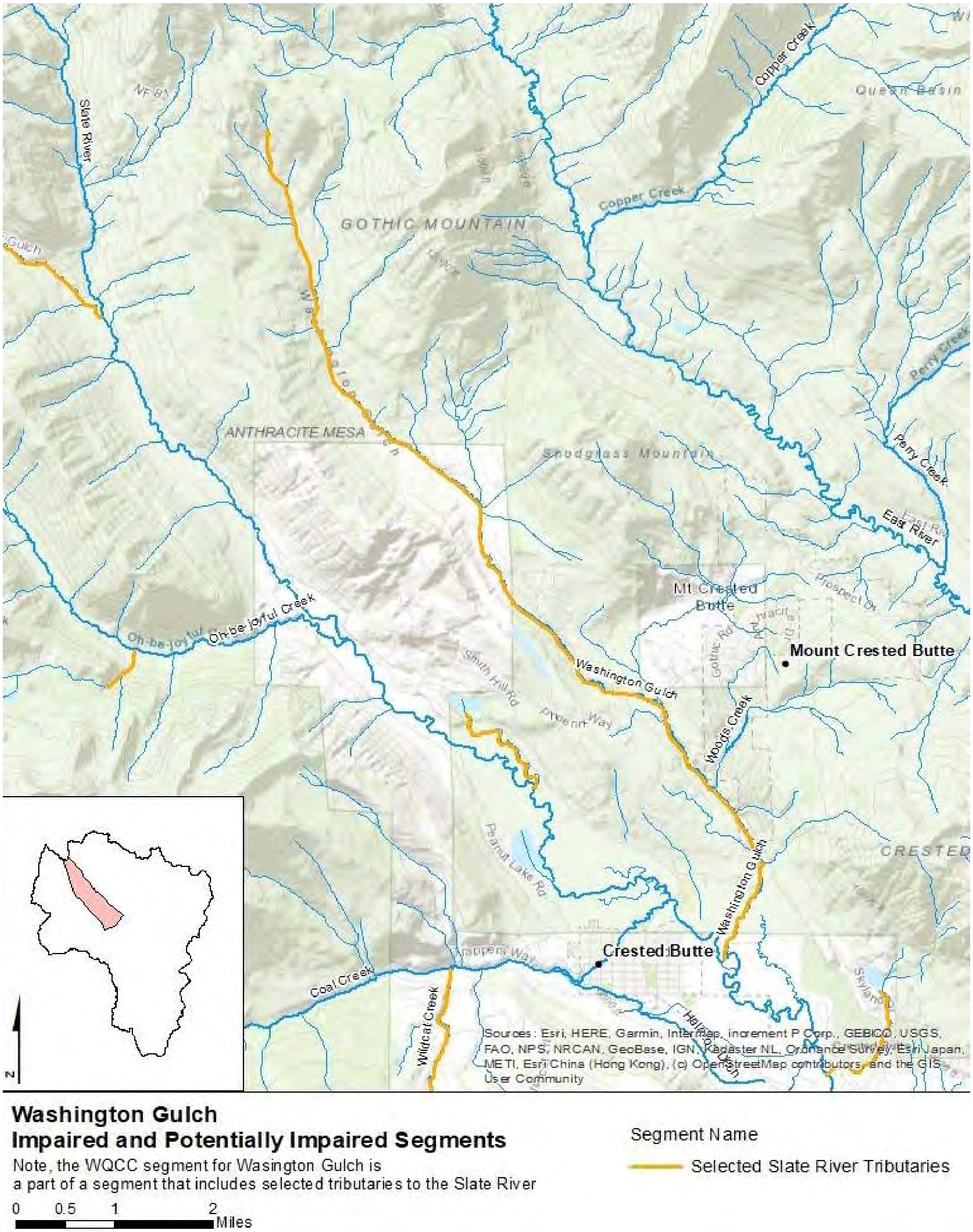


Figure 10-3: Impaired and potentially impaired stream reaches in Washington Gulch

10.3.4 Water Temperature

The WQCD installed a temperature sensor in Washington Gulch downstream of County Road 317 and the upper end of the recreation path (upstream of Woods Creek and the MCBWSD WWTF). The sensor was installed from fall 2014 to fall 2018; although data from 2017 and 2018 had not yet been reviewed and analyzed. An assessment of the temperature data from fall 2014 to fall 2016 identified exceedances of the chronic and acute temperature standards. The exceedances occurred between October 11 and 14, 2015 for the chronic standard and on October 15, 2015 for the acute standard.

Although the standards were exceeded, WQCD staff opted to list Washington Gulch as potentially impaired, rather than impaired. The 2017 and 2018 temperature data should be evaluated; along with temperature data collected as part of the 2019 *E. coli* study. This data could be used to determine the attainment status.

The temperature standards were exceeded in the first half of October, immediately following the transition from summer to winter temperatures standards on October 1. The Slate River has a site-specific temperature standard that delays the onset of the winter temperatures standards from the typically October 1 to October 15. Had the site-specific standard been applied to in Washington Gulch, the temperature standard would not have been exceeded. However, there is insufficient evidence to support a site-specific standard in Washington Gulch and several water management activities are likely to alter natural temperature regimes. A site-specific temperature standard or change to the underlying aquatic life is not proposed at this time.

10.3.5 Existing Instream Flow Rights

Washington Gulch from the headwaters to the confluence with the Slate River has a year-round instream flow water right of 2.5 cfs, as shown in Figure 10-4. The instream flow proposal was developed by CWCB and CPW staff in 1979.

In addition to the instream flow on Washington Gulch the CWCB approved Colorado Water Trust’s water acquisition for instream flow use on Washington Gulch and the Slate River. The 5.45 cfs of water from the Breem Ditch water right is used to satisfy instream flows in Washington Gulch and the Slate River. Historically, the Breem Ditch completely dried-up Washington Gulch near the confluence with the Slate River. The Breem Ditch transaction addresses this shortage and also helps to alleviate shortages in the Slate River by moving water downstream.

Due to both water acquisitions and a gage in the Slate River downstream of the confluence with Washington Gulch, the CWCB can place calls on junior users to satisfy the instream flow water right. Administrative calls were placed nine times between 2000 and 2018 to provide water to the instream flow water right (referred to as Slate River Segment 4) during the late summer and early fall.

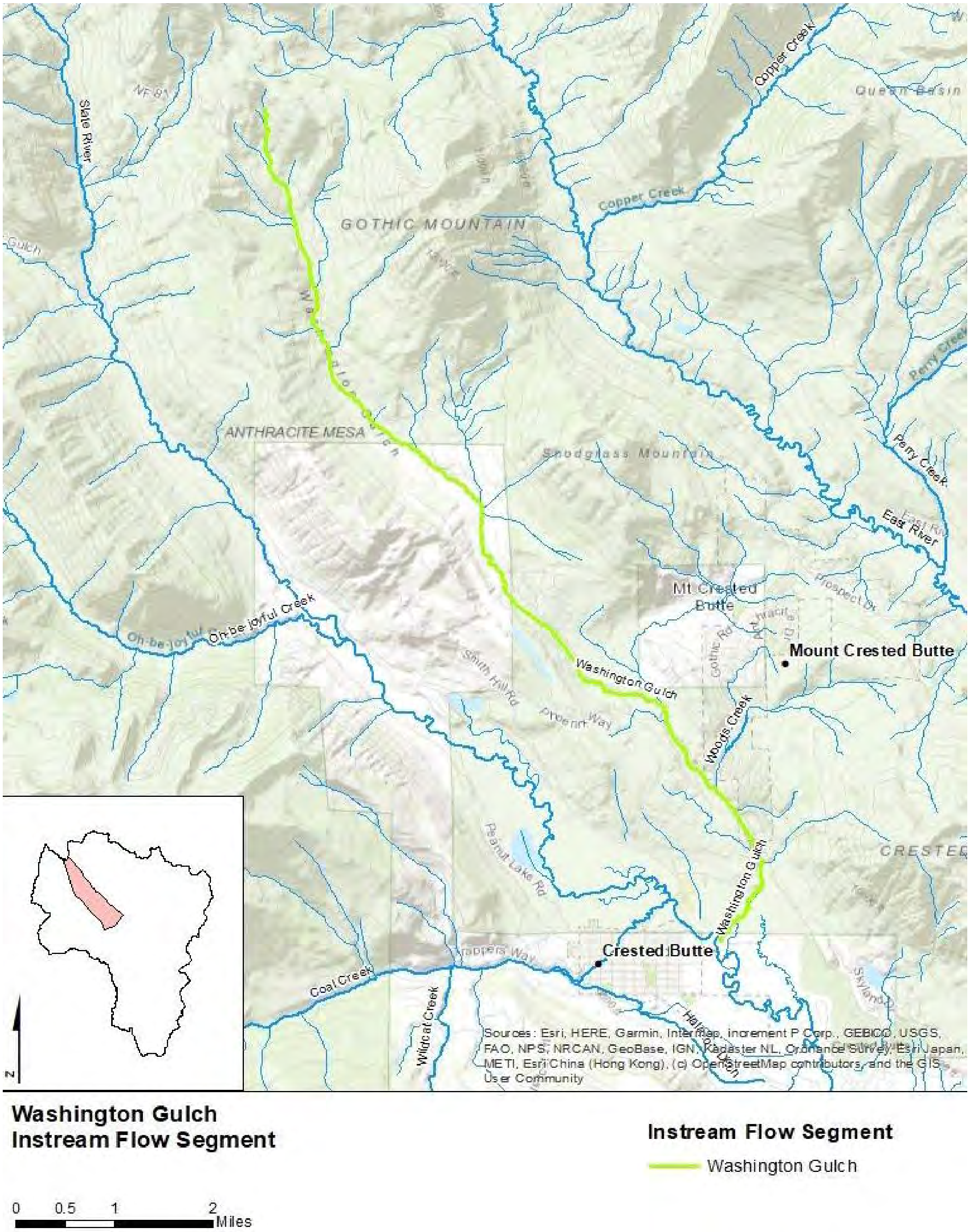


Figure 10-4: Washington Gulch instream flow water right; the only existing instream flow water right in the reach

10.3.6 Flow-limited Areas

Flows in Washington Gulch upstream of Meridian Lake Park Reservoir are natural. Flow in Washington Gulch downstream of the reservoir is heavily influenced by releases from Meridian Lake Park Reservoir and Meridian Lake Reservoir, discharges from the MCBWSD WWTF, and diversions by agricultural users.

The Meridian, Rozich, Wilson, and Renas ditches were identified by stakeholders as significant diversions that could cause near dry up in Washington Gulch in dry years.

Washington Gulch near the confluence with the Slate River lacked flow from mid-July to mid-September 2018.

10.3.7 Environmental Flow Goals

Because of the gage and instream flow acquisitions, increased management to provide water to the instream flow segments in the lower portion of Washington Gulch and the Slate River are appropriate environmental flow goals.

10.4 Recreational Water Use

There is an abundance of recreational use in the Washington Gulch Watershed. However, Washington Gulch does not support floating activities. Natural flows upstream of the Meridian Lake Park Reservoir should be sufficient to support the fishery and therefore angling activities in Washington Gulch.

Several stakeholders reported concerns about increasing recreational use creating water quality impacts particularly as it relates to *E. coli*, nutrients, and similar pollutants. The US Forest Service plans to install a permanent toilet in Washington Gulch to reduce the potential water quality and watershed health impacts of intensive recreational use in the watershed. Portable toilets will be used in 2019 and ideally the permanent toilet will be installed in 2020, pending funding. The Town of Mt. Crested Butte plans to install a public toilet and asphalt the parking lot at the Rasta Lot to serve as a trailhead and public parking area in Mt. Crested Butte.

If the current funding campaign is successful, the Crested Butte Land Trust will acquire the land bordering the southeast portion of Meridian Lake Reservoir.

10.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Limited data collected to date and the potential for elevated arsenic concentrations due to the local geology affecting household wells in identified areas where water quality characterization has not occurred.

Issue: Additional stormwater management in the areas near County Road 17and Woods Creek.

Issue: Augmentation water and the link between land use and water supply planning. As development continues in areas adjacent to Mt. Crested Butte, Crested Butte, and along the Highway 135 corridor, the need for augmentation water will increase. Several stakeholders have identified concerns with the Gunnison County Land Use Resolution and development review process particularly with respect to water supply planning.

Issue: Source water protection. MCBWSD uses water from Washington Gulch to provide water to the Meridian Lake Park Subdivision and four springs located on CBMR (in addition to the Malensek Ditch and East River in an adjacent reach) provide raw water in the Mt. Crested Butte service area. Maintaining the quality of the source water should be a priority if additional development or expansion of recreational use at CBMR or on public lands upstream of Meridian Lake Park Reservoir. Adjacent subdivisions rely on wells that are likely to have direct hydrologic connection with surface waters.

Issue: Understanding augmentation plans. The Meridian, Rozich, Renas and Willson ditches substantially dry up Washington Gulch. In short years, water users establish gentleman's agreement to share water and avoid calling out one another. Although irrigation occurs on these ditches, a portion of the water is used to fill augmentation ponds.

Issue: Dry-up, water quality, and environmental impacts. There is a need to better understand the relationship between water quantity and water quality in this reach.

Issue: Diversion structures entrain fish: Diversion structures in this reach prevent fish passage. When flow is greater into the ditch there is a greater chance for fish entrainment.

Issue: Is the MCBWCD Water Conservation Plan adequate to provide peak season water supply and future growth?

Issue: Terms included in the MCBWSD WWTF Discharge Permit. Work to address discharge needs.

Issue: Recreational use may degrade riparian areas in selected areas.

Issue: Erosion from trail and road crossings and unauthorized use. Field observations have identified a few areas where road and trail crossings increase erosion and/or limit riparian and floodplain function.

Issue: Impacts of dispersed camping.

Section 11. Reach 7 - Slate River Headwaters to Oh-Be-Joyful Creek

The headwaters of the Slate River form 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. Several unnamed, intermittent drainages join the Slate River upstream of Poverty Gulch and additional intermittent drainages flow into the Slate River downstream of Poverty Gulch. Oh-Be-Joyful Creek flows into the Slate River about nine miles below the headwaters. Most of the Upper Slate River headwaters reach is managed by the United States Forest Service. Small private in-holdings occur with the former town site of Pittsburgh and a few small mine claims. The Oh-Be-Joyful Campground, managed by the Bureau of Land Management (BLM), is located near the lower end of this reach. The headwaters of the Slate River are largely undeveloped with numerous historic mine features, grazing, and ample recreational use, including exceptional whitewater kayaking.

11.1 Agricultural Water Use

There are no diversions for agricultural use in this reach and no identified needs in the future.

11.2 Domestic Water Use

There are not currently municipal, or industrial uses in the headwaters of the Slate River to the confluence with Oh-Be-Joyful Creek. Future needs were not identified during the assessment.

Approximately 5-10 homes and cabins rely on wells or springs and use on-site wastewater treatment systems. Additional homes could be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

11.3 11.3 Environmental Water Use

The Upper Slate River Watershed Plan[30], prepared by the Coal Creek Watershed Coalition (CCWC), was a valuable reference for this environmental assessment.

---

[30] The Upper Slate River Watershed Plan and associated outreach documents are available at http://www.coalcreek.org/documents-and-data.html

11.3.1 Stream and Riparian Characteristics

In 2012, CCWC commissioned a geomorphic assessment of the Upper Slate River Watershed to address several stream stability and sediment transport issues identified by stakeholders. The 2012 geomorphic assessment[31] is referenced frequently in this section.

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

Photo 11-1: Baxter Creek (a local name for the unnamed tributary that drains Baxter Basin) upstream of the confluence with Poverty Gulch in July 2011. The extremely steep slopes and loose bedrock naturally deliver sediment to the valley floor.

---

[31] Alpine Eco- Alpine Eco and EcoMetrics, 2012. Upper Slate River Geomorphic Assessment Gunnison County, Colorado. Prepared for the Coal Creek Watershed Coalition.

Due to the steep slopes and the materials found on the slopes, hillslopes in the headwaters of the Slate River are naturally susceptible to mass erosion which includes landslides, earth flows, debris avalanches, debris flows, torrents, and snow avalanches. These sporadic events naturally deliver massive volumes of sediment to the valley floor. 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. 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. 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. 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 portions of this reach near the confluence with Poverty Gulch and near Oh-Be-Joyful Campground have 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. Over time the lower angle valley channel will winnow away the accumulated sediment. In the headwaters of the Slate River this process is natural and unaffected by human activity.

The Colorado Natural Heritage Program identified "almost the entire reach of the Slate River" as a Potential Conservation Area with significant high biodiversity, including multiple occurrences of globally vulnerable riparian plant communities[32]. The large wetland and beaver complexes found downstream of the confluence with Poverty Gulch are home to willows, sedges, and a wide range of riparian plants. Wetlands provide critical ecosystem services including water storage to support late season flows, high quality habitat for a large range of aquatic and terrestrial species, carbon storage, and generally improve overall watershed health.

Lateral moraines deposited glacial till on many of the valley hillslopes and create the bench-like features found on several slopes. Lateral moraines can support small surficial aquifers that support non-riparian wetlands.

11.3.2 Aquatic Life

In recent years, Colorado Parks and Wildlife (CPW) has surveyed fish in the Slate River. Brook and brown trout are abundant. Fish densities are typically high, but fish tend to be somewhat small. In 2012, CPW surveyed two areas in the Slate River near Oh-Be-Joyful

[32] Rocchio, J., Doyle, G. and Rondeau, R. (2004). *Survey of Critical Wetlands and Riparian Areas in Gunnison County*. Colorado Natural Heritage Program. Colorado State University. Available at http://www.cnhp.colostate.edu/download/documents/2004/Gunnison_County_Wetlands.pdf

Campground. The first location featured pools formed by large woody debris. 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. In fact, the pool habitats on the Slate River met the criteria for Gold Medal Waters (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[33].

Macroinvertebrates were sampled by CCWC and BLM throughout this reach in 2011 and 2013 to establish a baseline data set to support watershed planning.

The Slate River above the Pittsburg Mine was the highest elevation location sampled. In this area the Slate River flows through a narrow canyon with very steep hillslopes that support primarily alpine vegetation or are talus-covered. The sediment load in this portion of the headwaters is nearly all natural and very large; with significant input from mass erosion events. The health and diversity of the macroinvertebrates at this location fully support the aquatic life use.

Below the confluence with Augusta and Baxter Creeks, Poverty Gulch meanders through a large wetland complex. This location had the highest scores in both years that macroinvertebrates were sampled. This result is consistent with the water quality data that indicate metals and other pollutants are low. Although the basin has several abandoned mine features, most notably the Augusta Mine Portal, the features do not substantially impair water quality.

The Slate River downstream of Poverty Gulch also supported aquatic life use despite 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 upstream of Oh-Be-Joyful Campground, the health and diversity of the macroinvertebrates at this location fully support the aquatic life use.

[33] Dan Brauch, personal communication 2013.

11.3.3 Water Quality

The Upper Slate River Water Quality Data Analysis and Summary[34], prepared for the CCWC in 2011, was a valuable reference for this assessment.

Prospect pits and other small mine features are common in the headwaters of the Slate River and Poverty Gulch. Historic mining in Poverty Gulch is well-documented. The most notable mines in this reach occur in Augusta and Baxter Basins which are tributary to Poverty Gulch. The drainage from the Augusta Mine is substantial, however, metal concentrations are relatively low and typically attain the chronic standards used to protect aquatic life.

Photo 11-2: Staff from DRMS and a CCWC intern prepare to collect a water quality sample from the Augusta Mine portal in July 2011 as part of a collaborative watershed-wide sampling event to address data gaps.

Cadmium, copper, and zinc concentrations are generally less than the chronic aquatic standards in the headwaters of the Slate River and in Poverty Gulch. Samples collected by Colorado Division of Reclamation and Mine Safety (DRMS) staff in 2016 corroborated that metal concentrations from mine adits in Augusta and Baxter Basin are generally low.

Tributaries to the Slate River in the headwaters area, including Poverty Gulch, are listed as impaired for total recoverable arsenic for the water supply use, as shown in Table 11-1 and

[34] Bembenek, A. (2011). *Upper Slate River Water Quality Data Analysis.* Prepared for Coal Creek Watershed Coalition.

Figure 11-1. Total arsenic has been detected in a limited number of samples collected from Augusta Creek (downstream of the Augusta Mine).

The nearest downstream municipal water supply from this reach is the Skyland Metro District. Protecting the downstream water supply use in Skyland is an additional reason the water supply use is applied to this segment. Household wells and springs are used at residences scattered throughout the headwaters of the Slate River; treatment practices at individual residences were not evaluated in this assessment.

Table 11-1: Impaired and potentially impaired portions of the Slate River from the headwaters to Oh-Be-Joyful Creek.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Selected Slate River Tributaries	Aquatic Life Use	NA	Total Arsenic	High

CCWC has collected a limited number of *E. coli* samples from the Slate River from Oh-Be-Joyful Creek to Coal Creek since 2011. Initial studies, in 2011, 2013, and 2017, found that *E. coli* concentrations attained the primary contact standard used to protect recreational users. The 2018 study found that *E. coli* concentrations may have exceeded the primary contact standard in the Slate River upstream of Coal Creek. The upstream extent of the problem is currently unknown. *E. coli* sample collection, along with flow and temperature monitoring, is underway in 2019. One of the study objectives is to determine the upstream extent of elevated *E. coli* concentrations in the Slate River. Further characterization of this issue is critical due to extensive recreational use in the Headwaters of the Slate River. Additionally, data collection will occur up and downstream of the new permanent toilet installed at Musicians Camp.

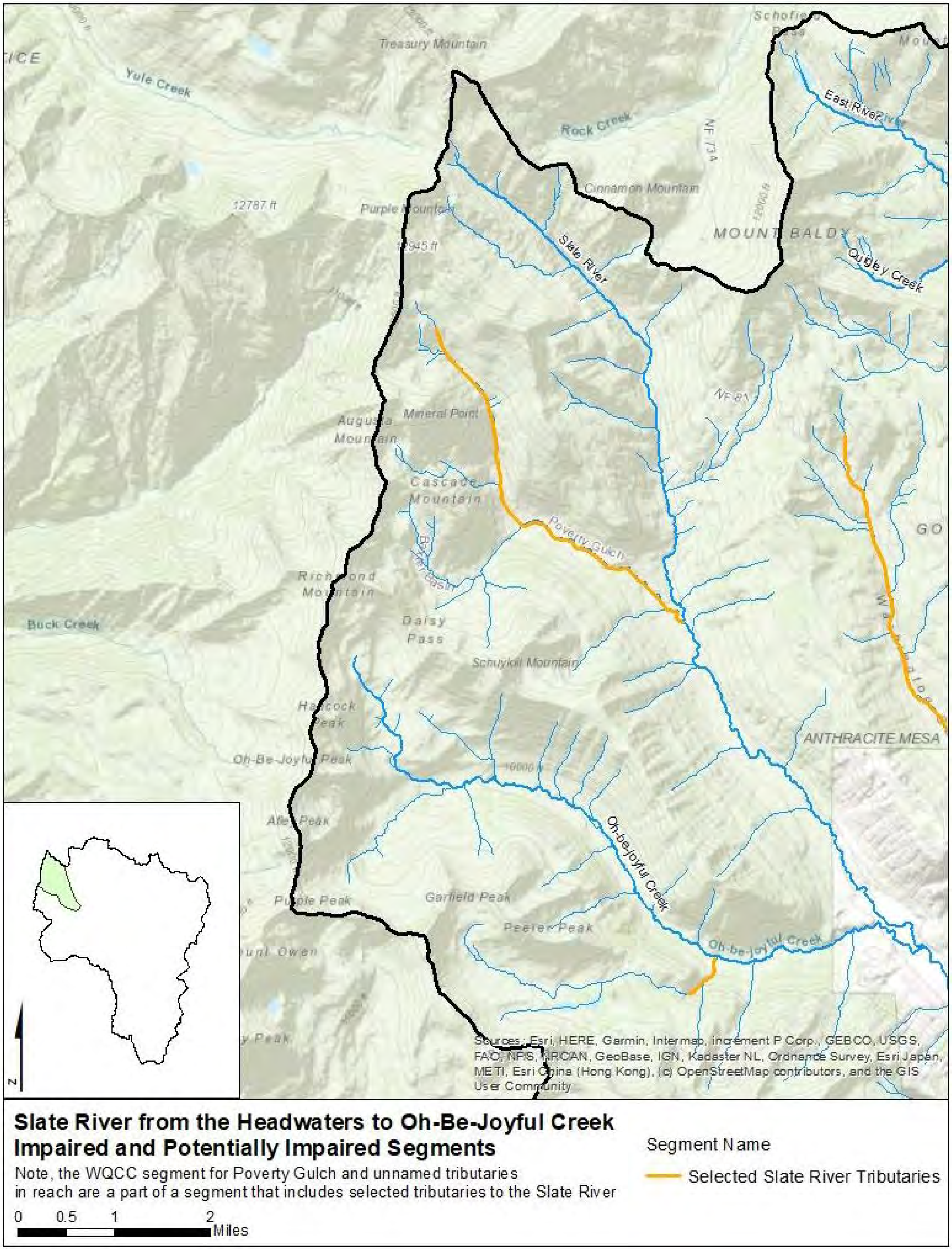


Figure 10-1: Impaired and potentially impaired reaches in the Slate River from its headwaters to the confluence with Oh-Be-Joyful Creek

11.3.4 Water Temperature

The BLM installed a temperature sensor in the Slate River upstream of the Oh-Be-Joyful Creek on the lower portion of this reach. The sensor collected continuous temperature data from the fall of 2012 to the fall of 2015 (three summers). During that period, water temperatures attained the chronic and acute temperature standards applied to protect sensitive cold-water species.

11.3.5 Existing Instream Flow Rights

The Slate River from the headwaters to the confluence with Poverty Gulch has a 5 cfs year-round instream flow rate, as shown in Figure 11-2. Poverty Gulch has two instream flow water rights, and both are applied year-round. The upper segment starts at the headwaters of Poverty Gulch and continues to the confluence with Baxter Creek (a local name for an unnamed tributary); the rate on the upper reach is 3 cfs. The lower segment begins at the confluence with Baxter Creek and ends at the confluence with the Slate River and has a year-round rate of 5 cfs

The Slate River from Poverty Gulch to Oh-Be-Joyful Creek has a seasonal instream flow water right that includes four flow tiers with two appropriation dates). The original instream flow proposal was developed by CWCB and CPW staff in 1980 and 1981. The proposal documents indicate that the original instream flow water right does not fully meet the criteria to support minimum flows to protect aquatic life. In 2014 the BLM staff, in partnership with High Country Conservation Advocates, created a proposal to increase the instream flow rights by 30 cfs May 1st to July 15th to better characterize the range of flows required during runoff to support aquatic life and preserve the natural environment.

Figure 11-2: Existing instream flow water rights on the Slate River from its headwaters to the confluence with Oh-Be-Joyful Creek.

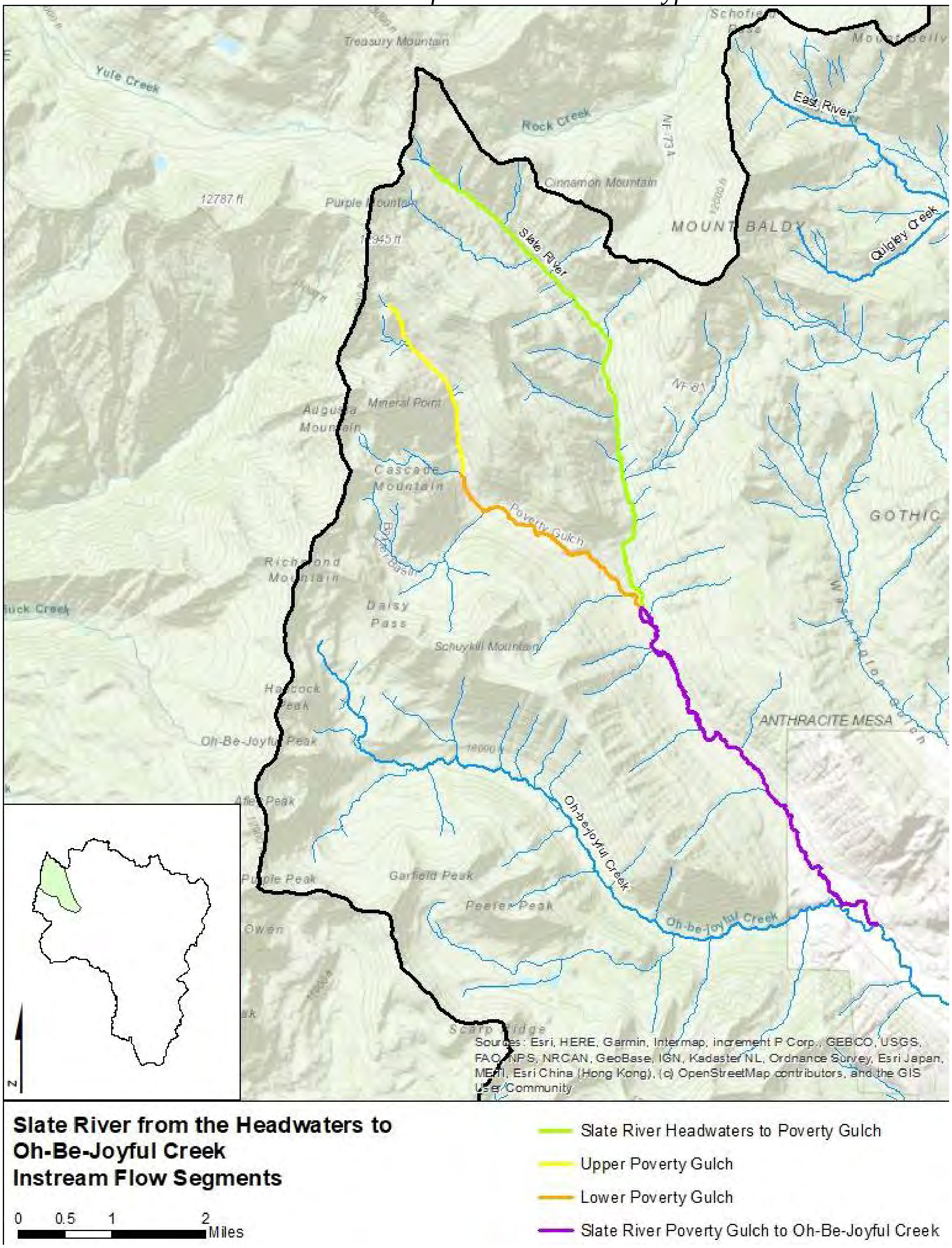


Figure 11-2: Existing instream flow water rights on the Slate River from its headwaters to the confluence with Oh-Be-Joyful Creek

11.3.6 Flow-limited Areas

There are very small water rights near the old mining town of Pittsburgh, upstream of the confluence of the Slate River and Poverty Gulch, but no diversions for irrigation in this reach.

The headwaters of the Slate River to Oh-Be-Joyful Creek are snowmelt dominated systems that flow in response to natural climate and precipitation patterns. There are no diversions in this reach. Flow-limited areas were not identified.

11.3.7 Environmental Flow Goals

Stream flow in the headwaters of the Slate River is natural, except for very minor water use near Poverty Gulch. Flow in each of the tributaries is also natural. Changes in current land and water uses are not expected. Due to the natural hydrology of the reach and lack of water use, environmental flow goals are not required in the headwaters of the Slate River. However, flows within this reach support downstream uses and as such the current conditions should be maintained for the benefit of the natural environment in this reach and downstream water users. In 2019, local Stakeholder groups weighed in on the US Forest Service's wild and scenic eligibility process to advocate for the inclusion of the Slate River for wild and scenic eligibility for recreational and ecological attributes. Wild and scenic eligibility may provide an additional layer of protection for this reach.

11.4 Recreational Water Use

The Upper Slate River and its tributaries are popular reaches for advanced Class V(-) and V(+) whitewater kayaking. These reaches are included in *Whitewater of the Southern Rockies* guidebook. The technical creek runs feature large waterfall drops and bedrock slides. Additional details on each reach are provided below.

Upper Slate River (aka North Fork of the Slate, Big Woody, or Big Wood Falls)

Use: Whitewater kayaking.

Description: The Slate River from Yule Pass to Pittsburg, approximately. Put-in is above Big Wood Falls and take-out is at Pittsburgh or OBJ Campground. The reach is about 1 mile long and classified as class V(-).[35]

Poverty Gulch (aka Daisy Creek)

Use: Whitewater kayaking.

[35] Stafford and McCutchen (2007). *Whitewater Guide of the Southern Rockies.* Pgs. 132-134.

Description: Poverty Gulch from the confluence of Baxter and Augusta Creeks to confluence with the Slate River at Pittsburgh. The large waterfalls in the reach are rarely run. Most use occurs on the lower portion of the reach, much of which is on private land.

Upper Slate River- Wicked Wanda

Use: Whitewater creek boating and kayaking.

Description: The put-in is near Musicians Camp if flows permit boaters can continue to Oh-Be-Joyful Campground; however, it is common to run a shorter section of the reach. The run is about two miles long and classified as V(+).

Recreational users enjoy the technical nature of these reaches and the overall proximity to the Town of Crested Butte. Woody debris is a serious hazard in these reaches. Due to the hydraulics, waterfalls, and canyon sections expert decision-making and an ability to self-rescue is required on these reaches. The local boating community has a strong ethic that promotes respecting the river and being self-sufficient. Some stakeholders, including boaters and first responders, identified a need to educate visiting boaters about the inherent risks of the headwaters of the Slate River.

Stakeholders also noted that there are several social trails from boaters and other visitors on several portions of these reaches. Recreational survey summaries are included below.

Other recreational uses in the Upper Slate River include camping, hiking, and motorized and non-motorized sports. The Oh-Be-Joyful Campground and Musicians Camp are two camping areas and there is dispersed camping in several areas. Due to heavy recreational use in this area, several toilets were installed at both campgrounds to improve water quality in the Slate River and overall aesthetics.

11.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Domestic wells. Promote water quality sample analysis. Because of the limited data collected to date and the potential for elevated arsenic concentrations due to the local geology, we recommend that domestic well owners sample their wells.

Issue: Multiple stakeholders are concerned about increasing use in the headwaters of the Slate River. This issue can be further classified in four areas:

- Some are concerned about potential water quality impacts, such as E. coli and nutrient concentrations, attributed to increased recreational use.
- Some are concerned about isolated impacts in specific areas (e.g. roads to access dispersed camping site causes site-scale impacts to riparian or wet meadow vegetation and increases erosion at a local-scale)
- Some are concerned about increased recreational use (camping, hiking, fishing, etc.) and a perceived lack of management and lack of infrastructure.
- Some are concerned that traffic and roads in the headwaters of the Slate River may alter natural sediment transport.

Issue: Access to popular river put-in at Poverty Gulch. The Crested Butte Land Trust holds an easement with a private property owner. There is an easement on the road right of way to allow access to Poverty Gulch which is a Forest Service road. High flows often make the Slate River impassable to vehicles. As a result, boaters and other recreational users often park on the gravel bars. Currently, parking is not allowed on the gravel bar adjacent to the river. Vehicles that attempt to cross at this location may become stuck during high flows.

Section 12. Reach 8 - Oh-Be-Joyful Creek

The headwaters of Oh-Be-Joyful Creek form in the south facing basin below Richmond Mountain (12,491 feet). Oh-Be-Joyful Creek tumbles down several steep faces to the confluence with the drainage from Blue Lake which is in the north facing basin beneath Purple Peak. The upper two-thirds of the Oh-Be-Joyful Watershed is in the Raggeds Wilderness. Oh-Be-Joyful Creek flows into the Slate River just upstream of Gunsight Pass Pedestrian Bridge.

12.1 Agricultural Water Use

There are no diversions for agricultural use in this reach and no identified needs in the future. Ranchers run cattle up this reach, but they primarily rely on natural surface water sources.

12.2 Domestic Water Use

There are no diversions for household, municipal, or industrial use in this headwater reach. A considerable portion of the Oh-Be-Joyful Creek Watershed, below the wilderness boundary, lies within the unpatented portion of the mine claims associated with the Keystone Mine. If mining were to occur, the Oh-Be-Joyful Creek Watershed would be impacted by mine operations.

12.3 Environmental Water Use

Upper Slate River Watershed Plan[36], prepared by the Coal Creek Watershed Coalition (CCWC), was a valuable reference for this assessment.

12.3.1 Stream and Riparian Characteristics

In 2012, CCWC commissioned a geomorphic assessment of the Upper Slate River Watershed to address several stream stability and sediment transport issues identified by stakeholders. The 2012 geomorphic assessment[37] is referenced frequently in this section.

Glaciers carve the steep U-shaped valleys and basins in the Oh-Be-Joyful Watershed and deposited glacial till on the valley floor. Lateral moraines deposited glacial till on many of the valley hillslopes and create the bench-like features found on several slopes. Lateral moraines can support small surficial aquifers that support non-riparian wetlands.

---

[36] *The Upper Slate River Watershed Plan* and associated outreach documents are available at http://www.coalcreek.org/documents-and-data.html

[37] Alpine Eco and EcoMetrics, 2012. *Upper Slate River Geomorphic Assessment Gunnison County, Colorado.* Prepared for the Coal Creek Watershed Coalition.

Slopes are covered with bedrock, talus or a thin veneer of soil. Vegetation communities include alpine tundra dominated by grasses and forbs, and spruce-fir forests. The streams, which are both intermittent and perennial, are steep entrenched channels that are often scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages.

Due to the steep slopes and the materials found on the slopes, hillslopes in the headwaters of Oh-Be-Joyful Creek are naturally susceptible to mass erosion which includes landslides, earth flows, debris avalanches, debris flows, torrents, and snow avalanches. These sporadic events provide massive natural sediment sources. Evidence of recent mass erosion is very common throughout the headwaters of Oh-Be-Joyful Creek. Natural mass erosion events are probable throughout the headwaters area. These natural hillslope processes are an enormous source of sediment to Oh-Be-Joyful. These events form the backdrop that human impacts must be evaluated against. In 2011, Briebart[38] 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.

Willows and riparian vegetation have colonized portions of narrow stream corridors in larger headwater tributaries where sediment deposition has supported soil development. Several basins have small lakes and large wetland complexes support a variety aquatic and wildlife habitat.

Aside from site-scale disturbances that occasionally occur near trails, the riparian area is undisturbed. Grazing occurs within the Oh-Be-Joyful Watershed. Although over-grazing can shift the composition of riparian vegetation or disturb the stream banks or vegetation due to trampling or compaction, these effects are not known to occur at a meaningful scale in the Oh-Be-Joyful Watershed.

12.3.2 Aquatic Life

The geology of the basin leads to a wide array of aquatic habitat in Oh-Be-Joyful Creek. In some areas the channel is scoured to bedrock which precludes the presence of macroinvertebrates in river sediments. There are multiple waterfalls that prevent fish passage, which leads to multiple distinct fish communities. Areas that lack fish may have particularly unique macroinvertebrate communities (i.e. more sensitive and rare species due to a lack of predation).

Oh-Be-Joyful Creek downstream of Redwell Creek has elevated metal concentrations due to drainage from historic abandoned mine and natural geologic features in Redwell Basin. In recent years, BLM, CCWC, and the Water Quality Control Division collected a total of four macroinvertebrate samples from Oh-Be-Joyful Creek. The macroinvertebrate samples, while

[38] Personal communication, Andrew Briebart, BLM, 2011.

variable in nature, attained the aquatic life use criteria. Macroinvertebrates are not known to have been sampled in Oh-Be-Joyful Creek upstream of Redwell Creek. Given that the macroinvertebrate community downstream of Redwell Creek attains the aquatic life use, it is reasonable that the portion of Oh-Be-Joyful Creek upstream of a large metal source, Redwell Creek, would also attain the aquatic life use.

In 2013, CPW surveyed fish 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 had robust riparian vegetation. The fish community is considered resident because the surveyed reach is isolated from the Slate River. A waterfall upstream of the survey area may preclude or limit upstream migration in Oh-Be-Joyful Creek. The fish density, for both brown and brook trout, was higher in Oh-Be-Joyful Creek than measured in the Slate River based on recent surveys.

12.3.3 Water Quality

Metals that originate from historic abandoned mines and natural features impair water quality in Redwell Creek. Redwell Creek and the adjacent features accounted for 75 percent of the water quality exceedances measured from 1995 to 2010. Redwell Creek delivers metals to Oh-Be-Joyful Creek, and Oh-Be-Joyful Creek below Redwell Creek accounted for 10 percent of the exceedances. With few exceptions, water quality in Oh-Be-Joyful Creek above Redwell Creek met water quality criteria and accounted for less than 1 percent of the exceedances. Conservatively, Redwell Basin was the origin of 85 percent of the pollution in the Upper Slate River Watershed. Although Oh-Be-Joyful Creek provides dilution, it is evident that metals that originate in Redwell Creek reach the Slate River, as shown in Figure 12-1.

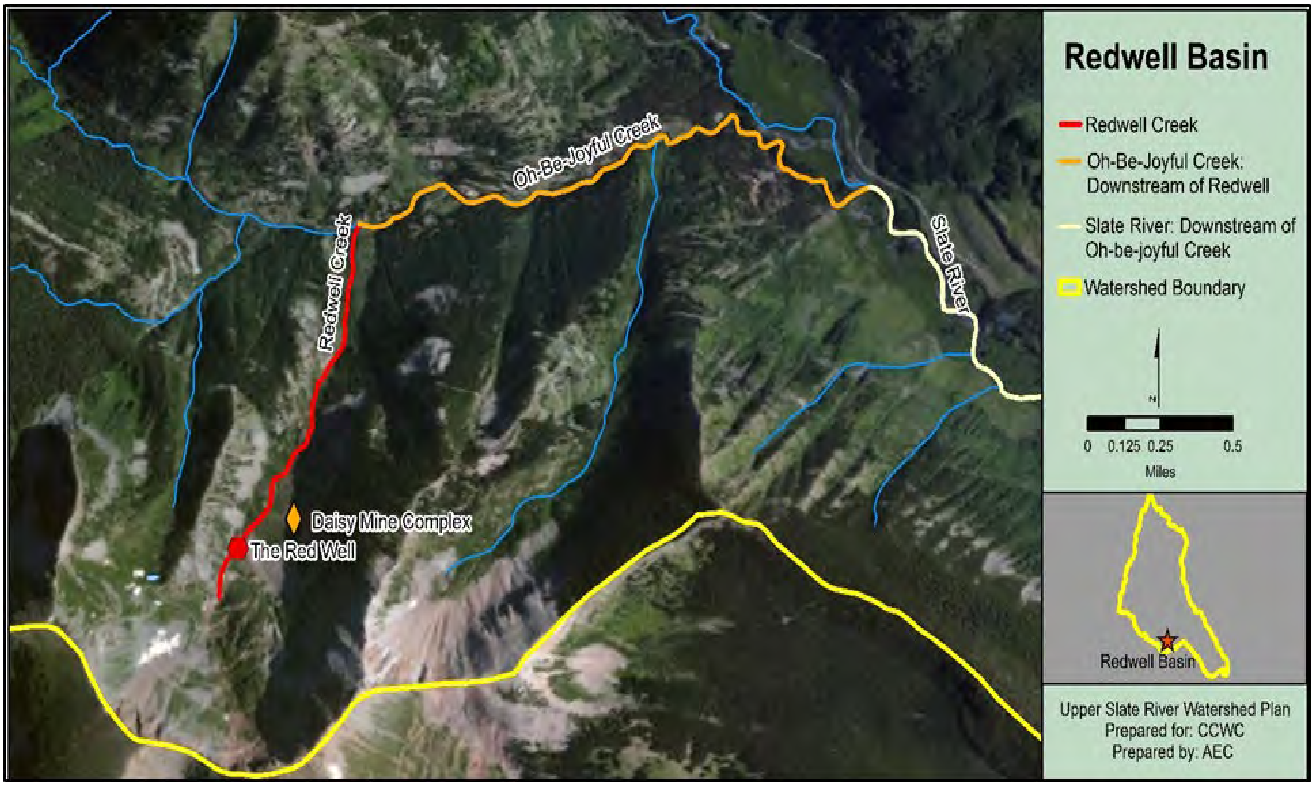


Figure 11-1: Metals that originate from historic abandoned mines and natural features pollute Redwell Creek. Redwell Creek, which has elevated concentrations of several metals, flows into Oh-B-Joyful Creek which is tributary to the Slate River. The effect of metals from Redwell Basin is apparent is Redwell Creek, Oh-Be-Joyful Creek and the Slate River.

The Upper Slate River Watershed Plan identified three major projects to improve water quality in the Redwell Basin which will affect the Oh Be Joyful watershed. To date, two of three projects have been completed, including the drill hole closure and reclamation at the Gunsight Processing Area.

The improperly abandoned drill hole in Redwell Basin was closed in 2012. Metal concentrations have declined following the drill hole closure. Additional water quality characterization could be useful to better understand the benefits of the drill hole closure project.

The Gunsight Processing Area was reclaimed in the fall of 2017. Initial post-project monitoring results suggest the reclamation project substantially reduced or eliminated acidic metal-rich seeps that originated from mine waste on the site. Post-project monitoring will continue in 2019. Weed control and reseeding are occurred in 2019.

Photo 12-1: The Daisy Mine Complex and Gunsight Pass Road in Redwell Basin, a tributary to Oh-Be-Joyful Creek

Photo 12-1 shows the Daisy Mine, on the East side of Redwell Basin, which once produced silver, copper, and zinc. Exploration began in the late 1800s and the mine operated sporadically until the 1970s. The mine was abandoned prior to the adoption of modern reclamation laws. The mine has multiple levels of underground tunnels with several portals. 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 water quality standards by two to four orders of magnitude for zinc, cadmium, copper and iron. The Daisy Mine is the single largest source of zinc in Redwell 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 in 2012. CCWC, the Colorado Division of Reclamation Mining and Safety continue to plan for reclamation at the Daisy Mine.

USGS and DOE researchers are studying the interaction of ground and surface water in Redwell Basin. Their studies will help inform reclamation design at the Daisy Mine and will help identify suitable water quality goals for the reclamation effort.

Redwell Creek is impaired for the aquatic life use due to elevated concentrations of cadmium, lead, copper, zinc, and macroinvertebrates. Redwell Creek is classified as potentially impaired for pH and silver based on the aquatic life standards (Table 12-1; Figure 12-2).

In 2018, the headwaters of Oh-Be-Joyful Creek (located in wilderness) were listed as impaired for total recoverable arsenic for the water supply use (Table 1; Figure 2). The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. The data that resulted in the listings were collected from Oh-Be-Joyful Creek immediately upstream of the confluence with Redwell Creek**.**

Table 12-1: Impaired and potentially impaired portions of Oh-Be-Joyful Creek.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
All tributaries to the Gunnison River, including wetlands, within the Raggeds Wilderness Area.	Water Supply Use	Dissolved Iron	NA	NA
		NA	Total Arsenic	High
Mainstem of Oh-Be-Joyful Creek from the boundary of the Raggeds Wilderness Area to the confluence with the Slate River	Aquatic Life Use	NA	Dissolved Cadmium	High
		NA	Dissolved Copper	High
		NA	Dissolved Lead	NA
		NA	Dissolved Zinc	High
		NA	Macroinvertebrates	High
Tributaries to Oh-Be-Joyful Creek not in the Raggeds Wilderness Area	Aquatic Life Use	NA	Total Arsenic	High
Redwell Creek and all tributaries and wetlands	Aquatic Life Use	pH	NA	NA
		Dissolved Silver	NA	NA
		NA	Dissolved Cadmium	High
		NA	Dissolved Lead	High
		NA	Dissolved Zinc	High
		NA	Dissolved Copper	High
		NA	Macroinvertebrates	High

Due to extensive recreational use throughout the summer, Oh-Be-Joyful Creek upstream of the confluence with the Slate River will be sampled as part of the 2019 *E. coli* study.

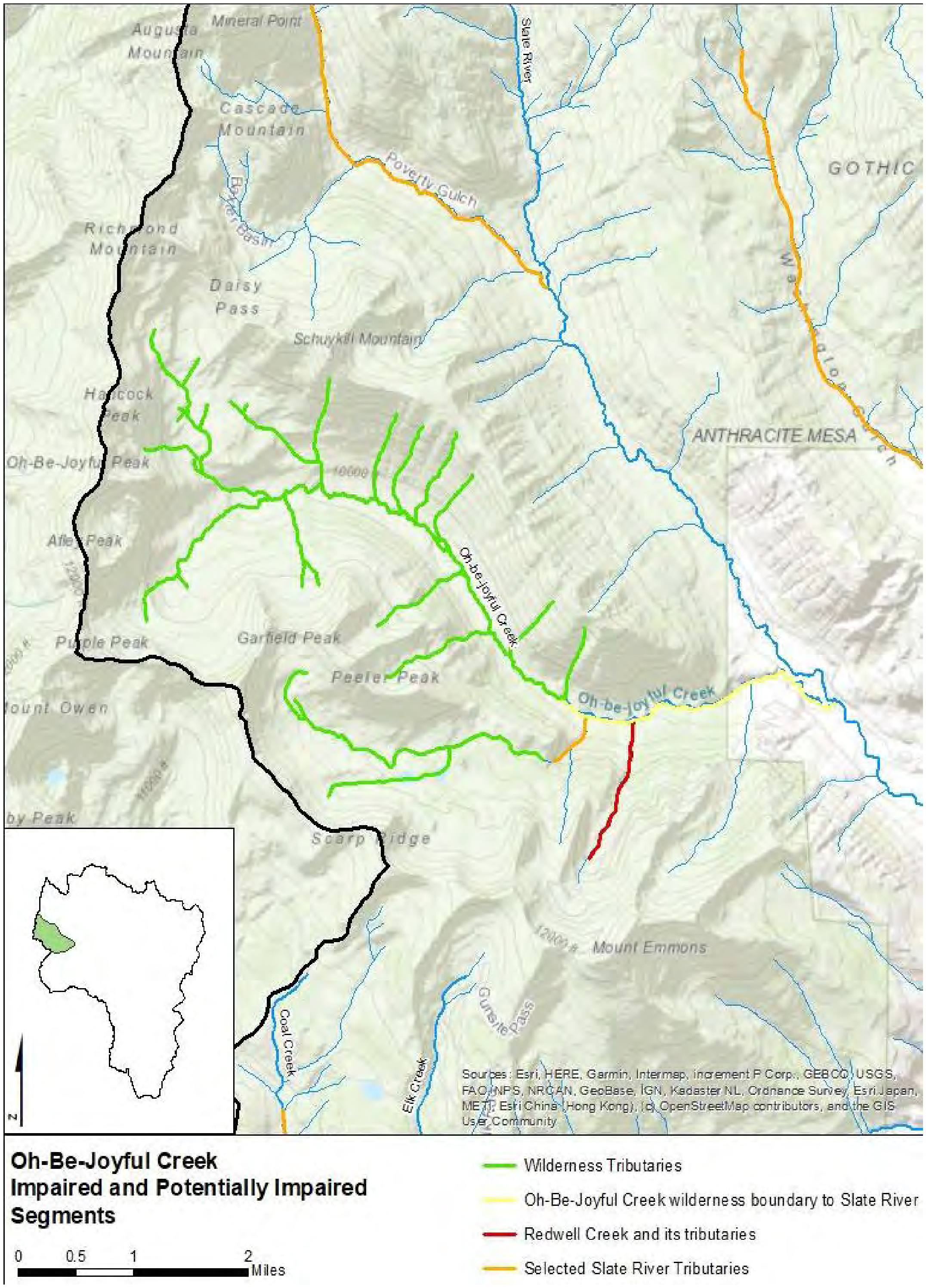


Figure 12-2: Impaired and potentially impaired stream reaches and tributaries in Oh-Be-Joyful Creek

12.3.4 Water Temperature

Continuous water temperature measurements are not known to have been collected in this reach. Water temperature is currently a data gap. However, due to the elevation and natural hydrology of Oh-Be-Joyful Creek and its tributaries, it is unlikely that temperature standards used to protect sensitive aquatic life would be exceeded.

12.3.5 Existing Instream Flow Rights

Oh-Be-Joyful Creek from the confluence of the Blue Lake drainage to the confluence with the Slate River has a seasonal instream flow water right, as shown in Figure 12-3, that includes four flow tiers with two appropriation dates. The original instream flow proposal was developed by CWCB and CPW staff in 1981. In 2014 the BLM staff partnered with High Country Conservation Advocates to increase the instream flow rights by 3 cfs from April 1^{st} to April 30^{th} and July 1^{st} to August 15^{th}, and by 14 cfs from May 1^{st} to July 15^{th}. This proposal better characterizes the range of flows required to support aquatic life and preserve the natural environment on Oh-Be-Joyful Creek.

The headwaters from the outlet of Blue Lake to the confluence with Oh-Be-Joyful Creek have a year-round instream flow rate of 1 cfs.

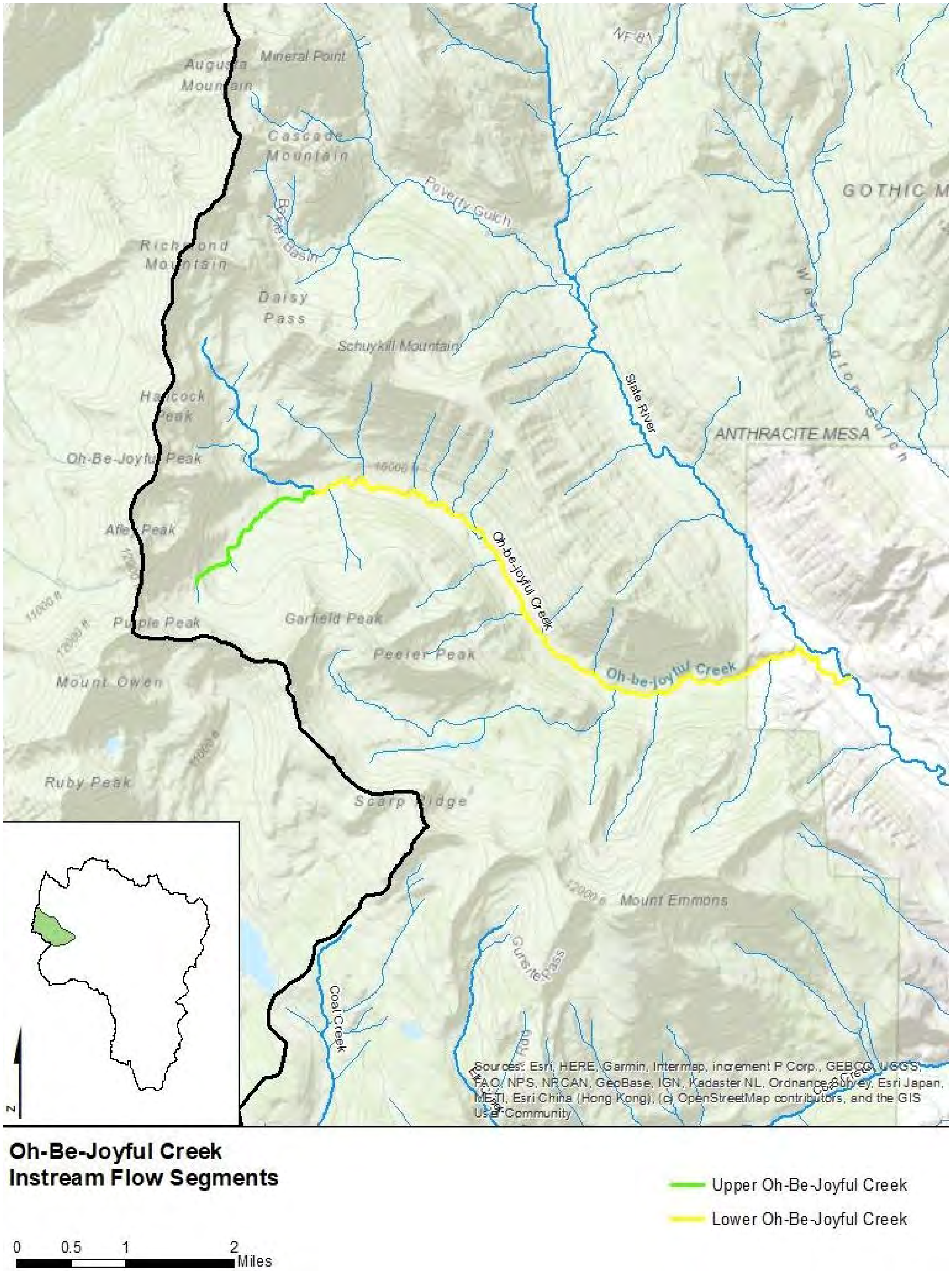


Figure 12-3: Instream flow water rights in Oh-Be-Joyful Creek

Flow-limited Areas

The Oh-Be-Joyful Creek Watershed is a snowmelt dominated system that flows in response to natural climate and precipitation patterns. There are no diversions in this reach. Flow-limited areas were not identified.

12.3.6 Environmental Flow Goals

Stream flow in Oh-Be-Joyful Creek is entirely natural. Flow in each of the tributaries is also natural. Changes in current land and water uses are not expected. Due to the natural hydrology of the reach and lack of water use, environmental flow goals are not required in the headwaters of the Oh-Be-Joyful Creek. However, flows within this reach support downstream uses and, as such, the current conditions should be maintained for the benefit of the natural environment in this reach and downstream water users.

The beauty and solitude of the basin combined with unique habitat (including fen ecosystems in Redwell Basin) and outstanding recreational opportunities, warrant additional protections. Oh Be Joyful Creek has been identified in the US Forest Service's Draft Wild and Scenic Eligibility Evaluation as having four eligible segments. Similarly, the BLM has identified Oh Be Joyful as eligible for Wild and Scenic designation in the BLM's 2009 Wild and Scenic River Eligibility Report. Special designation may be compatible with other local planning efforts. In the Gunnison Public Lands Initiative Report, the Oh-Be-Joyful basin was one of the areas identified by local stakeholders as appropriate for designation as a special management area for recreation and wildlife. Because of these unique attributes, Oh-Be-Joyful may be an excellent candidate for Wild and Scenic designation.

12.4 Recreational Water Use

Oh-Be-Joyful Creek from the wilderness boundary to near the Slate River is a popular whitewater kayaking reach, where class increases as flow increases. The run can begin and end at several different points along the reach but the most common put-in is immediately below the wilderness boundary and the take-out is above a significant slide fall above the confluence with the Slate

Photo 12-2: Expert kayakers enjoying Oh-Be-Joyful Creek during peak flow in late June 2019. Photo courtesy of the Oh-Be-Joyful Race.

River. The technical creek run features several large waterfall drops, as shown in Photo 12-2. An increasingly popular race, hosted by the Western Colorado University Whitewater Club, occurs when there is sufficient runoff. Recreational use is summarized below.

Recreational users enjoy the technical nature of this reach and the overall proximity to the Town of Crested Butte. Woody debris is a serious hazard in this reach. Due to the hydraulics, waterfalls, and canyon walls, expert decision-making and an ability to self-rescue is required on this reach. The local boating community has a strong ethic that promotes respecting the river and being self-sufficient. Some stakeholders, including boaters and first responders, identified a need to educate visiting boaters about the inherent risks of this reach.

Stakeholders also noted that there are several social trails, which are informal trails created by erosion due to foot traffic from people and animals, from boaters and other visitors on several portions of the stream. The lower portion of the reach could benefit from additional management to consolidate existing trails and reduce the formation of new trails.

12.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Oh-Be-Joyful Creek is a top-notch Class V whitewater kayak run with incredible scenery, and relatively easy access. Like other forms of recreation in the East River Watershed, whitewater kayaking is becoming more popular. Stakeholders identified a range of concerns including:

- Lack of formal trail system increases the number of trails and overall disturbance.
- Lack of facilities, including bathrooms and designated camping areas, may create water quality issues. Note, BLM is increasing the capacity of Oh-Be-Joyful campground which may help alleviate this issue to some extent.
- Safety infrastructure was identified as a need. Ideas included fixed anchors, ladders, and access to road for emergency situations.
- Excellent recreational resource lacks adequate protection.

Issue: Oh-Be-Joyful Creek is eligible for wild and scenic designation in BLM planning documents and draft USFS planning documents. There is an initial level of local support for this designation. Additional stakeholder discussion is necessary to determine whether local entities should advocate for designation.

Issue: The Daisy Mine, a historic abandoned mine in Redwell Basin, impacts water quality in Redwell Creek, Oh-Be-Joyful Creek, and the Slate River.

Section 13. Reach 9 - Slate River from Oh-Be-Joyful Creek to Coal Creek

This reach begins at the confluence of the Slate River and Oh-Be-Joyful Creek, the epicenter of one of the most popular recreation areas in the East River Basin. Oh-Be-Joyful Campground is immediately upstream of this reach. The Gunsight Pass Pedestrian Bridge spans the Slate River to connect many of the most beloved and popular hiking and biking trails in the Crested Butte area just below the confluence with Oh-Be-Joyful Creek. In the winter this reach provides excellent Nordic and backcountry skiing. Conservative estimates suggest that up 100,000 recreational visitors enjoy this reach each year.

Like Crested Butte, this portion of the Slate River was once home to mining activities. Rail lines followed the valley margins to haul hard rock ore from the Augusta, Daisy, Pittsburg, and smaller mines in the headwaters to the Peanut Mine processing area. Peanut Mine and Smith Hill were sizable coal mines. Portions of the Lower Loop trail were built on the old rail line and coal refuse remains scattered along the route.

Downstream of Gunsight Pass road, public and private lands, much of which are preserved through conservation easements, support outstanding wetland habitat as the Slate River gracefully flows to the confluence with Coal Creek just northeast of Crested Butte.

In 2014, the Coal Creek Watershed Coalition (CCWC) finalized the Upper Slate River Watershed Plan. In 2018, the Town of Crested Butte (Town) and the Crested Butte Land Trust (Land Trust) convened the Slate River Working Group, an 18-member consensus-based stakeholder group, to develop a floating management plan for the Slate River and to address potential wildlife impacts from recreation. These planning efforts have generated significant momentum to address water quality and recreation issues. Thus, this assessment summarizes existing plans and introduces additional elements to the watershed management planning effort.

13.1 Agricultural Water Use

There are two active irrigation diversions in the Slate River from Oh-Be-Joyful Creek to Coal Creek reach that serve approximately 31 acres of flood irrigated pasture grass. Table 13-1 shows the combined water rights and crop demands. The diversion records in this reach are missing a significant portion of the analysis period, and it is unclear if the recorded diversions prior to the current water commissioner include diversions to storage in Peanut Reservoir. Therefore, it is not reasonable to estimate actual crop consumptive use and shortages. However, based on the available records, it is likely that the ditches experience physical shortages in the late summer and fall.

Table 13-1: Agricultural water use statistics for the Slate River from Oh-Be-Joyful Creek to Coal Creek.

Reach Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	2	n/a
Irrigated Acreage	31	n/a
Water Rights	11.667	n/a
Crop Demand	50 acre-feet	40 - 920 acre-feet

Figure 13-1 shows the headgate diversion locations, ditch alignment, and irrigated acreage in this reach. The ditches are unlined and estimated to lose 20 percent of diverted water during delivery to the irrigated field. Return flows from this reach accrue to the Slate River above the confluence with Coal Creek.

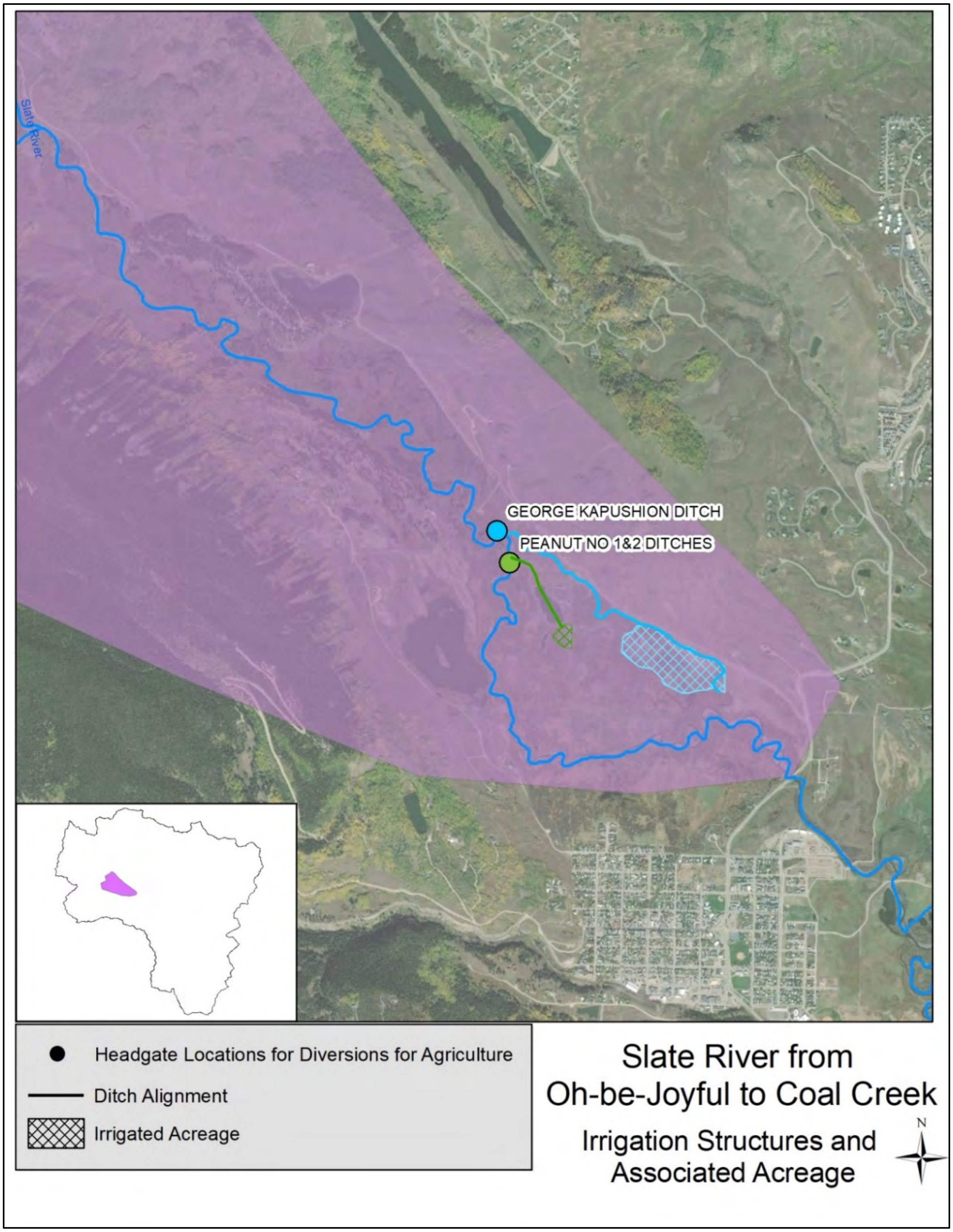


Figure 12-1: Diversion structures and irrigated acreage in the Slate River from Oh-Be-Joyful Creek to Coal Creek reach

13.2 Domestic Water Use

Mt. Emmons Mining Company holds a 30 cfs conditional water right with a 1996 appropriation date. Previous iterations of the mine plan of operations proposed a large water diversion from the Slate River in the vicinity of Gunsight Bridge. When in priority, such a diversion would severely impact the fishery and downstream habitat.

The Wildbird and Nicholson Lake communities and other homes in this reach rely on water from wells or springs and use on-site wastewater treatment systems. The Wildbird community's well was last sampled in October 2014. Metal concentrations and other constituents in the sample attained water supply standards. Additional homes may be built in the future.

13.3 Environmental Water Use

13.3.1 Stream and Riparian Characteristics

In 2012, Coal Creek Watershed Coalition (CCWC) commissioned a geomorphic assessment of the Upper Slate River Watershed to address several stream stability and sediment transport issues identified by stakeholders. The 2012 geomorphic assessment[39], and several other documents[40][41][42], are referenced throughout this section. In the past several years, multiple projects have been implemented to address some of the concerns identified in the 2012 study. This summary focuses on issues that have not been addressed.

Downstream of Gunsight Bridge the Slate River valley opens to an alluvial river valley. A terminal moraine lies near Gothic Road. The moraine acts as a grade control and decreases the river gradient, which allowed glacial and river sediments to accumulate in upstream reaches. A landslide formed the outlet of what is now Nicholson Lake. 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.

The river channel in the alluvial valley is comprised of gravels rather than cobbles, boulders, and bedrock which dominate the channels found upstream. The 2012 geomorphic assessment found that the current channel form is over-wide, entrenched or braided in selected segments due

[39] Alpine Eco and EcoMetrics, 2012. *Upper Slate River Geomorphic Assessment Gunnison County, Colorado.* Prepared for the Coal Creek Watershed Coalition.
[40] Cooper, 1993. *Wetlands of the Crested Butte Region, Mapping Functional Evaluation Hydrologic Regime.* Prepared for the Town of Crested Butte.
[41] Rocchio, J., Doyle, G., Rondeau, R. (2004). *Survey of Critical Wetlands and Riparian Areas in Gunnison County.* Colorado Natural Heritage Program. Colorado State University. Available at http://www.cnhp.colostate.edu/download/documents/2004/Gunnison_County_Wetlands.pdf
[42] HRS- HRS Water Consultants, Inc. 1995. *Slate River Hydrology Study*. Prepared for the Town of Crested Butte, Colorado, 21 p.

largely to man-made stressors. Over-widening has the potential to lead to increased stream temperatures through expanding surface area of the water and shallowing. 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.

Historic and current land use practices from Wildbird Bridge to the lower end of Peanut Lake created the largest impacts in this reach. The most severe stressors found in this area are attributed to in-channel gravel mining that occurred in the 1970s. 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 that is still visible. The river channel has a perched, abandoned floodplain that is about two to three feet higher than the current bankfull elevation. These activities have negatively impacted channel stability and increased sediment production both upstream and downstream of the gravel mine area. 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.

The 2012 assessment found that the risk for excessive bank erosion, channel enlargement, and sediment deposition were likely to create additional degradation on the reach between Wildbird and Peanut Lake. Channel incision that originated near Wildbird continues as the Slate River approaches Peanut Lake. Like the incised reach upstream, further degradation is possible. Over time, these channel instabilities have pushed the Slate River west toward Peanut Lake. 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 Land Trust partnered with Alpine Eco and EcoMetrics to address some of the channel stability issues identified in the 2012 assessment.

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, the EPA, Gunnison County, the Gates Foundation, the Land Trust, 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.

Gothic Road Bridge (County Road 317) is a clear stressor to the Slate River. During high flow, the bridge constricts the floodplain, which forces water to back up above the bridge in the Slate River and to a lesser extent in Coal Creek. The decreased water velocity causes sediment to deposit in the channel. This process has created the enormous sediment bars and braided channel found upstream of the bridge. There are three constrictions in this area; 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.

The photo on the left shows the Slate River immediately upstream of County Road 317 during peak flow. Note the pooled water flooding into the wetlands. The loss of velocity contributes to the massive gravel bars visible in the aerial imagery in the right image (image courtesy of Google Earth). The depositional area attributed to the bridge extends approximately half a mile upstream. These gravel bars may contribute to stability issues up and downstream of the bridge.

As suggested in 2012, this area requires further study to identify potential solutions to improve river stability, flood control, and stormwater management. The information could be used to determine bridge dimensions that better align with the channel and floodplain, as well as provide for improved habitat. Gunnison County plans to replace the bridge soon. Aside from the County Road 317 Bridge, sediment or stability issues associated with roads in this reach were not identified.

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.

The Colorado Natural Heritage Program (CNHP) identified a significant portion of the Slate River as a Potential Conservation Area for the substantial biodiversity in the wetlands. The area identified was “almost the entire reach of the Slate River”[43]. As described in the CNHP Study, the upland slopes of the watershed host spruce, lodgepole pine, and aspen. Willows and beaver complexes in the river corridor support multiple globally vulnerable riparian plant communities including Geyer and Drummond willows. Approximately half of this ecologically important area is on private lands, with the rest on public lands managed by the USFS and BLM. The Land Trust has acquired land and easements to protect this area and the surrounding wetlands. In the last decade, The Land Trust has used exclusion fencing to protect sensitive riparian areas.

13.3.2 Aquatic Life

In recent years, Colorado Parks and Wildlife (CPW) has surveyed fish in the Slate River. Brook and brown trout are abundant in the Slate River. Fish densities are typically high, but fish tend to be somewhat small. In 2012, CPW surveyed two reaches in the Slate River near Oh-Be-Joyful Campground. The first location featured pools formed by large woody debris. 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. In fact, the pool habitats on the Slate River met the criteria for Gold Medal Waters (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.[44]

Three macroinvertebrate samples were collected from the Slate River in 2013, the composition and health of the macroinvertebrate communities attained the aquatic life use standard. However, the macroinvertebrate community in the Slate River immediately upstream of the County Road 317 Bridge did not score as well as other locations in the reach, potentially indicating that sediment deposition affects habitat quality. Anecdotal observations suggest that embeddedness (a

[43] CNHP Study Page 209.
[44] Dan Brauch, personal communication 2013.

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.

13.3.3 Water Quality

Metals that originate from abandoned mines are the most common pollutants in the Slate River between Oh-Be-Joyful Creek and Coal Creek. The most problematic metals are zinc, cadmium, copper, lead, and manganese. This finding is consistent with both the current and historical land uses in the Watershed.

Metals that originate from abandoned mines and natural features impair water quality in Redwell Creek. Redwell Creek delivers metals to Oh-Be-Joyful Creek. Conservatively, Redwell Basin is the origin of 85 percent of the pollution in the Slate River Watershed upstream of Coal Creek. Although Oh-Be-Joyful Creek provides dilution, it is evident that metals that originate in Redwell Creek reach the Slate River. The Slate River from Oh-Be-Joyful Creek to Coal Creek is listed as impaired for aquatic life use for arsenic, lead, and zinc and potentially impaired for cadmium, Table 13-2; Figure 13-3. Unnamed tributaries to the Slate River in this reach are also listed as impaired for arsenic. The samples that indicated impairment for the Slate River tributaries were collected in tributaries on other reaches.

Table 13-2: Impaired and potentially impaired portions of the Slate River from the confluence with Oh-Be-Joyful to the confluence with Coal Creek.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of the Slate River from Oh-Be-Joyful Creek to a point immediately above the confluence with Coal Creek	Aquatic Life Use	NA	Total Arsenic	High
		Dissolved Cadmium		NA
			Dissolved Zinc	High
			Dissolved Lead	High
Selected Slate River tributaries	Aquatic Life Use	NA	Total Arsenic	High

CCWC has collected a limited number of *E. coli* samples from the Slate River from Oh-Be-Joyful Creek to Coal Creek since 2011. Initial studies, in 2011, 2013, and 2017, found that *E. coli* concentrations attained the primary contact standard used to protect recreational users. The 2018 study found that *E. coli* concentrations may have exceeded the primary contact standard in the Slate River upstream of Coal Creek. The upstream extent of the problem is currently unknown. E. coli sample collection, along with flow and temperature monitoring, is underway in 2019. One of the study objectives is to determine the upstream extent of elevated *E. coli* concentrations in the Slate River. *E. coli* concentrations are a data gap in this reach. Further characterization of this issue is critical due to extensive recreational use in the Slate River from Coal Creek to Highway 135.

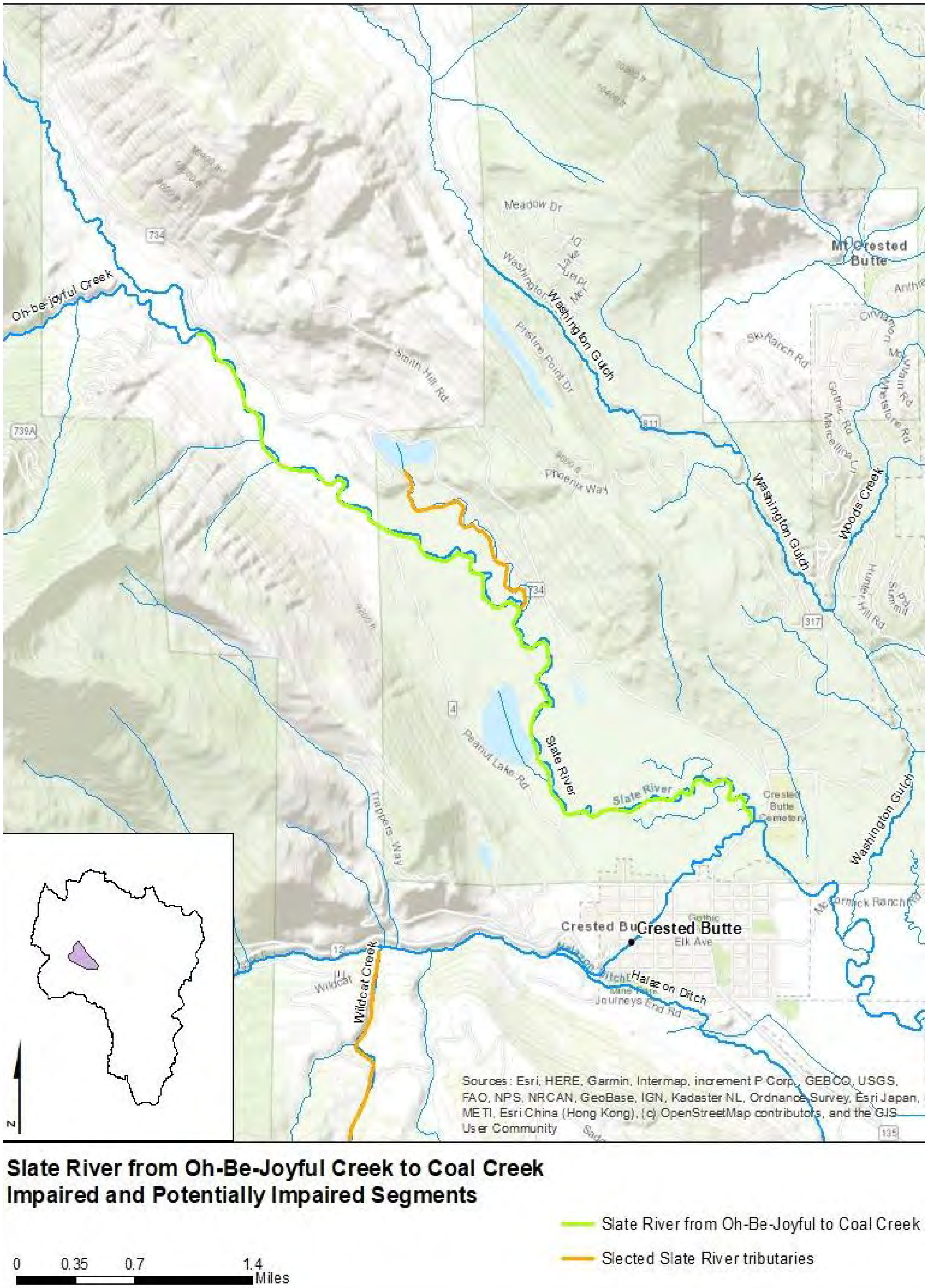


Figure 13-3: Impaired and potentially impaired stream reaches on the Slate River from Oh-Be-Joyful Creek to Coal Creek

13.3.4 Water Temperature

Continuous water temperature measurements are not known to have been collected in this reach. However, stream temperatures were measured in the Slate River upstream of Oh-Be-Joyful Creek. Given that there are no known thermal loads (e.g. major diversions, discharges, or hot springs) in this area, the temperatures measured in the Slate River upstream of Oh-Be-Joyful Creek should be representative of the Slate River from Oh-Be-Joyful Creek to Coal Creek.

13.3.5 Existing Instream Flow Rights

The existing instream flow water right was initially developed in 1980 by CWCB and CPW staff, as shown in Figure 13-4. In 2014 the instream flow water right was increased by BLM staff in partnership with High Country Conservation Advocates. BLM staff completed five R2CROSS assessments to support proposal development. The increase provides additional water during spring runoff to support flushing flows. The 2014 instream flow water right was a substantial increase. Nonetheless, the increased runoff rate of 65 cfs still only satisfies two of three R2CROSS criteria[45] because the physical and legal availability analyses resulted in a reduction to the instream flow rate.

[45] See Chapter 2, Section 1.2.

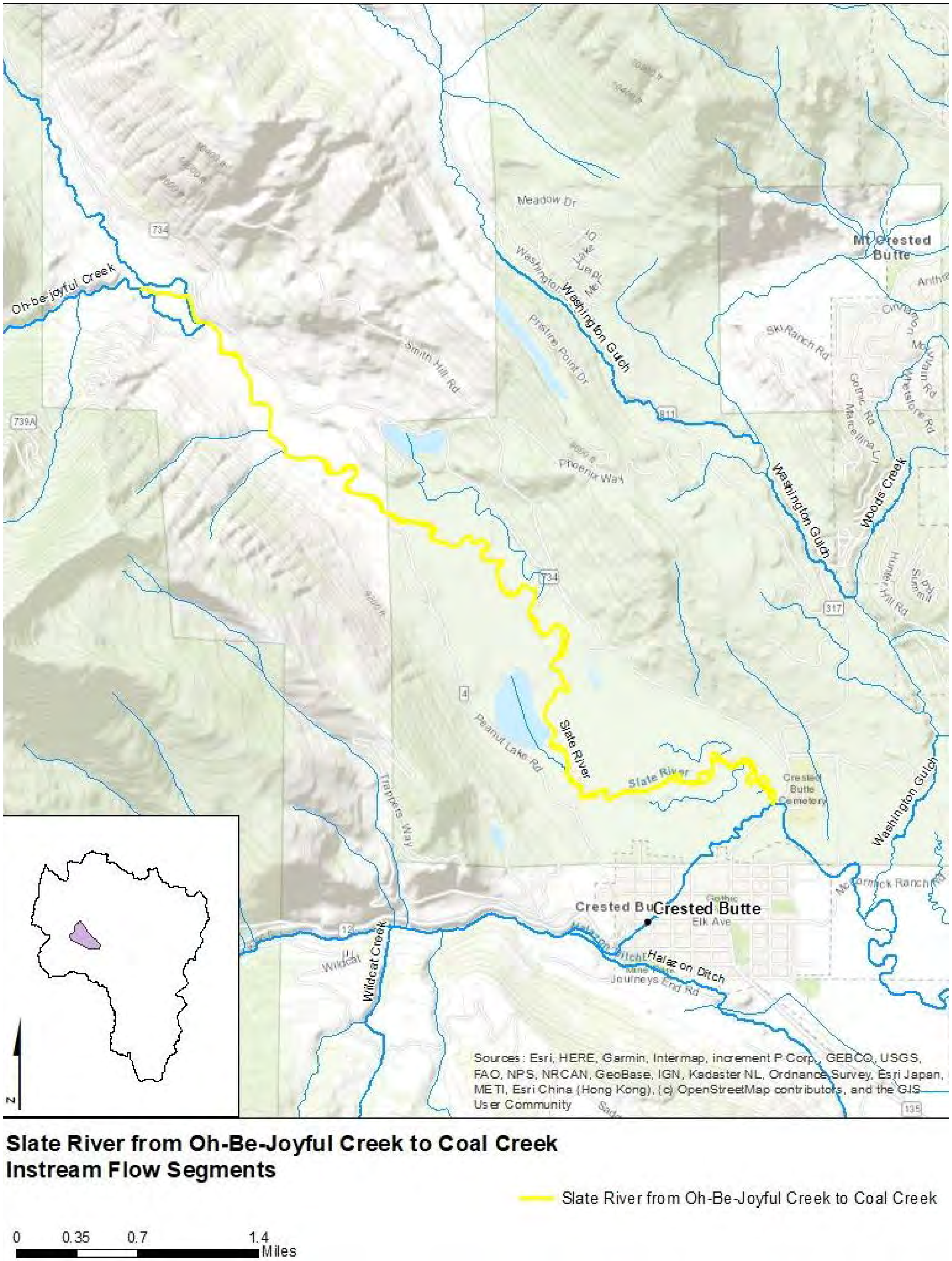


Figure 13-4: Instream flow rights for the Slate River from the confluence with Oh-Be-Joyful to the confluence with Coal Creek

13.3.6 Flow-limited Areas

There were no dry up locations identified in this reach. However, in isolated areas habitat connectivity may be an issue due to channel instability issues attributed to current and former land management practices (see Section 13.3.1).

13.3.7 Environmental Flow Goals

Stream flows in the Slate River from Oh-Be-Joyful Creek to Coal Creek are primarily a result of natural hydrology. Because of the status of the majority of the land along this reach, changes in current water uses are not expected, *unless conditional rights held on this reach are developed*. Therefore, at this time, developing traditional environmental flow goals is not currently a priority in this reach. However, the Slate River Working Group has developed a voluntarily no-float period from March 15 to July 15 to protect Great Blue Heron during sensitive incubation, hatching, and fledging periods. Preserving the Heron rookery, through a voluntary no-float period, is an alternative approach to environmental flow protections.

13.4 Recreational Water Use

This section relies heavily upon the 2019 Slate River Floating Management Plan[46].

Together, the Land Trust and Town have facilitated the conservation of over 1,000 acres in the Upper Slate River Valley, a landscape critical to the nature-driven quality of life valued by residents and visitors. As river-recreational use on the Slate River has intensified in the past five years, new concerns about habitat protection, water quality and private property rights have arisen.

In response, the Town and Land Trust convened a Working Group of 18 stakeholders with diverse perspectives to address emerging management challenges brought on by the increased river use. The goal of the Working Group was to provide input and partner in recommending river recreation management actions necessary for upholding the ecological integrity of the Slate River[47].

The Slate River Working Group identified a unique high-altitude heron rookery as an ecological asset that merits special protections. The river-dependent Great Blue Heron rookery, located on Land Trust property in this reach of the Slate River, is believed to be one of the highest in the country (8,900 feet above sea level).

The rookery sits in standing dead spruce trees directly above the Slate River and in adjacent wetlands, providing an ideal nesting and foraging area for the birds. These majestic birds practice

---

46 The 2019 Slate River Floating Management Plan is available on the Land Trust's website at: https://www.cblandtrust.org/wp-content/uploads/2019/05/2019-SRWG-Management-Plan_May-2019.pdf

47 The 2019 Slate River Floating Management Plan Executive Summary, page 3

site fidelity, and therefore return to the same nesting rookery each year. A 2018 study of the rookery finds it currently hosts up to 50 adult Great Blue Heron and more than 25 nests, making it a productive rookery (Magee, 2018)[48].

Recreational use in the Slate River Watershed has increased significantly in the last few years. This popular area accommodates recreation of all kinds including stand-up paddle boarding, hiking, biking, OHV, and others. The Slate River Working Group was developed to manage and address all concerns related to riparian habitat, water quality, and recreational use. The Working Group compiled a Slate River Floating Management Plan that represented a compromise between stakeholders and incorporates substantial feedback from the public. Major components of the plan are summarized below:

- The management solutions focus on seven key areas: private property rights, agricultural rights, wildlife, variable river flows, river etiquette, access and legal framework, and infrastructure needs.
- The proposed management solutions will be implemented over the short-term and long-term and focus on maintaining ecological integrity while also providing sustainable river-recreation opportunities.
- The solutions identified in the plan are adaptive management solutions that consider the need to collect additional data about river use, wildlife, and stream flows. In 2019 the following data will be collected:
    - Expanded study of blue heron
    - Increased survey of recreational users.
    - Additional flow analyses to better correlate recreational use with stream flows to establish high, medium, and low flows in the upper (Oh-Be-Joyful Campground to Recreation Path Bridge) and lower reaches (Recreation Path Bridge to Skyland Bridge).
- The management solutions include[49]
    - Improve fencing
    - Ask river users not to bring dogs
    - Institute and publicize a voluntary no-float period from March 15 to July 15 to protect Heron during biologically sensitive periods. The closure does not apply to portions of the river administered by the BLM.
    - After the closure, install signs to direct river users to be quiet while passing under the heron rookery.
    - Encourage and educate river users on the protocols for the quiet zone and other river etiquette

[48] Magee, P. and Zareba, M. (2018). *Ecology of the Great Blue Heron (Ardea Herodias) rookery on the Slate River, Crested Butte, Colorado and impacts of human activities: 2018 Pilot Study.*
[49] Please refer to the 2019 Slate River Floating Management Plan for complete details.

- Hire an intern to lead survey effort and public education.
- Develop and promote parameters for responsible river use
- Work towards a voluntary fee and or permit system to support additional education efforts
- Improve river access points
- Identify funding sources to implement infrastructure projects[50]

The Slate River Working Group is a group of local stakeholders and property managers whose primary goals are to maintain the integrity, habitat, and quality of the Slate River Watershed. The Slate River is crucial habitat to the Great Blue Heron, beavers, and other wildlife, supports a widespread wetland ecosystem, and is a popular recreational area for many sports.

To address increasing recreation, concern over the heron rookery, and watershed management, the Slate River Working Group developed a Slate River Floating Management Plan in 2019. The plan can be found on the Land Trust website[51], under "Our Projects" and Slate River Working Group. The Floating Management Plan includes preliminary recommendations on the Slate River is safe for floating and respectful to wildlife and property owners.

The voluntary closure extends through the segment of the Slate River running from Gunsight Bridge to the Town's Rec Path Bridge. The duration of the voluntary closure was identified based on heron behavior in the 2018 study. By July 15th, over 50 percent of the nests were vacant indicating that the heron had successfully reared chicks and migrated outside of the Slate River Watershed. Members of the Slate River Working Group identified 110 cfs as the minimum flow for recreational use based on observations from 2018 (as measured by the gage in the Slate River above Baxter Gulch). The minimum flow and voluntary closure end date were combined to estimate the floating season length for low, average, and high flow years, as shown in Figure 13-6. In a low flow year, like 2012, the voluntary closure eliminates an already short floating season. In an average year, like 2006, the voluntary closure may provide a very brief floating season; the duration of the floating season would be heavily dependent upon the weather in early summer (e.g. hot and dry weather would likely eliminate floating season in an average year). In a high flow year, like 2011, the floating season could be up to 23 days long.

---

[50] Please refer to page 20 of the 2019 Slate River Floating Management Plan

[51] https://www.cblandtrust.org/

Figure 13-6: Estimated duration of the floating season based on recent representative year types, where 2012 was selected to characterize a low flow year (yellow line), 2006 was used to characterize an average year (green line), and 2011 was used to characterize a high flow year (blue line). Observations from 2018 were used to establish an initial minimum flow for floating (red line). The end of the voluntary closure is July 15th (grey line).

13.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Water Quality

Issue: Wells in some areas of the reach could benefit from water quality sampling, based on the heterogenous nature of the geology.

Issue: Mine reclamation in Redwell Basin: In the Upper Slate River Watershed Plan, CCWC identified reclamation at the Daisy Mine in Redwell Basin as a top priority to improve water quality. Based on existing water quality trends, reclamation at the Daisy Mine would create benefits in the Slate River from Oh-Be-Joyful Creek to Coal Creek.

Issue: Stakeholders would like to know whether Peanut Lake is a source of contamination.

Issue: On-site water treatment systems (septic systems) may be a nonpoint source pollutant, particularly for *E. coli* and or nutrients.

Irrigation

Issue: Just downstream from the Land Trust's property is the George Kapushion headgate. The headgate is poorly designed and at risk of a breach. A breach of the headgate could result in damage to the downstream reach of the Slate River and private property.

Environmental and recreational uses

Issue: Numerous stakeholders are concerned that recreational use in the Slate River may impact the heron rookery (located near Wildbird). This area of the Slate is an important conservation area. The Slate River Working Group convened by the Town and the Land Trust developed the 2019 Slate River Floating Management Plan that identifies multiple solutions to address issues related to wildlife and recreational use.

Issue: Camping near water. Obvious camping area less than 100 ft. from water.

Issue: Human waste. A number of stakeholders have raised concerns about the impact of recreation on public lands on water quality. Examples include increased human waste at popular camping areas and trailheads. A range of individuals and entities identified this concern. Guides have also raised this and suggested that it would benefit their guiding companies to have designated facilities for clients.

Issue: Preserve recreational access. Boaters and floaters expressed a strong desire to preserve access to this reach of the Slate River.

Issue: Boater safety. Barbed wire fences across the stream pose a danger to boaters. These fences were identified in the 2019 Slate River Floating Management Plan.

Issue: Concerns about trespass on private land. To a limited extent, the Slate River Management Workgroup has begun developing options to minimize instances of recreationalist/land owner conflict.

<u>Stream Stability and Riparian Issues</u>

Issue: Need additional data to assess whether Peanut Lake stabilization effort was successful and to evaluate long-term stability.

Issue: Stream stability and irrigation diversions. The Slate River is a dynamic and meandering stream. There is a discussion of whether it might make sense to allow for some natural cutting at certain points on the Slate. How can diversion structures be designed to meet river and irrigator needs?

Issue: The County Road Bridge over the Slate River is undersized and substantially alters sediment transport in upstream areas the decrease the size and quality of wetlands adjacent to the river.

Section 14. Reach 10 - Coal Creek

The headwaters of Coal Creek form in Independence Watershed and merge with other small seeps, springs, and tributaries located on the southeast flank of Scarp Ridge above the Irwin town site. Due to an artificial outlet used to provide additional water to the Town of Crested Butte, a portion of Lake Irwin drains to Coal Creek via an unnamed tributary that meets the headwaters on Coal Creek in the Town of Irwin. Coal Creek flows south to the junction of Kebler Pass Road (County Road 12) and Lake Irwin Road (Forest Road 826), then flows east to Crested Butte and Kebler Pass Road, generally paralleling the stream. In Crested Butte, Coal Creek is directed northeast to the confluence with the Slate River.

Coal Creek is one of the most heavily used tributaries in the East River Watershed. Coal Creek provides drinking water to the Town of Crested Butte, has multiple historic mine sites (including the Standard Mine Superfund Site in the Elk Creek Watershed), receives treated discharge from the Keystone Mine water treatment plant (WTP), provides irrigation water for the parks and public spaces in the Town of Crested Butte, and provides water to several irrigated pastures that surround town. A man-made outlet structure provides releases from Lake Irwin (a transWatershed diversion that allows water to move east toward Crested Butte rather than west toward Paonia).

The commitment and substantial investments made by several stakeholders including the Coal Creek Watershed Coalition (CCWC), High Country Conservation Advocates (HCCA), the Town of Crested Butte, Gunnison County, the Colorado Division of Reclamation Mining, and Safety (DRMS), the Colorado Water Quality Control Division (WQCD), Environmental Protection Agency (EPA), and the various operators of the Keystone Mine WTP have resulted in tremendous progress to restore the health of Coal Creek. Prior to these efforts, Coal Creek often flowed orange in the town of Crested Butte due to heavy metals contaminants. The *Coal Creek Watershed Plan* has informed several of the issues and options identified in this section.

14.1 Agricultural Water Use

There are four active irrigation diversions in the Coal Creek reach, serving approximately 360 acres of flood irrigated pasture grass. Table 14-1 shows the combined water rights, average annual and range of diversions, crop demands, actual crop consumptive, and shortage estimates for the reach ditches based on 2009 and 2012. Diversion information for the four ditches is not available every year for the 1998 to 2017 period used for other reaches. Information recorded by the water commissioner indicated several years when diversion information was either not available for the Coal Creek Ditch and the McCormick Ditch, or that water was available, but the ditches did not divert. The Spann Nettick Ditch had structural issues and was not usable during the last part of the 1990s. The information provided represents the sum of the information for each diversion.

Table 14-1: Agricultural water use statistics for Coal Creek.

Reach Statistics	2009 and 2012 Average	2009 and 2012 Range
Number of Irrigation Structures	4	n/a
Irrigated Acreage	359	n/a
Water Rights	30.1033	n/a
Diversions	1,860 acre-feet	1,770 – 1,950 acre-feet
Crop Demand	640 acre-feet	590 - 680 acre-feet
Crop CU	510 acre-feet	500 - 520 acre-feet
Shortage/Need	130 acre-feet	160 - 90 acre-feet
Percent Shortage	20%	15% - 24%

Figure 14-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions through the Halazon Ditch and McCormick Ditch comingle to serve common acreage. In addition, the acreage served by the Spann Nettick Ditch also receives water from a tributary to the Slate River in the Slate River from Coal Creek to Highway 135 Bridge reach. The ditches are unlined except the Spann Nettick Ditch and McCormick Ditch which are piped through Crested Butte. Individual ditches are estimated to lose between 10 and 25 percent of diverted water during delivery to the irrigated fields depending on ditch length. Return flows from this reach, estimated to be an average of 1,350 acre-feet per year for the two representative years with available diversion records (2009 and 2012), accrue to the Slate River between Coal Creek and Highway 135 Bridge reach.

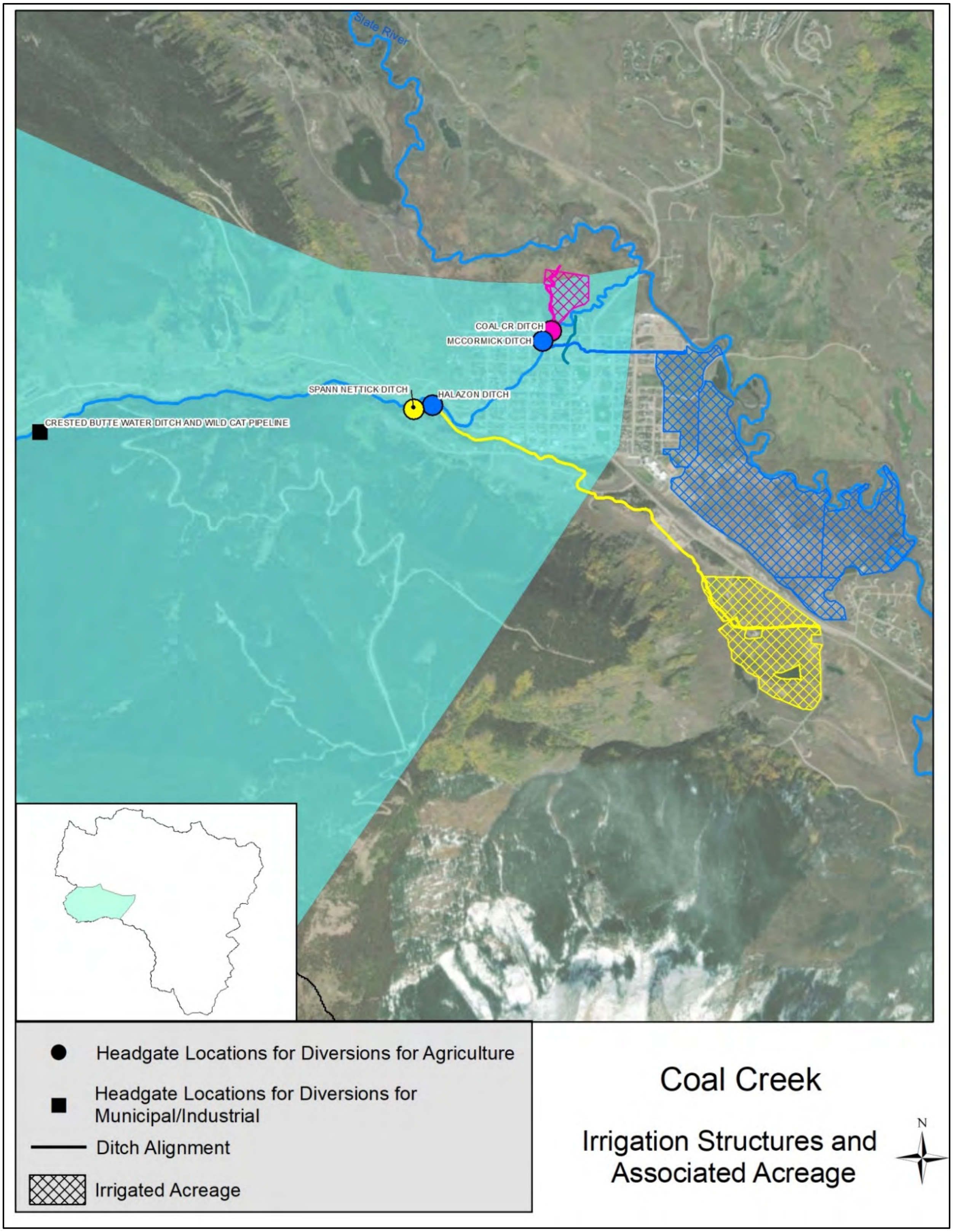
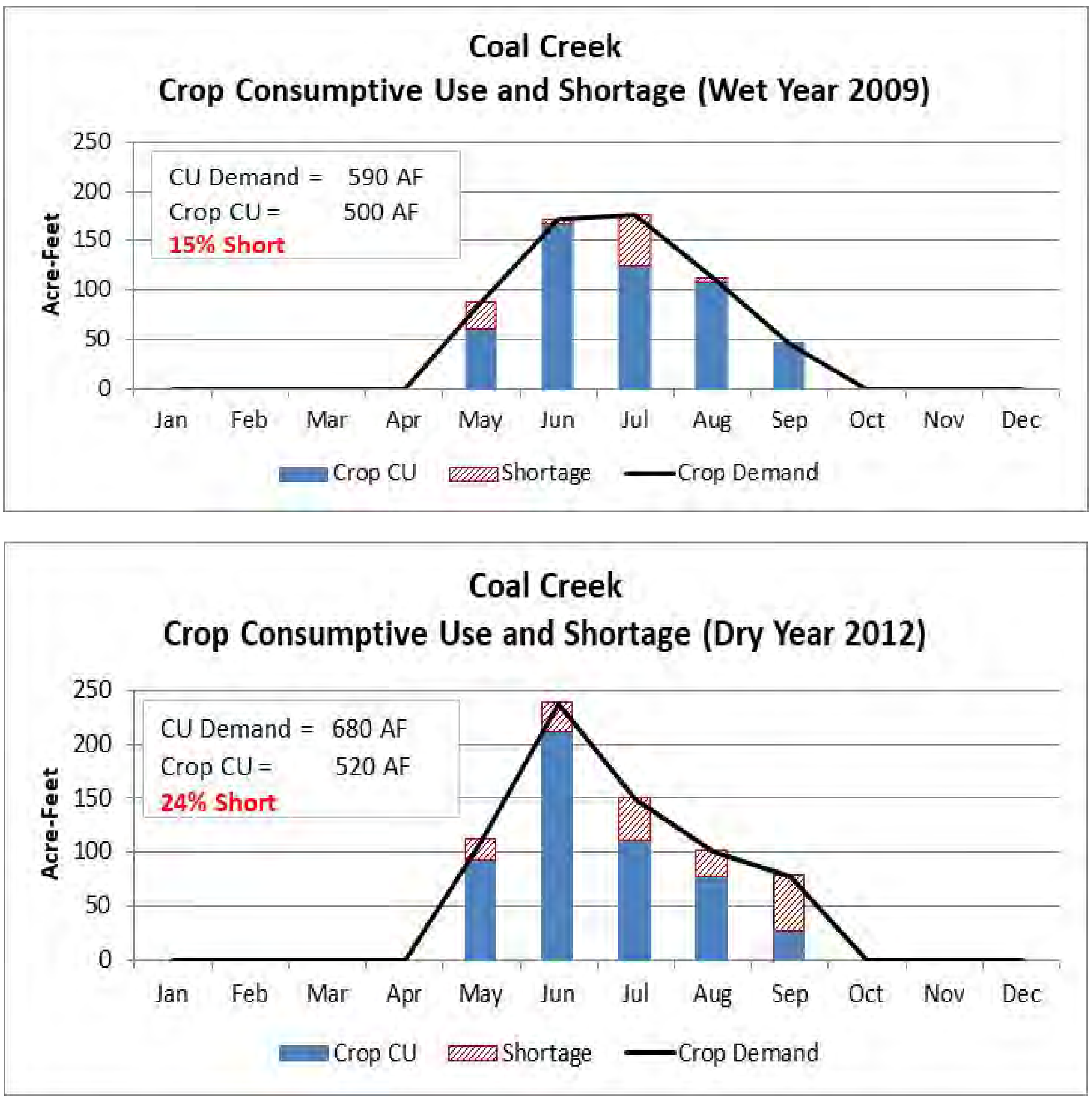


Figure 13-1: Diversion structures and irrigated acreage in the Coal Creek reach

Figure 14-2 shows the monthly crop demands, consumptive use, and associated shortages for two recent years, chosen to highlight hydrologic variability between a wet year (2009) and a dry year (2012). As noted above, these representative years vary from the representative years chosen for other reaches, as all the ditches did not have recorded diversions in other years.

Shortages were significant in the representative wet year (2009) especially in July. Shortages occurred every month during the representative dry year (2012). It is likely that shortages are due to physical supply limitations.

Figure 14-2: Crop consumptive use and shortage in Coal Creek



14.2 Domestic Water Use

The primary supply for the Town of Crested Butte is delivered from Coal Creek through the Crested Butte Water Ditch and Wildcat Pipeline, shown in Figure 14-1 above. The diversion has a water right for a combined 6 cfs decreed to divert from both Coal Creek and Wildcat Creek. In addition, the Town can deliver water through the Crested Butte Water Ditch and Wildcat Pipeline from their 367 acre-feet of storage in Lake Irwin between September 15 and May 1. Wildcat Creek is available as a secondary raw water source. The Town also has a 0.14 cfs water right in the McCormick Ditch that can be taken through the Crested Butte Water Ditch and Wildcat Pipeline as an alternate point to irrigate town parks and public properties. The Town can also use Halazon Ditch water to irrigate public properties that were historically irrigated by the ditch and can take 1 cfs of the Halazon Ditch water right through the Crested Butte Water Ditch as an alternate point for park irrigation. The Town serves a population of approximately 2,870. Diversions have not increased significantly from 2008 through 2017. Diversions through the ditch average 360 acre-feet per year, of which 130 acre-feet is estimated to be consumed based on standard municipal indoor and outdoor consumptive use factors of 10 percent and 80 percent respectively. Figure 14-3 shows the average monthly diversions from Coal Creek and Lake Irwin for the recent period 2008 through 2017.

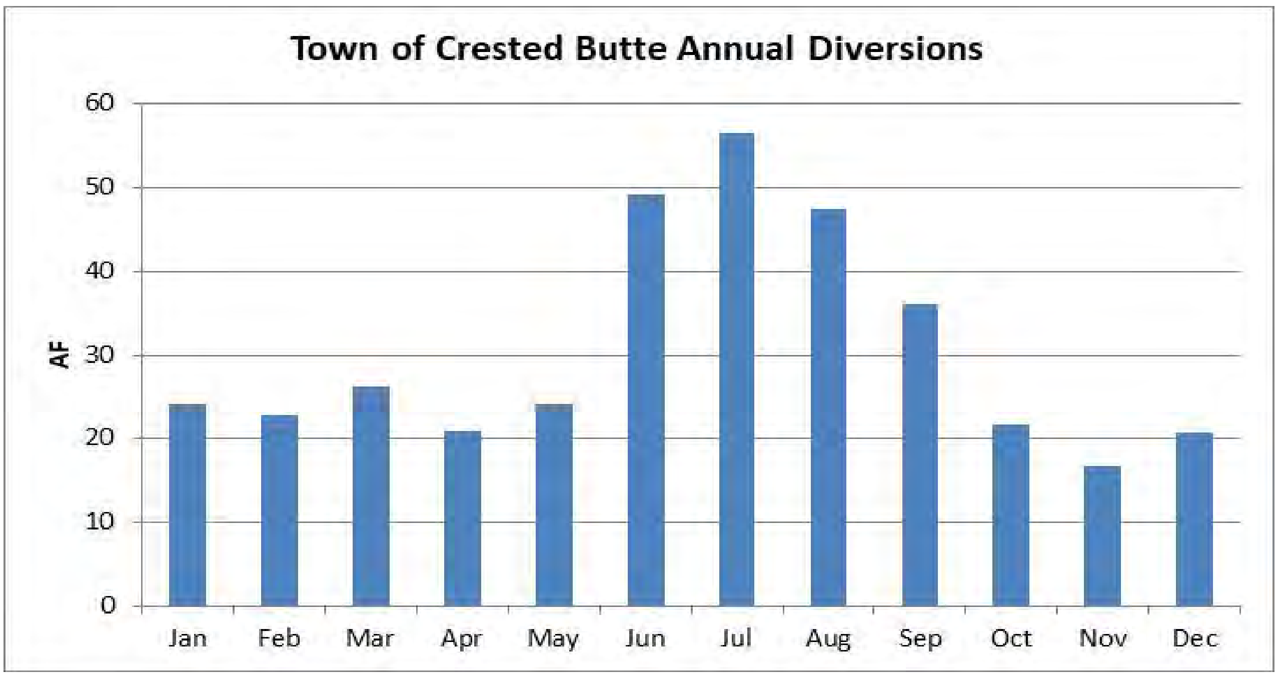


Figure 14-3: Average monthly diversions, in acre-feet (AF), for the Town of Crested Butte water supply, based on records from 2008 to 2017

Raw source water is delivered via the Crested Butte Water Ditch and Wildcat Pipeline to the Glazer Reservoir (named after long-time environmental advocate Steve Glazer). Resting time in the reservoir allows sediment to settle from the raw source water. The Glazer Reservoir and the Town's water treatment plant are located just west of town. The water treatment plant was recently redesigned to increase capacity and to maintain the quality of finished drinking water.

Water used indoors is collected and routed to the Town's wastewater treatment facility on the northeast side of town. Treated effluent is discharged to the Slate River.

Homes in the Town of Irwin, Trapper's Crossing and Treasury Hill subdivisions, and other homes within the Coal Creek watershed rely on wells for domestic drinking water and use on-site wastewater treatment systems. Groundwater and spring water quality in the Coal Creek Watershed is heavily dependent upon the local geology.

In 2014, the EPA sampled domestic wells in the Irwin Town site. Total arsenic concentrations ranged from less than 1 to 1,520 μg/L. Wells with the highest arsenic concentrations were within approximately 600 feet of Lake Irwin. Lake Irwin and the surrounding valley were created by glaciers. The Irwin Town site is located on a glacial moraine. Glacial moraines form as glaciers recede, leaving behind large deposits of rock scoured from the adjacent terrain. In the case of the Upper Coal Creek watershed, the adjacent terrain includes mineral veins, stockworks, or other features that may release arsenic, and possibly other metals, to the local groundwater system. Most notably, many of the deposits mined in the Coal Creek watershed contained arsenopyrite compounds, which when oxidized can release arsenic. The human-health criterion for arsenic is 0.02 µg/L. Arsenic concentrations measured in several homes in Irwin necessitate the use of advanced treatment systems and or hauling water for indoor use. Given that several residences rely on groundwater and spring sources, water quality characterization is recommended.

14.3 Environmental Water Use

14.3.1 Stream and Riparian Characteristics

The headwaters of Coal Creek form in Independence watershed and merge with other small seeps, springs, and tributaries located on the southeast flank of Scarp Ridge above the Irwin town site. Due to an artificial outlet used to provide additional water to the Town of Crested Butte, a portion of Lake Irwin drains to Coal Creek via an unnamed tributary that meets the headwaters on Coal Creek in Irwin. The Coal Creek riparian area and its tributaries are supported by flows from several seeps and springs that support a healthy, diverse and a largely undisturbed riparian area. Coal Creek flows south to the junction of Kebler Pass Road and Lake Irwin Road (Forest Road 826), also known as the Kebler Pass Y.

Downstream of the Y, Coal Creek bears east and descends through a valley flanked by Mount Emmons to the north and Mount Axtel and Gibson Ridge to the south. Where the valley is relatively wide, the riparian area supports large wetlands and beaver complexes that are relatively undisturbed. In addition to providing excellent aquatic and terrestrial habitat that increase overall biodiversity[52], wetland complexes attenuate flood flows, filter sediment, and store water to support late season flows.

The upland areas of the Coal Creek watershed are predominantly spruce-fir forest; drier southern facing slopes support sage brush steppe, grasslands, and aspen stands. Seeps and springs support wet meadow vegetation in selected areas.

The Colorado Natural Heritage Program Survey of Critical Wetlands and Riparian Areas in Gunnison County identified several Potential Conservation Areas (PCAs) in the Coal Creek watershed. The Mount Emmons Iron Fen PCA is located on the south-facing flank of Mount Emmons, 3 miles west of Crested Butte, and is fed by perennial cold springs of acidic highly mineralized water that flows from the complex fault systems underlying Mount Emmons. Coal Creek at the Keystone Mine PCA consists of the globally vulnerable Drummond willow and bluejoint reedgrass shrubland area around the beaver ponds approximately 4 miles west of Crested Butte. The Splains Gulch PCA is a large subalpine ring wetland system and lake-filling succession with salamanders. The Splains Gulch PCA is also referred to as Lily Lake.

The riparian area adjacent to Coal Creek is typically in good condition until approximately a half mile upstream of town. Coal waste piles from the former Jokerville Mine and the Spann Nettick and Halazon diversion structures alter natural sediment transport dynamics and cause channel-widening. The creek fully channelized through town, with extensive armoring to mitigate flood risk. Due to the amount of infrastructure present, there are few opportunities to support riparian restoration through town. Additional diversion structures on the north end of town impair channel function and riparian health. The McCormick Ditch diversion structure was recently improved; the redesigned structure allows for more efficient diversions and decreased maintenance work, while leaving some water in the channel and providing improved ecological function.

In recent years, the condition of the riparian area in the confluence parcel located near the mouth of Coal Creek has improved. It appears that riparian restoration efforts (some willow transplants), exclusion fencing, and beaver reintroduction have improved floodplain connectivity and watershed health. Note, an assessment completed in 2009 may have overstated the impacts to the riparian area.

14.3.2 Aquatic Life

Coal Creek from the headwaters to the confluence as well as the lower portions of Elk Creek support a brook and brown trout fishery. Macroinvertebrates have been sampled in Coal Creek since at least 2006 by multiple organizations including CCWC, EPA, and WQCD. At least

[52] Alexander, K., Ph.D. and Brown, W. (2009). *Assessment of Riparian and Aquatic Habitat with the Coal Creek Watershed,* Gunnison County, Colorado. Bio-Environs, LLC.

seven samples have been collected from Coal Creek upstream of Splains Gulch. Based on the sample results, the macroinvertebrate community is healthy, diverse, and readily attains the aquatic life use criteria.

Likewise, six macroinvertebrate samples collected from Elk Creek near the confluence of Coal Creek attained the aquatic life use criteria. As a result of historic mining operations, the macroinvertebrate community in the upper reaches of Elk Creek near the Standard Mine Superfund site is not as robust.

Macroinvertebrate samples collected from Coal Creek near the Town of Crested Butte's drinking water intake and the Keystone Mine WTP discharge readily meet the aquatic life criteria. Several samples taken at this location attained the "high-scoring" criteria (the best possible classification).

Water quality conditions, and as a result the aquatic habitat, have improved in the last forty years due to the commitment of several stakeholders working to improve water quality on this reach including the EPA, the Division of Reclamation Mining, and Safety (DRMS), WQCD, Town of Crested Butte, Gunnison County, High Country Conservation Advocates (HCCA), and CCWC. Additional discussion is presented in the water quality section.

14.3.3 Water Quality

Water quality in the Coal Creek watershed is a product of man-made and natural features that release metals to the environment. Metal concentrations are dependent upon complex interactions of the natural hydrologic cycle and are driven primarily by snowmelt, water management practices (including both diversions and discharges), and biogeochemical cycles mediated primarily by wetlands. Recently published studies suggest that wetlands and beaver ponds play a major role in seasonal metal concentrations in Coal Creek[53]; where the interaction of groundwater flow and chemistry mobilize, remobilize, or sequester metals in wetlands.

A discussion of water quality is not complete without a discussion of the major features in the Coal Creek watershed. The list below briefly summarizes the features included in Figure 14-4. Issues and potential options are underlined and will be discussed further in the needs and issues section.

---

[53] Zhi, W., Li, L., Dong, W., Brown, W., Kaye, J., Steefel, C., & Williams, K. H. (2019). *Distinct source water chemistry shapes contrasting concentration discharge patterns*. Water Resources Research, 55, 42334251. https://doi.org/10.1029/2018WR024257.
Briggs, M.A., Wang, C., Day-Lewis, F.D., Williams, K. H., and Dong, W., Land, J.W. (2019). *Return flows from beaver pons enhance floodplain-to-river metals exchange in alluvial mountain catchments*. Science of the Total Environment 685, 357-369.

- There are several small historic abandoned mine features on Scarp Ridge, where the headwaters of Coal Creek form. Recent characterizations by EPA suggest that these mine features are unlikely to impact water quality.
- Lake Irwin man-made outlet. The Town of Crested Butte has a water right in Lake Irwin that is used to supplement the Town's drinking water supply. Town staff have identified the outlet structure as an issue. Due to the configuration and age of the structure, it is challenging to manage flows during releases.
- Groundwater in the Irwin area has elevated arsenic concentrations that have been measured in both local wells and Lake Irwin. As mentioned previously, well water testing is recommended.
- Forest Queen and Forest King mines. The landownership of both properties has changed in recent years. Due to the potential human-health, safety issues, and environmental risks associated with the sites, outreach should occur to determine whether reclamation activities could be completed at one or both sites. DRMS is well-equipped to lead this effort.
- Wetlands in the upper portion of the watershed influence metal solubility and support late season flows. Within this area, bottomless culverts[54] have been used to alleviate habitat connectivity issues. Where possible, additional bottomless culverts should be used to maintain and improve habitat quality.
- Splains Gulch is a relatively undisturbed tributary to Coal Creek. The drainage includes extensive wetlands that are recommended for additional conservation. Metal concentrations, aside from arsenic, are typically at or near method detection limits and Splains Gulch inflows typically dilute metal concentrations in Coal Creek. Past versions of the Mt. Emmons Molybdenum Mine plan of operations included a tailings pipeline that was intended to deliver liquified tailings to proposed tailings storage facilities in the Carbon Creek watershed via this corridor. Explore options to further protect wetlands in Splains Gulch.
- Standard Mine Superfund Site. In 2017 the EPA completed the Phase I remedial action at the Standard Mine. Currently, the EPA and Colorado Department of Public Health and Environment (CDPHE) are in the second year of a 3 to 5-year interim monitoring period. Data collected during the interim monitoring period will be used to determine whether Phase II remedial actions are required.

  The Standard Mine Record of Decision identified attainment of the aquatic life standards as the remedial objective. Thus, water quality data to evaluate standards attainment is critical to the decision-making process. Although robust data collection is planned for the

[54] Bottomless culverts are U-shaped, rather than circular and allow the native stream bottom to continue beneath the road or trail crossing. This helps maintain more natural sediment transport dynamics and improves habitat connectivity.

duration of the interim monitoring period, it is possible that budgets and or priorities within each agency could change. Continued public involvement is recommended to assure the data collection and evaluation continues based on the terms provided in the Record of Decision. It is possible that a site-specific standard for Elk Creek could be developed based on data collected during the interim monitoring period. Such a proposal would require extensive review. Therefore, a careful review of any proposed changes to the water quality standards applied to Elk Creek is recommended. CCWC, HCCA, the Town of Crested Butte, and the County are actively engaged on water quality standards in the Coal Creek Watershed and are best equipped to continue this effort. Support from the WMP committee and Upper Gunnison River Water Conservancy District could be helpful. Data collected from the interim monitoring period will be used to inform operations of the Level 1 Bulkhead (e.g. when to open and close the bulkhead).

- Elk Creek. There are substantial conditional water rights associated with the Keystone Mine. Past versions of the Mt. Emmons Molybdenum Mine plan of operations included a reservoir in the Elk Creek drainage. As a result of remediation projects completed at the Standard Mine Superfund Site, water quality and habitat in Elk Creek have improved. Recently collected data indicate that Elk Creek up to the confluence with the Copley Lake drainage, and possibly even further upstream, supports a robust macroinvertebrate community and a small fish population. The EPA, CDPHE, and USGS are collaborating to operate a flume to measure flows in Elk Creek.
- Wetlands and beaver complexes between Elk Creek and tributaries that drain the Mt. Emmons Iron Fen are relatively undisturbed, provide excellent habitat, and support late season flows, along with other ecological services. Water quality data indicate that the large wetland and beaver complex adjacent to Coal Creek upstream of the Mt. Emmons Fen and Gossan influences metal concentrations by mobilizing, re-mobilizing, or sequestering metals depending upon hydrologic conditions.
- County Gravel Pit. In a 2011 study led by CCWC the county gravel pit was identified as the only substantial man-made sediment source (particularly the access road). Long-term management plans should be discussed with the county.
- Mt. Emmons Iron Fen. A fen is a groundwater fed wetland. The Mt. Emmons Iron Fen is fed by acidic metal rich water that originates from the fault system beneath Mt. Emmons. The fen is a natural metal source that increases metal concentrations in Coal Creek and to the Town's raw drinking water supply.

  The Mt. Emmons Iron Fen received a special designation from the Colorado Natural Heritage Program. The Fen supports a rare carnivorous plant called the roundleaf sundew (*Drosera Rotundifolia*) and a unique wetland plant community. Researchers affiliated with Rocky Mountain Biological Laboratory have studied the fen for decades. More recently, researchers affiliated with the Department of Energy have continued to study the fen.

The southern-most portion of the Fen was de-watered by a ditch used to manage stormwater run-off that would have flowed to Kebler Pass Road (County Road 12). Over the years, the ditch was breeched. The breeches created substantial erosion issues on the fill slope immediately above the road. In recent years CCWC and the US Forest Service have collaborated to address stormwater management issues in the area. Monitoring to assure that wetland function has returned to the restoration area is on-going. Additional resources may be required to fully restore wetland areas. The Forest Service is best equipped to address these issues.

- The Gossan. A gossan is a heavily weathered section of ore or mineral vein that is exposed at the surface. The composition of a gossan is like the ore that it is derived from. Typically, gossans are rich in pyrite, quartz, and base metals. However, the degree to which each is present is controlled by the amount of physical and chemical weathering that has occurred. Iron oxides are common and account for the red, brown, and yellow staining present at most gossans. In past studies, the fen and gossan were identified as large pollutant sources to Coal Creek.

  The 2011 characterization effort, led by CCWC, confirmed that the Mt. Emmons Iron Fen and the adjacent gossan are substantial natural metal loading sources in the Coal Creek Watershed. Cadmium, copper, lead, and zinc concentrations measured at the gossan were three to ten times higher than the concentrations measured in the fen area. Iron concentrations in the Mt. Emmons Iron Fen were consistently higher than in the gossan; iron solubility is controlled by geochemical conditions in the fen.

  Cooper, *et al.* (pending publication) found that metal concentrations in surface water and groundwater typically declined from east to west in the vicinity of the Mt. Emmons Iron Fen. Cooper attributed this trend to increased groundwater flows from glacial moraines, which are more prominent on the western portion of the fen. During Cooper's studies, groundwater from the glacial moraines was neutral in pH and lacked substantial metal concentrations; which sharply contrasts with the acidic metal rich waters that originate from the primary fen spring(s) which are in altered sulfur bearing bedrock. Dispersed flows from seeps, springs, and intermittent tributaries near the Mt. Emmons Iron Fen and gossan are significant sources of metals loading to Coal Creek during and immediately following snowmelt. During drier periods, dispersed flow sources play a less substantial role in metals loading to Coal Creek. However, preliminary findings from a piezometer study indicate that intense summer precipitation may generate surface flows (i.e. groundwater levels reach ground surface thereby activating spring and seep flow) more frequently than previously anticipated. However, water quality sample collection did not occur during or immediately following intense summer precipitation events; and the water quality during storm-related flow events remains unknown.

In the late 1970s, welders near the 2100 Portal of the Keystone Mine sparked a wildfire that burned vegetation on the gossan. To this day, vegetation has not fully recovered. Several stakeholders including Mt. Emmons Mining Company (MEMC), CCWC, HCCA, the town, and county are interested in restoring the gossan. A restoration project at the gossan would reduce metals loading and provide multiple benefits including improved source water quality for the Town of Crested Butte, increased assimilative capacity for both the Keystone Mine WTP and the town's wastewater treatment facility, and an increased probability of attaining water quality standards in Coal Creek from April to June. CCWC supported small-scale test plots that demonstrated that restoration, with appropriate chemical amendments and seed mixes being used to re-establish plant cover and reduce surface runoff.

- Culverts convey water under Kebler Pass Road. Flow from the fen and gossan reaches Coal Creek via a series of culverts that pass under Kebler Pass Road. Although substantial improvements have been made in recent years, there may be an opportunity to further improve stormwater management and watershed health in this area. Follow-up actions may be identified pending additional water quality data collection and evaluation by CCWC in 2019.
- Town of Crested Butte Water Supply Intake. The Town's drinking water supply intake is located approximately two miles downstream of the confluence of Coal Creek with Elk Creek (a total of about 4 miles downstream of the Standard Mine) and approximately a 1/2 mile upstream of the eastern portion of the gossan. All issues and potential projects discussed above could influence the Town's raw drinking water supply. The Town of Crested Butte has adopted a watershed protection ordinance that could benefit from additional review. Potential revisions to the watershed ordinance should be reviewed and discussed with Town staff.
- The Keystone Mine site and mine water treatment plant (WTP). The western portion of the Keystone Mine site is tributary to Coal Creek upstream of the Town's drinking water intake. Groundwater flow beneath Mount Emmons is controlled by a complex network of faults and fractures. A portion of the faults and fractures were mined at the Keystone, Standard, and Daisy Mines. The Keystone Mine has a bulkhead in the 2160 Level. Changes to the operation of the bulkhead have the potential to alter water quality in Coal Creek. The extent to which such changes would affect Coal Creek is unclear due to a limited understanding of deep groundwater flow in the area. Any changes in the operation of the bulkhead should be extensively reviewed.

Temporary modifications to the water quality standards for cadmium, copper, and zinc (used to protect aquatic life) have been in place on lower Coal Creek for over two decades. In 2017, the temporary modifications were removed from July to March and the values of the temporary modifications in place from April to June were revised to better characterize current water quality conditions. This change to the water quality standards will result in water quality improvements when the Keystone Mine WTP discharge permit is renewed because more stringent cadmium, copper, and zinc permit limits will be applied to the discharge.

Since 2013, the Keystone Mine WTP discharge permit has been on administrative renewal. Administrative renewal is a used when a permittee has complied with the terms of the permit but for administrative reasons the WQCD cannot renew the permit prior to its expiration. During an administrative renewal, the terms of the existing permit are applied, and the status quo is maintained until a renewal permit is issued. The Keystone Mine WTP permit could be renewed at any time. A careful review of the discharge permit and the terms of the compliance schedule is strongly recommended. CCWC, HCCA, the Town of Crested Butte, and County are actively engaged on water quality standards in the Coal Creek Watershed and are best equipped to lead this effort. Support from the WMP committee and Upper Gunnison River Water Conservancy District could be helpful.

In recent rulemaking hearings and in conversations with local stakeholders, MEMC (a subsidiary of Freeport McMoRan) has identified a potential cadmium compliance issue. The new WTP permit will likely include a compliance schedule for cadmium. Compliance schedules are used where discharges require additional time to comply with a new permit limit. Compliance schedules typically include implementation projects to reduce pollutant concentrations, either through treatment at the source or removal within the facility. Compliance schedules also identify a timeline to complete implementation projects and report progress in order to comply with future permit limits.

In 2016, shortly after MEMC acquired the property, the Town of Crested Butte, Gunnison County and several state agencies signed a memorandum of understanding to collaboratively address the items summarized above, the long-term operation and clean-up of the Keystone Mine site, and to establish appropriate site-specific standards for Coal Creek. The next water quality standards rulemakings are scheduled in 2020, 2021, and 2022.

- Red Lady Watershed tributaries. The tributaries that drain Red Lady Watershed contribute metals derived from natural and man-made sources. Site characterizations by

EPA, DRMS, and CCWC suggest that these mine features are unlikely to impact water quality.

- Wildcat Creek is a relatively undisturbed tributary to Coal Creek. Metal concentrations are typically at or near method detection limits. Wildcat Creek typically dilutes heavy metals concentrations in Coal Creek. The town's pipeline can collect water from Wildcat Creek.
- In 2019, the Town of Crested Butte set aside funds to draft a stormwater management plan for the municipality. It would be beneficial to provide input as the plan is reviewed to assure that stakeholder concerns about stormwater issues are addressed.

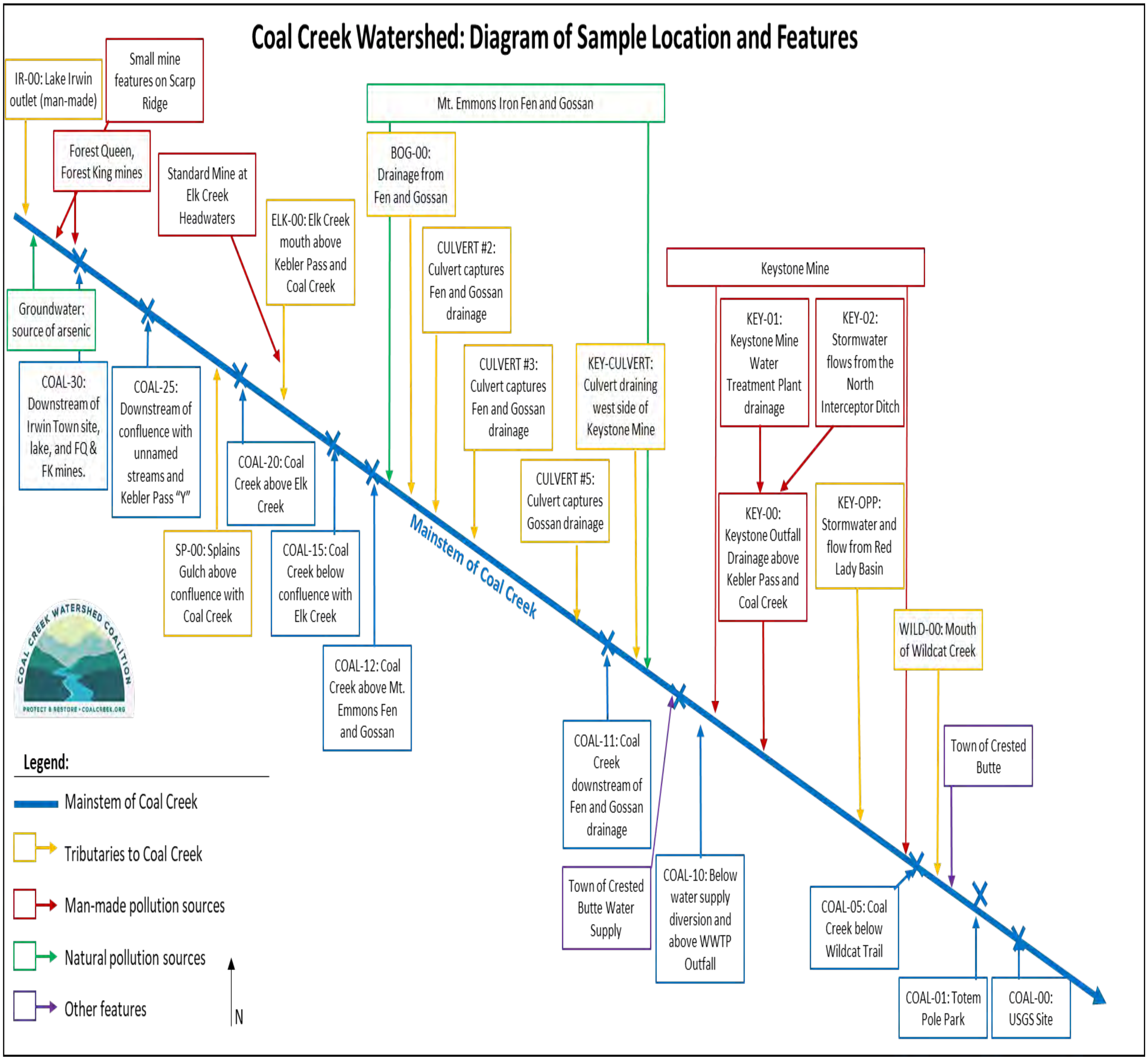


Figure 14-4: Major natural and man-made features in the Coal Creek Watershed. Courtesy of the Coal Creek Watershed Coalition.

Due to the multitude of interactive metal sources summarized above, several portions of Coal Creek are considered impaired for a variety of metals. The headwaters of Coal Creek, Splains Gulch, Red Lady Watershed, and other tributaries are listed as impaired for total recoverable arsenic, as shown in Table 14-2 and Figure 14-5. This impairment has been confirmed in multiple samples and is likely attributed to a combination of mineralized geology and historic abandoned mine sites.

Elk Creek is listed as impaired for aquatic life use for cadmium and zinc and for total arsenic for water supply use. The mainstem of Coal Creek from Elk Creek to the Keystone Mine discharge is impaired for aquatic life use for zinc. The mainstem of Coal Creek from the Keystone Mine discharge to the confluence with the Slate River is impaired for cadmium and zinc based on aquatic life use and impaired for total arsenic and manganese for water supply use.

Table 14-2: Impaired and partially impaired portions in the Coal Creek Watershed from the headwaters to the confluence with the Slate River.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of Coal Creek from headwaters to Elk Creek	Water Supply Use	NA	Total Arsenic	Low
Tributaries to Coal Creek, including Splains Gulch, Red Lady Watershed, and other unnamed tributaries	Aquatic Life Use	NA	Total Arsenic	High
Elk Creek and its tributaries	Aquatic Life Use	NA	Dissolved Cadmium	High
		NA	Dissolved Zinc	High
	Water Supply Use	NA	Total Arsenic	High
Mainstem of Coal Creek from the confluence with Elk Creek to a point immediately above the Keystone Mine discharge	Aquatic Life Use	NA	Dissolved Zinc	High
	Water Supply Use	NA	Total Arsenic	Low
Mainstem of Coal Creek, from the point immediately below the Keystone discharge to the confluence with the Slate River	Aquatic Life Use	NA	Dissolved Cadmium	High
		NA	Dissolved Zinc	High
	Water Supply Use	NA	Total Arsenic	Low
		NA	Dissolved Manganese	Low

The manganese water supply standard is a secondary standard (i.e. not based on human-health). Secondary standards are used to prevent staining, odor, and taste issues.

There are two water supply uses in Coal Creek. Coal Creek provides water for both domestic drinking water wells (which are generally assumed to be connected to surface waters) and a public water supply system. Domestic drinking wells are used throughout the reach; however, treatment practices at individual residences were not evaluated in this assessment. The Town of Crested Butte is a public water provider. Because of the dual water supply uses, the East River has been listed as impaired for arsenic.

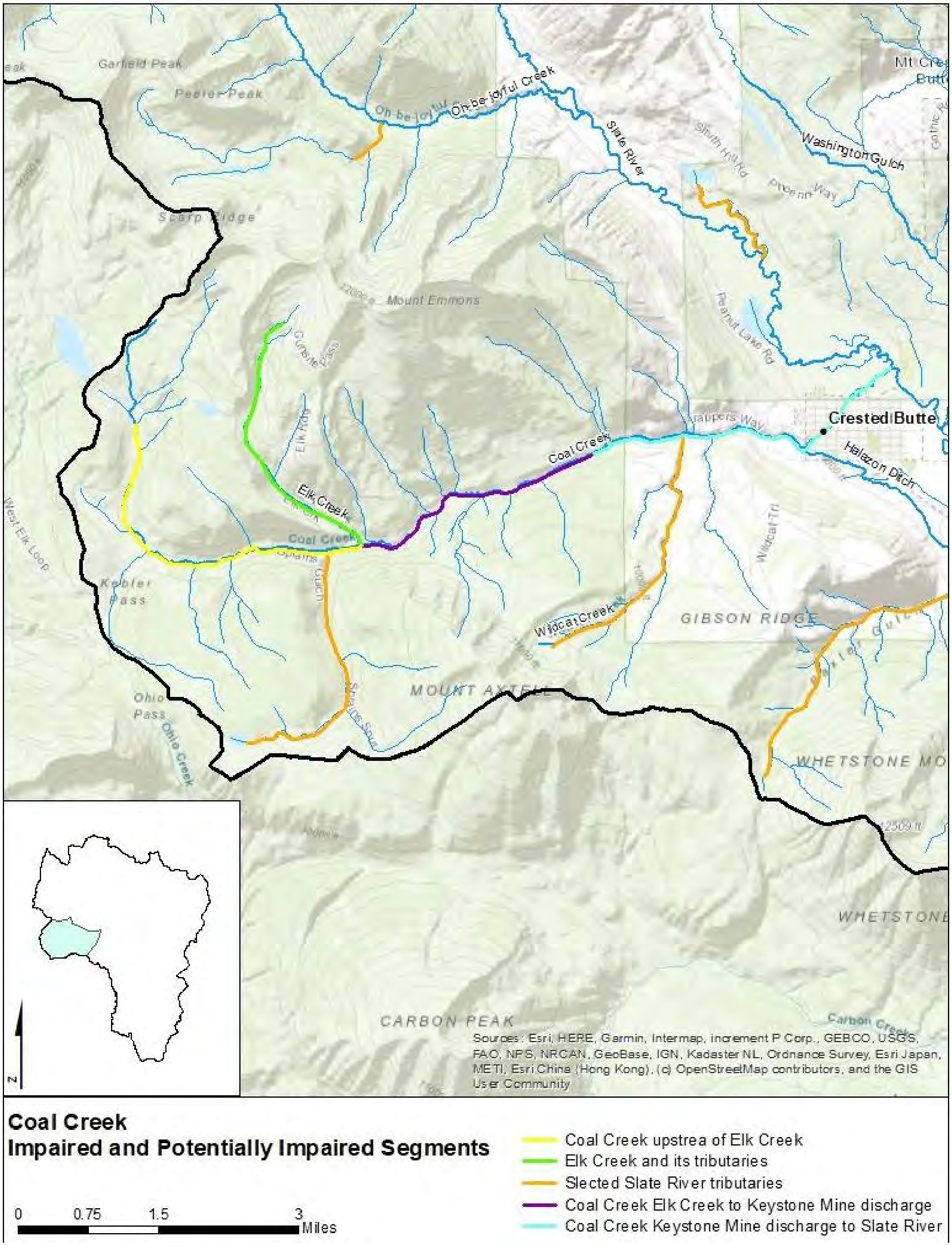


Figure 14-5: Impaired and potentially impaired stream reaches in Coal Creek

The CCWC and USGS haves collected a limited number of *E. coli* samples from the Coal Creek Watershed. *E. coli* concentrations generally attained the primary contact standard used to protect recreational users[55]. However, sample frequency may be a factor in the attainment results. The 2018 study found that *E. coli* concentrations exceeded the primary contact standard in Coal Creek above McCormick Ditch. The upstream extent of the problem is currently unknown. *E. coli* sample collection, along with flow and temperature monitoring, is underway in 2019. One of the study objectives for 2019 sampling is to determine the extent of elevated *E. coli* concentrations.

14.3.4 Water Temperature

Continuous water temperature measurements are not known to have been collected in this reach. Continuous water temperature monitoring is currently a data gap. The 2019 *E. coli* study will include temperature measurements in Coal Creek.

14.3.5 Existing Instream Flow Rights

There is an existing instream flow protection on Coal Creek of 2 cfs with an appropriation date of March 17,1980, as shown in Figure 14-6. This instream flow proposal was developed by the CWCB and CPW staff in 1980. In 2017 HCCA and American Rivers staff created a proposal to increase the instream flow rates in Coal Creek from the outlet of Lake Irwin to the Spann Nettick Ditch. In the 2017 proposal seasonal flows were developed that were based upon both minimum flow criteria and water availability. The Colorado Water Conservation Board voted to move forward with this appropriation. The appropriation is still pending as it was delayed by the Town of Mt. Crested Butte's change of water use.

There are no instream flow rights on Splains Gulch, Elk Creek or Wildcat Creek, three of the larger tributaries to Coal Creek.

An R2CROSS assessment was not completed on this reach in 2018 because a new instream flow proposal was submitted based on a proposal developed in 2017.

---

[55] The current protocol to evaluate compliance with the primary contact recreation standard for E. coli includes two steps. First, an anti-biasing method is applied, where the median is calculated from samples collected from a given segment in the same 7-day period. Second, a 60-day geometric mean is calculated. The 60-day geometric mean must be less than 126 col/100 mL to be in attainment of the standard. See CDPHE's 2020 303(d) Methodology.

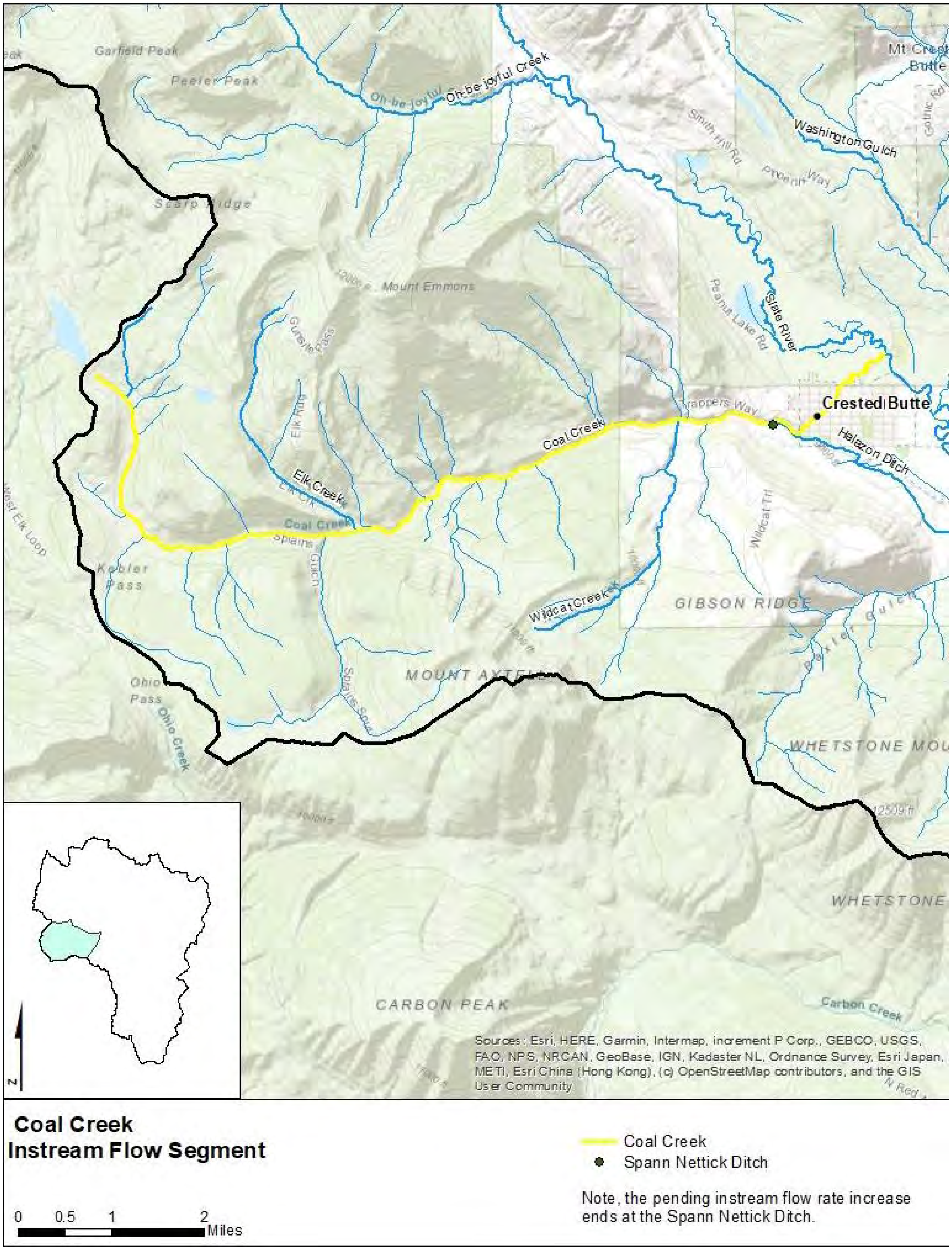


Figure 14-6: Instream flow water rights in the Coal Creek Reach

14.3.6 Flow-limited Areas

The following locations were identified by stakeholders in the Coal Creek watershed:

- Halazon and Spann Nettick Ditches: These ditches are significant diversions. In dry years they could create near dry up.
- Downstream of the Halazon and Spann Nettick diversions, Coal Creek transitions from a "near natural" flow regime to a heavily altered flow regime.
- Additional diversions on the north side of Crested Butte near Butte Avenue (McCormick and Coal Creek Ditches) frequently dry up Coal Creek in dry years and occasionally dry up the creek in the latter part of the irrigation season during average years.
- MEMC holds significant conditional water rights and storage rights in the Coal Creek watershed that, should they be developed, would impact the flow and operation of water in the drainage.

14.3.7 Environmental Flow Goals

The pending instream flow application represents a suitable minimum flow goal for Coal Creek. In 2014, the USGS installed a seasonal stream flow gage that operates from approximately April 1 to November 1 with the support of several local partners. Daily average flows from 2014 to 2019 were used to evaluate whether instream flows were met.

Figure 14-7 shows that despite extensive water use, flows in Coal Creek above McCormick Ditch meet the senior instream flow rate of 2 cfs 99 percent of the time on average and met it 76 percent of the time in 2018 which was an extreme dry year. Below McCormick Ditch flow attainment may be lower due to additional diversions.

Figure 14-7: Daily average flows in Coal Creek above the McCormick Ditch in a representative wet year (2017), an extreme dry year (2018), and the 2014-2019 daily average flows versus the instream flow rate.5657

A review of the flow data and diversion records from downstream of the gage clearly indicate that dry up and near dry up in Coal Creek from Butte Avenue to the confluence with the Slate

---

56 Julian day is a continuous count of the day of the year. For example, January 1 is Julian day 1. January 31 is Julian day 31 and April 15 is Julian day 106.

57 Daily average flow is plotted on a logarithmic scale (base 10). Logarithmic scales make it easier to see data that is widely variable. This method is useful for stream flow because peak flows are often 100 times greater than low flows in the fall and winter.

River occurs regularly. Outreach to local water users is recommended to assess interest and to identify voluntary measures to provide environmental flows while maintaining existing uses.

14.4 Recreational Water Use

There is an abundance of recreational use in the Coal Creek watershed. However, Coal Creek does not support floating activities. In the future, stakeholders may want to consider managing Lake Irwin to address recreational standup paddle boarding, canoeing, and fishing. However, at this time stakeholders did not raise this issue as a concern.

14.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: The assessment identified locations where dry up and near dry up occurs based on local knowledge. Additional work is needed to prioritize dry up locations based on the frequency and duration relative to the aquatic life, flow regime, and riparian conditions in adjacent portions of the stream.

Issue: Well sampling, because of the limited data collected to date and the potential for elevated arsenic concentrations due to the local geology.

Issue: Stakeholders have reported that the Wildcat Creek diversion structure needs maintenance.

Issue: The man-made outlet structure for Lake Irwin is difficult to operate and maintain.

Issue: In low flow years, the Town of Crested Butte lacks enough water to irrigate parks and public spaces.

Issue: The Spann Nettick Ditch diversion structure for the Smith Ranch and the Coal Creek Ditch located at Butte Avenue and Coal Creek should be reworked.

Issue: Low snow years, or extended drought, create water supply concerns. The Town is interested in projects that will help to create a reliable water supply for growth and peak tourist demand. Currently, Coal Creek and Wildcat Creek are the only raw water sources. May need to explore other areas for supplies.

Issue: The Town of Crested Butte expressed a desire to improve municipal irrigation efficiencies.

Issue: Mount Emmons Mining Company (MEMC) is concerned about their ability to comply with numeric permit limits for cadmium at the Keystone Mine WTP that discharges to Coal Creek. The discharge permit is currently on administrative renewal. Permit limits could be developed at any time.

Issue: Lower Coal Creek exceeds aquatic life standards for cadmium and zinc and water supply standards for arsenic and manganese. This was raised as an issue by numerous stakeholders, including CCWC, HCCA, the Town of Crested Butte, and Gunnison County. The Town of Crested Butte would like to "maintain [] the highest water quality standards consistent with State and Federal standards" on Coal Creek. Because there are several sources of loading contributing to water quality impairments on Coal Creek, this issue could be improved from a multitude of angles, discussed as other issues in this section.

Issue: There is a lack of risk assessment, communication protocols, and response practices to protect the drinking water supply in the event of a major incident.

Issue: Stormwater runoff into Coal Creek. Several individual stakeholders raised concerns about stormwater runoff along the lower sections of Coal Creek. Runoff from roads and pavement in town may impact water quality on Coal Creek.

Issue: There may be potential impacts to local stream temperatures from climate change. Multiple stakeholders were concerned that earlier runoff and warming ambient air temperatures

Issue: Potential impacts to water quality from increased human waste (and waste from pets) in the Coal Creek watershed. *E. coli* concentrations measured in Coal Creek above McCormick Ditch were above the primary contact recreation standard in 2018. Additional data collection will occur in 2019.

Issue: Standard Mine Superfund Site. Currently, the EPA and CDPHE are in the second year of a 3 to 5-year interim monitoring period. Data collected during the interim monitoring period will be used to determine whether Phase II remedial actions are required.

Issue: On-site water treatment systems (septic systems) in Irwin may be a nonpoint source pollutant, particularly for *E. coli* and or nutrients.

Issue: Sewage treatment capacity. There is concern about an increasing number of septic systems and outdated systems that have not been required to tie into the Town of Crested Butte’s municipal treatment system.

Issue: Habitat fragmentation from low flows in the lower portion of Coal Creek particularly near Butte Avenue. This issue is related to other environmental concerns, including instream flows and stream temperatures. The major diversions are the Town of Crested Butte Water Supply, the

Halazon Ditch, the Spann Nettick Ditch, the McCormick Ditch, and the Coal Creek Ditch. These diversions often remove enough water that, in many years, Coal Creek is dry at the Butte Avenue Bridge during the fall. The town is particularly concerned about this low flow for fish in the late summer and early fall.

Issue: Elk Creek, Splains Gulch, and Wildcat Creek lack minimum instream flow protections.

Issue: Unique and extensive wetland habitat in Splains Gulch is eligible for additional protections, but such protections have not been pursued.

Issue: Riparian health. The Town of Crested Butte is concerned about riparian condition of Coal Creek through town. The Creek is armored and fully channelized throughout much of town. Most areas lack floodplain connectivity. Where floodplain connectivity occurs, there is substantial infrastructure in the floodplain.

Issue: Flood risk and public safety. Based on recent peak flow observations, flood risk is highest where Coal Creek flows between 1st and 2nd street (particularly at town parking lot and in adjacent alley), the bridge near 2nd and Elk Avenue (although the bridge abutments were designed to dissipate energy), and within Totem Pole Park. During wet years, peak flows may pose a safety risk to the public.

Issue: Lack of connection to Coal Creek within the Town of Crested Butte.

Section 15. Reach 11 - Slate River from Coal Creek to Highway 135 Bridge at Skyland

Coal Creek flows into the Slate River immediately northeast of the Town of Crested Butte. The Slate River flows through the eastern portion of Crested Butte. The Slate River supports variety of uses including domestic uses in the Town of Crested Butte and outlying areas, extensive recreational use, somewhat limited agricultural use, and environmental use including robust aquatic life and expansive wetlands that provide habitat to a wide variety of wildlife.

15.1 Agricultural Water Use

There are six active irrigation diversions and one reservoir that supplies irrigation water in the Slate River from Coal Creek to Highway 135 Bridge reach, serving approximately 170 acres of flood irrigated pasture grass and 116 acres of sprinkler irrigated golf course grass mix. Table 15-1 shows the combined water right, average annual and range of diversions, crop demands, actual crop consumptive, and shortage estimates for the reach ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion. The diversions in this reach are in tributaries to the Slate River.

Table 15-1: Agricultural water use statistics for tributaries to the Slate River from Coal Creek to Highway 135 Bridge.

Reach Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	7	n/a
Irrigated Acreage	287	n/a
Water Rights	27.55	n/a
Diversions	1,230 acre-feet	590 – 2,420 acre-feet
Crop Demand	390 acre-feet	280 - 480 acre-feet
Crop CU	370 acre-feet	280 - 460 acre-feet
Shortage/Need	20 acre-feet	0 - 70 acre-feet
Percent Shortage	6%	0% - 27%

Figure 15-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, several ditches divert from local drainages and comingle to fill Lake Grant and to irrigate the golf course and landscaped areas in the Skyland Metropolitan District, including Columbine Reservoir and Ditch, Decker Ditch, Decker Ditch No 2, and Warrant Ditch. Diversions through Willow Ditch and Baxter Ditch comingle to serve common acreage. In addition, a portion of the acreage is also served by comingled diversion from Coal Creek. All of the ditches are unlined, and the individual ditches are estimated to lose between 10 percent of diverted water during delivery to the irrigated fields. Return flows from this reach, estimated to be an average of 860 acre-feet per year from 1998 to 2017, accrue to the Slate River above the Highway 135 bridge.

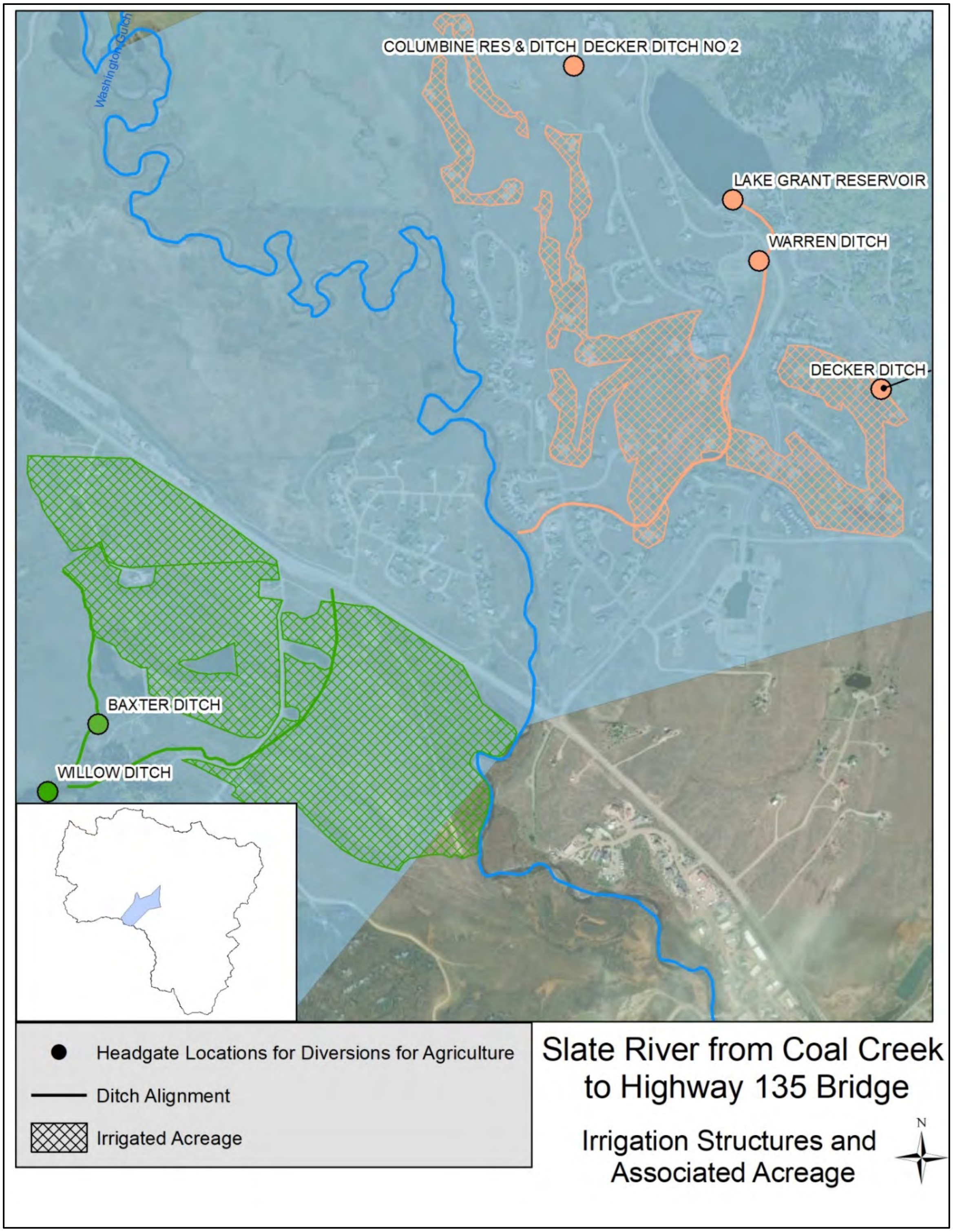
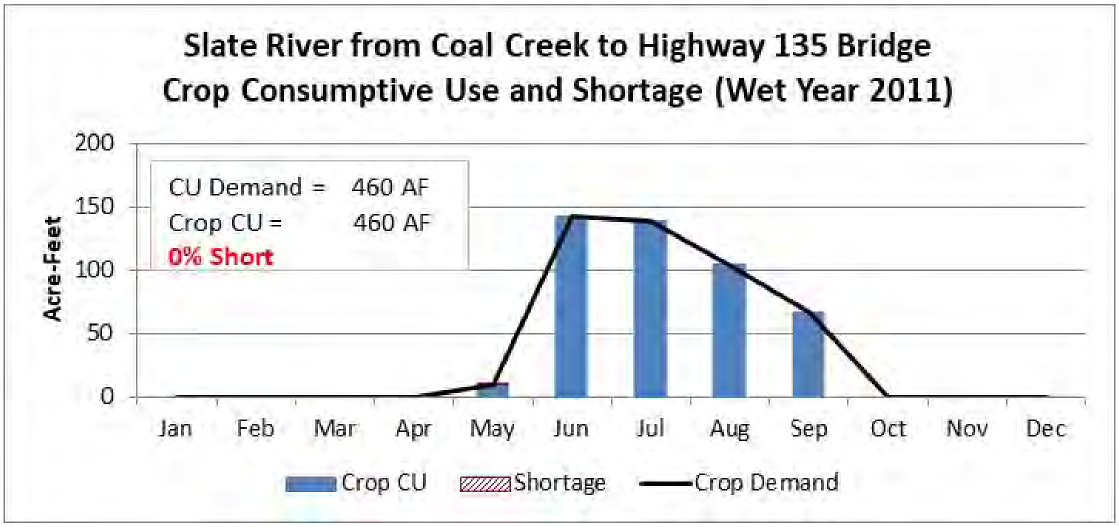
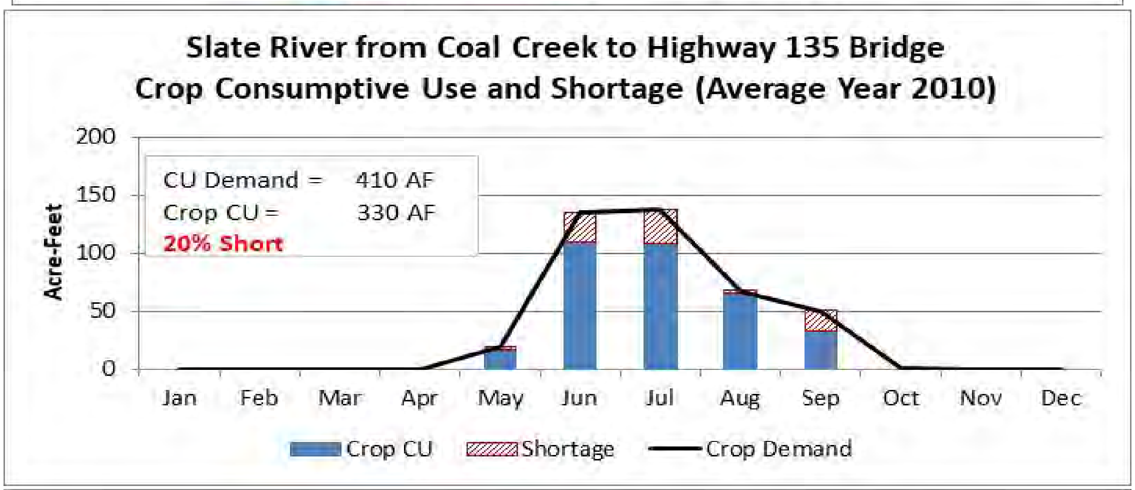


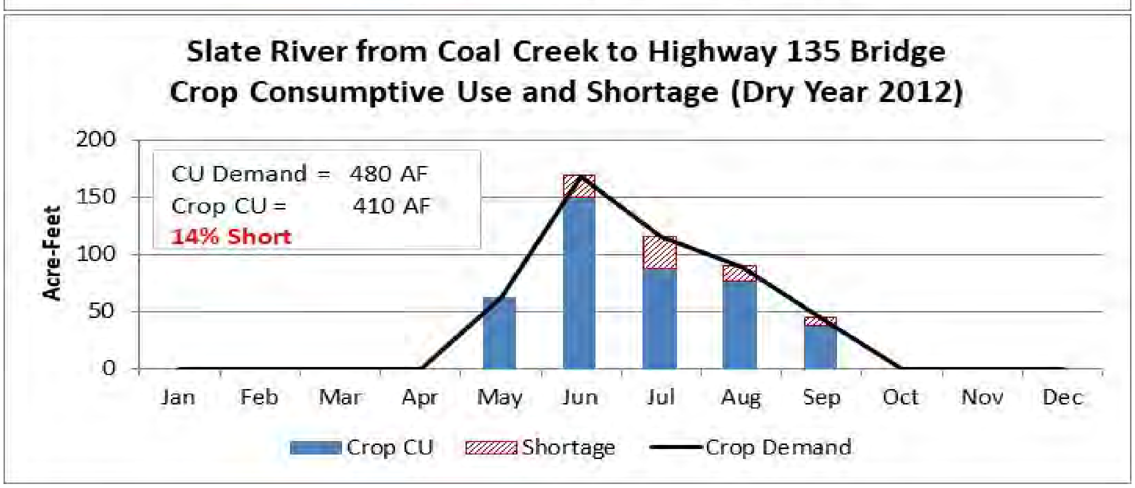
Figure 14-1: Diversion structures and acreage on the Slate River from Coal Creek to the Highway 135 Bridge. All diversions on this reach are located on tributaries

Figure 15-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). Both the Baxter Ditch and Willow Ditch divert off a smaller tributary to the Slate River and are limited by physical supply in average and dry years. The northern field receives a full supply more often, in part because of diversions delivered from Coal Creek through the Spann Nettick Ditch.

Figure 15-2: Crop consumptive use and shortage on the Slate River from Coal Creek to the Highway 135 Bridge. All diversions within this reach are located on tributaries to the Slate River







15.2 Domestic Water Use

Over the past several decades, the areas to the east and south of Crested Butte have been developed for residential use. The development occurred and continues to occur at a piecemeal rate, which has created a unique configuration of domestic water and wastewater systems, and smaller centralized systems operated by individual homeowners' associations. This section summarizes domestic and municipal well use within the Slate River from Coal Creek to Highway 135 reach from upstream to downstream.

The Town of Crested Butte diverts raw water from Coal Creek to provide drinking water to the Town of Crested Butte. The Town's drinking water supply is discussed in Section 14 of this Chapter. Water used indoors is collected and delivered to the Town's wastewater treatment facility located in the northeast side of town adjacent to the Slate River. Treated effluent is discharged to the Slate River immediately upstream of the recreation path bridge.

The Aperture Subdivision is currently being developed. At full buildout the subdivision will include 23 single-family homes limited to 5,000 square feet. Homes in the development will be served by the Town of Crested Butte's water and wastewater system. Trails and a river put-in will simultaneously be developed in the riparian corridor adjacent to the subdivision.

The Foxtrot Subdivision is currently being developed. At full buildout the subdivision will include four large single-family homes. Homes in the development will rely on wells and use on-site wastewater treatment systems.

McCormick Ranch Road includes seven large lots, of about 35-40 acres each. To date, two homes have been built. McCormick Ranch relies on wells and has an unusual arrangement for waste management where solids are treated in on-site wastewater systems and liquids are pumped to the Crested Butte Wastewater Treatment Facility.

Paradise Park, Verzuh Ranch Annexation, and other areas: Additional development is planned for the eastern side of Crested Butte, including several affordable housing projects. These areas will be served by the Town's municipal water and wastewater systems.

Silver Sage, River Green, Slate River Estates, Riverbend, Skyland, and adjacent areas: Skyland Metropolitan District and the East River Sanitation District serve most homes east of the Slate River in the vicinity of Highway 135 and the Brush Creek Road. Additional information on special district services is also provided in the East River from Brush Creek to Slate River reach. Skyland also pumps from two wells immediately adjacent to the Slate River.

There is substantial potential for additional development at this location. The water supply needs will be heavily dependent upon the density of the proposed developments. Gunnison County has been engaged throughout the planning process and is currently considering several potential measures to better link land use with water supply and water quality.

15.3 Environmental Water Use

The primary reason for dividing this reach at Highway 135 was due to recreational use. Where recreational use is very common on the Slate River in and near the Town of Crested Butte, it is less common in the Slate River downstream of Highway 135. As such, many of the environmental characteristics are very similar between the reaches.

15.3.1 Stream and Riparian Characteristics

The valley floor is composed of highly variable quaternary sediment deposits derived from glacial activity. There is a terminal moraine near the cemetery and the confluence of Coal Creek and the Slate River. The terminal moraine acts as a natural grade control that decreases the Slate River's energy upstream of this reach. Both the current County Road 317 bridge and the old bridge abutments increase the degree of constriction within this section of the Slate River. These man-made constrictions increase the quantity of sediment deposited in the Slate River upstream of this reach and contribute to stability issues that may reduce the quality of habitat immediately upstream of the confluence with Coal Creek.

The grade of the Slate River is briefly increased below the terminal moraine and flows in a straighter course as a result. However, the channel has likely been further straightened by human activities, including riparian vegetation removal, within this area. The river returns to a more natural course downstream of the Recreation Path Bridge. The Whetstone Mountain alluvial fan provides a grade control structure that leads to sediment deposition and increased groundwater elevations that support the extensive wetlands that span from the Town Ranch to the Silver Sage Subdivision just upstream of this reach.

15.3.2 Aquatic Life

The Slate River supports brown trout, brook trout, white suckers, fathead minnows, and few rainbow trout and kokanee salmon. Both brown and brook trout reproduce in this reach based on the size distributions found in CPW fish surveys that date back to 1977. Some private landowners manage to support angling in the Slate River between Coal Creek and Highway 135.

Macroinvertebrates have been sampled on at least three occasions since 2007. The Macroinvertebrate Multimetric Index (MMI) scores demonstrate that the Slate River from Coal Creek to Highway 135 supports aquatic life and has a healthy and relatively diverse macroinvertebrate community. Some older samples have indicated potential impairments. However, it is unclear how the sample collection protocol may have affected the results.

Stakeholders have reported increased algae growth in recent years, particularly during 2018 when flows were near record lows. Some stakeholders are also voiced concerned about the condition of the fishery within the reach.

15.3.3 Water Quality

The Slate River from the confluence with Coal Creek to the confluence with the East River is impaired for dissolved zinc for aquatic life use, as shown in Table 15-2 and Figure 15-3. Elevated zinc concentrations in the Slate River are attributed, in large part, to abandoned mines and geologic features in the Coal Creek and Oh-Be-Joyful Watersheds (additional information is presented in each reach assessment). Discharges to Coal Creek from the Keystone Mine Water Treatment Plant also influence zinc concentrations in the Slate River downstream of Coal Creek.

USGS collected water quality samples from the Slate River near McCormick Ranch Road (USGS 09111500) from 1993 to 2018. Dissolved zinc concentrations were measured intermittently since 1998; and more frequently, up to six times per year, in recent years. Since 1998, dissolved zinc concentrations have ranged from 5 to 455 μg/L. The data show a strong seasonal pattern where peak concentrations typically occur in April to June during the early part of runoff. During the remainder of the year, zinc concentrations are generally less than the chronic zinc standard.

In early 2019 USGS started collecting water quality samples from the Slate River above Baxter Gulch (USGS 385106106571000). This sample location will replace the Slate River near McCormick Ranch Road location.

Tributaries to the Slate River were listed as impaired for total recoverable arsenic for water supply use. Tributaries to the Slate River between Highway 135 and the East River have not been sampled. The data that resulted in the listings were collected from unnamed tributaries in the Coal Creek Watershed. Because tributaries to the Slate River share many characteristics, the listings were retained for all Slate River tributaries.

Table 15-2: Impaired and potentially impaired portions of the Slate River from Hwy 135 to the confluence with the East River

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of the Slate River from a point immediately above the confluence with Coal Creek to the confluence with the East River	Aquatic Life Use	NA	Temperature	High
		NA	Dissolved Zinc	High
Tributaries to the Slate River	Aquatic Life Use	NA	Total Arsenic	High

The Coal Creek Watershed Coalition (CCWC) has collected a limited number of *E. coli* samples from the Coal Creek and upper Slate River watersheds since 2011. Initial studies, in 2011, 2013, and 2017, found that *E. coli* concentrations attained the primary contact standard used to protect recreational users. The 2018 study found that *E. coli* concentrations exceeded the primary contact standard in the Slate River from the confluence with Coal Creek to McCormick Ranch Road. The downstream extent of the problem is currently unknown. *E.* coli sample collection, along with flow and temperature monitoring, is underway in 2019. One of the study objectives is to determine the downstream extent of elevated *E. coli* concentrations.

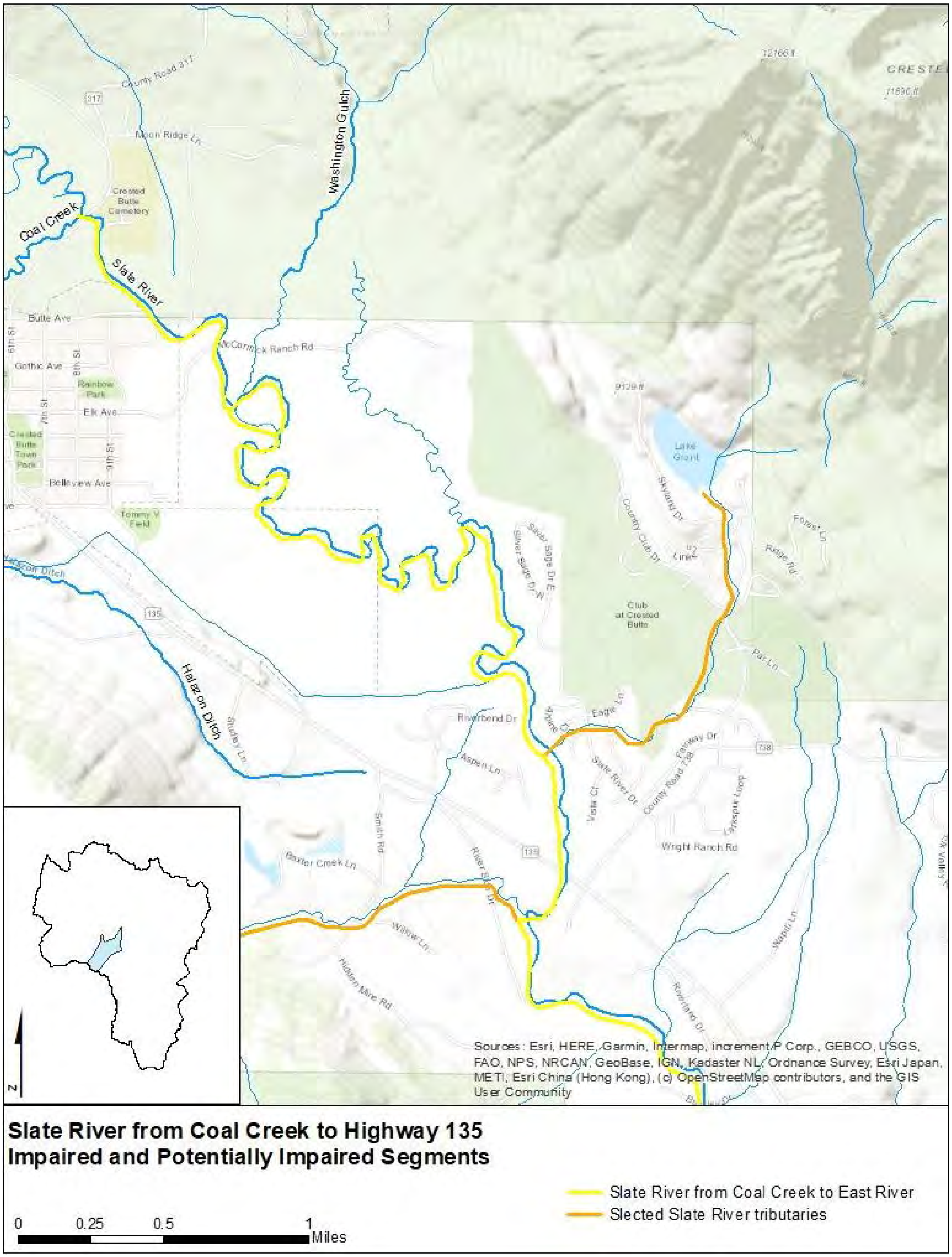


Figure 15-3: Impaired and potentially impaired stream segments in the Slate River from Coal Creek to the Highway 135 Bridge

15.3.4 Water Temperature

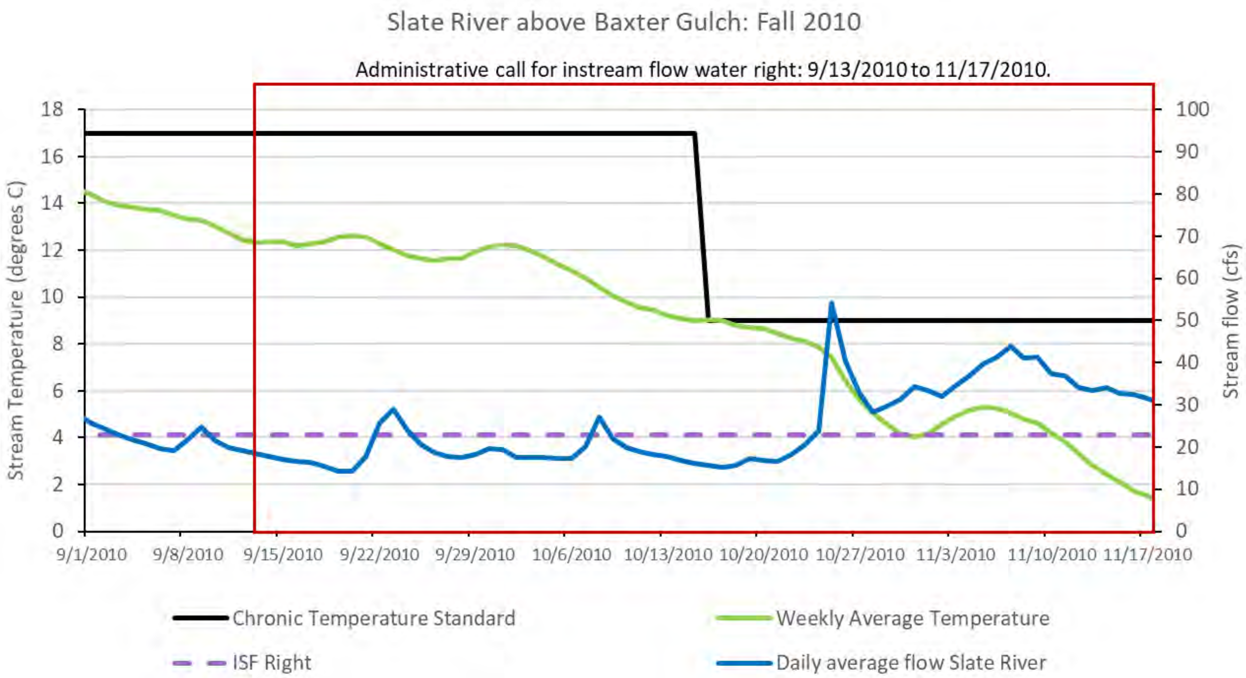
The Slate River from Coal Creek to the East River, which includes the entirety of this reach, has a site-specific temperature standard. The site-specific standard was developed by the Water Quality Control Division (WQCD) in 2017. The temperature standards used to protect sensitive cold-water aquatic species apply, but the duration of the summer season was extended to October 15[58]. As part of the process to develop the site-specific standard, the WQCD analyzed water temperatures in the Town of Crested Butte's wastewater treatment facility (WWTF). The analysis found that the temperature of the WWTF effluent does not increase temperatures in the Slate River. The WQCD also identified elevated stream temperatures during late September and early October in the Slate River near Oh-Be-Joyful Campground, which is upstream of all water diversions and permitted discharges.

The WQCD installed a continuous temperature sensor in the Slate River downstream of Highway 135 from October 2009 to January 2011. This data set includes one summer season and is the basis for the aquatic life use impairment for temperature. The chronic temperature standard (a running weekly average temperature) was exceeded on October 16, 2010, by one-tenth of a degree, as shown in Figure 15-4.

An administrative call was in place on the Slate River to provide water to the instream flow water right from September 13 to November 17, 2010. Stream flows increased at times during the call, either due to reservoir releases or precipitation events, but did not consistently exceed the instream flow rate until late October (Figure 15-4). It is possible that the chronic temperature standard may have been exceeded by a larger magnitude or for a longer duration without the administrative call to provide water to the instream flow water right.

[58] Typically, the winter temperature standard would apply on October 1.

Figure 15-4



As Figure 15-4 illustrates, the chronic temperature standard, which is based on weekly average temperatures, was exceeded on October 16, 2010 (where green line is slightly above the black line). From September 13 to November 17, 2010 the Slate River was on an administrative call to provide water to the Slate River instream flow water right. Water deliveries or precipitation events increased flows briefly in late September and mid-October (see blue line). Without the administrative call, water temperatures may have been higher or exceeded the chronic standard for a longer duration.

To date, there is only continuous temperature data from 2010. Fortunately, the UGRWCD, local stakeholders, and USGS collaborated to install a temperature sensor in the Slate River above Baxter Gulch (USGS 385106106571000) in the spring of 2019. The temperature sensor will also provide valuable context to understand *E. coli* concentrations in the Slate River from Coal Creek to Highway 135.

15.3.5 Existing Instream Flow Rights

The Slate River from Coal Creek to the East River has an instream flow water right of 12 cfs in the winter and 23 cfs in the summer; Figure 15-4. The instream flow proposals were developed by CWCB and CPW and included three R2CROSS assessments on the reach. During the physical and legal water availability assessment, the summer instream flow rate was reduced. The summer instream flow rate meets two of three R2CROSS criteria[59]. During the approval process the proposed instream flow water right was contested. However, the flow analysis in the proposal, which included data from USGS and Mt. Emmons Mining Company, was robust enough to maintain the proposed instream flow water rights.

In 2018 an R2CROSS assessment was performed in the Slate River upstream of the confluence with the East River near Highway 135. The R2CROSS recommendation was 16 and 24 cfs for winter and summer, respectively.

[59] See Chapter 2, Section 1.2.

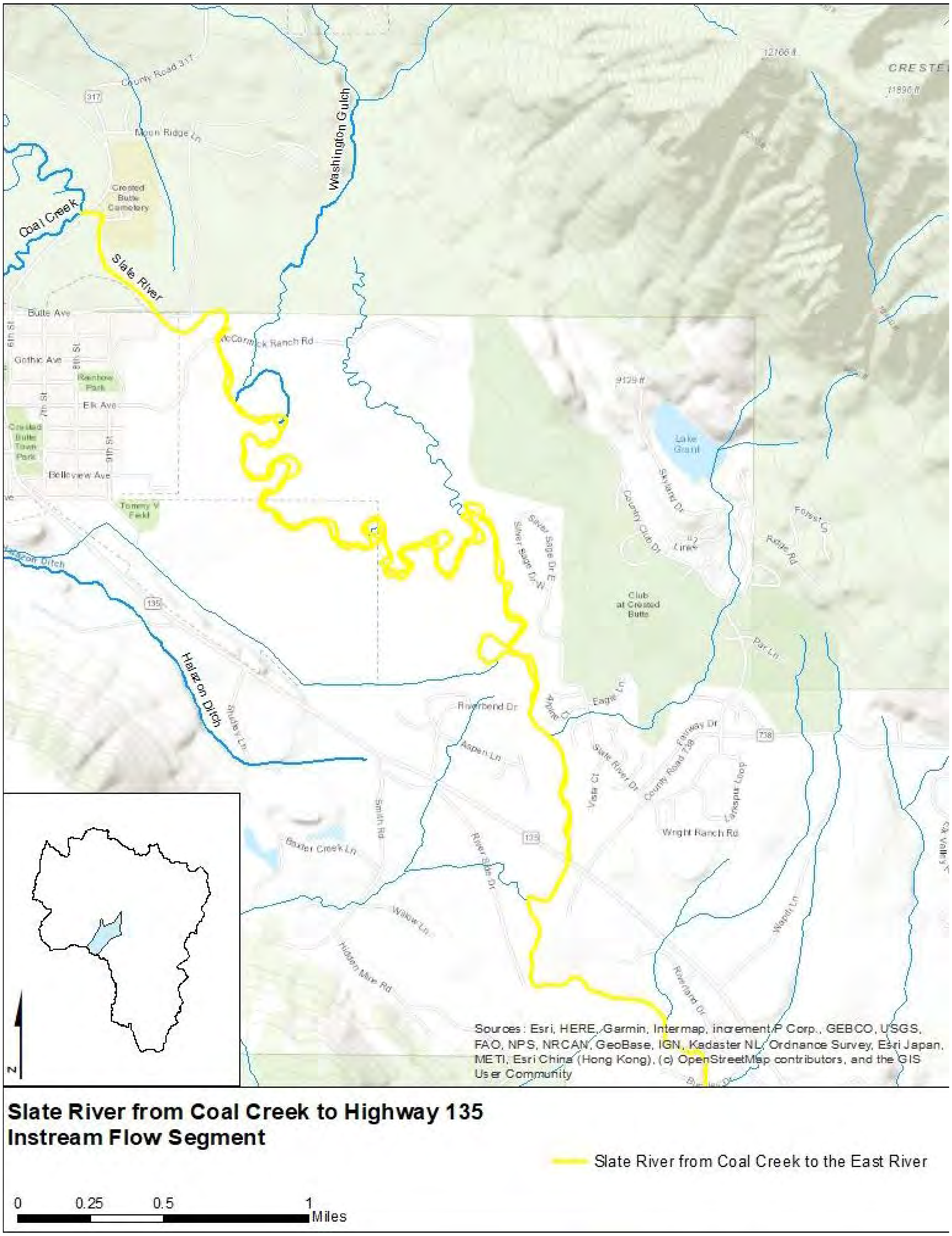


Figure 15-4: Slate River instream flow water right in the Slate River from Coal Creek and the Highway 135 Bridge

15.3.6 Flow-limited Areas

The following locations were identified by stakeholders in the Slate River from Coal Creek to the Highway 135 Bridge:

- Diversions do not occur on this reach, but diversions from Coal Creek and Washington Gulch have the potential to influence stream flows in the Slate River.
- The Town of Crested Butte has rights to release water from Lake Irwin from May to September. Such releases could improve flows in Coal Creek and the Slate River.

15.3.7 Environmental Flow Goals

Due to both water acquisitions and a gage on the reach, the CWCB can place calls on junior users to satisfy the instream flow water right. Administrative calls were placed nine times between 2000 and 2018 to provide water to the instream flow water right (referred to as Slate River Segment 4) during the late summer and early fall.

Flow data from the Slate River above Baxter Gulch gage, near the top of the reach, show that stream flows in dry and average years can fall below the winter instream flow rate. In late July of 2012, a very dry year, flows fell below the summer instream flow rate of 23 cfs and generally remained below the instream flow rate until approximately September 30. In 2013, an average year, flows in the Slate River briefly dropped below the instream flow rate from early to mid-September. In 2011, a wet year, the instream flow rater was attained throughout the year.

The summer instream flow rate is attained most of the time in average and wet years. During dry years, flows can fall below the instream flow rate for several weeks.

15.4 Recreational Water Use

The Slate River from Coal Creek to the Highway 135 Bridge attracts a wide variety of recreational uses. Swimming and water play are common at the Recreation Path Bridge and the Skyland Bridge. Angling occurs on private lands. Community members and visitors frequently float the Slate River from the Recreation Path Bridge to Skyland. Stand-up paddleboards are used most frequently, but other crafts, including kayaks and tubes, are also used.

The Slate River Working Group, a consensus-based group with 18 stakeholders convened by the Crested Butte Land Trust and the Town of Crested Butte, has begun addressing recreational issues in this reach. The 2019 Slate River Floating Management Plan[60] includes several suggestions to reduce conflicts between recreational and other uses on this reach.

[60] The plan is available at https://www.cblandtrust.org/project/slate-river-working-group/

In 2019, the Working Group will install additional signs, portable toilets, and employ an intern to collect additional information on river use. The survey results will be used to refine initial flow recommendations used to help recreational users make decisions on when to float. The Working Group will update the Floating Management Plan in 2020. Working Group members are also researching potential funding sources to pay for additional infrastructure on the reach. The initial results of the recreational use survey are provided below.

Recreational Use Summary - Slate River from Coal Creek to Highway 135

Reach Description: 4-mile run on the Slate River from the Recreation Path Bridge in Crested Butte to the Skyland Bridge.

Reach Information

- Put-in: Rec Path Bridge
- Take-out: Skyland Bridge at Hwy 135
- Craft types: SUP, kayaks, whitewater rafts, and float fishing boats
- Nearest Downstream Gage: USGS Slate River Above Baxter Gulch @Hwy 135 Near Crested Butte, CO

Survey Results

- Number of survey participants: 20
- Top three craft types: SUP, whitewater kayak, and whitewater raft.
- Top two methods to decide to float: Observation and conversation.
- Top three most enjoyable aspects: Technical level, convenience, and social opportunity.
- Top three hazards: Low bridges, fences, and take-out.
- Top three reasons for unintended contact: River conditions, resting, and re-routing.
- Flow in the reach is primarily natural. There are relatively few upstream diversions in the Slate River, Coal Creek, and Washington Gulch.
- The Slate River is a relaxing reach, scenic reach that is great for all skill levels
- Incidental contact or trespass are less likely to occur during higher flows, when all sections of the reach are passable and crafts do not touch the channel bottom.
- Fences are installed following peak flows to keep cattle from crossing the Slate River and wandering into town.

Estimated Gage Flow Range for Recreational Use: varies based on user preference, initial data collection suggests a minimum flow of 89 cfs.

The Slate River Working Group is a group of local stakeholders and property managers whose primary goals are to maintain the integrity, habitat, and quality of the Slate River Watershed. The Slate River is crucial habitat to the Great Blue Heron, beavers, and other wildlife, supports a widespread wetland ecosystem, and is a popular recreational area for many sports.

To address increasing recreation, concern over the heron rookery, and watershed management, the Slate River Working Group developed a Slate River Floating Management Plan in 2019. The plan can be found on the Crested Butte Land Trust website, under "Our Projects" and Slate River Working Group. The Floating Management Plan includes preliminary recommendations on the Slate River is safe for floating and respectful to wildlife and property owners.

15.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Some stakeholders are concerned about the condition of the fishery within the reach.

Issue: Water quality sample analysis for household wells.

Issue: Continued zinc data collection to better understand water quality trends and support discharge permitting.

Issue: Additional data collection is needed due to the impairment identified in the Slate River in the fall of 2010.

Continue to research water and wastewater practices in the Highway 135 Corridor: As development continues in the area, it will be important to understand the implications of a proposal's potential effect on water quantity and water quality.

Issue: Measures by Gunnison County to increase the connection between land use planning and water supply.

Issue: Continued support for the Upper Gunnison River Basin Water Quality Monitoring Program: Since the late 1990s, the UGRWCD and other local stakeholders have partnered with USGS to fund stream gages and water quality monitoring. The Slate River and local water users have benefitted from these data. On-going needs include flow, temperature, and water quality data especially *E. coli*, zinc and arsenic.

Issue: Evaluation of temperature data from the Slate River above Baxter Gulch: A continuous temperature sensor was installed at the gage on the Slate River above Baxter Gulch in the spring of 2019. The sensor will provide useful data to evaluate attainment with temperatures standards. In 2022, the Gunnison Basin will be the focal point of the 303(d) and Monitoring and Evaluation List assessment (WQCC Regulation 93).

Issue: Riparian degradation and channel alteration. The grade of the Slate River is briefly increased below the terminal moraine and flows in a straighter course as a result. However, the channel has likely been further straightened by human activities, including riparian vegetation removal, within this area.

Section 16. Reach 12 - Slate River from Highway 135 Bridge at Skyland to East River

The Slate River flows beneath Highway 135 near Brush Creek Road. The river arcs slightly west as it parallels Highway 135 en route to the confluence with the East River. Highway 135 crosses the Slate River a second time approximately one mile north of Cement Creek Road. The Slate River supports a wide variety of uses including agricultural, environmental, and recreational uses. There are residential and industrial developments adjacent to Highway 135 and several irrigated pastures.

16.1 Agricultural Water Use

There are eight active irrigation diversions in the Slate River from Highway 135 Bridge to East River reach, serving approximately 905 acres of flood irrigated pasture grass. Table 16-1 shows the combined water rights, average annual and range of diversions, crop demands, actual crop consumptive, and shortage estimates for the reach ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 16-1: Agricultural water use statistics – Slate River from Highway 135 Bridge at Skyland to East River.

Reach Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	8	n/a
Irrigated Acreage	905	n/a
Water Rights	133.2835	n/a
Diversions	18,040 acre-feet	10,170 – 24,510 acre-feet
Crop Demand	1,430 acre-feet	1,020 – 1,710 acre-feet
Crop CU	1,380 acre-feet	890 – 1,690 acre-feet
Shortage/Need	50 acre-feet	20 - 130 acre-feet
Percent Shortage	2%	1% - 2%

Figure 16-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, Anna Rozman Ditch and Rozman No 1 Ditch comingle to serve common acreage. Squaw Creek Ditch and Columbine Ditch also comingle to serve common acreage. All of the ditches are unlined, and the individual ditches are estimated to lose between 10 and 25 percent of diverted water during delivery to the irrigated fields, depending on their length.

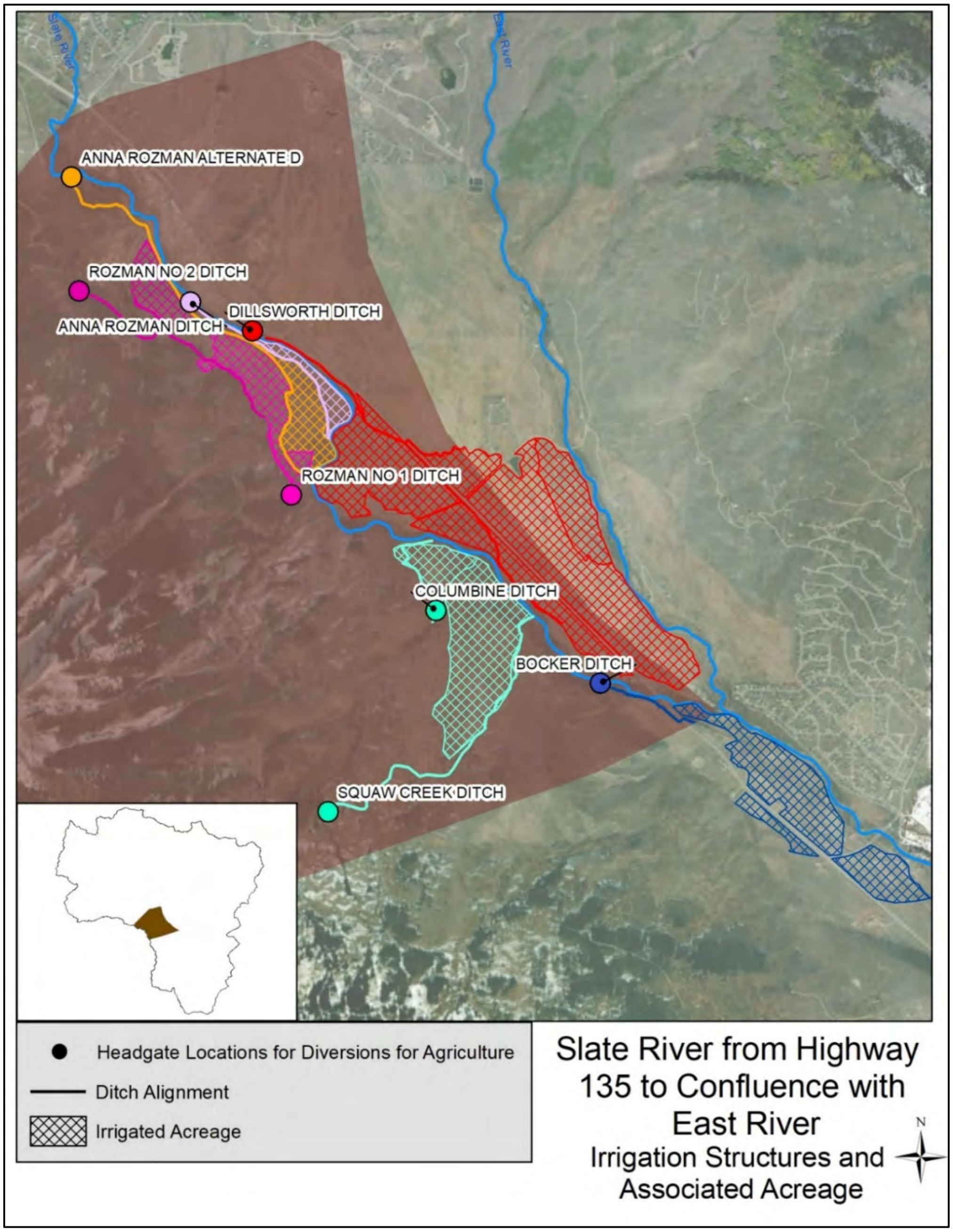


Figure 15-1: Slate River from Highway 135 Bridge at Skyland to East River diversion structures and acreage

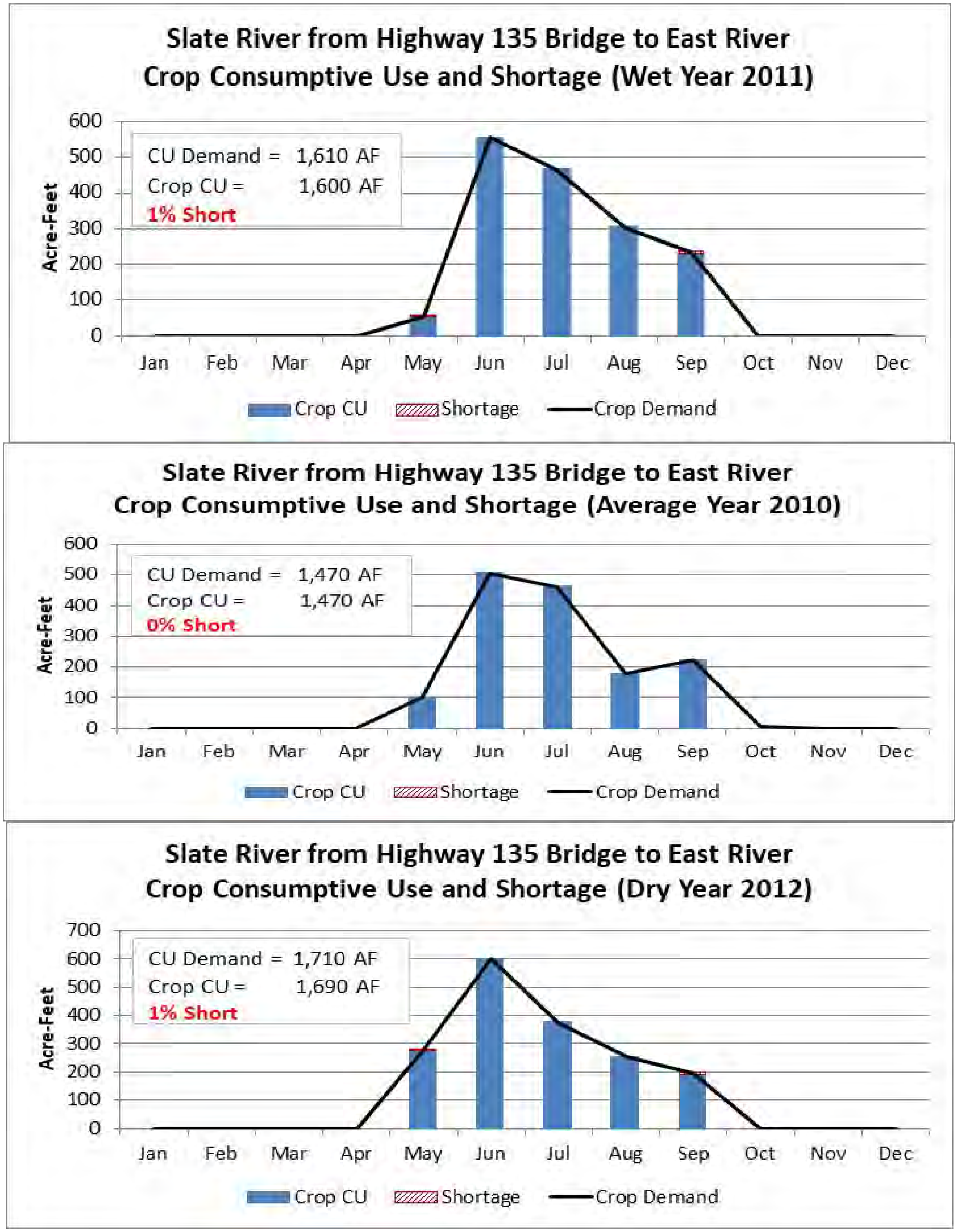
Table 16-2 shows the estimated percentage of water that returns to the Slate River from Highway 135 Bridge at Skyland to the East River and to adjacent reaches.

Table 16-2: Agricultural return flow locations in the Slate River from Highway 135 Bridge at Skyland to East River and adjacent reaches.

Return Flow Location	% of Total Return Flows	1998 to 2017 Ave Annual Return Flows (Acre-Feet)
Slate River from Highway 135 Bridge to East River	70%	11,660
East River from Slate River to Alkali Creek	20%	3,330
East River from Brush Creek to Slate River	10%	1,670

Figure 16-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, these senior water rights receive a near full supply during every month of the irrigation season, even during dry hydrologic years.

Figure 16-2: Slate River from Highway 135 Bridge at Skyland to East River



16.2 Domestic Water Use

Over the past several decades, some of the agricultural lands south of Crested Butte have been developed for residential and commercial use. The development occurred and continues to occur at a piecemeal rate, which has created a unique configuration of domestic water and wastewater systems, and smaller centralized systems operated by individual homeowners' associations. Skyland and East River Sanitation are the largest providers to the homes near the intersection of Highway 135 and Brush Creek Road. The domestic services provided by Skyland and East River Sanitation are summarized in the East River from Brush Creek to the Slate River reach.

The Riverland and Whetstone industrial parks are immediately adjacent to the Slate River and Highway 135. This industrial area houses a variety of businesses and is the most heavily industrial area in the East River Watershed.

The Rozman Gravel Pit is likely the largest water user within this area. As gravel and aggregate are mined, groundwater swells to the surface, which necessitates management prior to discharging to surface waters. Permits and operational practices were not evaluated during this assessment.

Approximately, 20 homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

There is substantial potential for additional development, including commercial, industrial, and residential developments, along the Highway 135 corridor.

16.3 Environmental Water Use

16.3.1 Stream and Riparian Characteristics

Within this reach, the valley floor is composed of highly variable quaternary sediment deposits derived from glacial activity. Large alluvial fans and landslide debris from Whetstone Mountain have, in part, shaped the course and form of the Slate River from Highway 135 to the East River, (Photo 16-1). The Whetstone alluvial fan provides the grade control that helps support the extensive wetlands that span from the Town Ranch to the Silver Sage Subdivision just upstream of this reach. These wetlands continue into the upper portion of this reach.

Below this area, the grade of the river increases, which formed the terrace features that persist until the confluence with the East River. Within this reach, the riparian corridor adjacent to the Slate River is generally narrower than in other portions of the watershed due to the narrower and steeper terraces.

The size of the riparian corridor has decreased somewhat due to vegetation removal, reduced flows, altered ground and surface water hydrology, and in some areas channel incision. Infrastructure, including roads, ditches, and bridges, adjacent to the river further narrows the riparian corridor in some portions of the reach. Bank armoring has occurred near some of the infrastructure in the reach. Grazing has deteriorated the condition of the riparian area in isolated portions of the reach. Despite these issues, the river corridor typically supports riparian vegetation throughout the reach.

Photo 16-1: Over time the Slate River has winnowed a course through glacial sediment deposits, large alluvial fans, and landslide debris from Baxter Gulch and unnamed drainages from Whetstone Mountain. The complex topography of Whetstone Mountain is due, in part, to natural and very active erosional processes that deliver large volumes of sediment to the lower portion of the mountain and the valley floor.

16.3.2 Aquatic Life

The Slate River supports brown trout, brook trout, white suckers, fathead minnows, and few rainbow trout and kokanee salmon. Both brown and brook trout reproduce in this reach based on the size distributions found in CPW fish surveys that date back to 1977. Some private landowners manage to support angling in the Slate River between Highway 135 and the East River.

Macroinvertebrates have been sampled on at least three occasions since 2008. The Macroinvertebrate Multimetric Index (MMI) scores demonstrate that the Slate River from

Highway 135 to the East River supports aquatic life and has a healthy and relatively diverse macroinvertebrate community.

Other studies have suggested that the configuration of diversion structures within this reach, specifically the Dillsworth and Anna Rozman ditches may increase channel width, prevent fish passage, and entrain fish.

16.3.3 Water Quality

Slate River water quality is discussed in detail in Section 15 of this Chapter. See Figure 16-3.

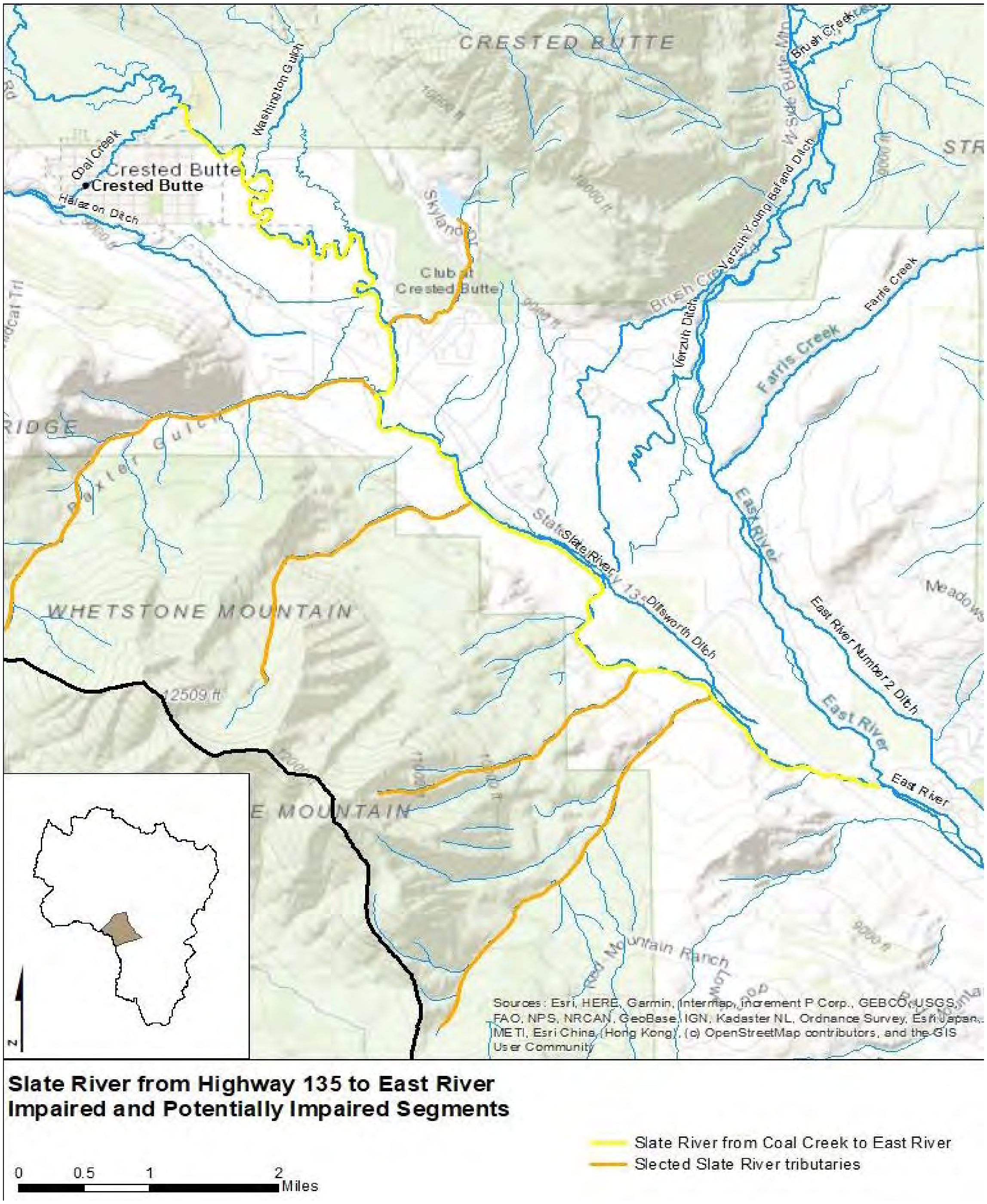


Figure 16-3: Impaired and potentially impaired stream segments in the Slate River from Highway 135 at Skyland to the East River

16.3.4 Water Temperature

Water temperature is discussed in detail in Section 15 of this Chapter.

16.3.5 Existing Instream Flows

The existing instream flows are discussed in detail in Section 15 of this Chapter. See Figure 16-5.

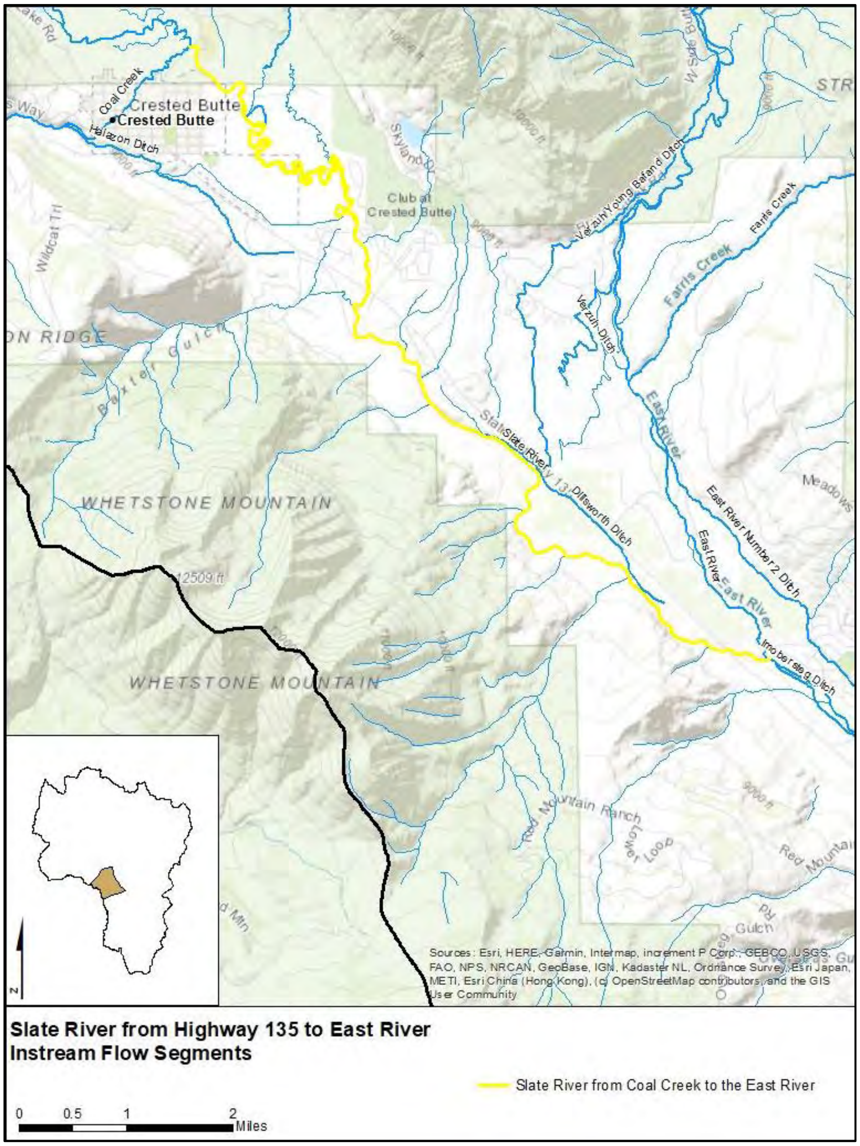


Figure 16-5: Instream flow water right in the Slate River from Highway 135 to the East River reach

16.3.6 Flow-limited Areas

The following locations were identified by stakeholders in the Slate River from Highway 135 at Skyland to the East River:

- Dillsworth Ditch: Dries up the river in most years by late in the irrigation season. Requires tarp and push-up dam to fully divert the decreed water right during low flows, as shown in Photo 16-2. This well-known dry up location is located on the upper half of the reach.
- Bocker Ditch: May not result in near dry up in normal years but is a significant diversion.

Photo 16-2: A large diversion in the Slate River caused substantial dry down during early fall 2018. The diversion structure dried a portion of the channel (see left side of photo) and the push-up dam prevented fish passage. The diversion structure also increases labor costs for the irrigator.

16.3.7 Environmental Flow Goals

The 2018 R2CROSS assessment produced results similar to the existing instream flow water right. The winter and summer instream flow rates meet two of the three R2CROSS criteria[61] to preserve the natural environment to a reasonable degree.

[61] See Chapter 2, Section 1.2.

16.4 Recreational Water Use

The Slate River from Highway 135 at Skyland to the East River is an approximately six-mile float, depending upon the put-in and take-outs used, that provides float fishing and on occasion whitewater rafting, kayaking, and standup paddle boarding. During the survey process, this reach was presented as the Slate River from the Recreation Path Bridge to Crested Butte South. Thirty-eight surveys were completed but it appears that many users exit the river at the Skyland Bridge immediately upstream of this reach.

However, some users float the entire reach. Recreational users identified fences, low bridges, diversion structures, and woody debris as the primary hazards. Landowners within the reach reported that at times, fences have been cut and recreational users have exited the river and returned to the highway through private property, without permission. Landowners reported that some users appeared unprepared for rapids and other challenges found on the reach and they believed that was often the cause of trespass.

Following peak flow, many operations have to place fences across the river to properly manage cattle grazed on lands adjacent to the river.

Recreational users, municipalities, and private landowners agree that a more comprehensive river education program, including signs, maps, and educational information would improve user experiences and alleviate conflicts.

16.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality sample analysis for household wells.

Issue: Potential nonpoint source pollution within the industrial area.

Issue: Water and wastewater practices in the Highway 135 Corridor as development continues in the area.

Issue: Identifying the best strategy for recreational use on this reach.

Section 17. Reach 13 - Cement Creek

The headwaters of Cement Creek originate between Crystal Peak and Lambertson Peak. Cement Creek drains a 36-square mile area in a narrow valley with steep slopes and flows south-southwest to the East River. The Cement Creek watershed is a beloved destination for residents of Crested Butte South as it offers convenient, high-quality year-round recreational opportunities. There is significant geothermal activity in this basin, and hot springs daylight at several locations.

17.1 Agricultural Water Use

There are ten active irrigation diversions in the Cement Creek reach, serving approximately 310 acres of flood irrigated pasture grass. Table 17-1 shows the combined water rights average annual and range of diversions, crop demands, actual crop consumption, and shortage estimates for reach ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 17-1: Agricultural water use statistics for Cement Creek.

Reach Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	10	n/a
Irrigated Acreage	307	n/a
Water Rights	55.163	n/a
Diversions	6,930 acre-feet	3,740 – 11,400 acre-feet
Crop Demand	490 acre-feet	350 - 580 acre-feet
Crop CU	410 acre-feet	310 - 470 acre-feet
Shortage/Need	80 acre-feet	110 - 40 acre-feet
Percent Shortage	15%	10% - 27%

Figure 17-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, Maxson Ditch and Jordan Ditch No 1 comingle to serve common acreage; and Cement Creek Ditch and Granite Ditch comingle to serve common acreage. All of the ditches are unlined, and the individual ditches are estimated to lose between 10 and 25 percent of diverted water during delivery to the irrigated fields depending on their length.

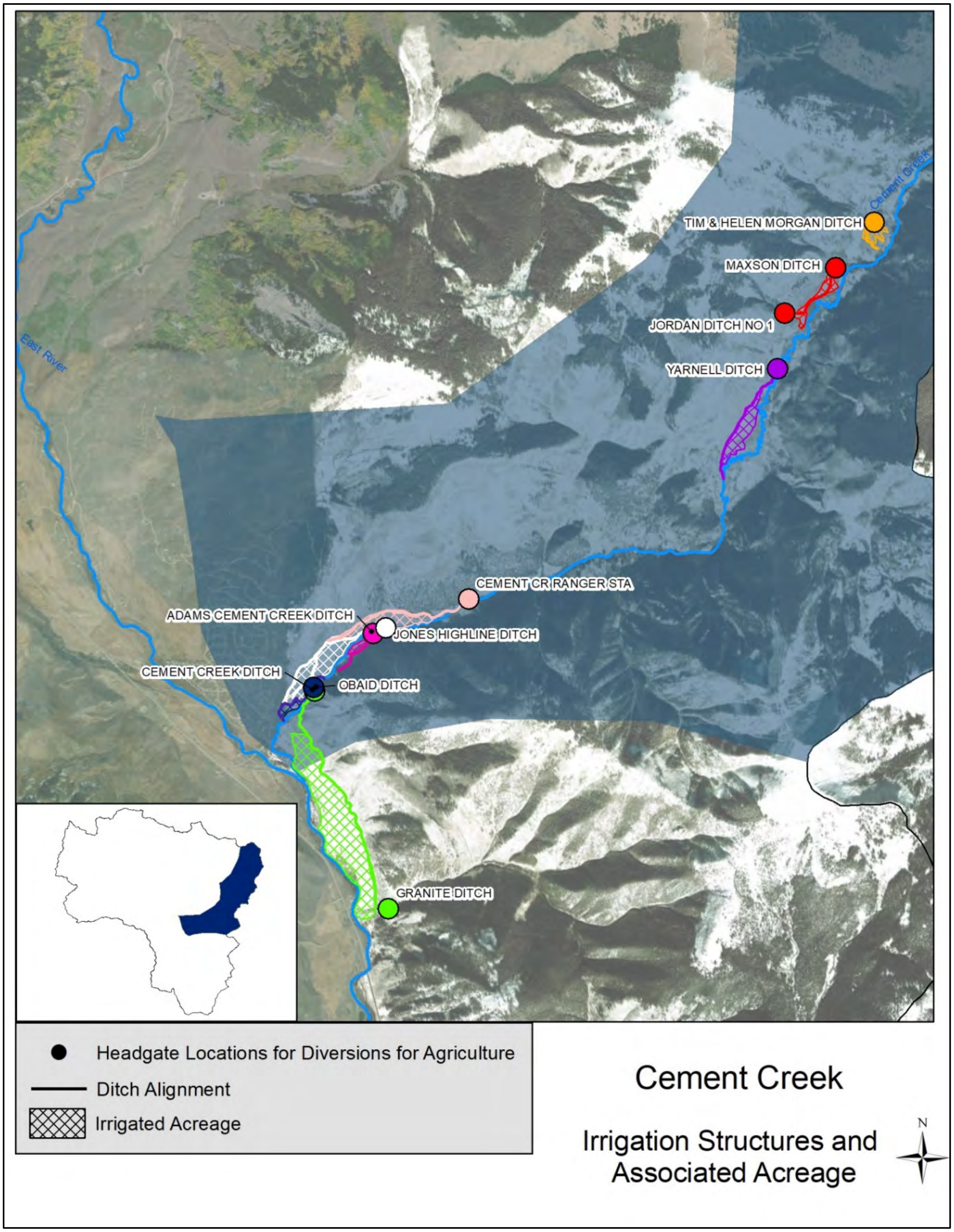


Figure 16-1: Diversion structures and irrigated acreage in the Cement Creek reach

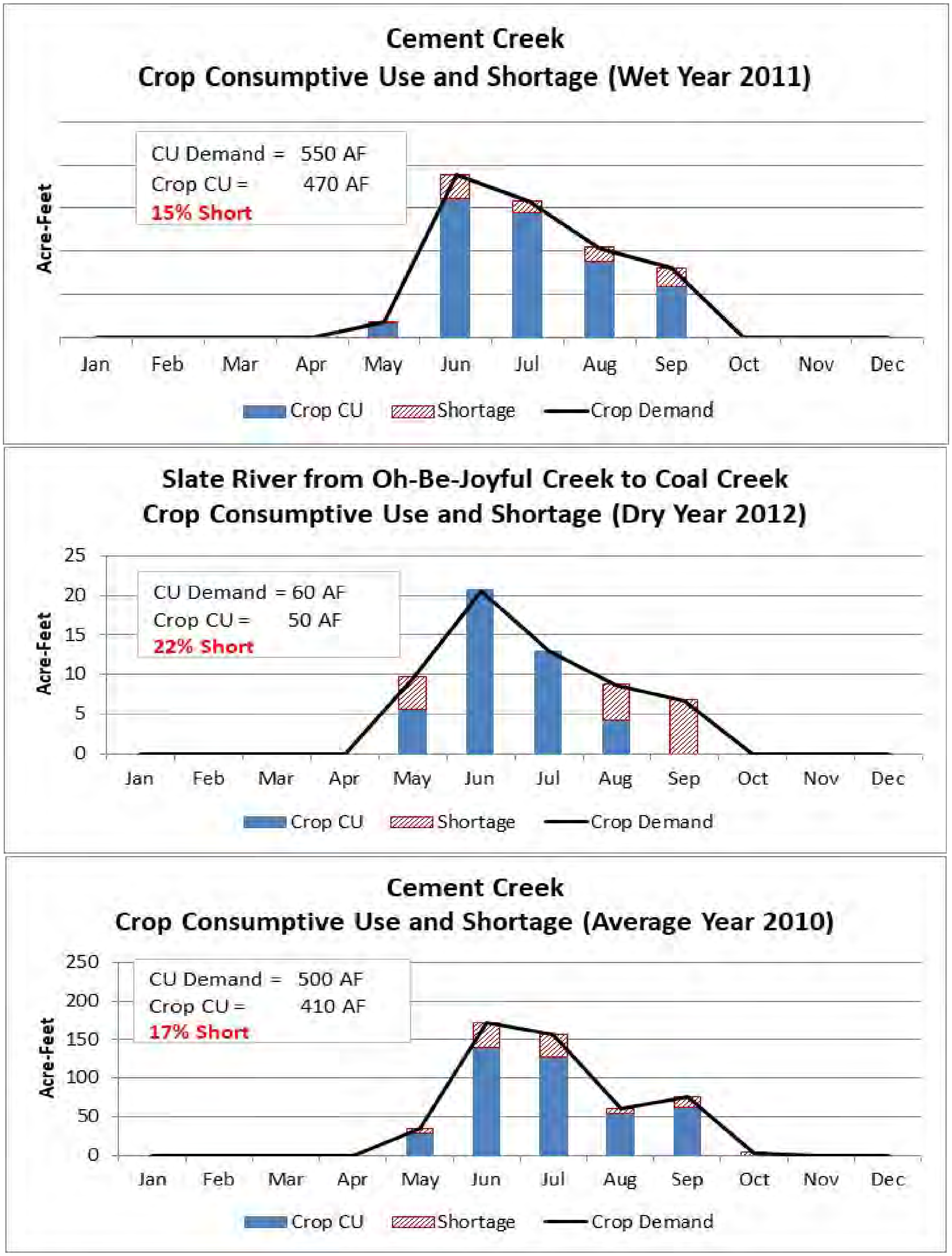
Table 17-2 shows the estimated percentage of water that returns to Cement Creek and to adjacent reaches.

Table 17-2: Agricultural return flow locations for Cement Creek.

Return Flow Location	% of Total Return Flows	1998 to 2017 Ave Annual Return Flows (Acre-Feet)
Cement Creek	50%	3,260
East River from Slate River to Alkali Creek	50%	3,260

Figure 17-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years that were chosen to highlight the hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, the upstream ditches on Cement Creek experience some shortages in physical supply most months, with greater shortages in dry hydrologic years. The lower ditches, including Obaid Ditch and Cement Creek Ditch generally receive a full supply.

Figure 17-2: Crop consumptive use and shortage for Cement Creek



17.2 Domestic Water Use

There are no diversions for municipal or industrial use in this headwater reach and no identified needs in the future. However, some household use occurs in the reach.

Approximately, 30 homes in the Cement Creek Reach rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

The Crested Butte South Metropolitan District provides water and wastewater services to Crested Butte South. One of their key wells is located adjacent to Cement Creek. This use is presented in Section 18 of this Chapter.

17.3 Environmental Water Use

17.3.1 Stream and Riparian Characteristics

The headwaters of Cement Creek form above treeline beneath Hunters Hill, Crystal Peak, Lambertson Peak, and Italian Mountain. These steep areas are covered with talus, debris from mass wasting, mass erosion and other natural deposition processes. Limited soil development has occurred on these slopes. The perennial stream channels that drain the headwater valleys are naturally steep, entrenched channels that are often scoured to bedrock. Intermittent tributaries in the headwaters are often even steeper and more entrenched and on occasion flow as debris torrents.

Below treeline, spruce and fir forests are mixed with aspen stands on sheltered slopes, while lower elevation and south-facing slopes tend to support sagebrush steppe vegetation. In most areas, the riparian corridor is relatively undisturbed and supports both active and abandoned beaver and wetland complexes in several areas.

Photo 17-1: Cement Creek near Cement Creek Ranch. The creek supports ample riparian vegetation. Italian Mountain is visible in the background.

In addition to a generally healthy mixed riparian, there is a unique growth of extreme rich fen along Cement Creek. In 2004, the Colorado Natural Heritage Program at Colorado State University recommended to the Colorado Department of Natural Resources that the Cement Creek extreme rich fen is a Potential Conservation Area (PCA). The assessment ranked the Cement Creek PCA as having “very high biodiversity significance” and noted that “[t]his PCA supports a globally imperiled (G2) extreme rich fen plant community and numerous state rare plants.” In contrast to the wide distribution of intermediate and rich fens, extreme rich fens appear restricted to a small area in Colorado, primarily the west and north portions of South Park and Cement Creek. On a global basis, extreme rich fens also appear to be quite uncommon. Only three other small locations of extreme rich fens are known in the Western U.S. Not only is the water chemistry unique, but it hosts rare plant communities that include a rare green sedge and an extreme rich fen plant community of Pacific bog sedge and alpine meadow rue along with rare plants such as Rolland’s bulrush and variegated scouring rush. These rare plants and rich fen pockets dot the floodplain in various locations in the Cement Creek riparian area.

Private residences dot the riparian area from the Deadman Gulch Trailhead to Crested Butte South. Most of these houses are used seasonally. Several of these homes are built in the riparian area and may also have bridges that span Cement Creek. Several of the bridges are undersized and cause site-scale impacts.

Agricultural and household uses increase as Cement Creek approaches the East River. The riparian corridor narrows, and vegetation removal may contribute to an over-wide channel in select areas. Cement Creek has carved a terrace through alluvium. In the terraced area, the riparian area is at times wider. However, multiple structures have been placed in the riparian area and floodplain including homes, roads, and bridges. Upper Allen Road confines Cement Creek. Homes adjacent to Lower Allen Road are in the floodplain. Vegetation removal may contribute to stability issues. Additional assessment to better characterize potential stability issues and to identify potential solutions is recommended for the lower portion of Cement Creek.

17.3.2 Aquatic Life

Cement Creek supports a healthy aquatic ecosystem and is home to a mixed fishery. Sampling conducted by Colorado Parks and Wildlife (CPW) in 2005 and 1973 identified Colorado River cutthroat, brook trout, and brown trout.

17.3.3 Water Quality

Water quality samples are not known to have been collected in this reach within the past twenty years. Older studies exist but were not evaluated during this assessment.

17.3.4 Water Temperature

Continuous water temperature measurements are not known to have been collected in this reach. Water temperature information is currently a data gap.

17.3.5 Existing Instream Flows

Cement Creek from the headwaters to the confluence with the East River has a year-round instream flow water right of 10 cfs, see Figure 17-3. The original instream flow proposals were developed by CWCB and CPW staff in 1979 and 1980. The proposal documents indicate that the existing instream flow water right does not fully meet the R2CROSS criteria.[62] In 2019, HCCA developed a proposal to increase the summer instream flow right from 10 to 13 cfs to further preserve the natural environment in Cement Creek. Hunter Creek, Waterfall Creek, and Horse Basin Creek do not have instream flow water rights.

---

62 See Chapter 2, Section 1.2.

.

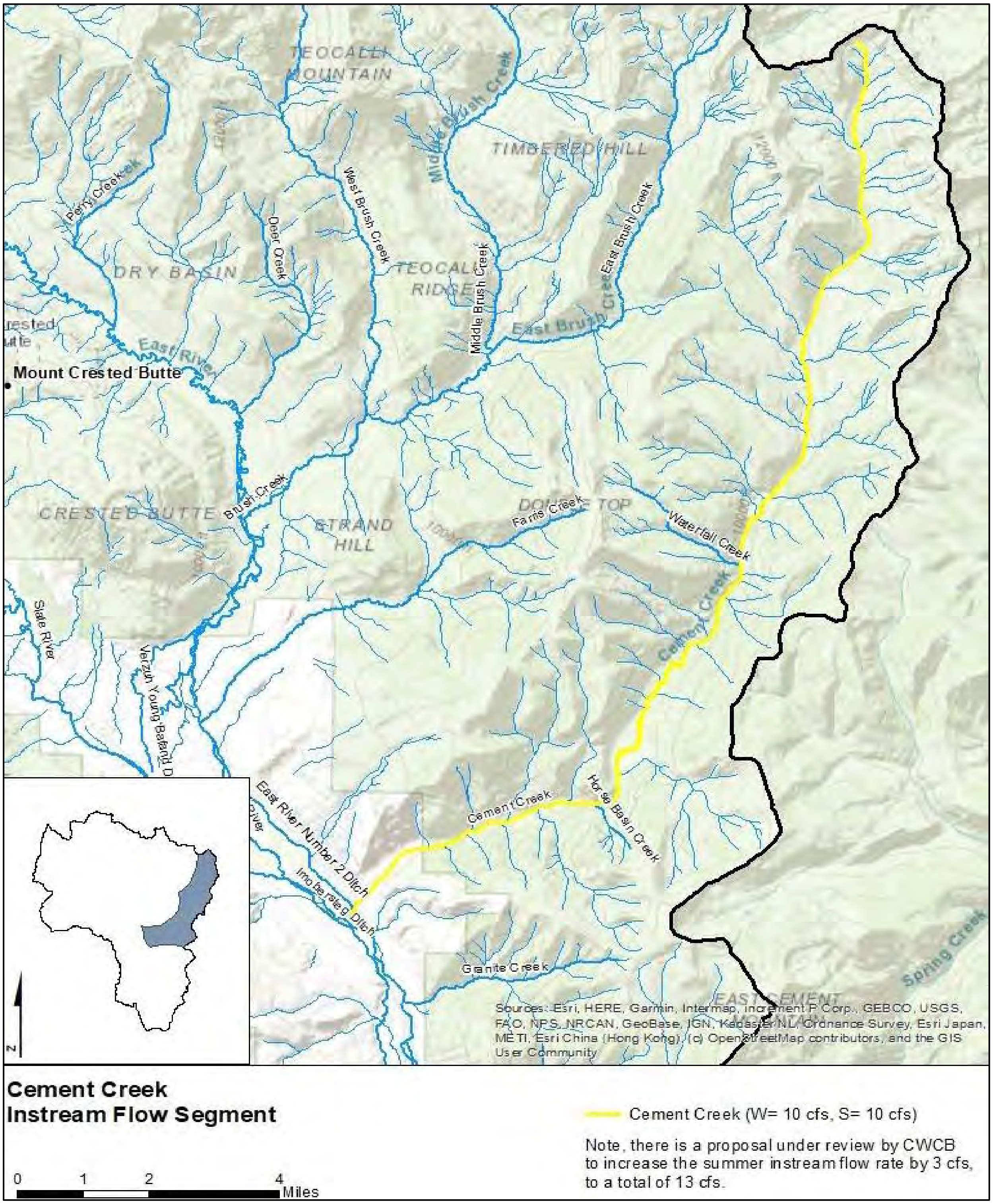


Figure 17-3: Cement Creek instream flow water right

17.3.6 Flow-limited Areas

Although there is some historical gage information available for Cement Creek from the USGS, there is not an active stream gage on Cement Creek.

Cement Creek Ditch is a location identified by stakeholders as a significant diversion. In dry years it would create near dry up.

Photo 17-2: Cement Creek near the Cement Creek trailhead in late September 2018.

17.3.7 Environmental Flow Goals

Stream flow in most of Cement Creek is driven by natural hydrology. Near the confluence with the East River, water diversions remove a substantial portion of flow. Site scale assessment of the stream and riparian habitat is recommended to further evaluate the habitat and flow needs.

17.4 Recreational Water Use

Cement Creek is not a floatable reach, but the watershed hosts a range of other recreational uses. Activity in the upper Cement Creek Basin consists primarily of land-based recreation. Near the headwaters there is a well-used trail system that includes roads open to motorized and non-motorized recreational use. In addition to concentrated motorized activity higher up, there is quite a bit of recreation throughout the entire Cement Creek basin, including multiple USFS campgrounds along the riparian corridor. Recreational opportunities in this watershed include fishing, mountain biking, OHVs, and Nordic skiing in the winter season.

17.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Given that several residences rely on groundwater and spring sources, water quality characterization is recommended

Issue: Development within the floodplain may pose a risk to private property and reduce riparian health, habitat connectivity, and watershed function.

Issue: Undersized bridges may decrease stream and riparian function in localized areas. These undersized bridges generally occur between the Deadman Creek and Caves trailheads.

Issue: Multiple stakeholders reported “muddying” or extreme sedimentation of Cement Creek during or following precipitation events. In some cases, elevated turbidity last for several days following precipitation events[63]. Although, there are several reported observations of sedimentation and sediment transport, there is limited evidence to suggest the cause of these events. It is likely that much of this activity is attributed to natural processes.

Issue: Stakeholders reported several locations where trails and roads may degrade stream conditions. The Hunter Creek trail shows signs of erosion including widening channel where it crosses Cement Creek. An adjacent stream was also reported to have a trail crossing with similar impacts. The Block and Tackle trail crosses Cement Creek and shows significant and spreading erosion. Two roads were also identified as potential issues; the first crosses a small wetland area and the other crosses a small creek area. These roads may cause erosion and serve as sources of contaminants.

[63] Due to the slopes and geology of the headwaters and upper reaches of tributaries to Cement Creek, natural mass erosion events occur naturally.

Issue: Selected culverts obstruct fish passage. Two locations were identified where culverts may inhibit fish passage. One location is a culvert that drains a smaller tributary to upper Cement Creek and has a significant drop on the downstream side. This culvert would prove to be a barrier to any fish inhabiting the upper reaches of the Cement Creek valley. A second location, observed in September of 2015, had a drop on the downstream end that may inhibit fishes' ability to travel along the stream reach.

Issue: There is a low-lying area of Cement Creek Road adjacent to a wetland complex that includes several beaver dams. A portion of the road is periodically inundated during high flow or by beaver dam expansion. This is an ongoing issue; the USFS has added fill and removed beaver dams to maintain the road.

Issue: Diversion structure that is supported with temporary materials including T- posts. This structure has a drop of a foot or more on downstream end that may act as a barrier to fish passage. It also creates a scour pool that may be affecting downstream bank stability.

Issue: A ditch may have been installed to drain water from a wet pasture to promote more grass. This ditch may effectively lower the local water table reducing or inhibiting riparian plant

Issue: The USFS has identified irrigation challenges at the Cement Creek Ranger Station. At this location the USFS irrigates grass pasture for their horses. Two ditches on this property have serious maintenance needs. Furthermore, the down-ditch water user has complained that they are not receiving their full water right amounts because of the way that these ditches are administered.

Issue: The unique and rare fen along Cement Creek lacks adequate protection. The following notes are cited from *The Survey of Critical Wetlands and Riparian Areas in Gunnison County*.

> "The Survey identified approximately 4,416 acres as particularly significant. This area sits in the same valley as the Cement Creek Ranch and some horse and cattle grazing occurs within the floodplain, both within and upstream of the PCA. There are already minor impediments to the PCA, including Forest Road 740, which traverses the northern side of the PCA. However, the CNHP Study noted that in 2004, "Current management seems to favor the persistence of the elements in the PCA, but management actions may be needed in the future to maintain the current quality of the element occurrences." The study noted that "extreme rich fens cannot be restored to historic conditions after massive disturbance in any time period relevant to humans" and recommended that because the fen's unique elements "are dependent on natural hydrological processes associated with Cement Creek and its tributaries upstream activities such as water diversions, impoundments, improper livestock grazing, and development are detrimental to the hydrology of the riparian area."

Because of the ecological importance and rareness of this riparian area, this area should be considered for conservation measures. A substantial portion of this PCA is privately owned; thus, any proposed management must be supported by the landowner.

Issue: Degraded riparian area. Several areas alongside Cement Creek show signs of impacts to riparian vegetation. At a few locations the channel appears visibly different than reaches farther upstream with more consistent riparian vegetation. Multiple locations of potentially degraded riparian area were identified in a previous study.

Section 18. Reach 14 - East River from Slate River to Alkali Creek

Much of the riparian corridor of the East River from the Slate River to Alkali Creek is privately owned. This reach supports the most irrigated acreage in the East River Watershed. Grazing is an important use throughout the reach and the area also provides habitat for big game animals.

18.1 Agricultural Water Use

There are 17 active irrigation diversions in East River from Slate River to Alkali Creek reach that collectively serve approximately 3,180 acres of flood irrigated pasture grass. Table 18-1 shows the combined average annual and range of water rights, diversions, crop demands, actual crop consumptive, and shortage estimates for the reach ditches from 2003 to 2017. Note that this period is shorter than the 1998 to 2017 used for most reaches because three of the larger ditches are missing diversion records during the 1998 through 2002 period. The information provided represents the sum of the information for each diversion.

Table 18-1: Agricultural water use statistics – East River from Slate River to Alkali Creek.

Reach Statistics	2003 to 2017 Average	2003 to 2017 Range
Number of Irrigation Structures	17	n/a
Irrigated Acreage	3177	n/a
Water Rights	409.325	n/a
Diversions	42,600 acre-feet	33,430 – 50,220 acre-feet
Crop Demand	5,730 acre-feet	5,100 – 6,570 acre-feet
Crop CU	5,140 acre-feet	4,670 – 5,660 acre-feet
Shortage/Need	590 acre-feet	910 - 430 acre-feet
Percent Shortage	10%	6% - 16%

Figure 18-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, several ditches comingle to serve common acreage. All of the ditches are unlined, and the individual ditches are estimated to lose between 10 and 25 percent of diverted water during delivery to the irrigated fields depending on their length.

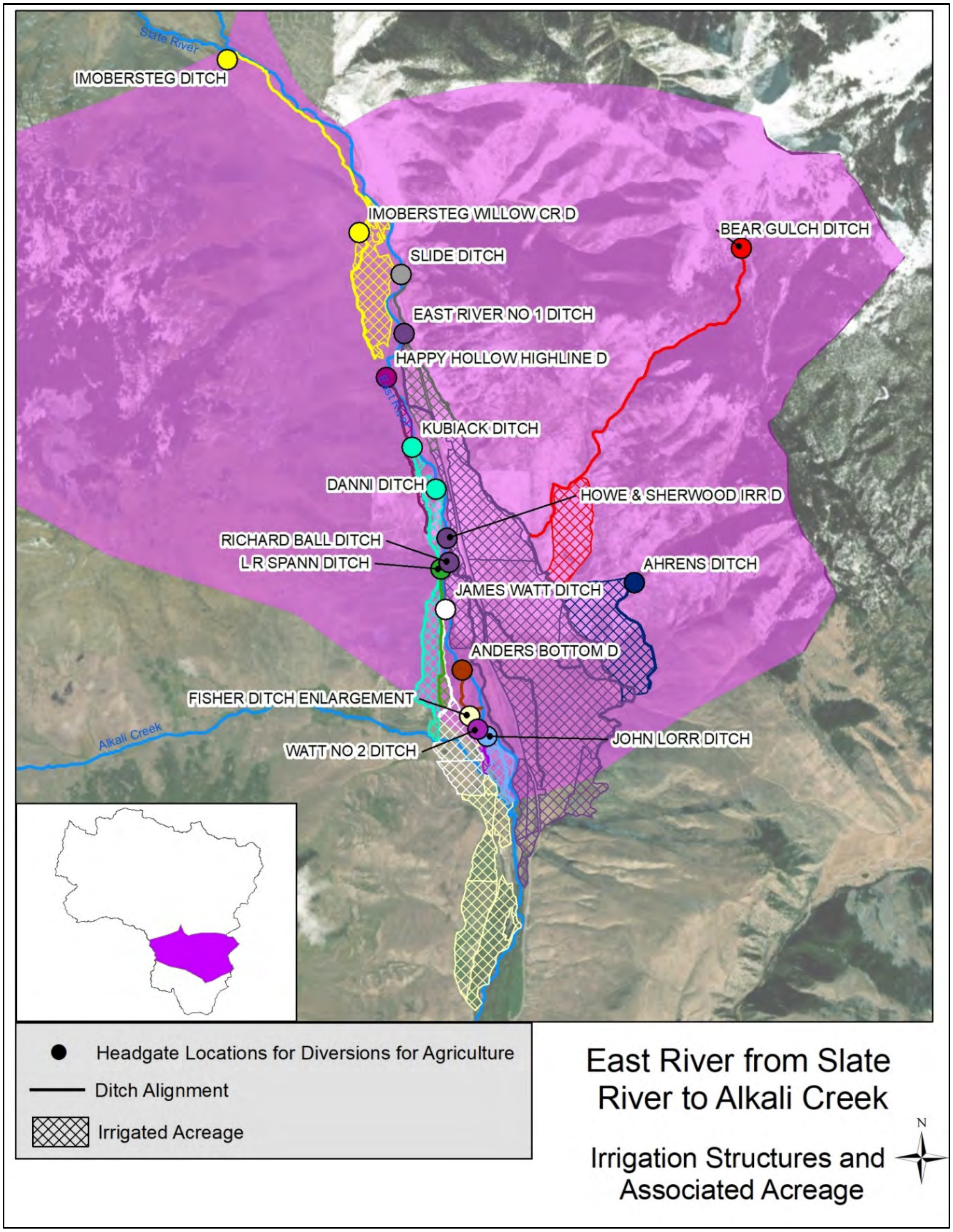


Figure 17-1: East River from Slate River to Alkali Creek diversion structures and acreage

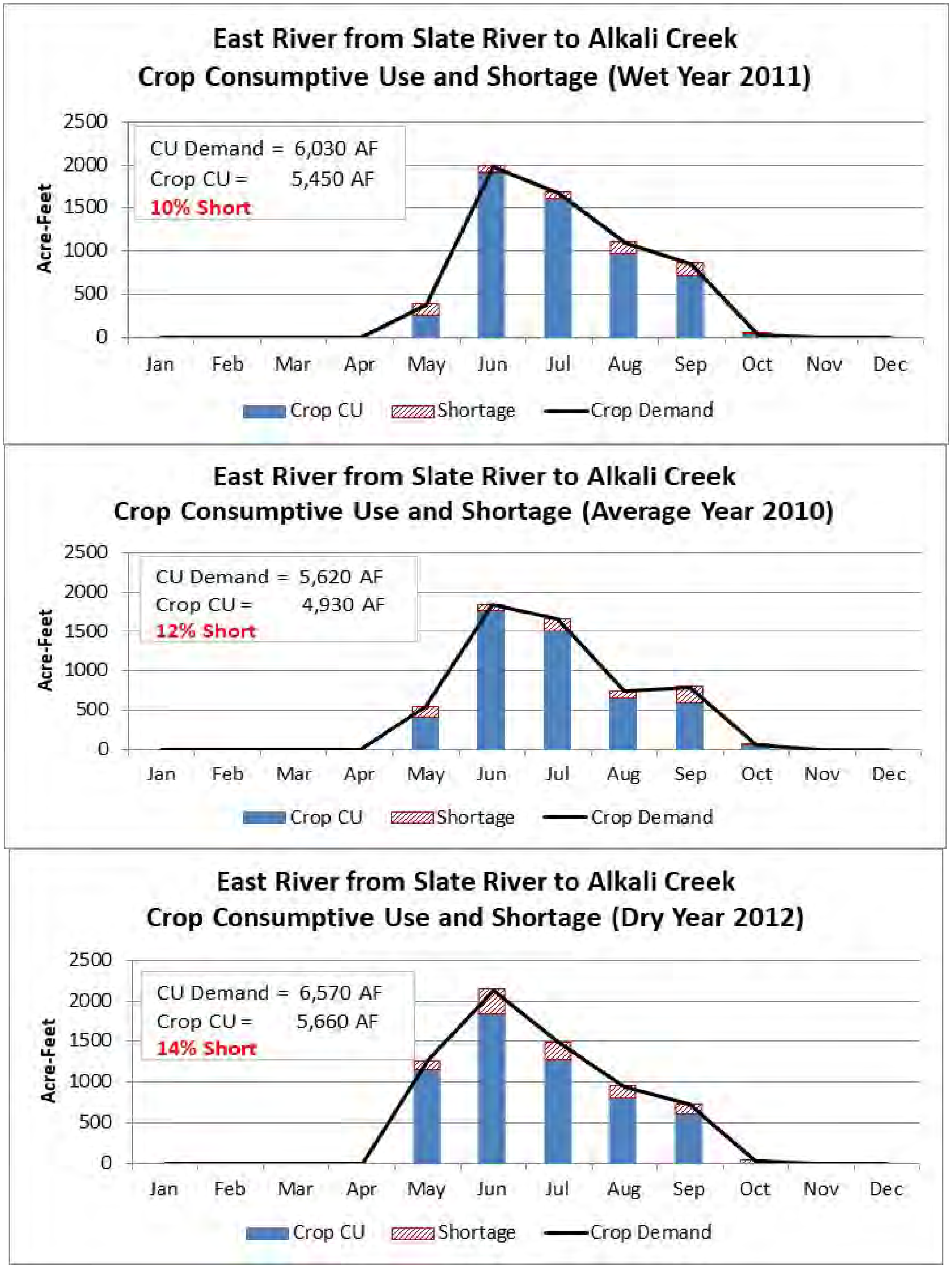
Table 18-2 shows the estimated percentage of water that returns to the East River and downstream reaches.

Table 18-2: Agricultural return flow locations – East River from Slate River to Alkali Creek.

Return Flow Location	**% of Total Return Flows**	**2003 to 2017 Avg Annual Return Flows (Acre-Feet)**
East River from Slate River to Alkali Creek	60%	22,480
East River from Alkali Creek to Gunnison River	40%	14,980

Figure 18-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There is generally physical flow available to meet the crop demands for the ditches diverting from the East River, and several of the ditches have very senior water rights and experience minimal shortages; however, the ditches diverting from the tributaries in this reach experience significant shortages in every month that increase with drier hydrology.

Figure 18-2: East River from Slate River to Alkali Creek



18.2 Domestic Water Use

The Crested Butte Metropolitan District (Metro District) provides water and wastewater treatment services to the Crested Butte South and Lower Allen Lane subdivisions. The water and wastewater systems are summarized below.

Raw water is pumped from five wells and routed to the water treatment plant[64]. The water distribution system is plastic which eliminates corrosion within the distribution system, therefore avoiding the mobilization of metals like lead and copper that may pose a human health risk.

The water system was designed to serve 1200 residential units. The Metro District is concerned about water supply as the subdivision is not fully developed and there is a trend toward increased home density. Additional development is planned for the commercial area and infrastructure has not been fully installed.

Currently, the Metro District lacks sufficient yield from their wells to pump their full water right. The Metro District has water rights in the East River but is concerned about the priority of these rights, especially in the future. In 1975, the Metro District changed 6 cfs of the senior water right in the East River at the East River No. 2 Ditch to replace impacts of year-round pumping of the Utilities, Inc. Well No 1. (See Section 9 of this Chapter for additional details.)

The Metro District has watering guidelines and outdoor water use restrictions that are implemented during droughts. Additionally, the Crested Butte South Property Owners Association received funding in 2019 for assistance for Phase I of a multiyear irrigation efficiency project and education and outreach effort that will result in greater water use efficiency for the Property Owners Association and the Metro District.

Water used indoors is collected and routed to the wastewater treatment facility (WWTF) located near the intersection of Cement Creek Road and Teocalli Road. Infiltration and inflow to the collection system can create challenges at times, typically during the spring of wet years. In recent years, the Metro District has implemented projects to reduce infiltration and inflow to the collection system[65].

---

[64] Groundwater can be an ideal raw source water, because the chemistry tends to be more stable than surface water, particularly with respect to total suspended solids, total dissolved solids, and dissolved organic carbon (all of which can increase treatment needs, especially during spring runoff).

[65] Infiltration and inflow are undesirable because it increases the total volume of water treated at the WWTF and in extreme cases can create operational challenges in the WWTF (e.g. equipment capacity, treatment contact time).

The most recent WWTF expansion occurred in 2010. Due to the proximity of wetlands adjacent to Cement Creek and the East River, the footprint of the plant is limited. There is potential for an additional facility expansion, but full buildout of the subdivision and commercial area may require the relocating the WWTF (or an expensive engineered solution in a riparian wetland). The WWTF discharges treated effluent to the East River, just upstream of the confluence with Cement Creek.

Approximately 40 homes, including homes on Upper Allen Lane, rely on water from wells or springs. Homes outside of the Metro District service area use on-site wastewater treatment systems. Additional homes may be built in the future. Because household well use does not impact stream flows in the East River, the quantity of household water use was not explored further as part of this effort.

Very limited data collection has occurred to characterize groundwater and spring water quality.

18.3 Environmental Water Use

18.3.1 Stream and Riparian Characteristics

Steep glaciated valleys and canyons form the headwaters of the East River. Natural mass erosion dominates sediment supply in the headwaters and smaller tributaries. Tributary channels and adjacent hillslopes are extremely efficient at moving sediment. In contrast, lower gradient channels in the East River downstream of the Slate River have a lower capacity to carry sediment which often results in large sediment deposits, including ample woody debris, and frequent adjustments to channel form and location. Over time, the lower gradient channel winnows away accumulated sediment. The stream system may establish a tenuous and temporary equilibrium, but natural sediment delivery and erosion processes are very dynamic due to the topography, geology, and climate.

Prior to human settlement, the East River likely supported a larger riparian area with multi-threaded channels, and a wider variety of habitats. Although the riparian corridor has narrowed, most of the river supports wetlands, riparian forest or other riparian habitat. The size of the riparian corridor has decreased somewhat due to vegetation removal, reduced flows, altered ground and surface water hydrology, and in some areas channel incision.

Homes on Lower Allen Road and the Crested Butte South WWTF were built in the floodplains of both the East River and Cement Creek. Additional development may occur on the river front throughout the reach. There are a handful of under-sized bridges and other infrastructure that confine the river in this reach.

Cattle are grazed in pastures adjacent to the river. The lower portion of the reach provides important winter range for deer and elk.

18.3.2 Aquatic Life

The East River is a high-quality fishery that includes rainbow trout, brown trout, and white suckers. Some private landowners manage their land to support angling in the East River and several have constructed manmade ponds that are filled via diversions. Private owners lease portions of the East River to commercial guides. Data to further characterize aquatic life were not evaluated during this assessment.

18.3.3 Water Quality

The USGS collects water quality samples from the East River below Cement Creek, located near the top of the reach. Since 1963, approximately 470 samples have been collected. Standards evaluations completed by USGS and the WQCD indicate that the East River attains all applicable water quality standards for the constituents analyzed at the site.

Tributaries to the East River in this reach have not been sampled in recent years. Given other water quality issues in the upper East River Basin and the fact that the East River below Cement Creek and at Almont attain water quality standards, collecting baseline water quality samples for tributaries to the East River is not a top priority at this time.

18.3.4 Water Temperature

In recent years, continuous water temperature measurements have not been collected in this reach. USGS operated a continuous temperature sensor from May 1995 to September 1999. Stream temperatures in the East River below Cement Creek attained the applicable temperature standards developed to protect sensitive cold-water species.

18.3.5 Existing Instream Flows

The East River from Brush Creek to the confluence with Alkali Creek has a year-round instream flow water right of 10 cfs, as shown in Figure 18-3. The instream flow proposals were developed by CWCB and CPW staff from 1979 to 1982. The original intent was to create two instream flow reaches- the East River from Brush Creek to the Slate River, and the East River from the Slate River to Alkali Creek. The R2CROSS output from the original cross-sections identified the minimum stream flows to meet the physical criteria for the upper reach were 20 and 40 cfs for winter and summer (respectively) and for the lower reach were 35 cfs for winter and 65 cfs for summer.

The proposal was contested. The instream flow rate was reduced to 10 cfs and converted to a year-round rate. The originally proposed reaches were combined into a single reach. As a result of this, the existing instream flow water right does not provide ideal protection for aquatic life in this reach. An R2CROSS assessment was not completed on this reach in 2018 because

R2CROSS cannot be used to create instream flow recommendations where the bankfull width of the river, in riffle sections, exceeds 100 feet. With few exceptions, the bankfull width of the East River is greater than 100 feet between Slate River and Alkali Creek.

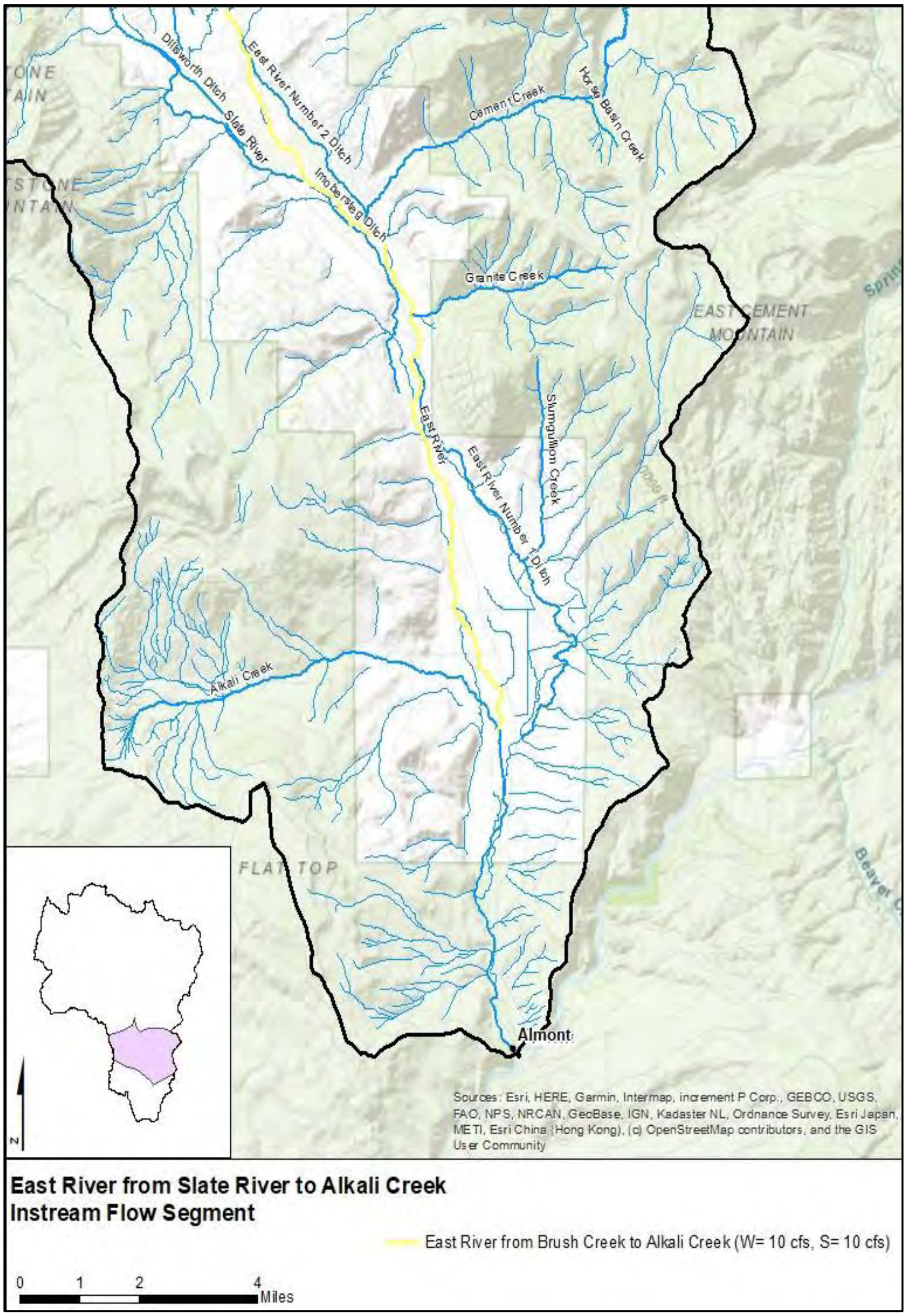


Figure 18-3: East River from Brush Creek to Alkali Creek instream flow water right

18.3.6 Flow-limited Areas

The following locations were identified by stakeholders in the East River from the Slate River to Alkali Creek:

- Richard Ball Ditch is a significant diversion. In dry years it could create dry down.
- The Bear Gulch Ditch and Ahrens Ditch divert substantial portions of the unnamed tributaries that each ditch diverts from.
- The East River below Cement Creek has an average annual stream flow of about 233,400 acre-feet and the East River at Almont averages about 240,700 acre-feet. Annual irrigation season diversions in the reach average 42,600 acre-feet (Table 1), or approximately 22 percent of the irrigation season streamflow.

18.3.7 Environmental Flow Goals

The gages in the East River below Cement Creek and the East River at Almont provide a unique opportunity to evaluate the effect of irrigation diversions on streamflow patterns and timing. This comparison is possible for the following reasons:

- The average annual stream flows at both gages are very similar. The East River below Cement Creek has an average flow of about 233,400 acre-feet and the East River at Almont averages about 240,700 acre-feet, a difference of 3 percent[66].
- The limited number of tributaries between the two gages corroborates the small percent difference in flows between the two gages. Alkali Creek is the most notable tributary within the reach; and stakeholders have noted dry up in the lower portions of Alkali Creek.
- In the winter (December 1 to April 1), flows in the East River at Almont average 6 cfs higher than flows in the East River below Cement Creek. The increase in flow is likely attributed to groundwater. If larger increases in flow are observed during the irrigation season, a substantial portion of the increase may be attributed to irrigation return flows.
- Annual irrigation season diversions in the East River from Slate River to Alkali Creek reach average 42,600 acre-feet (Table 18-1) and annual irrigation season diversions in the East River from Alkali Creek to the Gunnison River average 7,720 acre-feet[67].
- Irrigation return flows in both reaches accrue to the East River upstream of the gage in Almont.

[66] The average annual stream flows are based upon the entire period of record available for each gage. The East River below Cement Creek includes the following years 1964 to 1972, 1980 to 1981, and 1994 to present. The East River at Almont includes the following years 1911 to 1922 and 1935 to present.

[67] As noted previously in the assessment, diversion records often lack accurate start and stop dates and typically include only one flow rate per 30-days.

- Annual irrigation season diversions on both reaches are about 27 percent of the total annual stream flow during the irrigation season in the East River. Up to 50 percent of the irrigation water that reaches the field returns to the river in four days or less as surface runoff, which equates to approximately 12 percent of the stream flow during the irrigation season.
- Because irrigation diversions account for a substantial portion of stream flows, about 27 percent, fluctuations in flow during the irrigation season are more likely to be attributed to irrigation practices than other factors.

Due to uncertainty attributed to potential groundwater flows[68] and the uncertainty in diversion records, especially irrigation stop and start dates, this comparison uses daily average flows from 2000 to 2018. The comparison generalizes irrigation's effect on stream flows and does not characterize any specific year type. Very wet or very dry years are likely to result in different return flow patterns and timing.

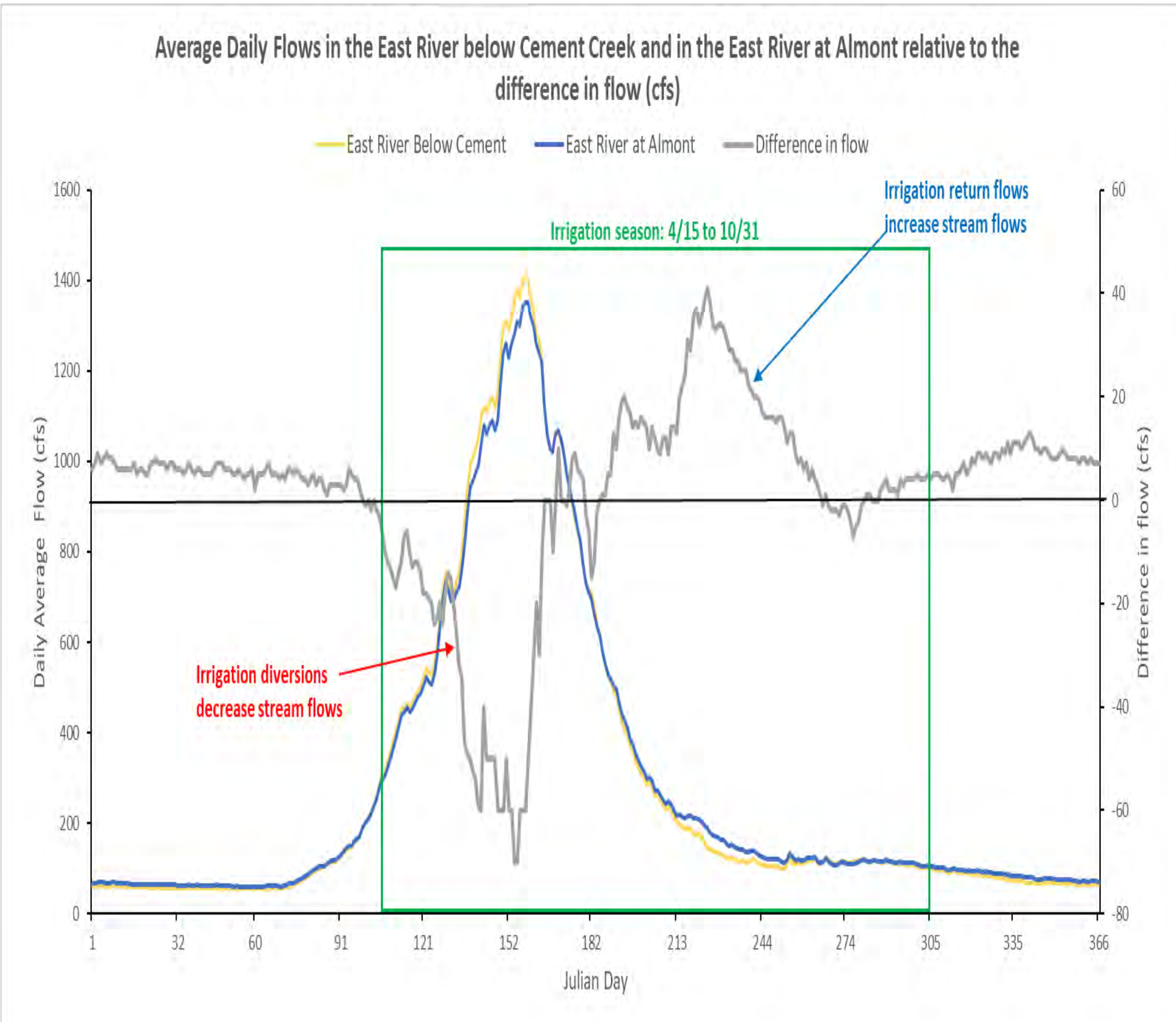
The comparison of average stream flows found the following, as shown in Figure 18-4:

- On average, irrigation diversions begin to reduce stream flows by the second week of May (red arrow and Julian day 130).[69]
- As peak flows recede, return flows typically begin to increase stream flows sometime in early to mid-July (blue arrow and Julian day 182).
- Return flows appear to increase stream flows until the third week of September, on average (blue arrow and Julian day 265).

---

[68] This comparison does not characterize the potential role of groundwater. The Almont Fault extends north from Almont to the Roaring Judy area. The fault's position and hydrologic characteristics have not been studied in detail.
[69] Julian day is a continuous count of the day of the year. For example, January 1 is Julian day 1. January 31 is Julian day 31 and April 15 is Julian day 106. Each number on the horizontal axis of Figure 4 is start of a new month, approximately (e.g. Julian day 182 is about July 1).

Figure 18-4: Average Daily Flows in the East River below Cement Creek and at Almont



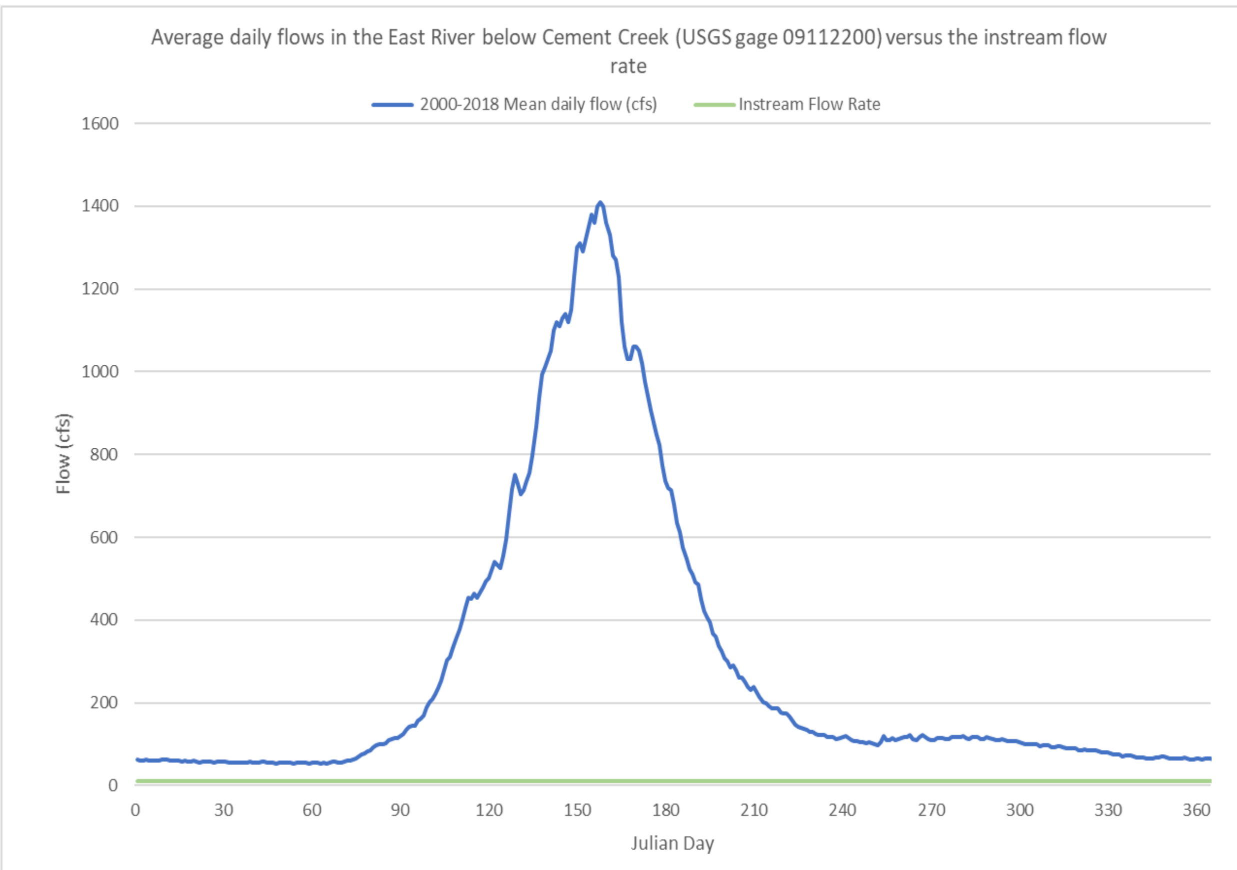
Average daily flows in the East River below Cement Creek (yellow line) and in the East River at Almont (blue line), based on flows measured from 2000 to 2018 (plotted on the left axis), relative to the difference in flow between the gages (grey line plotted on right axis). When the difference in flows is negative (i.e. grey line below the horizontal black line) flow in the East River at Almont was less than flow in the East River below Cement Creek and irrigation diversions decreased stream flow. When the difference in flows is positive (i.e. grey line above the black line) flow in the East River at Almont was greater than flow in the East River below

Cement Creek and irrigation return flows likely increased stream flow.

The East River from the Slate River to Alkali Creek is a strong candidate for tiered environmental flow goals because the reach provides high-quality fish habitat, has a generally intact riparian corridor that includes a variety of riparian habitats, high recreational value (fishing, wildlife viewing, and aesthetics), and private landowners that lease fishing rights or manage the river for angling.

From 2000 to 2018, the average daily flow in the East River below Cement never fell below the existing instream flow rate of 10 cfs, as shown in Figure 18-5.

Figure 18-5: Average daily flows in the East River at Almont versus the existing instream flow rates (winter= 27 cfs, summer= 50 cfs).



Average daily flows, from 2000 to 2018, in the East River below Cement Creek were used to calculate Montana Method metrics. The excellent criteria, which is 30 percent of the average annual flow, creates a flow goal of 85 cfs. The outstanding criteria, which is 40 percent of the average annual flow, generates a flow goal of 114 cfs. Based on flows measured from 2000 to 2018, the excellent criterion was attained 100 percent of the time in the summer (May 1 to September 30) and the outstanding criterion was attained 84 percent of the time.

18.4 Recreational Water Use

The East River from the confluence with the Slate River to the Gunnison River is a popular reach for whitewater rafting, kayaking, float fishing, and wade fishing. Because users often put in at the Cement Creek Road bridge, a part of the East River from the Slate River to Alkali Creek reach, and float through all or part of the East River from Alkali Creek to the Gunnison River reach the recreational use surveys for these reaches were combined.

Recreational users identified low bridges and large diversions structures that create challenges while floating this reach. Specific infrastructure was not identified in the survey responses. A handful of recreational users suggested that a boat ramp at the Almont Campground would improve the recreational experience and allow for safer access than existing options immediately adjacent to the highway at the confluence of the East River and Taylor River.

A range of individuals and entities, from a variety of user groups, have raised concerns about the impact on water quality of recreation on public lands. Examples include increased human waste at popular camp sites and trailheads, increased erosion from OHV use, illegal use of roads and trails, and impacts from boaters pulling over on public or private lands without facilities. Commercial guides have also raised these issues and suggested that it would benefit their guiding companies to have additional facilities.

The Metro District allows recreational users to put into the East River on their property. When river use is at its peak during high flow years, the put-in can sometimes create safety issues at the WWTF (e.g. lack of access should an emergency occur at the WWTF), conflicts with downstream users including landowners in Lower Allen Lane, the Reserve on the East River, and others.

Survey responses indicate that floating typically occurs when the East River upstream of Almont is flowing between 500 and 2,500 cfs. These flows generally correlate with peak flows. Recreational use is summarized below.

Summary of Recreational Use on East River from Slate River to Alkali Creek

Reach Description: 10-mile reach on the East River from Crested Butte South to Almont.

Reach Information

- Put-in: Crested Butte South Bridge
- Take-out: Almont Bridge upstream of confluence
- Activities: Whitewater rafting, kayaking, SUP, float fishing, and foot fishing
- Nearest Downstream Gage: USGS East River At Almont, CO

Survey Results

- Number of survey participants: 7
- Top two methods to decide to float: USGS gage and observation
- Top three most enjoyable aspects: Convenience, technical level, and good fishing
- Top three suggestions for improvement: Parking, restrooms, and boat ramps
- Top three hazards: Strainers, bridges, and fences
- Top three reasons for unintended contact: River conditions, incidental, or rest stops

Estimated Gage Flow Range for Recreational Use: 500-2,500 cfs. Estimated flow at the bottom of the reach when gage reports 500 cfs is 500 cfs.

Floating Season: May through Mid-July.

18.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality in household wells.

Issue: There may be a need for recreational management at the Crested Butte South put-in.

Issue: Tailwater returns. In Crested Butte South, a large tailwater ditch parallels Teocalli Road and is an artifact of past irrigation activities in the subdivision. Water in the ditch is often stagnant and provides a breeding ground for mosquitos. Dried sections of the ditch and ponds are unattractive. Additionally, the Crested Butte South POA owns the wetlands adjacent to the East River and upstream of Cement Creek Road. The POA has expressed an interest in maintaining and improving the wetlands. By returning the tailwater to the East River north of Crested Butte South, the wetlands would benefit, and the unnecessary tail water ditch could be removed within the subdivision.

Issue: Metro District augmentation. There are preliminary plans for augmentation ponds, but additional evaluation is required. Initial analyses suggest it may be more economical for the Metro District to purchase augmentation water from existing sources rather than develop their own.

Issue: Advisability of developing tiered environmental flow goals.

Issue: Need for more comprehensive approach to educate recreational users.

Section 19. Reach 15 - East River from Alkali Creek to Gunnison River

Much of the riparian corridor of the East River from Alkali Creek to the Gunnison River is privately owned. The primary exception is the Roaring Judy Fish Hatchery, an 840-acre facility that provides public access for fishing and other recreational uses. The hatchery is located west of the East River downstream of the confluence with Alkali Creek. Hatchery staff raise kokanee salmon, cutthroat and rainbow trout. CPW also irrigates pasture to graze cattle through leasing agreements and to provide winter range for big game.

19.1 Agricultural Water Use

There are seven active irrigation diversions in East River from Slate River to Alkali Creek reach, serving approximately 435 acres of flood irrigated pasture grass. Table 19-1 shows the combined water rights, average annual and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the ditches located on this reach from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 19-1: Agricultural water use statistics – East River from Alkali Creek to Gunnison River

Reach Statistics	1998 to 2017 Average	1998 to 2017 Range
Number of Irrigation Structures	7	n/a
Irrigated Acreage	435	n/a
Water Rights	41.626	n/a
Diversions	7,720 acre-feet	4,930 – 9,790 acre-feet
Crop Demand	830 acre-feet	650 - 950 acre-feet
Crop CU	670 acre-feet	560 - 760 acre-feet
Shortage/Need	160 acre-feet	190 - 90 acre-feet
Percent Shortage	18%	10% - 39%

Figure 19-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, McDonald Ditch and Schupp Ditch comingle to serve common acreage. All of the ditches are unlined, and the individual ditches are estimated to lose between 10 and 25 percent of diverted water during delivery to the irrigated fields depending on their length. Return flows from this reach, estimated to be an average of 7,050 acre-feet per year from 1998 to 2017, accrue within the reach above the confluence with the Gunnison River.

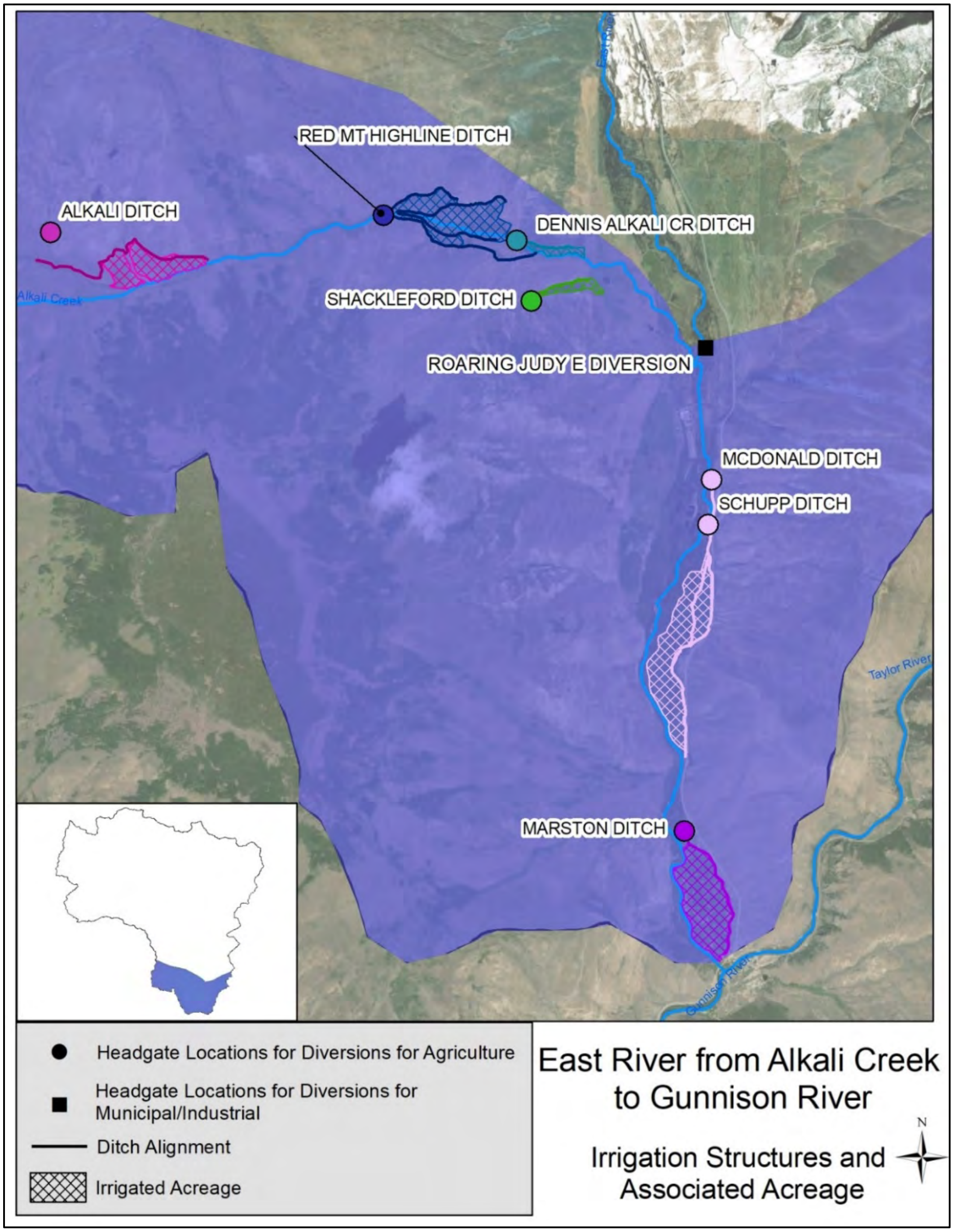
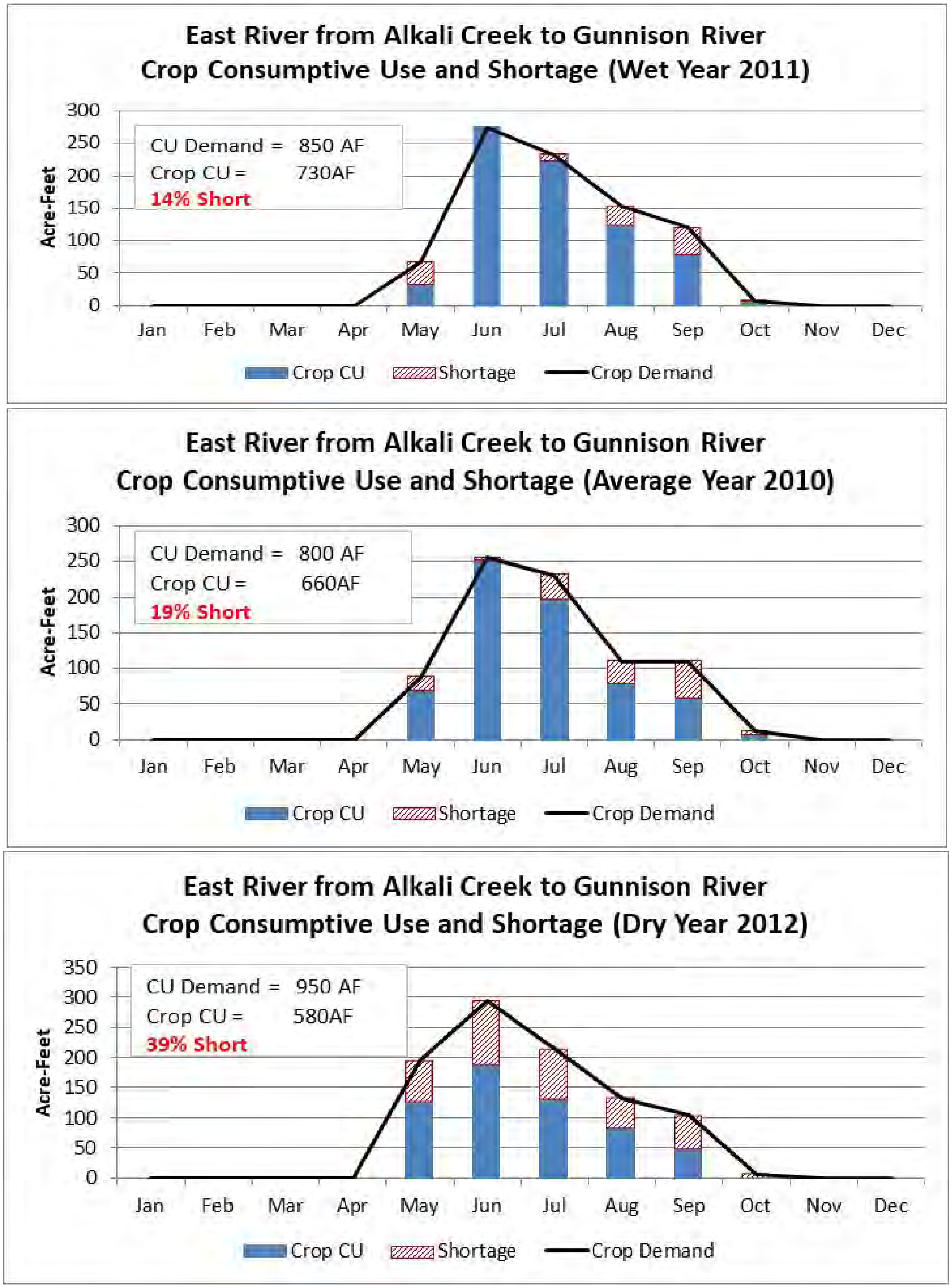


Figure 18-1: East River from Alkali Creek to Gunnison River diversion structures and acreage

Figure 19-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). The shortages shown are primarily from diversions on Alkali Creek. Mainstem ditches receive close to a full supply even in dry hydrologic years.

Figure 19-2: East River from Alkali Creek to Gunnison River



19.2 Domestic Water Use

Domestic use in this reach relies on groundwater primarily from exempt well permits. Because domestic use does not impact stream flows in the East River on this reach, the quantity of domestic water use was not explored further as part of this effort.

Approximately, 20 homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

The Roaring Judy E Diversion diverts water for the Roaring Judy Fish Hatchery; however, diversion records are not maintained. The flow-through diversions experience minimal losses to evaporation. The fish hatchery has a general discharge permit. The discharge permit assigns limits to assure that operations at the hatchery do not degrade water quality in downstream reaches. The Roaring Judy Hatchery is in compliance with the limits assigned in its discharge permit.

19.3 Environmental Water Use

Photo 19-1. The East River downstream of Roaring Judy Road Bridge on August 27, 2018. The flow measured during the assessment was 65 cfs. The average daily flow for the East River at Almont is 158 cfs. The 2018 flow was just 41 percent of average.

19.3.1 Stream and Riparian Characteristics

Steep glaciated valleys and canyons form the headwaters of the East River. Natural mass erosion dominates sediment supply in the headwaters and smaller tributaries. Tributary channels and adjacent hillslopes are extremely efficient at moving sediment. In contrast, lower gradient channels in the East River downstream of Alkali Creek have a lower capacity to carry sediment which often results in large sediment deposits, including ample woody debris, and frequent adjustments to channel form and location. Over time, the lower gradient channel winnows away accumulated sediment. The stream system may establish a tenuous and temporary equilibrium, but natural sediment delivery and erosion processes are very dynamic due to the topography, geology, and climate.

Cattle are grazed in pastures adjacent to this reach of the river. The lower portion of the reach provides important winter range for deer, elk, and bighorn sheep.

When the Roaring Judy Hatchery was built, the mainstem of the East River was pushed east toward Highway 135 and straightened to create an area large enough to house the hatchery buildings and fish runs. As a result, the riparian corridor through the hatchery is the most manipulated section on the reach. Over the years, CPW staff have completed multiple stabilization projects, including extensive streambank armoring and earthen berms, to maintain the current channel form. There is interest in additional projects at the hatchery.

19.3.2 Aquatic Life

The East River is a high-quality fishery, including rainbow trout, brown trout, and white suckers, that is a favorite of local anglers. Kokanee salmon, cutthroat and rainbow trout are raised at the Roaring Judy Hatchery. The East River downstream of the hatchery is a salmon run. Data to further characterize aquatic life were not evaluated during this assessment.

Photo 19-2. A kokanee caught near the Roaring Judy Hatchery. Kokanee fishing is heavily regulated.

19.3.3 Water Quality

The USGS collects water quality samples from the East River at Almont, located at the bottom of the reach. Since 1959, nearly 600 samples have been collected. The Riverwatch program also monitors water quality in the East River at Almont. Standards evaluations completed by USGS and the Water Quality Control Division indicate that the East River attains all applicable water quality standards for the constituents analyzed at the site.

Tributaries to the East River, including Alkali Creek have not been sampled in recent years. Given other water quality issues in the upper East River Watershed and the fact that the East River at Almont attains water quality standards, collecting baseline water quality samples for tributaries to the East River is not a top priority.

Homes in the East River from Alkali Creek to the Gunnison River reach rely on on-site wastewater treatment systems. Several stakeholders identified concerns related to the performance of centralized wastewater treatment facilities and on-site wastewater treatment systems (septic systems). The concerns were focused on water quality issues including *E. coli*, nitrogen, phosphorus, and temperature. In recent years, *E. coli,* nitrogen, phosphorus concentrations measured in the East River at Almont have been very low and readily attained water quality standards.

19.3.4 Water Temperature

In conjunction with the 2016 Temporary Modifications Rulemaking Hearing, CPW reported that stream temperatures applied to the East River were attained based on monitoring conducted at the Roaring Judy Hatchery. Other continuous water temperature measurements were not identified during the assessment. USGS instantaneous temperature measurements have not exceeded applicable standards.

19.3.5 Existing Instream Flows

The East River from Alkali Creek to the confluence with the Taylor River[70] has an instream flow water right of 27 cfs for winter and 50 cfs for summer as shown in Figure 19-3. The instream flow proposals were developed by CWCB and CPW staff from 1978 to 1982. The R2CROSS output from the original cross-sections identified the minimum stream flows to meet the R2CROSS criteria were 40 and 105 cfs for winter and summer, respectively. Prior to submitting the proposal staff reduced the recommendation to 35 and 65 cfs for winter and summer, respectively, based on legal availability. The revised proposal was contested, and the instream flow rates were further reduced. The existing instream flow water right does not provide ideal protection for aquatic life in this reach.

[70] This confluence creates the Gunnison River.

On August 27, 2018, an R2CROSS assessment was completed on the upper portion of the Roaring Judy Hatchery. The flow measured during the cross-section was 65 cfs (in a notably low-flow year). R2CROSS provided a preliminary output of 73 and 94 cfs for winter and summer, respectively. Based on these findings and the analyses presented below (see preliminary environmental flow goals), it may be possible to enlarge the summer and winter instream flow rates in the East River near the hatchery. If an enlargement proposal is pursued, it may be necessary to adjust the segment termini based on the legal availability analysis.

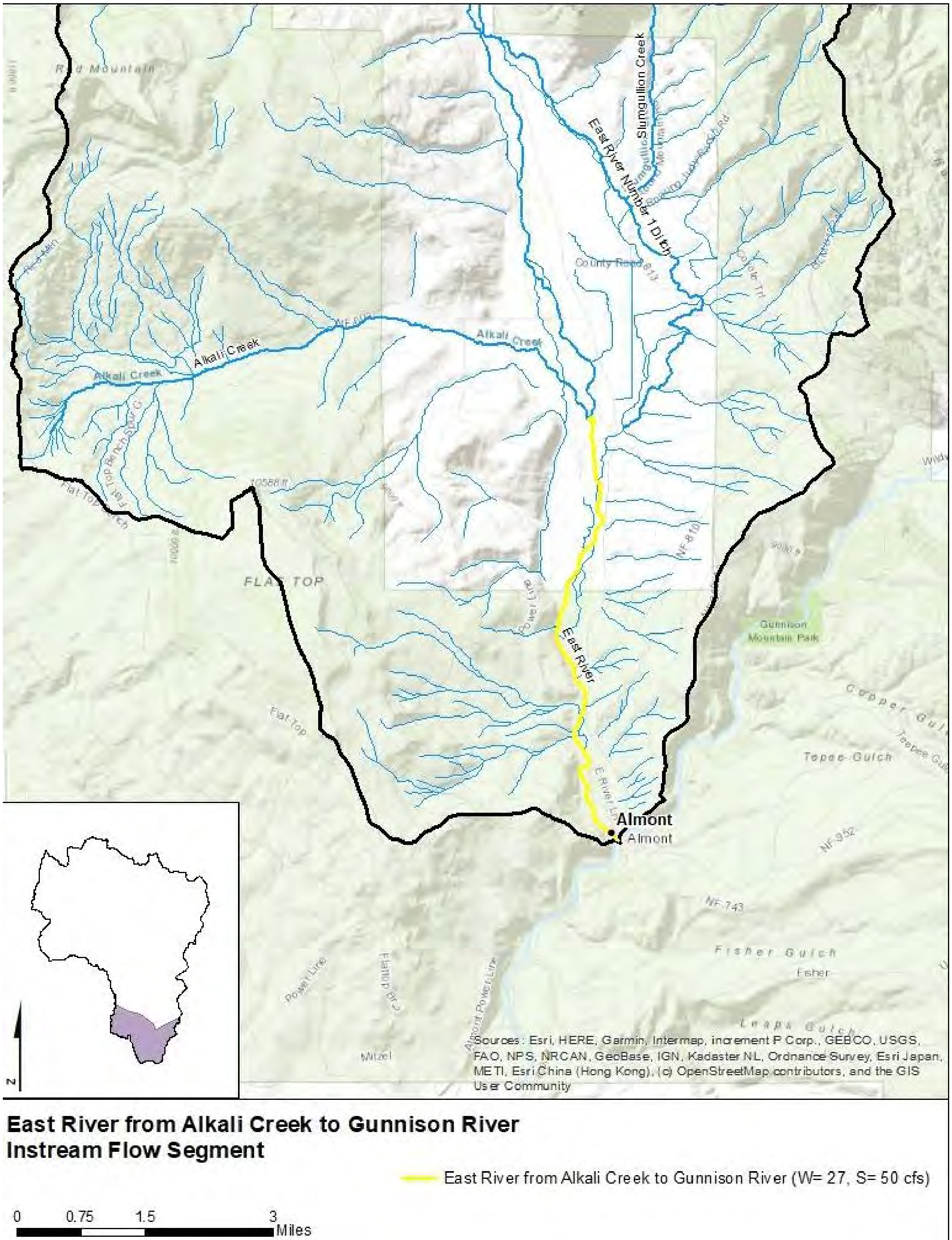


Figure 19-3: Instream flow water rights in the East River from Alkali Creek to the Gunnison River

19.3.6 Flow-limited Areas

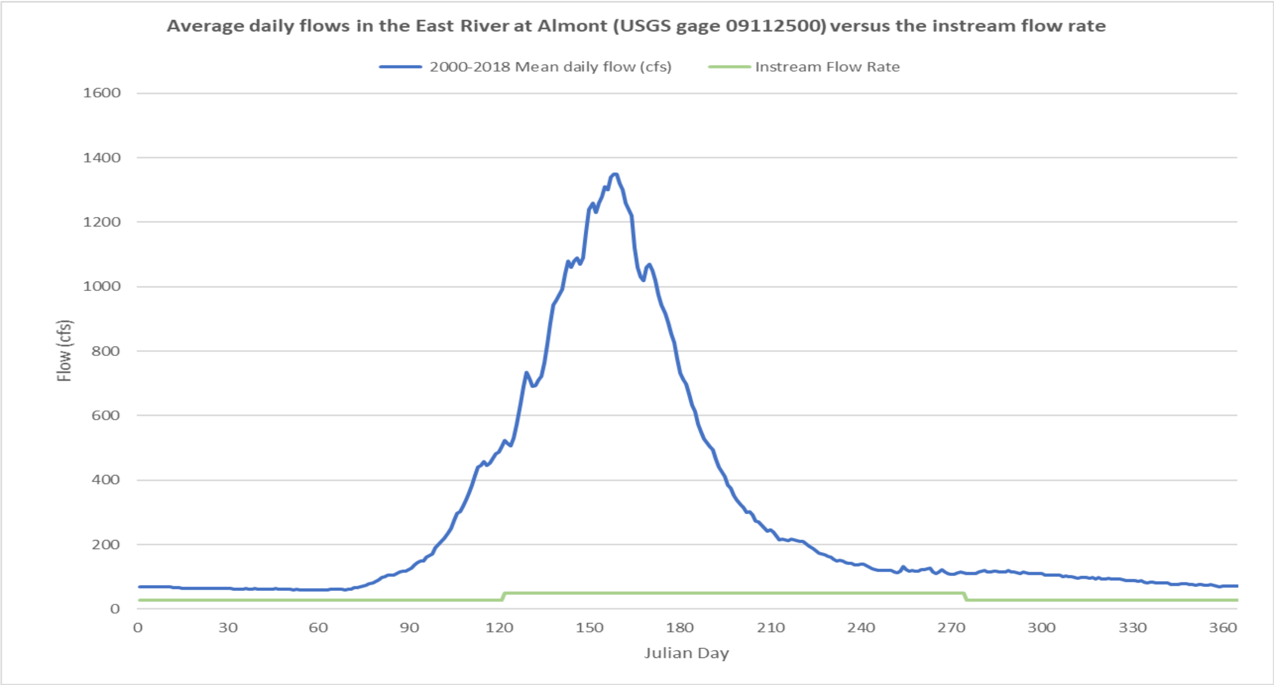
Alkali Creek near the confluence with the East River was identified by stakeholders as an area where the cumulative effects of upstream diversions can substantially reduce flows in Alkali Creek.

19.3.7 Environmental Flow Goals

The East River from Alkali Creek to the Gunnison River is a strong candidate for tiered environmental flow goals because the reach provides high-quality fish habitat, has a generally intact riparian corridor including riparian forest, and high recreational value (fishing, wildlife viewing, and aesthetics).

From 2000 to 2018, the average daily flow in the East River at Almont never fell below the instream flow rates, as shown in Figure 19-4.

Figure 19-4: Average daily flows in the East River at Almont versus the existing instream flow rates (winter= 27 cfs, summer= 50 cfs).71



[71] Julian day is a continuous count of the day of the year. For example, January 1 is Julian day 1. January 31 is Julian day 31 and April 15 is Julian day 106. Each number on the horizontal axis of Figure 4 is start of a new month, approximately (e.g. Julian day 182 is about July 1).

Average daily flows, from 2000 to 2018, in the East River at Almont were used to calculate Montana Method metrics[72]. The excellent criteria, which is 30 percent of the average annual flow, creates a flow goal of 86 cfs. The outstanding criteria, which is 40 percent of the average annual flow, generates a flow goal of 114 cfs. Based on flows measured from 2000 to 2018, the excellent criterion was attained 100 percent of the time in the summer (May 1 to September 30) and the outstanding criterion was attained 94 percent of the time. Additional analyses and stakeholder outreach are recommended to further refine these preliminary environmental flow goals. Future analyses should consider critical periods for aquatic life, such as salmon and trout spawning, instream habitat conditions, and legal water availability, and the location of return flows.

19.4 Recreational Water Use

The East River from the confluence with the Slate River to the Gunnison River is a popular reach for whitewater rafting, kayaking, float fishing, and wade fishing. Recreational uses are addressed in Section 18 of this Chapter.

19.5 Needs for this Reach; Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Temperature monitoring. Due to the value of the fishery within this reach, continuous temperature monitoring should be discussed further with CPW staff.

Issue: Irrigation shortages occur on Alkali Creek. Irrigators have also identified a diversion structure that could use improvement on Alkali Creek.

Issue: Water quality characterization for household wells.

---

[72] The Montana method, also called the Tennant method, was developed by USGS hydrologists and other natural resource professionals to identify the flows necessary to sustain the biological integrity of river and riparian ecosystems. The study, conducted in the 1970s, included physical surveys of a variety of rivers in Montana, Nebraska, and Wyoming and stream flow data from hundreds of locations in 21 states. The study related a portion of the mean annual or seasonal flow to criterion (i.e. minimum, acceptable, excellent) to protect environmental flows. The primary benefit of the Montana method is that it is simple to calculate the criteria from stream gage data. The Montana method was used on a select number of reaches in the East River due to the spatial distribution of gages and existing water use practices. The Montana method criteria are specific to the stream where the criteria were developed. See: Tennant, D.L. 1976. *Instream flow regimens for fish, wildlife, recreation and related environmental resources.* Fisheries 1: 6-10.

Issue: Stakeholders raised concern about on-site wastewater treatment systems (septics), nitrogen, and temperature.

Issue: The condition of the riparian corridor through the fish hatchery.

Issue: Potential enlargement of the existing instream flow water right.

Issue: Potential safety issues at the waste water treatment plant at Crested Butte South due to recreational boating and parking for access.

Issue: Boater conflicts with landowners in Lower Allen Lane and the Reserve on the East River.

Chapter 7
The Lake Fork Basin

Section 1. Basin Characteristics

The Lake Fork Basin is made up of a diverse array of water users and uses including ranchers and irrigators, full time and seasonal residents, tourists, trout fisheries, boating and angling enthusiasts, and mining. Major tasks for the WMP were to review and assess the available information, update and refine the information, identify data gaps, and recommend future data collection efforts. Information collected as part of the data inventory process served as a key component to both identify needs in the Lake Fork Basin and to improve modeling and field assessment tools being used to assess these needs

Figure 1-1 shows the Lake Fork of the Gunnison River (Lake Fork) Basin boundary, highways and local roads, active streamflow gages, and public land designation. Approximately 85 percent of the land within the basin boundary is public. A significant portion of the private land is adjacent to the Lake Fork and other tributaries and includes ranches and horse properties, the town of Lake City, County based subdivisions, and patented mining claims.

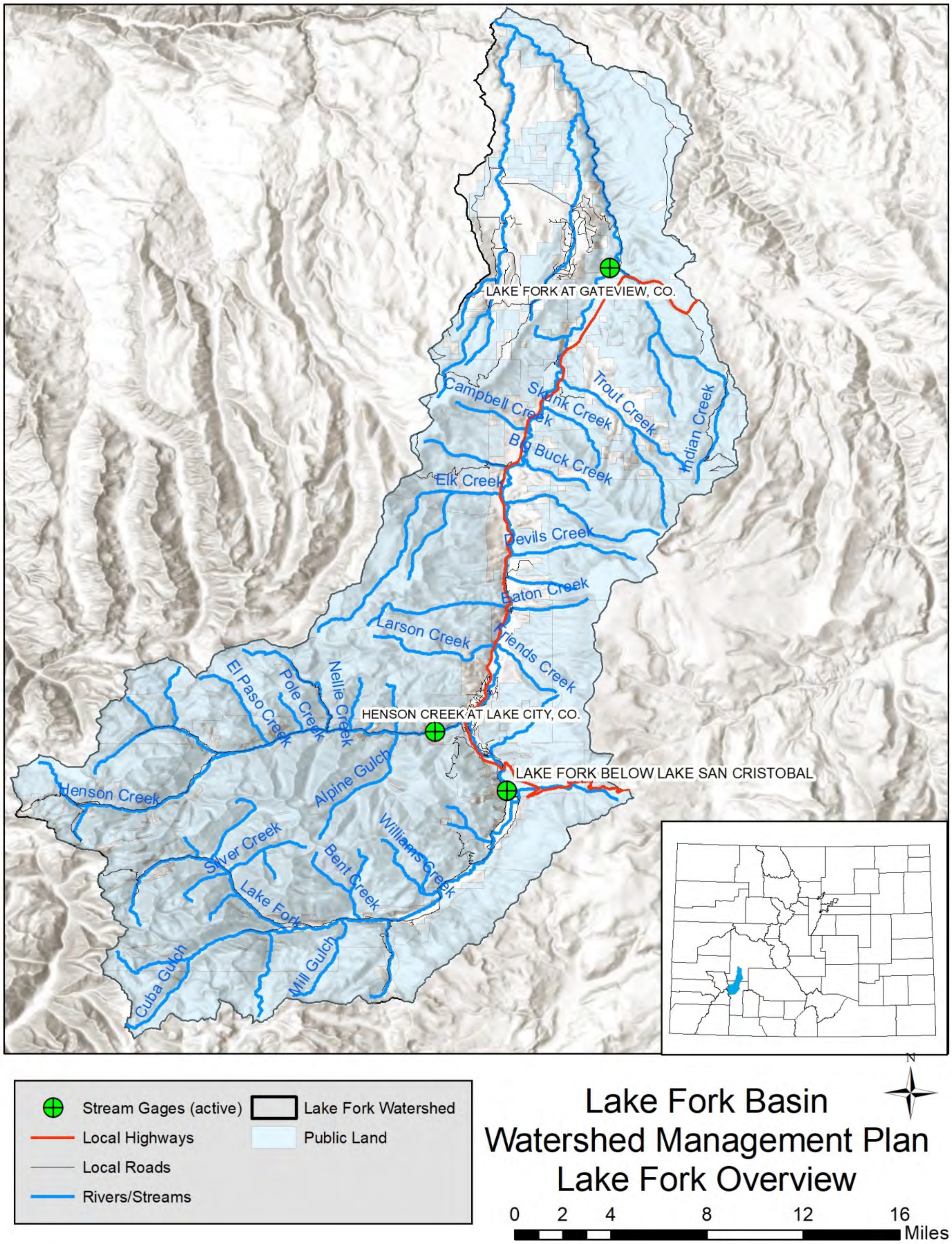


Figure 1-1: Lake Fork Basin Overview Map

Section 2. Data Assessment

2.1 Streamflow Measurements

Three stream gauges currently measure streamflow in the Lake Fork Basin, the Lake Fork at Gateview, the Lake Fork below Lake San Cristobal, and Henson Creek at Lake City. At the time of assessment, only the Lake Fork gauges were used, as the Henson Creek gauge was only recently reactivated. Historic stream flow data was also used from the previously inactive Henson Creek gauge, in addition to two others. Table 2-1 summarizes the drainage area, period of record, and average annual flow for both the active and inactive stream gages. Figure 1-1 includes the locations of the three active gages. A gage was installed on Henson Creek at Alpine Gulch but was only used to monitor flood conditions. To improve water rights administration, the DWR and UGRWCD identified potential locations where additional gages could be installed and the gage at Henson Creek was reactivated. One possible location to install an additionalg gage would be on Elk Creek.

Table 2-1: Summary of Active and Inactive Stream Gages in the Lake Fork Basin

Stream Gage Name	Gage ID	Status	Drainage Area (Sq. Mi.)	Period of Record	Average Annual Flow (acre-feet)
Lake Fork below Mill Gulch	09123400	Inactive	57.5	1982-1986	73,900
Lake Fork below Lake San Cristobal	09123450	Active	106	2013-Present	74,600
Lake Fork at Lake City	09123500	Inactive	115	1918-1924 1932-1937	85,800
Henson Creek at Lake City	09124000	Reactivated	83.1	1918-1919 1932-1937 2019 - present	72,500
Lake Fork at Gateview	09124500	Active	339	1938-Present	168,900

The streamflow in the Lake Fork Basin is highly variable depending on snowpack. Figure 2-2 shows daily flow for the period 2013 through 2017 for the two active gages on the Lake Fork. The following observations can be made based on the figure:

- The runoff pattern and peak flow months are similar for these two locations.
- This period includes wet years of 2014 and 2015 and one of the driest years of record, 2012.
- The difference in annual stream flow between 2012 and 2014 is more than 114,000 acre-feet at the Lake Fork at Gateview gage.

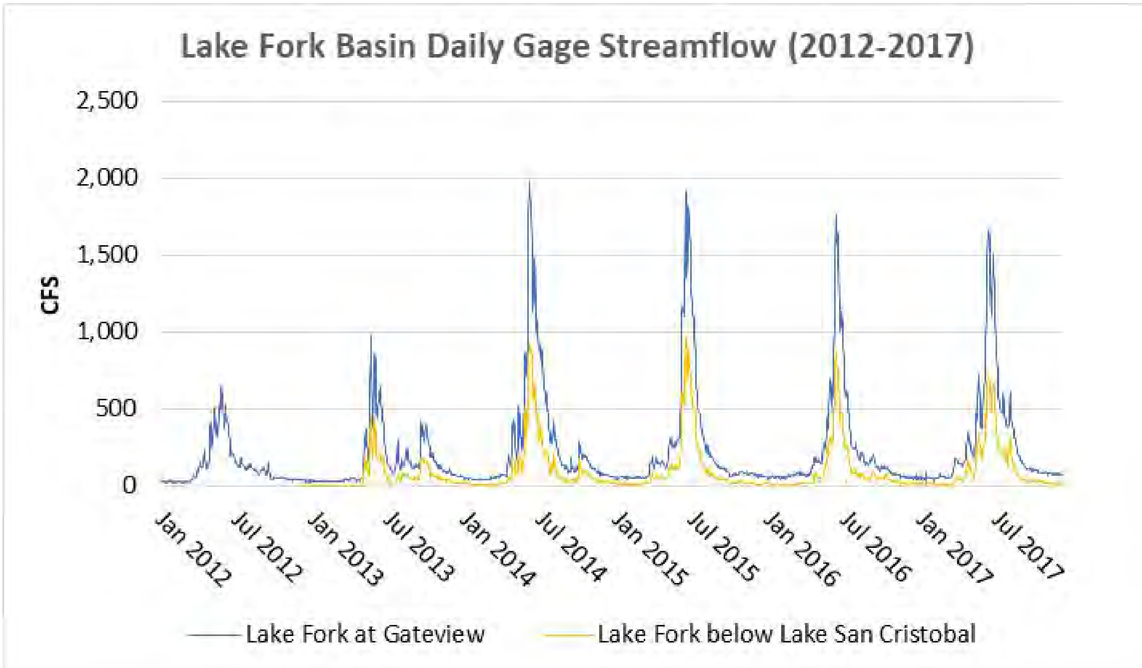


Figure 2-2: Lake Fork Basin Streamflow (2005-2017)

Figure 2-3 shows the historical annual streamflow volume for the period 1938 through 2017, along with the 10-year running average for the Lake Fork at Gateview gage. As shown, streamflow varies widely from year to year. Although the 10-year running average is highly variable, it does not indicate a long-term trend in terms of total flow volumes. The peak runoff is variable depending on snowpack. In average years, the peak generally occurs in early June and shifts to mid or even late June in extremely high runoff years. In about 25 percent of the gaged record corresponding to the driest 25 years, the peak runoff occurred in May. Several of the years with earlier runoff correspond to low flow years seen since 2000. The 1960s decade also showed a significant number of years with earlier runoff, and there does not appear to be a permanent shift in the peak.

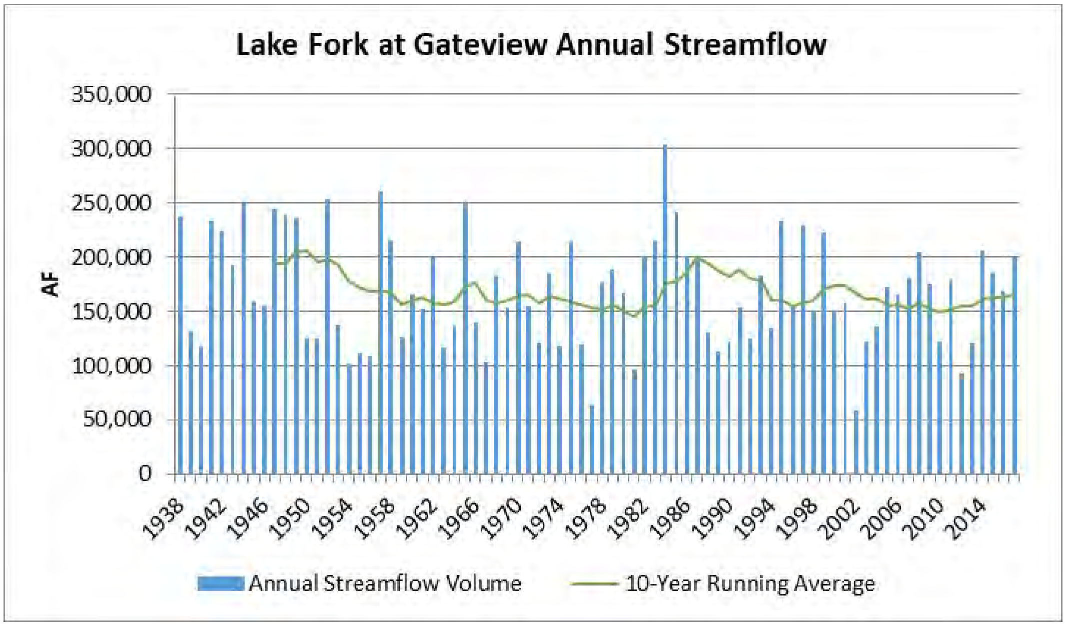


Figure 2-3: Lake Fork at Gateview Annual Streamflow (1938-2017) in acre-feet

Figure 2-4 shows the average monthly flow at the Lake Fork at Gateview gage from 1998 through 2017. Water from snowmelt runoff in May, June, and July accounts for nearly 70 percent of the annual streamflow.

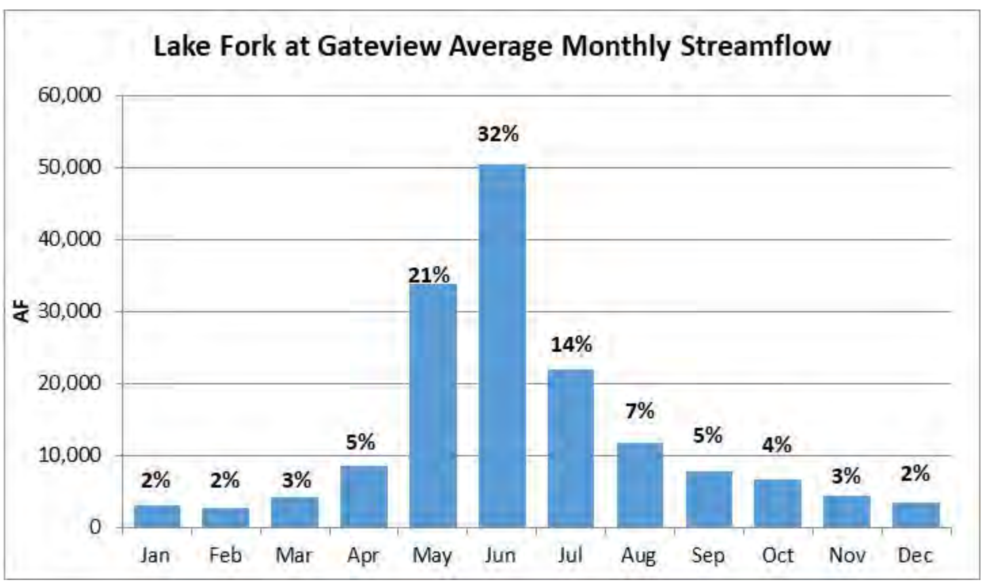


Figure 2-4: Lake Fork at Gateview Average Monthly Streamflow (1998-2017)

2.2 Climate Data

Crop irrigation demands are dependent on weather and temperature during the irrigation season. Figure 2-5 highlights the variability of average irrigation season temperature (May through September) at the long-term NWS Coop station in Lake City. The 10-year running average shows a clear trend toward higher temperatures during the non-irrigation season since 1980. There has not been a trend toward higher temperatures during the October through April period.

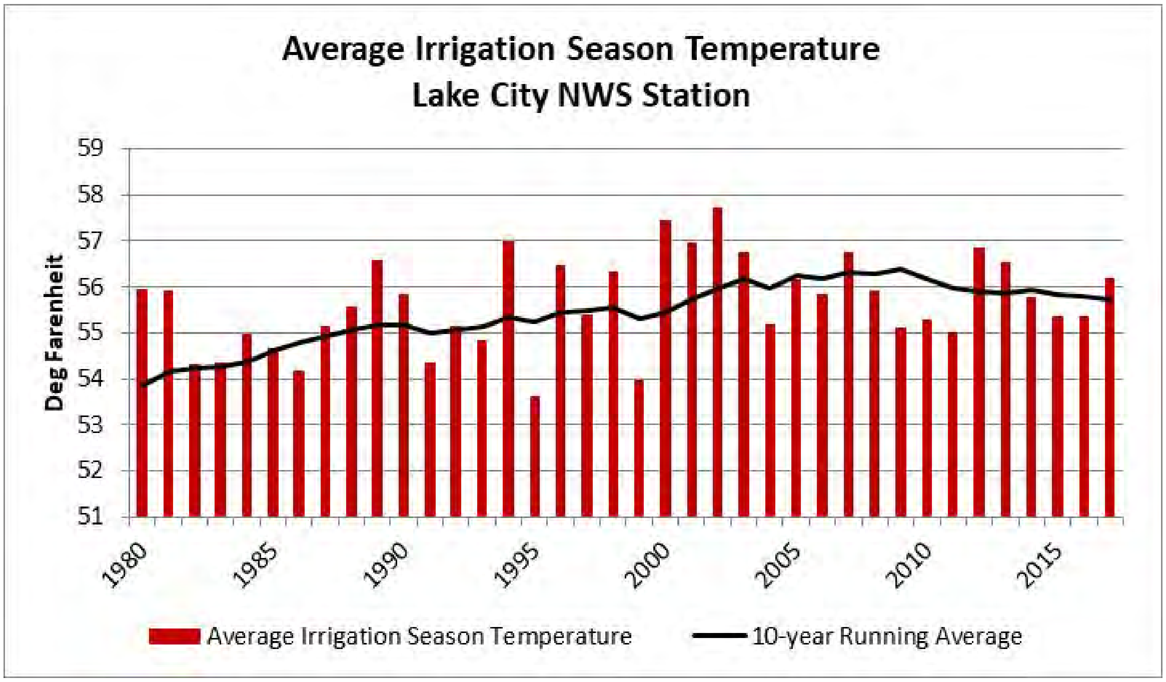


Figure 2-5: Average Irrigation Season Temperature at Lake City (1980-2017)

Precipitation during the irrigation season reduces the amount of water required from irrigation to meet crop demands. Figure 2-6 highlights the variability of total precipitation during irrigation season (May through September) also recorded at the long-term NWS Coop station. As shown, the total precipitation during irrigation season varies from 11.8 inches in 1982 to only 4.1 inches in 1980. Even though precipitation has been relatively high from 2012 through 2017, the 10-year average has yet to recover from the drier summers between 2008 and 2011. Note that although higher irrigation season precipitation reduces the amount of water crops need from an irrigation source, water available from runoff is the primary factor in river diversion variability.

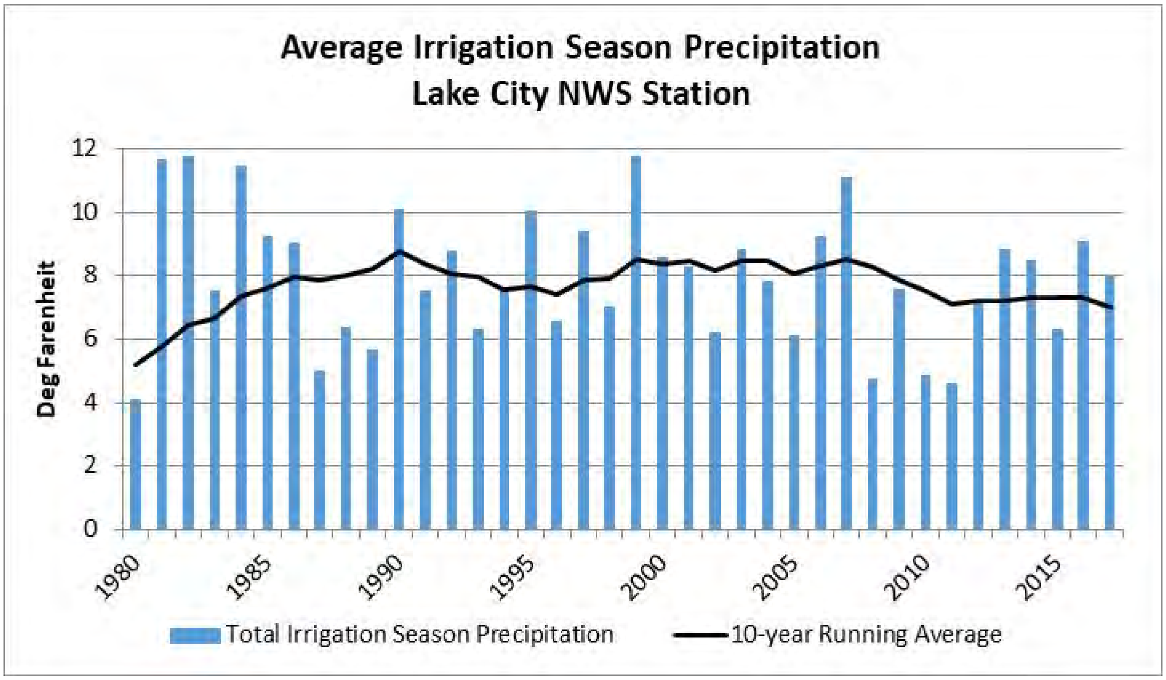


Figure 2-6: Total Irrigation Season Precipitation at Lake City (1980-2017)

2.3 Irrigation Acreage

The majority of consumptive water use in the Upper Gunnison River Basin is for irrigation of pasture grass; therefore, it is essential to accurately represent the irrigated acreage and associated irrigation demand. CWCB developed irrigated acreage snapshots for the Gunnison River Basin for 1993, 2005, 2010, and 2015 as a key component of the CDSS. The data sets include acreage, crop type, and associated river diversion ditch or canal. The WMP assessment determined that the acreage was appropriately represented, but the association between acreage and the supply ditch was not detailed enough to accurately tie the acreage to diversions and associated water rights. Through discussions with CWCB and DWR, it was recognized that the irrigated acreage assessment needed to be refined and disaggregated to represent each ditch discreetly.

During this assessment, consultants worked with local water commissioners and water users to more accurately tie irrigated acreage to the source ditch and associated water rights. This was a major effort and resulted in a more accurate representation of irrigation demands for each active ditch in the Upper Gunnison River Basin. This information was provided to the state, and consultants continue to work with CWCB to make the corresponding updates to the historical GIS snapshot coverages (2010, 2005, and 1993) for inclusion in the State's records. Each of the updated coverages will be made available on the CDSS website.

Given the difficulty in obtaining accurate historical diversion records, it is especially important to understand local and ditch-specific irrigation practices to inform planning efforts.

Although irrigation is not a large user of water in the Lake Fork Basin, it is the basin's largest consumptive water use. Pasture grass is the primary crop grown in the Lake Fork Basin and supports small-scale cattle operations and horse properties. The total irrigated acreage in the Lake Fork Basin as of 2015 is approximately 1,500 acres. Based on review of aerial photos, and discussion with local water experts, there has been only a slight reduction in irrigated acres in recent years.

Pasture grass is grown on all of the irrigated acreage in the basin. Water is applied using flood irrigation techniques. Some of the diversions are "push-up" dams that are re-worked each irrigation season. Depending on spring temperatures, irrigators begin applying water to their fields in early May, with irrigation generally beginning earlier in the lower portions of the Basin. Irrigators get one cutting of hay each summer in late July or early August. After cutting, some users will continue to irrigate while many of the smaller enterprises will keep their fields dry to allow their cattle or horses to graze. It generally takes 1 to 2 weeks to dry out, so diversions are cut back in the first or second week of July. Although this practice is widespread, decreased diversion rates to allow for dry out during the hay harvest are not reported in the diversion records.

There has never been an administrative water right call on the Lake Fork mainstem and there generally is physical water available through the fall. Cutting back or ceasing irrigation during the summer or early fall is generally an irrigator's choice and not reflective of water supply conditions. Several of the lower tributaries to the Lake Fork, including Trout Creek, Elk Creek and Indian Creek, have diversions near the confluence that can cause significant depletion of natural flows. Regardless of diversions, these tributaries experience minimal flows in the late summer.

2.4 Water Rights

DWR created unique identifiers for each of the decreed points of diversion. DWR developed the official water rights tabulation, based on water court decrees, and assigned each water right to the associated ditch. Based on consultants' experience in the Gunnison Basin and other basins throughout Colorado, the water rights assignments in HydroBase are believed to be accurate and appropriate for use in the WMP efforts.

The Lake Fork Basin has minimal active storage; just over 2,000 acre-feet of absolute storage rights primarily for recreation, stock, wildlife, and augmentation. In addition to active storage, there is approximately 14,000 acre-feet decreed by CWCB to protect minimum levels in natural lakes, most of it decreed for Lake San Cristobal. Lake San Cristobal also has active storage for other uses including augmentation, as discussed further below.

Figure 2-7 represents the cumulative absolute direct flow water rights in the Lake Fork Basin, highlighting major basin adjudication dates and key water rights. The DWR Administration Number indicates the water right priorities based on both appropriation date and adjudication date and is used by DWR for administration throughout the state. As discussed in Section 1,1 of

Chapter 2 and shown in the figure, Aspinall Unit water rights are subordinated to current and future Upper Gunnison River Basin water rights junior to the Aspinall Unit water rights up to 40,000 acre-feet of annual depletions.

The figure also highlights the major water rights adjudication dates in the Lake Fork Basin and other key water rights dates that can impact the Lake Fork Basin water rights, including the Gunnison Tunnel adjudication date and the date of the Colorado River Compact.

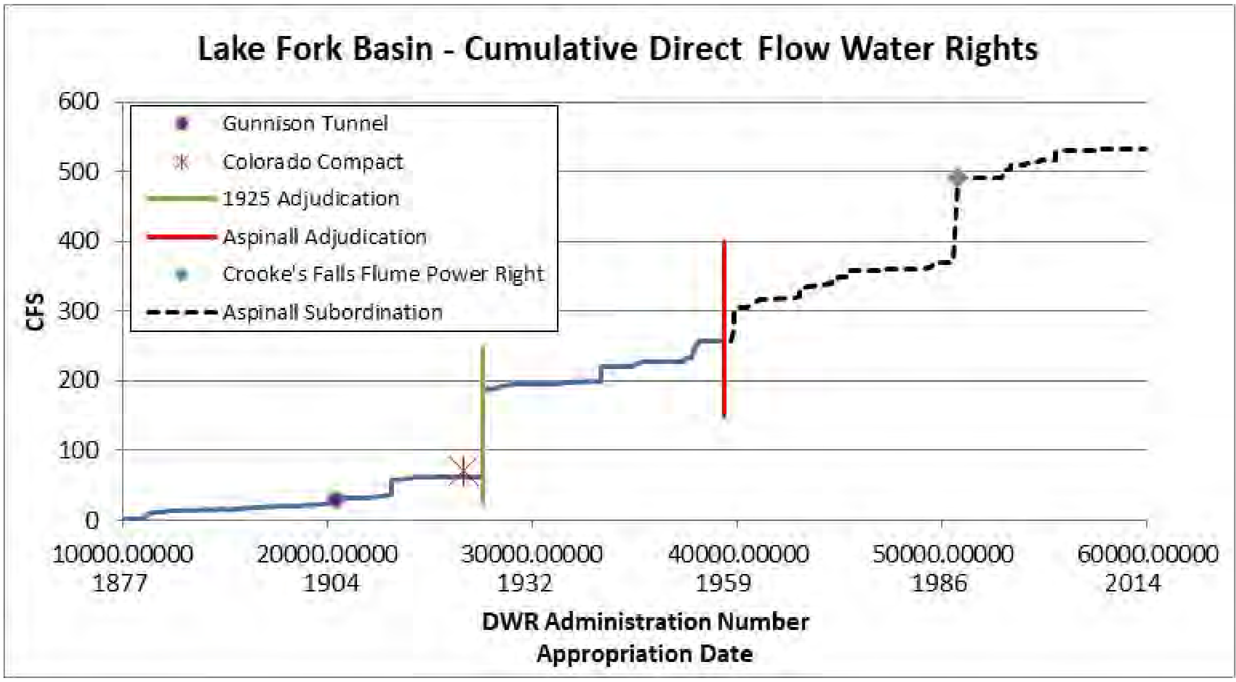


Figure 2-7: Lake Fork Basin Cumulative Absolute Direct Flow Water Rights

There are conditional direct flow water rights totaling 268 cfs in Lake Fork Basin. Two conditional water rights account for most of the decreed rate: Hidden Treasure Pipeline has a 215 cfs conditional water right for commercial use, and Crooke's Fall Flume has a conditional water right for 29 cfs. Most of the remaining conditional water rights are for domestic use, with rates of less than 1 cfs. Conditional storage rights total 2,110 acre-feet in the Lake Fork Basin. Most of the conditional storage rights (1,900 acre-feet) are for all uses, including augmentation, in Lake San Cristobal.

The Lake Fork Basin includes 33 decreed instream flow water rights, shown in Table 2-2 and Figure 2-8. Details of these rights are described in Sections 5 through 10 of this Chapter. These rights are junior to most of the irrigation rights in the basin. Most instream flow rights in the Lake Fork Basin were appropriated between 1980 and 1984. In 2009, three instream flow water rights were increased to accommodate larger flows during runoff and summer months.

Table 2-2: Existing CWCB Instream Flow Rights in the Lake Fork Basin

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Alpine Gulch	Headwaters of Alpine Gulch	Confluence with Henson Creek	1/26/2010	5.7	1	5
Bent Creek	Near the headwaters of Bent Creek	Confluence with Lake Fork River	1/27/2009	3.0	2	3.55
Cataract Gulch	Outlet of Cataract Lake	Confluence with Cottonwood Creek	3/17/1980	3.8	5	
Cooper Creek	Outlet of Cooper Creek	Confluence with the Lake Fork River	3/17/1980	3.6	2	
Cottonwood Creek	Confluence with Snare Creek and Cuba Gulch	Confluence with Lake Fork River	3/17/1980	4.0	12	
Cuba Gulch	Headwaters of Cuba Gulch	Confluence with Cottonwood Creek	3/17/1980	4.0	5	
Devils Creek	Headwaters of Devils Creek	Steele Ditch Headgate	1/29/1998	3.4	0.75	0.75
Elk Creek	Headwaters of Elk Creek	Confluence with the Lake Fork River	3/17/1980	10	3	
El Paso Creek	Near Headwaters of El Paso Creek	Confluence with Henson Creek	7/7/1983	3.6	3	
Fourth of July Creek	Headwaters of Fourth of July Creek	Carris Thompson Ditch Headgate	1/16/2016	6.0	0.6	1.1
Grizzly Gulch	Outlet of Grizzly Lake	Confluence with the Lake Fork River	1/27/2009	2.1	0.6	2.9

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Henson Creek – Lower	Confluence with Nellie Creek	Confluence with the Lake Fork River	5/4/1984	5.5	15	25
Henson Creek – Middle	Confluence with North Fork Henson Creek	Confluence with Nellie Creek	5/4/1984 1/27/2009	3.6	12	23
Henson Creek – Upper	Confluence with Palmetto Gulch	Confluence with North Fork Henson Creek	5/4/1984	7.2	9	
Independence Gulch	Headwaters of Independence Gulch	Confluence with the Lake Fork River	3/17/1980	5.5	1	
Lake Fork River – Lower	Confluence with Henson Creek	Confluence with Blue Mesa Reservoir	3/17/1980	30.4	25	45
Lake Fork River – Middle	Confluence with Cottonwood Creek	Confluence with Henson Creek	3/17/1980	16.4	20	35
Lake Fork River – Upper	Outlet of Sloan Lake	Confluence with Cottonwood Creek	3/17/1980	9.6	18	
Larson Creek	Headwaters of Larson Creek	Confluence with the Lake Fork River	3/17/1980	5.1	2	
Mill Gulch	Headwaters of Mill Gulch	Confluence with Lake Fork River	3/17/1980	3.0	4	
Nellie Creek	Headwaters of Nellie Creek	Confluence with Henson Creek	7/7/1983	5.8	2.5	
North Fork Henson Creek – Lower	Confluence with	Confluence with Henson Creek	5/4/1984	2.4	10	

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
	Matterhorn Creek					
North Fork Henson Creek – Upper	Headwaters of North Fork Henson Creek	Confluence with Matterhorn Creek	5/4/1984	3.7	2	
Schafer Gulch	Headwaters of Schafer Gulch	Confluence with Henson Creek	5/4/1984 1/27/2009	1.8	1 2.3	
Silver Creek	Near the headwaters of Silver Creek	Confluence with Lake Fork River	3/17/1980	2.2	4	
Snare Creek	Headwaters of Snare Creek	Confluence with Cuba Gulch	3/17/1980	2.8	5	
Trout Creek	Headwaters of Trout Creek	Johnson Ditch Headgate	5/11/1998	7.5	0.75	1.25
Wager Gulch	Headwaters of Wager Gulch	Confluence with Lake Fork River	3/17/1980	2.7	5	
Williams Creek	Near the headwaters of Williams Creek	Confluence with Lake Fork River	3/17/1980	2.3	1	
Willow Creek	Headwaters of Willow Creek	Confluence with Blue Mesa Reservoir	3/17/1980	17.7	2	
Schafer Gulch	Headwaters of Schafer Gulch	Confluence with Henson Creek	5/4/1984 1/27/2009	1.8	1	2.3
Silver Creek	Near the headwaters of Silver Creek	Confluence with the Lake Fork River	3/17/1980	2.2	4	
Snare Creek	Headwaters of Snare Creek	Confluence with Cuba Gulch	3/17/1980	2.8	5	

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Trout Creek	Headwaters of Trout Creek	Johnson Ditch Headgate	5/11/1998	7.5	0.75	1.25
Wager Gulch	Headwaters of Wager Gulch	Confluence with Lake Fork River	3/17/1980	2.7	5	
Williams Creek	Near the headwaters of Williams Creek	Confluence with Lake Fork River	3/17/1980	2.3	1	
Willow Creek	Headwaters of Willow Creek	Confluence with Blue Mesa Reservoir	3/17/1980	17.7	2	

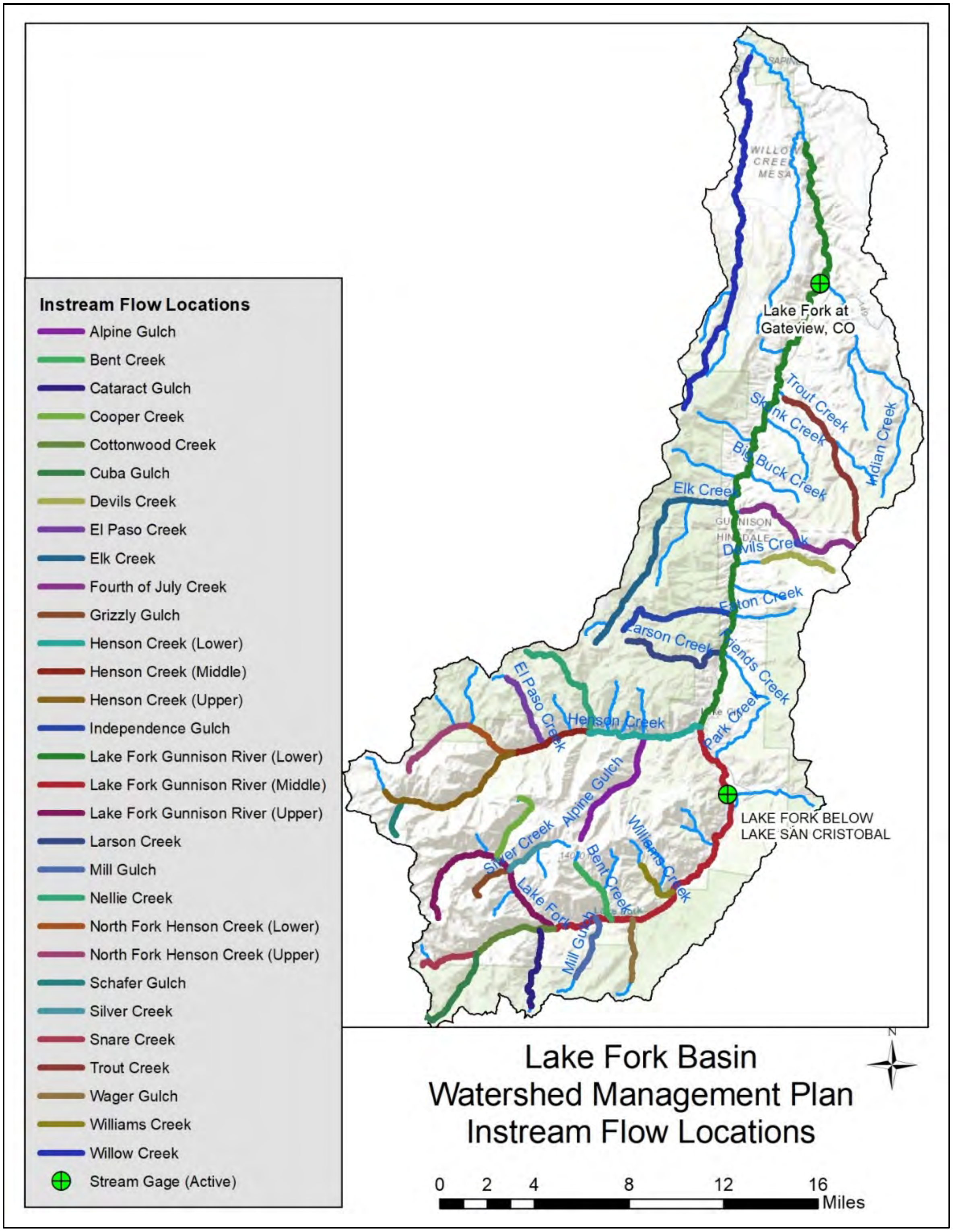


Figure 2-8: Instream Flow Reaches in the Lake Fork Basin

Figure 2-9 shows the instream flow rights along with the cumulative direct flow water rights. Total decreed instream rates are almost half of the rates decreed for irrigation use.

On top of the Lake San Cristobal minimum water level is 950 acre-feet of water reserved for augmentation, and managed by the Lake San Cristobal Water Activity Enterprise, a partnership of UGRWCD, Town of Lake City, and Hinsdale County.

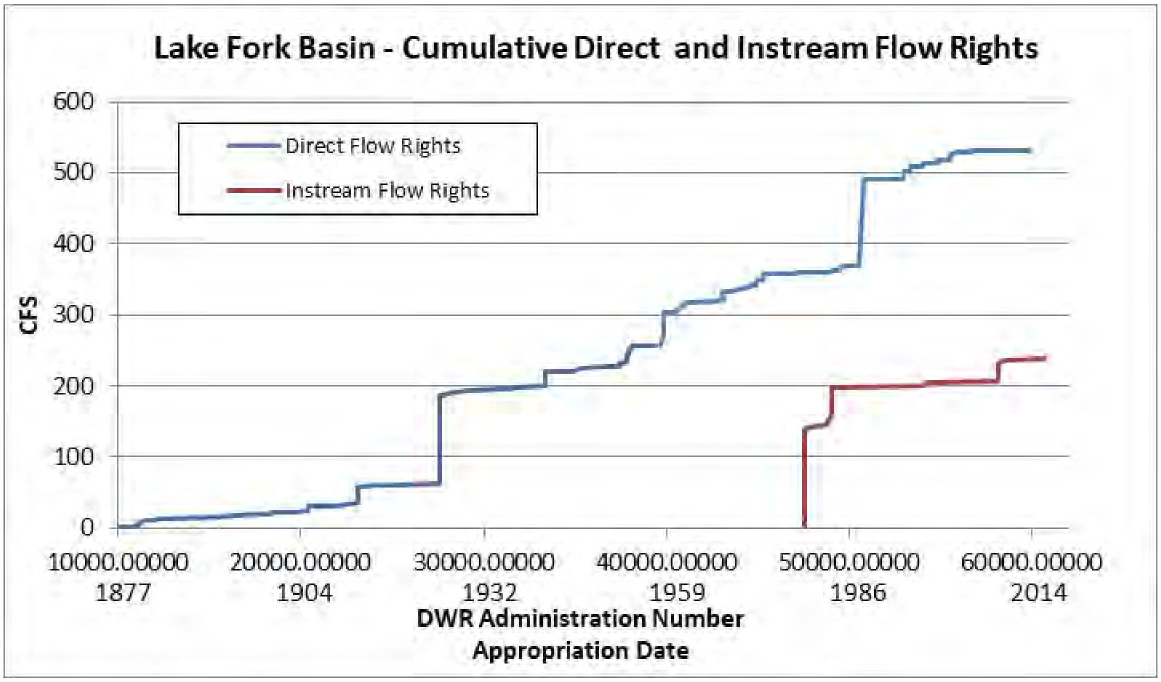


Figure 2-9: Lake Fork Basin Cumulate Direct Flow and Instream Flow Water Rights

CWCB also has storage rights to protect minimum water levels in seven natural lakes in the Lake Fork Basin, totaling 14,017 acre-feet. The largest right for minimum water levels is 13,545 acre-feet for Lake San Cristobal. The other six natural lakes are near the headwaters, above other water right uses.

2.5 Diversion Records

The water commissioner is responsible for recording diversions for over 275 ditches that divert water various uses in Water District 62, of which only a portion divert in the Lake Fork Basin. Many of the ditch headgates are challenging to access and require a significant amount of time to visit. Diversion records are either provided by the water user annually or, most commonly, by a "spot-diversion" record. A spot-diversion is reported when the water commissioner visits the headgate and records the amount of water diverted on that date and time.

DWR uses the "fill-forward" approach where the spot-diversion record is repeated for each day until the water commissioner again visits the headgate and reports an updated diversion rate.

Based on the review of diversion records and discussions with the water commissioner, it is common for him to visit each headgate only once per month during the irrigation season. Note, that although this is typical of most water districts in western Colorado, diversion records do not mimic changes in daily stream or ditch flow. In addition, daily variation in flows, most notably during runoff or following large precipitation events, can cause diversion rates to change throughout the day, which cannot be captured even if the water commissioner visited each diversion once per day. Figure 2-10 provides example diversions in the Lake Fork Basin for 2011 and 2012 where the standard fill-forward approach was used by DWR. In many cases, the irrigation start and stop dates are estimated by the water commissioner rather than reported by the water users. The diversion records do not include information about operational practices; for example, reducing diversions to allow fields to dry before haying.

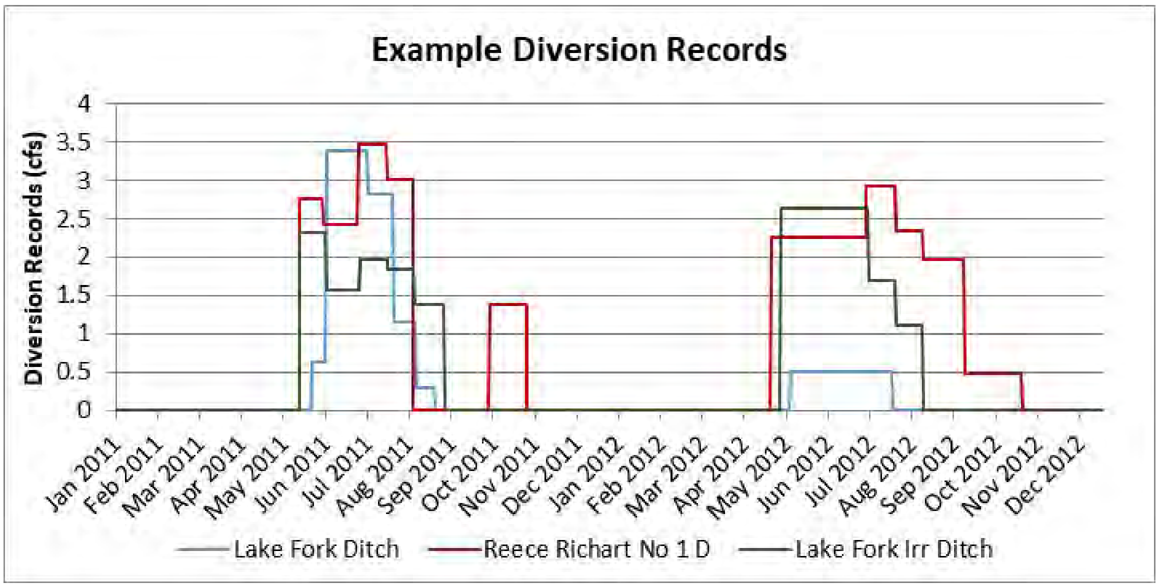


Figure 2-10: Example of the Fill-Forward Approach for Reporting Diversions

Consultants also identified the number of diversions that have Parshall Flumes or other flow control measurement devices that allow both the water commissioner and water users to quickly record diversions. Based on information from the water commissioner, about 90 percent of the headgates actively diverting for irrigation in the Lake Fork Basin have a measurement device. For diversions without measurement devices, the water commissioner either estimates flow for the remaining structures using the “chip-test” approach by estimating velocity and depth to determine flow rate, or simply provides a “water taken but no data available” comment in the official record.

Based on the review of diversion records, discussions with the water commissioner, and feedback from the Division 4 Engineer, the most effective way to improve diversion records is to encourage irrigators to document their use on a daily or weekly basis, in addition to installing flumes. More specifically, they can report dates when they start and stop irrigating each year and provide flume measurements when diversions increase or decrease with flows in the river. An important process for the WMP is to inform irrigators that keeping accurate diversions records and providing those records to the water commissioner is the best way they can protect their water rights.

The diversion records maintained by DWR are still the best source of data available. There are 47 active irrigation ditches in the Lake Fork Basin. For the recent period from 2008 to 2017 (excluding 2016), diversions averaged 17,220 acre-feet per year. Note that Water District 62 had an open water commissioner position in 2016, and no diversions were reported for the year. Similar to streamflow, annual diversions are variable, as shown in Figure 2-11. On average, irrigation diversions in the Lake Fork Basin are around 10 percent of streamflow measured at the Lake Fork at Gateview gage.

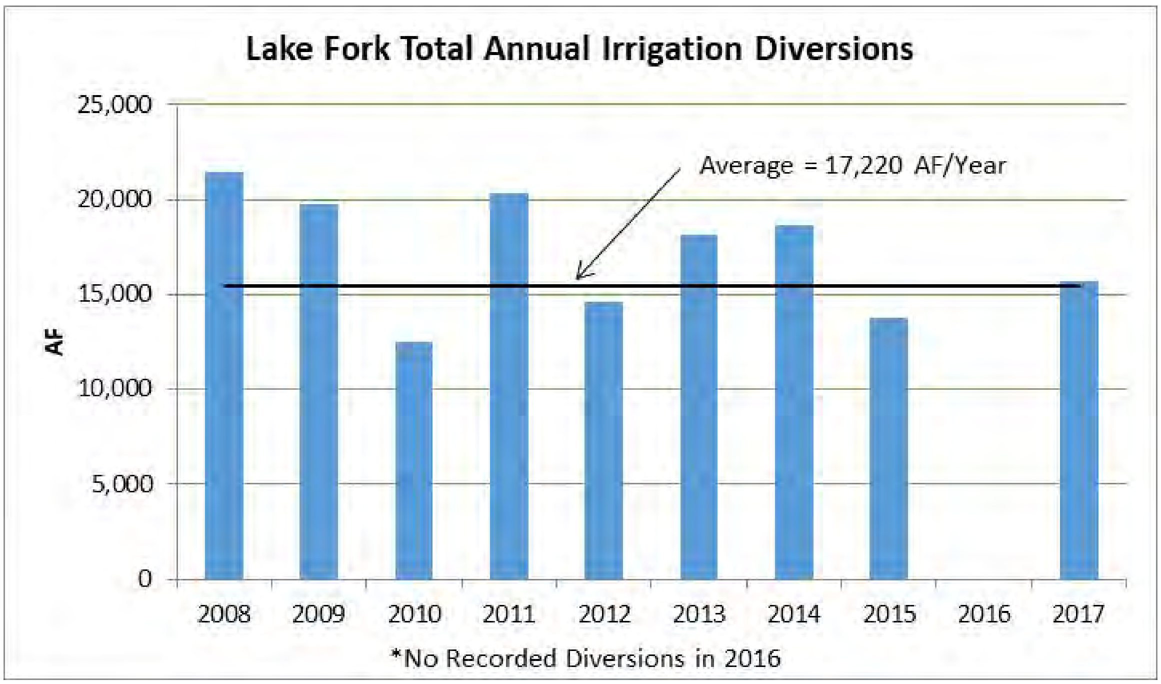


Figure 2-11: Annual Lake Fork Basin Diversions

Figure 2-12 shows total monthly irrigation diversions for a representative average (2009), wet (2008), and dry (2012) hydrologic year in the Lake Fork Basin. As shown, the annual amount diverted is similar for the representative wet and average years. In the 2012 representative dry year, reduced runoff resulted in lower diversions throughout the irrigation season. Water supply dropped off significantly in July 2012.

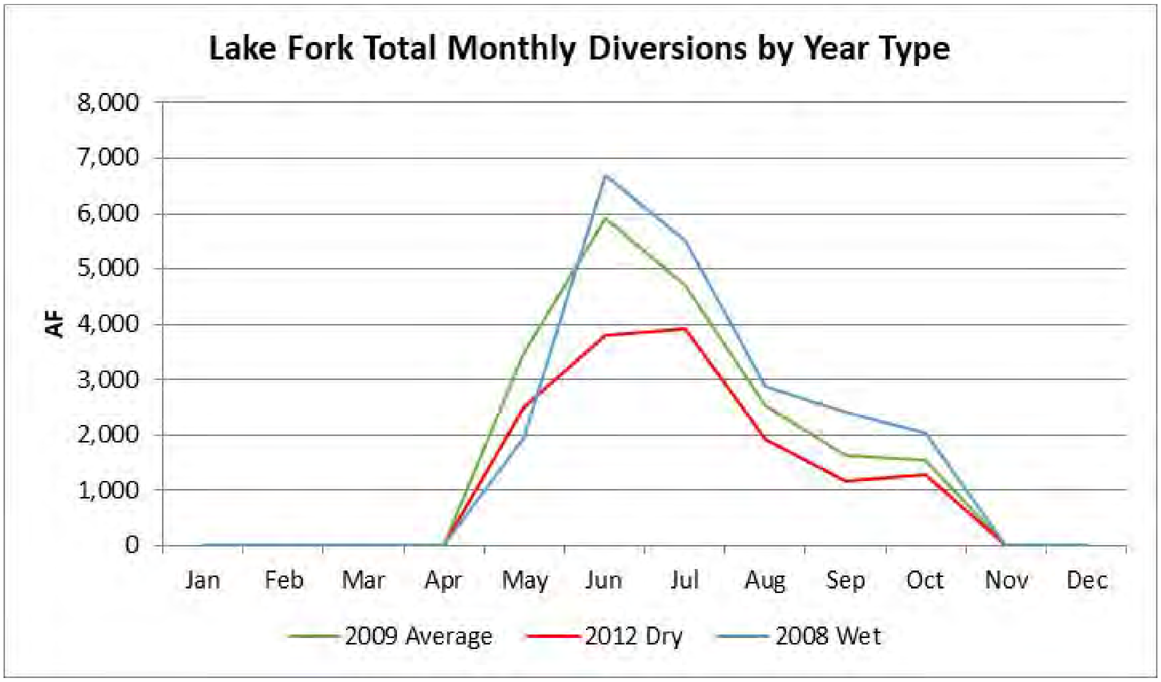


Figure 2-12: Monthly Lake Fork Basin Irrigation Diversions for Representative Years

Figure 2-13 shows the location and magnitude of average annual diversions in the Lake Fork Basin. About half of the ditches divert less than 200 acre-feet per year.

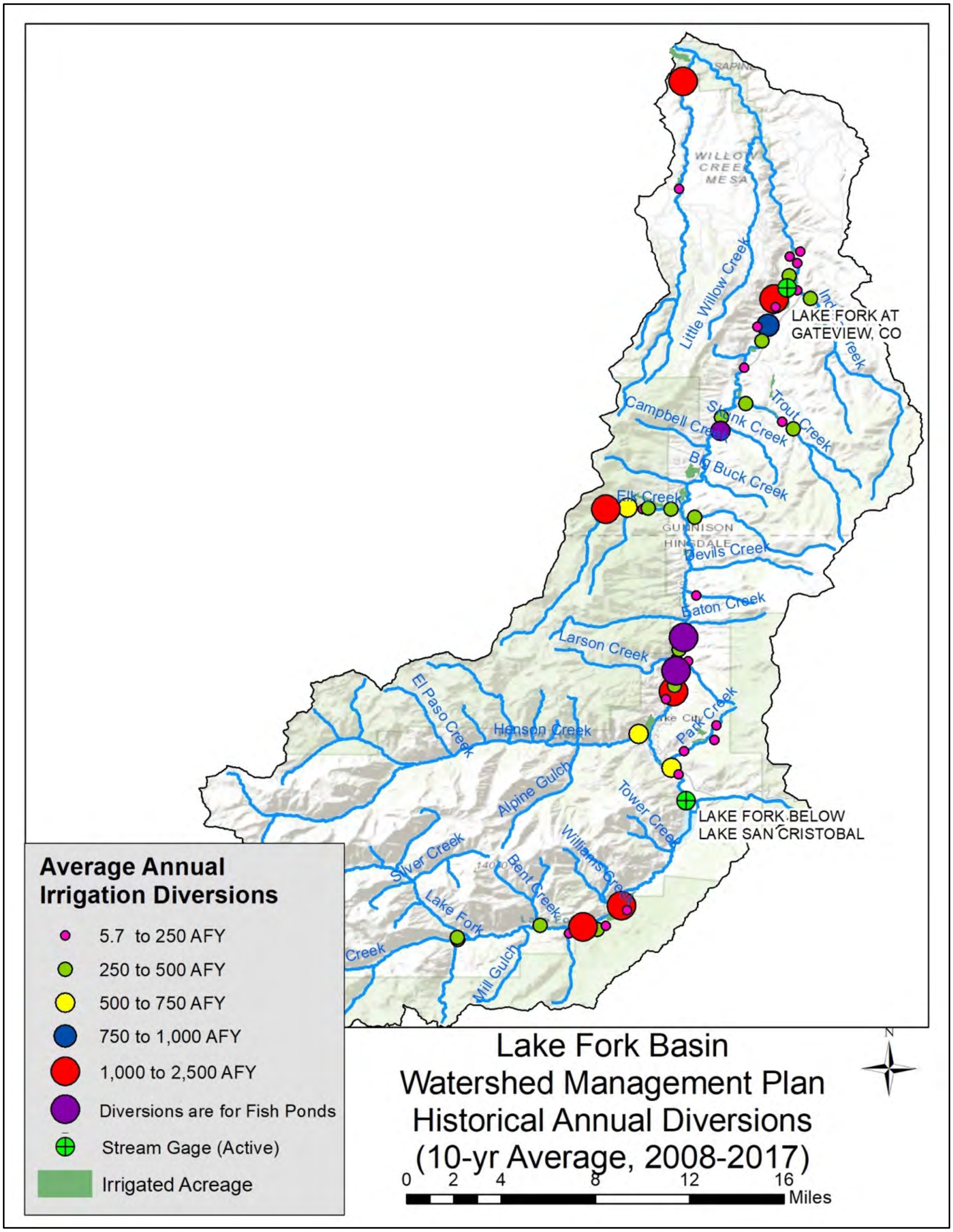


Figure 2-13: Average Annual Historical Irrigation Diversions, 2008-2017

In addition to diversion for irrigation, there are currently over 15 ditches that have recorded diversions to fish ponds for flow-through and evaporation replacement.

2.6 Return Flow Parameters

Representing return flow quantities, locations, and timing are critical for investigating the changes to river flows and water availability at downstream locations. Many of the opportunities to improve watershed health include changes in irrigation use, including efficiency improvements. It is important to accurately represent return flow parameters in StateMod to understand comparative changes to streamflow, and potential impacts to downstream water right holders.

Section 3. Needs Assessment Methods

The Lake Fork Basin was split into six reaches with unique characteristics and challenges. The three Lower Lake Fork Tributaries are combined into one reach description. The approach to investigating consumptive water needs, environmental and water quality needs, and recreational needs was tailored for specific reaches. Figure 3-14 shows the reaches. Table 3-3 summarizes general characteristics of each reach and the issues identified by stakeholders. Specific characteristics and issues are discussed in Sections 5 through 10 of this Chapter.

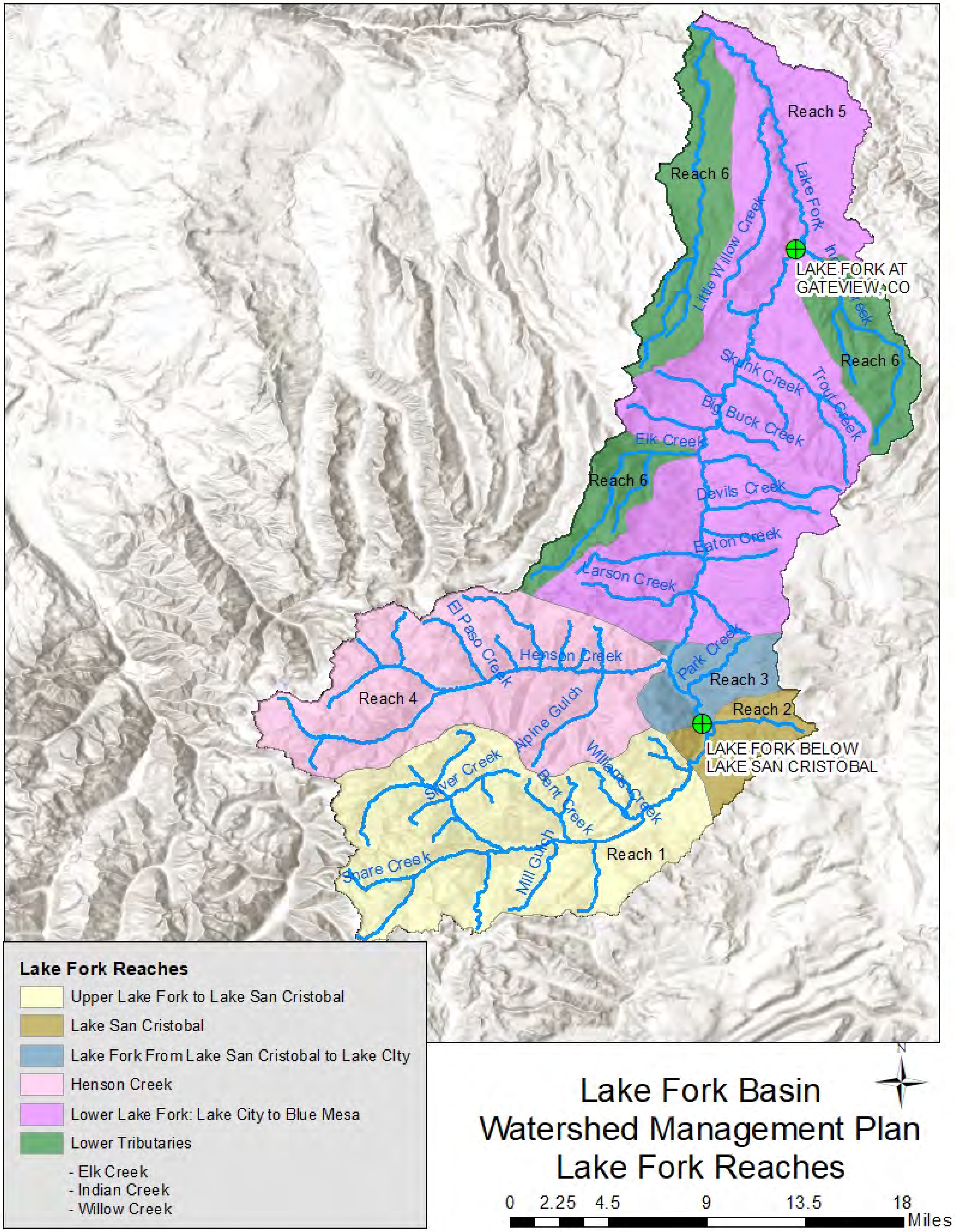


Figure 3-14: Lake Fork Basin Reaches

Table 3-3: Lake Fork Basin Reach Characteristics

Reach	General Characteristics	Stakeholder Identified Issues
Upper Lake Fork to Lake San Cristobal	Predominately agricultural, some domestic use (wells), fish ponds	Water quality, habitat health, habitat connectivity, water supply shortages
Lake San Cristobal	Predominately recreational, augmentation source, domestic use (wells)	Water quality, water temperature, sediment delivery, infrastructure
Lake Fork from Lake San Cristobal to Lake City	Agricultural, municipal, some recreational, hydroelectric power, fish ponds	Water quality, water temperature, water supply shortages, habitat connectivity, fish and macroinvertebrate habitat, land conservation
Henson Creek	Municipal (irrigation and fire protection), domestic use (wells), recreational	Water quality and water supply shortages
Lower Lake Fork: Lake City to Blue Mesa	Agricultural, domestic use (wells), recreational, fish ponds	Water supply shortages, stream stability, flood risk, habitat health, water temperatures, recreational conflicts
Lower Tributaries: Elk Creek, Indian Creek, Willow Creek	Agricultural, domestic use (wells), recreational	Water quality and water supply shortages

Identified uses and needs are different for each reach; therefore, different approaches were used to assess the needs and whether they are currently being met. Current uses and needs can generally be grouped into consumptive categories of agricultural, industrial, and municipal water use, and non-consumptive categories of environmental and recreational flows. Understanding existing uses and assessing future needs for all three categories requires an understanding of hydrologic variability both throughout the year and for different hydrologic year types.

Section 4. Assessing Current Uses

4.1 Agricultural Water Use

This assessment details irrigation diversions, consumptive use, and return flows to assist in developing options to address issues identified by stakeholders.

Consumptive use analyses compare expected crop water demand to actual crop water use to identify consumptive use shortages. Consumptive use analyses also estimate permanent depletions to the river attributed to crop consumptive use, and temporary depletions to the river which are caused by conveyance and application inefficiencies. Conveyance loss is water that infiltrates into the soil in route to the field. Conveyance losses return to the river, generally within a few days to weeks of diversion. Application losses are the portion of water applied to an irrigated field that returns to the river through surface runoff or infiltrates beyond the crop root zone and lags back the river.

StateCU was used to perform a consumptive use analysis to estimate agricultural water shortages from 1998 to 2017. First, StateCU estimates crop demand – the amount of water the crops could use if provided a full irrigation supply – based on monthly climate data and irrigated acreage. Next, StateCU uses diversion records and estimated conveyance and application efficiencies to determine the actual (supply-limited) crop consumptive use and associated shortages. Consumptive use shortages occur when the crop demand is greater than the crop consumptive use. Diversion records limit the reliability of the consumptive use analysis, because often a single instantaneous diversion rate is reported for up to a 30-day period; and the records do not report actual start and stop dates. Despite their limitations, the diversion records are the best available information for agricultural water use.

Conveyance efficiencies vary based on soil permeability and ditch length and have been estimated for each ditch in the Lake Fork Basin. In the Lake Fork Basin, conveyance efficiencies range from 75 to 90 percent depending on ditch length. Flood irrigation application efficiency is also estimated based on soil types, soil thickness, and underlying geology. The soil profile overlays gravel deposits, therefore application efficiency is relatively low. Based on information from decrees and soil reports, a maximum application efficiency of 45 percent was used for irrigation in the Lake Fork Basin.

The estimated annual diversions often exceed the annual crop demands in the Lake Fork Basin. Based on review of early decrees for water rights on the Lake Fork, a common duty of water was 1 cfs per 40 acres, reflecting that the soils are relatively porous. Note that the Lake Fork soils are not as cobbly or porous as soils in other areas of the Upper Gunnison River Basin, including the East River and the Tomichi Creek Basins. This is still a relatively low duty of water; in other areas in Colorado where the duty of water is typically between 1 cfs per 40 acres and 1 cfs per 80 acres, meaning the soils in the Lake Fork Basin can require up to two times more water than some other areas in the state.

The amount of water diverted at the river headgate is not all available to meet crop demands. The amount available to the crop is the diverted water less ditch conveyance loss and irrigation application losses. For example, if 100 acre-feet is diverted and the conveyance loss is 20 percent, only 80 acre-feet is available at the farm turnout. The maximum flood application efficiency, based on the porous nature of the soil, is 45 percent; therefore, of the 100 acre-feet diverted in this example, only 36 acre-feet (80 acre-feet x 45 percent) is available to meet crop demands. As noted, the accuracy of the crop consumptive use estimate is highly dependent on the accuracy of diversion records.

Excess water applied to the fields during flood irrigation returns to the river over time. Based on irrigation surface runoff; aquifer characteristics; and the location of the irrigated parcels, over 50 percent of diversions not consumed by crops are estimated to return to the river within four days of application, with over 85 percent returning within two months of application.

Figure 4-15 shows the annual variability of agricultural water use for the period 1998 through 2017. The results are for the Lake Fork Basin; but each ditch was represented individually in the consumptive use analysis. Average annual consumptive use from irrigation for 1998 through 2017 was 2,580 acre-feet, varying from a low of 1,890 in the extremely wet summer of 2017 to over 2,900 acre-feet in the hot, high-runoff year of 2011. No diversions were recorded in 2016 and there were also no diversions recorded until May of 2017, which may account for the lower than average consumptive use that year.

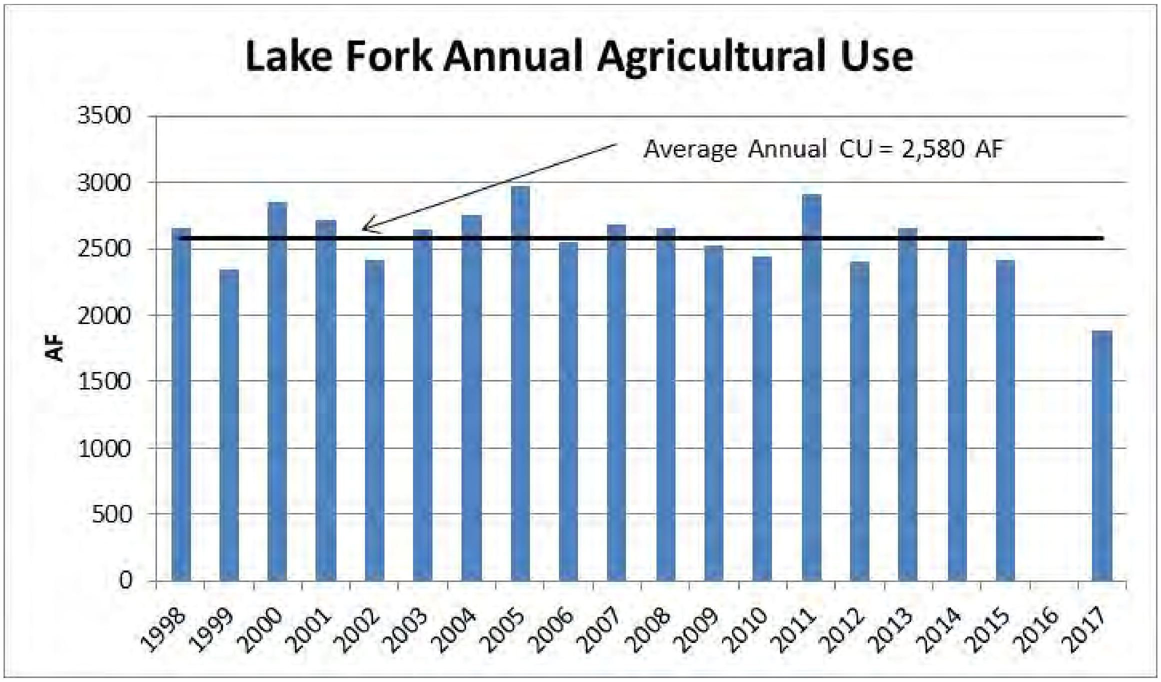


Figure 4-15: Annual Lake Fork Basin Agricultural Use, 1998 through 2017 (acre-feet)

Shortages to consumptive crop demands occur when the amount of water available to the irrigated fields is not enough to satisfy the full crop demands. The Lake Fork has a hydrograph dominated by snowmelt resulting in a supply of river water that is higher during the spring runoff and then decreases as the snowmelt runoff decreases. This leads to agricultural shortages during the late irrigation season and, in many years, throughout the irrigation season. Detailed results of the agricultural water use and needs are presented by reach in the reach sections [appendices]. In many cases, ditches divert water within a reach to irrigate lands physically located in a downstream reach. Because the stream depletions occur at the point of diversion, the consumptive use and associated shortages are reported based on the reach where the diversions occur.

4.2 Domestic Water Use

Municipal water providers and industrial water users were interviewed as part of the stakeholder outreach process. Existing uses and potential future needs were discussed with each entity. Detailed results of municipal and industrial water use and needs are presented by reach in the following sections.

There is one gold mine in the Lake Fork Basin that has been inactive for the past few years. At this, time it is not known if this mine will be reactivated. If such plans were to move forward, extensive analysis would be required to assure that water quantity and water quality of existing uses, including environmental uses and watershed health, would be protected. This assessment does not specifically address the impacts of potential mining operations.

4.3 Environmental Water Use

Several environmental characteristics were assessed and summarized based on information collected from existing studies, stakeholder interviews, and field assessments. The paragraphs below summarize the techniques used in the environmental water use and needs assessment.

4.3.1 Stream and Riparian Characteristics

The current condition of a stream and the adjacent riparian areas reflect the action of both natural processes and human activity. Stream and riparian characteristics provide important context to understand stream stability and watershed function. This assessment included a cursory review of channel and landscape form, debris supply, floodplain connectivity, stream stability, and physical structure. The objective of this portion of the assessment was to preliminarily evaluate issues identified by stakeholders and to support the selection of field assessment locations.

4.3.2 Aquatic Life

Perennial and intermittent streams within the Lake Fork Basin are typically expected to provide high-quality aquatic habitat, except where stressors have decreased the condition of the stream. Historic abandoned mines and runoff from developed areas are examples of water quality stressors that occur in some portions of the basin. some portions of the Lake Fork, environmental stressors overlap. The overlap may create outsized effects on the aquatic community. For example, the stress imposed by elevated zinc concentrations is exacerbated when stream temperatures are also elevated.

4.3.3 Water Quality

Aquatic life, recreation, agriculture, and water supply uses are applied to segments in the Lake Fork Basin. Each of the use classifications has specific standards for many water quality parameters. The water use classification with the most conservative criteria (e.g., lowest value) is applied as the effective standard for each parameter (e.g., temperature, nitrogen 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 Lake Fork Basin, the numeric standards associated with aquatic life (most metals), recreation (*E. coli*) or water supply (arsenic, iron) are typically the lowest and are therefore applied as the effective standard for many parameters.

4.3.4 Existing Instream Flow Water Rights

As part of this assessment, existing instream flow water rights were reviewed. During the review, the consultants evaluated original cross-section data, field notes, and R2CROSS model output. Unfortunately, due to their age, some instream flow segments in the Lake Fork Basin lacked some of the components included in the original proposal. Nevertheless, the review provided useful insights related to the existing instream flow water rights. In general, the original R2CROSS output and preliminary instream flow water rights were revised downward as a result of professional judgment and input from the local water commissioner, typically because of water availability limitations. The resulting instream flow rights are not consistent with current protocols for instream flow proposals. In many cases, the existing instream flow water rights in the Lake Fork Basin do not fully meet the physical criteria to preserve the natural environment to a reasonable degree.

In Sections 5 through 10 of this Chapter, a summary of the existing instream flow water rights is provided, as well as identifying locations where it may be possible to appropriate a new instream flow water right or enlarge the existing instream flow with a new instream flow appropriation or acquisition. Additional field work is likely needed to for any future instream flow proposals. Figure 4-16 shows the field assessment locations for the Lake Fork Basin. R2CROSS assessments and pebble counts were completed at nine locations. Further information about the R2CROSS results are presented in the respective reach sections.

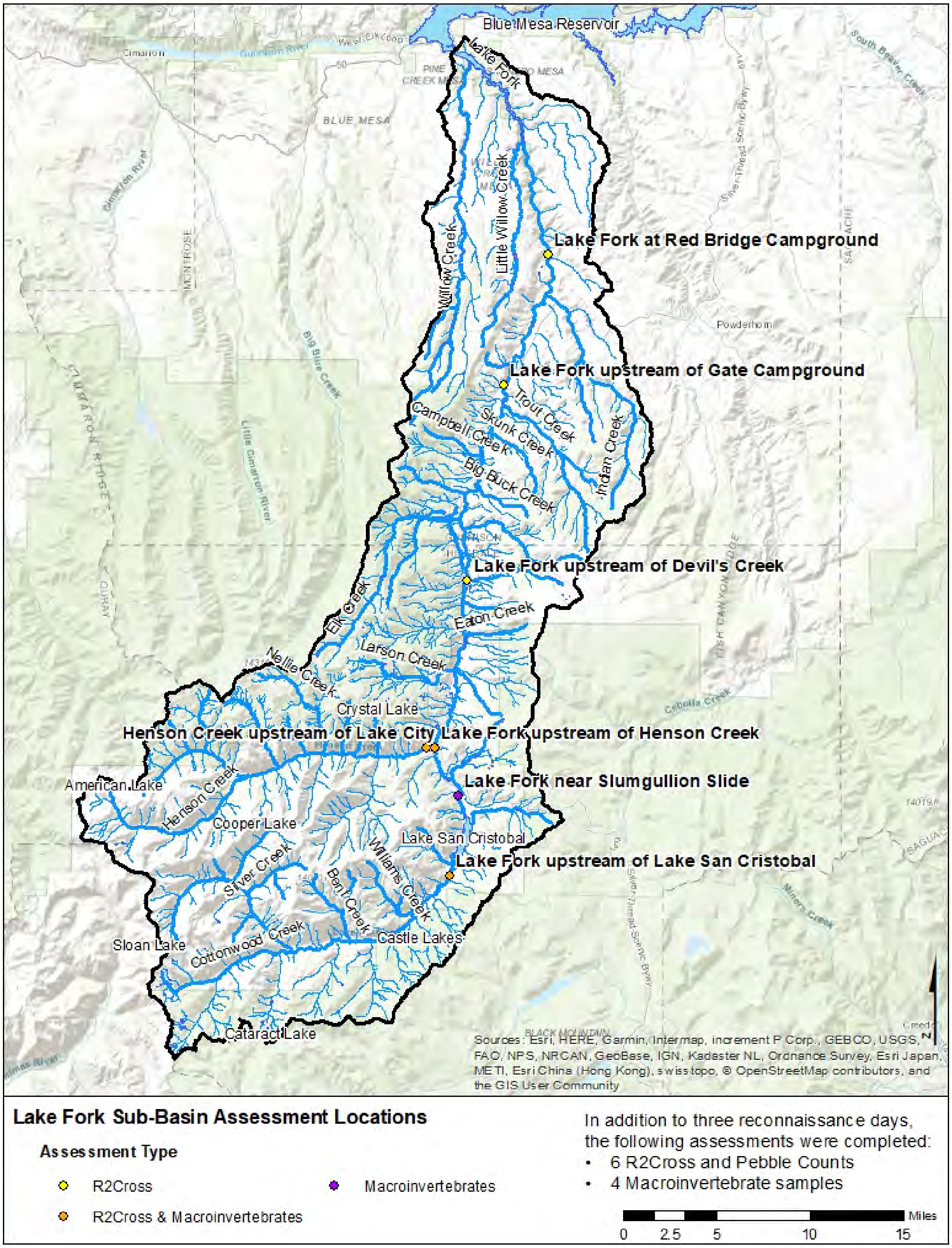


Figure 4-16: Lake Fork Sub-Basin Assessment Locations

Streamflow gages can be used to assess whether the instream flows are met at the gage location; however, the single active gage in the Lake Fork Basin does not represent the low-flow point within the lower instream flow reach; and there are not active streamflow gages within any of the other instream flow reaches in the Lake Fork Basin. In addition, in order to appropriate an instream flow right through the water court process, the initial requested flows are often reduced to account for river depletions associated with existing water rights.

4.3.4 Flow Limited Areas

Dry up or near dry up locations are presented by reach in the following sections.

4.3.5 Environmental Flow Goals

Recommendations related to existing and potential instream flows are presented for each reach in this section.

4.4 Recreational Water Use

Recreation is one of the primary land and water uses in the Lake Fork Basin. Recreation occurs year-round and includes hiking, biking, camping, fishing, birdwatching, kayaking, rafting, OHV use, Nordic skiing, backcountry skiing and snowboarding, snowmobiling, and hunting, among others. Water sports, like rafting, kayaking, standup paddle boarding, and tubing are increasingly common on larger reaches within the basin. Angling, including float fishing and wading, is also an important use in the basin.

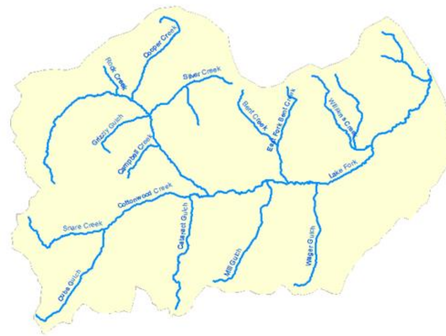
Recreation and tourism are a critical part of the local economy and culture. River recreation supports several businesses, including fly-fishing shops and outfitters, commercial guides, rentals, and retail stores, and jobs within the community. Due to recent increases in tourism and recreation, the community is very engaged on issues related to recreation management.

As part of this assessment recreational users were surveyed to better understand how they enjoy rivers in the area. Six unique surveys were created for each recreational boating reach in the Lake Fork Basin. To be eligible to complete a survey, the user had to confirm that they had floated the reach in the past. The criterion was used to avoid bias, particularly for Class V waters.

The four-page survey included questions related to craft type, floating experience, and infrastructure (parking, restrooms, fences, etc.). The survey included flow calendars for high and low flow years. Survey respondents used the calendar to identify the week of the month when they prefer to flow the reach, and could also reference flows, if needed. For rafting and kayaking, users were asked to identify high, medium, and low flow conditions on selected reaches. This approach was preferred over asking respondents to estimate stream flows, as most users are better able to remember when they floated a reach, but the particulars of flow may be difficult to recall. Where an adequate number of surveys were gathered, the use data was correlated with average daily stream flows at the nearest downstream gage. Data related to infrastructure and other components of the survey were tabulated and are reported in the reach summaries below.

Anglers were interviewed to determine quality of fishing along various reaches and needs for habitat and infrastructure improvements.

Section 5. Reach 1 - Upper Lake Fork to Lake San Cristobal



The Lake Fork of the Gunnison River forms in American Basin, near the summit of Cinnamon Pass, and flows into Lake San Cristobal approximately 4 miles south of Lake City. This reach drains approximately 107 square miles of rugged terrain including three peaks over 14,000 feet. The Lake Fork and its tributaries total approximately 72 miles in this portion of the Lake Fork sub-basin.

5.1 Agricultural Water Use

There are 11 active irrigation diversions in the Upper Lake Fork to Lake San Cristobal reach, serving approximately 164 acres of flood irrigated pasture grass. Table 5-1 shows the total irrigation water rights, combined annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the 11 ditches in this reach from 1998 to 2017. There was an open water commissioner position in the Lake Fork in 2016 and no diversions were recorded; therefore 2016 was not included in the table statistics. Table 3-2 presents the total for all of the agricultural diversions in the watershed reach (i.e. includes diversions located on the Lake Fork and its tributaries).

Table 5-1: Agricultural Water Use Statistics Upper Lake Fork to Lake San Cristobal

Reach Statistics	1998 to 2017 Average excluding 2016	1998-2017 Range excluding 2016
Number of Irrigation Structures	11	n/a
Irrigated Acreage	164	n/a
Water Rights	39.283 cfs	n/a
Diversions	3,060 acre-feet	2,130 – 4,480 acre-feet
Crop Demand	190 acre-feet	150 - 210 acre-feet
Crop CU	180 acre-feet	150 - 200 acre-feet
Shortage/Need	10 acre-feet	0 - 10 acre-feet
Percent Shortage	3%	0% - 14%

Figure 5-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, the French Ditch 2 and French Ditch 3 commingle to serve common acreage and the three Reece Richart ditches commingle to serve common acreage. All of the ditches are unlined, and each individual ditch is estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from this reach, estimated to be an average of 2,800 acre-feet per year from 1998 to 2017, accrue to the Lake Fork River above Lake San Cristobal.

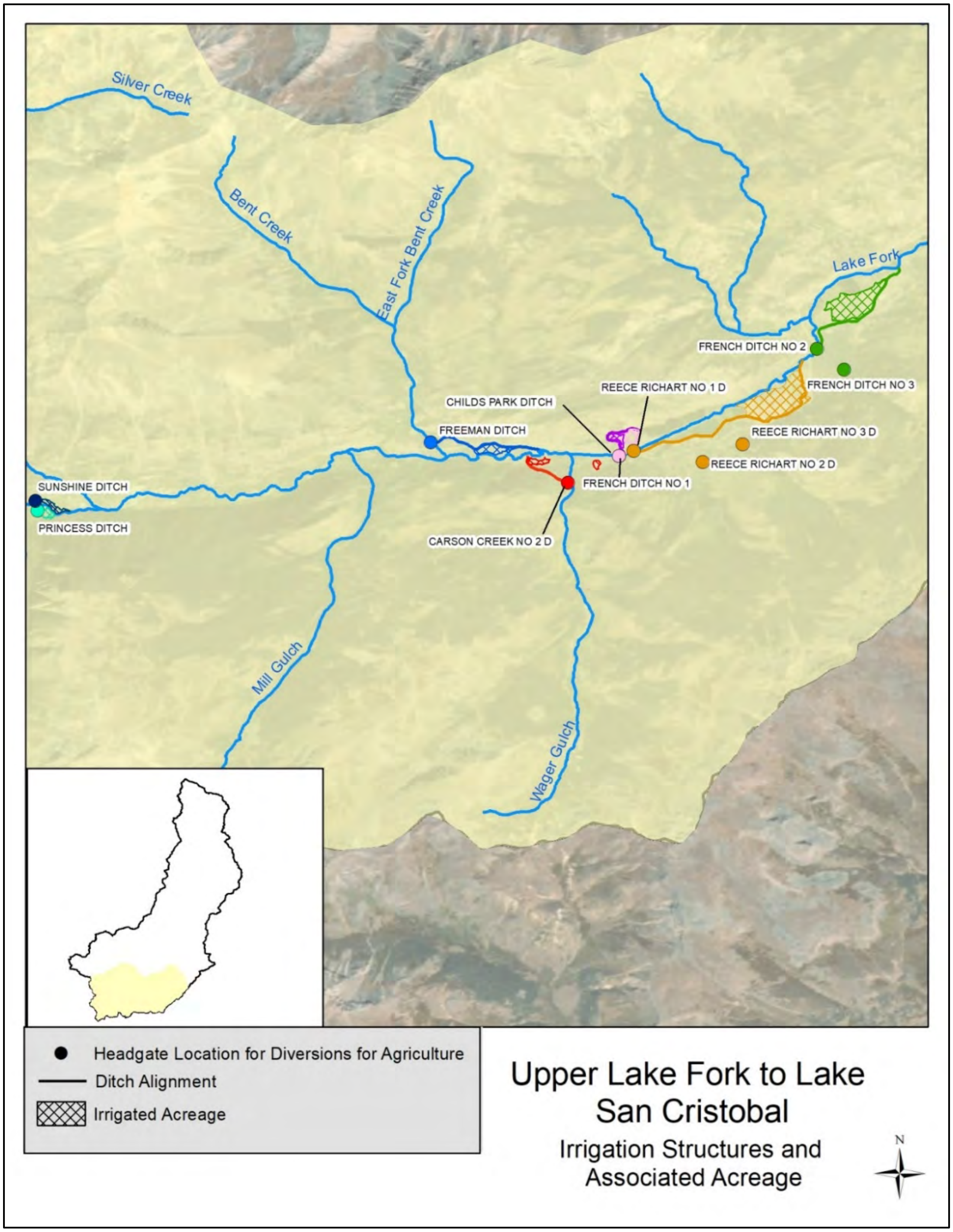
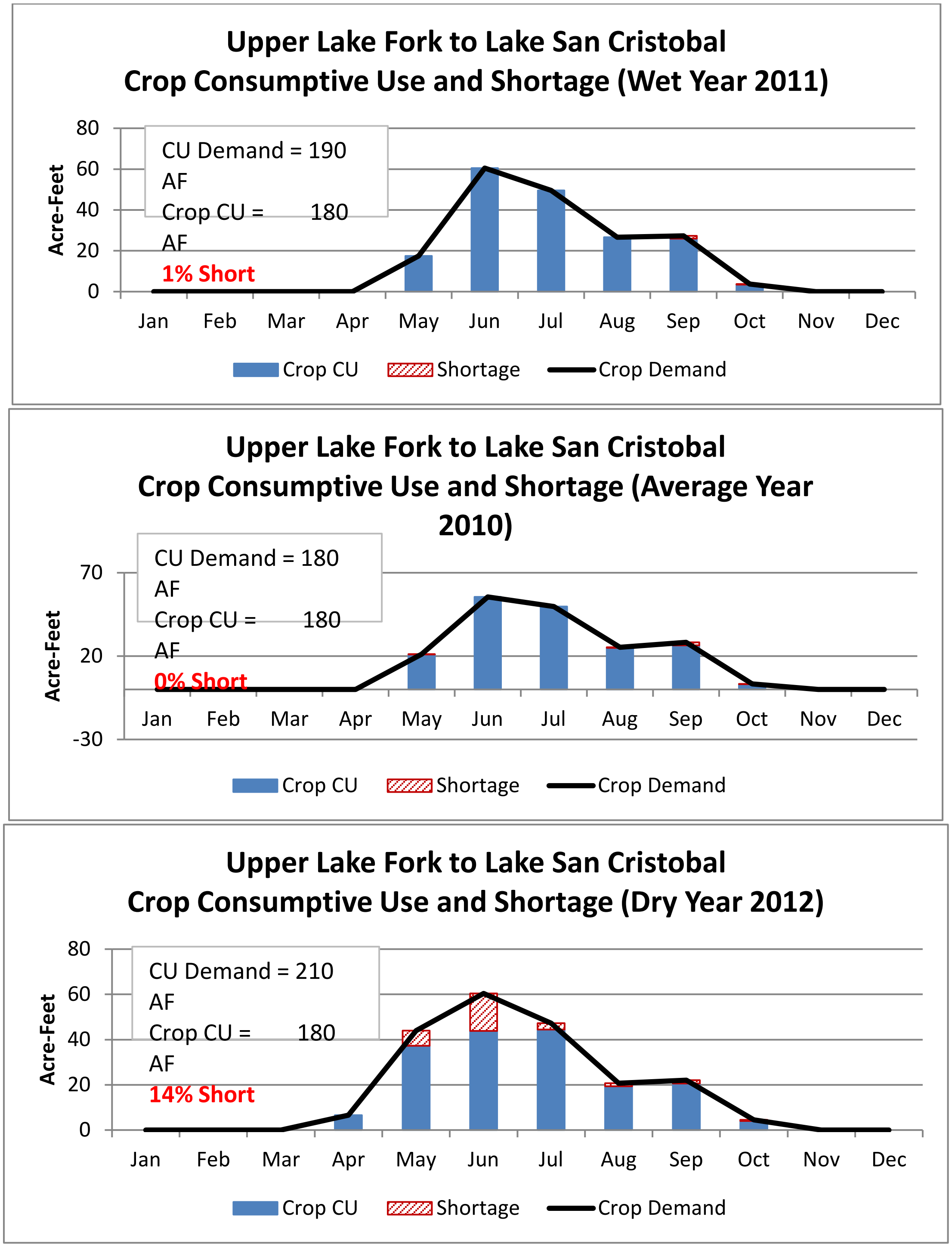


Figure 5-1: Upper Lake Fork to Lake San Cristobal, Irrigation Structures and Acreage

Figure 5-2shows the monthly crop demands, crop consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, ditches in this reach generally receive a full supply in wet and average years, and experience minor shortages in drier years. Note that in all three representative years, the crop demand in August significantly from July and is generally less than September. In all three of the representative years, a portion of the August demand was met from monsoonal rainfall.

Figure 5-2: Upper Lake Fork to Lake San Cristobal – Crop Consumptive Use and Shortage



5.2 Domestic Water Use

There are no diversions for municipal or industrial use in this headwater reach and no identified needs in the future.

Most of the residences within this reach are near County Road 30 (Cinnamon Pass Road) and the mainstem of the Lake Fork River between Cottonwood Creek and Lake San Cristobal. Wells provide household water and individual onsite wastewater treatment systems are used to manage wastewater.

There are several springs with water rights near Edith Mountain, at historic mine sites, and on private lands throughout the reach.

5.3 Environmental Water Use

5.3.1 Stream and Riparian Characteristics

Steep glaciated valleys and canyons form the headwaters of the Lake Fork River. Slopes are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. The streams, which are both intermittent and perennial, are steep entrenched channels that are often scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages. These flow events can be quite dramatic as evidenced by this past winter's avalanche cycle.

Due to the steep slopes and the materials found on the slopes, hillslopes in the headwaters are naturally susceptible to mass erosion which includes landslides, earth flows, debris avalanches, debris flows, torrents, and snow avalanches. These sporadic events provide massive natural sediment sources as shown in Photo 5-1. Evidence of recent mass erosion is very common throughout the headwaters area. Natural mass erosion events are probable throughout the headwaters area. These natural hillslope processes are an enormous source of sediment to the Lake Fork River. Natural mass erosion dominates sediment supply in the headwaters. These events form the background that human impacts must be evaluated against.

Photo 5-1: View from the Summit of Cinnamon Pass.
Steep hillslopes covered with evidence of mass erosion.

Stream channels in the headwaters area are extremely efficient at moving sediment. In contrast, the lower portion of the reach has lower gradient channels where the valley widens and flattens below Sherman. These changes decrease the channel's capacity to carry sediment and often results in large sediment deposits and frequent adjustments to channel form and location. Alluvial deposits occur where flow from steep drainages deposit and bury riparian areas. A large event such as this happened at Sherman town site in the 1960s, from Cataract Gulch.

The area down gradient of the confluence of the Lake Fork and Cottonwood Creek is also a prime example of these natural dynamics in action. Over time, the lower angle valley channel will winnow away accumulated sediment. The stream system may establish a tenuous and temporary equilibrium, but natural sediment delivery and erosion processes are very dynamic due to the topography, geology, and climate. Human efforts to confine or stabilize the stream channel may be effective for brief periods, but long-term stability should not be expected in this environment. Where possible, infrastructure and other resources should be located away from the riparian corridor.

Willows and riparian vegetation have colonized portions of narrow stream corridors in larger headwater tributaries where sediment deposition has supported soil development. In the valley reaches below Sherman, large wetland complexes support a variety of aquatic and wildlife habitats. These wetland complexes also attenuate flood flows and store water to support late season flows. Some development, including homes and man-made ponds occur within the riparian corridor. In some cases, including near Castle Lakes, the Lake Fork River has been straightened.

Approximately two miles up-valley from Lake San Cristobal, the valley narrows and the Lake Fork River flows through a small canyon with an increased channel slope and narrower riparian corridor. The valley widens as the Lake Fork flows into Lake San Cristobal.

5.3.2 Aquatic Life

From 2004 to 2018, approximately 20 macroinvertebrate samples were collected from multiple locations within the headwaters of the Lake Fork River and its larger tributaries. Most of the samples attained the Multi-metric indices (MMI) criteria used to assess macroinvertebrate community health and indicated that the macroinvertebrate community is healthy and robust. A portion of the samples did not attain the MMI criteria. Following a detailed review of sample collection methods, macroinvertebrate identification methods, water quality data, and habitat conditions, the Water Quality Control Division did not list the upper Lake Fork as impaired for aquatic life use.

The Upper Lake Fork River supports a modest fish population that mainly includes introduced species such as brook and brown trout; and less frequently rainbow trout. Lake Fork Falls, immediately upstream of Sherman, is a substantial habitat barrier that creates to distinct fish populations- up and downstream of the waterfall. Smaller features, including waterfalls and bedrock glides, may also create habitat barriers.

5.3.3 Water Quality

The Upper Lake Fork reach has been sampled on three occasions. The sample events were large characterization projects where major tributaries, abandoned mine features, and the mainstem of the Lake Fork were sampled to identify pollution sources. The existing water quality data suggests impairment at some locations in the Upper Lake Fork reach. The metal pollutants are characteristic of mineralized watersheds with abandoned mine features. Some samples collected near abandoned mine features had elevated metal concentrations; others did not. The data suggests that both ambient background conditions and abandoned mine features supply metals in this upper part of the reach. Based on data collected during these events, metal concentrations in the Lake Fork River downstream of Cottonwood Creek was supportive of aquatic life uses. Table 5-2 and Figure 5-3 summarize impairments and potential water quality impairments in this reach.

Table 5-2: Impaired and potentially impaired stream reaches in the Lake Fork River from the headwaters to Lake San Cristobal.

Listed Portion of Stream	Affected Use	Potentially Impaired (M&E List)	Impaired (303(d) List)	Impairment Priority
Lake Fork River upstream of Cooper Creek	Aquatic Life Use	Dissolved Cadmium	NA	NA
		Dissolved Zinc		
	Water Supply Use	Total Arsenic		
		Dissolved Manganese		
Lake Fork River between Cooper Creek and Silver Creek	Aquatic Life Use	Dissolved Cadmium	NA	NA
		Dissolved Zinc		
	Water Supply Use	Total Arsenic	Dissolved Manganese	Low
		NA		
Lake Fork River between Silver Creek and Cottonwood Creek	Aquatic Life Use	Dissolved Cadmium	NA	NA
		Dissolved Zinc		
	Water Supply Use	**Total Arsenic**		
		Dissolved Manganese		

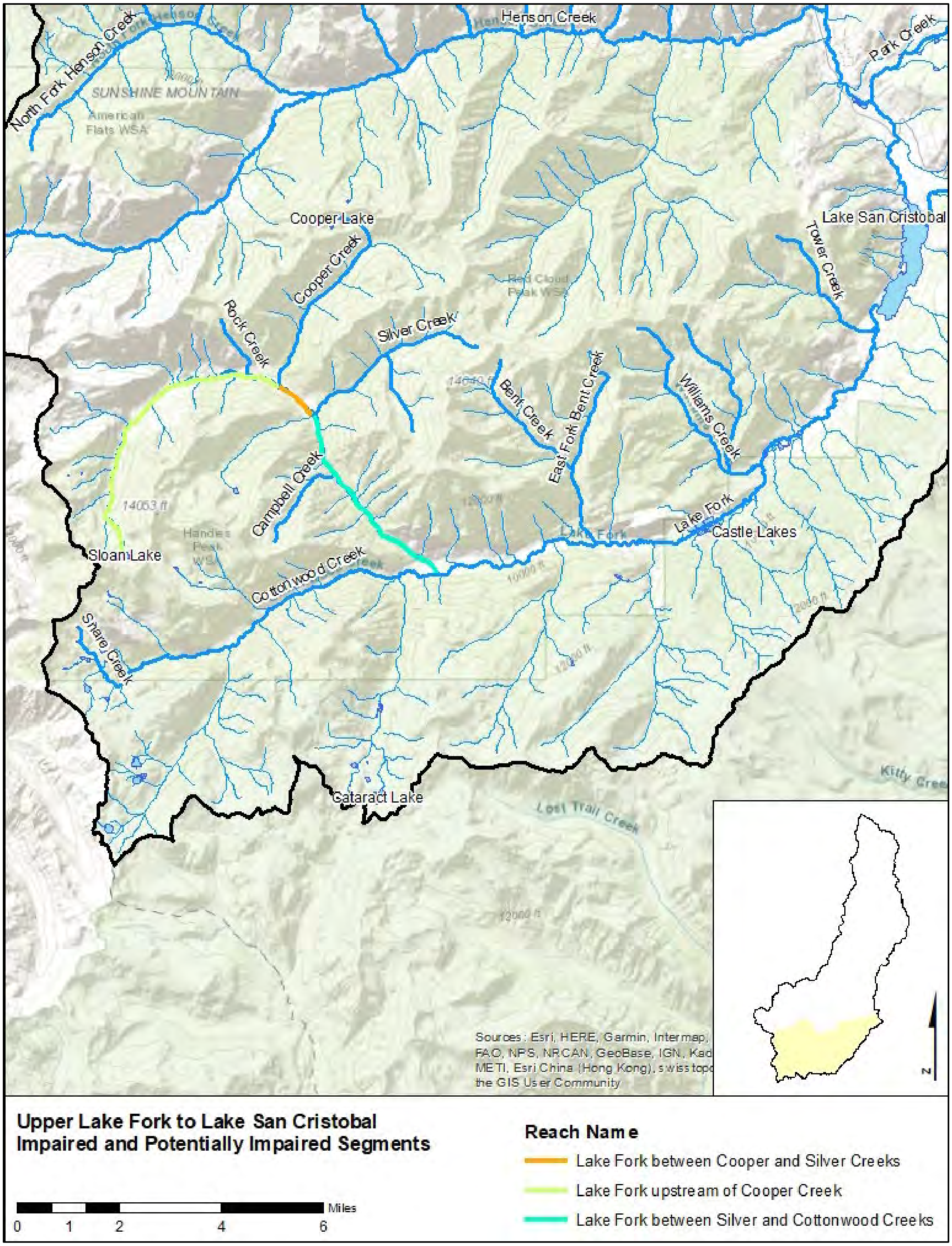


Figure 5-3: Impaired and potentially impaired stream reaches in the upper Lake Fork River from the headwaters to Lake San Cristobal

5.3.4 Water Temperature

The Bureau of Land Management installed continuous temperature sensors to characterize stream temperatures in the Lake Fork River at Mill Creek Campground and in Cottonwood Creek downstream of Cataract Gulch as shown in Table 5-3. Both locations attained the applicable stream temperature standards.

Table 5-3: Summary of stream temperature monitoring data collected in the Lake Fork River from the headwaters to Lake San Cristobal.

Location	Monitoring Start Date	Monitoring End Date	Number of Summers	Standard Attained
Cottonwood Creek downstream of Cataract Gulch	10/30/2013	10/25/2017	3	Yes
Lake Fork River at Mill Creek Campground	11/5/2012	9/24/2015	2	Yes

5.3.5 Existing Instream Flows

There are 13 instream flow reaches in the headwaters of the Lake Fork River upstream of Lake San Cristobal as shown in Figure 5-4. Ten of the instream flow water rights are year-round flat rates. In 2009, the BLM supported instream flow water rights for Grizzly Gulch and an increase to the summer rate for Bent Creek.

Photo 5-2. The Lake Fork River approximately 1 mile upstream of Lake San Cristobal during 2018 R2Cross and pebble count.

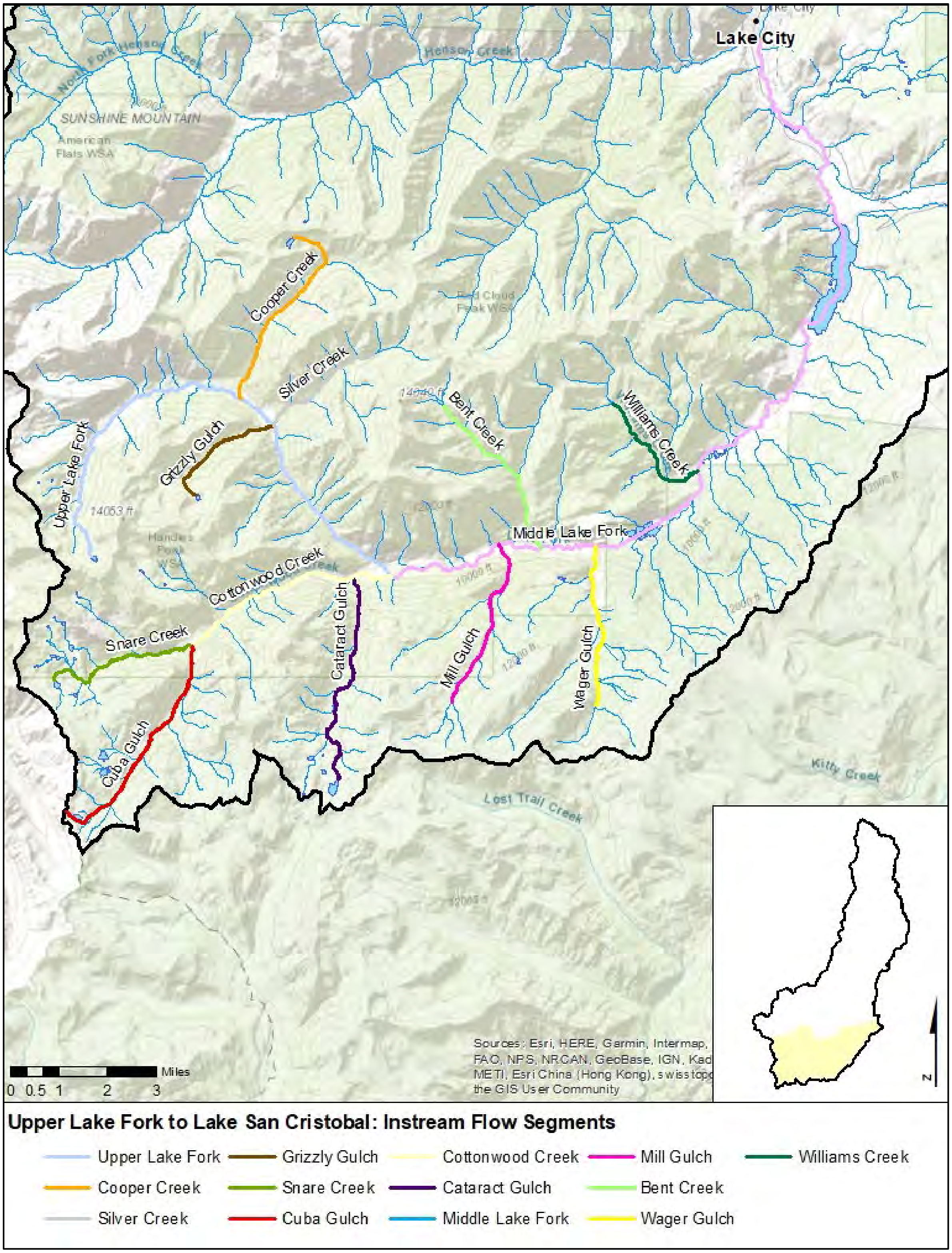


Figure 5-4: Instream flow water rights in the Upper Lake Fork to Lake San Cristobal

5.3.6 Flow-limited Areas

Lake Fork River upstream of Cottonwood Creek does not have any substantial diversions and stream flows are unaltered. Stream flow in Cottonwood Creek is unaltered until just above the confluence with the Lake Fork River (the Princess and Sunshine Ditches divert water from Cottonwood Creek just above the confluence with the Lake Fork River).

Diversions near the mouth of Wager Gulch and the mouth of Bent Creek may take a substantial portion of water from the tributary channel and limit habitat connectivity with the Lake Fork River.

During the latter part of the summer and early fall of average and dry years, stream flows in the mainstem of the Lake Fork River downstream of Bent Creek may decline as a result of irrigation within the reach. In the Lake Fork River upstream of Lake San Cristobal, average monthly flows, derived from the nearest gage, range from 131 cfs in July to 50 cfs in September. Given that water rights in the reach total about 72 cfs, diversions may alter stream flows substantially. It is generally understood that all water diverted within this reach returns to the Lake Fork River upstream of Lake San Cristobal due to highly porous substrate.

5.3.7 Environmental Flow Goals

The Lake Fork River upstream of Cottonwood Creek and nearly all of Cottonwood Creek have unaltered natural stream flows. Diversions from the Lake Fork River from the confluence with Bent Creek to downstream of Castle Lakes may substantially alter stream flows in the Lake Fork in dry and average years.

5.4 Recreational Water Use

The headwaters of the Lake Fork River from American Basin to Lake Fork Falls, immediately upstream of Sherman, are classified as a Class 5 whitewater kayaking reach called Cinnamon Gorge. This extremely technical run is paddled by expert kayakers during peak flow conditions in wetter than average years.

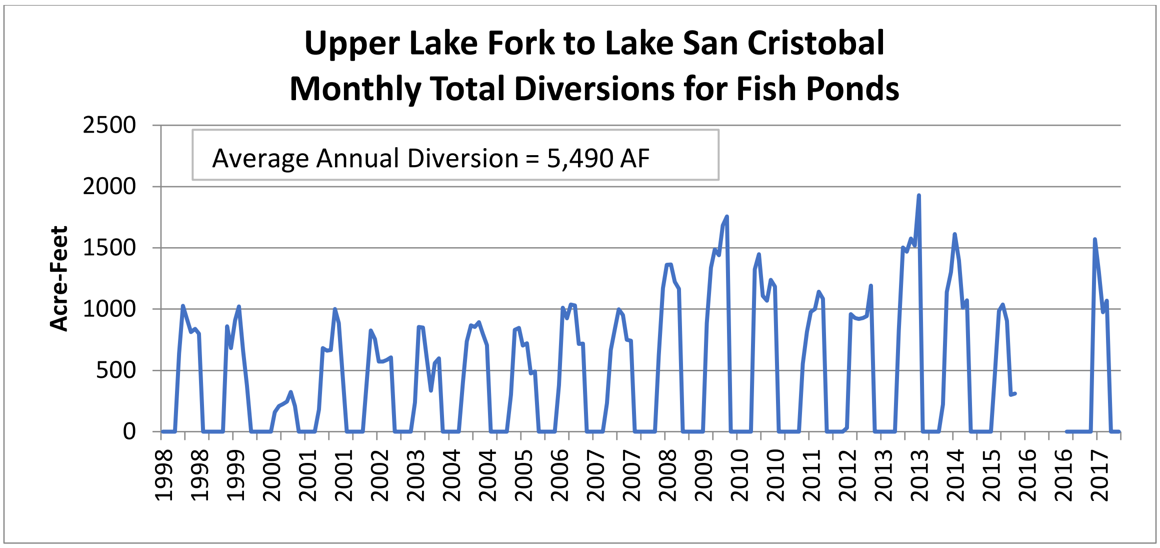
The quality of fish habitat varies widely in this reach. The Lake Fork River downstream of Lake Fork Falls provides fishing opportunities on a mixture of public and private lands. Some private landowners in this portion of the watershed are avid anglers and promote their properties as prime fisheries.

5.4.1 Fish Pond Diversions

There are several private fish ponds within this reach. Figure 5-5 shows the location of the six measured river diversions that fill fish ponds within the reach. The only depletions associated with pond diversions are replacement of pond evaporation; the diversions are generally flow-through and can result in significant de-watering of the river between the diversion and the river return location. Table 5-4 shows the total recorded diversions for fish ponds within the reach. Diversion for fish ponds typically begin in late April or early May and end in October. As noted previously, the water commissioner position was vacant in 2016 and no diversions were recorded.

Most of the ponds are unlined and do not have storage decrees. Depletions associated with the junior diversions to replace pond evaporation are generally replaced under small augmentation plans. Average annual diversions from the 1998 through 2017 period were 5,490 acre-feet, compared to average annual diversions for irrigation for the same period of 2,980 acre-feet.

Table 5-4: Monthly Total Diversions for Fish Ponds



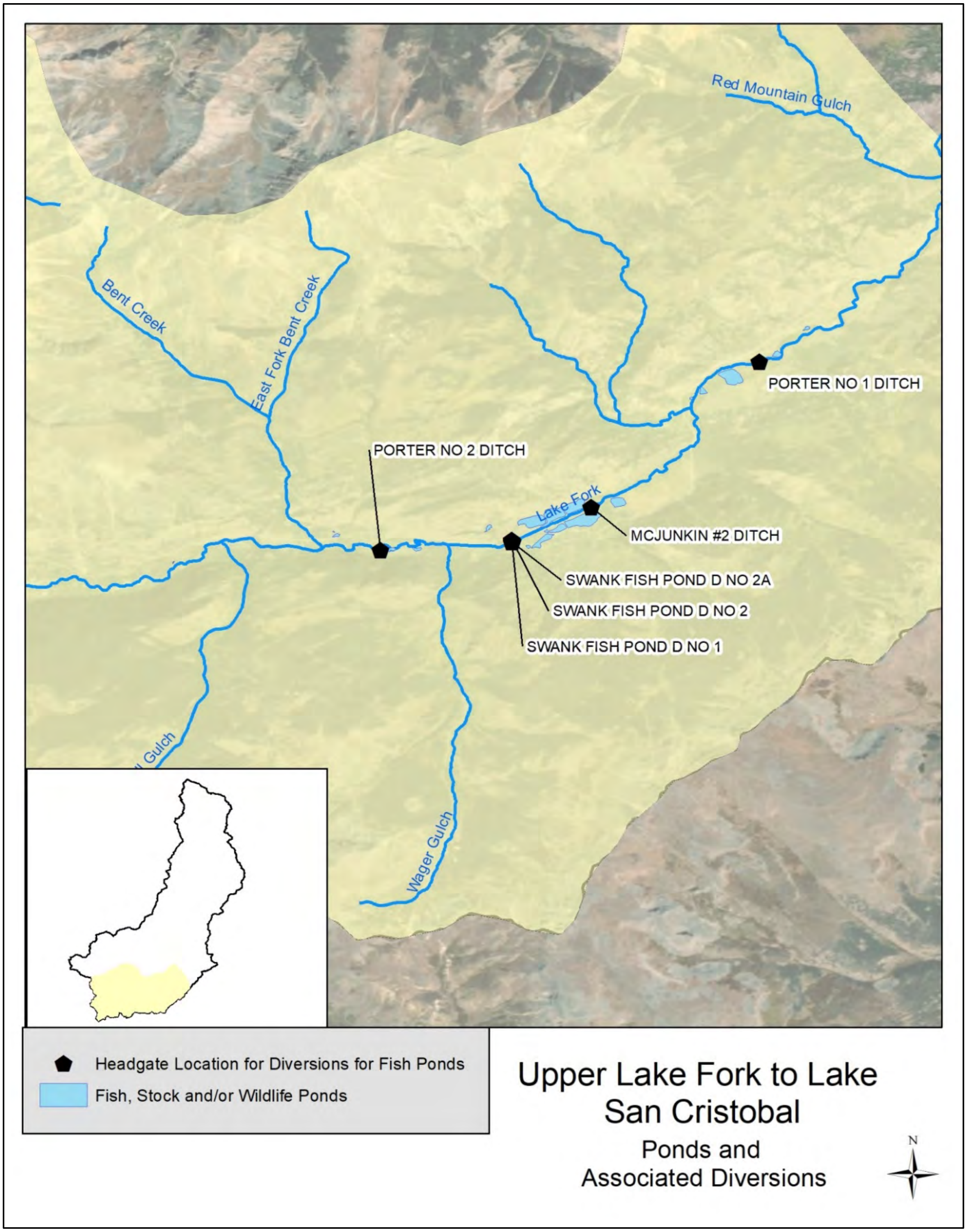


Figure 5-5: Upper Lake Fork to Lake San Cristobal, Fish Pond Diversions

5.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Quality of well water in highly mineralized areas.

Issue: Historic abandoned mines. The Colorado Division of Reclamation, Mining and Safety (DRMS) continues to work with private landowners and BLM to assure that mine features have safety closures in place to protect public health. The Cinnamon Pass project will be completed in the next 1-2 years. DRMS and BLM are evaluating the need for reclamation at the draining Gnome Mine in American Basin. Surface water, seeps, and drainage from the adit flow through mine waste en route to the Lake Fork River. Cooper Creek has a large abandoned mine that needs further assessment, especially in regard to impacts on aquatic life. This will be discussed as we move forward with planning in the next phase.

Issue: Habitat connectivity between the Lake Fork River and selected tributaries: Diversions near the mouth of Wager Gulch and the mouth of Bent Creek may take most of the tributary steam's flow and eliminate habitat connectivity between the tributary and the Lake Fork River. Additional data collection and discussion with landowners and CPW staff is recommended to determine whether habitat connectivity is a priority for these tributaries.

Issue: Potential for summer rate increases for instream flow water rights in tributaries to the Lake Fork. In 2009, BLM staff completed field work to support two instream flow water rights in the Upper Lake Fork. Because the majority of the Upper Lake Fork is public land, it may be worthwhile to prioritize tributaries where additional development is most likely to occur (e.g. private in-holdings associated with mining claims).

Issue: Potential for cutthroat trout reintroduction above the falls, once brook trout populations are removed.

Issue: Additional macroinvertebrate samples, fish surveys, and habitat assessment may be useful to further characterize conditions in this reach. Techniques to delineate man-made impairments (e.g. effects from historic abandoned mines or channel-straightening) from natural impairments (e.g. natural mineralization and sediment transport processes) will be critical in future studies. Specific objectives should be developed prior to initiating additional studies.

Issue: Better characterize low flows and habitat limitations, if any, in Wager Gulch and Bent Creek.

Section 6. Reach 2 - Lake San Cristobal

Approximately 800 years ago, a massive volume of hydrothermally altered volcanic sediment slumped from the edge of Mesa Seco (Lipman 1976, USGS, 1996). [73][74] The earth flow traveled nearly 4.5 miles downhill and dammed the Lake Fork of the Gunnison River to create Lake San Cristobal. The earth flow continues to evolve. Researchers have used radiometric dating and soil development to identify two significant periods of movement (Madole, 1996; Parise et al, 2003; Coe et al)[75][76][77]. The second earth flow began about 300 years ago; this movement occurs on and in the original slide sediments (Parise et al, 2003; Coe et al, 2003). Recent investigations by the USGS and academic researchers suggest that continued movement of the slide is most common at the narrow neck near the middle as well as near the head and toe of the active slide (Parise et al, 2003; Coe et al 2003; USGS, 1996). The active slide is now 2.4 miles long, with a leading edge that is up to 25 feet tall and that continues to flow downslope as much as 20 feet per year in some areas (Parise and Guzzi, 1992)[78]. Variations in material density, water content, precipitation, and weather drive the movement measured in recent years (Coe et. al; 2003).

The bizarre angles of trees growing on some areas of the slide provide clear evidence of recent shifts of the landslide. The bulk of the earth flow is weathered yellow and red material with textures ranging from clay to silty sand derived from the original volcanic sediments (Chelborad et. al, 1996)[79]. The degree of soil development is limited on the slide, an indicator of both continued movement and young geologic age (Parise et al, 2003). Due to hydrothermal alteration of the sediments prior to the slide, the earth flow material is high in soluble salts, iron (Chelborad et. al 1996) and significant quantities of other metals.

---

73 Lipman, P. (1976). *Caldera-collapse Breccias in the western San Juan Mountains, Colorado.* Geological Society of America Bulletin, Vol. 87, pgs. 1397-1410.
74 US Geological Survey (1996). *The Slumgullion Earth Flow: A Large-Scale Natural Laboratory.* USGS Survey Bulletin 2130, US Printing Office, Washington.
75 Madole, R.F. (1996). *Preliminary Chronology of the Slumgullion Landslide, Hinsdale County, Colorado.* USGS Survey Bulletin 2130, US Printing Office, Washington.
76 Parise, M. et al (2003). *The Slumgullion Landslide (Southwestern Colorado, USA): Investigation and Monitoring.*
77 Coe, J. A. et al (2003). *Seasonal movement of the Slumgullion Landslide determined from Global Positioning System surveys and field instrumentation, July 1998-March 2002.* Engineering Geology, Vo. 68, Issues 1-2, Pgs. 67-101.
78 Parise, M. and Guzzi, R. (1992). *Volume and Shape of the active and inactive parts of the Slumgullion Landslide, Hinsdale County, Colorado.* USGS Open-File Report 92-216.
79 Chleborad, A.F. et al (1996*). Geotechnical Properties of Selected Materials from the Slumgullion Landslide.* USGS Survey Bulletin 2130, Chapter 11, pgs. 67-72.

In the 1950s USGS investigated increasing the spillway height of Lake San Cristobal to increase the size of the lake and store additional water. A large spillway was deemed undesirable due to the on-going instability of the Slumgullion Landslide.

As the state's second largest lake, Lake San Cristobal is a popular recreational site. Local and visitors enjoy swimming, motorized boating, stand-up paddle boarding, and fishing on the lake. Hinsdale County operates Wupperman Campground on the eastern shores of the lake. There are several homes and an RV park on the north end of Lake San Cristobal.

6.1 Agricultural Water Use

There are no diversions for agricultural use from Lake San Cristobal and no identified needs in the future.

6.2 Domestic Water Use

There are no direct diversions for municipal or industrial use in this reach. The top 3 feet of water in Lake San Cristobal is decreed for augmentation and is used to replace out-of-priority depletions by wells or other diversion structures that would otherwise be curtailed by a senior water rights call in the Lake Fork or Gunnison River. The augmentation storage is owned by the Lake San Cristobal Water Activity Enterprise (LSCWAE) and managed by the UGRWCD. The Enterprise sells Augmentation Certificates to water users who require augmentation and currently has an adequate inventory to satisfy anticipated future needs. The Town of Lake City relies on Enterprise Augmentation Certificates to augment the Town's municipal wells.

Homes around the lake derive their household water from springs and wells. Most homes are on individual septic systems. The Lake View Cabin subdivision at the south end of the lake has its own sewage system in place.

6.3 Environmental Water Use

6.3.1 Stream and Riparian Characteristics

The inlet of Lake San Cristobal supports a large wetland complex that provides vital habitat to wildlife and aquatic life. In 2013, the 156-acre wetland was placed into a conservation easement held by Colorado Open Lands (a certified land trust). The conserved wetland is littered with beaver ponds, relic channels, and a wide variety of riparian vegetation. The conservation easement allows public access for fishing.

View of Lake San Cristobal. Photo courtesy of Hall Realty/Lakecity.com

6.3.2 Aquatic Life

Rainbow trout and lake trout call Lake San Cristobal home. Colorado Parks and Wildlife stock Lake San Cristobal with rainbow trout.

Due to its elevation, water temperatures, and chemistry, Lake San Cristobal is not ideal habitat for zebra and quagga mussels. However, CPW regularly monitors to for the presence of zebra and quagga mussels, and to date, they have not been identified in the lake. However, there is need for more active education here, as there is potential threat of invasion with the number of boats that are brought in.

Didymosphenia geminata, commonly known as didymo, or rock snot, is a species of diatom that produces nuisance growths in cold freshwater rivers and streams with low nutrient levels. Didymo has been identified at the lake outlet. It is not known at this time what effect its presence has on aquatic life.

6.3.3 Water Quality

In 2010, Lake Fork Valley Conservancy (LFVC) staff and volunteers collected water quality samples from one meter below the surface and one meter above the lake bottom. Manganese concentrations exceeded the water supply standard (50 µg/l) in 12 of 13 instances. The manganese water supply standard is not a human health-based standard, but rather a secondary water supply standard, intended to assure that the water is palatable and that infrastructure (i.e. pipes and fixtures) are not damaged (Herman, 1996). Manganese concentrations in Lake San Cristobal are not detrimental to aquatic life. It appears that the Fleece-Ilma Mine Site and Slumgullion Creek deliver manganese to Lake San Cristobal. The

Lake Fork River also contributes manganese, but the contributions are small relative to the contributions from the Fleece-Ilma Mine and Slumgullion Creek.

To date, all nitrate, nitrite and ammonia measurements have been below regulatory criteria. Chlorophyll data does not indicate that problematic algal blooms occur in Lake San Cristobal. In fact, the nutrient status of the lake may limit primary productivity; which is typical of high-altitude lakes.

LFVC staff also used Secchi disks to assess water clarity during 2010; the data indicate that the water clarity is exceptionally high. Relative to similar lakes, as reported in the *Colorado Lake and Reservoir Management Association Database*, Lake San Cristobal generally has higher clarity, as measured by Secchi disk depth.

6.3.4 Water Temperature

In 2009 and 2010, LFVC and EPA staff and volunteers used multi-parameter probes to measure water temperatures. Water temperatures were sufficiently cool to protect aquatic life and displayed typical stratification patterns. However, the data were not collected frequently enough to assess attainment with the applicable temperature standards.

6.3.5 Existing Natural Lake Level Right

Instream flows are not applied to lakes. However, natural lake levels are used to preserve the natural environment in and adjacent to lakes. Lake San Cristobal has a natural lake level protection of 13,545 acre-feet with an appropriation date of May 12,1976 (Case No W-3366-77). In connection with the adjudication of the storage right discussed in Section 6.2 above, the UGRWCD negotiated an injury with mitigation agreement with the Colorado Water Conservation Board to protect this natural lake level water right.

6.3.6 Environmental Flow Goals

The goal in Lake San Cristobal is to maintain a lake level that meets both augmentation needs as decreed in the LSCWAE storage right, and ecosystem needs of the surrounding lake wetlands.

6.4 Recreational Water Use

Lake San Cristobal is one of the most pristine lakes in the state that has such available access. It is a popular recreation site with multiple boat launches, docks, and access points. Many varieties of water-based recreation occur in Lake San Cristobal, such as motorized boating, Kayaking, standup paddle boarding, fishing. Human powered boating is increasing in popularity.

6.5 Needs for this Reach: Issues Identified

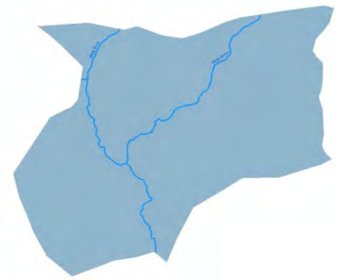
This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Fleece-Ilma Mine site and sediment retention ponds. The Fleece-Ilma Mine Site is located immediately west of Lake San Cristobal. A minimal amount of reclamation and stabilization work has been completed by the mine owners and through a bond forfeiture. However, the current condition of the site poses a risk to water quality in Lake San Cristobal and in downstream portions of the Lake Fork River. Previous water quality evaluations have confirmed low pH and very high metal concentrations at the mine site.

Issue: Sediment delivery and instability in Slumgullion Creek adjacent to Lake San Cristobal. Slumgullion Creek drains the southern half of the Slumgullion Slide debris. Erosion and sediment delivery are common due to a lack of riparian and upland vegetation which is attributed to the low pH and high metal concentrations found in the slide materials.

Issue: Infrastructure needs at the Lake. Hinsdale County has identified need for an updated water supply system at Wupperman Campground. In addition, the access points at the lake need better day use infrastructure and educational kiosks to inform about invasive species and recreation regulations.

Section 7. Reach 3 - Lake Fork from Lake San Cristobal to Lake City



The Slumgullion Slide forms the East side of the Lake Fork River from the outlet of Lake San Cristobal to the Highway 149 road crossing; or about 1.2 miles. Park Creek is the largest tributary to the Lake Fork River within this reach.

Several historic abandoned mines litter the hillslopes upgradient of the Lake Fork River. This complex of mines was heavily mined in the late 1800s and early 1900s and are linked via a network of shafts and adits to the Fleece Ilma mine at the outlet of Lake San Cristobal.

The Vickers Ranch is located in the Park Creek tributary watershed. 1,500 acres of the upper ranch is under conservation easement with The Nature Conservancy. The lower ranch has been subdivided into numerous home sites. This ranch still contains extensive wetland pasture and relatively intact riparian corridor.

The Golden Wonder Mine, the only recently active mine in the watershed, is also located within this reach, accessible via the Vickers Ranch. It is located in Deadman Gulch, which has shown evidence of impact from historic and possibly more recent mining activity. Efforts are underway to conduct a TMDL for the Gulch.

7.1 Agricultural Water Use

There are three active irrigation diversions in the Lake Fork River from Lake San Cristobal to Lake City that serve 109 acres of flood irrigated pasture. Table 7-1 shows the total irrigation water rights, combined annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the 11 ditches in this reach from 1998 to 2017. As discussed in Section 2, there was an open water commissioner position in the Lake Fork in 2016 and no diversions were recorded; therefore 2016 was not included in the table statistics. In addition, 2012 and 2013 were excluded as discussed below. Table 3-2 presents the total for all of the agricultural diversions in the watershed reach (i.e. includes diversions located on the Lake Fork and its tributaries).

Table 7-1: Agricultural Water Use Statistics
Lake Fork River from Lake San Cristobal to Lake City

Reach Statistics	1998 to 2017 Average excluding 2012, 2013,2016	1998-2017 Range excluding 2012, 2013,2016
Number of Irrigation Structures	3	n/a
Irrigated Acreage	114	n/a
Water Rights	11 cfs	n/a
Diversions	360 acre-feet	180 - 570 acre-feet
Crop Demand	210 acre-feet	170 - 250 acre-feet
Crop CU	100 acre-feet	60 - 160 acre-feet
Shortage/Need	110 acre-feet	110 - 90 acre-feet
Percent Shortage	49%	19% - 71%

Figure 7-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. All of the ditches are unlined and are estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from this reach, estimated to be an average of 240 acre-feet per year from 1998 to 2017, accrue to the Lake Fork from Lake San Cristobal to Lake City reach.

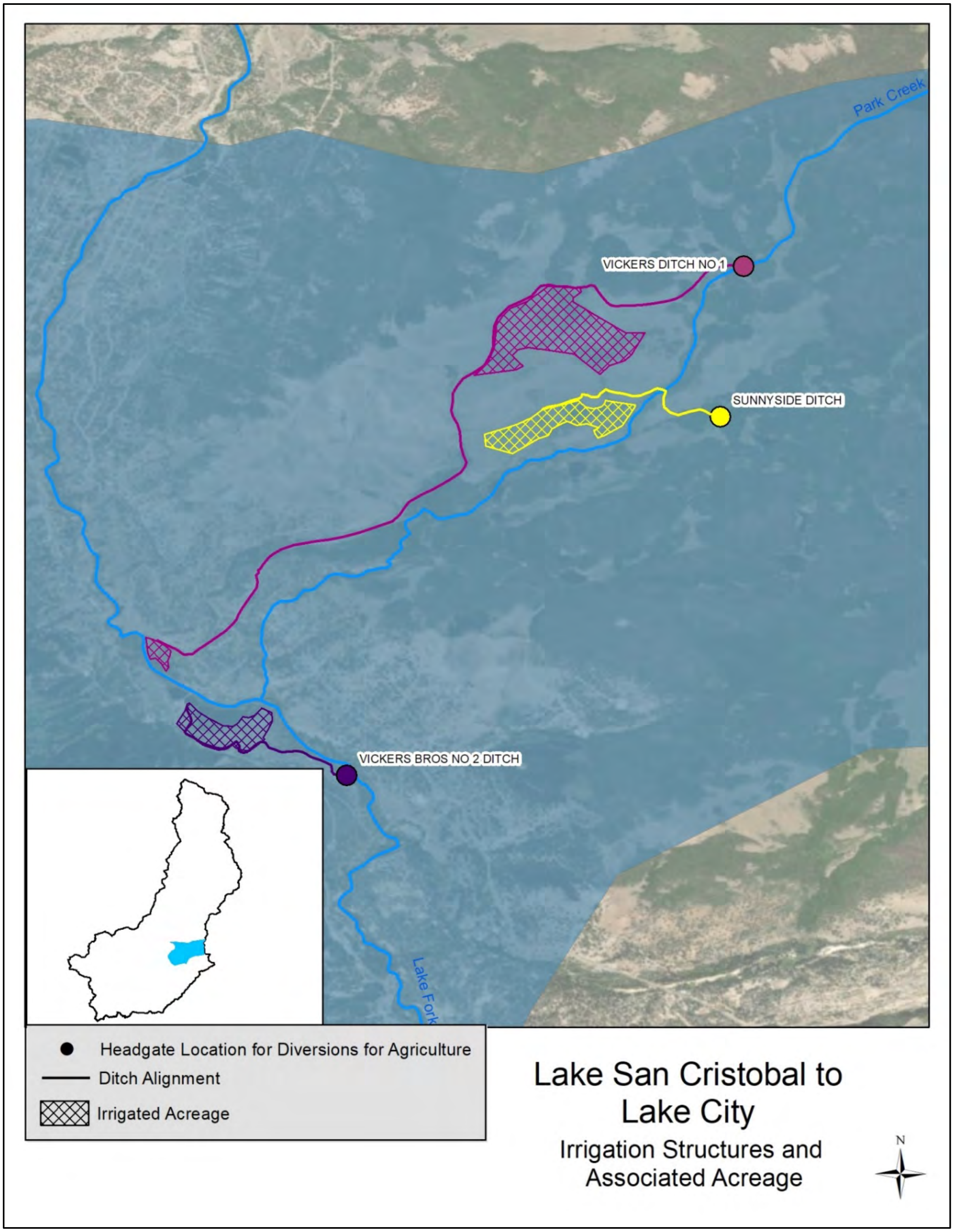
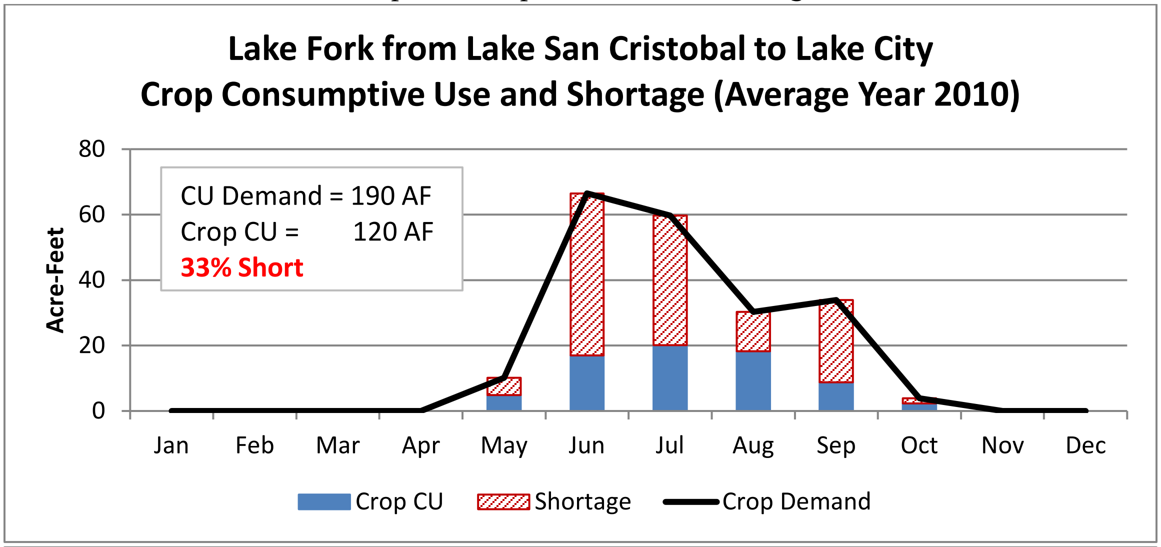


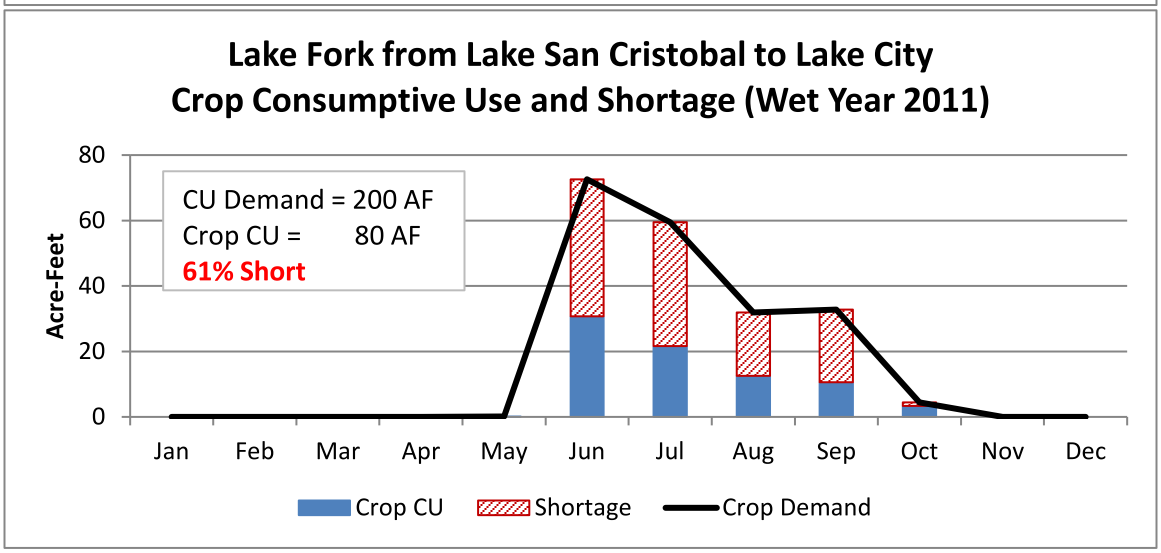
Figure 7-1: Lake San Cristobal to Lake City, Irrigation Structures and Acreage

Figure 7-2 shows the monthly crop demands, crop consumptive use, and associated shortages for two recent years, chosen to highlight hydrologic variability between a wet year (2011) and a relatively average year (2010). Vickers Brother No 2 Ditch diverts from the Lake Fork and received a full supply in most years of the analysis; shortages are almost all attributable to the two ditches diverting from Park Creek. This small tributary has water available to irrigate pasture only during peak runoff; therefore there are significant shortages throughout the summer.

During the 2012 dry representative year selected for the WMP, Vickers Brother No 2 Ditch had water available for use, but did not divert according to the water commissioner notes. They also did not divert in 2013. The notes do not indicate if there was a headgate maintenance issue. This skewed the results for those years and the representative dry year (2012) is not shown and not included in the statistics in Table 7-1. Beginning in 2014, the ditch started diverting at pre-2011 levels.

Figure 7-2: Lake Fork from Lake San Cristobal to Lake City
Crop Consumptive Use and Shortage





7.2 Domestic Water Use

The town of Lake City water supply is provided from two wells located within the city limits, drilled to a depth of 60 feet and 70 feet. Both wells are classified as groundwater by the CDPHE. These wells are located at the mouth of Henson Canyon in Pumphouse Park and at the north end of Memorial Park.

According to the town clerk, the wells serve a full-time population of 408, in addition to seasonal homes and numerous tourists in the summer season. Total number of water taps and associated accounts for both residential and business uses are 589. As with other municipalities, the consumptive use of the pumped water is approximately 5 percent for indoor use. During the lawn and landscaping season, consumptive use increases to a high of 90 percent of water pumped in July and August. Figure 7-3 shows the volume of groundwater pumped for municipal use and the associated consumptive use for 2017. Lawn irrigation return flows and treated effluent return to the Lake Fork within the Lake San Cristobal to Lake City reach.

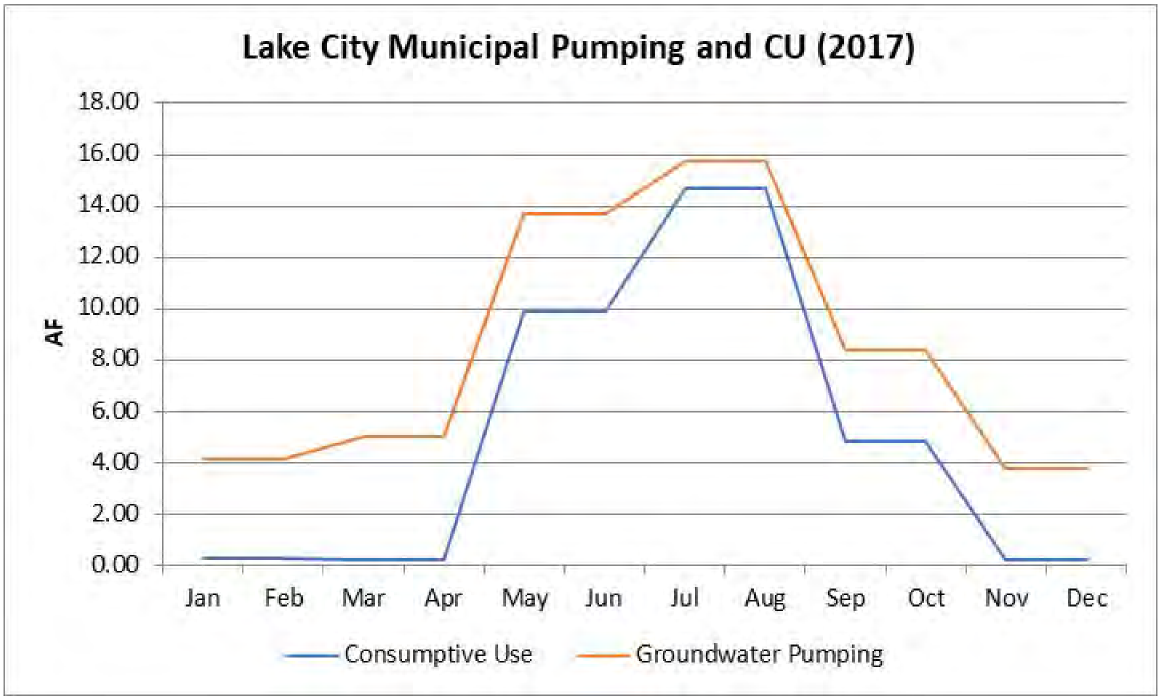


Figure 7-3: Lake City Municipal Pumping and CU (2017)

The Town of Lake City Drinking Water Quality Report, was prepared in 2018 using data collected in 2017 (the most recent version of the report currently available), found that copper concentrations in the distribution system exceeded the action limit. The Town was eventually removed from the exceedance list as it was shown that this elevated copper level was from one individual home that had corroded copper pipes. Copper can be mobilized within drinking water distribution systems as corrosive waters (low pH or low hardness water) flow through copper plumbing. Copper plumbing is typically found in private homes, but on occasion is used within older portions of public distribution systems. Copper mobilization within the distribution system can be exacerbated by seasonal use, where water is exposed to copper plumbing for a longer period while the property is vacant. In some cases, copper mobilized from the distribution system may create challenges for wastewater treatment facilities that are required to meet copper limits; particularly if those facilities discharge into low hardness waters, like the Lake Fork River.

Town wastewater is treated at a facility at the north end of Town. Effluent from this site has met all water quality standards. There are an additional two subdivision wastewater treatment systems along this reach, but data is not available regarding water quality. In the 1990s, a hydro-electric plant was constructed at the Black Crooke mill site on the Lake Fork south of Lake City.

This facility only provides electricity to the adjacent home and is not connected to the electricity grid. This property is currently on the market and the potential exists to upgrade this site to provide electricity to the town.

7.3 Environmental Water Use

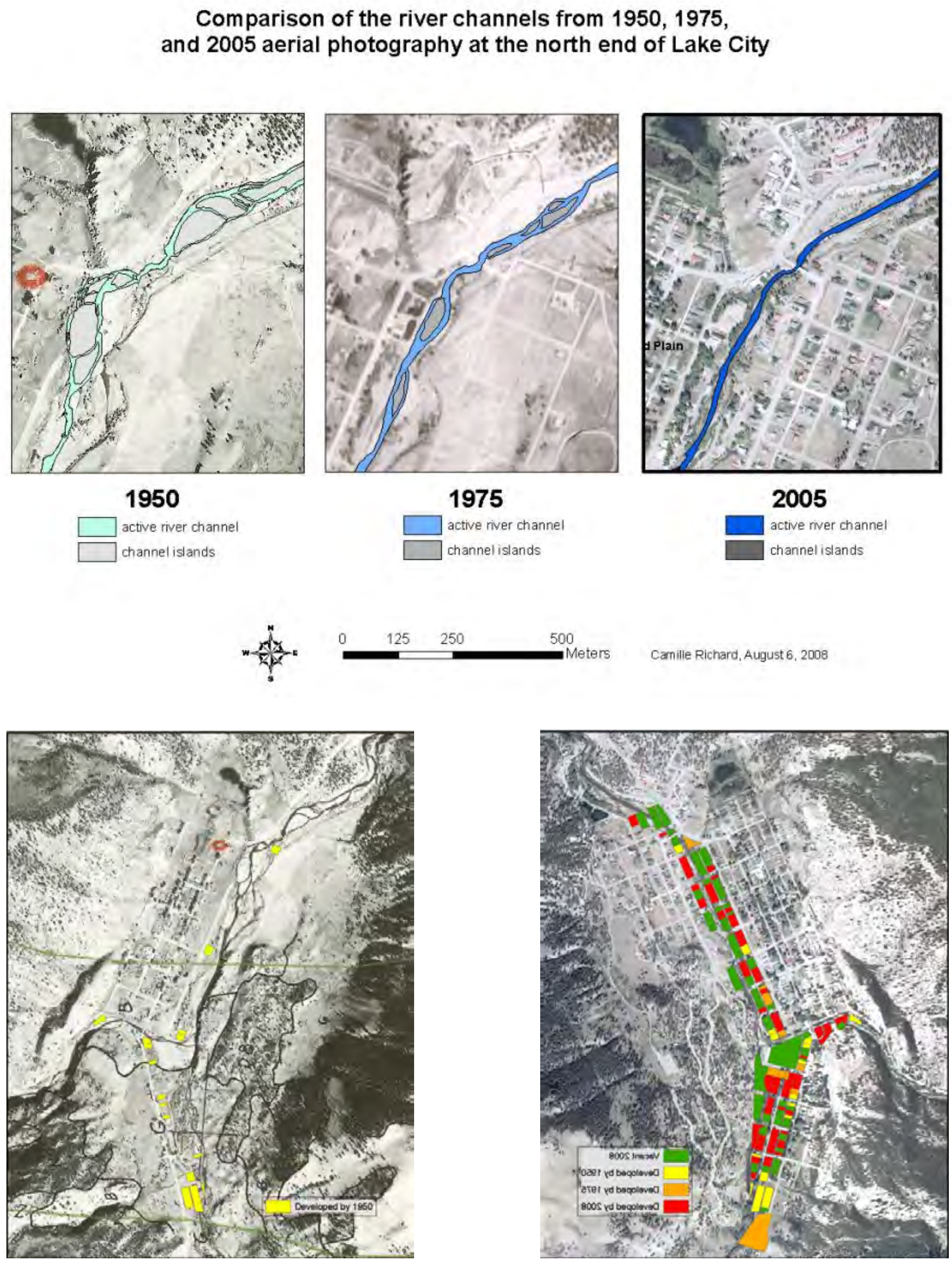
7.3.1 Stream and Riparian Characteristics

The Lake Fork River in this reach is somewhat confined by small canyons, slide debris, and development within the riparian corridor from the outlet of Lake San Cristobal to Lake City. Spruce trees, willows, alders, and other riparian vegetation typically form a narrow ribbon within the riparian corridor.

Native vegetation has been altered by development within the riparian corridor, especially in the vicinity of the Town. Figure 7-4 shows changes in the river from the 1950s to 2005 and the constriction of the river due to development. This created a number of problems, including aggradation of the river channel, channel braiding, reduction of fisheries habitat, and instability of banks.

The Lake Fork Valley Conservancy has been actively restoring the river channel along this stretch of river in Lake City. This work, where completed, has stabilized banks, and improved aquatic and riparian habitat along the reach in the town. The structures have also helped attenuate flood waters by keeping the river flows mainly within the defined channel, at flow levels that have exceeded 2,000 cfs on the Lake Fork and over 1,000 cfs on Henson Creek. Stakeholders have not reported additional channel stability issues. Some identified concerns related to fish habitat on private lands near Lake City, mainly in terms of access, but also due to channelized sections that have not yet been addressed in the restoration effort.

Figure 7-4: Constriction of the Lake Fork due to development. The two images at bottom show scale of development in the Town of Lake City from 1950 and 2008



7.3.2 Aquatic Life

In 2018 two macroinvertebrate samples were collected from the Lake Fork River. The first was near the Slumgullion Slide and upstream of the Silver Thread Scenic Byway (Highway 149) and the second was in Lake City upstream of Spring Street and Henson Creek. The objective was to collect baseline data and evaluate the effect of the Slumgullion Slide (primarily composed of acidic and metals-laden materials). The multi-metric index (MMI) scores for both sites indicate the aquatic life use may be impaired within the reach. This finding is generally consistent with stakeholder observations regarding fishing quality within this reach.

This reach of the Lake Fork River supports rainbow and brown trout. The hydroelectric dam, located approximately 0.6 miles north of Lake City, likely prohibits fish movement. There may be additional natural features that prevent fish passage. Stakeholders reported that fish populations and size may decline above the hydroelectric dam (relative to the lower Lake Fork River).

7.3.3 Water Quality

In 2010, Deadman Gulch segment was added to the 303(d) List for impairment of aquatic life standards for cadmium, copper, iron, manganese, pH, and selenium, and for impairment of the iron standard for domestic water supply (Table 7-1). The data was collected by EPA and LFVC staff between 2004 and 2007. CDPHE listed historic mining as the primary cause of non-attainment. Historic mining occurred in Deadman Gulch and exploration activities continue at the Golden Wonder Mine. The active mining section of DRMS plans to sample the Golden Wonder Mine and Deadman Gulch in 2019.

Table 7-1: Impaired stream reaches in the Lake Fork River sub-basin between Lake San Cristobal and Lake City.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Deadman Gulch and its tributaries	Aquatic Life Use	NA	Dissolved Cadmium	High
			Dissolved Copper	High
			Total Iron	High
			Dissolved Manganese	Low
			pH	High
			Dissolved Selenium	High
			Dissolved Zinc	High
	Water Supply Use		Dissolved Iron	Low

Deadman Gulch is an intermittent drainage that flows in the spring during and following snowmelt. Deadman Gulch may also flow following large precipitation events in the summer and fall. Intermittent flows have prevented additional sample collection and total maximum daily load (TMDL) development.

Although metal concentrations in Deadman Gulch readily exceed aquatic life standards, Deadman Gulch does not appear to have a substantial effect on water quality in the Lake Fork River. USGS sampled the Lake Fork River approximately 1.5 miles downstream of Deadman Gulch every other month for six years from 2007 to 2013 (USGS-09123490, n= 42). Table 7-2 summarizes selected water quality analytes and applicable water quality standards for the Lake Fork River downstream of Deadman Gulch. Metal concentrations were less than the applicable standards in all samples.

Table 7-2: Summary of selected water quality analytes and aquatic life standards in the Lake Fork River downstream of Deadman Gulch (samples collected by USGS at 09123490 from 2007 to 2013, n=4)

Analyte	Min.	Avg.	85th Percentile	Max.	Chronic Standard	Attains Chronic Standard	Acute Standard	Attains Acute Standard
Hardness (mg/L)	37	69	NA	106	NA			
Dissolved Cadmium (µg/L)	<0.02	<0.02	0.021	0.03	0.5	Yes	1.3	Yes
Dissolved Copper (µg/L)	<0.5	<0.5	1.19	3.4	7	Yes	9.5	Yes
Dissolved Iron (µg/L)	<6	16	23	37	Water supply standard 300 µg/L-attained			
Dissolve Manganese (µg/L)	18	50	71	151	1,458	Yes	2,639	Yes
pH (s.u.)	6.6	NA	NA	8.4	Within acceptable range of 6.5 to 8.5			
Dissolved Zinc (µg/L)	<1	1.5	2.5	7	86	Yes	114	Yes

Deadman Gulch, however, does affect residents of the subdivision near its confluence with the Lake Fork. One homeowner has abandoned their pond due to high concentrations of metals in the water. Ground water wells in this area are also of poor quality, most likely due to the high mineralization in the area.

Water quality samples were recently taken from the Lake Fork at the Weems Malter Placer subdivision, upstream of Deadman Gulch. Results showed elevated sulfates and metals, most likely originating from the slide materials, but several upstream mine workings are present and draining. It is not clear what portion of these metals and salts are anthropogenic in nature.

7.3.4 Water Temperature

The Bureau of Land Management installed a continuous temperature sensor in the Lake Fork River downstream of Lake San Cristobal, as shown in Table 7-3. Stream temperatures attained the applicable standards to protect aquatic life.

Table 7-3: Summary of stream temperature data in the Lake Fork River downstream of Lake San Cristobal.

Location	Monitoring Start Date	Monitoring End Date	Number of Summers	Standard Attained
Lake Fork River downstream of Lake San Cristobal	10/25/2013	9/24/2015	2	Yes

7.3.5 Existing Instream Flows

There is one instream flow water right in this reach. An instream flow water right for the Lake Fork River from the confluence with Cottonwood Creek to the confluence with Henson Creek was appropriated in March of 1980, as shown in Table 7-4. This 16-mile reach of the Lake Fork River has a winter instream flow rate of 20 cfs and a summer rate of 35 cfs. The original R2CROSS surveys in the 1980s produced a winter rate of 35 cfs and a summer rate of 80 cfs. The preliminary values were reduced based on channel form and discussions with the local water commissioner.

Table 7-4: Summary of instream flow water rights in the Lake San Cristobal to Lake City reach.

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Lake Fork River	Confluence with Cottonwood Creek	Confluence with Henson Creek	3/17/1980	16.4	20	35

Augmentation water stored in Lake San Cristobal to address out of priority depletions for the Lake Fork River was appropriated in 2003 and 2008 by the Lake San Cristobal Water Activity Enterprise (LSCWAE), which is administered by the UGRWCD. This project involved the installation of Obermeyer weir gates that control the top three feet of water level in the lake. Releases of the augmentation water from Lake San Cristobal increase flows in the Lake Fork River downstream of Lake San Cristobal, during times of water administration, for both instream flow rights as well as consumptive uses.

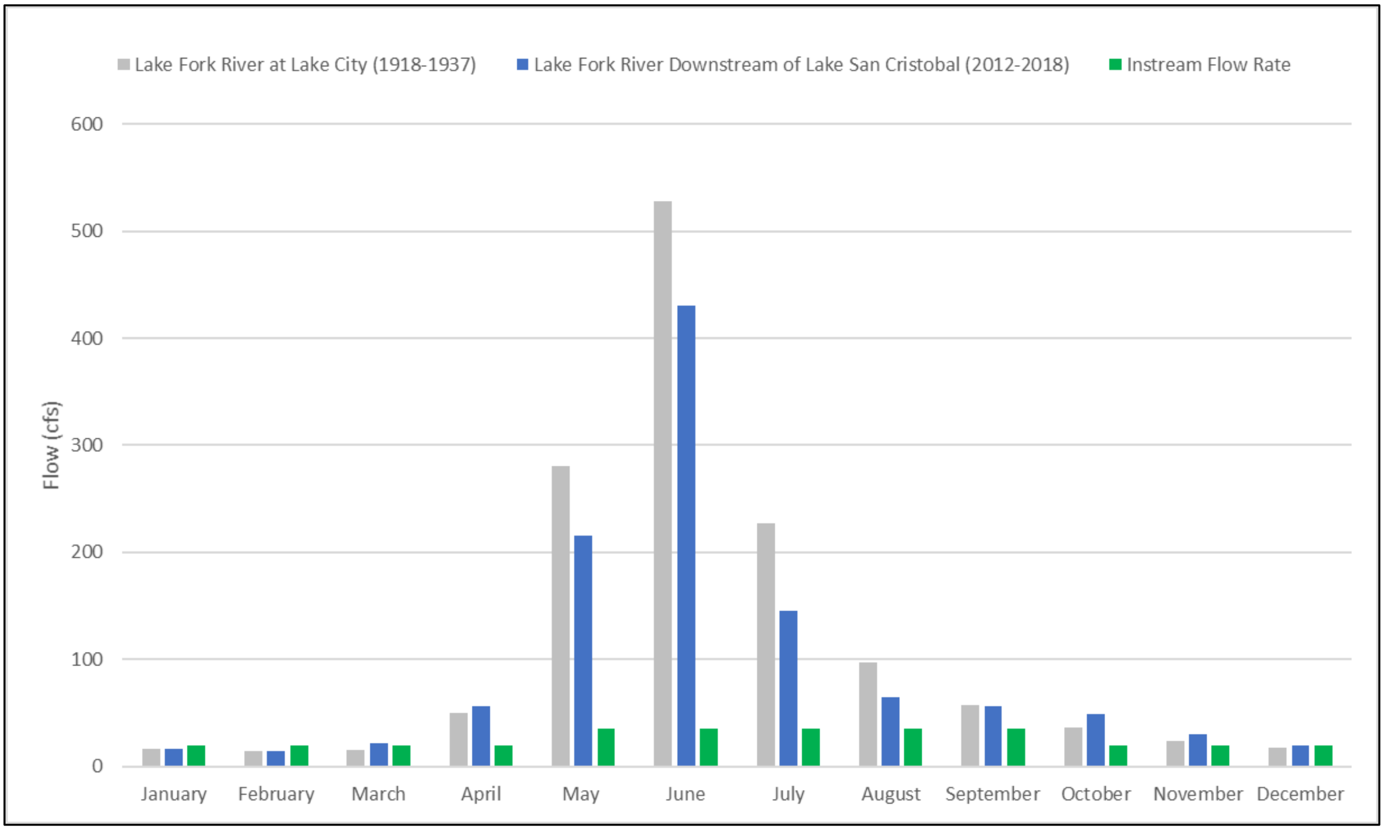
7.3.6 Flow Limited Areas

Diversions from Park Creek may limit flow in Park Creek and decrease habitat connectivity with the Lake Fork River. However, natural habitat barriers may also be present in Park Creek near the Lake Fork River (i.e. very steep channel as stream descends to valley bottom).

7.3.7 Environmental Flow Goals

Average monthly flows measured in this portion of the Lake Fork River suggest that it may be possible to expand the existing instream flow rate from April to August, as shown in Figure 7-5. 2018 R2CROSS results produced a summer instream flow recommendation of 66 cfs, based on the average of two cross-sections completed in the reach. The existing winter instream flow rates seem appropriate based on average monthly flows and 2018 R2CROSS results.

Figure 7-5: Average monthly flows in the Lake Fork River at Lake City (USGS 09123500) from 1918 to 1937, Lake Fork River downstream of Lake San Cristobal (USGS 09123450) from 2012 to 2018, and existing instream flow rates for the Lake Fork River from the confluence with Cottonwood Creek to Henson Creek.



Future planning efforts should include a more detailed analysis of macroinvertebrate, fish, and creel survey data to determine the condition, distribution, and needs of the aquatic community within this reach. A better understanding of the aquatic community is needed to develop moderate or ideal environmental flow goals.

Park Creek, the largest tributary to the Lake Fork between Lake San Cristobal and Lake City, lacks an instream flow water right. The Park Creek watershed supports multiple lakes, wetlands, and wildlife habitat. In recent years, Vickers Ranch has expanded operations to include land development, hospitality and tourism business in addition to traditional agriculture operations. As such, there may be an interest in protecting wildlife and riparian health in addition to maintaining healthy pastures. Interest has already been expressed in protecting the wetland and riparian zones along the Lake Fork in the lower ranch area.

Wades Gulch, which drains the north side of Red Mountain and flows through the south edge of Lake City before its confluence with the Lake Fork River, supports a healthy riparian area. This tributary may be a candidate for an instream flow water right. StreamStats reports that average flows from the 2.5 square mile watershed range from a low of 0.3 cfs in February to a high of 13 cfs in June.

7.4 Recreational Water Use

Much of the Lake Fork from Lake San Cristobal to Lake City is private, and not readily accessible to the public. There are some private parcels that do have fishing access easements. Angling is the main recreational use along this reach. Floating only occurs through the Town. The major put-in for Lake Fork is at Memorial Park for access to the lower Lake Fork.

Above town, floating is uncommon due to Crooke Falls hydroelectric dam, as well as Argenta Falls below Lake San Cristobal.

7.4.1 Fish Pond Diversions

Figure 7-7shows the location of the two identified river diversions that fill fish ponds within the reach. The only depletions associated with pond diversions are replacement of pond evaporation; the diversions are generally flow-through and can result in significant de-watering of the river between the diversion and the river return location. According to the water commissioner, Moseley Ditch diverts from the Lake Fork to fill an off-channel pond, but diversion records are not maintained. In addition, there are several ponds that can fill from Park Creek during the runoff. No measurement information is maintained for these ponds. Figure 7-6 shows the total recorded through the Vickers Bros No 1 Ditch for fish ponds within the reach. Diversion for fish ponds typically begin in late April or early May and end in October. As noted previously, the water commissioner position was vacant in 2016 and no diversions were recorded.

Most of the ponds are unlined and do not have storage decrees. Depletions associated with the junior diversions to replace pond evaporation are generally replaced under small augmentation plans. Average annual measured diversions from the 1998 through 2017 period were 780 acre-feet, compared to average annual diversions for irrigation for the same period of 330 acre-feet.

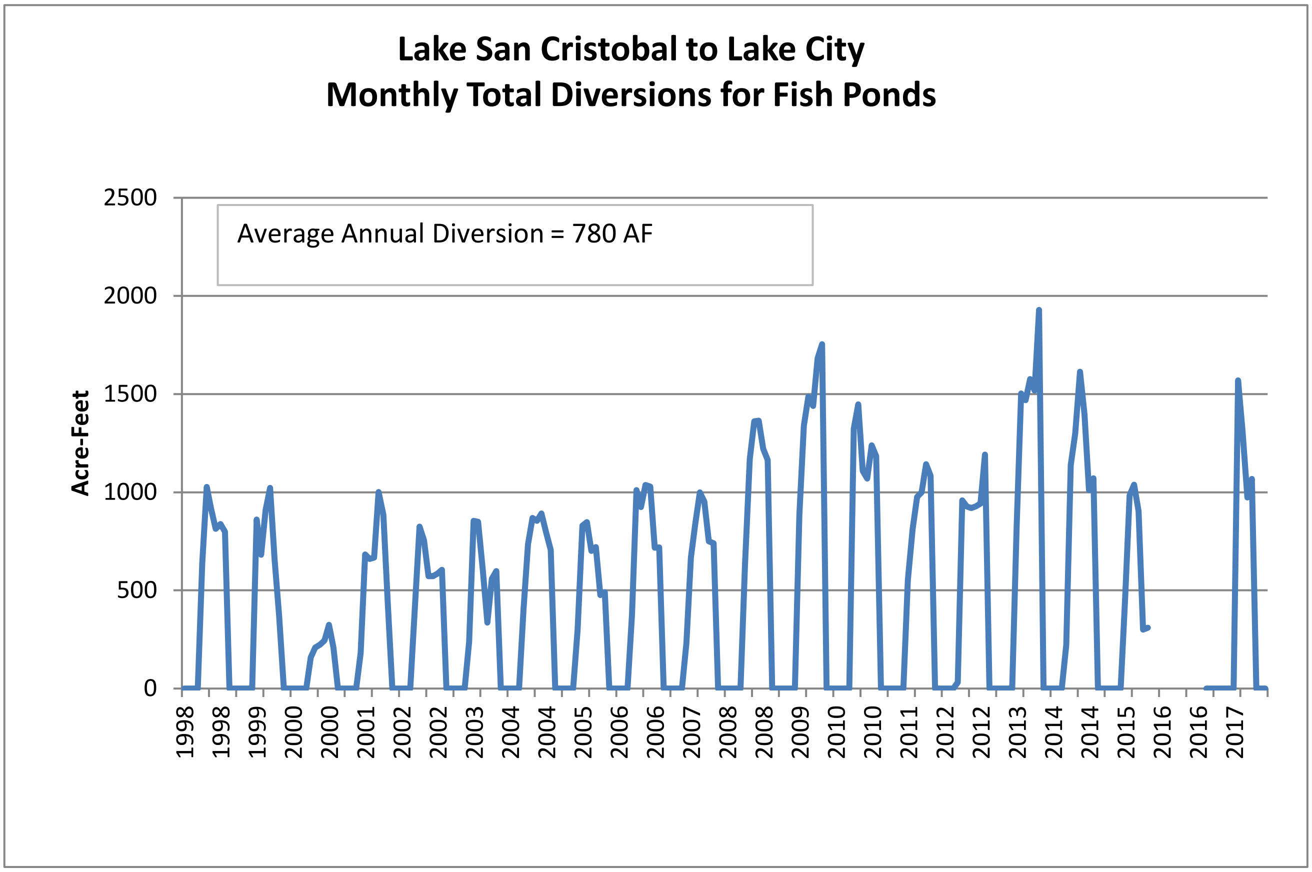


Figure 7-6: Lake Fork from Lake San Cristobal to Lake City Measured Diversions for Fish Ponds

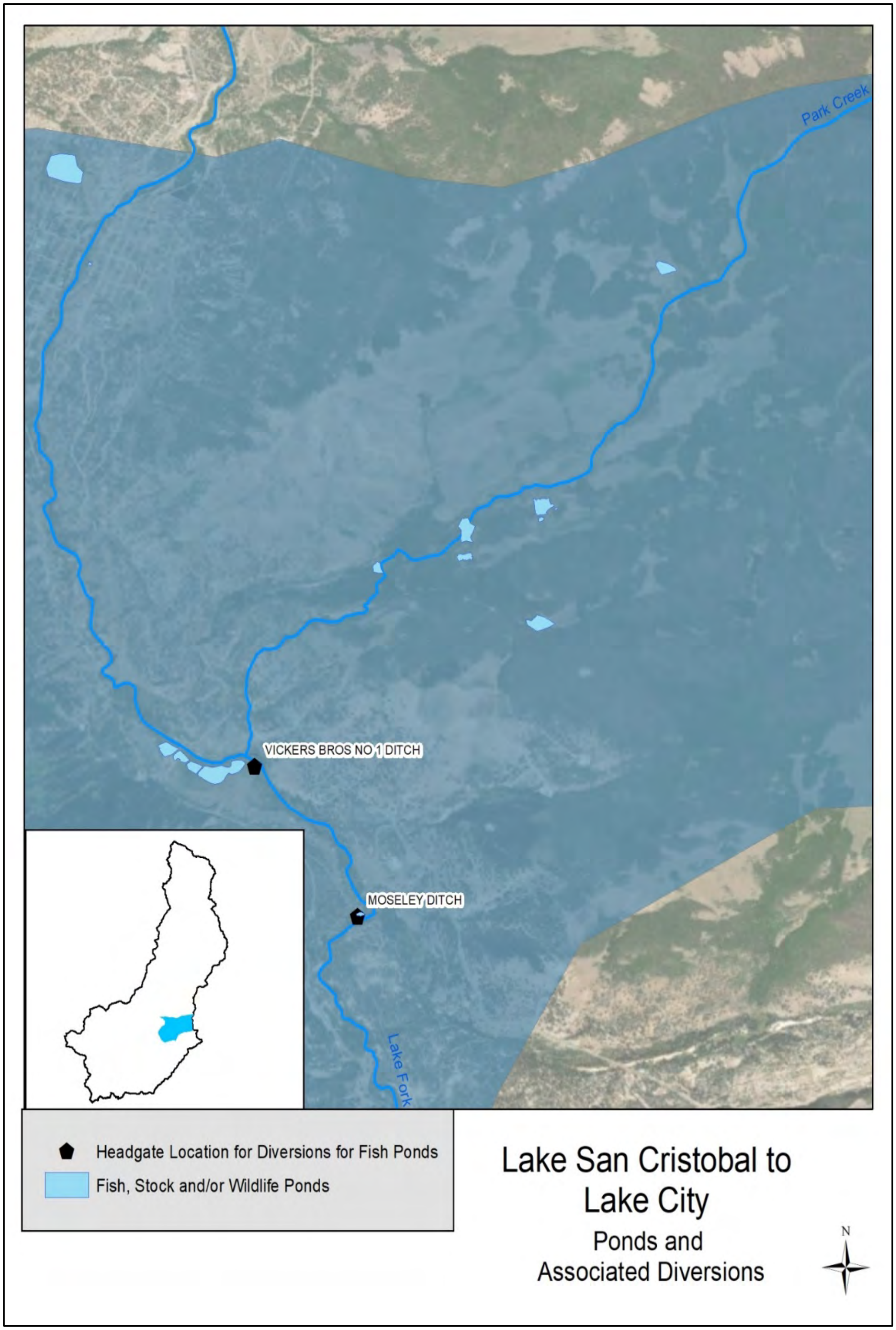


Figure 7-7: Lake Fork from Lake San Cristobal to Lake City, Fish Pond Diversions

7.5 Needs for this Reach: Issues Identified

Issue: Gladiator Mine complex and its impacts on the Lake Fork.

Issue: TMDL development for Deadman Gulch: Deadman Gulch, an intermittent tributary the Lake Fork River near the base of Slumgullion Pass and the Packer Memorial site, is on the 303(d) List for impairment of the aquatic life standards for multiple metals. The Golden Wonder Mine is located within the Gulch and a TMDL will ensure that future mining operations do not exceed recommended standards.

Issue: Development activities at the Golden Wonder Mine in Deadman Gulch

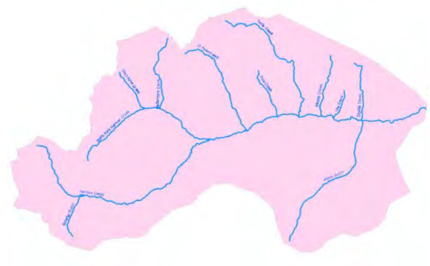
Issue: Potential instream flow water right for Park Creek. The Park Creek watershed supports multiple lakes, wetlands, and habitat. It would benefit from an instream flow right.

Issue: Potential enlargement of summer instream flow rate and segmentation for Lake Fork River. A review of stream flow data suggests that the Lake Fork River may require a higher summer instream flow to better preserve the natural environment.

Issue: Land Conservation: Several properties along this reach have potential for conservation, including the toe of the Slumgullion Earthflow, lower Vickers Ranch, Pete's Lake wetland, and riparian habitat in Lake City. The Lake Fork Valley Conservancy is currently working on a conservation easement for their 58 acres on Slumgullion Earthflow.

Issue: Pete's Lake. Pete's Lake is a 5 acres wetland located at the north end of town and is owned by the Town of Lake City. Wetland quality was compromised in 2002 due to the lake being drained to meet instream needs on the Lake Fork. This affected habitat, especially for bird breeding and increase in weeds at the wetland periphery. The LFVC has proposed a water storage and habitat improvement project that will raise the water level up to 1.5 feet and isolate mid lake islands to promote bird breeding habitat. In addition, the Town of Lake City will once again apply for a water storage right for environmental and recreational purposes, which can be released for downstream calls on the Lake Fork.

Section 8. Section 8. Reach 4 - Henson Creek



The headwaters of Henson Creek form at the northwestern borders of the Uncompaghre and Lake City Calderas and contain highly mineralized zones. Henson Creek flows southeast toward Engineer Pass Road (County Road 20) and the confluence with Palmetto Gulch. Henson Creek flows east to Whitmore Falls, a large and scenic waterfall. Down-valley the drainage widens and allows for a riparian area upstream of the confluence with the North Fork of Henson Creek, at Capital City. The North Fork of Henson Creek drains the northern aspects of Dolly Varden and Sunshine mountains. Below the confluence with the North Fork, Henson Creek descends through a steep and narrow canyon, where the creek is further confined by Engineer Pass Road. Tributaries to Henson Creek within this reach are steep and dynamic channels that deliver ample sediment, debris, and water. Large avalanche paths are common throughout the Henson Creek Basin.

The majority of the Henson Creek Basin is managed by the BLM as either wilderness or wilderness study areas. Private lands tend to occur near Henson Creek and Engineer Pass Road. The USFS Uncompaghre Wilderness occurs along the northern edge of thebasin.

The Henson Creek Basin was mined extensively from the summit of Engineer Pass to Lake City and many prominent sites in between. For over a decade, the Lake Fork Valley Conservancy, BLM, and DRMS have partnered to reclaim nine mines in the Henson Creek Basin. DRMS has also completed many safety closures to prevent the public from accessing the workings of historic mines.

Engineer Pass Road links Lake City to Ouray and Silverton. This connection provides substantial recreational and economic opportunities for the community. Throughout the summer Engineer and Cinnamon Pass roads provide access to stunning alpine terrain, historic mine sites, hiking, camping, biking, climbing, and other outdoor pursuits. Limited fishing and kayaking occur in Henson Creek and the North Fork of Henson Creek.

8.1 Agricultural Water Use

There are no diversions for agricultural use in this headwater reach and no identified needs in the future.

8.2 Domestic Water Use

The Lake City Town Ditch diverts water from Henson Creek for irrigation and fire protection, at 5 cfs from May 1 to October 1.

There are several springs and wells with water rights near historic mine sites, and on private lands throughout the reach. Most of the residences in the Henson Creek Basin are near Engineer

Pass Road and Henson Creek. Wells provide water for household use and individual onsite wastewater treatment systems are used to manage wastewater.

8.3 Environmental Water Use

8.3.1 Stream and Riparian Characteristics

Steep glaciated valleys and canyons form the headwaters of Henson Creek. Slopes are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. The streams, which are both intermittent and perennial, are steep entrenched channels that are often scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths parallel these drainages.

Photo 8-1. View from the summit of Engineer Pass. The drainage in the foreground is Palmetto Gulch near the Hough Mine reclamation site. The background slopes are characteristic of steep tributaries to Henson Creek.

Due to the geology and steep slopes, hillslopes in the headwaters are naturally susceptible to mass erosion which includes landslides, earth flows, debris avalanches, debris flows, torrents, and snow avalanches. Natural mass erosion events are probable throughout the headwaters area. These sporadic events provide massive natural sediment sources, as shown in Photo 8-1. Evidence of recent mass erosion is very common throughout the headwaters area. These natural hillslope processes are an enormous source of sediment to the Lake Fork River. Natural mass erosion dominates sediment supply in the headwaters.

Henson Creek and its tributaries are extremely efficient at moving sediment. In contrast, the valley widens and flattens somewhat near Capital City. These changes decrease the channel's capacity to carry sediment and often results in large sediment deposits and frequent adjustments to channel form and location. Over time, the lower angle valley channel will winnow away accumulated sediment. The stream system may establish a tenuous and temporary equilibrium, but natural sediment delivery and erosion processes are very dynamic due to the topography, geology, and climate. Human efforts to confine or stabilize the stream channel may be effective for brief periods, but long-term stability should not be expected in this environment.

Willows and riparian vegetation have colonized portions of narrow stream corridors in larger tributaries to Henson Creek where sediment deposition has supported soil development. In the reach near Capital City, large wetland complexes support a variety of aquatic and wildlife habitats. These wetland complexes also attenuate flood flows and store water to support late season flows.

Downstream of Capital City and the confluence with the North Fork of Henson Creek, Henson Creek flows through a steep canyon en route to Lake City. Tributaries and hillslopes within this portion deliver large volumes of sediment as Henson Creek cuts through several narrow canyon reaches. The Ute-Ulay mine site and its two dams are in the lower stretch of Henson Creek. At several points County Road 20 further confines Henson Creek. There are a handful of small and undersized bridges that span Henson Creek near Lake City.

8.3.2 Aquatic Life

From 2015 to 2018, five macroinvertebrate samples were collected from locations in the Henson Creek Basin. MMI scores at four locations, including the headwaters of Henson Creek, Henson Creek downstream of Palmetto Gulch, the North Fork of Henson Creek, and Henson Creek near Lake City, attained the aquatic life use criterion. A very limited number of macroinvertebrates occur in Palmetto Gulch due to metals loading from historic mine sites. Based on the samples collected to date, Palmetto Gulch is likely impaired for aquatic life use, but has not been nominated or listed as such.

Photo 8-2: Field staff prepare transects for macroinvertebrate sample collection in the North Fork of Henson Creek in August 2015.

Henson Creek supports a small fish population that includes brook, brown, and rainbow trout. Whitmore Falls, upstream of Capital City, is a substantial habitat barrier. In the past, CPW stocked Colorado Cutthroat upstream of Whitmore Falls; the waterfall prevents competition with other species of trout downstream, but these were out-competed by brook trout upstream. Other local experts recommend caution if additional stocking is considered in this reach, as upper Henson Creek may be a naturally fishless stream, which is rarer and allows for unique and robust macroinvertebrate communities (Alexander, 2018). Smaller features, including waterfalls and bedrock glides, may create habitat barriers in other portions of Henson Creek.

8.3.3 Water Quality

Historic abandoned mines in Palmetto Gulch, a tributary to Henson Creek, are the primary source of metals in the Henson Creek Basin. Prospecting in the Lake City area started in 1870, with several mines active in Palmetto Gulch within a few years. Mining continued for several decades.

In 2002 Palmetto Gulch was added to the 303(d) List for impairment of the aquatic life standards for dissolved cadmium and zinc. This initial impairment listing added momentum to a collaborative effort to further characterize mine features, water quality conditions, and develop and implement reclamation projects in the Henson Creek Basin. Table 8-1 and Figure 8-1summarize the water quality impairments and potential impairments in the Henson Creek Basin.

Table 8-1: Impaired and potentially impaired stream reaches in the Henson Creek Basin.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of Palmetto Gulch including all tributaries	Aquatic Life Use	Dissolved Silver	NA	NA
		pH	NA	NA
		NA	Dissolved Copper	NA
		NA	Total Iron	M
		Dissolved Cadmium – TMDL approved in June 2010		
		Dissolved Zinc – TMDL approved in June 2010		
	Water Supply Use	NA	Dissolved Manganese	Low
Mainstem of Henson Creek from the headwaters to the confluence with the Lake Fork River	Aquatic Life Use	Dissolved Cadmium – TMDL approved in July 2010		
		Dissolved Zinc – TMDL approved in July 2010		
	Water Supply Use	Total Arsenic	NA	NA
All tributaries and wetlands of Henson Creek, except for the North Fork of Henson Creek	Water Supply Use	Total Arsenic	NA	NA
North Fork of Henson Creek Including all tributaries and wetlands except for Henson Creek	Water Supply Use	Dissolved Manganese	NA	Low
Tributaries to the Lake Fork River, including wetlands, within the Powderhorn and Uncompahgre Wilderness Areas[1]	Water Supply Use	NA	Total Arsenic	High
		Dissolved Iron	NA	NA

[1] The tributaries within wilderness areas in Henson Creek have not been sampled. Arsenic and iron concentrations measured in streams in the Raggeds Wilderness provided the information necessary to list the wilderness tributaries. Given the data set in the Henson Creek Basin, the total arsenic listing is likely appropriate, but the M&E listing for dissolved iron may not be appropriate.

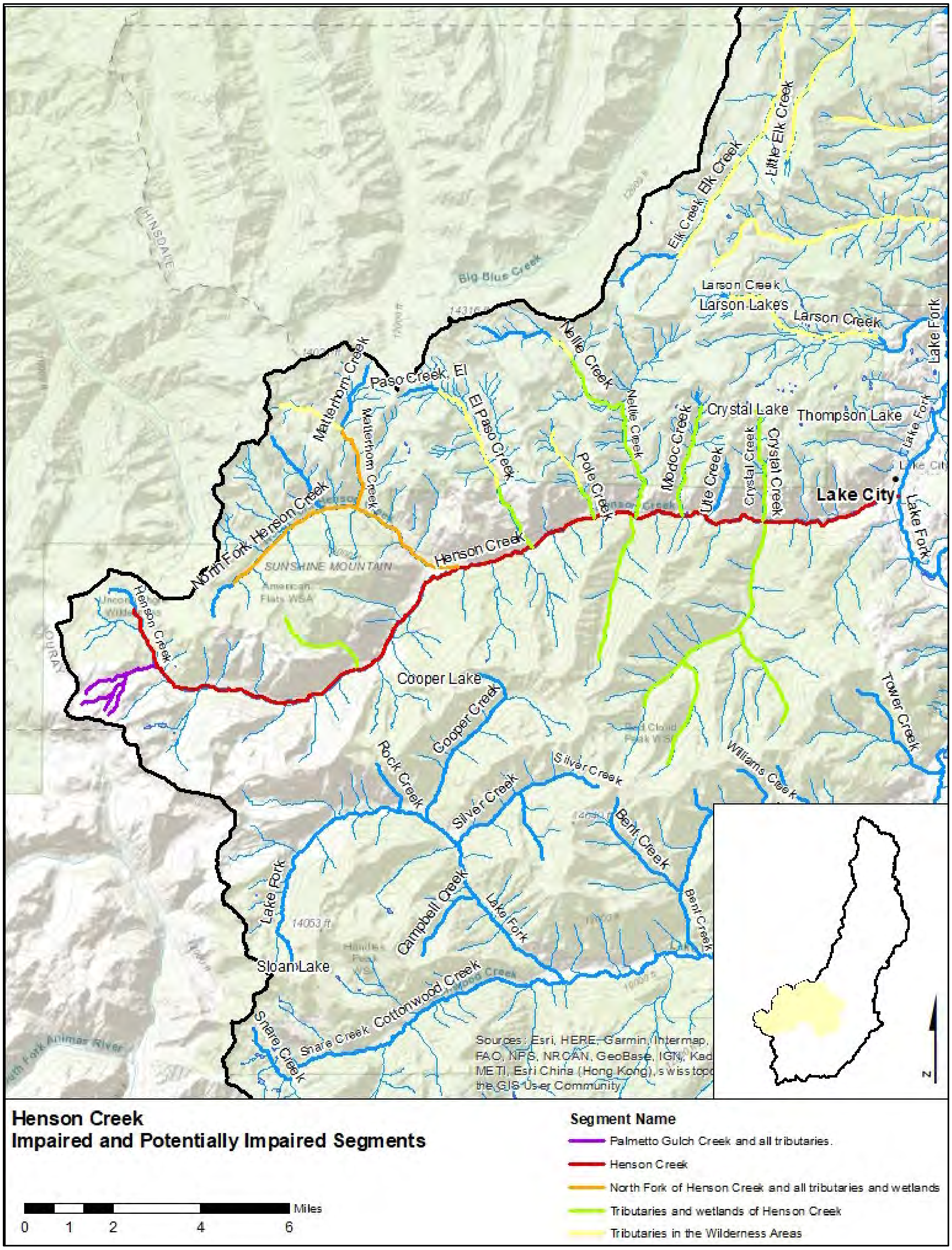


Figure 8-1: Impaired and potentially impaired stream reaches in the Henson Creek Basin

Palmetto Gulch drains just over one square-mile of alpine tundra below the summit of Engineer Pass. Three small unnamed tributaries, locally referred to as North, Middle, and South Palmetto Gulch flow into Palmetto Gulch. Field surveys completed by DRMS staff identified 12 mine waste piles and four adits, which equates to one abandoned mine feature per 40 acres (Owen, 2009).

Photo 8-3: Drainage from the Hough Mine en route to North Palmetto Gulch in September 2016, one year following reclamation. The right side of the photo includes edge of the mine waste repository.

The Hough Mine, located just below the summit of Engineer Pass at nearly 13,000 feet, was the largest mine in Palmetto Gulch. Prior to reclamation the site had an open draining adit, a partially collapsed shaft, and two large waste dumps with a footprint of approximately seven acres. Major reclamation activities included consolidating contaminated mine wastes into a repository, lining and capping the repository to prevent surface water infiltration, constructing three run-on channels to divert water around the repository, and revegetation of disturbed areas. A grate is installed over the adit and drainage flows into a constructed channel. Reclamation at the Hough Mine took two field seasons and was completed in late fall of 2014. Revegetation was completed in early summer 2015.

The Roy Pray Mine is in Middle Palmetto Gulch. In 2003, the bulkhead at the Roy Pray Mine was sealed to prevent acid mine drainage. In 2005 a permanent diversion and collection structure was installed to further control water movement on site. The waste pile associated with the adit was moved in 2005 to prevent leaching from the mine waste (Krabacher *et al.*, 2006). Data collected in recent years suggests that maintenance work is required to assure the bulkhead continues to function as designed. In 2018, DRMS staff drilled into the Roy Pray mine workings to collect data that will be used to improve the bulkhead's performance. The Sara Woods Mine is also in Middle Palmetto Gulch.

The Wyoming Mine is in South Palmetto Gulch. During reclamation, run-on water was routed around waste rock to prevent contamination and amendments were added to the waste rock to neutralize acidity and reduce metals mobilization.

Metal concentrations measured in 2016, one after year reclamation at the Hough Mine, are promising. Initial results indicate that metal concentrations in North Palmetto Gulch have declined relative to historic and pre-reclamation concentrations and that metal concentrations decline as the distance from the mine increases. In Palmetto Gulch, initial results suggest that the concentrations of some metals have declined following reclamation. Reclamation may have decreased the concentration of selected metals throughout Henson Creek.

Additional sample collection occurred in 2016 and 2017, preliminary evaluations of the data suggest that metal concentrations continued to decline in North Palmetto Gulch, Palmetto Gulch downstream of North, Middle and South Palmetto Gulch, and in Henson Creek. Further, revised cadmium standards were adopted in late 2017. Additional data collection and or analysis is recommended to evaluate the current attainment status of aquatic life standards in Henson Creek downstream of Palmetto Gulch, downstream of the North Fork of Henson Creek, and Henson Creek near Lake City.

The Yellowstone Mine is tributary to the North Fork of Henson Creek. Reclamation activities at the site have isolated mine water from surface water and revegetated disturbed areas.

8.3.4 Water Temperature

BLM staff installed two continuous temperature sensors in the Henson Creek Basin in recent years. One sensor was installed in the North Fork of Henson Creek at the County Road 20 bridge, upstream of the confluence with Henson Creek. The other sensor was installed in Henson Creek near Alpine Gulch, shown in Photo 8-4. Water temperatures at both locations attained the aquatic life standards during all three summers that the sensors were deployed, shown in Table 8-2.

Photo 8-4: BLM employees remove the temperature sensor from Henson Creek near Alpine Gulch in October 2017.

Table 8-2: Summary of stream temperature data in the Henson Creek Basin.

Location	Monitoring Start Date	Monitoring End Date	Number of Summers	Standard Attained
North Fork of Henson Creek	9/11/2014	10/25/2017	3	Yes
Henson Creek at Alpine Gulch	11/1/2013	10/25/2017	3	Yes

8.3.5 Existing Instream Flows

Figure 8-2 shows there are nine instream flow reaches in the Henson Creek Basin. Eight of the reaches were established in 1984. In 2009 BLM staff secured summer rate increases for the middle Henson Creek and Shafer Gulch reaches. The Alpine Gulch instream flow water right was established by the BLM in 2010. Five of the existing instream flow water rights have year-round rates and four reaches have winter and summer rates.

Securing instream flow water rights in the Henson Creek Basin, particularly in tributaries without historic mine features or limited water quality impacts, could be pivotal to the effort to restore Henson Creek. Tributaries, such as Schafer Gulch, El Paso Creek, and Alpine Gulch generally have better water quality than Henson Creek, which provides both dilution and high-quality habitat. Tributaries may support repatriation of additional aquatic life in Henson Creek. Further, there are multiple private land in-holdings in the Henson Creek Basin that could be developed in the future. Wildlife habitat, grazing, and recreational use in the Henson Creek Basin benefit from instream flows.

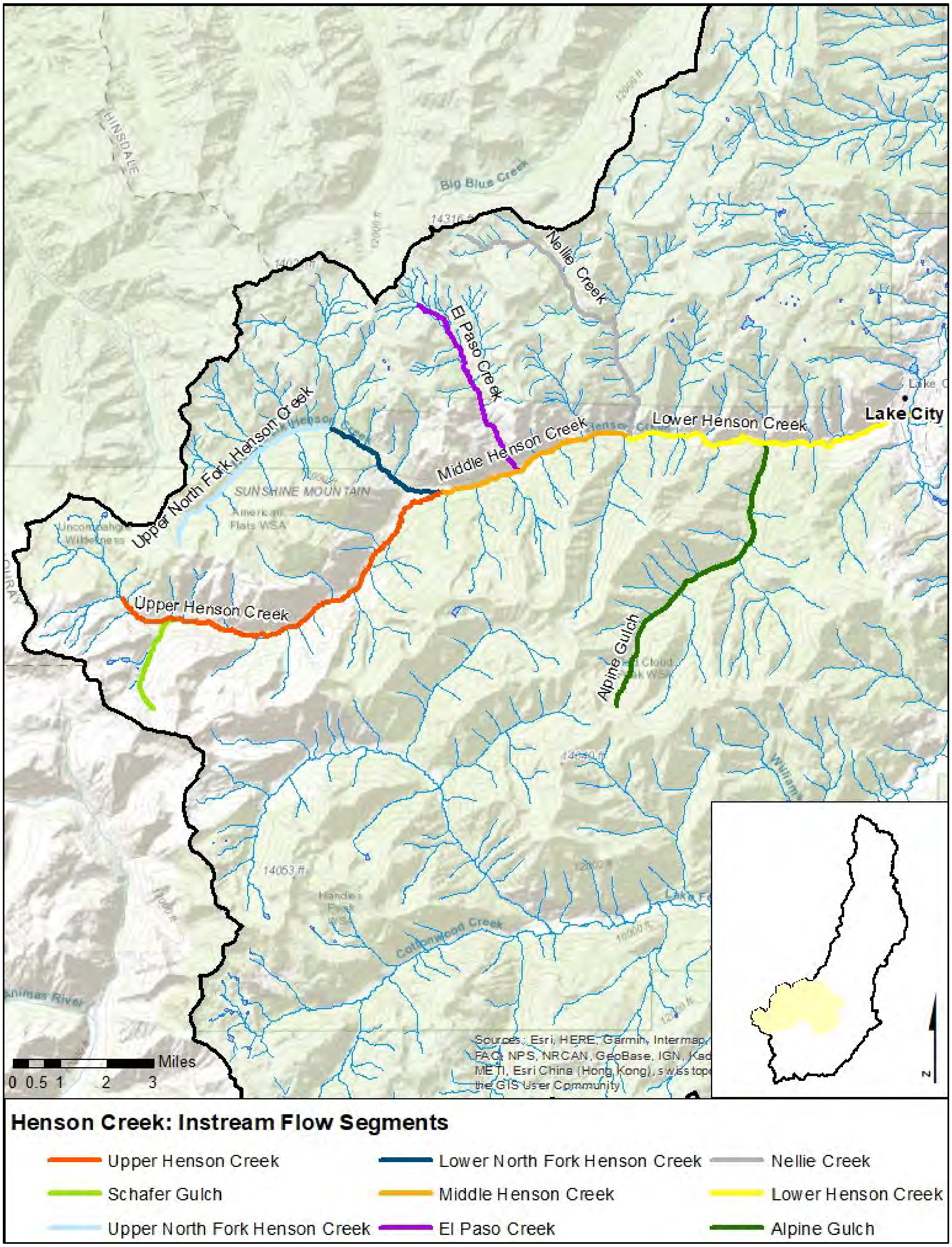


Figure 8-2: Instream flow water rights in the Henson Creek Basin

8.3.6 Flow-limited Areas

Snowfall and precipitation support groundwater and surface water flows in Henson Creek. The only diversion in the reach is in Lake City immediately upstream of the confluence with the Lake Fork River. Flow-limited areas were not identified in this reach due to very limited water use.

8.3.7 Environmental Flow Goals

Henson Creek flows freely to the Lake Fork, except for one small diversion near Lake City. The historic gage on Henson Creek was reestablished in early May of 2019 to support flood management and mitigation. Another gage was established at Alpine Gulch at the same time to provide early flood warning.

8.4 Recreational Water Use

Angling occurs along Henson Creek below Capital City. Whitewater boating occurs in Henson Creek Canyon from below the Ute-Ulay Dam to where the canyon flattens. The reach is very technical, class V, and requires extensive scouting to assure each portion of the reach is passable. It is generally understood that kayaking in the reach is limited to peak or near peak flows in above average years.

The lower portion of Henson Creek, from Gene Brown's Bridge to Lake City is an adventurous float during high flow. This short reach is best enjoyed in kayaks or on standup paddle boards. Most of the land within this reach is public. Recreational use surveys are being gathered to better characterize use patterns and potential recreational improvements needed on this reach, as part of a future Lake Fork River Recreation Corridor Plan.

8.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Historic abandoned mines impair water quality.

Issue: Assess conditions at historic mine sites in the Henson Creek Basin following 2019 avalanche season: Historic sized avalanches decimated slide paths and adjacent forested hillsides in the Henson Creek Basin during March of 2019. Avalanche debris may have disturbed reclamation sites, safety closures, and historic mine features.

Issue: Roy Pray Mine maintenance activities.

Issue: Review of water quality data from Palmetto Gulch and Henson Creek.

Issue: Potential to establish additional instream flow reaches in the Henson Creek Basin.

Issue: Extent of recreational use (kayaking) and angling in the Henson Creek Basin.

Issue: Water quality for household wells.

Section 9. Section 9. Reach 5 - Lower Lake Fork: Lake City to Blue Mesa

This reach stretches from the Town of Lake City to the where the Lake Fork flows into Blue Mesa Reservoir in Curecanti National Recreation Area. The river flows 32 miles to its confluence with the Gunnison River and drains an area of approximately 135 square miles. The Lake Fork River becomes a fourth order stream at Lake City, where Henson Creek flows into the Lake Fork. Stream flows in the are seasonally high in May and June due to snowmelt runoff. Flows on the Lake Fork near its terminus range from less than 50 CFS in the winter months to a historic recorded high of 2,900 CFS in May 1984. he river has carved a spectacular canyon on its journey to the Gunnison River, and is a prime destination for recreational activities such as boating and fishing. Much of this stretch is considered Gold Medal waters, although not formally designated as such.

The riparian corridor of the Lower Lake Fork has been identified as a riparian community of high global biodiversity significance by the Colorado Natural Hertitage Program (narrowleaf cottonwood - blue spruce / thinleaf alder riparian woodland (*Populus angustifolia* - *Picea pungens* / *Alnus incana* woodland. Adjacent upland vegetation is comprised of both sagebrush parks and montane forests. The sagebrush park zone is part of the large semiarid inter-montane Gunnison Basin, dominated by sagebrush shrub land and steppe vegetation. The montane zone is located at elevations of 7000 to 9000 feet, above the sagebrush park zone, although they are commonly intermixed, and both zones include aspen patches. Dominant forest species are Ponderosa pine, Douglas fir and quaking aspen. In much of the lower watershed, soil properties and topographic aspect favor one zone over the other. Highest elevation areas of this reach are dominated by Engelmann spruce, with sub-alpine fir in wetter areas and quaking aspen in lower reaches.

9.1 Agricultural Water Use

There are 28 active irrigation diversions in the Lower Lake Fork reach, serving approximately 719 acres of flood irrigated pasture grass. Table 9-1 shows the combined water rights, average annual and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the 28 ditches from 1998 to 2017. There was an open water commissioner position in the Lake Fork in 2016 and no diversions were recorded; therefore 2016 was not included in the table statistics. The information provided represents the sum of the information for each diversion.

Table 9-1: Agricultural Water Use Statistics – Lake Fork from Lake City to Blue Mesa.

Reach Statistics	1998 to 2017 Average excluding 2016	1998-2017 Range excluding 2016
Number of Irrigation Structures	28	N/A
Irrigated Acreage	719	N/A
Water Rights	103.575 cfs	N/A
Diversions	9,040 acre-feet	5,640 – 12,540 acre-feet
Crop Demand	1,510 acre-feet	1,290 – 1,50 acre-feet
Crop CU	1,330 acre-feet	1,200 – 1,480 acre-feet
Shortage/Need	180 acre-feet	90 - 170 acre-feet
Percent Shortage	12%	3% - 27%

Figure 9-1 and Figure 9-2 show the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, the B and B Ditch and Baker No 2 Ditch commingle to serve common acreage; F S William No 1 Ditch and Lake Fork Irrigating Ditch commingle to serve common acreage, and Lake Fork No 1 Ditch and Spring Branch Ditch commingle to serve common acreage.

There are two irrigation diversions on Indian Creek near the confluence with the Lake Fork (Indian Creek Irrigating Ditch and Indian Creek North Ditch that commingle with Addington No 1 Ditch and Moore Ditch to irrigate common acreage near the confluence of Indian Creek and the Lake Fork. Because they irrigate common acreage with Lake Fork ditches, their use is included with this reach instead of with the Lower Lake Fork Tributary section.

About 240 acres of the 710 total acres (about 1/3) is irrigated from diversions on smaller tributaries near the confluence with the Lake Fork. The crop demand associated with these ditches account for the majority of the shortages in the reach in wet and average years; ditches that irrigate from the mainstem generally receive a full supply except in dry hydrologic years.

All of the ditches are unlined and are estimated to lose approximately 10 percent of diverted water during delivery to the irrigated fields, depending on ditch length. Return flows from this reach, estimated to be an average of 7,710 acre-feet per year from 1998 to 2017, accrue to the Lake Fork just downstream the irrigated lands.

Figure 9-1: South half of lower Lake Fork from Lake City to Blue Mesa Reservoir (Map 1 of 2), Irrigation Structures and Acreage

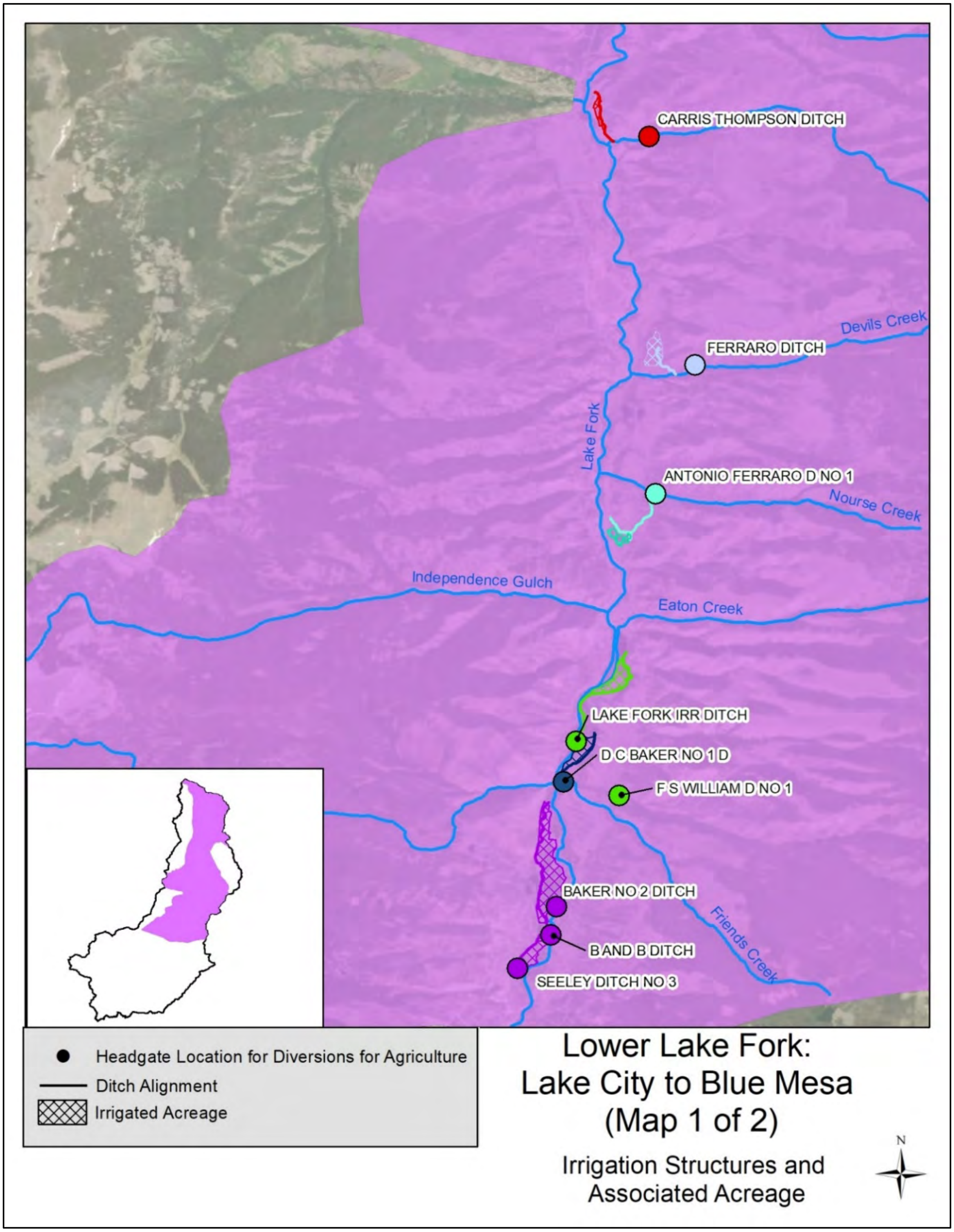


Figure 9-2: North half of lower Lake Fork from Lake City to Blue Mesa Reservoir (Map 2 of 2), Irrigation Structures and Acreage

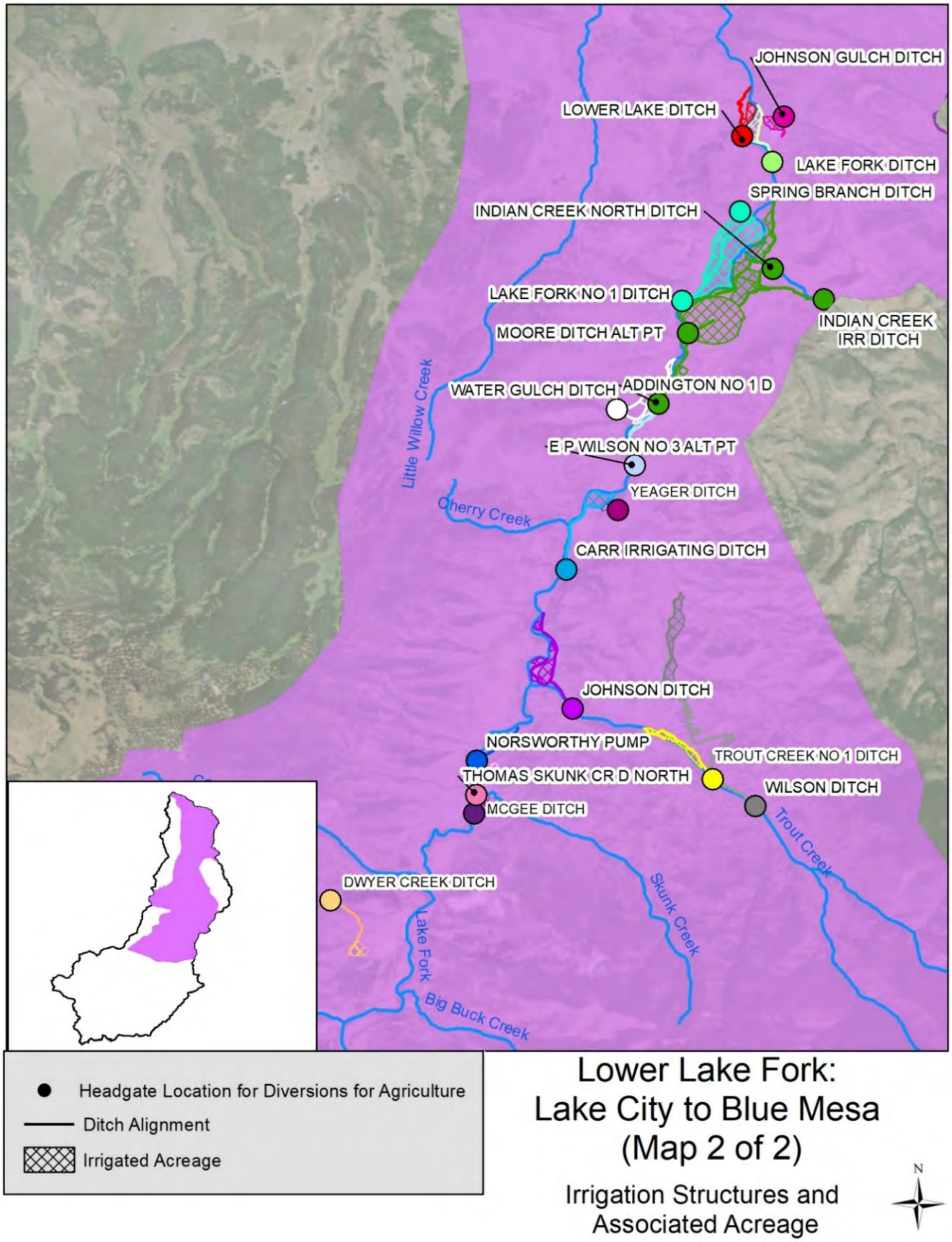
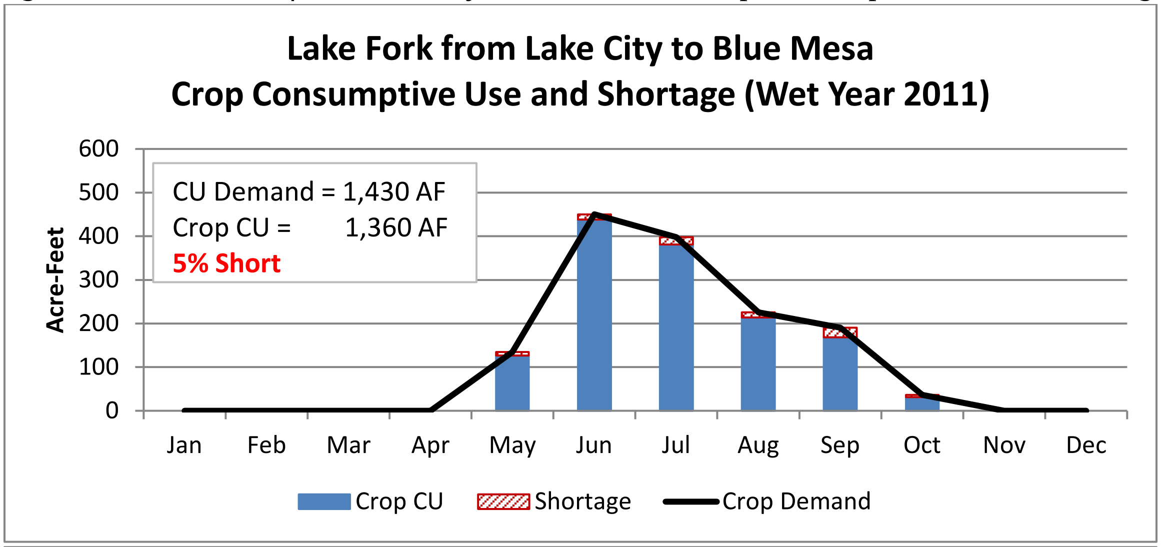
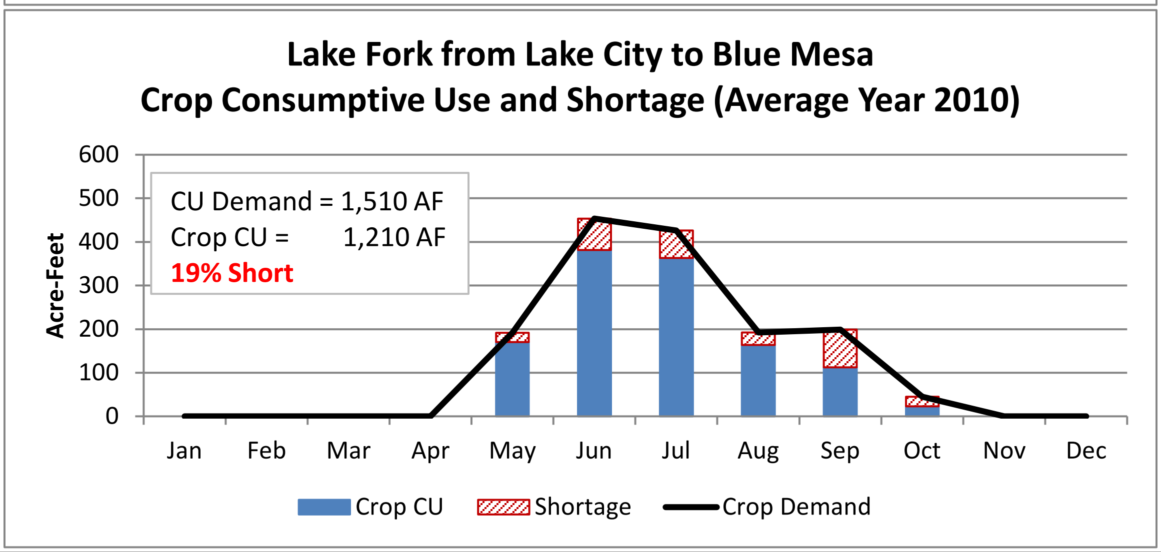
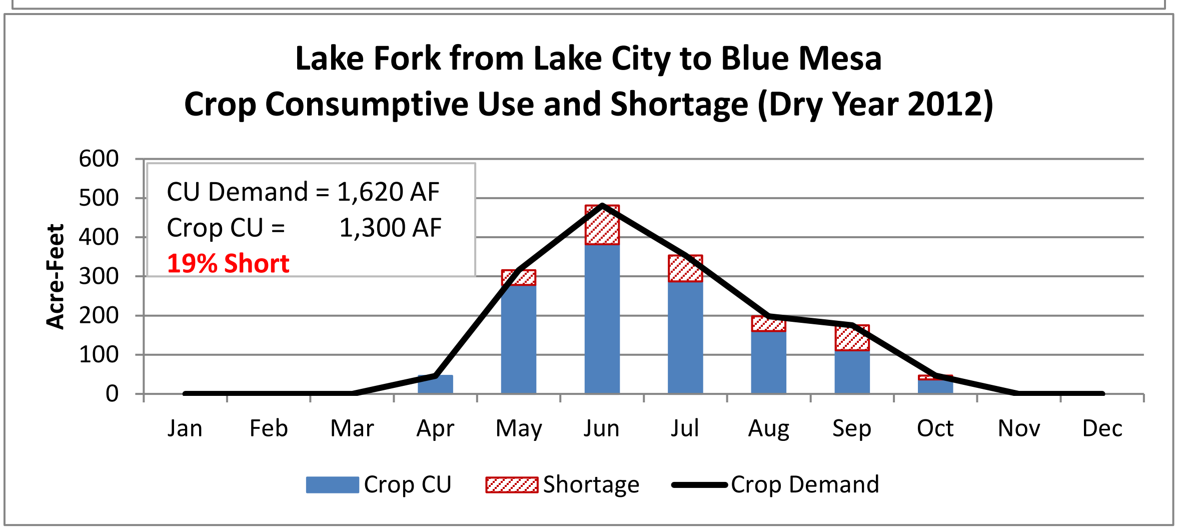


Figure 9-3 shows the monthly crop demands, crop consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were minimal shortages during the representative wet year, and the shortages were associated with acreage irrigated from the smaller tributaries. Each of the ditches supplying water from the smaller tributaries experiences shortages during the representative average and dry years.

Figure 9-3: Lake Fork from Lake City to Blue Mesa – Crop Consumptive Use and Shortage







9.2 Domestic Water Use

There are no diversions for municipal or industrial use in this headwater reach and no identified needs in the future.

There are homes and small subdivisions distributed along the Lake Fork River from Lake City to Blue Mesa. These developments are generally adjacent to Highway 149 or near county roads. Wells provide household water and individual onsite wastewater treatment systems are used to manage wastewater. None of the lower Lake Fork subdivisions below Lake City have centralized wastewater treatment systems.

9.3 Environmental Water Use

9.3.1 Stream and Riparian Characteristics

The Lake Fork River downstream of Lake City passes through striking landforms that are predominantly attributed to the volcanic geology. The geology in this area is a complex mixture of caldera margins, ash, lava, and debris deposits attributed to ancient volcanic activity. Erosional processes act on many of the relatively soft deposits to form steep tributary gullies, hillslopes, and small canyons. Following large precipitation events these tributaries occasionally flow as debris torrents and naturally deliver ample volumes of sediment to the streams and rivers. Natural mass erosion events are probable throughout the lower Lake Fork Basin.

Tributary channels and adjacent hillslopes are extremely efficient at moving sediment. In contrast, lower gradient channels where the valley widens and flattens decrease the channel's capacity to carry sediment and often results in large sediment deposits and frequent adjustments to channel form and location. Over time, the lower gradient channel will winnow away accumulated sediment. The stream system may establish a tenuous and temporary equilibrium, but natural sediment delivery and erosion processes are very dynamic due to the topography, geology, and climate.

The Lake Fork River is somewhat confined by small canyons, slide debris, and development within the riparian corridor from Lake City to Blue Mesa. Blue Spruce, willows, alders, and other riparian vegetation typically form a narrow ribbon within the riparian corridor. In some areas native vegetation has been altered by development within the riparian corridor.

In some instances, stakeholders reported channel stability issues. Several man-made constrictions, like undersized bridges, and channel stabilization features, armored banks, and vane structures are apparent in aerial imagery.

Stream stability and channel manipulation on a 1.3-mile section of the Lake Fork River approximately 1.5 mile north of Lake City.

Photo 9-1: Lake Fork River in September 1998 (image by USGS via Google Earth). In the center of the image multi-thread channels navigate large, wide sediment deposits. A low-water ford allowed vehicles to cross the river. Prior stream stability and channels configurations are unknown.

Photo 9-2: Lake Fork River in October 2005 (image by USDA Farm Service Agency via Google Earth). A large channel stabilization project was completed some time between 1998 to 2005. The project increased the channel sinuosity, narrowed the channel width, and installed many cross vanes and J-hooks throughout the reach. The project objectives were to improve fisheries, A bridge was installed across the river and a picnic pavilion was later built immediately downriver from the bridge.

Photo 9-3: Lake Fork River in October 2015 (image by Google Earth). Notice that the channel width has increased throughout the reach. Which combined with decreased water depth likely reduces habitat quality. Sediment deposition has buried at least two cross vanes on the lower portion of the reach. It also appears that this sediment deposition has affected the performance of the diversion structure used to fill the ponds near the bottom of the reach. Access roads developed during construction remain and likely limit floodplain connectivity within the reach.

9.3.2 Aquatic Life

Since the late 1990s several organizations have sampled macroinvertebrates at multiple locations in the Lake Fork River from Lake City to Blue Mesa. Collectively, the results suggest that the macroinvertebrate community near Lake City is not as robust as in the lower portion of the reach.

The Lake Fork River from Lake City to Blue Mesa supports excellent fisheries, considered by many to be Gold Medal standard, although not designated as such. Brown trout and rainbow trout occur throughout the reach. Kokanee salmon occur from Red Bridge to Blue Mesa, but also swim upstream to Lake City during spawning. In 2016, CPW surveyed a 1.2-mile reach near Red Bridge Campground to characterize the density of fish greater than five inches in length. CPW found 733 brown trout and 351 rainbow trout per mile (CPW, 2016). Both rainbow trout and kokanee are stocked within this reach.

Overwinter and refuge habitat, especially deeper pools, may influence the distribution of fish within this reach. Near Lake City the Lake Fork River tends to be relatively shallow with fewer pools. While the Lower Lake Fork River has generally experienced less manipulation and benefitted from some habitat restoration projects near Red Bridge Campground. The restoration projects were completed in the 1990s as compensation for habitat lost due to the construction of the Aspinall Unit (Blue Mesa, Morrow Point, and Crystal reservoirs). CPW reported that fish weight and number of “quality-sized” fish doubled in the years following the habitat restoration project near Red Bridge Campground (CPW, 2016). BLM staff have suggested that it may be necessary to complete maintenance on restoration work completed in the late 1990s to assure habitat improvements are maintained.

The lower Lake Fork River, near the Gateview Campground, supports a large heron rookery.

9.3.3 Water Quality

In 2018 the Lake Fork River downstream of Eaton Creek to Blue Mesa Reservoir and tributaries located in wilderness areas within the upper Gunnison River basin were listed as impaired for total arsenic for water supply use, shown in Table 9-2 and Figure 9-4. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the Lake Fork Basin have not been sampled. The data that resulted in the listing were collected from Oh-Be-Joyful Creek near Crested Butte. Because tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries. There is need to conduct follow-up sampling to see if this listing is appropriate for the Lake Fork reach. TO date, no TMDLs have been completed for these listings.

The National Park Service samples water quality in the Lake Fork River at Red Bridge Campground. Based on an extensive analysis of water quality data collected from 2001 to 2014 indicates that water quality standards were rarely exceeded. E. coli, pH, chloride, ammonia, nitrite, cadmium, manganese, selenium, silver, and zinc were less than water quality standards in all 63 samples collected in the study period. In less than 5 percent of the samples phosphorus, copper, and lead exceeded the applicable water quality standard (NPS, 2019).

Table 9-2: Impaired and potentially impaired stream reaches in the Lake Fork River Basin from Lake City to Blue Mesa.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of the Lake Fork River and all tributaries and wetlands from a point immediately above the confluence with Eaton Creek to Blue Mesa Reservoir	Water Supply Use	NA	Total Arsenic	High
Tributaries to the Gunnison River, including wetlands, within the Powderhorn and Uncompahgre Wilderness Areas	Water Supply Use	NA	Total Arsenic	High
		Dissolved Iron	NA	NA

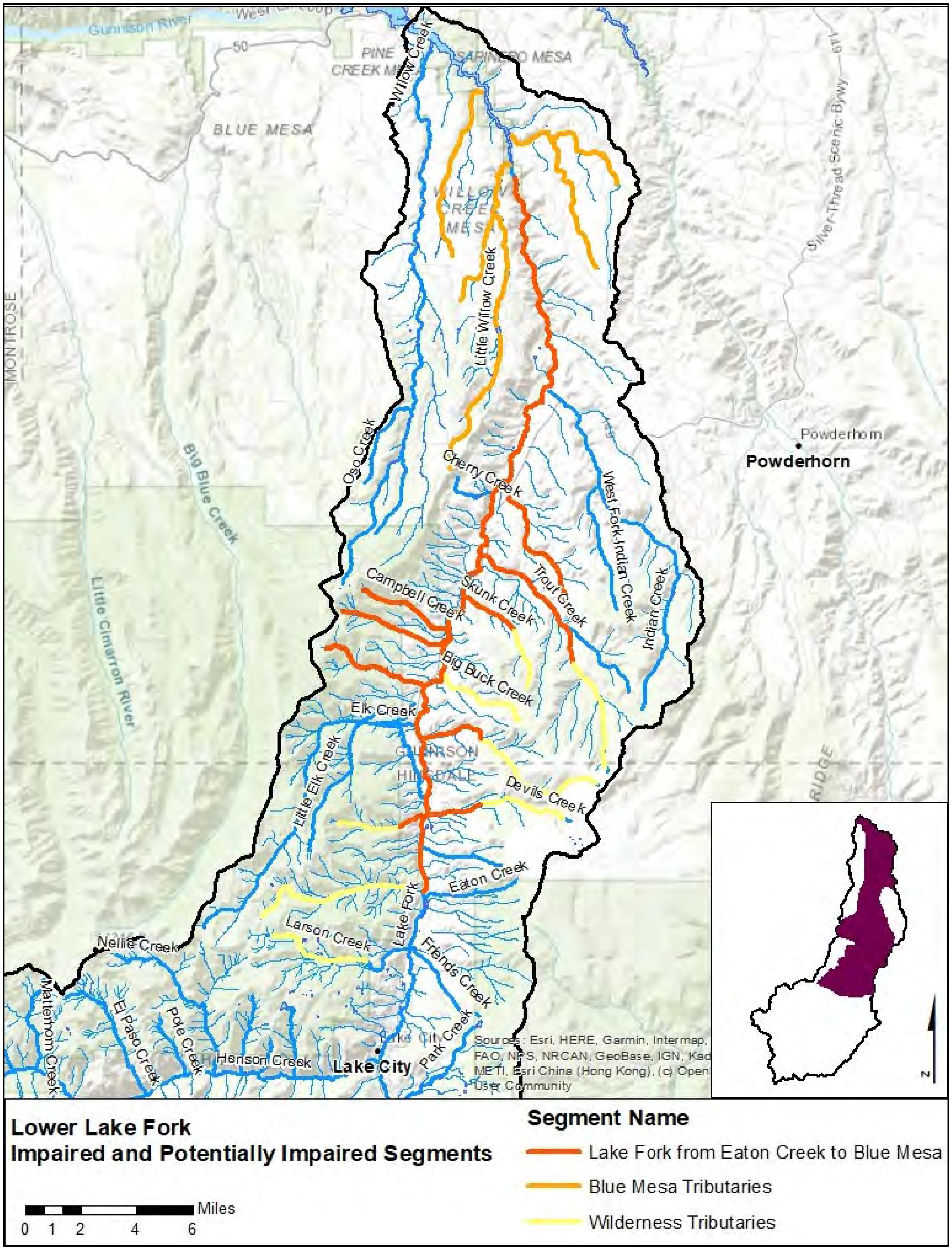


Figure 9-4: Impaired and potentially impaired stream reaches in the Lake Fork River Basin from Lake City to Blue Mesa Reservoir.

9.3.4 Water Temperature

Photo 9-4: Lake Fork River near the confluence with Devil's Creek. This area is a popular fishing area.

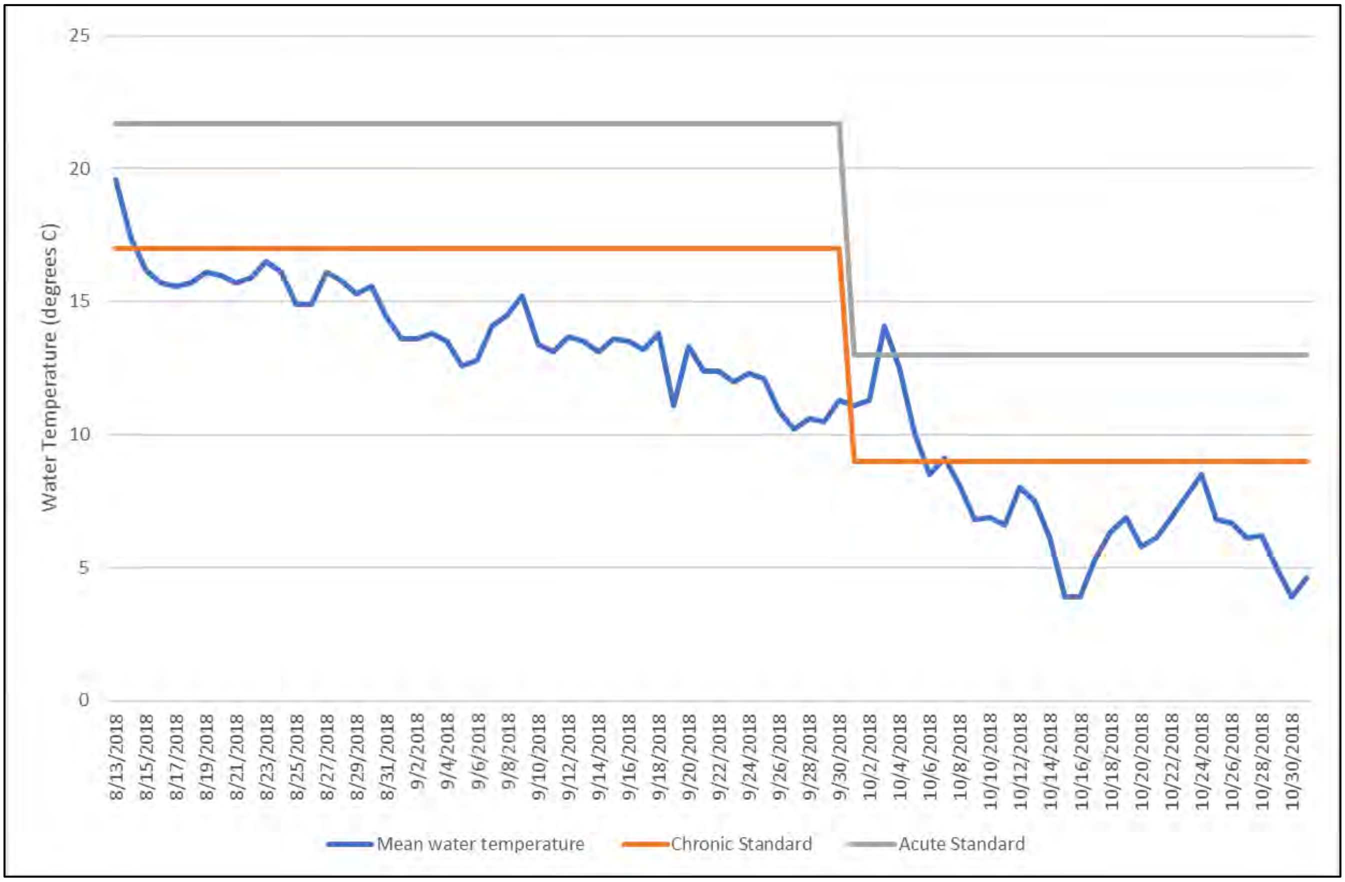
BLM staff installed two continuous temperature sensors in the Lake Fork River in recent years. One sensor was installed in the Lake Fork River at Devil's Creek (Photo 9-4) and the other was installed in the Lake Fork River at Gateview Campground. Water temperatures at both locations attained the aquatic life standards during each of the summers that the sensors were deployed, shown in Table 9-3 and Figure 9-5.

In August 2018, USGS, with support from several partners, installed a continuous temperature sensor. Stream temperatures in the late summer of 2018 may have exceeded the aquatic life standards, due to extreme drought. CWCB released water from Lake San Cristobal to help reduce water temperatures and meet instream flows in the Lake Fork River downstream of the Lake.

Table 9-3: Summary of stream temperature data in the Lake Fork River from Lake City to Blue Mesa.

Location	Monitoring Start Date	Monitoring End Date	Number of Summers	Standard Attained
Lake Fork River at Devil's Creek	10/4/2012	9/24/2015	2	Yes
Lake Fork River at Gateview Campground	9/11/2014	9/7/2017	3	Yes

Figure 9-5: Average daily stream temperature in Lake Fork River at Gateview August 13, 2018 to October 31, 2018.



9.3.5 Existing Instream Flows

There are six existing instream flow water rights in the Lake Fork Basin between Lake City and Blue Mesa Reservoir, shown in Figure 9-6. The instream flow water rights for Larson Creek and Independence Gulch are year-round rights.

There are several named tributaries that lack instream flow water rights in this reach including Little Willow Creek, Nourse Creek, Eaton Creek, Friends Creek, Cherry Creek, Campbell Creek, Narrow Grade Creek, Big Buck Creek, and Skunk Creek. These tributaries were not investigated as part of this assessment.

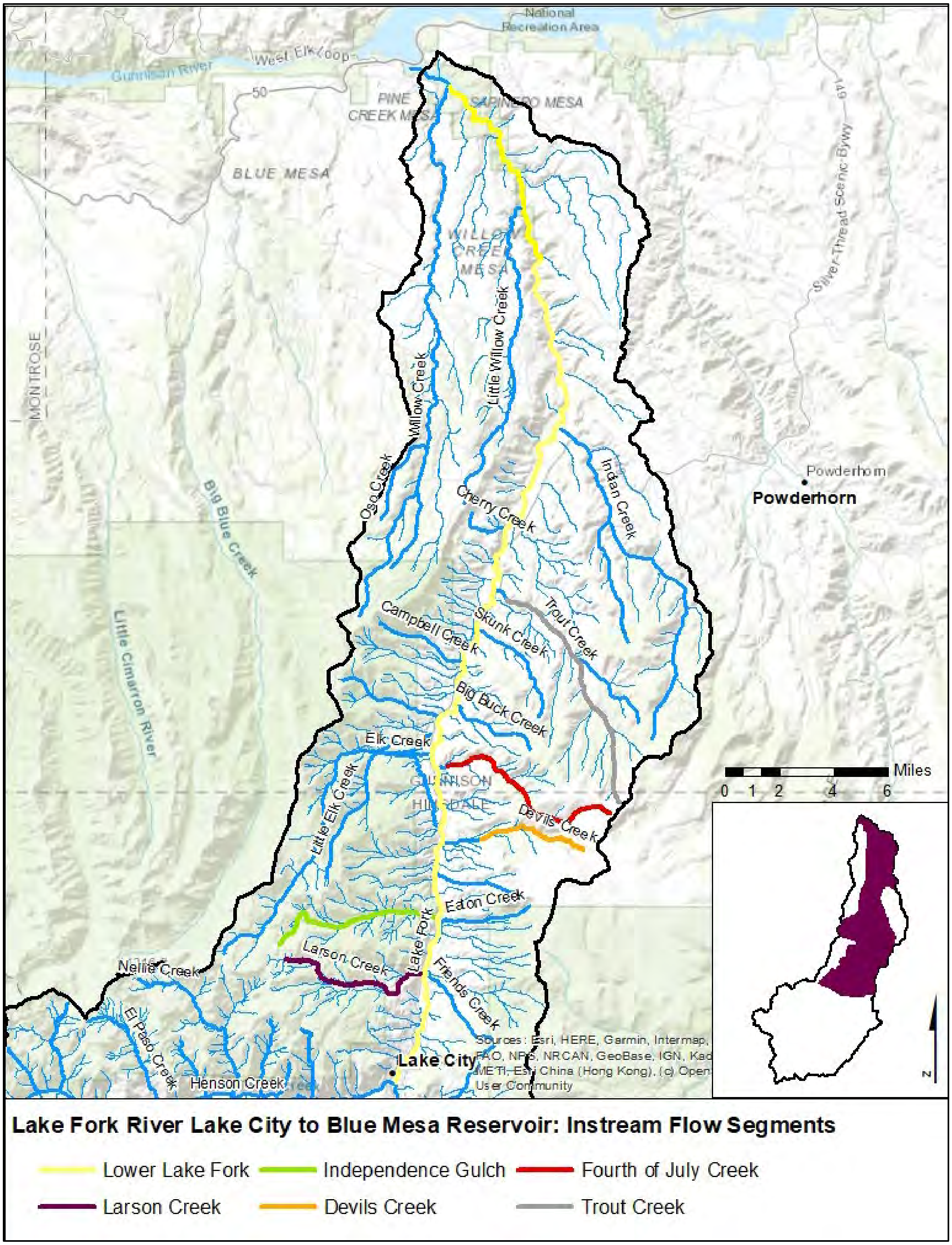
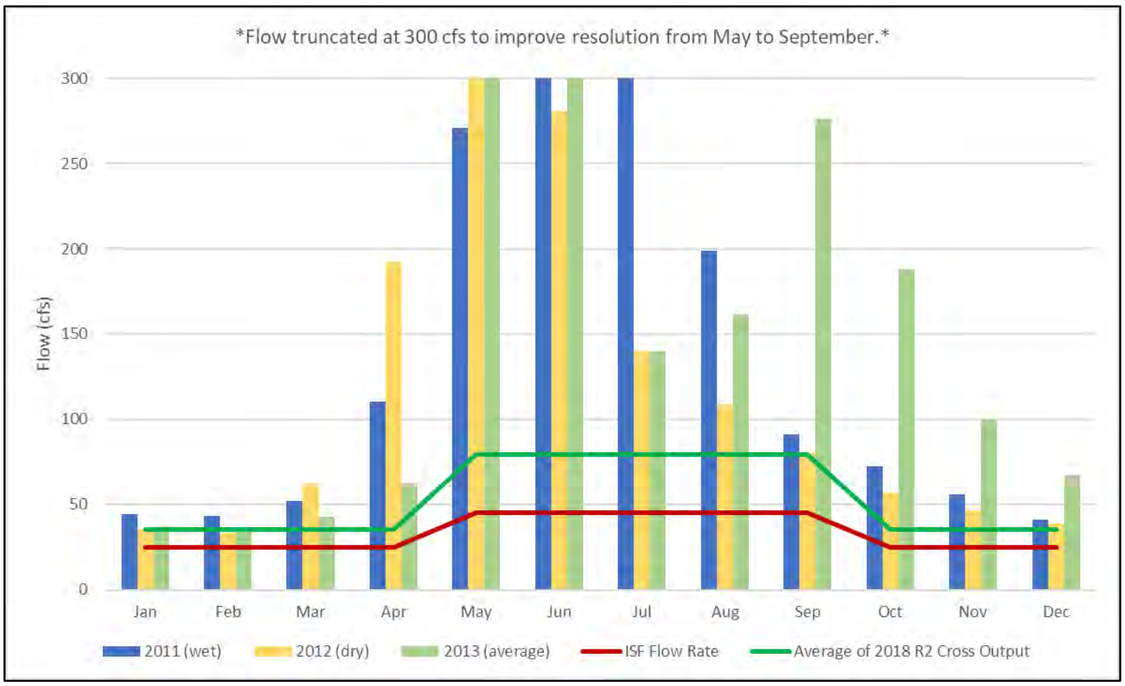


Figure 9-6: Instream flow water rights in the Lake in the Lake Fork River Basin from Lake City to Blue Mesa Reservoir.

The existing instream flow water right on the Lake Fork River from Henson Creek to Blue Mesa Reservoir provides minimum flow protections of 25 cfs in the winter and 45 cfs in the summer. As the original proposal was developed, staff noted that the winter rate did not meet the hydraulic criteria and the summer rate was reduced based on discussions with the water commissioner. However, a review of average monthly flows shows that stream flows consistently exceed the existing instream rates, shown in Figure 9-7. Like the original R2CROSS assessments, the 2018 R2CROSS assessments created recommendations higher than the existing instream flow water rights for both summer and winter.

Figure 9-7: Lake Fork River at Gateview (USGS 09124500) monthly average flows in 2011 (wet), 2012 (dry), and 2013 (average), along with existing instream flow rates, and the average of the 2018 R2Cross results (n=3).



As mentioned in previous sections, it may be possible to increase existing instream flow rates on upstream reaches of the Lake Fork River and Henson Creek, shown in Figure 9-8.

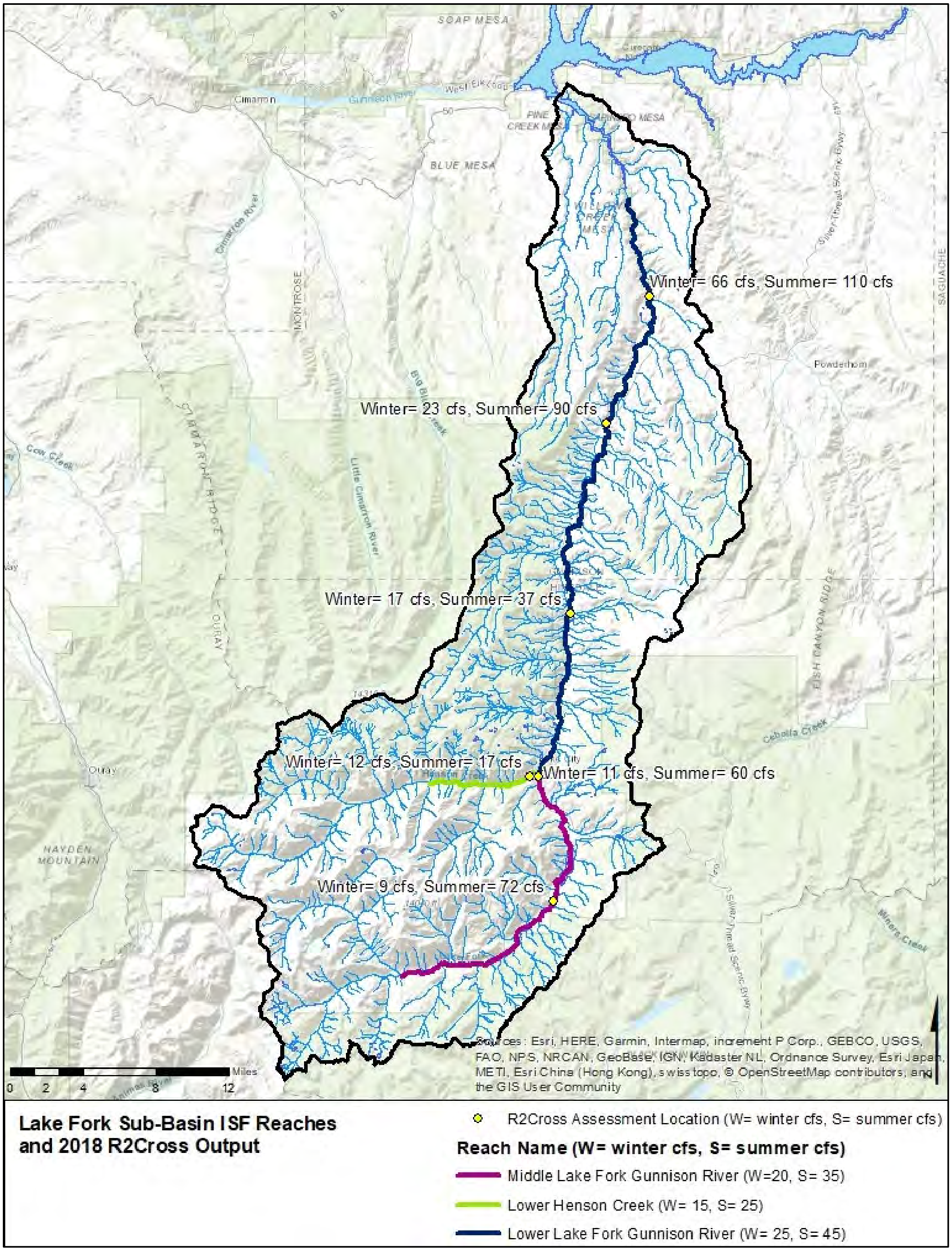


Figure 9-8: Existing instream flow water rights in the Lake Fork Sub-basin and 2018 R2CROSS Output

9.3.6 Flow-limited Areas

Water rights calls have not been recorded in the Lake Fork River Basin from Lake City to Blue Mesa Reservoir, which is promising with respect to flow-limited areas. Gentleman's agreements to avoid calls are common in the Upper Gunnison Basin so call records may not fully characterize flow issues. Based on water rights within the reach, 116.5 cfs, stream flows may be reduced significantly by diversions in low and average flow years from July to October. Under these circumstances, habitat downstream of large diversion structures may become fragmented (i.e. fish may not be able to travel upstream of the diversion), water temperatures may increase, and the vigor of riparian vegetation may be decreased in down-gradient areas.

The lower termini of the Devils Creek, Fourth of July Creek, and Trout Creek instream flow reaches end at headgates which suggests that these areas are flow-limited and may, at times, lack connectivity with the Lake Fork River.

9.3.7 Environmental Flow Goals

The Lake Fork River downstream of Lake City is an excellent candidate for tiered environmental flow goals for the following reasons:

- Outstanding fishery and macroinvertebrates.
- Good to excellent water quality conditions.
- Consistent attainment of stream temperature standards. Limited data suggest that temperatures may exceed the chronic standard during low flow conditions, which could be remedied or improved with alternative water management practices.
- Several miles of public access, and reasonably good infrastructure at three existing campgrounds, to allow for recreational use.
- Water rights held by CWCB and LSCWAE and stored in Lake San Cristobal provide opportunities for water releases to protect aquatic life.

9.4 Recreational Water Use

The Lake Fork Town Run (called Lake City Town Reach in WSR Guidebook) has many variations. Some users, especially those with standup paddle boards or innertubes, run the River through town from Memorial Park to the 8 ½ Street Bridge. Other users, including kayakers and rafters, run the river down to Independence Gulch Trailhead for a total distance of 12 miles or to Devils Creek Bridge, an additional two miles. This reach is most suitable under high flow conditions, or in above average years.

Devils Creek to The Gates is a popular float for both anglers and entry-level white-water enthusiasts, although this stretch can be more technical at high water due to narrow and winding canyon walls. Standup paddle board use is becoming increasingly common too. This stretch is most popular during moderate flows, approximately 600-800 cfs, for scenic views and fishing.

Low bridges prevent rafting at higher flows, but smaller craft can negotiate under these structures at high flow.

Lower Lake Fork Canyon below Red Bridge Campground flows across BLM and National Park Service land and is a popular white-water river run, especially at high flow. This area has good access and recreational amenities and there is currently no need for any boating infrastructural improvements.

9.4.1 Fish Pond Diversions

There are several private fish ponds within this reach. Figure 9-10 shows the location of the eight measured river diversions that fill fish ponds within the reach. The only depletions associated with pond diversions are replacement of pond evaporation; the diversions are generally flow-through and can result in significant de-watering of the river between the diversion and the river return location. Figure 9-11 shows fish ponds in the lower section of the Lake City to Blue Mesa reach; note that there are no measured diversions to fish ponds in that section. Figure 9-9 shows the total recorded diversions for fish ponds within the reach. Diversion for fish ponds typically begin in late April or early May and end in October. As noted previously, the water commissioner position was vacant in 2016 and no diversions were recorded.

Most of the ponds are unlined and do not have storage decrees. Depletions associated with the junior diversions to replace pond evaporation are generally replaced under small augmentation plans. Average annual diversions from the 1998 through 2017 period were 3,230 acre-feet, compared to average annual diversions for irrigation for the same period of 9,040 acre-feet.

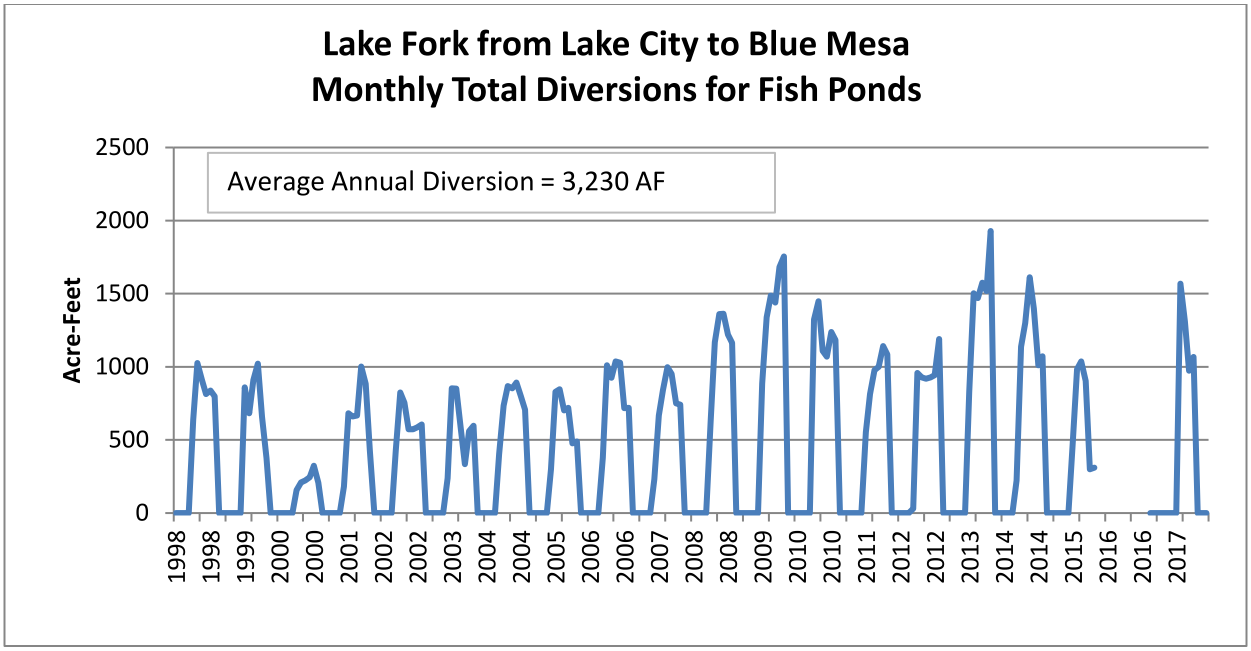


Figure 9-9: Lake Fork from Lake City to Blue Mesa – Measured Diversions for Fish Ponds

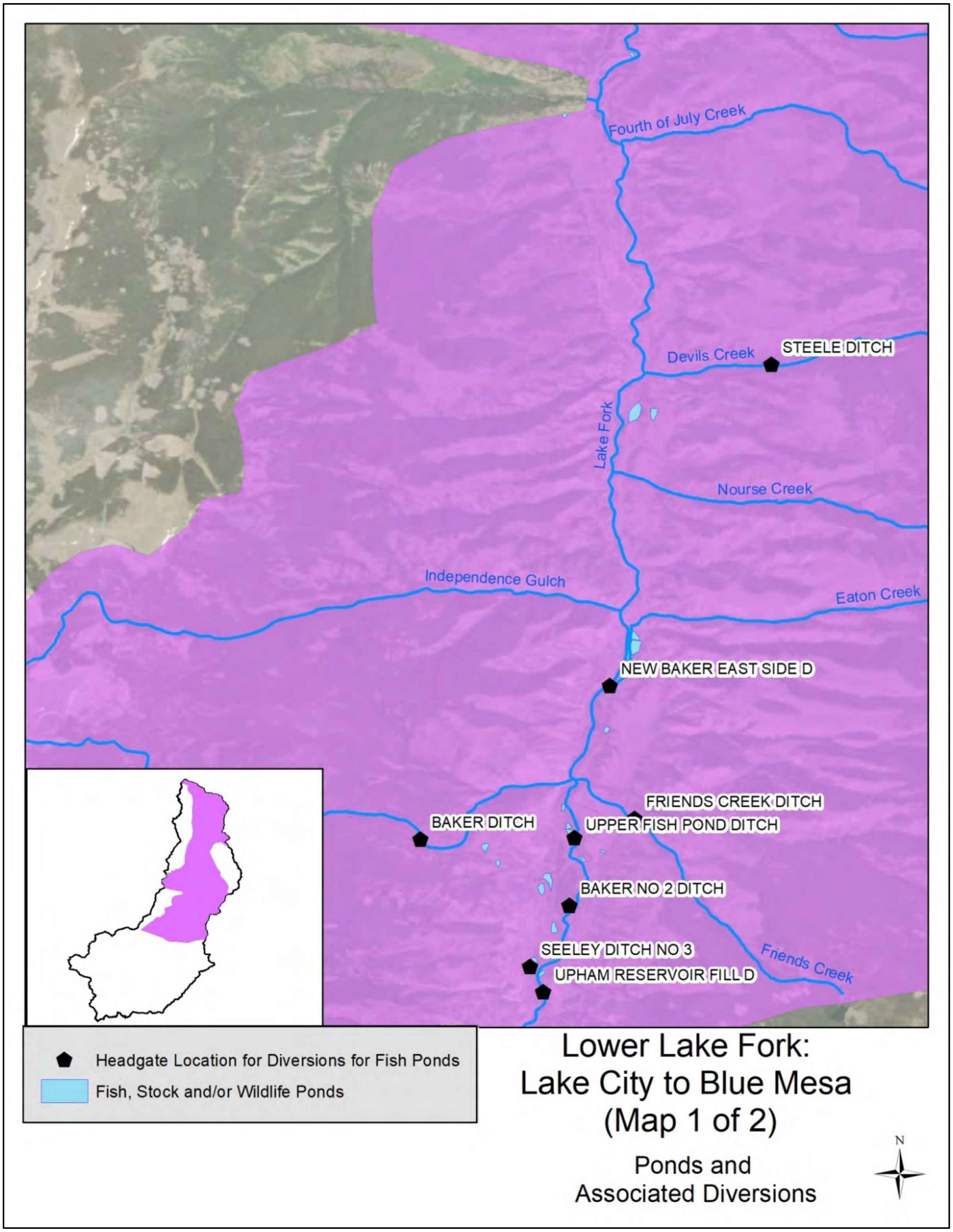


Figure 9-10: Lake Fork from Lake City to Blue Mesa, Fish Pond Diversions, Map 1 of 2

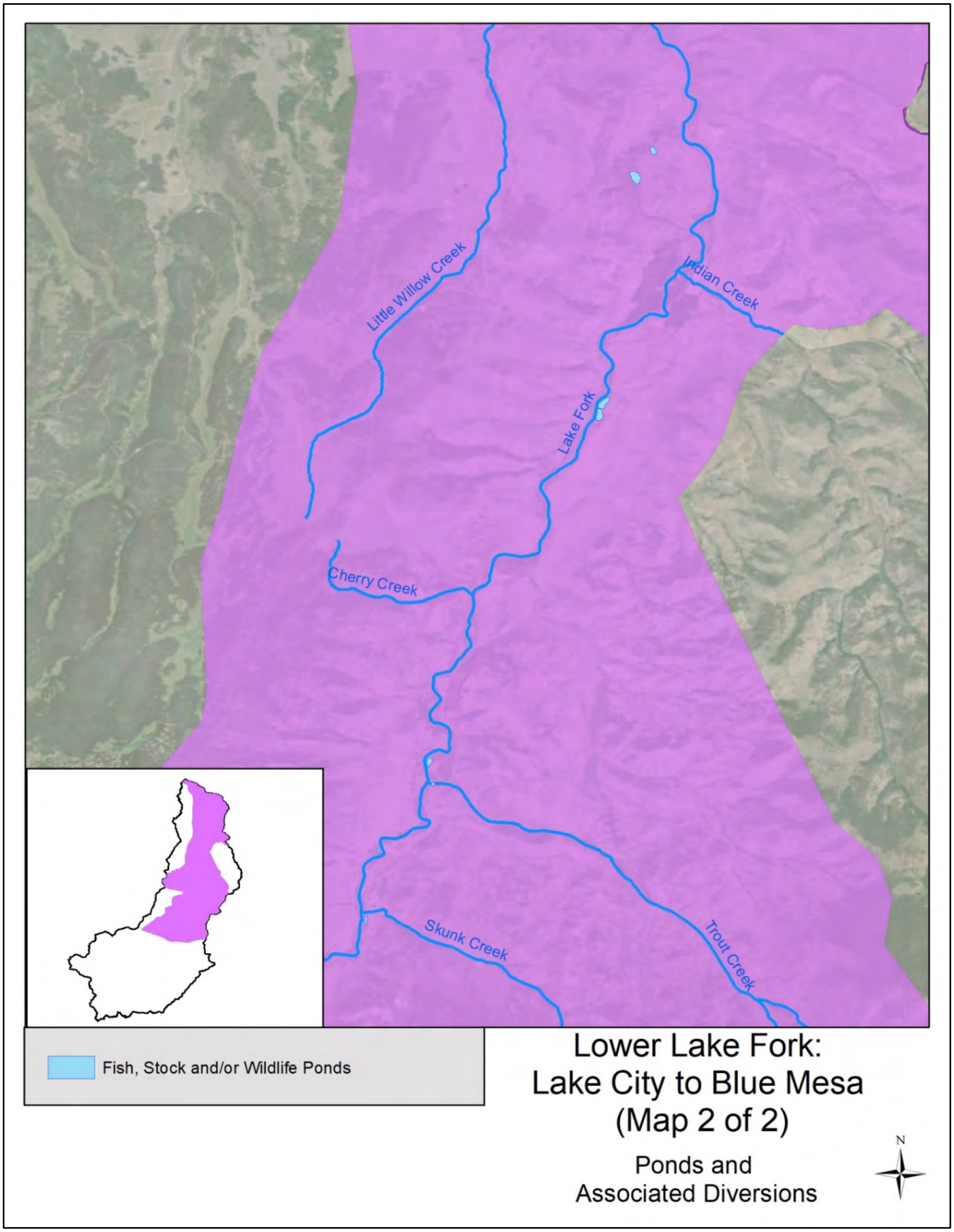


Figure 9-11: Lake Fork from Lake City to Blue Mesa, Fish Pond Diversions, Map 2 of 2

9.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality for household wells.

Issue: Water supply and water rights in San Juan Ranch Subdivision. The subdivision, one mile north of Lake City, relies on spring fed wells. Some stakeholders are concerned about the effect of senior water rights calls, and others are more generally concerned about overall water supplies.

Issue: Potential to appropriate additional instream flow reaches in the Lower Lake Fork Basin.

Issue: Potential for enlarging the existing instream flow water rights for the Lake Fork River from Lake City to Blue Mesa Reservoir.

Issue: Extent of recreational use, angling and trespass on private land in the Lake Fork River from Lake City to Blue Mesa.

Some residents within this reach are concerned about water supply and augmentation for their wells and ponds, especially as water use and water rights administration increases.

Issue: Follow-up sampling to see if the impaired listing is appropriate for the Lake Fork River in this reach. To date, no TMDLs have been completed for this listing.

Section 10. Reach 6 - Lower Lake Fork Tributaries (Elk Creek, Indian Creek, Willow Creek)

This section describes water use along the three larger tributaries of the Lower Lake Fork that have substantial water rights on them. These were separated from the lower Lake Fork section because they experience more intense water shortage issues than the mainstem of the Lake Fork.

10.1 Agricultural Water Use

There are two irrigation diversions on Indian Creek near the confluence with the Lake Fork. The diversions supply water to irrigated fields that also use water diverted from the Lake Fork mainstem. The use is presented in section 9 - Lower Lake Fork: Lake City to Blue Mesa.

There are five active irrigation diversions on Elk Creek lower tributary to the Lake Fork, serving approximately 365 acres of flood irrigated pasture grass. Table 10-1 shows the total irrigation water rights, combined annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the 11 ditches in this reach from 1998 to 2017. There was an open water commissioner position in the Lake Fork in 2016 and no diversions were recorded; therefore 2016 was not included the table statistics.

Table 10-1: Agricultural Water Use Statistics – Lake Fork Lower Tributaries (Elk Creek)

Reach Statistics	1998 to 2017 Average excluding 2016	1998-2017 Range excluding 2016
Number of Irrigation Structures	5	n/a
Irrigated Acreage	365	n/a
Water Rights	61.66 cfs	n/a
Diversions	3,210 acre-feet	1,800 – 4,170 acre-feet
Crop Demand	740 acre-feet	580 - 820 acre-feet
Crop CU	690 acre-feet	570 - 790 acre-feet
Shortage/Need	50 acre-feet	10 - 30 acre-feet
Percent Shortage	6%	1% - 11%

Figure 3-11 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. Note that the ditch alignment for the Hunter Elk Creek Ditch could not be identified. All the ditches are unlined and are estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from these tributaries, estimated to be an average of 2,460 acre-feet per year from 1998 to 2017, accrue to the Lake Fork River, primarily below the confluence with Elk Creek.

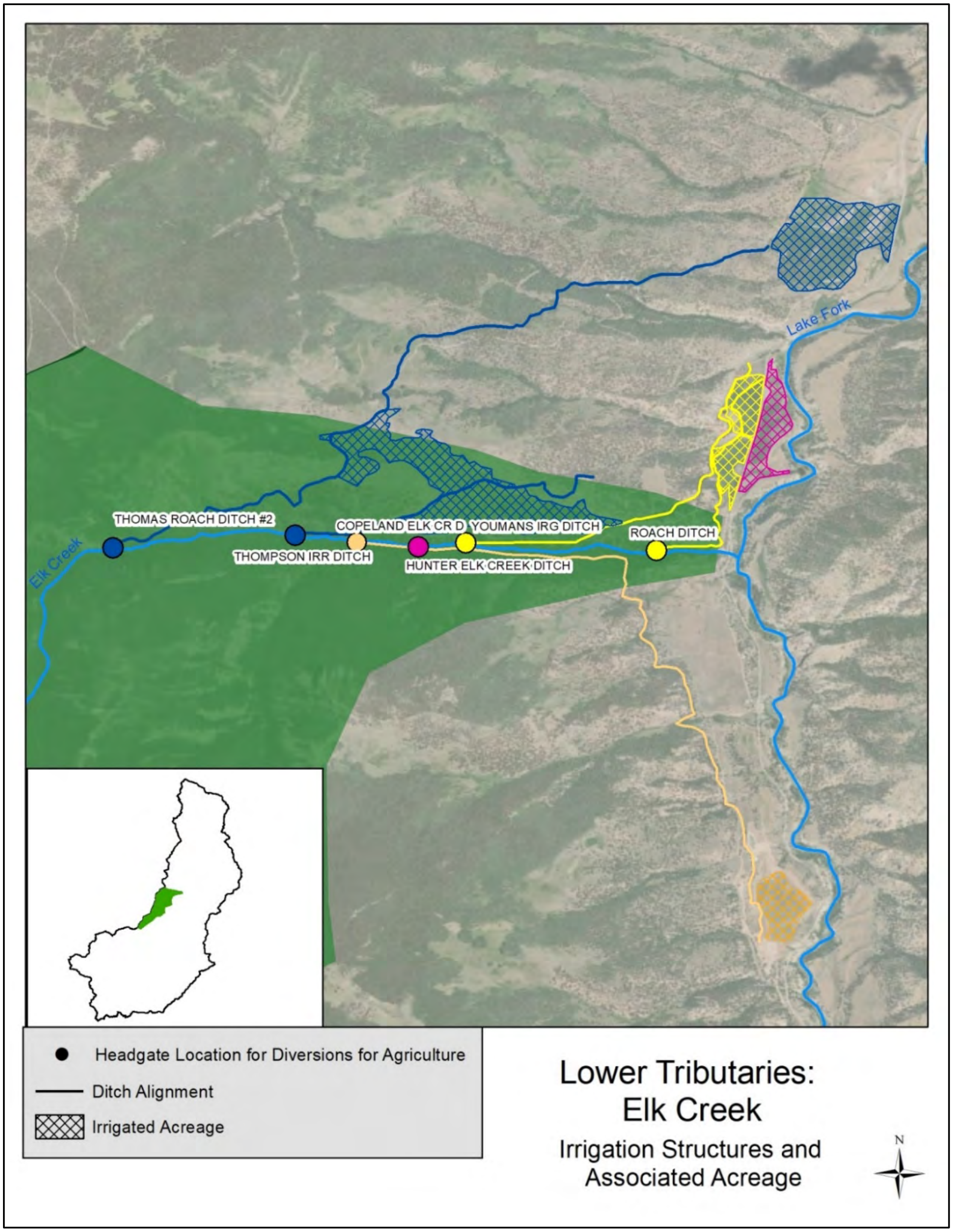
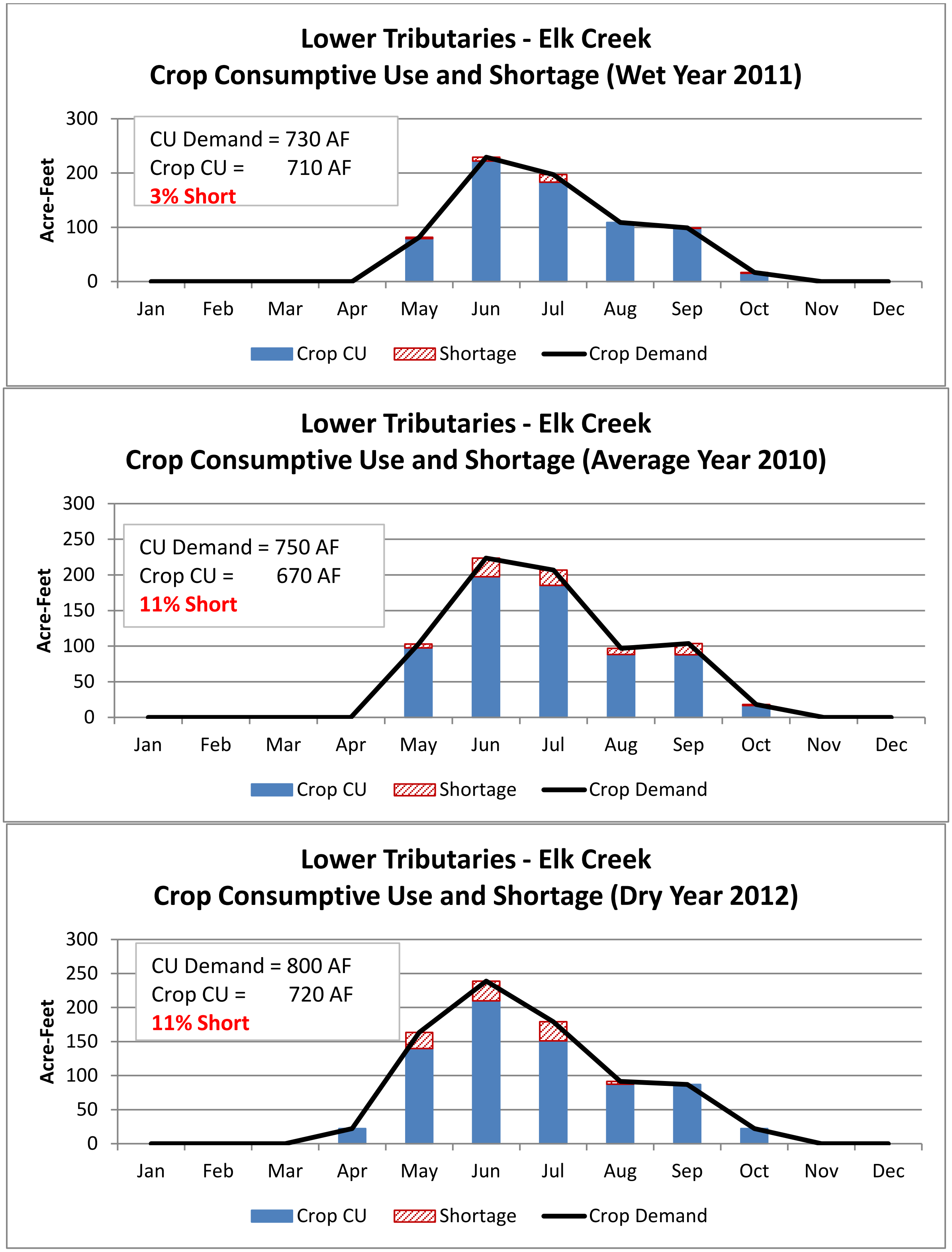


Figure 10-1: Lake Fork Lower Tributaries, Irrigation Structures and Acreage (Elk Creek)

Figure 10-2 shows the monthly crop demands, crop consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were minimal shortages during the representative wet year and, as shown, shortages were largest in the representative dry year in May, June and July.

Figure 10-2: Lake Fork Lower Tributaries (Elk Creek) – Crop Consumptive Use and Shortage



There is one active irrigation diversion on Willow Creek that irrigates approximately 140 acres of pasture grass near Blue Mesa Reservoir. Table 10-2 shows the total irrigation water rights, combined annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the ditch in this reach from 1998 to 2017.

Table 10-2: Agricultural Water Use Statistics – Lake Fork Lower Tributaries (Willow Creek)

Reach Statistics	1998 to 2017 Average	1998-2017 Range
Number of Irrigation Structures	1	n/a
Irrigated Acreage	140	n/a
Water Rights	11.71 cfs	n/a
Diversions	1,100 acre-feet	0 – 2,310 acre-feet
Crop Demand	310 acre-feet	260 - 340 acre-feet
Crop CU	280 acre-feet	50 - 340 acre-feet
Shortage/Need	30 acre-feet	210 - 0 acre-feet
Percent Shortage	2%	0% - 21%

Figure 10-3 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. The ditch is unlined and is estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from the diversion, estimated to be an average of 920 acre-feet per year from 1998 to 2017, accrue to Blue Mesa Reservoir.

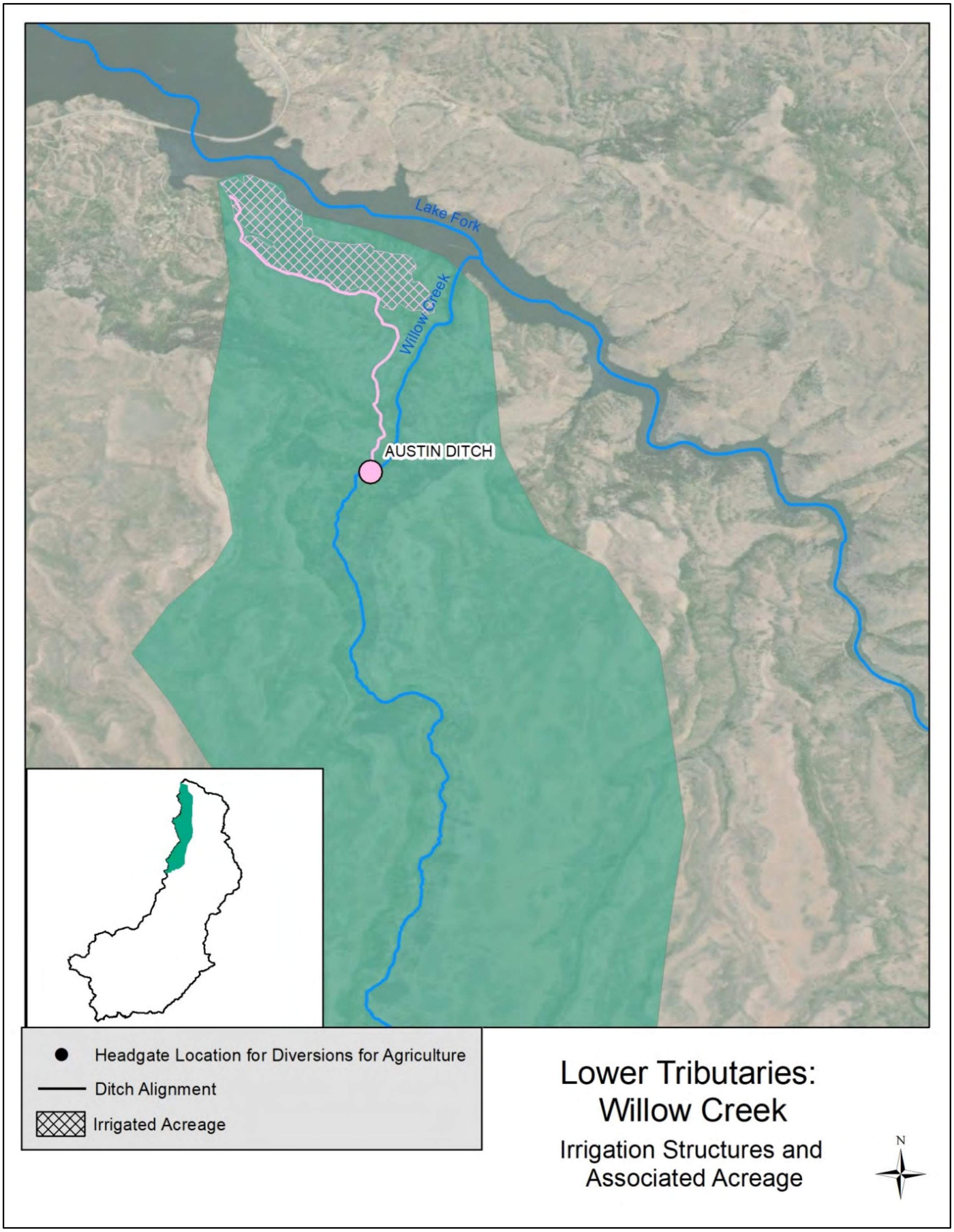
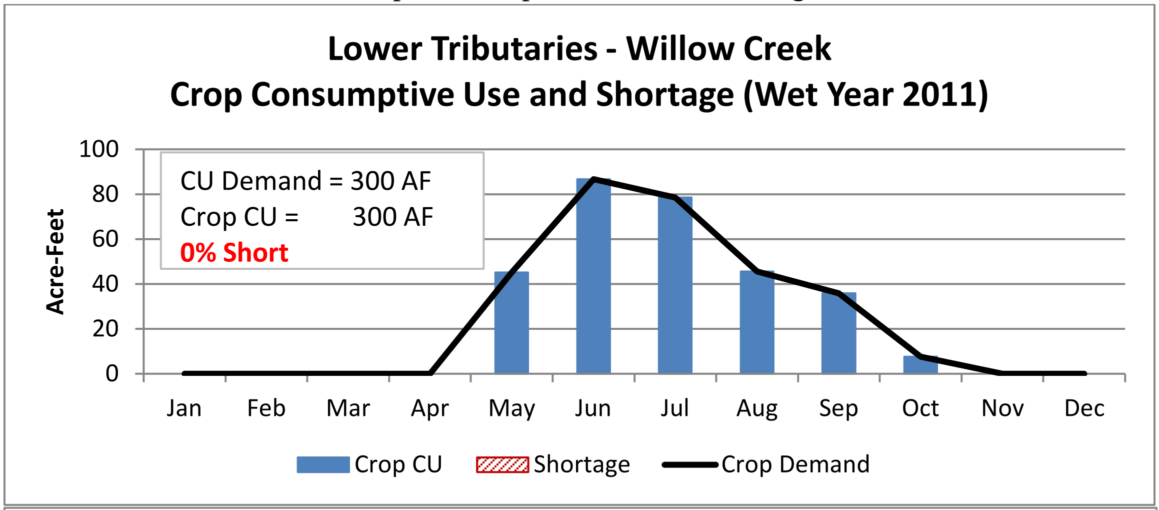
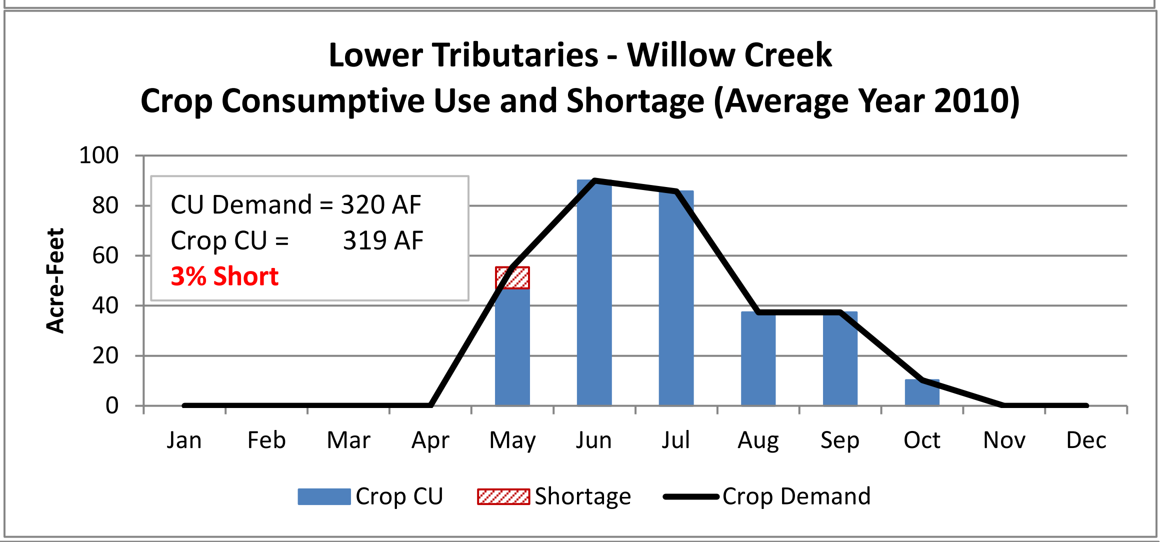


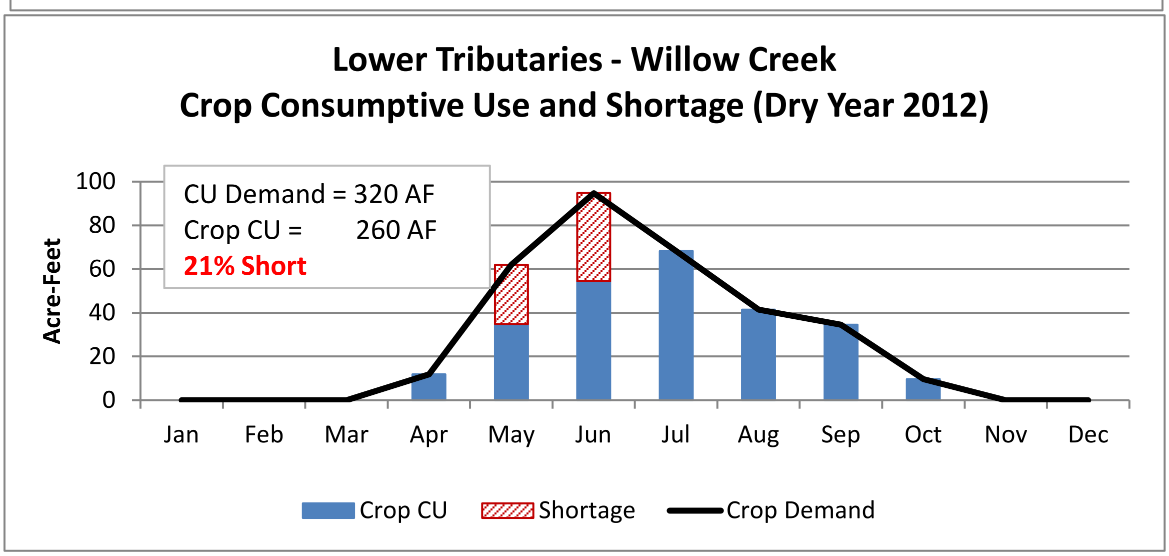
Figure 10-3: Lake Fork Lower Tributaries (Willow Creek), Irrigation Structures and Acreage

Figure 10-4 shows the monthly crop demands, crop consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). The ditch received a full supply in the representative wet year and had minimal shortages in the representative average year. As shown, shortages were largest in the representative dry year in May and June.

Figure 10-4: Lake Fork Lower Tributaries (Willow Creek)
Crop Consumptive Use and Shortage







10.2 Domestic Water Use

There are a handful of homes on the lower portion of Elk Creek, a reservation with multiple homes near Willow Creek. These homes rely on wells for household use and individual onsite wastewater treatment systems.

10.3 Environmental Water Use

10.3.1 Stream and Riparian Characteristics

The headwaters of Elk Creek are nestled between mesas at over 12,000 feet. Dense forests cover north-facing slopes, while sage parks are common on south-facing slopes. Aside from a few diversion structures and the area near Highway 149, Elk Creek's riparian corridor supports undisturbed native vegetation. Diversions from lower Elk Creek, likely prevent the creek from flowing into the Lake Fork River during most times of the year.

The headwaters of Willow Creek form on the southern edge of the Alpine Plateau. The north-facing headwaters are forested. The riparian corridor is largely undisturbed and supports native riparian vegetation. Sagebrush parks and wet meadow vegetation occur on the lower reaches of Willow Creek. Willow Creek meanders freely from the headwaters to the confluence with the Lake Fork River.

Like Elk and Willow creeks, the headwaters of Indian Creek are forested on north-facing slopes and sage brush parks are common on south-facing slopes. In selected areas, the valley confines riparian vegetation to areas immediately adjacent to the stream channel. Where the valley is broader, Indian Creek meanders and supports a larger riparian area with a mixture of willows and wet meadow vegetation. There are a handful of abandoned diversion structures along Indian Creek. The riparian vegetation is less robust in formerly irrigated areas. Near Highway 149, the Indian Creek Irrigation Ditch diverts nearly all of Indian Creek to irrigate lands southwest of Highway 149. Additional diversions remove water from Indian Creek. Aside from runoff season, Indian Creek is unlikely to reach the Lake Fork River.

10.3.2 Aquatic Life

Each of these tributaries to the Lake Fork River have the potential to support a robust aquatic life community. No macroinvertebrate sampling and fish surveys are known to have occurred in Elk Creek, Willow Creek or Indian Creek.

10.3.3 Water Quality

No water quality samples are known to have been collected from Elk Creek, Willow Creek, or Indian Creek. Elk Creek, Willow Creek, and Indian Creek are a part of a segment that is listed for impairment of the water supply use for arsenic.

10.3.4 Water Temperature

No water temperatures are known to have been measured in Elk Creek, Willow Creek, or Indian Creek. Addressing this data gap is not currently a priority.

10.3.5 Existing Instream Flows

Both Elk Creek and Willow Creek have year-round flat rate instream flows that were established in 1980, shown in Figure 10-5. Observations from late fall 2018 suggest that the instream flow rate for Elk Creek could potentially be increased. Indian Creek lacks an instream flow water right.

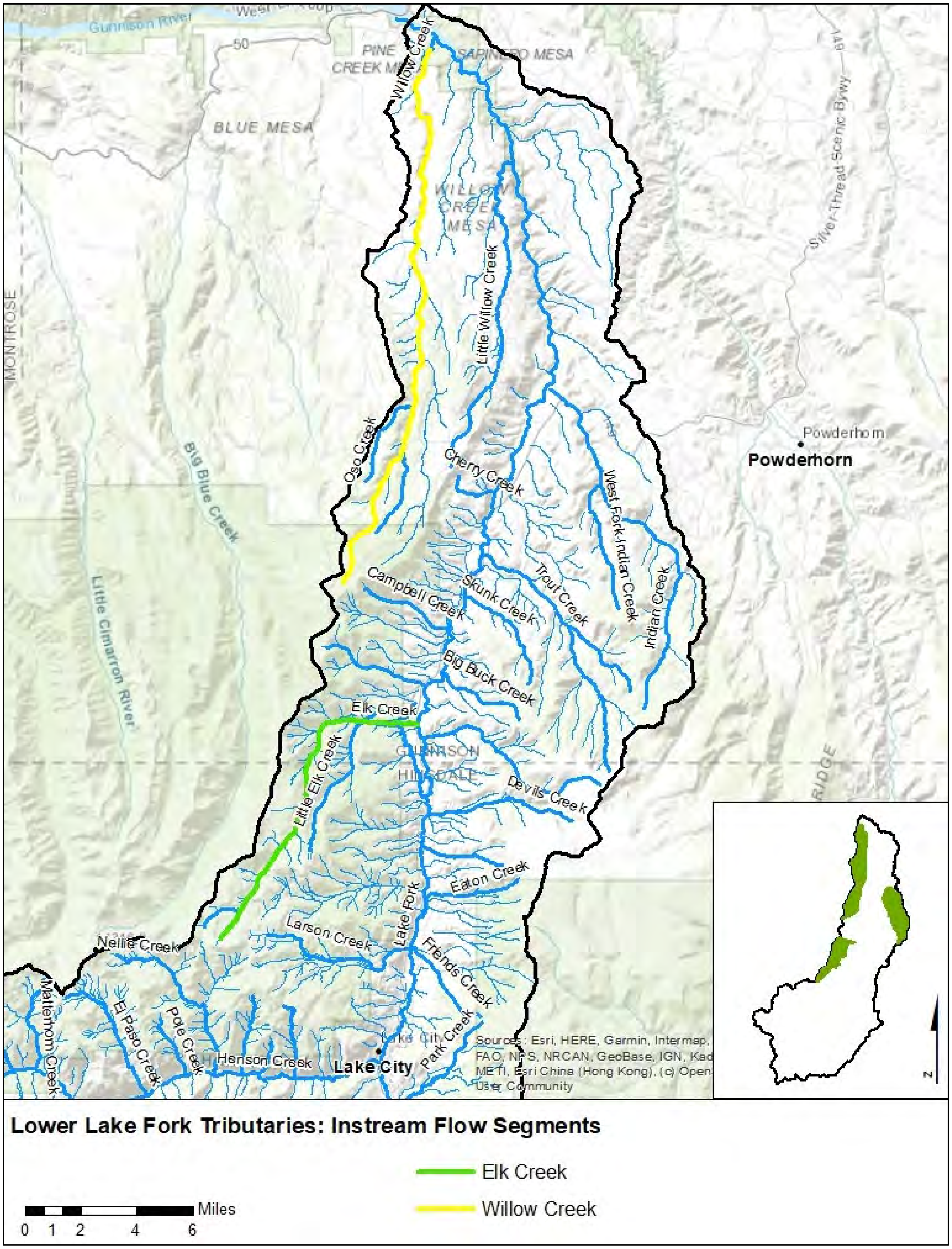


Figure 10-5: Instream flow reaches in the lower Lake Fork tributaries.

10.4 Recreational Water Use

Limited fly fishing may occur in Elk, Willow, and Indian creeks. All three creeks are too small for floating based recreation use. To date, recreation use needs have not been identified.

10.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality for household wells. Elk Creek, Willow Creek, and Indian Creek are a part of a segment that is listed for impairment of the water supply use for arsenic.

Issue: Potential for appropriation of an instream flow water right for Indian Creek.

Issue: Potential for enlarging the existing instream flow water rights for Elk Creek.

Chapter 8
Identification of Potential Demonstration Projects

Working with stakeholders and through the needs assessment process, potential demonstration projects, practices, or improvements were identified. The potential projects identified in this section are a starting point of addressing watershed goals and objectives to meet consumptive and non-consumptive needs. They will also be used to educate stakeholders from all areas within the Basin. Scoping and planning for implementation of some of these potential projects has begun as part of Phase I and will continue in subsequent phases as the list is refined.

During the process of identifying potential projects, the WMPC also developed project selection criteria as summarized below.

- The WMPC will acknowledge broad stakeholder support in its consideration of projects.
- Projects should reflect the goals of the WMPC and the Upper Gunnison River Water Conservancy District
- Projects must address an assessed need from the watershed management planning process
- Projects must have landowner approval and cooperation, or agency approval and cooperation on public lands
- Projects should benefit multiple users or Basin wide water supply as a whole
- Projects should not diminish the existing ecological function of the area where it is proposed, and will preferably enhance it
- Recognizing that project designs are site specific, the demonstration projects should be relevant for other Basins in terms of design approach and scientific rigor
- The projects should be supported by good scientific and technical analysis and the best available knowledge of Basin hydrology.
- The projects should have a strong likelihood of implementation

A. Summary of Potential Ohio Creek Projects Identified Through the Needs Assessment Process

- Berry Gulch Reservoir – This project involves a potential off channel reservoir site. Surveying is under way and additional evaluations will be necessary by engineering contractor.

Berry Gulch Potential Reservoir Site

- Perrier Diversion Structure Rehabilitation – The diversion does not adequately divert water at lower flows which often happens in this area. A newly designed structure by a channel restoration specialist will be needed.

- Gooseberry Diversion Structure Rehabilitation – The diversion does not adequately divert water at lower flows. A newly designed structure by a channel restoration specialist will also be needed in this area.

Gooseberry Diversion Structure

- Carbon Creek Reservoir Site Evaluation – Potential off channel reservoir site. Surveying of the site is underway and additional evaluation will be necessary by dam engineering contractors.

Carbon Creek Reservoir Site

- Harris Bohm Potato Diversion Rehabilitation – This diversion is unstable and requires regular maintenance. The water users plan to replace the structure in 2019 with a newly designed structure with funds from the District's Grant Program.

- Channel Restoration Upstream of Confluence with Mill Creek –The landowner is interested in addressing segments of Ohio Creek with bank instability on property located upstream of the confluence with Mill Creek. This project will require a contractor with channel restoration experience.

Harris Bohm Potato Diversion

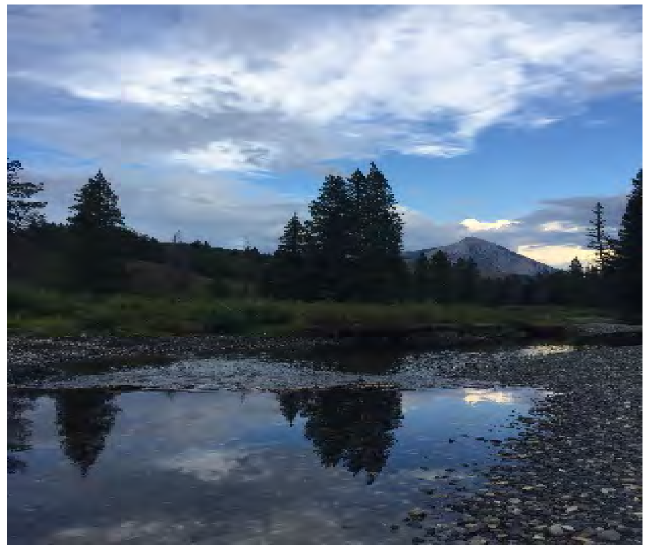
B. Summary of Potential East River Projects Identified Through the Needs Assessment Process

- *E. Coli* Monitoring on the Upper East River Watershed – This project would include additional water quality testing and monitoring in order to identify potential sources of loading and options to mitigate these impacts.

- Coal Creek/Lake Irwin Man-Made Outlet – Project will involve developing a new outlet structure at Lake Irwin to optimize releases, meet instream flows, maximize water quality benefits, and help the Town of Crested Butte meet shortages. This project will require contractors with engineering expertise to identify potential design solutions.

- Protection of the Fen at Cement Creek – This project will involve discussions with private landowners and USFS about options to protect the fen in order to maintain existing integrity of the fen and wetland community. These options could include conservation easements or environmental covenants.

- Recreational Management on the Upper Slate River – Increase recreational use on the Upper Slate River has resulted in potential disturbances to the Great Blue Heron Rookery, potential conflicts with recreationalists and landowners, and a range of other potential impacts including human waste and heavy use of distinct riparian areas. This project will involve working with the Slate River Working Group process and the facilitations of the floating management plan.



Recreational Management on the Upper Slate River

- Pumphouse Operations and East River Winter Dry-Down – This project will address dry down in the late fall and early winter at the Pumphouse caused by diversions for municipal use and snowmaking. It will involve real-time monitoring of withdrawals to assure compliance with bypass flow and to assess instream flow attainment rates; the creation of snowmaking ponds so that water can be diverted during higher flow periods and stored to use during lower flows; and the exploration of options to create pools and channel configurations that provide additional habitat and refuge options for fish during low flow and freezing conditions.

- Dry-Down on Brush Creek – The needs assessment of Brush Creek identified five locations where dry-up and near dry-up conditions occurs. Due to the outstanding fish habitat in both Brush Creek and the East River, additional investigation should occur to identify solutions to improve habitat connectivity. This would include continued discussion with landowners/water right holders to identify potential strategies to improve stream flow and riparian conditions in this area.

- Removal of Old Bridge Abutments on Slate River/Coal Creek – The project will include developing a project plan for removal and restoration of old bridge abutments near the 135 Bridge in Crested Butte. These abutments constrict the river, force excess sediment deposition, and reduce channel stability and habitat quality.

- Slate River Instream Flow (Slate River Segment 4-Coal Creek to East River) – This project will involve identifying mutually beneficial designs to reduce maintenance needs, improve water delivery, and improve habitat and fish passage on this segment of the Slate River. This will include increased coordination with CWCB to more frequently attain the summer instream flow rate during dry years and the development of options to improve the function of diversion structures and in-channel conditions.

- Mine Reclamation at the Daisy Mine in Redwell Basin – The Daisy Mine has been identified as a key contributor to water quality impairment in the Slate River. This project would aid in reclaiming the mine site in order to improve water quality on the Slate River.

- Bank Instability at Roaring Judy Fish Hatchery – This project would address issues identified with bank instability which threatens infrastructure. This infrastructure may also be impacting stream geomorphology and habitat. The project will involve additional assessment work to identify methods to protect infrastructure and improve bank stabilization. This may include geomorphic assessment and development of riparian restoration strategies.

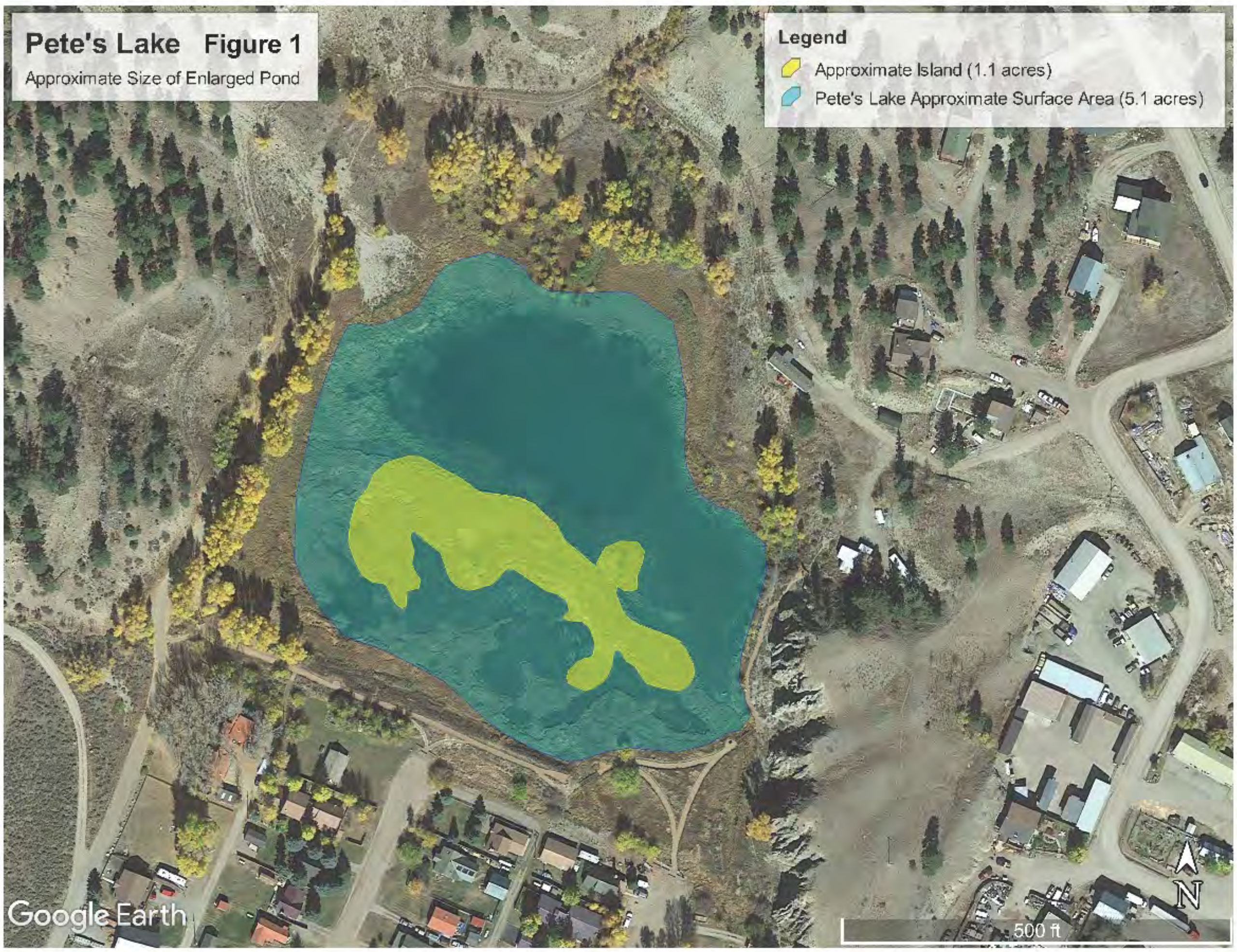
Bank Instability at Roaring Judy Fish Hatchery

- Address Dry-Down in the East River from the Slate to Alkali Creek – This project will include evaluating the possibility of returning tailwaters to the East Rivers on the north end of Crested Butte South subdivision. The will aid in improving the conditions of the wetlands adjacent to the East River and upstream of Cement

Creek Road. It could also help address dewatering of the East River and flooding in the CB South municipal area.

C. Summary of Potential Lake Fork of the Gunnison River Projects Identified Through Needs Assessment Process

- Pete's Lake Project – This project involves the protection and enhancement of the Pete's Lake wetlands in the Town of Lake City to provide improved habitat for birds and other wetland species, while simultaneously increasing water storage and creating additional recreational opportunities such as increased hiking/biking trails and fishing access.



- Town Ditch Project – This project would explore the potential to expand the Town Ditch system from the existing Town headgate on Henson Creek. This will help reduce the pressure on Town Wells and allow for denser development with the Town municipal water supply areas.

Town Ditch Project

- Town Ditch Project (2) – The project would include investigating the expansion of the Town water supply area to include the needs of residences upstream of town to Vickers Ranch (which has its own water supply system). This area along the Lake Fork is extremely rocky with steep canyon walls, which makes it difficult to reach groundwater.

- West Slumgullion Creek Sediment Control – This project would involve exploring engineering options to slow deposition of Slumgullion sediment into Lake San Cristobal.

West Slumgullion Creek Sediment Control

- Fleece Ilma Mine Site Sediment Control – The potential project would include working with land owner, DRMS, and EPA to determine ways to prevent sediment pond releases into Lake San Cristobal. The ponds are currently filling up with metal laden waters and sediment.

Fleece Ilma Mine Site Sediment Control

- Lake San Cristobal Outlet Management – This project would involve investigating water level management impacts and options at the Lake San Cristobal outlet to promote more natural draw down to support wetland processes and habitats at the conserved wetland area at the lake inlet, This wetland is an important habitat for a number of species of concern, and it is not currently known what impact maintaining the lake at full levels has on the flora and fauna.

- Town of Lake City River Restoration Project – Phase III – This project would involve completing the river restoration work in the Town of Lake City in order to provide bank stability, better fishing habitat, and improve water conveyance to an existing fishing pond.

- Lake Fork Fishing Access and Education Project – This project involves developing signage form Sherman downstream to Blue Mesa Reservoir to delineate public and private land, mapping of public fishing access areas, and promotion of more catch and release areas. This would also include outreach to anglers, and this would be an important component of the project.

- Boaters Education Project – The project would involve developing proper signage at river put ins and take outs to educate boaters about safety and trespass issues as well as optimal floating levels for different water craft. The area of focus for this project would be from the Town of Lake City at Memorial Park and along Henson Creek, downstream to Blue Mesa Reservoir. This project would include outreach to land owners regarding Right to Float laws and to gain more support for such recreational uses. Also, signage and infrastructure would be installed to indicate public sections of the river where boaters can stop.

- Lake Fork River Recreation Corridor Establishment Project – This project would involve improving river access and recreational infrastructure from lower Henson Creek down through Town to the sewage treatment plant. This would include expanding the river interpretive trail, acquiring easements to the river, improving bank stability to facilitate easier access to the river, and signage to indicate private and public lands.

Chapter 9
Options for Improved Water Use Efficiency

A. Ohio Creek

- Water Distribution and Irrigation Scheduling Project – This project will include infrastructure improvements for ditches on Lower Ohio Creek to improve control and water management. Irrigation shortages and over irrigation were issues identified by stakeholders. This project will require a contractor with irrigation design experience.

Water Distribution and Irrigation Scheduling Project

- Dry Year Shortage Mitigation Project – The project would involve evaluating volumes and locations where storage can best support base flows for irrigation and ecological uses. This project will require contractors with engineering hydrologic, ground water, and restoration experience to guide the effort.

Teachout Ditch Loss

- Teachout Mesa Ditch Conveyance Improvement – Water right owner would like to reduce ditch losses allowing more water to be delivered to the irrigated field. This project will require a contractor with experience designing irrigation systems. Trout Unlimited has secured $50,000 to assist in a conveyance improvement trial.

- Hyzer Videl Miller Irrigation Shortages – This project will involve modeling flows by year types to evaluate coordination and efficiency options to improve water availability upstream of the diversion.

B. East River

- East River No. 2 Diversion Structure – The project would address issues identified by stakeholders and would involve identifying solutions to improve administration of minimum bypass flows. The project would also include redesigning the structure and continuing to explore beneficial options for the Verzuh Young Bifano, Verzuh, and East River No. 2 ditches.

C. Lake Fork

- Elk Creek Ditch Improvements – This potential project will include identifying water management options and ditch improvements for Elk Creek, which currently suffers from regular dry-up during the irrigation season due to over-appropriation.

Appendix A

This appendix documents the Gunnison Basin Models and the changes that were made in support of the Upper Gunnison WMP effort. The original model documentation is not repeated here, but is referenced frequently. The goal of the appendix is to allow the reader to understand how Wilson Water Group refined the model to meet the needs of the project.

For the complete CDSS Gunnison Basin Model documentation, refer to the *Gunnison Historic CU* (2016) and *Gunnison River Basin Water Resources Planning Model User's Manual* (2016), found at https://www.colorado.gov/pacific/cdss/modeling-dataset-documentation.

This appendix also provides detailed information on the status of the existing data, the review process implemented by Wilson Water Group (WWG), how WWG refined the data, how the models were updated to include the refined data, and the appropriate application of the models.

Gunnison Basin Model Overview

The State of Colorado, through the Colorado Water Conservation Board (CWCB) and the Colorado Division of Water Resources, has developed and updated the Colorado Decision Support System (CDSS) to aid in water resources planning. The Decision Support System consists of a database of hydrologic and administrative information (HydroBase) related to water use in Colorado, and a variety of tools and models for reviewing, reporting, and analyzing the data. CDSS uses two primary models: consumptive use model platform (StateCU) and water right allocation model platform (StateMod).

HydroBase, StateCU, and StateMod were utilized for the Upper Gunnison WMP. The input data for the models was primarily derived from HydroBase. StateCU estimates the amount of water required by the crops or the irrigation water requirement (IWR), given the irrigated acreage, crop type, irrigation practices and efficiencies, and monthly time series of temperature and precipitation. This results in a good understanding of the existing crop demand. StateCU is used in the Gunnison WMP to estimate the amount of water delivered to the crops, based on historical diversion records, return flows from up-gradient ditches, irrigation practices and efficiencies. This results in a good understanding of current consumptive use. The difference between the IWR and the current consumptive use is the crop consumptive use shortage. Consumptive use shortage impacts crop yields and the economic viability of agriculture.

The existing crop demand, consumptive use, and shortage results from StateCU are reported in Section 3. Additionally, crop demand from StateCU is provided as input to the Gunnison Basin StateMod Model. StateMod is the best available tool for estimating the change in water available for beneficial use, both consumptive and non-consumptive, under varying hydrologic conditions. StateMod is a general water rights allocation model which determines availability of water to individual users and projects based on hydrology, water rights, delivery capacity, and demand.

The Gunnison Basin StateMod Model (Gunnison Basin Model) represents the full extent of the watersheds within the Upper Gunnison River Water Conservancy District – as well as all other watersheds in the Gunnison River basin, including complex operations associated with the Aspinall Unit reservoirs and the lower Gunnison River basin. The Gunnison Basin Model user documentation is available on the CDSS website and provides detailed information on model development, calibration, and operations.

The Gunnison Basin Model was first developed in 1994. The model was updated in the late 1990s and most recently in 2015. The model has a monthly Historical Calibration scenario and a Baseline scenario. The Historical Calibration scenario represents changing conditions through time and throughout the basin as accurately as possible. This historical representation was used to calibrate the model, with an emphasis on matching simulated and observed streamflow, diversions, and reservoir storage. As part of the Upper Gunnison WMP effort, the Gunnison Basin Model calibration was updated, as discussed in detail below.

The CDSS Baseline Scenario builds off the Historical Calibration scenario but applies only current demands and assumes all existing water resources systems were on-line and operational throughout the hydrologic model simulation period. Although historical diversions may have been limited by physical supplies (hydrology), legal (water rights) availability, or irrigation practices (such as user-decisions not to irrigate after haying); baseline agricultural demands represent full crop irrigation use. This allows the model to determine if historical shortages were due to physical or legal water limitations, providing an understanding of why there were agricultural shortages. This Baseline Scenario is an appropriate starting point for evaluating various “what if” scenarios over a long hydrologic time period containing dry, average, and wet hydrologic cycles

As indicated in the Gunnison Basin Model user documentation, the key results of the most recent major update (2015) to the Gunnison Basin Model prior to the UG WMP effort are as follows:

- A water resources planning model has been developed that can make comparative analyses of historical, current, and future water management policies in the Gunnison River basin. The model includes 100 percent of the basin's surface water use.
- The model has been calibrated for a study period extending from calendar years 1975 to 2013.
- The calibration in the Historical scenario is considered very good, based on a comparison of historical to simulated streamflow, reservoir contents, and diversions.
- A Baseline data set has been prepared which, unlike the Historical data set, assumes all existing water resources systems were on-line and operational for calendar years 1909 to 2013.

Upper Gunnison WMP Modeling Approach

The approach for the Gunnison WMP modeling was to start with the existing CDSS models and refine them to meet the needs of the project. In order to refine the models, the input data to the models needed to be evaluated and updated, if possible. WWG developed a review process and this appendix documents how the data was refined, how the models were updated to include the refined data and the appropriate application of the models. As part of the Gunnison WMP, the following information required for the Gunnison StateCU and StateMod models was reviewed and refined:

1. Streamflow measurements
2. Climate data
3. Irrigated acreage
4. Water rights
5. Diversion records
6. Irrigation practices
7. Return flow parameters

Additional discussion on the data assessment is found in Section 2.

Data Assessment and Refinement

The quality of model results is limited by the quality of the input data; high quality information provided to the model allows the model to produce high quality results. In order to provide the most useful Gunnison models possible, WWG needed to review the information used to generate model inputs. The review process identified several areas that needed refinement in order to allow the models to produce results on a finer temporal and spatial scale than previously developed. This section discusses the data components that required refinement and the limitations of available information.

Streamflow Measurements

The streamgage records are recorded by USGS include estimates. According to the USGS, the streamflow measurements for the majority of the gages are “good except for estimated daily discharges, which are poor”. A good rating indicates that “95% of the daily discharges are between 10 and 15% of true value.” Estimated daily discharges are generally reported in the winter months and are likely poor due to icing issues.

Diversion Records

As discussed in Section 2, diversion records in the basin lack the temporal resolution necessary for a daily model. Ideally, a daily model would be provided with the average daily diversion at each diversion structure. However, there are no diversions with continuous records, so average daily diversion records are not available. Instead, diversion records are composed of "spot-diversions" that are reported on an irregular basis by the water commissioner. This information is more appropriate for a monthly time step model, depending on the frequency of the spot measurements relative to changes in the diversion amount. However, the monthly time step was not useful for the Gunnison WMP because the issues of concern occur on a daily or even hourly scale. The diversion record limitations impose limitations on the model quality.

Irrigated Acreage

It is essential to accurately represent the irrigated acreage and the associated irrigation demand because the majority of consumptive water use is for irrigation. As part of CDSS, CWCB has developed irrigated acreage snapshots through time. As part of the WMP, the more recent CDSS 2015 irrigated acreage coverage was significantly enhanced specifically to better represent irrigation use. The primary enhancements relate to parcel size and water supply (ditch) assignment more than a bulk change in the overall acreage. The irrigated acreage assessment is outlined in more detail in Section 2. These changes were critical to allow the model to more accurately determine physical and legal availability of water and any associated shortages, a critical component of the WMP needs assessment. In addition, streamflow estimates between structures also improved due to the more accurate representation of irrigation demands.

Return Flow Parameters

Representing return flow quantities, locations, and timing are critical for understanding current conditions in the basin and for investigating how changes to current irrigation practices impact downstream flows. Many of the opportunities to improve watershed health include changes in irrigation use, including efficiency improvements.

Existing return flow parameters were developed on a courser scale than was needed for the Gunnison WMP. The return flow parameters were reviewed and refined by WWG to account for the finer scale required.

Return Flow Quantities

Return flows are generally considered in two components; return flows from ditch seepage and return flows from field irrigation application. In previous CDSS efforts, lack of information necessitated that these two return flow components be combined. For the StateMod model to be useful in predicting changes to return flows and associated water available for downstream water rights, and changes to streamflows for specific demonstration projects and future identified options, it was critical that the two components of return flows be disaggregated and refined.

The first component of return flows is from ditch seepage as water is conveyed to the irrigated acreage, represented in the models as conveyance efficiency. Understanding conveyance efficiencies allows a better estimate of diverted water that makes it to the farm for irrigation use. Prior to the Stream Management Planning process, ditch alignments had not been mapped for the majority of ditches in the Upper Gunnison Basin – either digitally in GIS or on paper maps. As part of matching funding for the project, DWR provided funding for WWG to develop ditch alignment GIS coverage for the entire Upper Gunnison Basin. Previously, DWR used GPS to site river headgate locations. The headgate information, along with the updated irrigated acreage assessment, was used to create the initial ditch line-work. WWG relied on the local water commissioners for review and approval of the effort. Each ditch alignment was assigned to the water district identifier in the GIS attribute table; allowing a link between the headgate GIS coverage and the irrigated acreage GIS coverage. WWG worked with CWCB to assure the process and review were documented in the GIS metadata and the coverage made available on the CDSS website. The resulting ditch lengths, along with statewide soil parameter coverages were used to better understand and quantify conveyance efficiencies. The NRCS has developed relationships between ditch length and soil types. These relationships are found in the *Farm irrigation Rating Index (FIRI) - A method for planning, evaluating, and improving irrigation management* (June 1991) and are used for this project. The ditch conveyance efficiencies, coupled with estimated or reported diversions, are used to quantify ditch seepage. During WWG interviews with water users in the basin, WWG confirmed that the estimates of ditch seepage were reasonable. Water users agreed with our average values, with the caveat that ditch seepage can be significantly higher than the average values at the beginning of the season.

The second component of return flows is generated from on-field irrigation application. Information from decrees, soil parameter coverages, and UGRWCD staff indicate that the local gravelly soils, coupled with flood irrigation, allow a maximum application efficiency of 45 percent. Unlike ditch conveyance efficiency, application efficiency varies significantly with water supply, as it takes much more effort to be efficient. In general, application efficiencies are lower during the higher runoff period and in wet summers. Application efficiencies approach 45 percent in the later irrigation season in normal years and throughout the season in dry years. The maximum application efficiency is a function of both crop irrigation requirements and estimated or reported diversions and is calculated by both CDSS models.

Return Flow Locations

The CDSS modeling effort generally estimated that return flows accrued to the river above the next downstream ditch. As discussed above, significant effort was made to refine StateMod return flow locations for both ditch seepage and application losses, which is critical for understanding how changes would impact water users and streamflow. The primary information source was GIS mapping, including the ditch alignment coverage, irrigated acreage coverage, topographic coverages, and coverages showing local drainages and tributaries. Information from interviews with water users and the water commissioner was used to supplement and enhance return flow locations for the larger ditches. As discussed in Section 2, information from the interviews was used to understand and represent irrigation surface return flows that accrue directly to down-gradient ditches.

In many parts of the Upper Gunnison Basin, return flows do not simply re-enter the stream. This is a relatively unique set-up and is not common in other parts of Colorado. In these cases, return flow moves across the surface of fields and through the sub-surface groundwater system, and directly enter the next down-gradient ditch. Therefore, these return flows serve as a supply to a down-gradient ditch or irrigated parcel without being measured at the down-gradient ditch headgate. The ramifications of this are significant. In areas with high concentrations of irrigated parcels (i.e. the lower East River and Ohio Creek), water is diverted and measured at up-gradient headgates, some of which is immediately consumed by the hay crop. Surface return flows often are capture and reused by down-gradient ditches without re-entering the river. This unmeasured supply can be significant for the down-gradient ditch and help eliminate consumptive use shortages. It also means that the StateMod model needs to have the correct return flow locations, or the model will simulate incorrect amounts of streamflow between diversion headgates.

Return Flow Timing

A portion of return flows from irrigation application "runoff" directly to drainages, tributaries, or down-gradient ditches within a few days of irrigation application, while a portion of return flows percolate through the ground water alluvium and lags back to the river over several days or months. Based on information from water users and decrees, and CDSS investigations, it was estimated that the portion of return flows from diversion and subsequent flood irrigation that return quickly as surface runoff is as high as 50 percent.

A common method for estimating return flows that lag through the ground water system is the Glover analytical solution. The method requires estimates of alluvial aquifer properties, generally obtained from pump tests performed on existing high-capacity wells. Review of available information did not yield additional ground water property information beyond what was used in CDSS to estimate return flow lagging patterns in the upper Gunnison River basin. The existing CDSS patterns were discussed with water users and the water commissioner and determined to be appropriate for continued use.

The existing CDSS patterns were used in the Gunnison Model and are described in the *Gunnison Model User's Manual* (2016) as:

- Instantaneous (within the same time step as the diversion) returns,
- Artificial snowmaking returns in the fourth month following the diversion,

- Irrigation return flow pattern, which represents both surface water and shallow groundwater returns

The existing irrigation return flow pattern assumes that a portion of return flows will occur as surface water returns, such as tailwater or flood irrigation application water that did not soak into the ground, and a portion will occur as shallow groundwater. Note that incidental losses in the Gunnison are estimated to be 3 percent of unused water. This accounts for water lost to the hydrologic system through non-crop consumptive use, deep groundwater storage, or evaporation. It is assumed the incidental losses occur in the same month as diversions.

In order to correctly represent the timing of return flows for the daily model, two new irrigation return flow pattern was developed: daily irrigation immediate return flows and daily lagged return flows. Discussions with water users suggested that irrigation immediate return flows appear the day after diversion and last for approximately three days. The daily lagged return flows represent irrigation water that has soaked into the ground and is slowly seeping into a stream or down-gradient ditch. The timing of the lagged return flows is shows in Figure 1.

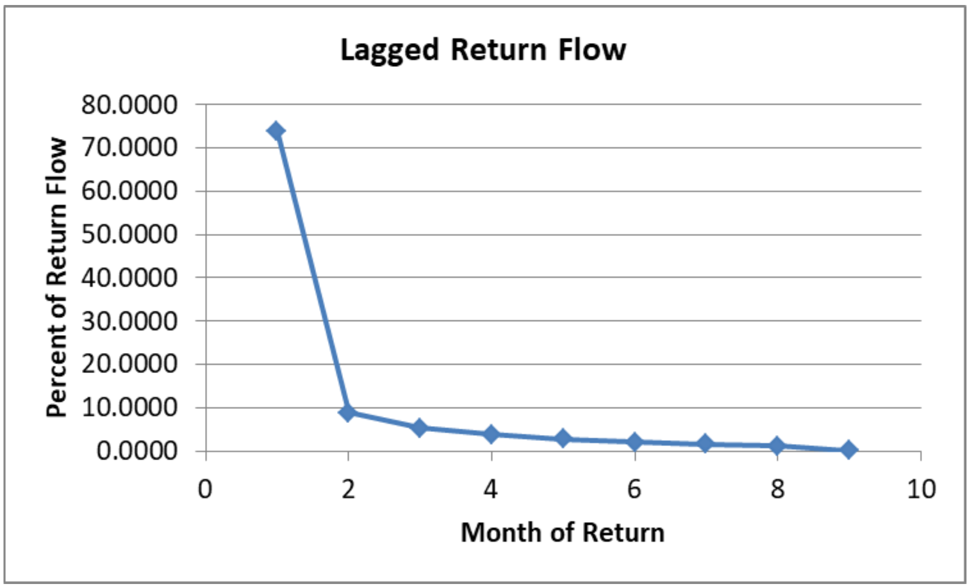


Figure 1: Monthly Lagged Return Flow Pattern developed for Upper Gunnison WMP

UG WMP Model Enhancements

The Gunnison Basin Model underwent significant updates as part of the WMP effort. These updates were based on data collection and user-interviews so that individual reaches could be better represented and evaluated for impacts to existing consumptive and non-consumptive uses. As discussed in Section 2, the data collection and user-interview process also highlighted uncertainties in data that is available for model development. Based on the data collection efforts, it is important to stress that the model should not be relied upon to provide absolute information, including predicted reach streamflows. Instead, the model should be used to compare “what if” scenarios. For example, the model can examine how water availability changes with new demands or operations. Note that this is how the StateMod platform has been used in the past for state-wide water planning efforts, such as the Colorado Water Plan.

For the Gunnison WMP effort, the modeling team focused on refining the Historical Scenario. The updates to the Gunnison Model included incorporating the reviewed and refined data discussed above. Specific enhancements are:

- Incorporating the updated irrigation assessment developed for the UG WMP.
- Disaggregating irrigation diversions so that each headgate is represented as a single structure.
- Updating return flow locations to represent the disaggregated diversions and to capture return flows that move directly into down-gradient ditches, without returning to the stream.
- Representing both conveyance efficiency and irrigation application efficiency, instead of the previous model representation of overall system efficiency.
- Increasing explicit representations of tributaries (added Perry Creek, Coal Creek, Washington Gulch, Pass Creek, Middle Creek, Willow Creek, Henson Creek, and Elk Creek to model).
- Including explicit representation of municipal/industrial water users (Town of Crested Butte, Mount Crested Butte Water and Sanitation District, Mount Crested Butte snowmaking, and Lake Fork City).
- Adding representation of Lake San Cristobal.
- Adding the transbasin import from Lake Irwin to Coal Creek.
- Increasing the number of instream flow reaches explicitly represented.
- Extended the model period from 2013 through 2017.
- Updated the natural flow distribution to ungaged locations.
- Converting the model from a monthly to a daily timestep (discussed in more detail below).
- Re-calibrating the monthly and daily model.

Structure Disaggregation

An important enhancement to the Gunnison Basin Model that directly supports the UG WMP effort involved disaggregating structures within the model and refining return flow location assumptions. The 2015 version of the model was developed with the main purposes of performing basin-wide, comparative analysis such as shortages or impacts of reservoir operations. For this purpose, representing smaller ditches as a single “aggregated” structure was appropriate. However, the UG WMP goals require streamflow to be evaluated at a higher resolution, reach by reach, and thus each ditch in aggregated model structures is now represented individually at the location of diversion.

Once the diversions were more discreetly represented, another important step included improving return flow location assignments. As noted above, previous versions of the model were intended for more course comparative analysis at a monthly timestep. The UG WMP's disaggregation enabled the model to more precisely identify where return flows, mainly from flood irrigation, re-entered the stream. Information gained from meetings with the Water Commissioner and irrigators helped inform these updated return flow location assignments.

Daily Timestep

One of the most significant changes to the Gunnison Basin Model was the conversion from a monthly timestep to a daily timestep. From a project evaluation and water resources planning standpoint, a monthly timestep is typically appropriate; therefore, the CDSS modeling focuses on development and updates to monthly models. For the UG WMP effort, daily information was needed to assess impacts on non-consumptive needs. Note that the daily model routine in StateMod does not include streamflow routing. While this is not appropriate for an operational model, it is appropriate for a planning model and for use in comparative modeling.

To convert from a monthly timestep to a daily timestep, the monthly naturalized streamflow is distributed to daily timestep based on pattern gages. This preserves the volume of the monthly naturalized streamflow. The daily pattern gages are selected by location to best represent natural conditions. Care was taken to find suitable pattern gages that resulted in good calibration and captured the timing of snowmelt. The daily pattern gage approach requires a complete daily gage record; therefore, due to data availability limitations, the daily model simulation period represents the more recent hydrologic time period of 1998 through 2017. The period from 1998 through 2013 includes dry, wet, and average runoff cycles; plus represents current basin operations and administration.

To convert the monthly diversion demands to daily, the monthly diversion demands were distributed based on a linear interpolation between the monthly mid-points. This option also allows the continued use of monthly irrigation water requirements from the StateCU model. The drawback to this approach is that irrigation practices, such as turning off diversions to dry the field before cutting hay, or gentleman's agreements to rotate diversions between ditches to share the limited supply, are not represented in the daily model. However, the lack of daily diversion records seriously limits the available options for a daily model.

Daily instream flow demands are represented based on their water rights.

Natural Flow Development

Natural flow development is a key step in building a StateMod model. This process is documented in the *Gunnison Basin Model User's Manual* and summarized below.

In order to simulate river basin operations, StateMod begins with an estimate of the amount of water that would have been in the stream without the impact of man. These "Natural Flows" allow any future water right or operating strategy to be imposed on a naturalized historical hydrologic sequence. StateMod estimates naturalized flows at streamgages based on gaged flow, historical diversions, reservoir operations, water use efficiency and return flows. This process is performed prior to a simulation so that the resulting naturalized flow file becomes part of the input data set for a subsequent simulation. Naturalized flow estimation requires a minimum of two steps: 1) adjust gaged flows using historical records; and 2) distribute gains above and between gages to user-specified, ungaged naturalized flow nodes.

Natural Flow Calculation at Gages

Natural flow at a site where historical gage data is available is computed by adding historical values of all upstream depletive effects to the gaged value, and subtracting historical values of all upstream augmenting effects from the gaged value:

$$Q_{Natural} = Q_{Gage} + Diversions - Returns - Imports +/- \Delta Storage + Evap$$

Historical diversions, imports, and reservoir contents are provided directly to StateMod to make this computation. Evaporation is computed by StateMod based on historical evaporation rates and reservoir contents. Return flows are similarly computed based on diversions, crop water requirements, conveyance and application efficiencies, and return flow parameters.

Natural Flow Distributed to Ungaged Points

In order for StateMod to have flow on tributary headwaters, natural flow must be estimated at all ungaged headwater nodes. In addition, gains between gages are modeled as entering the system to reflect increased flow due to unmodeled tributaries.

StateMod has an operating mode that distributes a portion of natural flow at gaged locations to ungaged locations based on drainage area and average annual precipitation. The default method is the "gain approach". In this approach, StateMod pro-rates natural flow gain above or between gages to ungaged locations using the product of drainage area and average annual precipitation. A second option for estimating headwater natural flows can be used if the default "gain approach" method created results that do not seem credible. This method, referred to as the "neighboring gage approach", creates a natural flow time series by scaling the natural flows at a specified gage. This approach is effective when the runoff at an ungaged location does not follow the same pattern as the gains along the main stem. For example, a small ungaged tributary that peaks much earlier or later than the main stem should use the neighboring gage approach with a streamgage in a similar watershed.

Natural Flow Refinement

For the Upper Gunnison WMP model, the natural flow estimates at ungaged locations were refined based on the addition of new tributaries and information provided by the water commissioner and water users.

Figures 2 through 8 show the average monthly natural flow and the observed streamflow at USGS gages throughout the basin from 1998 through 2017, or the period of record for the gage. The difference between the natural flow and the observed streamflow are depletions from consumptive use and retiming of water due to lagging of return flows.

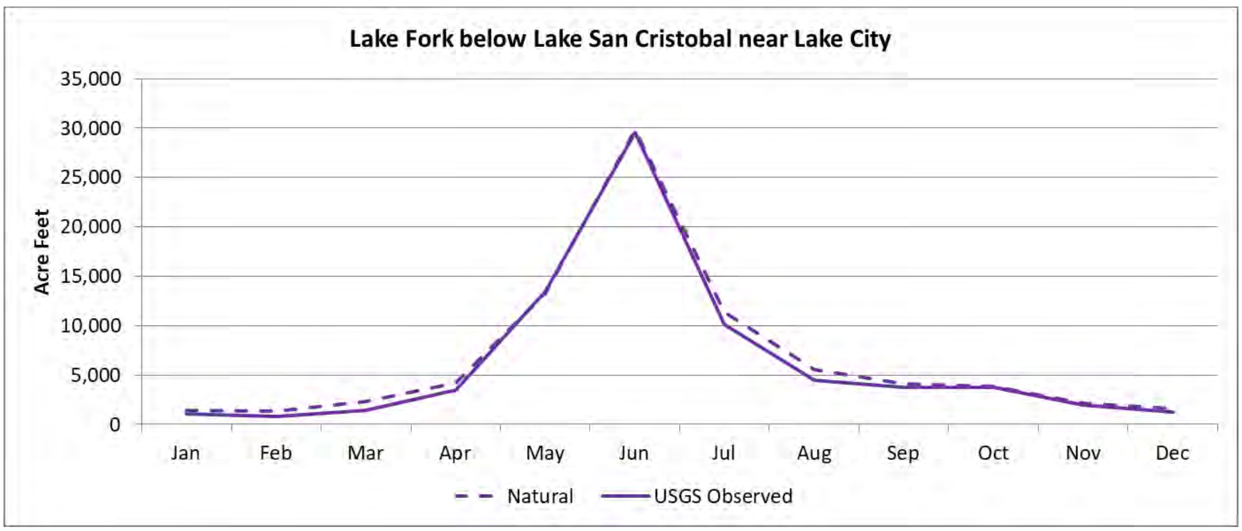


Figure 2: Monthly Average Natural Flow and USGS Gage Flow - Lake Fork below Lake San Cristobal near Lake City, 2012-2017

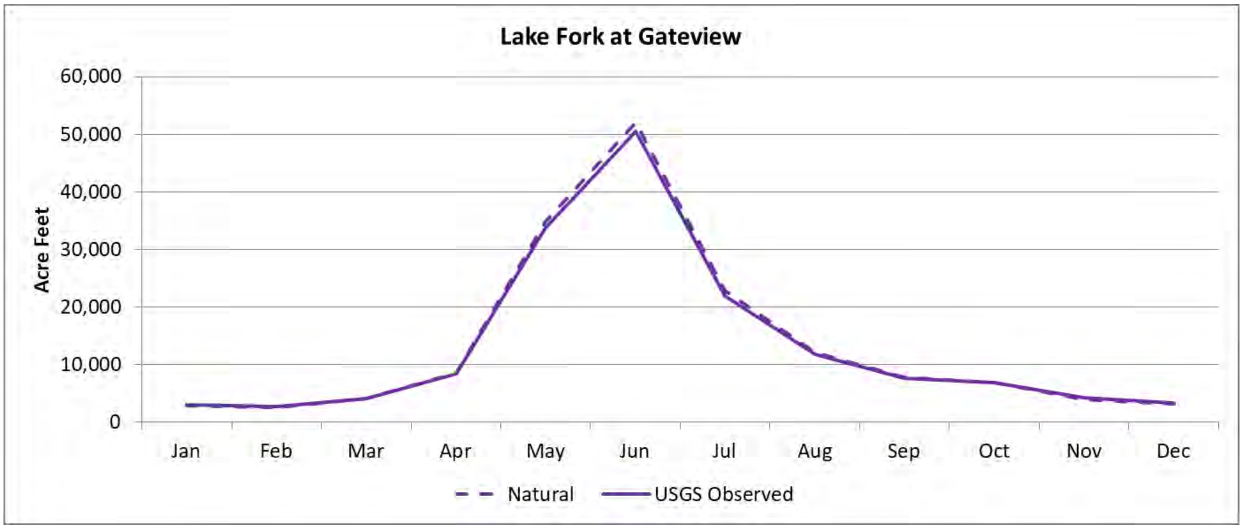


Figure 3: Monthly Average Natural Flow and USGS Gage Flow - Lake Fork at Gateview, 1998-2017

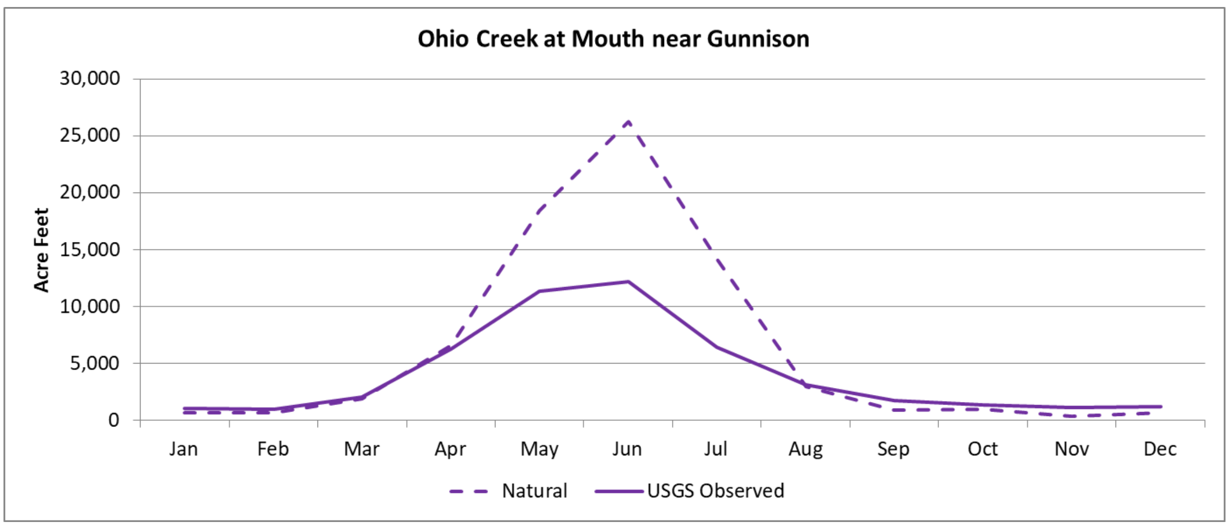


Figure 4: Monthly Average Natural Flow and USGS Gage Flow - Ohio Creek at Mouth near Gunnison, 1999-2017

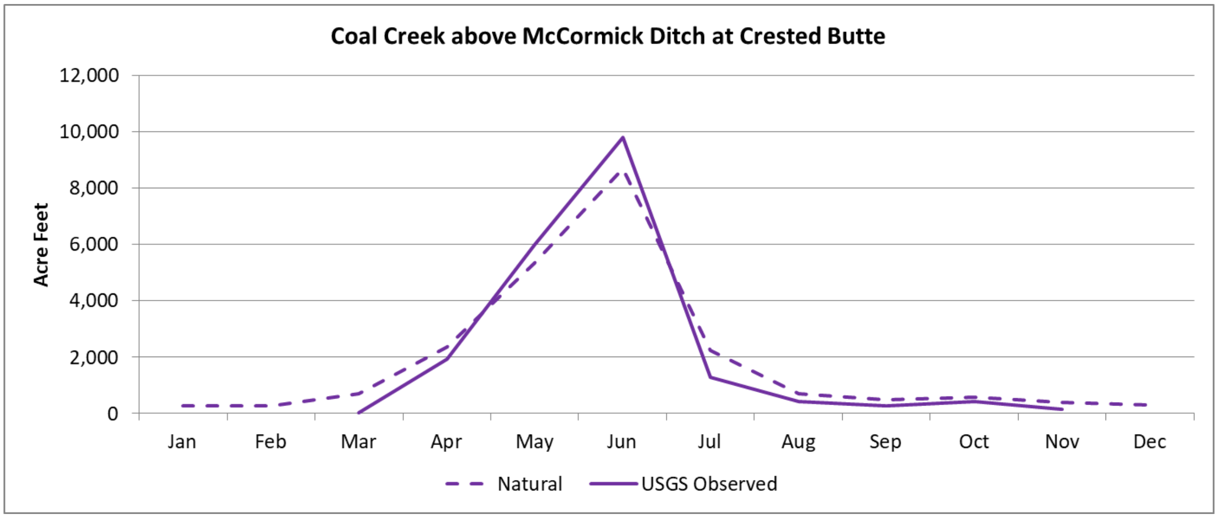


Figure 5: Monthly Average Natural Flow and USGS Gage Flow - Coal Creek above McCormick Ditch at Crested Butte, 2015-2017

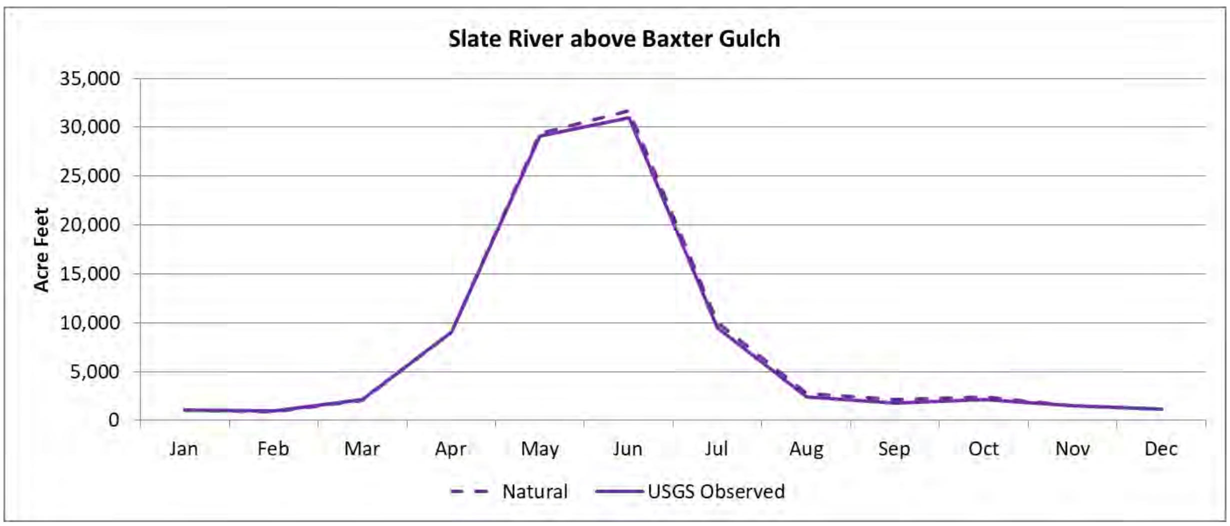


Figure 6: Monthly Average Natural Flow and USGS Gage Flow - Slate River above Baxter Gulch, 1998-2017

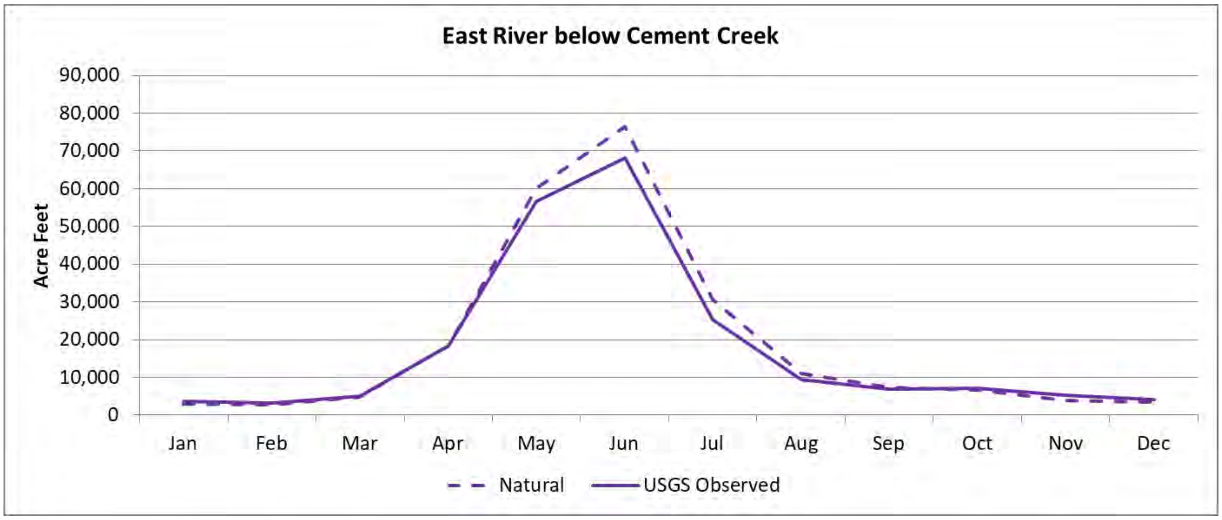


Figure 7: Monthly Average Natural Flow and USGS Gage Flow - East River below Cement Creek, 1998-2017

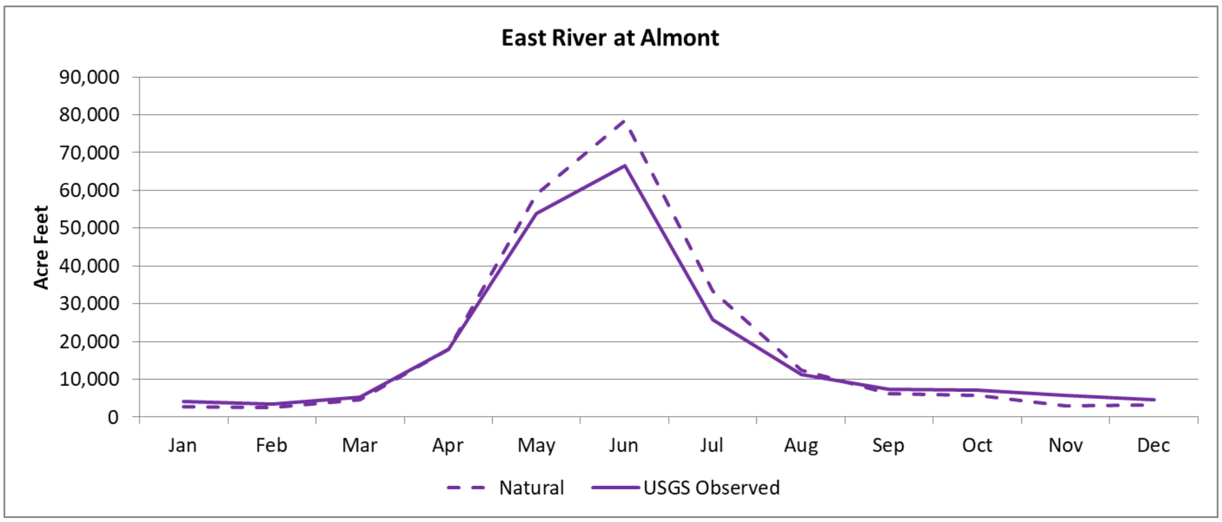


Figure 8: Monthly Average Natural Flow and USGS Gage Flow - East River at Almont, 1998-2017

Model Calibration

The original monthly calibration for the Gunnison Basin Model is considered very good and was improved with the updates made as part of the UG WMP effort, specifically updates to irrigated acreage and return flow locations (described above). The Gunnison Basin Model was re-calibrated at a monthly timestep before converting it to daily; then calibration was also confirmed on a daily basis. As discussed in Section 2, water-users and the water commissioner indicated that there has been cooperation among water users, both within the East River basin and downstream, to share limited supplies and purposefully not place a water rights call on the river. The decision was made to maintain historical water right priorities within the basin and allow representation of the legal priority system. This is consistent with the State of Colorado's approach to StateMod modeling and is a conservative assumption. Because in most years diversions are much less than observed streamflow, this representation results in good calibration.

Figures 9 through **23** show daily streamflow calibration results at three streamflow gage locations in the Upper Gunnison basin: Slate River above Baxter Gulch, East River below Cement Creek, East River at Almont, Ohio Creek above the Mouth near Gunnison, and Lake Fork at Gateway. Time series graphs are shown for both the full daily simulation periods (1998-2017) and for a shorter, more recent period (2010-2012). The period 2010 through 2012 was chosen to highlight because it includes a very wet year (2011), a very dry year (2012), and a relatively average year (2010). In dry years, the model is limiting diversion in order to satisfy senior users; therefore, the model shows more streamflow than was historically observed when senior users did not place a call. This is highlighted in **Figures 19** and **22** for the 2012 dry year.

In general, the model does an excellent job of replicating observed streamflow during both wet and dry year types. In addition, a scatter plot for the full daily simulation period is presented for each location, showing a high correlation between observed and modeled streamflow. The equation on each graph has the y-intercept set to zero and indicates that there is nearly a one to one relationship between observed data and model results. In addition, the correlation coefficient (R^2) is very close to 1.0 which means that there is high agreement between the observed and model results.

Figures 12 through **14** for Ohio Creek above the Mouth near Gunnison show the poorest calibration. This is due to the lack of a continuous daily gage record for the model period of record (1998 through 2017) in Ohio Creek. Therefore, the pattern gage selected to disaggregate the monthly natural flow to daily is the combined Slate River at Baxter Gulch and Slate River at Crested Butte gages. Although the watersheds are similar, they are not identical. The Slate River gages do not exactly capture the timing of runoff and late season draw down in the Ohio watershed.

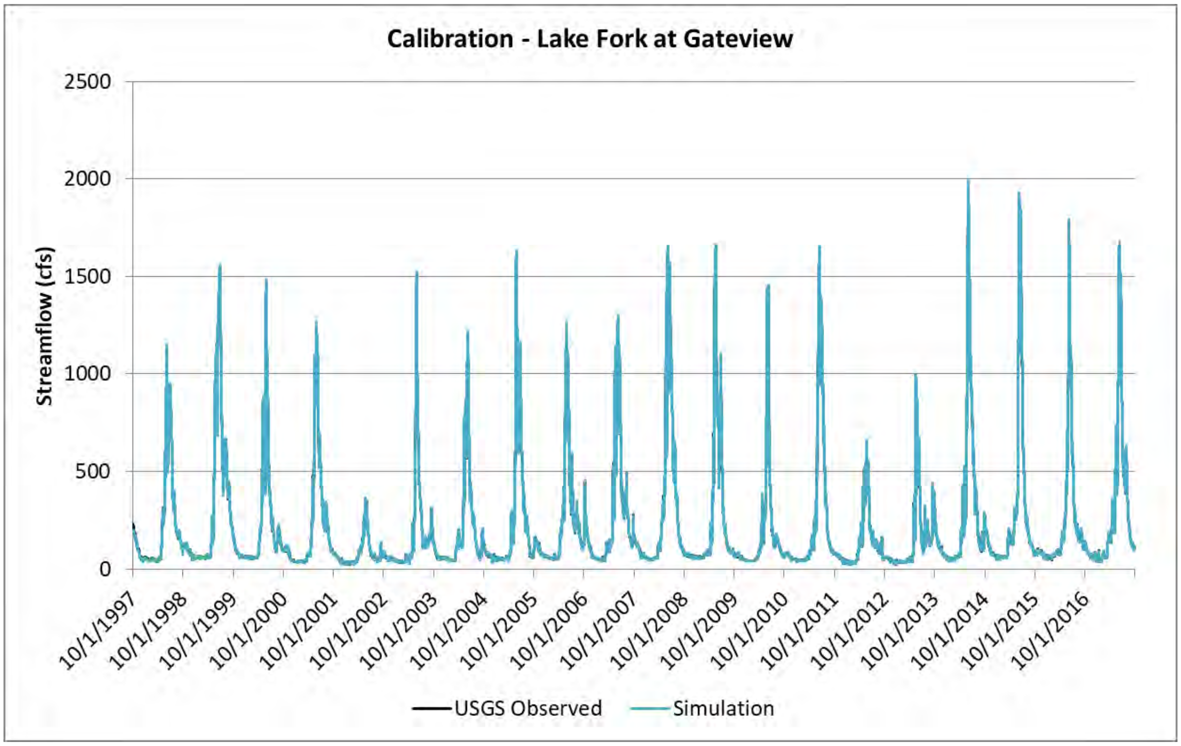


Figure 9: Daily Calibration Time Series - Lake Fork at Gateview, 1998-2017

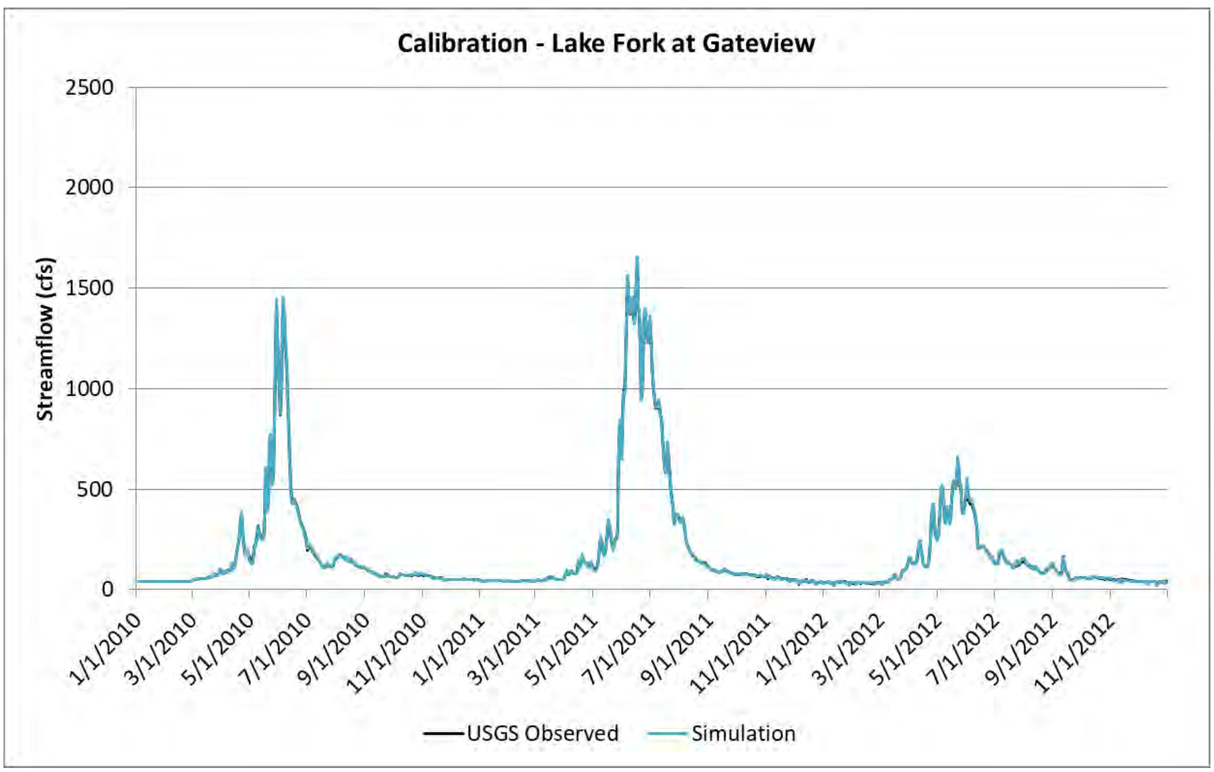


Figure 10: Daily Calibration Time Series - Lake Fork at Gateview, 2010-2012

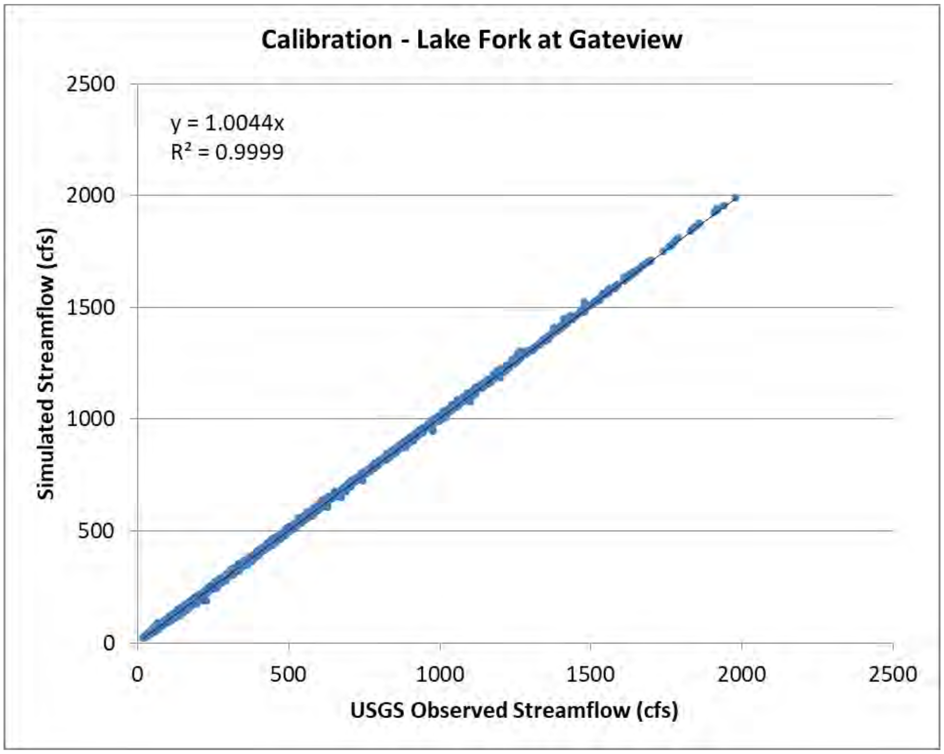


Figure 11: Daily Calibration Scatter Plot - Lake Fork at Gateview, 1998-2017

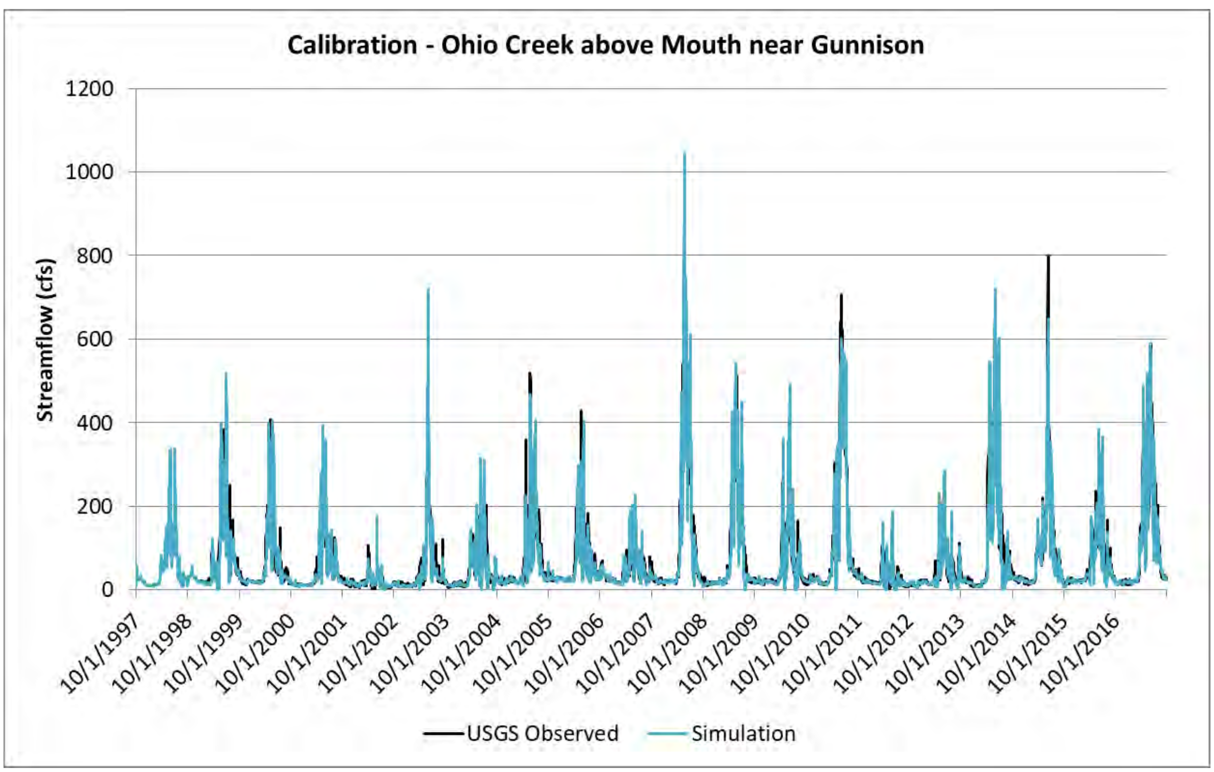


Figure 12: Daily Calibration Time Series - Ohio Creek above Mouth near Gunnison, 1998-2017

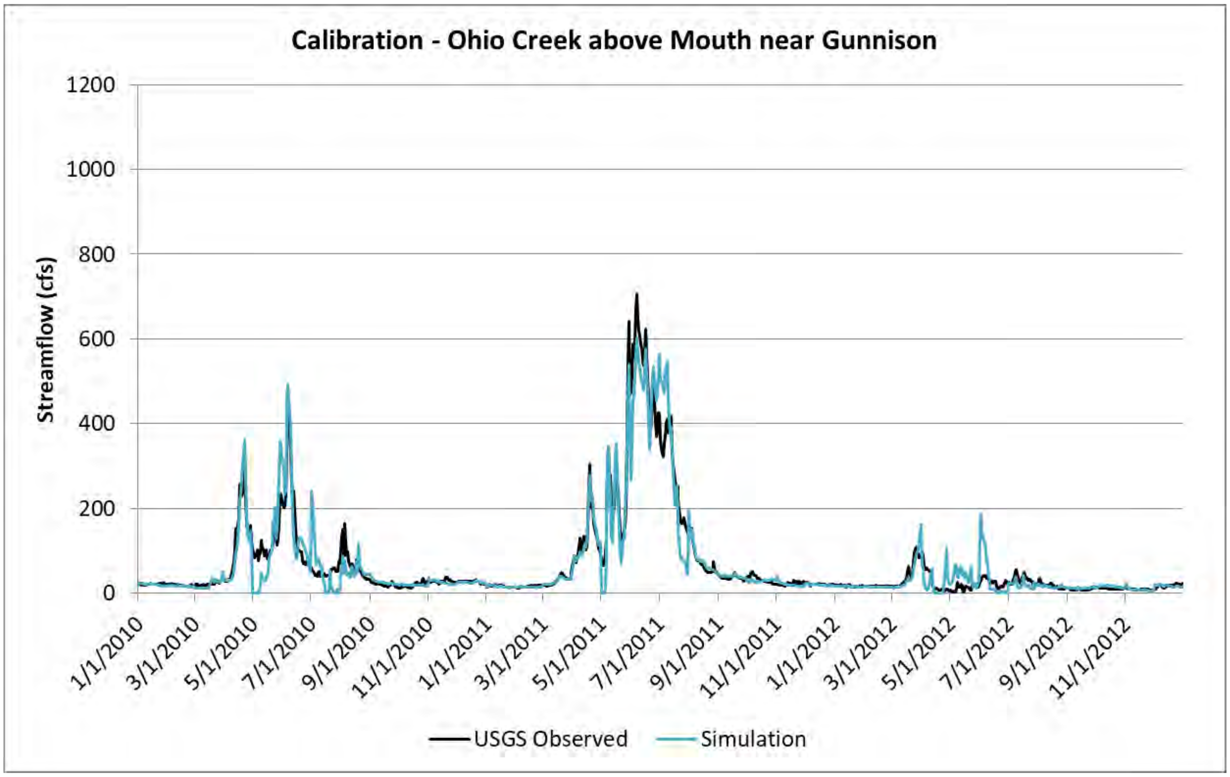


Figure 13: Daily Calibration Time Series - Ohio Creek above Mouth near Gunnison, 2010-2012

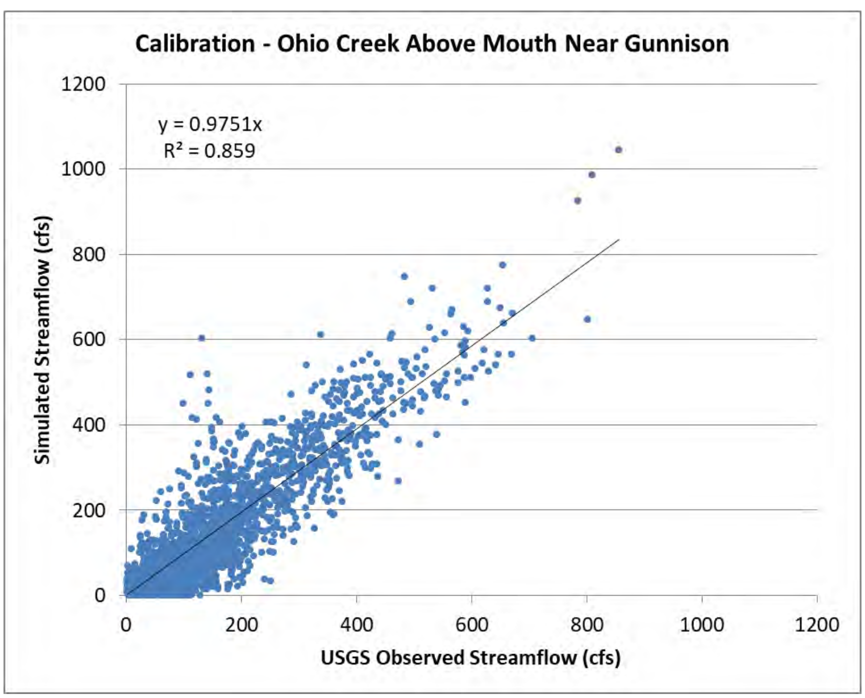


Figure 14: Daily Calibration Scatter Plot - Ohio Creek above Mouth near Gunnison, 1998-2017

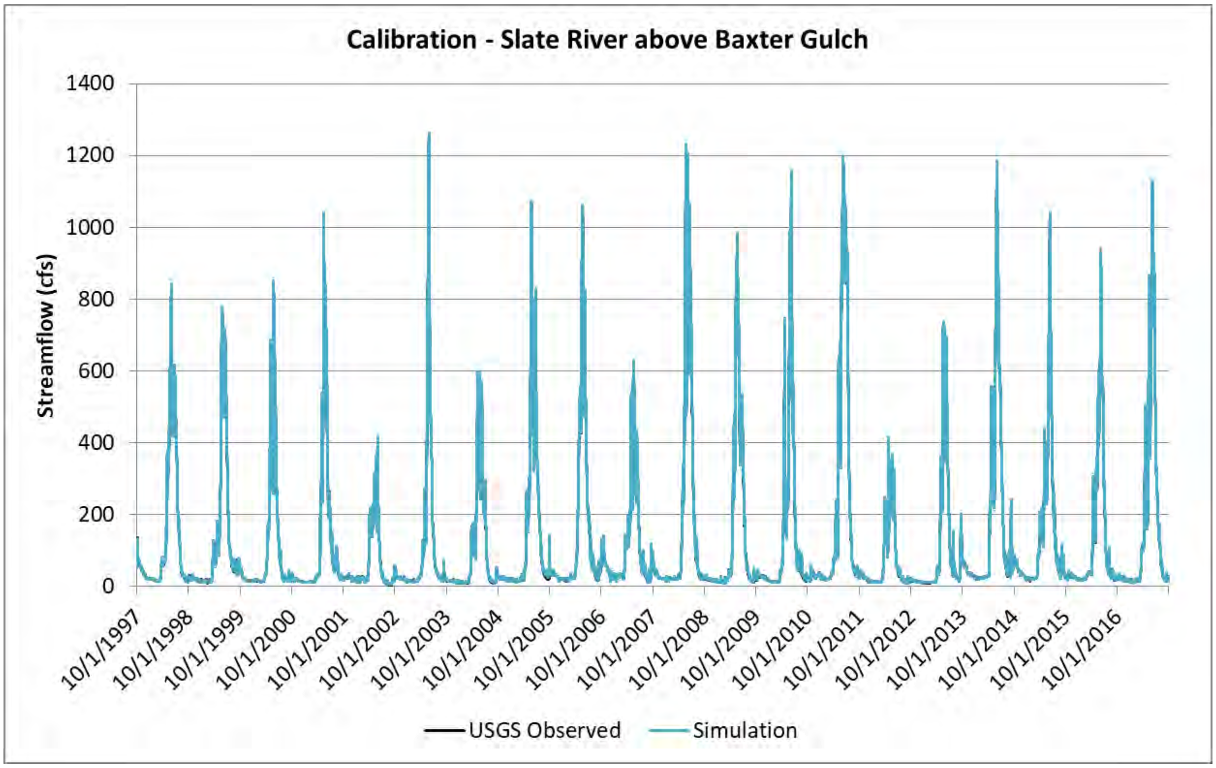


Figure 15: Daily Calibration Time Series - Slate River above Baxter Gulch, 1998-2017

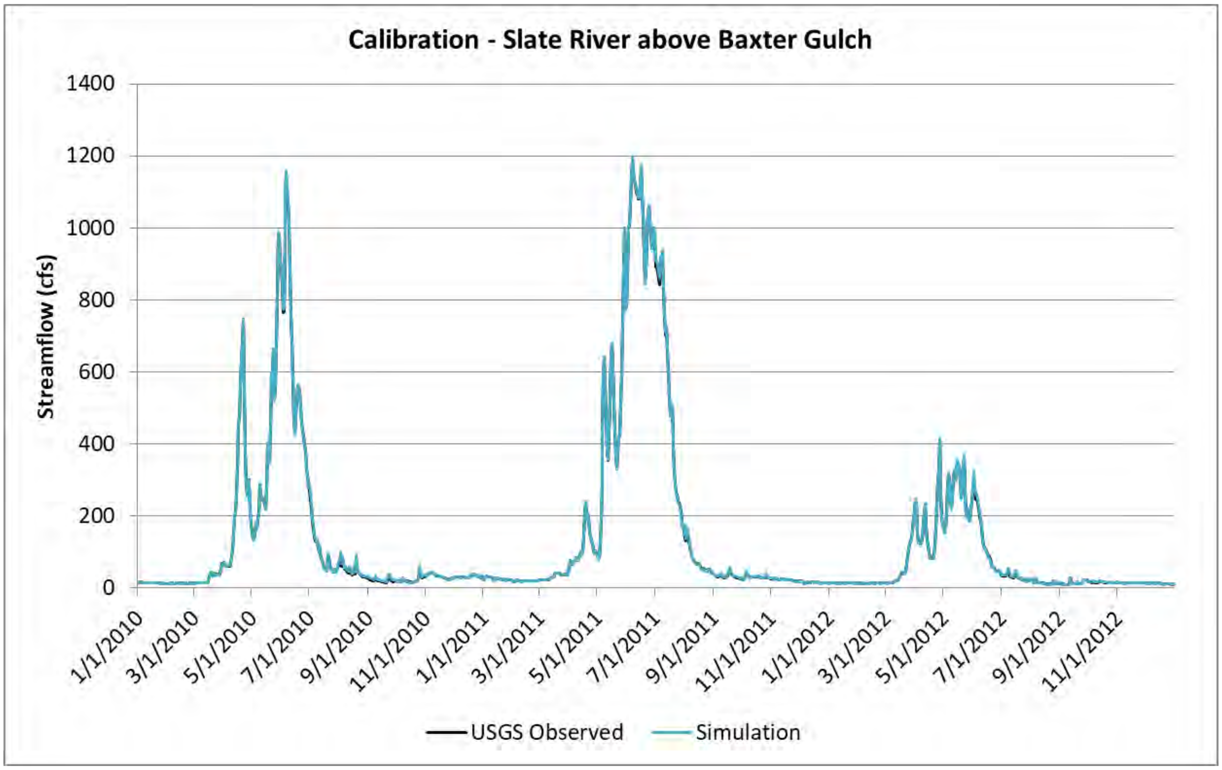


Figure 16: Daily Calibration Time Series - Slate River above Baxter Gulch, 2010-2012

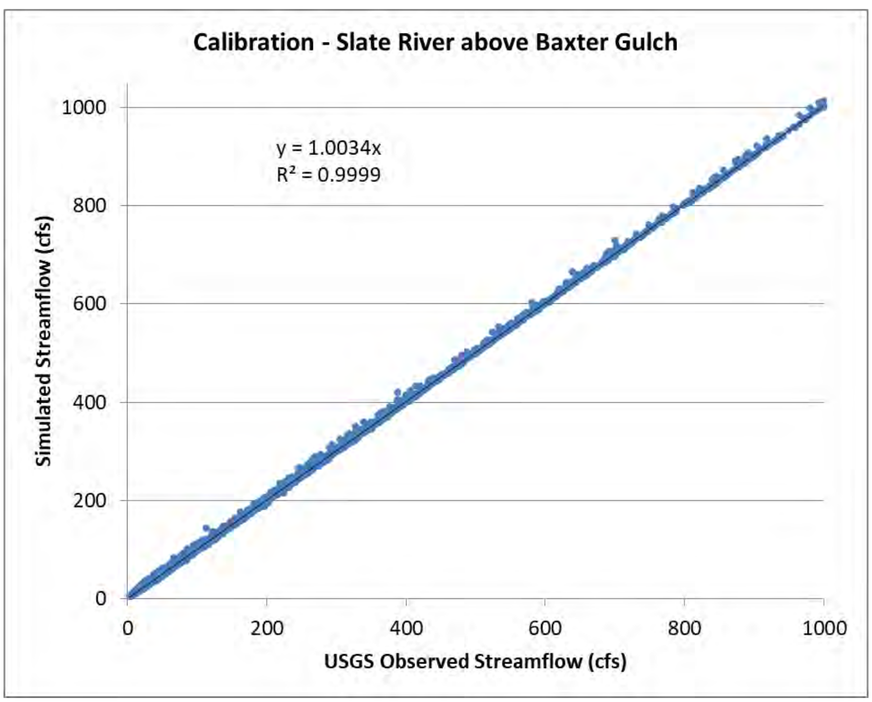


Figure 17: Daily Calibration Scatter Plot - Slate River above Baxter Gulch, 1998-2017

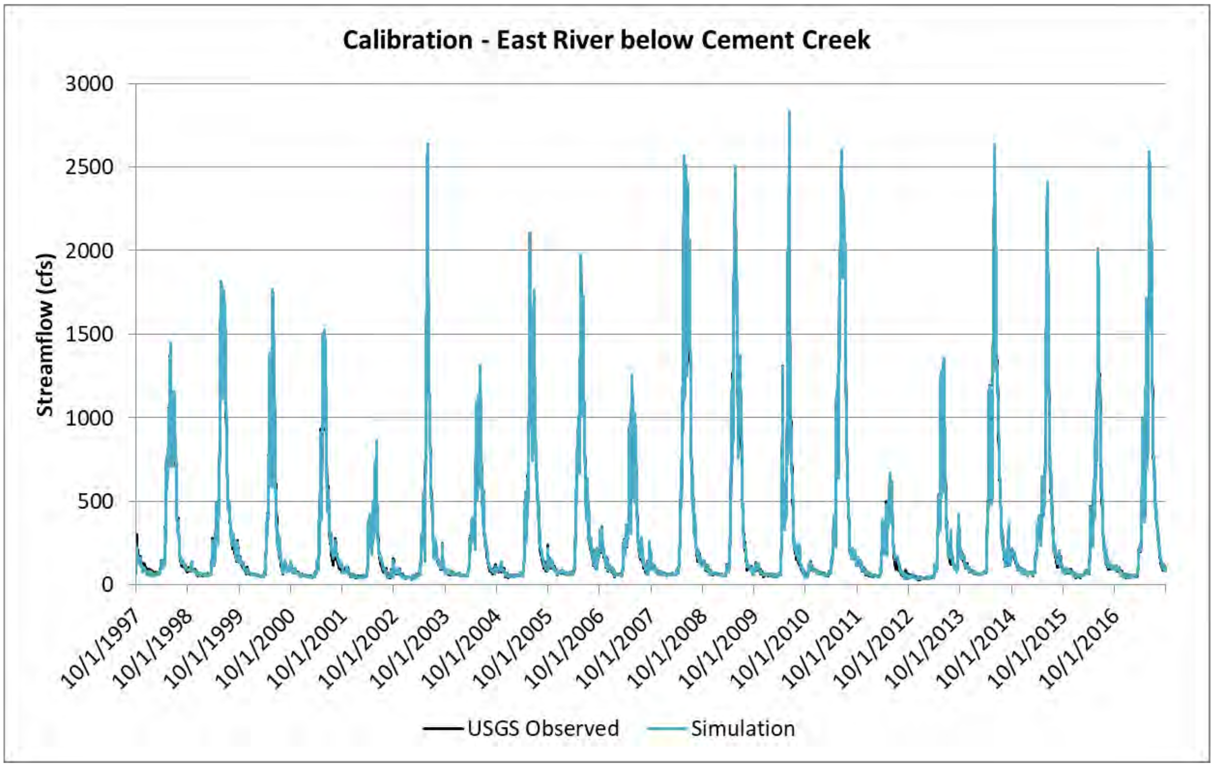


Figure 18: Daily Calibration Scatter Plot - East River below Cement Creek, 1998-2017

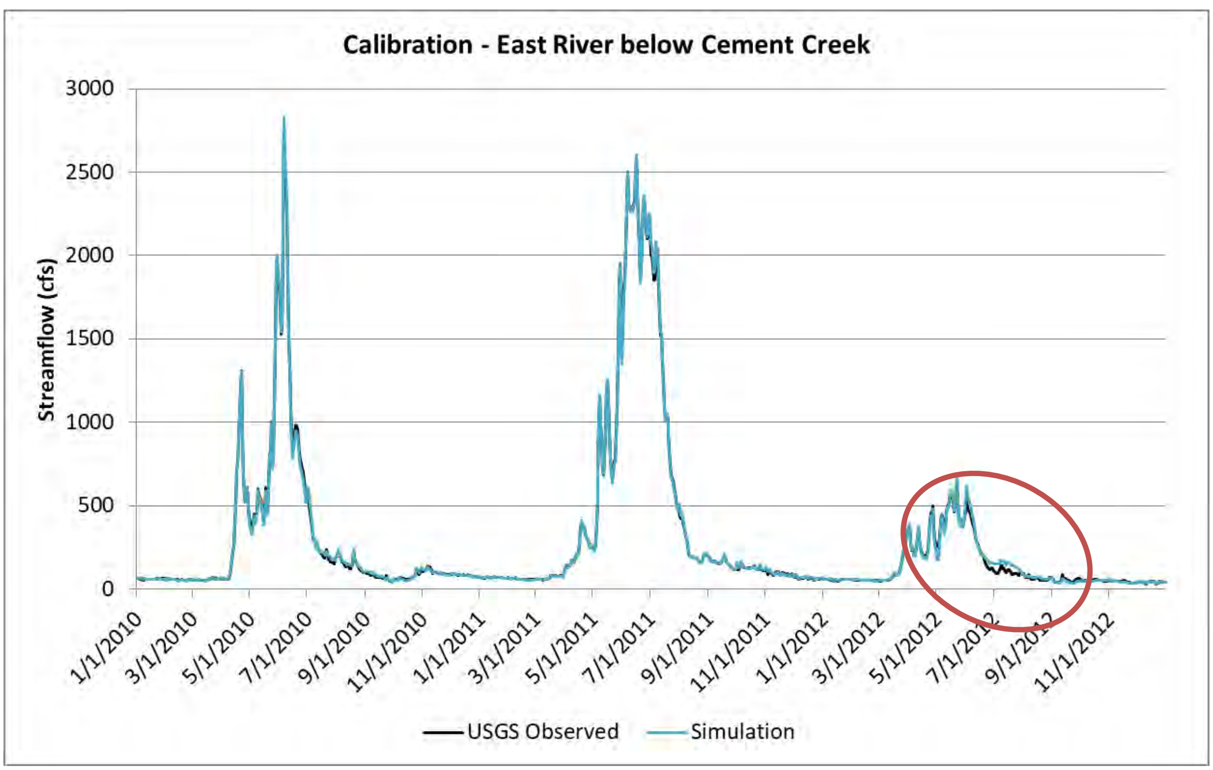


Figure 19: Daily Calibration Scatter Plot - East River below Cement Creek, 2010-2012

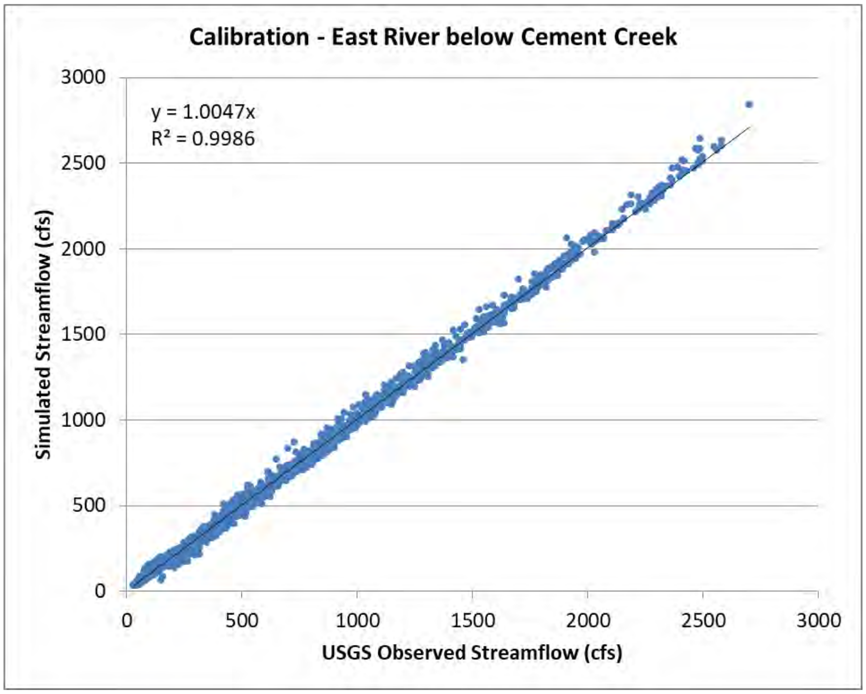


Figure 20: Daily Calibration Scatter Plot - East River below Cement Creek, 1998-2017

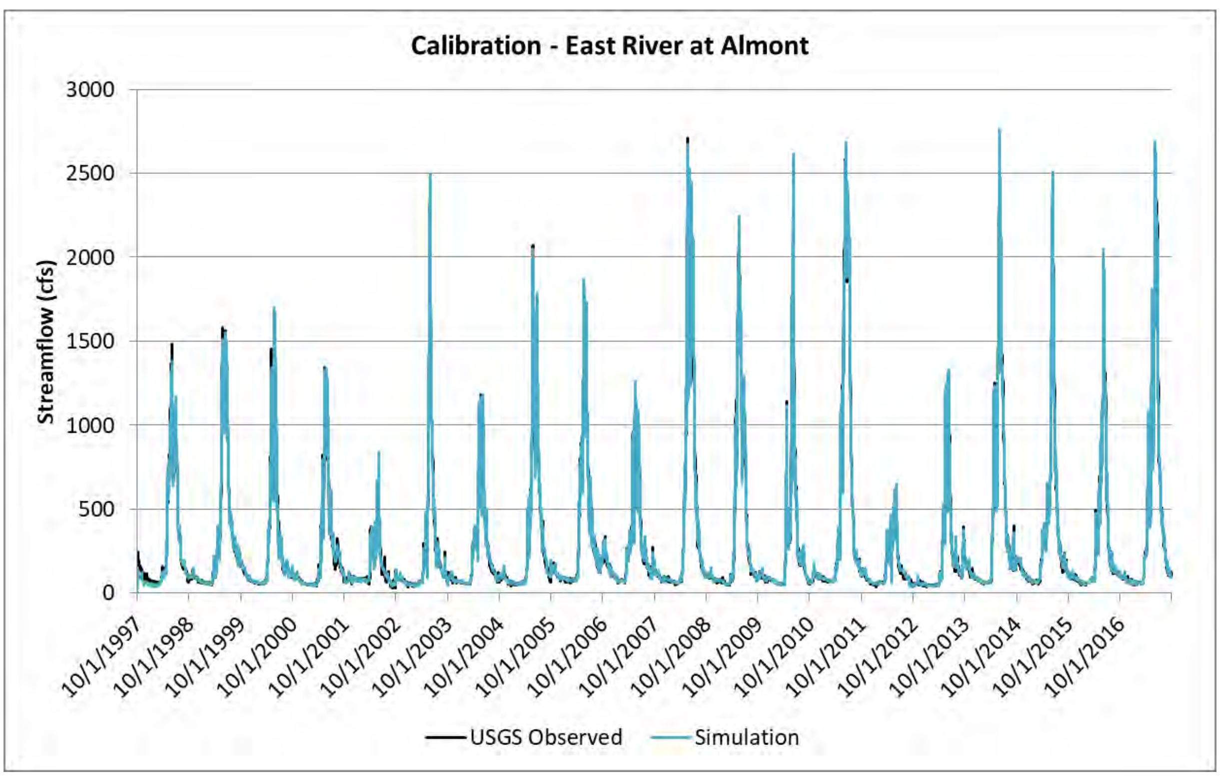


Figure 21: Daily Calibration Scatter Plot - East River at Almont, 1998-2017

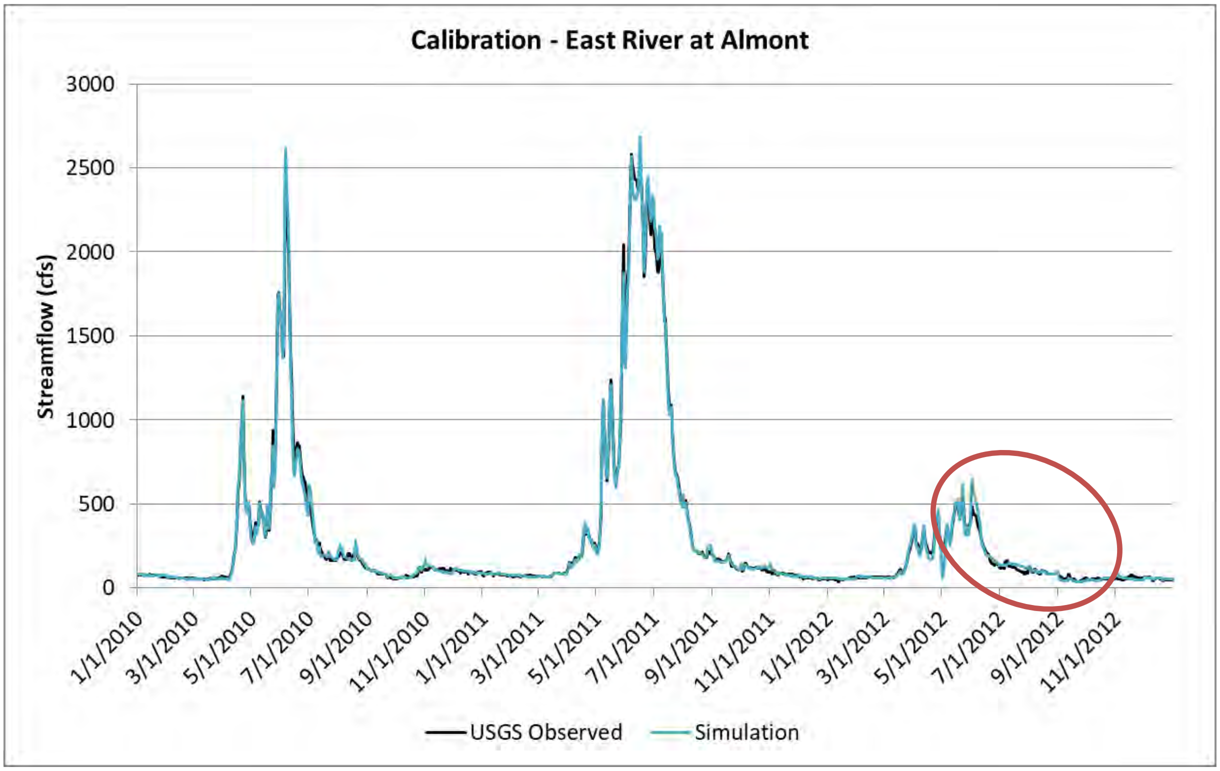


Figure 22: Daily Calibration Scatter Plot - East River at Almont, 2010-2012

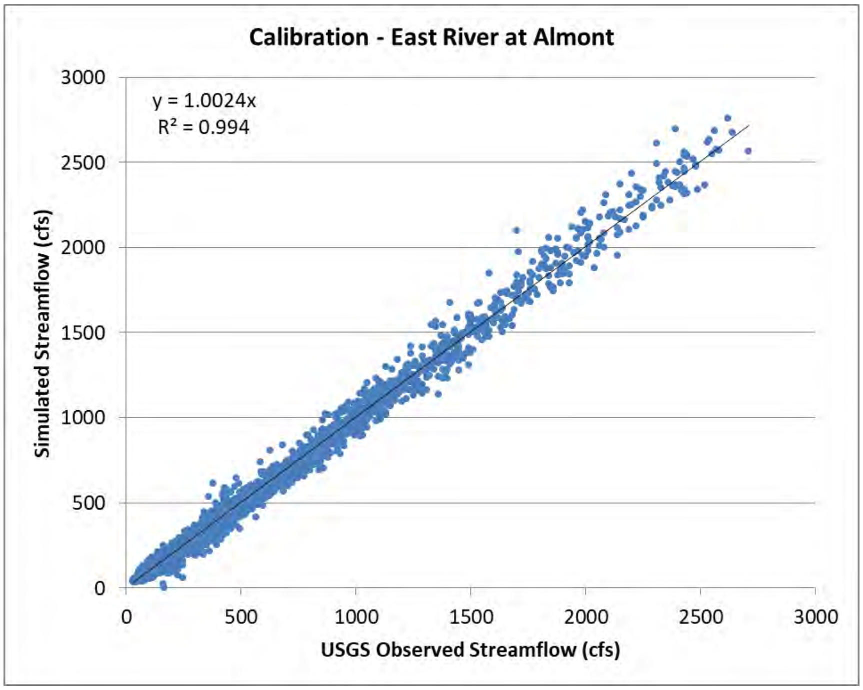


Figure 23: Daily Calibration Scatter Plot - East River at Almont, 1998-2017

Appropriate Model Applications

StateMod is a water rights allocation modeling platform. The objective of the platform is to provide information about water availability based on the prior appropriate doctrine and Colorado water right administration. Operations in a basin that depend on "gentleman's agreements" to divert water out of strict priority are not accurately reflected in the model. In addition, the model is not a physical process model. It depends on historical streamflow, diversion, and reservoir records, estimates of consumptive use, and return flow parameters set by the modeler. Therefore, the results are limited by the quality of the records.

The modeling platform is most appropriately used as a comparative tool. Results from many "what if" scenarios can be compared and contrasted to understand the relative magnitude of impacts from a change in demand or operations. For example, a scenario with a new reservoir could be compared to the current use scenario to determine the water availability for storage, changes to peak flows and late season flows at a location downstream of the reservoir, or changes to water supply for reservoir users. This makes StateMod an ideal tool for large scale planning efforts and has been successfully used by the State of Colorado to support the Colorado Water Plan (which looked at multiple growth and development scenarios), Colorado River Compact Compliance, Endangered Species Recovery Programs, and by the Gunnison, Yampa/White/Green, and North Platte Basin Roundtables to support their Basin Implementation Plans.

It is not appropriate to use StateMod to determine precise physical streamflow measurements because StateMod does not consider physical stream channel parameters or routing processes. For example, it assumes that reservoir releases are delivered to downstream diversions in the same time step as the reservoir release with no lag or attenuation. This is a model simplification that generally does not impact monthly planning efforts but can significantly impact the accuracy of daily StateMod streamflow results, depending on the size of the basin and the channel grade.

It is important to consider how natural flow was estimated by the model in order to understand the uncertainty of model simulated streamflow throughout a basin. As discussed in the "Natural Flow Development" section above, natural flows are estimated at streamflow gages based on historical records of water use and distributed to ungaged locations based on gains between streamflow gages. Therefore, stream reaches with long-term, high frequency and accurate records of streamflow and diversions have less uncertainty in natural flow estimates. Ungaged tributaries or stream reaches above streamflow gages have the most uncertainty because natural flow estimates rely on limited data. Limitations in the streamgage network impact the level of uncertainty for streamflow results.

Regardless of these constraints, the Gunnison StateMod model is still appropriate to use to explore “what if” scenarios in a comparative manner. The following are a few examples of comparative opportunities the model can assess to improve watershed health:

- How much additional flow can be generated from voluntary, compensated fallowing and is the saved water re-diverted without the benefit of shepherding?
- How can improvements in conveyance and/or application efficiencies improve river flows and how do they impact downstream water available to senior water rights?
- How can storage be used to reduce consumptive shortages and improve streamflows?