REPORT

Colorado Basin Roundtable Watershed Flow Evaluation Tool Study

Prepared for:

Northwest Colorado Council of Governments

Funded by:

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Prepared by:

John Sanderson, Ph.D.
The Nature Conservancy

Brian Bledsoe, Ph.D., P.E.
N. LeRoy Puff, Ph.D.
Thomas Wilding
Colorado State University

William Miller, Ph.D.
Miller Ecological Consultants, Inc.

Nathan Fey
American Whitewater

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CDM Smith

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Acronyms

BLM	U.S. Bureau of Land Management
CDSS	Colorado Decision Support System
cfs	cubic feet per second
CWCB	Colorado Water Conservation Board
ELOHA	Ecological Limits of Hydrologic Alteration
FLPMA	Federal Land Policy and Management Act
GIS	geographic information system
GVC	geomorphic valley classification
IBCC	Interbasin Compact Committee
IHA	Indicators of Hydrologic Alteration
PCI	Potential for Conflict Index
StateMod	State of Colorado's Stream Simulation Model
Upper Colorado River Model	Upper Colorado River Basin Water Resources Planning Model
USGS	U.S. Geological Survey
WFET	Watershed Flow Evaluation Tool
WSRA	Water Supply Reserve Account
WUA	Weighted Usable Area

Section 1
Introduction

1.1 Background

The last decade brought many changes to the State of Colorado's water supply outlook. During the past two decades, the state has experienced significant population growth, and Colorado's population is expected to nearly double within the next 40 years. Colorado needs to provide an adequate water supply for its citizens and the natural environment, yet Colorado is transitioning from an era where some water remains to be developed to an era in which we need to manage a more developed resource and make tough decisions about re-allocating water resources among priorities. Meeting the state's municipal, industrial, agricultural, environmental, and recreational water needs will require a mix of local water projects and processes, conservation, reuse, agricultural transfers, and the development of new water supplies, all of which should be pursued concurrently. Ultimately, the future of Colorado—both its vibrancy and its beauty—is dependent on how our water resources are sustained, used, and developed (Colorado Water Conservation Board [CWCB] 2011).

In 2005, the legislature reaffirmed the need to prepare for a future in which water resources are increasingly limited by passing the Colorado Water for the 21st Century Act. This legislation established nine basin roundtables and created a voluntary, collaborative process to help the state address its water challenges. The roundtables were organized to represent Colorado's eight major river basins and a separate basin roundtable for the Denver Metro area (Figure 1-1). In addition to the nine basin roundtables, the Colorado Water for the 21st Century Act established the 27-member Interbasin Compact Committee (IBCC) to facilitate conversations between basins and to address statewide issues. The focus of this study is the Colorado River Basin.

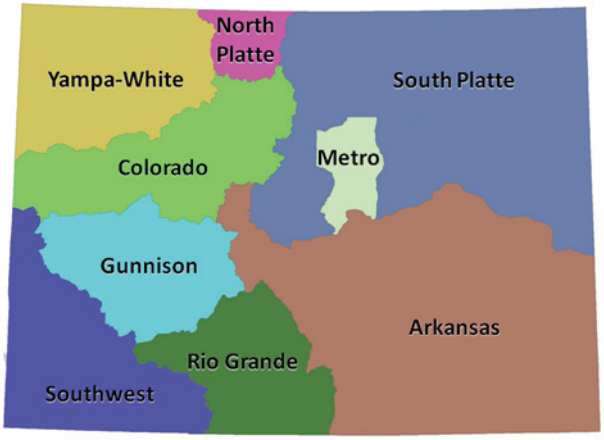


Figure 1-1 Colorado's Nine Basin Roundtables

The basin roundtables are required to complete basinwide needs assessments. The needs assessments are to include the following:

- An assessment of consumptive water needs (municipal, industrial, and agricultural)
- An assessment of nonconsumptive water needs (environmental and recreational)
- An assessment of available water supplies (surface and groundwater) and an analysis of any unappropriated waters
- Proposed projects or methods to meet any identified water needs and achieve water supply sustainability over time

All basins in the state, including the Colorado Basin, have followed a similar outline for assessing nonconsumptive needs and identifying projects and methods for meeting those needs (Figure 1-2). The CWCB, who oversees the roundtables, has been working closely with the roundtables as they conduct their assessments and establish projects and methods to meet their nonconsumptive (environmental and recreational) needs. All nine of the basin roundtables have created a list of nonconsumptive attributes for their basin and developed focus area mapping that shows where those attributes occur (CWCB 2011). Some basins have quantified water needs for nonconsumptive attributes, and some have studied other aspects of nonconsumptive attributes. A few basins are beginning to describe projects and methods to meet nonconsumptive needs, and it is expected that more basins will be doing so in the coming years. Examples of projects and methods include restoration projects related to improving fisheries, voluntary flow management agreements to address an environmental or recreational need, or a CWCB instream flow to protect an environmental need. Early in the nonconsumptive assessment process, the Colorado Basin Roundtable decided they wanted to quantify streamflow needs for their nonconsumptive attributes. Because existing methods for streamflow quantification address only a limited number of stream segments and are expensive to implement in multiple locations, the basin roundtable decided to participate in a pilot of the Watershed Flow Evaluation Tool (WFET) in the Roaring Fork watershed. The WFET offered an approach to assess the flow-related status of nonconsumptive attributes at multiple locations across a watershed. Having judged the Roaring Fork pilot of the WFET a success, the Colorado Basin Roundtable applied for a CWCB Water Supply Reserve Account (WSRA) Grant to apply the WFET throughout the Colorado River Basin. To support the development of the WFET, and to support an "alternative to wild and scenic" process on the mainstem of the Colorado River, the basin roundtable included in the WSRA application a request for funding to complete data collection efforts for a site-specific quantification at three locations between Kremmling, Colorado and No Name, Colorado.

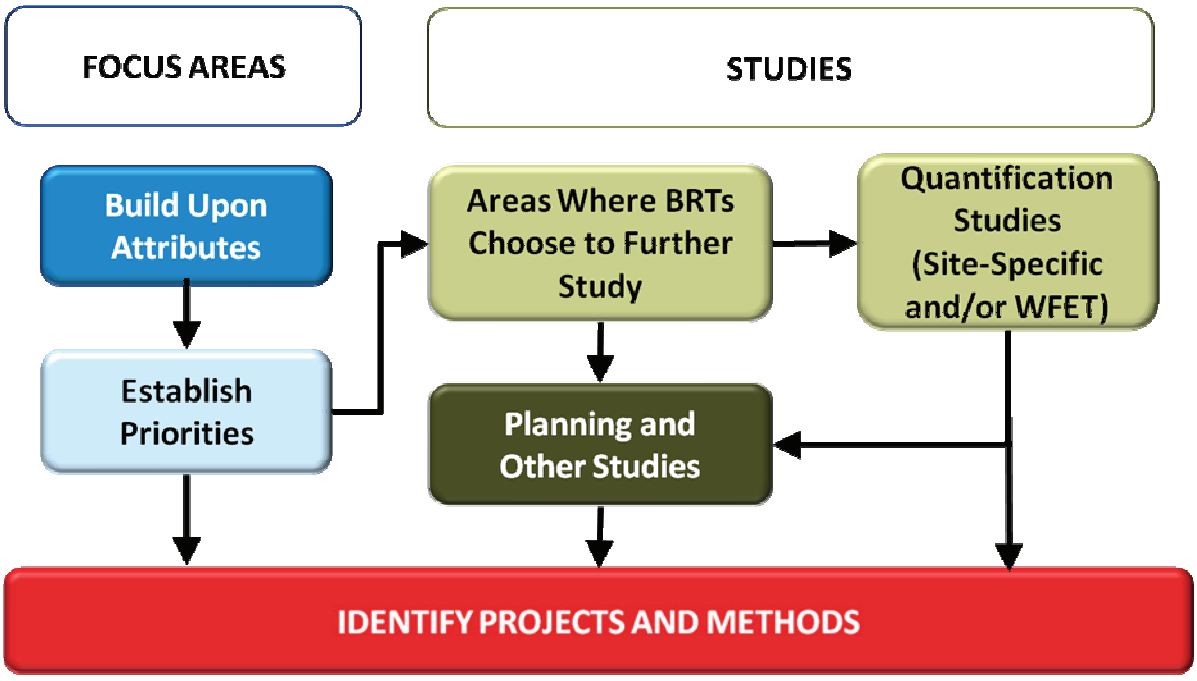


Figure 1-2 State of Colorado Nonconsumptive Needs Assessment Approach

For this study, CWCB has participated in the stakeholder meetings and is overseeing the grant as part of normal WSRA grant procedures. It should be noted that this study is a Colorado Basin Roundtable work product and not a CWCB work product.

1.2 Study Objectives

Following are the study objectives summarized in the WSRA Grant application:

- Build upon existing quantification efforts in the basin to maintain consistency in approaches
- Conduct site-specific quantification of instream flow needs for Colorado River between Kremmling and No Name which would determine the current state of the aquatic ecosystem in this river reach including physical geomorphic characteristics, hydrologic characteristics, riparian characteristics, and instream aquatic habitat characteristics
- The site-specific quantification for the Colorado River between Kremmling and No Name would also determine expected changes as a result of hydrologic change with additional water regulation such as expected geomorphic changes, expected riparian changes, and expected aquatic habitat changes
- Complete evaluation of Colorado River Basin using the WFET
- Conduct study within a stakeholder process with the Colorado Basin Nonconsumptive Needs Assessment Committee and basin roundtable

The portion of the site-specific quantification for the Colorado River funded as part of this WSRA Grant included data collection efforts. These efforts collected data needed to calibrate and simulate River 2D for a range of flow conditions. The site-specific study report for the Colorado River mainstem is included in this report as Appendix A.

The purpose of this report is to summarize the WFET study's approach, results, conclusions, and recommendations. The report is summary in nature and detailed investigations that occurred during the study are detailed in the report appendices.

1.3 Report Overview

This report contains the following sections:

- **Section 2 Watershed Flow Evaluation Tool Approach** provides an overview of the WFET, suggested uses for the study results in the future, and the methods used in the analysis and validation of results.
- **Section 3 Watershed Flow Evaluation Tool Results** summarizes the results of the analysis and validation.
- **Section 4 Conclusions and Recommendations** presents the conclusions and recommendations of the WFET Study.
- **Section 5 References** includes the previous studies and literature used throughout the study.

1.4 Acknowledgements

The project team would like to acknowledge the hard work of the Colorado Basin Roundtable's Nonconsumptive Committee in overseeing the analysis and results of the Colorado Basin WFET Project. The committee is led by Lane Wyatt and Ken Neubecker. To date, the committee has conducted 10 meetings. Appendix B contains the meeting summaries from the stakeholder meetings. Appendix C contains a response to stakeholder comments.

Section 2

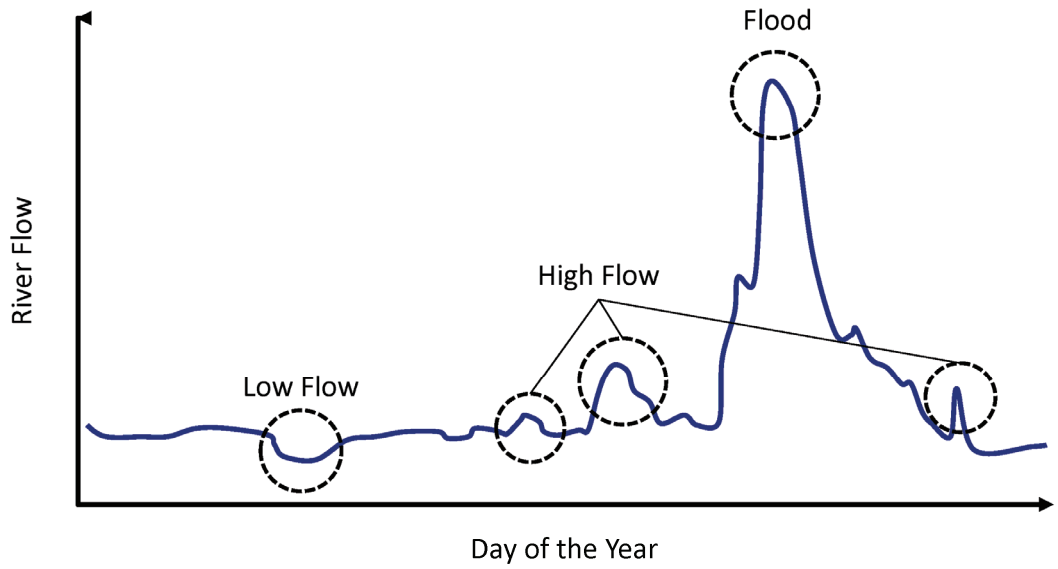
Watershed Flow Evaluation Tool Approach

2.1 Watershed Flow Evaluation Tool Approach Overview

The Colorado Basin Roundtable has expressed interest in quantifying the flows needed to sustain their nonconsumptive attributes. Several long-standing methods exist for quantifying water needs for recreation and the environment, but these methods are: (i) designed for assessing individual river segments, (ii) primarily oriented toward fish (i.e., they did not address other ecosystem needs such as maintaining riparian areas), and (iii) expensive to implement (currently $50,000 – $75,000 for results applicable to tens of miles), making it cost-prohibitive to apply them across all streams and rivers in a watershed. As discussed in Section 1, to fill the need for a broadly applicable assessment of flow related to nonconsumptive attributes, the Colorado Basin Roundtable has used CWCB's WSRA Grant funds to complete the WFET[1] study. This study provides a regional framework for understanding ecological risk for environmental attributes related to flow and establishes a baseline for recreational flow needs in the Colorado River Basin. A regional approach was of interest to the Colorado Basin Roundtable because of the time and expense of conducting site-specific quantification studies throughout the basin. Site-specific quantification is based on data from short stream segments (hundreds of feet) and can be extrapolated only to relatively short segments (at most tens of miles) that the sample reach represents. The Colorado River Basin has an area of approximately 9,800 square miles and contains about 4,800 miles of named streams (U.S. Geological Survey [USGS] National Hydrography Dataset 2011).

A key assumption of the WFET approach is that flow regime is a primary determinant of the structure and function of aquatic and riparian ecosystems for streams and rivers (Poff et al. 1997). Environmental flows are defined as "explicit management of water flows through freshwater ecosystems such as streams, rivers, wetlands, estuaries, and coastal zones to provide an appropriate volume and timing of water flow to sustain key environmental processes and ecosystem services valued by local communities " (Poff et al. 2010 and Appendix D). Environmental flows address specific components of the hydrograph that support specific environmental attributes, include a variable flow regime versus a minimum low flow, as shown in Figures 2-1 and 2-2. Figure 2-1 summarizes the different portions of the flow regime that are tied to ecological function. Low flows are needed to maintain aquatic habitat. Seasonal high flows are often needed to flush fine sediment and cue spawning of certain types of fish. Flood flows are needed to sustain riparian ecosystems, scour the channel, and to maintain alluvial water storage (Postel and Richter 2003). The portions of the flow regime related to ecological attributes for the Yampa River at Maybell, Colorado are summarized in Figure 2-2.

[1] Development of the Watershed Flow Evaluation Tool generally followed the framework presented by Poff NL, Richter BD, Arthington AH, Bunn SE, Naiman RJ, Kendy E, Acreman M, Apse C, Bledsoe BP, Freeman MC, Henriksen J, Jacobson RB, Kennen JG, Merritt DM, O'Keeffe JH, Olden JD, Rogers K, Tharme RE, Warner A. 2010. The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards. *Freshwater Biology* **55**: 147-170.



Modified from Rivers for Life (Postel and Richter 2003)

Figure 2-1 Example of Environmental Flow Hydrograph

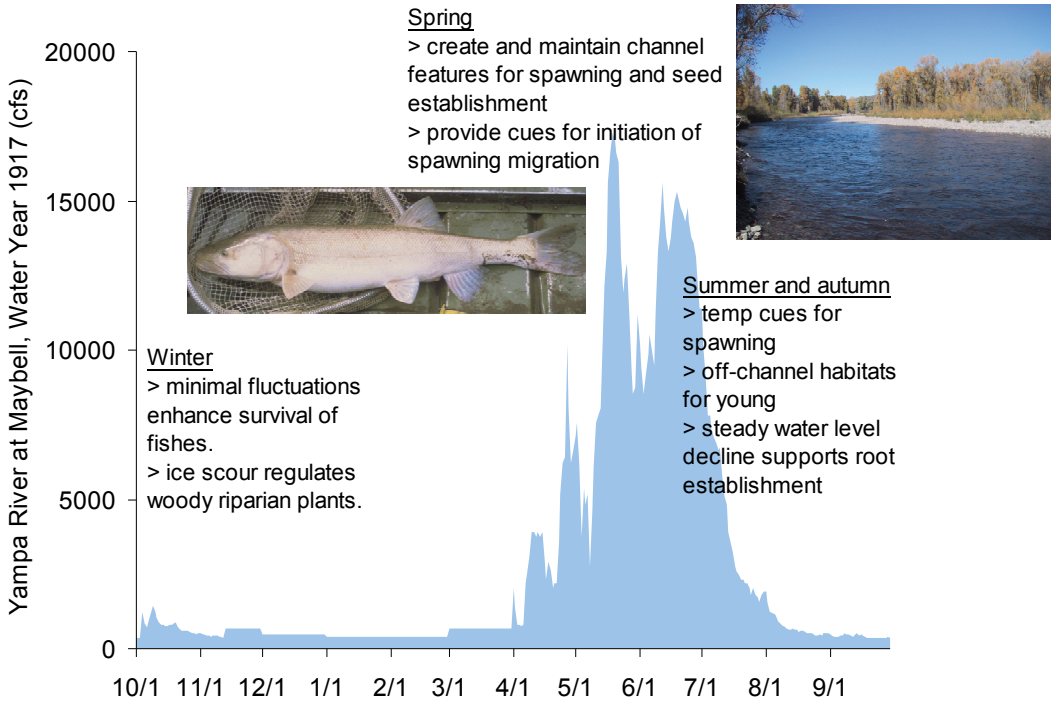


Figure 2-2 Example of Attributes Supported by Environmental Flows in the Yampa River

The WFET is based on the Ecological Limits of Hydrologic Alteration (ELOHA) framework for assessing and managing environmental flows across large regions, when lack of time and resources precludes detailed (or intensive) field evaluations of all rivers individually. ELOHA uses information from rivers that have been studied and translates this to rivers that have not, without requiring detailed site-specific information for each river (The Nature Conservancy 2011). The scientific basis for ELOHA was published in 2006 by an international group of river scientists (Arthington et al. 2006). Practical guidelines for its application have been developed by consensus of leading international environmental flow experts (Poff et al. 2010).

Table 2-1 describes the steps of the ELOHA Framework (The Nature Conservancy 2011) and how these steps were adapted for the WFET for the Colorado River Basin. Development of the Colorado Basin WFET generally follows the ELOHA framework steps but varies in step 5 as this WFET study is intended for use in water supply planning efforts and not to establish policy in Colorado. The methodologies for each step are described in the remainder of this section.

Table 2-1 ELOHA Framework and Application in Colorado Basin WFET Study

ELOHA Framework Steps	Colorado Basin WFET Steps
Step 1: Building a hydrologic foundation of daily streamflow hydrographs representing at least two conditions – baseline (pre-development) and present-day – for a single time period for every analysis point within the region.	Step 1: Hydrologic Foundation. This step is identical to the ELOHA's Step 1. The Colorado Decision Support System (CDSS) StateMod model for the Colorado River was utilized to develop the hydrologic foundation for the Colorado Basin WFET.
Step 2: Classifying river types according to hydrologic and other characteristics.	Step 2: Geomorphic Subclassification. This step is similar to the ELOHA's step 2. Rivers in the Colorado River Basin were not classified based on hydrological characteristics as all streams are considered snowmelt driven. A geomorphic subclassification was conducted as part of the Colorado Basin. This subclassification was developed to describe the key geomorphic factors that influence riparian systems across large regions.
Step 3: Assessing flow alteration from baseline conditions at every analysis point.	Step 3: Calculate Flow Metrics. The step is similar to ELOHA's step 3. Baseline and current conditions flows were developed for the following flow metrics using The Nature Conservancy's Indicators of Hydrologic Alteration (IHA) software: August mean flow, September mean flow, 90-day maximum flow for wet years, 30-day minimum flow, maximum average daily flow, mean annual flow, January mean flow, and 2-year flow.
Step 4: Determining flow-ecology relationships that quantify biological responses to different degrees of hydrologic alteration for each river type, based on existing biological and related data and models.	Step 4: Develop Flow-Ecology and Flow-Recreation Relationships. This step is similar to ELOHA's step 4. For the Colorado Basin WFET, flow-ecology relationships were developed for trout, cottonwood, macroinvertebrates, and warm water fish. Flow-ecology relationships are applied only in specific geomorphic settings.
Step 5: Implementing policies to maintain and restore environmental flows through a social process involving stakeholders and water managers informed by the flow-ecology relationships.	Step 5: Develop Ecological Risk Mapping. This step in the Colorado Basin WFET effort varies from the ELOHA approach. The Colorado Basin WFET was developed for use in water planning efforts and has not been utilized to implement policy in Colorado.

The Colorado Basin WFET study has also examined recreational flow needs in addition to ecological flows described above. The recreational aspects of the Colorado Basin WFET study has built upon work conducted by American Whitewater through the United States in developing ranges of flow suitable for whitewater boating. The methods used to examine recreational flow needs in the Colorado River Basin are described in Section 2.7.

2.2 Applications and Capabilities of the WFET for Ecological Attributes

WFET, as applied in this investigation, is used to assess the risk that stream-based ecological resources may have changed as a result of human uses and the diversion of water. The WFET can help identify watershed areas where the alteration of streamflow is most likely to have modified ecological resources from conditions that may have historically existed prior to the time that water was first diverted for irrigation, domestic use, and other purposes. The WFET can also be used to examine ecological responses to future streamflow scenarios resulting from new water development projects, a compact call, or climate change.

Flow is considered a "master variable" that is of central importance in maintaining river health (Poff et al. 1997). At the same time, natural influences on ecological resources may include the physical, chemical, geological, and biological properties of the watershed, local climatic conditions, and other related factors such as fire and tree mortality (insect/disease). Anthropogenic activities such as fisheries management, land use practices, physical disturbance, stream channelization, and nonpoint source runoff may also influence ecological resources. The variables that influence ecological resources may be directly or indirectly related to streamflow, or may be unrelated to streamflow. The WFET evaluates the relationship between streamflow and ecology, but does not explicitly consider the other variables, conditions, and interactions not related to streamflow, which can influence the sensitivity of an ecological resource to change.

For many tens of locations throughout a watershed where natural and managed flows have been modeled, the WFET identifies the relative probability that the state of an ecological resource may have changed due to long-term changes in flow, i.e., the WFET evaluates the risk of a change in the river ecosystem resulting from changes in flow. Because of the complex nature of river ecosystems, if the WFET analysis identifies that an ecological resource may be at risk of change as a result of hydrologic alteration, it does not necessarily indicate that an actual change in the ecological resource has occurred, or that any such ecological change that has occurred is specifically attributable to flow alteration.

Using flow metrics to assess the viability of an ecological community necessitates certain assumptions, and the validity of these assumptions can affect the reliability of the results of the WFET. Some of these assumptions are:

- Flow regime is one of the primary determinants of the structure and function of aquatic and riparian ecosystems. This assumption is well-supported by copious peer-reviewed literature spanning well over two decades.
- Modeled streamflows, for both undepleted (a.k.a., "natural " or "undeveloped ") as well as existing (a.k.a., "altered," "managed," or "developed") conditions, are accurate. StateMod was used in the WFET because it is the best hydrologic model available that extends over the entire basin area. Accuracy is expected to be high in some locations and lower in others. Where accuracy is low, additional site-specific measurements of hydrologic conditions may be warranted.
- The 31-year study period for which streamflow estimates have been developed is representative of the long-term climatic conditions to which the ecological resources in the study area are adapted. Several researchers have investigated this assumption, and they have

concluded that a 31-year period of record is sufficient to characterize climatic conditions as well as the year-to-year variability inherent in streamflows (Kennard et al. 2009).

- While the ecological attributes that WFET chose to model are important in their own right, there is an assumption that these attributes are also indicators of potential changes in diverse ecological systems, e.g., that cottonwoods also represent other riparian species and that trout also represent other fish.
- Flow-ecology relationships accurately represent the response of the ecological attributes to a change in flow conditions. The flow-ecology relationships are based on current best available science.

Based on the key assumptions outlined above, the findings of the WFET pilot studies and comparison with limited site-specific information, the primary capabilities, and limitations of the WFET are summarized below.

Capabilities

- The WFET can provide a regional assessment of the risk of ecological change from streamflow alteration, identifying locations with minimal to high risk of change based on flow conditions for specific stream attributes without detailed site-specific information.
- The WFET can identify important seasonal streamflow conditions that may be associated with a risk of ecological change.
- The WFET can be used to target areas that may need further site-specific studies.
- The WFET can be used to identify areas with environmentally healthy flow conditions where nonflow restoration efforts are especially warranted if there are ecological impairments at that location.
- The WFET can help facilitate discussions on a watershed level regarding social preferences and priorities relating to natural resource management and nonconsumptive needs.
- The WFET can be used to assess the vulnerability to ecological change from large-scale water-management scenarios, including major new water development projects, the effects of a Colorado River compact call, benefits or risks associated with a water bank, or future hydrology under climate change scenarios.
- The WFET can be used to identify watersheds with concentrations of "low risk" streams. In these areas, there may be, for example, increased chances of long-term maintenance of environmental goals, because larger connected stream networks are more resilient disturbance.
- The WFET may be used by water providers in the initial planning stages of project development to help determine which project or operation alternative is likely to have the fewest red flags associated with it and/or which may help the environment.
- Although the WFET does not assess or identify any conflicts between recreational and ecological needs, it can potentially be used to explore ways that management scenarios can be crafted to support both recreational and environmental needs.

Limitations

- Because the WFET does not require site-specific ecological data to identify the potential risk of ecological change, it should not serve as the basis for reach specific flow prescriptions in administrative or judicial processes, absent site-specific data.
- The WFET has been developed to identify the risk of ecological change due to flow alteration, but is insufficient to quantify nonconsumptive water needs on a site-specific basis. Also, the WFET is only one tool in the toolbox for assessing environmental condition as it relates to flow management.
- The WFET will not provide results as detailed or as accurate as a site-specific analysis.
- The WFET does not identify areas where ecological change may be associated with factors other than streamflow, and the WFET does not explicitly evaluate or consider these additional factors that influence ecological and recreational resources, although some of these factors are implicitly considered in the flow-ecology relationships.
- The WFET does not speak to the value of a given change in a resource. For example, it does not address whether or not a change in cottonwood establishment is desirable or not. Rather, the WFET indicates the risk of a change.
- Due to the complexity of determinant factors and ecological response, the WFET does not predict the structure and function of an ecological community under past or future conditions.

2.3 Hydrologic Foundation

The hydrologic foundation for the Colorado Basin WFET was developed using the Upper Colorado River Basin Water Resources Planning Model (Upper Colorado River Model). The Upper Colorado River Model is an implementation of the State of Colorado's Stream Simulation Model (StateMod), which is a program developed by the State of Colorado to simulate water allocation and accounting for making comparative analyses of various historic and future water management policies in a large-scale river basin. No modifications of the model were made for this study, and it was also assumed that the model output was sufficient for relative comparisons needed to complete the analysis of the changes between baseline and existing hydrologic conditions. For the WFET, the Upper Colorado River Model was utilized to generate the baseline (i.e., human influences removed) and existing conditions for flows for the Colorado River Basin in Colorado.

StateMod, including the Upper Colorado River Model, is a water allocation model that simulates the availability of water to individual users and projects based on hydrology, water rights, and operating rules and practices in the Upper Colorado River Basin. The model uses nodes (representing reservoirs, major diversions, instream flow reaches, flow gages, etc.) and arcs (representing rivers, streams, channels, etc.) to construct the continuity in the system. Figure 2-3 at the end of this section shows the schematic of the Upper Colorado River Model. Figure 2-4 at the end of this section shows the distribution of the 250 nodes where hydrologic data was generated for the hydrologic foundation.

StateMod is capable of simulating both short-term (daily) and long-term (monthly) water allocation conditions. The version of StateMod utilized for the Colorado Basin WFET effort was 12.29.15 dated 2/4/2009. The time period the Upper Colorado River Model covers is water years 1975 – 2005 (October 1, 1974 to September 30, 2005) for daily simulation and water years 1909 – 2005 (October

1908 to September 2005) for monthly simulation. More detailed information regarding StateMod and Upper Colorado River Model can be obtained in the CDSS website: http://cdss.state.co.us.

To generate baseline flow conditions, the inputs to the Upper Colorado River Model were changed to turn off the diversions, instream flow rights, and reservoir operations in the basin. Daily model simulations were performed. Table 2-2 summarizes the inputs with associated changes.

Table 2-2 Summary of CDSS Model Inputs with Changes for Simulating Baseline Flow Conditions

Types of Simulation	Input Files	Changes
Daily	cmdlyB.rsp	Line 17, comment out cm2005.opr
	cmdly.ctl	Line 37, use 0 to represent the soil moisture accounting factor
	cm2005.ddr	Change every "on/off" from 1 to 0
	cm2005.ifr	Change every "on/off" from 1 to 0
	cm2005B.rer	Change every "on/off" from 1 to 0

2.4 Geomorphic Subclassifciation

The upper Colorado River Basin contains a diverse mosaic of geomorphic settings and fluvial riparian ecosystems. From the steep, v-shaped, and glacial valleys of the high country to the gentle gradients and expansive floodplains of lowland alluvial valleys, geomorphic setting mediates the relationship between hydrology and riparian ecosystems. Colorado State University has collaborated with the U.S. Forest Service over the last 4 years in the development of a geomorphic valley classification (GVC) for describing the key geomorphic factors that influence riparian systems across large regions. The classification is geographic information systems (GIS) based and delineates different geomorphic valley settings using energy, hillslope coupling, and lateral confinement as the primary diagnostic characteristics. The GVC derives its class descriptions from geomorphic thresholds corresponding to significant transitions in the physical processes and boundary conditions that give rise to distinct floodplain and channel forms, disturbance regimes, and ecological attributes.

In the GVC, energy refers to the hydraulic power available to scour and shape valley bottoms and the channels they contain. Energy is characterized using unit stream power or valley slope as its surrogate. The slope thresholds selected for distinguishing between valley energy types correspond to widely recognized shifts in hydro-geomorphic processes. For example, valleys steeper than 3 to 4 percent slope tend to contain confined step-pool and cascade channels with varying degrees of hillslope coupling. As valley slopes become less than 3 to 4 percent, the channel types gradually shift to broader floodplains containing plane bed, pool-riffle, and sandy streams.

Coupling refers to the proximity of the hillslopes to the channel and the likelihood that landslides and debris flows on those slopes may move directly across the valley bottom into the stream channel at the slope base. In coupled settings, the channels and the riparian communities occurring along them may be more influenced by materials transported directly from hillslopes (colluvium) than by materials transported from upstream by water (alluvium). In uncoupled settings, sediment recruitment and transport largely become consequences of erosion of the streambed and banks.

Finally, confinement refers constraints on the planform (e.g., meandering, braiding) and lateral adjustability of stream channels. It is quantified by comparing the width of the valley bottom available for channel meandering and migration versus the size of the channel. A sinuous channel typically requires a minimum valley bottom width of approximately seven channel widths to freely meander. By distinguishing between coupling and confinement, the GVC provides a tool for mapping locations

where hillslope processes may largely control riparian attributes versus those locations where fluvial processes dominate, as well as a method for distinguishing the degree to which valley bottom widths constrain channel patterns and floodplain processes.

The results of the geomorphic subclassification are presented in Section 3. These results were utilized in assessing where to apply the riparian flow-ecology and warm water flow-ecology metrics. Appendix E contains a detailed report summarizing the geomorphic subclassification and results.

2.5 Flow Metric Calculations

Certain flow metrics can be considered ecologically important (Olden and Poff 2003). Because flow-ecology relationships do not capture all aspects of river health, maps that show the differences between baseline and existing conditions using the equation below were generated for each applicable StateMod node in the Colorado River Basin. These flow metrics relate to portions of the hydrograph summarized in Figures 2-1 and 2-2. In addition, the following flow metrics were determined to be relevant to one or more of the nonconsumptive needs assessment attributes defined in the basin and therefore were calculated at each node where flow data were available:

- Mean annual flow
- Mean August flow
- Mean September flow
- Mean January flow
- Mean annual peak daily flow
- 2-year flood flow

Indicators of Hydrologic Alteration software (Richter et al. 1996) was used to calculate these flow metrics for the baseline and existing condition datasets outputs from the Upper Colorado River Model. These flow metrics were selected out of 67 statistical parameters (Richter et al. 1996) to accommodate the calculation of the ecologically relevant flow statistics. These results will be discussed in Section 3.

$$\frac{Q_{existing}-Q_{baseline}}{Q_{baseline}}$$

where Q=flow (cubic feet per second [cfs]).

2.6 Flow-Ecology Relationships and Flow-Ecology Risk Mapping

The flow-ecology relationships were initially developed in the WFET pilot study for the Roaring Fork and Fountain Creek watershed completed by CWCB in 2009. For this study, the flow-ecology relationships from the pilot were reviewed and updated for the following attributes:

- Trout
- Warm Water Fish
- Macroinvertebrates
- Riparian Vegetation

Based on the hydrologic foundation discussed above and the flow-ecology relationships developed for this study, flow-ecology risk maps were developed for the attributes listed above with the exception of

macroinvertebrates. This section describes the flow-ecology relationships and the approach for mapping flow-ecology risk.

2.6.1 Trout Flow-Ecology Relationships

The flow-ecology metric for trout was developed in the WFET pilot study as discussed previously. As part of the Colorado Basin WFET study, the flow-ecology metric for trout was reviewed by comparing the metric with site-specific physical habitat studies. This effort is summarized in Appendix F. The flow-ecology metric for trout is based on a categorical rating of low-flow suitability for trout (cutthroat, brook, brown, and rainbow), from Binns and Eiserman (1979). The flow-ecology relationship is based on summer flows (average for August to mid-September) and is expressed as a percent of baseline mean annual flow using the following equation.

$$\frac{(\text{Mean August } Q_{\text{existing}} + \text{Mean September } Q_{\text{existing}}) \div 2}{\text{Mean Annual } Q_{\text{baseline}}} \times 100$$

where:

Q=flow (cfs)

The Colorado Division of Wildlife provided guidance on where this metric should be applied based on the map of CDSS nodes presented in Figure 2-4. Using percentages produced by the above equation, the CDSS nodes were assigned different colors based on the following risk classes for trout:

- <10 percent: Red node color. Low flows are inadequate to support trout (very high flow-ecology risk)
- 10 to 15 percent: Orange node color. Low flows have potential for trout support is sporadic (high flow-ecology risk)
- 16 to 25 percent: Yellow node color. Low flows may severely limit trout stock every few years (moderate flow-ecology risk)
- 26 to 55 percent: Blue node color. Low flows may occasionally limit trout numbers (minimal flow-ecology risk)
- >55 percent: Green node color. Low flows may very seldom limit trout (low ecological risk)

2.6.2 Warm Water Fish Flow-Ecology Relationship

The flow-ecology metric for native bluehead sucker and flannelmouth sucker was revised for this study, as summarized in Appendix G. The flow-ecology metric is represented by the following equation:

$$\% \text{ maximum native sucker potential biomass} = 0.1025 \times \text{30-day min flow}^{0.3021}$$

where '30-day minimum flow' is a running mean calculated over the summer-autumn flow period (1 July to 30 November) for each year, then averaged over the study period (1975 – 2005). In this manner, biomass is estimated for both baseline (natural) conditions and existing flow conditions. Percent reduction in biomass is then calculated as:

$$\%\ \text{reduction in potential biomass} = \frac{(\text{baseline-existing})}{\text{baseline}} \times 100$$

Flannelmouth and bluehead sucker are warmwater fish, so it is important that the method is not applied where cool water temperatures may override the flow response. Therefore, the sucker method was applied at nodes below 7,000 feet elevation. More specific limits were specified for the mainstem of the Colorado River - Radium at 6,850 feet (downstream of USGS 09058030). Likewise, on the Roaring Fork River a specific upstream limit at the Frying Pan confluence is recommended (6,590 feet). Within this temperature envelope, application of the sucker method should be further constrained to exclude geomorphic settings with low energy reaches (channel slope <0.1 percent) to focus on reaches with more suitable habitat (rocky substrate).

The CDSS nodes were assigned different colors based on flow-ecology risk and differentiation among risk levels were derived directly from the flow-ecology relationships for warm water fish as defined above. Risk levels were assigned as follows based on expert recommendations:

- 50 to 100 percent reduction in potential biomass – nodes were assigned a red color (high flow-ecology risk)
- 25 to 50 percent reduction in potential biomass – nodes were assigned an orange color (moderate flow-ecology risk)
- 10 to 15 percent reduction in potential biomass – nodes were assigned a yellow color (minimal flow-ecology risk)
- <10 percent reduction in potential biomass – nodes were assigned a green color (low flow-ecology risk)

2.6.3 Macroinvertebrate Flow-Ecology Relationship

A flow-ecology relationship for macroinvertebrates was developed for the Colorado Basin WFET study and is summarized in Appendix H. The relationship only applies to a small number of locations within the basin and therefore flow-ecology risk maps were not developed for this attribute.

2.6.4 Riparian Vegetation Flow-Ecology Relationship

The WFET pilot study for the Roaring Fork watershed developed a quantitative relationship between flow alteration and riparian vegetation using many literature sources. The source literature covered a diverse range of vegetation types, including cottonwood, willow, and herbaceous plants. In response to feedback received on the pilot, as well as peer-review comments received during and after an expert workshop, the approach was refined and narrowed as described in detail in Appendix I. This section summarizes that detail. Specific changes and refinements to the methods used in the Roaring Fork WFET pilot include:

- Quantitative flow-ecology relationships were developed for the two riparian types:
  i) cottonwoods on low- and moderate-gradient, meandering (open or unconfined) rivers; and
  ii) cottonwoods in moderate-gradient rivers of confined valleys and high-gradient rivers in unconfined valleys. Despite some evidence of willow dependence on floods (Cooper et al. 2006), we lacked sufficient data to quantify this dependence over a range of flow alteration. For willows, the flow ecology relationship is described only conceptually in Appendix I.

- Flow-ecology relationships are now applied only in the specific elevation ranges and select geomorphic settings where that relationship is expected to exist.
- A new, large dataset on cottonwoods (Merritt and Poff 2010) allowed for development of a robust quantitative flow-ecology relationship for cottonwoods in low-gradient, unconfined geomorphic settings.
- Flood magnitude alteration is calculated only in the 30 percent of years with the highest mean annual flow.
- No hydrographs are developed based on break-points between risk classes, in contrast to the Roaring Fork pilot.

For cottonwood in unconfined geomorphic settings the attribute was applied for CDSS node locations with a geomorphic setting of moderate-energy unconfined, low-energy floodplain, and glacial trough. In addition, the metric was not applied in locations above 8,700 feet in elevation. Two quantitative flow-ecology relationships exist for cottonwood in unconfined settings; one for adult cottonwood abundance and the other for cottonwood recruitment. The hydrologic metric for adult cottonwood abundance is the change in average 90-day maximum flow in wet years only between current and undeveloped scenarios. "Wet years" are those in the top 30th percentile for mean annual flow in the undeveloped flow time series. Cottonwood abundance is calculated as:

% abundance = 1.038 x % flow alteration + 1.005.

For cottonwood abundance, the CDSS nodes were assigned different colors based on the following flow-ecology risk classes:

- Flow alteration of 50 to 100 percent was assigned a red node color representing very high flow-ecology risk
- Flow alteration of 30 to 50 percent was assigned an orange node color representing high flow-ecology risk
- Flow alteration of 15 to 30 percent was assigned a yellow node color representing moderate flow-ecology risk
- Flow alteration of 0 to 15 percent was assigned a green node color representing low flow-ecology risk

For cottonwood recruitment the hydrologic metric is the same as for adult cottonwood and is also calculated for only wet years. The probability of cottonwood recruitment is calculated as:

- If flow alteration is 0 to -4 percent, then recruitment = 1.
- If flow alteration is -4 to -55 percent, then recruitment = 2.91 x %flow alteration^3 + 7.27 x %flow alteration^2 + 5.26 x %flow alteration + 1.21.
- If flow alteration is -55 to -100 percent, then recruitment = 0.

For cottonwood recruitment, the CDSS nodes were assigned different colors based on the following flow-ecology risk classes:

- Flow alteration of 30 to 100 percent was assigned a red node color representing very high flow-ecology risk
- Flow alteration of 18 to 30 percent was assigned an orange node color representing high flow-ecology risk
- Flow alteration of 7 to 18 percent was assigned a yellow node color representing moderate flow-ecology risk
- Flow alteration of 0 to 7 percent was assigned a green node color representing low flow-ecology risk

For cottonwood in confined settings the method developed in the pilot study was retained but applied only in moderate-energy confined geomorphic settings and at elevation less than 8,700 feet. The flow-ecology metric was calculated using the following equation:

$$\%\ \text{departure from reference condition} = \frac{\text{Annual Peak Daily Flow}_{\text{existing}} - \text{Annual Peak Daily Flow}_{\text{baseline}}}{\text{Annual Peak Daily Flow}_{\text{baseline}}} \times 100\%$$

For cottonwood in confined settings, the CDSS nodes were assigned different colors based on the following flow-ecology risk classes:

- Flow alteration of 42 to 100 percent was assigned a red node color representing very high flow-ecology risk
- Flow alteration of 21 to 42 percent was assigned an orange node color representing high flow-ecology risk
- Flow alteration of 8 to 21 percent was assigned a yellow node color representing moderate flow-ecology risk
- Flow alteration of 0 to 8 percent was assigned a green node color representing low flow-ecology risk

In addition to cottonwood, a willow flow-ecology metric to apply at higher elevations was investigated. There was not sufficient data to develop a quantitative flow-ecology relationship for willow. A conceptual model for willow flow-ecology is discussed in Appendix I.

2.7 Recreation Flow Relationship

The purpose of the recreational analysis conducted as part of the study was to develop a baseline set of information for whitewater recreation in the Colorado Basin. This information can be utilized in the future when evaluating future water management actions, climate change analyses, or risk management strategies. The following information was developed as part of the analysis:

- A list of whitewater recreation segments in the Colorado River, reach description, types of users, seasonal usage information, and flow ranges related to recreational activity. The flow ranges related to recreational activity were based on survey data collected by American Whitewater. The survey methods are summarized below and described in further detail in Appendix J.

- A map showing the geographic extent of the whitewater recreation segments was developed.
- A usable days analysis based on historic flow information and the flow ranges from the survey information. Historic flow information was based on the CDSS model for current conditions unless it was not available for a particular gage. If CDSS information was not available, historical USGS data was used. The analysis shows the average number of days in a given month that the reach would be usable based on flow information only. There are many factors that affect whether a whitewater recreation reach will be used on a given day beyond flow, such as temperature, climatic conditions, financial considerations, permit availability, etc. The purpose of the analysis is to provide a baseline set of data to provide insight into future water management decisions. The information can be one piece of information that is utilized in discussing future water management activities in the basin.

In the summer of 2007, the Kremmling and Glenwood Springs field offices for the U. S. Bureau of Land Management (BLM) published a Wild and Scenic River's Eligibility Report for the Upper Colorado Basin as a part of their Resource Management Plan revision process mandated by the Federal Land Policy and Management Act (FLPMA) (43 U.S.C. 1701 et seq.). The study evaluates which river and stream segments meet the criteria for inclusion into the National Wild and Scenic Rivers System.

Out of the 244 segments evaluated, 27 were identified as eligible for future study. Of these segments, American Whitewater identified at least 11 where whitewater paddling occurs and where additional information is needed to describe stream flows that provide whitewater recreation value. In the fall of 2007, American Whitewater conducted an online instream flow study for the Upper Colorado Basin, which included the 11 whitewater segments under consideration for the Wild and Scenic designation. The online survey focused on four main stem segments of the Upper Colorado River under consideration, which include Gore Canyon, Pumphouse, State Bridge to Dotsero, and Glenwood Canyon.

The usable days approach includes instream flow survey data and the structural norm approach; a technique used to graphically represent social norms, and has been utilized to examine the acceptability of instream flows on river stretches across the United States and Canada for over 20 years (Whittaker & Shelby 2002). The graphic representation, commonly referred to as an impact acceptability curve, is used to describe optimum flows, ranges of tolerable flows, norm intensity, and level of norm agreement (Shelby, Vaske, &, Donnelly 1996). The Potential for Conflict Index (PCI) takes the graphic representation of social norms one step further by displaying information about their central tendency, dispersion and form. In the Wild and Scenic Study, these techniques were combined to describe the instream flow-whitewater recreation relationship for four segments of the Upper Colorado River. Further details of these methods and results are presented in Appendix J.

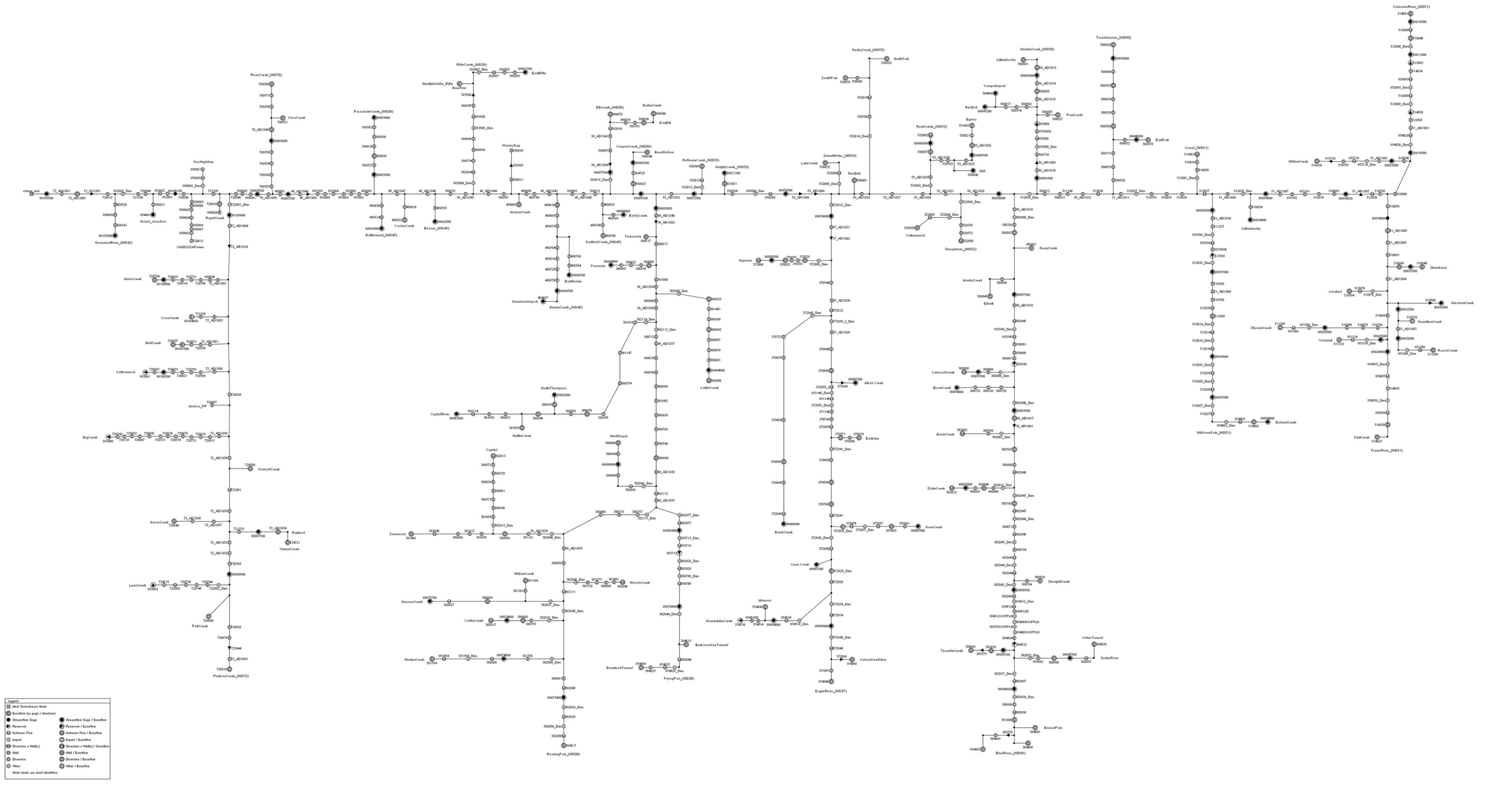
For areas of the Colorado River Basin that were not part of the survey, expert opinion from guidebooks supplemented with input from Colorado River Outfitters Association and American Whitewater was utilized for the analysis. This information is presented in Section 3.

2.8 Validation for Colorado River Mainstem

During the last few years site-specific data and habitat modeling has been conducted for the mainstem of the Colorado River. Information from this modeling effort was used to compare the WFET flow-ecology risk levels to site-specific habitat modeling. The site-specific data was obtained using a two-dimensional habitat model applied at three locations (Miller and Swaim 2011). The comparison used

data from the Weighted Usable Area (WUA) function for adult and juvenile rainbow and brown trout, and adult flannelmouth sucker and hydrology at several locations.

The comparison for trout was completed as follows. Each flow level was converted to habitat area using the WUA function for each species and life stage. The habitat area for each specific flow was then compared to the maximum habitat area at the site for the specific species and life stage to calculate the percent of maximum WUA. The value for each percent maximum WUA was compared to the WFET Risk level. The comparison for flannelmouth sucker was completed the same as for trout and the biomass for each risk level was compared to the percent maximum WUA. In both cases, results were compared to assess if both models (WFET and two-dimensional habitat model) were indicating similar levels of ecological risk as flows were reduced. Further information on methods and results of the validation are presented in Appendix K.


Legend
Ident Downstream Node
Baseflow (no gage / structure)
Streamflow Gage
Reservoir
Instream Flow
Import
Diversion + Well(s)
Well
Diversion
Other
Streamflow Gage / Baseflow
Reservoir / Baseflow
Instream Flow / Baseflow
Import / Baseflow
Diversion + Well(s) / Baseflow
Well / Baseflow
Diversion / Baseflow
Other / Baseflow
Node labels are short identifiers
colosup_end
72_ADC001
72_ADC005
72_ADC061
GunnisonRiver_(WD42)
GovHighline
OMID/USAPower
RapidCreek
72_ADC064
72_ARC010
MetaCreek
CoonCreek
BullCreek
CottonwoodCreek
72_ADC060
BigCreek
Molina_PP
72_ADC055
KimballCreek
72_ADC056
GroveCreek
72_ADC057
72_ADC054
Buzzard
OwensCreek
72_ADC053
72_ADC052
LeonCreek
PoleCreek
72_ADC051
PlateauCreek_(WD72)
RoanCreek_(WD70)
70_ADC040
ClearCreek
PiceanceCreek_(WD39)
Grand_Junction
RifleCreek_(WD39)
West&Middle_Rifle
EastRifle
HoneyGap
MidmmCreek
ElkCreek_(WD39)
BoilerCreek
EastElk
CanyonCreek_(WD39)
BeaWillow
BaldyCreek
Thirtemile
StaffieldCreek_(WD45)
Fourmile
EastDivide
DivideCreek_(WD45)
Gunnisonsimport
Bottlement_(WD45)
CocheCreek
Beaver_(WD45)
NoNameCreek_(WD53)
GuiltyCreek_(WD53)
LakeCreek
SweetWater_(WD53)
RedDirt
DebyCreek_(WD53)
NorthFork
SouthFork
Gypsum
CottonwoodCreek
RockCreek_(WD53)
Egnes
Dill
Vasquezimport
RedDirt
LittleMuddy
MuddyCreek_(WD50)
PassCreek
Troublesome_(WD50)
EastFork
Cessal_(WD51)
LittleMuddy
ColoradoRiver_(WD51)
WillowCreek
Stambaugh
Crooked
MeadowCreek
StLouisCreek
HamiltonCreek
Vasquez
RanchCreek
FirstCreek
FraserRiver_(WD51)
WilliamsFork_(WD51)
BobtailCreek
DeepCreek
MartinCreek
Elliott
CataractCreek
BlackCreek
BirchCreek
SlateCreek
StraightCreek
TennilleCreek
VidlerTunnel
SnakeRiver
BoxesPass
BlueRiver_(WD39)
Sheephorn_(WD52)
Idmount
HomestakeCreek
Bush-IronhoreTunnel
ColumbineDitch
EagleRiver_(WD37)
AlkaliCreek
EastLake
BirchCreek
GoreCreek
Core Creek
Snowmass
Capitol
WestSopris
WillowCreek
WoodyCreek
MaroonCreek
CastleCreek
HunterCreek
NorthThompson
CrystalRiver
NettleCreek
BoundaryTunnel
FryingPan_(WD38)
RoaringFork_(WD38)

Legend

- Diversion, Reservoir, and Instream Flow Node
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 2-4
Colorado River Decision Support System Nodes Available for Watershed Flow Evaluation Tool

CDM Smith

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Section 3

Watershed Flow Evaluation Tool Results

3.1 Watershed Flow Evaluation Tool Results Overview

This section summarizes the results of the hydrologic metrics analysis, geomorphic analysis, validation efforts, flow-ecology risk mapping, and recreation analysis. For the hydrologic metrics the difference between baseline and current condition flows are presented graphically. As discussed in Section 2, these metrics are presented because the flow-ecology relationships do not represent the entire hydrograph and the Colorado Basin Roundtable wanted some understanding of hydrologic changes in the basin. It should be noted that the ecological risks of these flow changes are unknown at this time except for the hydrologic metrics that have an associated flow-ecology curve as described in Section 2 of this report. For the geomorphic analysis, a summary of the results are presented in graphical form. The validation efforts comparing the WFET results for trout and warm water fish with efforts completed on the Colorado River mainstem are summarized. Flow-ecology risk mapping for trout, warm water fish, and riparian are summarized graphically. Finally, recreation information for the major recreation reaches in the basin is summarized including a usable days analysis.

3.2 Hydrologic Metrics

As was discussed in Section 2, the CDSS StateMod model was used to develop baseline and current conditions hydrology throughout the basin. Using information developed from StateMod, the difference between baseline and current conditions was calculated for the following hydrologic metrics:

- Mean annual flow
- Mean August flow
- Mean September flow
- Mean January flow
- Mean annual peak daily flow
- 2-year flood flow

3.2.1 Mean Annual Flow

Figure 3-1 at the end of this section shows the results for mean annual flow. This figure presents results for the entire Colorado River Basin in Colorado. StateMod nodes with a higher difference between baseline and current flow conditions are shown in purple. Nodes with a moderate change between baseline and current flow conditions are show in brown and tan colors. Off-white colored nodes indicated areas with a lower difference between baseline and current flow conditions. Water districts with the most nodes in the highest flow alteration category (<-50 percent) are water districts 51 (Upper Colorado/Fraser Rivers) and 72 (Lower Colorado River). Additionally, the water districts with the highest numbers of locations with flow alterations in the lowest flow alteration category (>-10 percent) are water districts 39 and 36. Following is a brief summary of mean annual flow results in each water district. Water District specific maps are provided in Appendix L.

- Blue River Basin - Water District 36: StateMod nodes with the highest amount of alteration are below Dillon Reservoir and nodes with lower amount of alteration are found in the upper part of the district.
- Eagle River Basin - Water District 37: StateMod nodes with highest amount of alteration are in the headwaters and nodes with lower amount of alteration are found in the lower part of the district.
- Roaring Fork River Basin – Water District 38: StateMod nodes with the highest amount of alteration are spread throughout the watershed.
- Rifle/Elk/Parachute Creeks – Water District 39: StateMod nodes with the highest amount of alteration are along the Colorado River mainstem and nodes with lower amount of alteration are found in the upper parts of the watershed.
- Divide Creek – Water District 45: StateMod nodes with the highest amount of alteration are along the Colorado River mainstem and nodes with lower amount of alteration are in the upper parts of the watershed.
- Muddy/Troublesome Creeks – Water District 50: StateMod nodes with the highest amount of alteration are in the lower portion of the watershed and nodes lower amount of alteration are in the upper part of the watershed.
- Upper Colorado/Fraser Rivers – Water District 51: StateMod nodes with the highest amount of alteration are located in the headwaters of this watershed.
- Piney/Cottonwood Creeks – Water District 52: In this watershed there are too few StateMod nodes to identify any patterns.
- Tributaries North of Colorado River – Water District 53: StateMod nodes with the most amount of alteration are highest along the mainstem of the Colorado River.
- Roan Creek Basin – Water District 70: In this watershed there are too few StateMod nodes to identify any patterns.
- Lower Colorado River – Water District 72: StateMod nodes with the highest amount of alteration are located along Plateau Creek.

3.2.2 Mean August Flow

Figure 3-2 at the end of this section shows the results for mean August flow. This figure presents results for the Upper Colorado River Basin in Colorado. StateMod nodes with a higher difference between baseline and current flow conditions are shown in purple. Nodes with a moderate change between baseline and current flow conditions are shown in brown and tan colors. Off-white colored nodes indicated areas with a lower difference between baseline and current flow conditions. Water districts with the most nodes in the highest flow alteration category (<-35 percent) are water districts 50 (Muddy/Troublesome Creeks) and 51 (Upper Colorado/Fraser Rivers). Additionally, the water districts with the highest amount of locations with flow alterations in the lowest flow alteration category (>-10 percent) are water districts 45 (Divide Creek) and 39 (Rifle/Elk/Parachute Creeks). Following is a brief summary of mean August flow results in each water district. Water District specific maps are provided in Appendix L.

- Blue River Basin - Water District 36: StateMod nodes with the highest amount of alteration are below Dillon Reservoir and nodes with lower amount of alteration are found in the upper part of the district.
- Eagle River Basin - Water District 37: StateMod nodes with highest amount of alteration are in the headwaters and nodes with lower amount of alteration are found along the mainstem of the Eagle River.
- Roaring Fork River Basin – Water District 38: StateMod nodes with the highest amount of alteration are located in the lower parts of the watershed.
- Rifle/Elk/Parachute Creeks – Water District 39: StateMod nodes with highest amount of alteration are located in the tributaries to the Colorado River.
- Divide Creek – Water District 45: StateMod nodes with the highest amount of alteration are located in the tributaries to the Colorado River.
- Muddy/Troublesome Creeks – Water District 50: StateMod nodes with the highest amount of alteration are located along Muddy and Troublesome Creeks.
- Upper Colorado/Fraser Rivers – Water District 51: StateMod nodes with the highest amount of alteration are in the headwaters of the watershed.
- Piney/Cottonwood Creeks – Water District 52: In this watershed there are too few StateMod nodes to identify any patterns.
- Tributaries North of Colorado River – Water District 53: In this watershed StateMod nodes with highest amount of alteration are found throughout the watershed.
- Roan Creek Basin – Water District 70: In this watershed there are too few StateMod nodes to identify any patterns.
- Lower Colorado River – Water District 72: StateMod nodes with the highest amount of alteration are found along Plateau Creek.

3.2.3 Mean September Flow

Figure 3-3 at the end of this section shows the results for mean September flow. This figure presents results for the entire Colorado River Basin in Colorado. StateMod nodes with a higher difference between baseline and current flow conditions are shown in purple. Nodes with a moderate change between baseline and current flow conditions are shown in brown and tan colors. Off-white colored nodes indicated areas with a lower difference between baseline and current flow conditions. Water districts with the most nodes in the highest flow alteration category (<-35 percent) are water districts 50 (Muddy/Troublesome Creeks) and 51 (Upper Colorado/Fraser Rivers). Additionally, the water districts with the highest amount of locations with flow alterations in the lowest flow alteration category (>-10 percent) are water districts 45 (Divide Creek) and 36 (Blue River Basin). Following is a brief summary of mean September flow results in each water district. Water District specific maps are provided in Appendix L.

- Blue River Basin – Water District 36: Nodes with the highest amount of alteration are located below Dillon Reservoir and those with lower amount of alteration are located in the upper portions of the watershed.
- Eagle River Basin – Water District 37: Nodes with the highest amount of alteration are located in some of the lower tributaries in the watershed and the remaining nodes are minimally altered.
- Roaring Fork River Basin – Water District 38: Nodes with the highest amount of alteration are located in the lower part of the watershed.
- Rifle/Elk/Parachute Creeks – Water District 39: The majority of nodes in the watershed are minimally altered.
- Divide Creek – Water District 45: The majority of nodes in the watershed are minimally altered.
- Muddy/Troublesome Creeks – Water District 50: Nodes with the highest amount of alteration are located along Muddy and Troublesome Creeks.
- Upper Colorado/Fraser Rivers – Water District 51: The majority of nodes in the water have higher alteration.
- Piney/Cottonwood Creeks – Water District 52: In this watershed there are too few StateMod nodes to identify any patterns.
- Tributaries North of Colorado River – Water District 53: Nodes along the Colorado River mainstem have the highest amount of alteration.
- Roan Creek Basin – Water District 70: In this watershed there are too few StateMod nodes to identify any patterns.
- Lower Colorado River – Water District 72: Nodes with the highest amount of alteration are located along Plateau Creek.

3.2.4 Mean January Flow

Figure 3-4 at the end of this section shows the results for mean January flow. This figure presents results for the entire Colorado River Basin in Colorado. StateMod nodes with a higher difference between baseline and current flow conditions are shown in purple. Nodes with a moderate change between baseline and current flow conditions are shown in brown and tan colors. Off-white colored nodes indicated areas with a lower difference between baseline and current flow conditions. Water districts with the most nodes in the highest flow alteration category (<-20 percent) are water districts 51 (Upper Colorado/Fraser Rivers) and 72 (Lower Colorado River). Additionally, the water districts with the highest amount of locations with flow alterations in the lowest flow alteration category (>40 percent) are water districts 50 (Muddy/Troublesome Creeks) and 39 (Rifle/Elk/Parachute Creeks). Following is a brief summary of mean January flow results in each water district. Water District specific maps are provided in Appendix L.

- Blue River Basin – Water District 36: Nodes with the highest amount of alteration are located below Dillon Reservoir and those with lower amount of alteration are located in the upper portions of the watershed.
- Eagle River Basin – Water District 37: Nodes with the highest amount of alteration are located in the headwaters.
- Roaring Fork River Basin – Water District 38: Nodes with the highest amount of alteration are located in headwaters in the basin.
- Rifle/Elk/Parachute Creeks – Water District 39: Nodes with the highest amount of alteration are located on the tributaries in the basin and the least altered nodes are located along the Colorado River mainstem.
- Divide Creek – Water District 45: Nodes with the highest amount of alteration are located on the tributaries in the basin and the least altered nodes are located along the Colorado River mainstem.
- Muddy/Troublesome Creeks – Water District 50: The nodes with the highest amount of alteration are located along Troublesome Creek.
- Upper Colorado/Fraser Rivers – Water District 51: The nodes with highest amount of alteration are in the headwaters in the basin.
- Piney/Cottonwood Creeks – Water District 52: In this watershed there are too few StateMod nodes to identify any patterns.
- Tributaries North of Colorado River – Water District 53: For this basin the location of nodes with the highest amount of alteration are located in the tributaries and not along the Colorado River mainstem.
- Roan Creek Basin – Water District 70: In this watershed there are too few StateMod nodes to identify any patterns.
- Lower Colorado River – Water District 72: The nodes with the highest amount of alteration in this watershed are located along Plateau Creek.

3.2.5 One-day Maximum Flow

Figure 3-5 at the end of this section shows the results for the one-day maximum flow. This figure presents results for the entire Colorado River Basin in Colorado. StateMod nodes with a higher difference between baseline and current flow conditions are shown in purple. Nodes with a moderate change between baseline and current flow conditions are shown in brown and tan colors. Off-white colored nodes indicated areas with a lower difference between baseline and current flow conditions. Water districts with the most nodes in the highest flow alteration category (<-34 percent) are water districts 45 (Divide creek) and 53 (Tributaries North of Colorado River). Additionally, the water district with the highest amount of locations with flow alterations in the lowest flow alteration category (>-10 percent) is water districts 39 (Rifle/Elk/Parachute Creeks). Following is a brief summary of the one-day maximum flow results in each water district. Water District specific maps are provided in Appendix L.

- Blue River Basin – Water District 36: Nodes with the highest amount of alteration are located below Dillon Reservoir.
- Eagle River Basin – Water District 37: Nodes with the highest amount of alteration are located in the upper portions of the watershed.
- Roaring Fork River Basin – Water District 38: Nodes with the highest amount of alteration are located along the mainstem of the Roaring Fork River.
- Rifle/Elk/Parachute Creeks - Water District 39: Nodes with the highest amount of alteration are located along the Colorado River mainstem.
- Divide Creek – Water District 45: Nodes with the highest amount of alteration are located along the Colorado River mainstem.
- Muddy/Troublesome Creeks – Water District 50: Nodes with the highest amount of alteration are located along Troublesome Creek.
- Upper Colorado/Fraser Rivers – Water District 51: Nodes with higher alteration are located in the lower portion of the watershed.
- Piney/Cottonwood Creeks – Water District 52: In this watershed there are too few StateMod nodes to identify any patterns.
- Tributaries North of Colorado River – Water District 53: Nodes with the highest amount of alteration are located along the Colorado River mainstem.
- Roan Creek Basin – Water District 70: In this watershed there are too few StateMod nodes to identify any patterns.
- Lower Colorado River – Water District 72: Nodes along the Plateau Creek mainstem have nodes with the highest amount of altered nodes.

3.2.6 Two-year Flood Flow

Figure 3-6 at the end of this section shows the results for the two-year flood flow. This figure presents results for the entire Colorado River Basin in Colorado. StateMod nodes with a higher difference between baseline and current flow conditions are shown in purple. Nodes with a moderate change between baseline and current flow conditions are shown in brown and tan colors. Off-white colored nodes indicated areas with a lower difference between baseline and current flow conditions. Water districts with the most nodes in the highest flow alteration category (<-35 percent) are water districts 53 (Tributaries North of Colorado River) and 72 (Lower Colorado River). Additionally, the water district with the highest amount of locations with flow alterations in the lowest flow alteration category (>-10 percent) are water districts 38 (Roaring Fork River Basin) and 45 (Divide Creek). Following is a brief summary of the 2-year flow results in each water district. Water District specific maps are provided in Appendix L.

- Blue River Basin – Water District 36: Nodes with the highest amount of alteration are located below Dillon Reservoir.

- Eagle River Basin – Water District 37: Nodes with the highest amount of alteration are located in the upper part of the basin.
- Roaring Fork River Basin – Water District 38: Nodes with the highest amount of alteration occur along the Roaring Fork River and Fryingpan River.
- Rifle/Elk/Parachute Creeks – Water District 39: In this basin, the nodes with the highest amount of alteration are located along the Colorado River mainstem.
- Divide Creek – Water District 45: In this basin, the nodes with the highest amount of alteration are located along the Colorado River mainstem.
- Muddy/Troublesome Creeks – Water District 50: Nodes with the highest amount of alteration in this watershed are located along Troublesome Creeks.
- Upper Colorado/Fraser Rivers – Water District 51: Nodes with the highest amount of alteration are located in the lower portion of the watershed.
- Piney/Cottonwood Creeks – Water District 52: In this watershed there are too few StateMod nodes to identify any patterns.
- Tributaries North of Colorado River District 53: Nodes along the Colorado mainstem in this watershed have the highest alteration.
- Roan Creek Basin – District 70: In this watershed there are too few StateMod nodes to identify any patterns.
- Lower Colorado River – Water District 72: In this watershed, nodes with higher alteration are located along Plateau Creek.

3.3 Geomorphic Subclassification

Figure 3-7 shows the results of the geomorphic subclassification. Each of the geomorphic subclasses is displayed as a different color on this map. Full results are summarized in Appendix E. The results from this effort were used in the warm water fish and riparian vegetation flow-ecology risk mapping efforts as described in Section 2.

3.4 Validation Results

As discussed in Section 2, site-specific data collection and detailed habitat modeling have been conducted for the mainstem of the Colorado River. Information from this modeling effort was used to compare the WFET results in the same stretch of the Colorado River to compare how the WFET flow-ecology risk levels compare to the habitat modeling based on site-specific data. The site-specific analyses were performed using a two dimensional habitat model (2D model) applied at three locations (Miller and Swaim 2011). The comparisons used data from the WUA function for adult and juvenile rainbow and brown trout, and adult flannelmouth sucker and hydrology at several locations for several discharge levels.

Details of the validation effort are summarized in Appendix K. Conclusions from the validation effort are as follows:

- In general, the WFET trout model corresponds with the adult trout habitat predicted by the site-specific model.
- The juvenile trout habitat predicted by the site-specific model does not correspond with the WFET risk values.
- The warmwater WFET model corresponds with the habitat area predicted by the flannelmouth sucker site-specific values. Correspondence increases in the downstream sections of the river.

3.5 Flow-Ecology Risk Mapping Results

In this section, the flow-ecology risk mapping results for trout, warm water fish, and riparian vegetation attributes are summarized. As discussed in Section 2, the flow-ecology metric for trout and warm water fish are based on low-flow metrics that occur in late summer and fall. For unconfined geomorphic settings, the riparian flow-ecology metric is based on a 90-day max flow metric that occurs during wet years and for confined settings, the flow-ecology metric is based on a one-day maximum over the full period of record.

3.5.1 Flow-Ecology Risk Summary

Summary maps (Figures 3-8 through 3-11) were used to assess the flow-ecology risk for all attributes – trout, warm water fish, and riparian – at each node StateMod location. Attributes are represented by a different symbol and color across all maps. The summary maps also outline water quality and habitat concerns that were summarized by the committee during Phase I Nonconsumptive Needs Assessment mapping efforts. These concerns are located in call-out boxes for each applicable water district.

Figure 3-8 shows the high flow-ecology risk locations, including nodes with high/very high trout, high warm water fish, and very high riparian flow-ecology risk. The attribute with largest amount of high risk flow-ecology relationship nodes is riparian recruitment (unconfined geomorphic settings) followed by trout. Figure 3-9 is a summary of moderate trout and warm water fish flow-ecology risk and high riparian flow-ecology risk. The attribute with the most nodes with moderate flow-ecology risk is riparian abundance (unconfined geomorphic settings). Trout, riparian recruitment (unconfined geomorphic settings), and riparian in confined settings have nearly the same number of moderate flow-ecology risk nodes. A summary of minimal risk locations is shown in Figure 3-10 and includes minimal trout and warm water fish flow-ecology risk and moderate riparian flow-ecology risk. Trout and riparian abundance (unconfined geomorphic settings) have the majority of minimal flow-ecology risk nodes. Finally, Figure 3-11 is a summary of low flow-ecology risk locations for trout, warm water fish and riparian vegetation attributes. The majority of low-flow ecology risk nodes are trout and warm water fish.

3.5.2 Trout Flow-Ecology Risk Mapping Results

Figure 3-12 displays the results for the trout flow-ecology mapping. Nodes with lower risk of limiting trout numbers are shown in green or blue. Nodes with higher risk of limiting trout numbers are shown in red or orange. Water districts with the most nodes classed as high risk are water districts 45 (Divide Creek) and 72 (Lower Colorado River). Additionally, the water district with the least nodes classed as low risk are water districts 36 (Blue River Basin) and 38 (Roaring Fork River Basin). Following is a brief summary of the trout flow-ecology risks for each water district. Water District specific maps are provided in Appendix L.

- Blue River Basin – Water District 36: The majority of nodes in this watershed have lower flow-ecology risk for trout.
- Eagle River Basin – Water District 37: The majority of nodes in this watershed have lower flow-ecology risk for trout.
- Roaring Fork River Basin – Water District 38: The majority of nodes in this watershed have lower flow-ecology risk for trout except for nodes along Cattle Creek, Fourmile Creek, and Thompson Creek.
- Rifle/Elk/Parachute Creeks – Water District 39: The majority of nodes in this watershed have lower flow-ecology risk for trout.
- Divide Creek – Water District 45: The majority of the nodes in the tributaries of this watershed have moderate and high flow-ecology risk for trout.
- Muddy/Troublesome Creeks – Water District 50: The majority of the nodes in this watershed have moderate and high flow-ecology risk for trout.
- Upper Colorado/Fraser Rivers – Water District 51: The majority of the nodes in the upper part of the watershed have lower flow-ecology risk for trout. In the lower reaches of the watershed, the majority of nodes have a moderate flow-ecology risk for trout.
- Piney/Cottonwood Creeks – Water District 52: There are limited nodes in this watershed, but they have moderate to high flow-ecology risk for trout.
- Tributaries North of Colorado River – Water District 53: The majority of nodes in this watershed have lower flow-ecology risk for trout except for nodes along Rock Creek, Red Dirt Creek, and Sweetwater Creek.
- Roan Creek Basin – Water District 70: The nodes in the watershed have low flow-ecology risk for trout.
- Lower Colorado River – Water District 72: The nodes in the upper portions of the watershed have higher flow-ecology risk and those in the lower portion of the basin have minimal to moderate flow-ecology risk.

3.5.3 Warm Water Fish Results

Figure 3-13 displays the results for the warm water fish flow-ecology mapping. Nodes with lower risk of reduced fish biomass are shown in green or blue and nodes with higher risk of reduced fish biomass are shown in red or orange. Water districts with the most nodes classed as high risk are water districts 53 (Tributaries North of Colorado River) and 72 (Lower Colorado River). Additionally, the water district with the least nodes classed as low risk are water districts 37 (Eagle River Basin) and 38 (Roaring Fork River Basin). Following is a brief summary of the warm water fish flow-ecology risks for each water district. Water District specific maps are provided in Appendix L.

- Blue River Basin - Water District 36: The warm water fish metric does not apply to any nodes.
- Eagle River Basin – Water District 37: The majority of the nodes have a low risk for warm water fish.

- Roaring Fork River Basin – Water District 38: The warm water fish metric applies to few nodes. Where it does apply, the nodes have low to minimal flow-ecology risk for warm water fish.
- Rifle/Elk/Parachute Creeks – Water District 39: The majority of the nodes have a low to minimal risk for warm water fish. A few nodes have moderate to high risk.
- Divide Creek – Water District 45: A majority of the nodes have a low flow-ecology risk for warm water fish. A few nodes have a moderate to high risk.
- Muddy/Troublesome Creeks – Water District 50: The warm water fish metric does not apply to any nodes.
- Upper Colorado/Fraser Rivers – Water District 51: The warm water fish metric does not apply to any nodes.
- Piney/Cottonwood Creeks – Water District 52: The warm water fish metric does not apply to any nodes.
- Tributaries North of Colorado River – Water District 53: The warm water fish metric applies to few nodes. Where it does apply, most nodes have low to minimal flow-ecology risk for warm water fish. Some nodes have a moderate to high risk.
- Roan Creek Basin – Water District 70: Low, minimal, and moderate flow-ecology risk.
- Lower Colorado River – Water District 72: A majority of the nodes have a low flow-ecology risk. There are also a few minimal and moderate to high flow-ecology risk nodes.

3.5.4 Riparian Vegetation Results

Figure 3-14 displays the results for the riparian vegetation flow-ecology risk mapping that include an assessment of cottonwood in unconfined and confined settings. Cottonwood flow-ecology risk in unconfined settings is based on the assessment of cottonwood recruitment and abundance. Nodes with lower flow-ecology risk are shown in green or yellow and nodes with higher flow-ecology risk are shown in orange or red. Water district 51 (Upper Colorado/Fraser Rivers) has the highest amount of unconfined locations with higher flow-ecology risk. Water districts 38 (Roaring Fork River Basin) and 72 (Lower Colorado River) have the highest amount of confined locations with a higher flow-ecology risk. Additionally, water district 37 (Eagle River Basin) has the highest amount of unconfined locations with a lower flow-ecology risk. Water district 51 (Upper Colorado/Fraser Rivers) also has the highest amount of unconfined-abundance locations with a lower flow-ecology risk and water district 38 (Roaring Fork River Basin) has a higher amount of unconfined-abundance locations with a lower flow-ecology risk. Following is a brief summary of the riparian flow-ecology risks for each water district. Water District specific maps are provided in Appendix L. In addition, Appendix M provides a pictorial guide to riparian changes following flow alteration. During the study, there were many discussions on how changes in the riparian community may change due to flow alteration and this appendix provides an illustration to the types of change that could occur in the future.

- Blue River Basin – Water District 36: A majority of nodes for unconfined settings have a low and moderate flow-ecology risk for abundance and recruitment, respectively. Two nodes have a moderate flow-ecology risk for cottonwood in unconfined settings.

- Eagle River Basin – Water District 37: A majority of nodes for unconfined settings have a low to moderate flow-ecology risk, while a few nodes have a high to very high flow-ecology risk. Most of the nodes have a low flow-ecology risk for cottonwood in confined settings, while a few have moderate and very high flow-ecology risk.

- Roaring Fork River Basin – Water District 38: Most nodes range from low to moderate and moderate to very high flow-ecology risk for abundance and recruitment, respectively. Nodes with a high flow-ecology risk for abundance are located on the Roaring Fork mainstem until the confluence with the Crystal River. Nodes range from low to very high flow-ecology risk for cottonwood in confined settings.

- Rifle/Elk/Parachute Creeks – Water District 39: A majority of nodes have a low to moderate flow-ecology risk for abundance and recruitment range. High flow-ecology risk for abundance occurs on the Colorado mainstem. For a majority of the nodes, the method for cottonwood in confined settings does not apply.

- Divide Creek – Water District 45: A majority of nodes have a high and very high flow-ecology risk for cottonwood abundance and recruitment, respectively. The flow-metric does not apply to nodes on tributaries, but the Colorado mainstem has a high flow-ecology risk for abundance. Node flow-ecology risk for cottonwood in confined settings range from low to high.

- Muddy/Troublesome Creeks – Water District 50: Flow-ecology risk for abundance and recruitment range from low to high for cottonwood abundance and moderate to very high for cottonwood recruitment. For a majority of the nodes, the cottonwood in confined settings flow metric does not apply. Where the metric does apply, flow-ecology risk is low.

- Upper Colorado/Fraser Rivers – Water District 51: Flow-ecology risk for abundance and recruitment range from low to very high. Cottonwood abundance upstream from the confluence of Williams Fork has a high to very high flow-ecology risk. For a majority of the nodes, the method for cottonwood in confined settings does not apply. Where the metric does apply, flow-ecology risk ranges from low to very high.

- Piney/Cottonwood Creeks – Water District 52: The flow-ecology risk for abundance is low and high, for recruitment is moderate and very high, and for cottonwood in confined settings is moderate. There are only three nodes in this water district.

- Tributaries North of Colorado River – Water District 53: A majority of nodes have a high flow-ecology risk for cottonwood abundance and a very high flow-ecology risk for recruitment along the Colorado mainstem. For a majority of the nodes, the cottonwood in confined settings does not apply. Where the metric does apply, flow-ecology risk ranges from low to high.

- Roan Creek Basin – Water District 70: There are few nodes in this water district. The flow-ecology risk for abundance ranges from low to high and for recruitment ranges from moderate to very high. For a majority of the nodes, the cottonwood method for confined settings does not apply. Where the metric does apply, flow-ecology risk is low.

- Lower Colorado River – Water District 72: A majority of nodes have a high flow-ecology risk for cottonwood abundance and a very high flow-ecology risk for recruitment. Flow-ecology

risk for abundance appears to be higher downstream. The cottonwood method for confined settings does not apply to any nodes.

3.6 Recreation Flow Relationship Results

For recreation analysis, information was collected for the major recreation segments across the basin. The major recreation segments are shown in Figure 3-15 and information about each of the segments is described in Table 3-1, which includes:

- Reach difficulty, length, and gradient;
- The types of users that utilize the reach for recreation;
- The season that the reach is used;
- The number of users that typically use the reach during the year; and
- The flow ranges that support recreation use in the segment based on survey work completed by American Whitewater and expert opinion.

For each of the reaches in Table 3-1, a usable days analysis was completed as described in Section 2. The usable days analysis utilizes the flow ranges presented in Table 3-1 and compares this information to historic hydrology to estimate the amount of usable days for whitewater recreation for a given recreation reach. The usable days analysis is presented in Figures 3-16 through 3-43 at the end of this section. Each figure is summarized below.

Colorado River

- 3-16 (Hot Sulphur Springs to Byers Canyon). Useable days analysis indicates usable days likely to occur for low flow range during April to August; for standard flow range during May to July. Steam flow peaks in late may for this river reach.
- 3-17 (Gore Canyon). Usable days analysis shows usable days likely to occur for low flow range during all months of the year except February, for standard flow range during March to November, and high flow range during April to September. Historical streamflow peaks in late-May and again in late-June.
- 3-18 (Pumphouse to State Bridge). Usable days analysis indicates usable days likely to occur for low flow range for all months of the year except January, for standard flow range during April to October, and high flow range during May through August. Historical streamflow peaks in late May and again in mid-June.
- 3-19 (State Bridge to Burns). Usable days analysis indicates usable days likely to occur for low flow range for all months during the year, for standard flow range during March to November, and high flow range during April to August. Historical streamflow peaks in mid-May.
- 3-20 (Burns to Dotsero). Usable days analysis indicates usable days likely to occur for low flow range for all months of the year, for standard flow range during March to October, and high flow range during May to July. Historical streamflow peaks in mid-May.

- 3-21 (Hanging Lake Exit to Shoshone Power Plant Exit). Usable days analysis shows usable days likely to occur for low flow range year-round and for standard flow range from April to October. Historical peak flow occurs in mid-to late-May.
- 3-22 (Shoshone Power Plant to Grizzly Creek). Useable days analysis indicates usable days likely to occur for low flow range year-round, for standard flow range from April to October, and for high flow range from April to August. Streamflow historically peaks in mid to late May.
- 3-23 (Grizzly Creek to Two Rivers Park). Usable days analysis indicates usable days likely to occur for low flow range year-round, for standard flow range from March to October, and high flow range during May to July. Streamflow historically peaks in mid to late May.
- 3-24 (Two Rivers Park to Silt Takeout). Usable days analysis shows usable days likely to occur year round for low flow range and for standard blow range during April to October. Historically, streamflow peaks in mid to late May.
- 3-25 (Big Sur). Usable days analysis indicates usable days likely to occur for low flow range and standard flow range during May to July and for standard flow range in June. Streamflow peaks in mid to late May.
- 3-26 (Loma Launch to Westwater Launch). Usable days analysis shows usable days likely to occur for low flow range during all months of the year and for standard flow range during April through August. Historical streamflow peaks in mid to late May.

Fraser River

- 3-27 (Tabernash to Granby). Usable days analysis indicates usable days likely to occur for low and standard flow range during May to July. Historic streamflow peaks in mid-June.

Williams Fork

- 3-28 (Horseshoe Campground to Reservoir). Usable days analysis indicates usable days likely to occur for low flow range from April to August and for standard flow range during May and June. Historic streamflow peaks in June.

Blue River

- 3-29 (Breckenridge Town Run). Useable days analysis indicates usable days likely to occur for low flow range from April through October and for standard flow range during May to September. Peak flow historically occurs mid-May through mid-June.
- 3-30 (Campground to FR 2400). Useable days analysis indicates usable days likely to occur for low flow range and standard flow range from May through September. Streamflow historically peaks in June.
- 3-31 (Green Mountain Reservoir to Spring Creek and Lower Blue River to Confluence with Colorado River). Useable days analysis shows usable days likely to occur for low flow range from May to October and for standard flow range from May to August. Historic streamflow peaks in June.

Rock Creek

- 3-32 (Gore Pass to Highway 131). Useable days analysis indicates usable days likely to occur for low flow range during April to May and for standard flow range during May. Streamflow historically peaks in May.

Homestake Creek

- 3-33 (Homestake Creek). Useable days analysis shows usable days likely to occur for low flow range during May to August. Steamflow historically peaks in May.

Cross Creek

- 3-34 (Cross Creek). Useable days analysis indicates usable days likely to occur for low flow and standard flow range during May through July. Streamflow historically peaks in late-May.

Gore Creek

- 3-35 (Gore Creek-Vail Town Run). Useable days analysis indicates usable days likely to occur for low flow range during May to July. Historic streamflow peaks in May.

Eagle River

- 3-36 (Eagle River (Forest Service Visitor Center to Riverbend Bus Stop) and Upper Eagle River (Minturn Slalom Course)). Useable days analysis indicates usable days likely to occur for low flow range during May to July. Streamflow historically peaks in May.

- 3-37 (Avon to Dotsero). Useable days analysis indicates usable days likely to occur for low flow range during April through August and for standard flow range during May to July. Streamflow historically peaks in May.

Piney River

- 3-38 (Piney Crossing to State Bridge). Useable days analysis indicates usable days likely to occur for low flow range during May and June. Streamflow historically peaks in late-May to June.

Roaring Fork

- 3-39 (Upper Roaring Fork through Aspen Town Run). Useable days analysis indicates usable days likely to occur for low flow range during May to August and standard flow range from May to July. Streamflow historically peaks during May and June.

- 3-42 (Weller Lake to Difficult Camp Ground). Useable days analysis indicates usable days likely to occur for low flow range during May to August and standard flow range from May to July. Streamflow historically peaks during June.

- 3-43 (Cemetery). Useable days analysis indicates usable days likely to occur for low flow range during all months of the year and standard flow range from March to November. Streamflow historically peaks during June.

Crystal River

- 3-40 (Avalanche Creek to Narrows). Useable days analysis indicates usable days likely to occur for low flow range during April to August and standard flow range from May to July. Historic streamflow peaks during June.

- 3-41 (Marble to Penny Hot Springs). Useable days analysis indicates usable days likely to occur for low flow range during April to August and standard flow range from May to July. Streamflow historically peaks during June.

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Table 3-1 Colorado Basin WFET Recreation Matrix

Map ID	Reach Name	Reach Description	Types of Users	Season Per User Group	Annual Number of Users	Flow Ranges	USGS Gage or StateMod Node
1	Colorado River (Hot Sulphur Springs to Hwy 40 bridge (Byers Canyon))	Usual Difficulty: IV Length: 3 miles Average Gradient: 42 fpm	Kayaking Non-commercial (intermediate to advanced)	May 1 to June 30	Unknown	Minimum: 700 cfs Optimum: 1700 cfs Maximum: None (AW Study; Stafford & McCutchen says 2000 cfs max)	09034250
			Rafting Non-commercial	May 1 to June 30			
			Kayaking Commercial (instruction only)	May 1 to June 30			
2	Colorado River (Gore Canyon)	Usual Difficulty: IV/V Length: 9.5 miles Average Gradient: 35 fpm Max Gradient: 120 fpm	Kayaking Commercial	April 1 to October 31	Minimum: 342 Maximum: 440 (2008-2009 BLM) Included in Pumphouse data	Minimum: 700cfs (900cfs commercial) Optimum: 1300 cfs Maximum: 2500 cfs Low Preferred: 750-1050 cfs Standard Preferred: 1050-2000 cfs High Preferred: 2000-2500 (AW Study; guide books confirm max)	09058000
			Rafting Commercial				
			Kayaking Non-commercial	Year Round (ice dependent)			
			Rafting Non-commercial				
3	Colorado River (Pumphouse to State Bridge)	Usual Difficulty: II/III Length: 11.6 miles Average Gradient: 17 fpm	Canoeing Commercial	April 1 to September 30	Minimum: 31,000 Maximum: 43,000 (1999-2008, CROA) Minimum: 29,449 Maximum: 42,933 (2000-2009 BLM)	Minimum: 900 cfs Optimum: 1100-4500 cfs Maximum: None (AW Study)	09058000
			Float-Fishing Commercial				
			Kayak Commercial				
			Inflatable Commercial				
			Canoeing Non-commercial	Year Round (ice dependent)	Minimum: 6577 Maximum: 25,012 (2000-2009 BLM)	Minimum: 900 cfs Optimum: 2500 cfs Maximum: None Low Preferred: 900-1500 cfs Standard Preferred: 1500-3500 cfs High Preferred: 3500-5800 cfs (AW Study)	
			Float-Fishing Non-commercial				
			Kayak Non-commercial				
			Inflatable Non-commercial				
4	Colorado River (State Bridge to Burns (Burns Hole))	Usual Difficulty: II/III Length: 20 miles Average Gradient: 16 fpm	Float-Fishing Commercial	April 1 to September 30	Unknown	Minimum: 900 cfs Optimum: 2500 cfs Maximum: None Low Preferred: 900-1300 cfs Standard Preferred: 1300-4000 cfs High Preferred: 4000-7400 cfs (AW Study)	09070500 (Subtracted out 09070000)
			Kayak Commercial				
			Rafting Commercial				
			Float-Fishing Non-commercial	Year Round (ice dependent)			
			Kayak Non-commercial				
			Rafting Non-commercial				
5	Colorado River (Burns to Dotsero (Burns Canyon))	Usual Difficulty: II/III Length: 26 miles Average Gradient: 17 fpm	Float-Fishing Commercial	April 1 to September 30	Unknown	Minimum: 900 cfs Optimum: 2500 cfs Maximum: None Low Preferred: 800-1400 cfs Standard Preferred: 1400-4500 cfs High Preferred: 4500-8800 cfs (AW Study)	09070500 (Subtracted out 09070000)
			Kayak Commercial				
			Rafting Commercial				
			Float-Fishing Non-commercial	Year Round (ice dependent)			
			Kayak Non-commercial				
			Rafting Non-commercial				
6	Colorado River (Hanging Lake Exit 125 (I-70) to Shoshone Power Plant Exit 123 (I-70) (Barrel Springs)); this is the bypass reach	Usual Difficulty: IV/V (V+) Length: 2.5 miles Average Gradient: 66 fpm	Kayak Non-commercial	Year Round (ice dependent)	Unknown	Minimum: 900 cfs Optimum: 1900 cfs Maximum: None (AW Study)	09070500
			Rafting Non-commercial				
7	Colorado River (Shoshone Power Plant, Exit 123 (I-70) to Grizzly Creek, Exit 121 (I-70) (Shoshone))	Usual Difficulty: III/IV Length: 2 miles Average Gradient: 39 fpm	Float-Fishing Commercial	Year Round (ice dependent)	Minimum: 42,500 Maximum: 65,000 (1999-2008, CROA)	Minimum: 900 cfs Optimum: 2500 cfs Maximum: 5500 cfs (AW Study) Gentleman's Agreement: No Commercial Trips > 5500 cfs	09070500
			Kayak Commercial				
			Rafting Commercial				
			Float-Fishing Non-commercial		Minimum: 40,000 Maximum: 50,000 2007 Estimate (USFS)	Minimum: 900 cfs Optimum: 2500 cfs Maximum: None (AW Study) Low Preferred: 1000-1900 cfs Standard Preferred: 1900-4900 cfs High Preferred: 4900-9400 cfs	
			Kayak Non-commercial				
			Rafting Non-commercial				
8	Colorado River (Grizzly Creek to Two Rivers Park)	Usual Difficulty: II/II+/III	Kayak Commercial Instruction	Year Round (ice dependant),	Minimum: 42,500	Minimum: 900 cfs	09070500

Table 3-1 Colorado Basin WFET Recreation Matrix

Map ID	Reach Name	Reach Description	Types of Users	Season Per User Group	Annual Number of Users	Flow Ranges	USGS Gage or StateMod Node
		Length: 6 miles Average Gradient: 19 fpm Maximum Gradient: 30 fpm	Rafting Commercial Float-Fishing Commercial Inflatables Non-commercial Kayak Non-commercial Rafting Non-commercial	Peak: April 1 to September 30	Maximum: 65,000 (1999-2008, CROA) Included in 2007 USFS estimate above	Optimum: 2500 cfs Maximum: None Low-Preferred: 1250 to 1800 cfs Standard Preferred: 1800 to 5500 cfs High- Preferred: 5500 to 8600 cfs (AW Study)	
9	Colorado River (Two Rivers Park to Silt Takeout)	Usual Difficulty: II/III Length: 21 miles Average Gradient: 16 fpm	Float-Fishing Commercial Kayak Commercial Rafting Commercial Float-Fishing Non-commercial Kayak Non-commercial Rafting Non-commercial	August 1 to October 31 Year Round (ice dependent) August 1 to October 31 Year Round (ice dependent)	Unknown Unknown	Minimum: 500 cfs (non-commercial) Optimum: 3250 cfs Maximum: None (Stafford & McCutchen)	09085100
10	Colorado River (Big Sur)	Usual Difficulty: III Length: 0.1 miles Average Gradient: 15 fpm	Kayak Non-commercial	Flow Dependant	Unknown	Minimum: 18,000 cfs Optimum: 24,000 cfs Maximum: None (Stafford & McCutchen)	09095500
11	Colorado River (Loma launch to Westwater launch)	Usual Difficulty: II Length: 25 miles Average Gradient: 7 fpm	Canoeing Commercial Float-fishing/Hunting Commercial Inflatable Kayak Commercial Kayak Commercial Rafting Commercial Canoeing Non-commercial Float-fishing/Hunting Non-commercial Inflatable Kayak Non-commercial Kayak Non-commercial Rafting Non-commercial	Year Round (ice dependant) Duck Hunting Season October - January Year Round (ice dependant) Duck Hunting Season October - January Year Round (ice dependant)	Minimum: 2300 Maximum: 4500 (1999-2008, CROA) Unknown	Minimum: 1800 cfs Optimum: 10,000 cfs Maximum: 20,000 cfs (Stafford & McCutchen)	09163500
12	Fraser River (Tabernash to Granby)	Usual Difficulty: III/IV Length: 9.3 miles Average Gradient: 35 fpm	Kayak Non-commercial Rafting Non-commercial (few)	May 1 to June 30	Unknown (small)	Minimum: 700 cfs Optimum: 1300 cfs (AW Study) Maximum: 2000 cfs (AW website)	Confl_8
13	Williams Fork (Horseshoe Campground to Reservoir)	Usual Difficulty: II-IV Length: 9.7 miles Average Gradient: 68 fpm	Float-Fishing Non-commercial Kayak Non-commercial Rafting Non-commercial	Year Round (flow and ice dependant)	Unknown	Minimum: 200 cfs High: 1500 cfs (AW Website)	09037500
14	Blue River (Breckenridge Town Run)	Whitewater Park in Breckenridge	Kayak Non-commercial	May 1 to June 30	Unknown	Min: 50 cfs Optimum: 90 cfs Design Minimum: 200 cfs (Stafford & McCutchen)	361008
15	Blue River (Campground to FR 2400 (Upper Blue Dillon to Green Mountain))	Usual Difficulty: III/IV Length: 3 miles Average Gradient: 47 fpm Maximum Gradient: 50 fpm	Float-Fishing Commercial Kayak Commercial Rafting Commercial Float-Fishing Non-commercial Kayak Non-commercial Rafting Non-commercial	May 1 to October 15	Unknown	Minimum: 400 cfs Optimum: 1000 cfs Maximum: None (Stafford & McCutchen)	09050700
16	Blue River Green Mountain Reservoir to Spring Creek Road (Green Mountain Canyon) and Lower	Usual Difficulty: III Length: 16 miles	Float-Fishing Commercial	April 1 to October 31	Minimum: 0 Maximum: 2,900 (1998-	Minimum: 900 cfs (commercial) Optimum: 1300 cfs (commercial)	09057500

Table 3-1 Colorado Basin WFET Recreation Matrix

Map ID	Reach Name	Reach Description	Types of Users	Season Per User Group	Annual Number of Users	Flow Ranges	USGS Gage or StateMod Node
	Blue River (Green Mountain Reservoir to Confluence with Colorado River)	Average Gradient: 41 fpm	Kayak Commercial Rafting Commercial Float-Fishing Non-commercial Kayak Non-commercial Rafting Non-commercial		2008, CROA)	Maximum: 2300 cfs (commercial) (AW Study) Minimum: 700 cfs Optimum: 1500 cfs Maximum: None (AW Study)	
17	Rock Creek (Gore Pass to Highway 131)	Usual Difficulty: V Length: 11 miles Average Gradient: 180 fpm	Kayak Non-commercial	April 1 to May 31	Unknown	Minimum: 150 cfs Maximum: 400 cfs (Stafford & McCutchen)	09060500
18	Homestake Creek	Usual Difficulty: V Length: 0.25 miles Average/Maximum Gradient: 292 fpm	Kayak Non-commercial, Teva Competition	April 1 to July 31	Unknown	Optimum: 50 to 250 cfs (Stafford & McCutchen)	09064000
19	Cross Creek	Usual Difficulty: V+ Length: 1.3 mile Average Gradient: 130 fpm	Kayak Non-commercial	June 15 to July 31	Unknown	Minimum: 140 cfs Optimum: 160 cfs Maximum: 250 cfs (Stafford & McCutchen)	09065100
20	Gore Creek (Vail town run)	Usual Difficulty: III-IV Length: 9.2 miles Average Gradient: 67 fpm	Rafting Commercial Kayak Non-commercial Rafting Non-commercial	May 1 to July 15	Unknown	Minimum: 300 cfs Optimum: 800 cfs Maximum: None (Stafford & McCutchen)	09065500
21	Eagle River (Forest Service Visitor Center to Riverbend bus stop (Dowd Chute)) Upper Eagle River (Minturn Slalom Course)	Usual Difficulty: IV Length: 1 mile Average Gradient: 70 fpm Usual Difficulty: III/IV Length: 1.5 miles Average Gradient: 70 fpm	Float-Fishing Commercial Kayak Commercial Rafting Commercial Float-Fishing Non-commercial Kayak Non-commercial Rafting Non-commercial Kayak Commercial Paddleboard Commercial Rafting Commercial Float-Fishing Non-commercial Kayak Non-commercial Paddleboard Non-commercial Rafting Non-commercial	August 1 to October 31 May 1 to July 31 August 1 to October 31 May 1 to July 31 April 1 to October 31 August 1 to October 31 April 1 to October 31	Included in Upper Eagle and Eagle River (Edwards to Eagle), Unknown Unknown	Minimum: 500 cfs Optimum: 2000 cfs Maximum:None (Stafford & McCutchen)	09064600 (from USGS not StateMod)
22	Eagle River (Avon to Dotsero (Lower Eagle))	Usual Difficulty: II/III Length: 40 miles Average Gradient: 35 fpm	Float-Fishing Commercial Kayak Commercial Paddleboard Commercial Rafting Commercial Float-Fishing Non-commercial Kayak Non-commercial Paddleboard Non-commercial Rafting Non-commercial	August 1 to October 31 April 1 to October 31 August 1 to October 31 April 1 to October 31	Unknown	Minimum: 600 cfs Optimum: 1000 cfs Maximum: None (Stafford & McCutchen)	09070000
23	Piney River (Piney Crossing to State Bridge)	Usual Difficulty: V+ Length: 19 miles Average Gradient: 129 fpm Maximum Gradient: 400 fpm	Kayak Non-commercial	May 1 to June 30	Unknown	Minimum: 700 cfs Optimum: 1500 cfs Maximum: None (AW Study)	9059500 (from USGS not StateMod)

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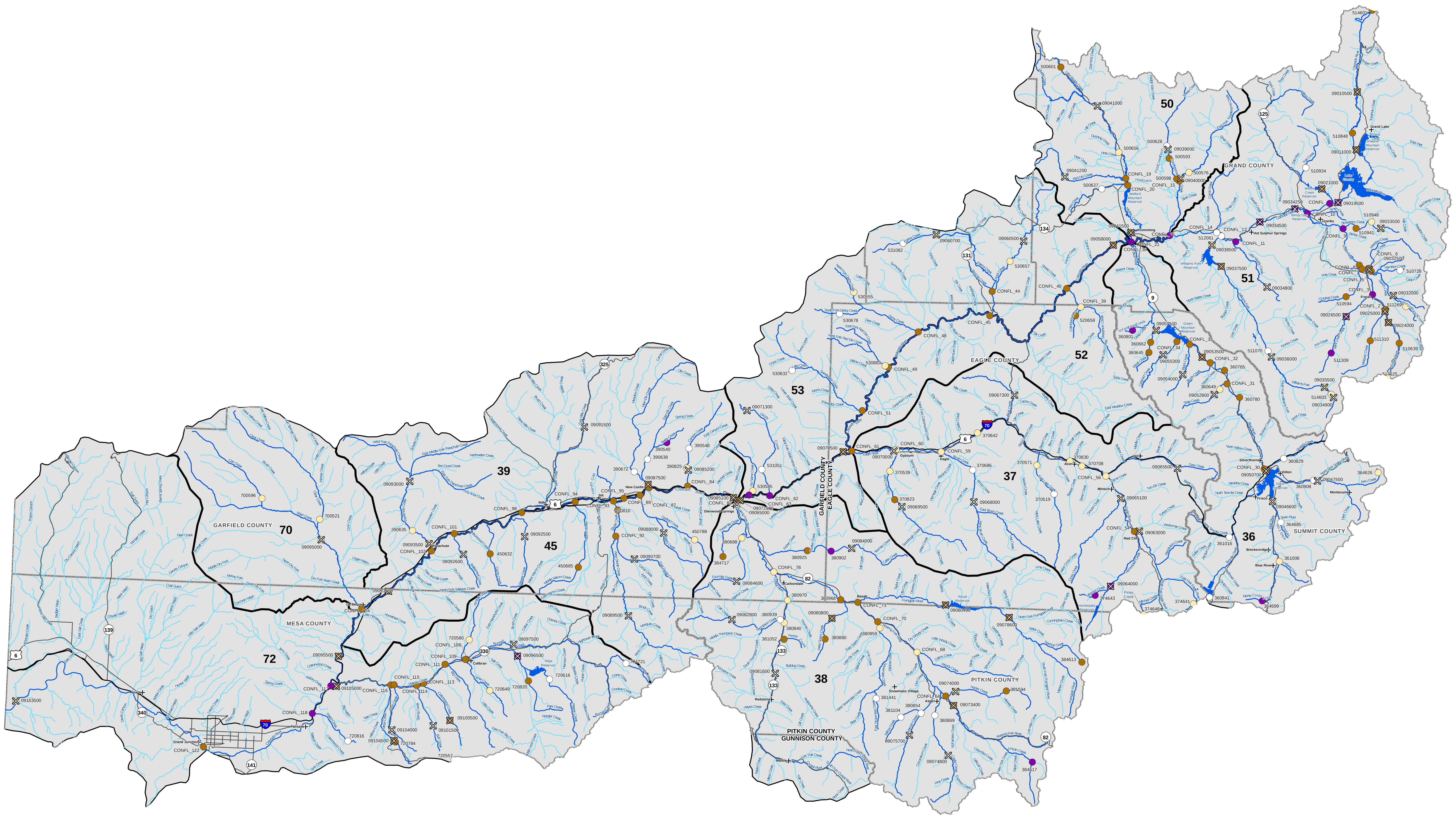


Legend

Mean Annual Flow % Change

- < -50%
- -50% to -25%
- -25% to -10%
- > -10%
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N
W E
S

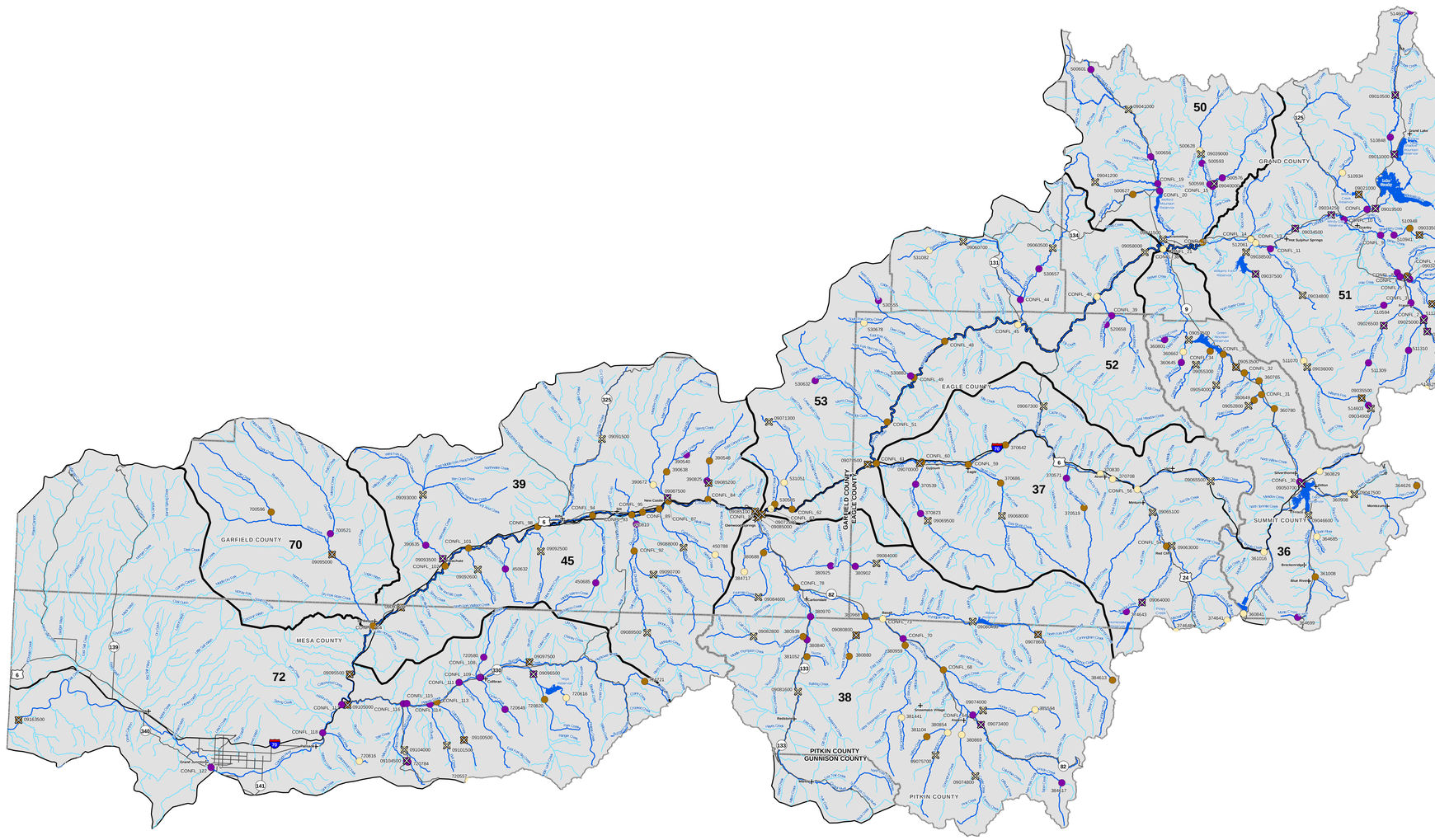
0 3 6 12 18
Miles

Figure 3-1
Colorado Basin Watershed Flow Evaluation Tool

Mean Annual Flow Percent Difference between Natural and Existing Flow Conditions

CDM Smith

Document: \\Dengissvr1\cdmgis\SWSI\NONCONSUMPTIVE\COLORADO_WFET\MXD\Flow Metric Figures



Legend

Mean August Flow % Change

- < -35%
- -35% to -10%
- > -10%
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 3-2
Colorado Basin Watershed Flow Evaluation Tool

Mean August Flow Percent Difference between Natural and Existing Flow Conditions

CDM Smith

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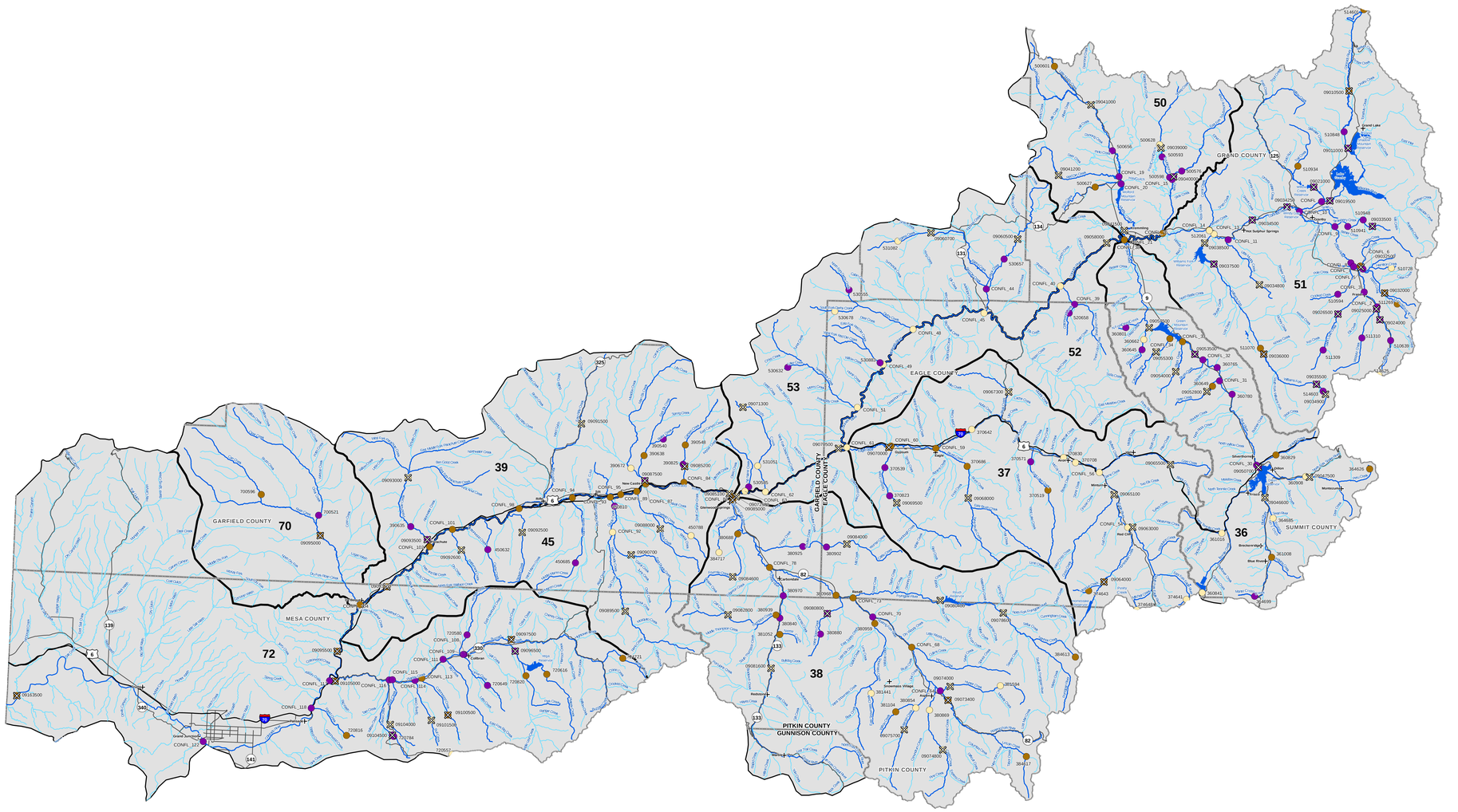

Legend

Mean September Flow % Change

- < -35%
- -35% to -10%
- > -10%
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 3-3
Colorado Basin Watershed Flow Evaluation Tool

Mean September Flow Percent Difference between Natural and Existing Flow Conditions

CDM Smith

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Legend

Mean January Flow % Change

- < -20%
- -20% to 0%
- 0% to 40%
- > 40%
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N
W E
S

0 3 6 12 18
Miles

GRAND COUNTY
EAGLE COUNTY
GARFIELD COUNTY
MESA COUNTY
SUMMIT COUNTY
PITKIN COUNTY
GUNNISON COUNTY

50
51
52
53
39
45
37
36
38
72
70

Figure 3-4
Colorado Basin Watershed Flow Evaluation Tool

Mean January Flow Percent Difference between Natural and Existing Flow Conditions

CDM Smith

Document: \\Dengissvr11\cdmgis\SWS\NONCONSUMPTIVE\COLORADO_WFET\MXD\Flow Metric Figures

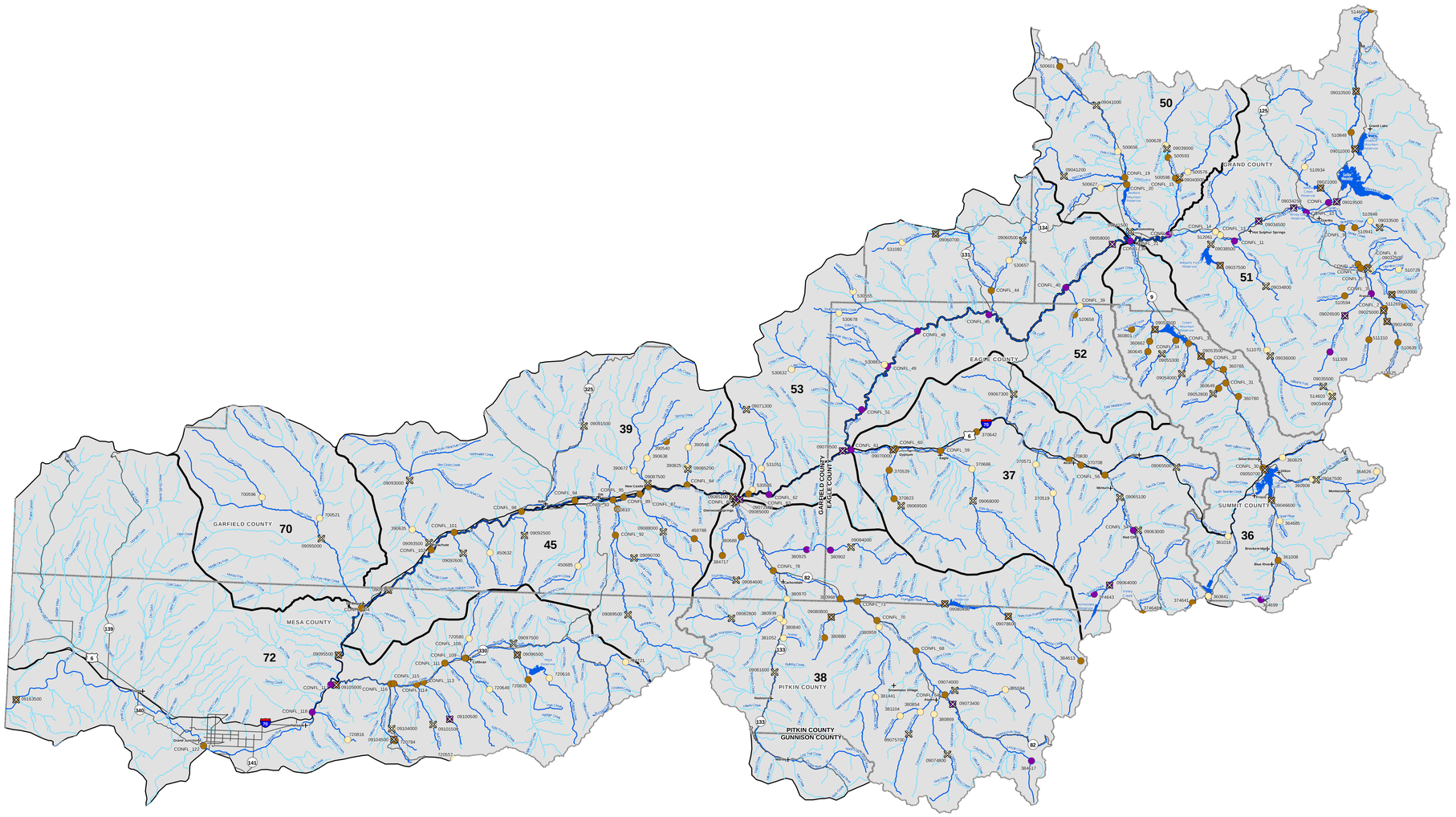

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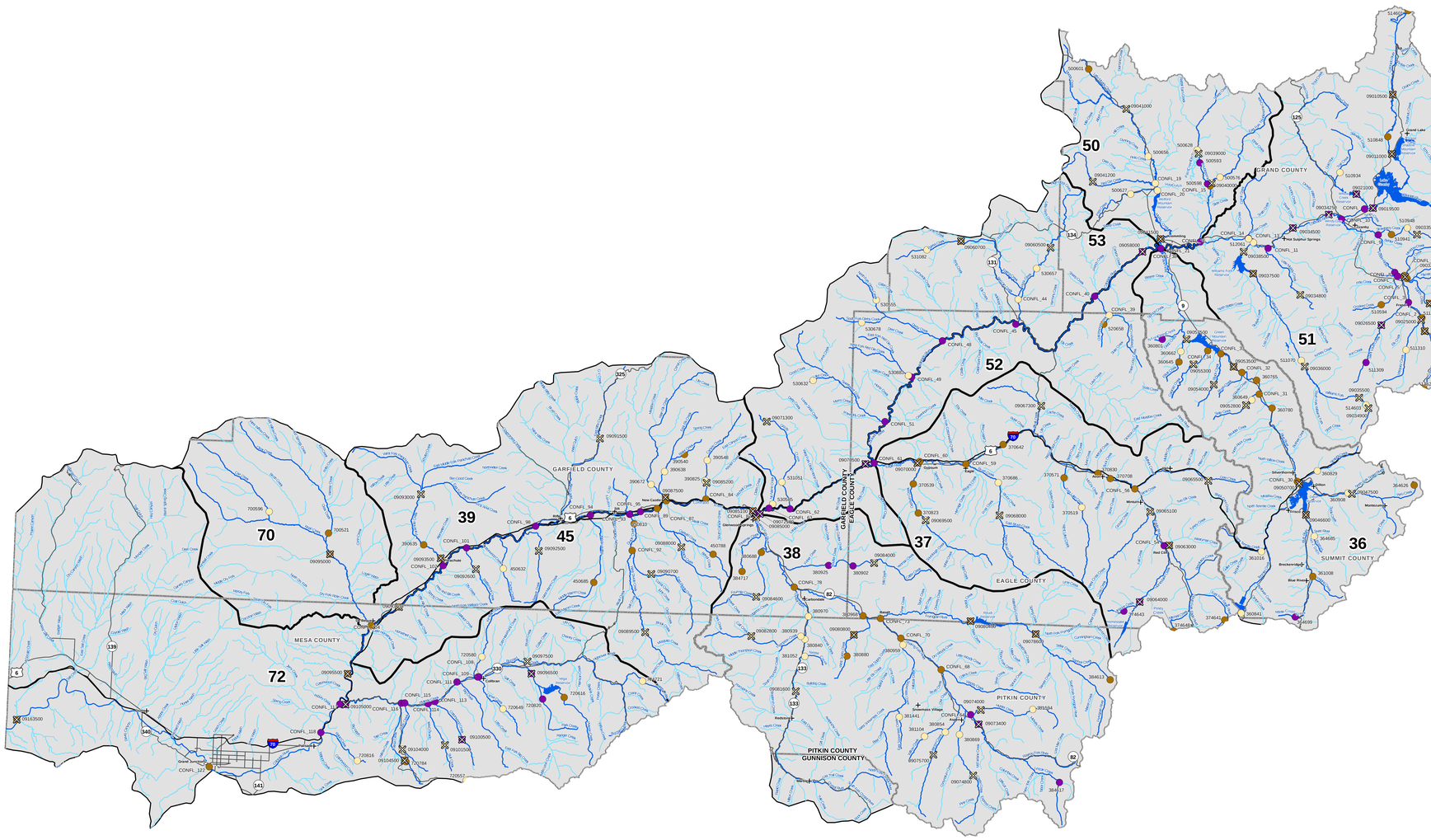
Figure 3-5
Colorado Basin Watershed Flow Evaluation Tool

1-Day Maximum Flow Percent Difference between Natural and Existing Flow Conditions

CDM Smith



Legend

2-Year Flow % Change

- < -35%
- -35% to -10%
- > -10%
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

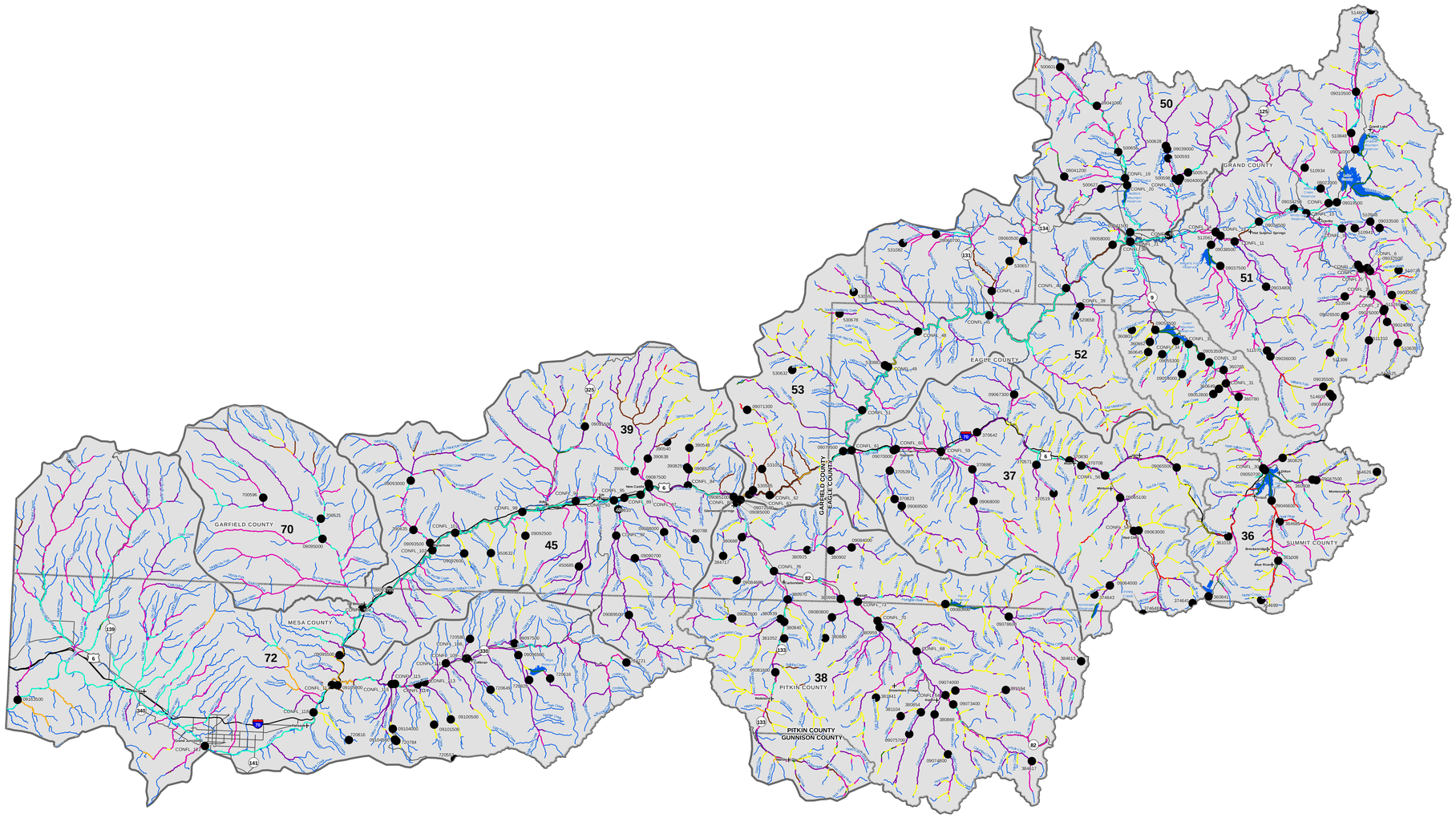
0 3 6 12 18 Miles

Figure 3-6
Colorado Basin Watershed
Flow Evaluation Tool

2-Year Effective Discharge
Percent Difference between
Natural and Existing Flow Conditions

CDM Smith

Document: \\Dengissvr11\cdmgis\SWS\NONCONSUMPTIVE\COLORADO_WFET\MXD\Flow Metric Figures



Legend

- Canyon
- Glacial Trough
- Gorge
- High-energy Coupled
- High-energy Open
- Headwaters
- Low-energy Floodplain
- Moderate-energy Confined
- Moderate-energy Unconfined
- CDSS Model Nodes
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N
W
E
S

0 3 6 12 18
Miles

Figure 3-7
Colorado Basin Watershed Flow Evaluation Tool

Geomorphic Subclassification

CDM Smith

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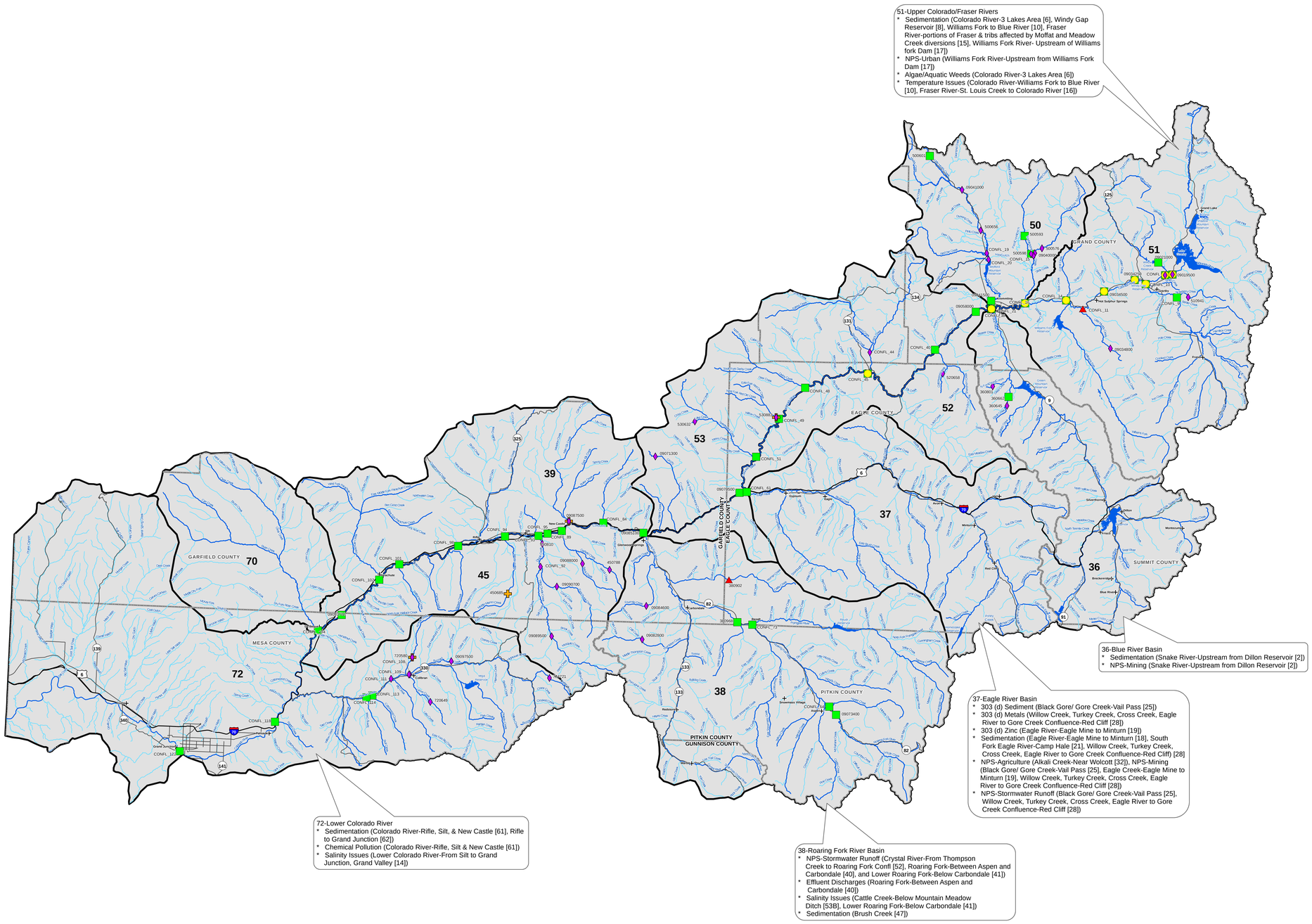

Legend

- Trout Flow-Ecology Significant/High Risk
- Warm Water Fish Flow-Ecology High Risk

Cottonwood in Confined Settings

- Confined Flow-Ecology Very High Risk

Cottonwood in Unconfined Settings

- Abundance Flow-Ecology Very High Risk
- Recruitment Flow-Ecology Very High Risk
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 3-8
Colorado Basin Watershed Flow Evaluation Tool

Summary of High Flow-Ecology Risk Locations for Riparian, Trout, and Warm Water Fish

CDM Smith

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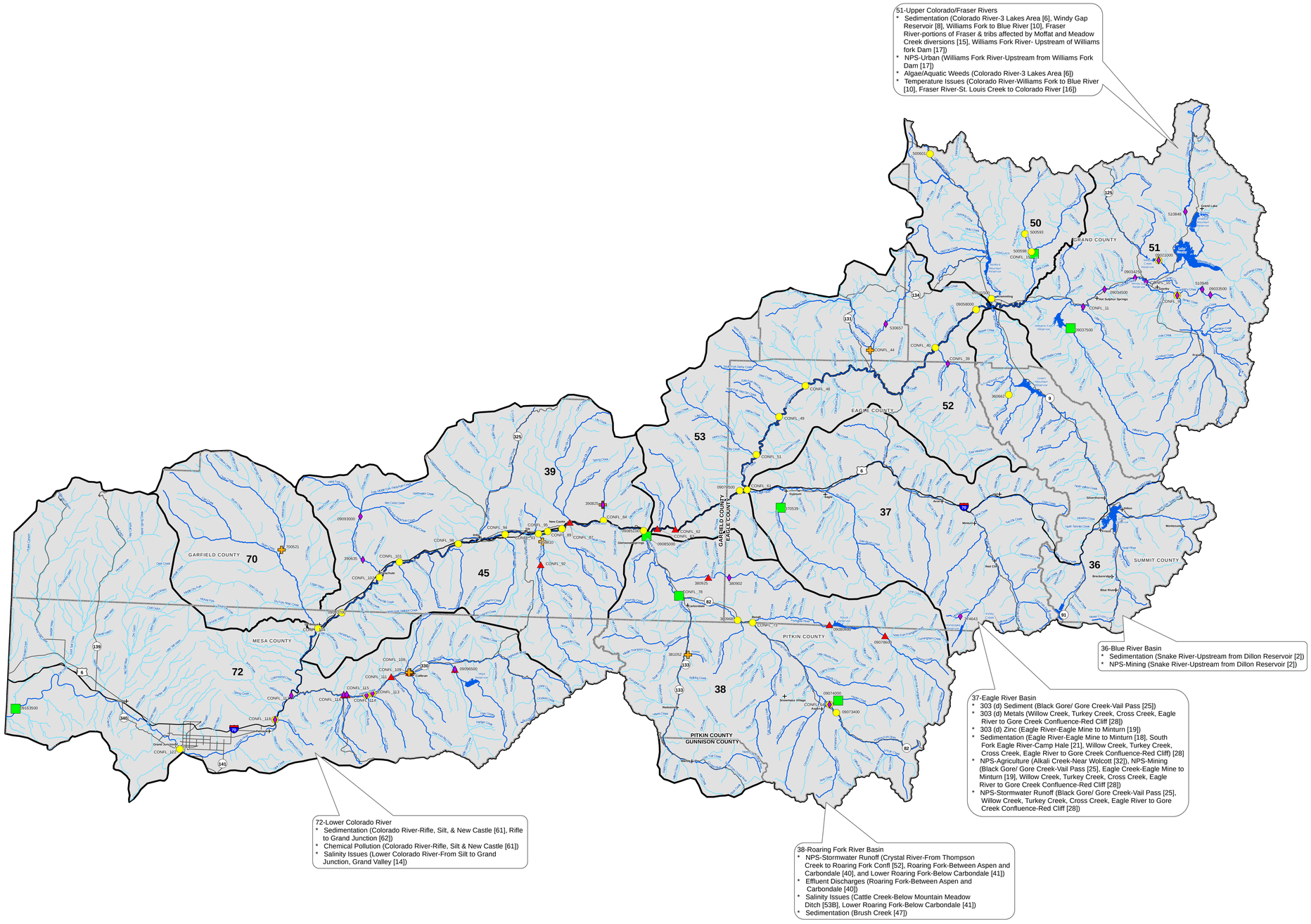

Legend

- Trout Flow-Ecology Moderate Risk
- Warm Water Fish Flow-Ecology Moderate Risk

Cottonwood in Confined Settings

- Confined Flow-Ecology High Risk

Cottonwood in Unconfined Settings

- Abundance Flow-Ecology High Risk
- Recruitment Flow-Ecology High Risk
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 3-9
Colorado Basin Watershed Flow Evaluation Tool

Summary of Moderate Flow-Ecology Risk Locations for Riparian, Trout, and Warm Water Fish

CDM Smith

Document: \\Denglissvr1\cdmgis\SWS\NONCONSUMPTIVE\COLORADO_WFETM\MXD

51-Upper Colorado/Fraser Rivers
* Sedimentation (Colorado River-3 Lakes Area, Windy Gap, Williams Fork to Blue River, Ranch Creek Tributaries, Fraser, St. Louis and Vasquez Creeks, Williams Fork-Portion affected by Moffat and Meadow Creek Diversions)
* NPS-Mining (Williams Fork River-Upstream from Williams Fork Dam)
* Algae/Aquatic Weeds (Colorado River-3 Lakes Area)
* Temperature Issues (Colorado River-Williams Fork to Blue River, Fraser River-St. Louis Creek to Colorado River)

36-Blue River Basin
* Sedimentation (Snake River-Upstream from Dillon Reservoir)
* NPS-Mining (Snake River-Upstream from Dillon Reservoir)

37-Eagle River Basin
* 303 (d) Sediment (Black Gore/ Gore Creek-Vail Pass)
* 303 (d) Metals (Willow Creek, Turkey Creek, Cross Creek, Eagle River to Gore Creek Confluence-Red Cliff)
* 303 (d) Zinc (Eagle River-Eagle Mine to Minturn)
* Sedimentation (Eagle River-Eagle Mine to Minturn, South Fork Eagle River-Camp Hale, Willow Creek, Turkey Creek, Cross Creek, Eagle River to Gore Creek Confluence-Red Cliff)
* NPS-Agriculture (Alkali Creek-Near Wolcott)
* NPS-Mining (Black Gore/ Gore Creek-Vail Pass, Eagle Creek-Eagle Mine to Minturn, Willow Creek, Turkey Creek, Cross Creek, Eagle River to Gore Creek Confluence-Red Cliff)

38-Roaring Fork River Basin
* Sedimentation (Brush Creek)
* NPS-Urban Runoff (Crystal River-From Thompson Creek to Roaring Fork Confl, Roaring Fork-Between Aspen and Carbondale, and Lower Roaring Fork-Below Carbondale)
* Effluent Discharges (Roaring Fork-Between Aspen and Carbondale)
* Salinity Issues (Cattle Creek-Below Mountain Meadow Ditch, Lower Roaring Fork-Below Carbondale)

72-Lower Colorado River
* Sedimentation (Colorado River-Rifle, Silt, & New Castle, Lower Colorado River-Rifle to Grand Junction)
* Chemical Pollution (Colorado River-Rifle, Silt & New Castle)
* Salinity Issues (Lower Colorado River-From Silt to Grand Junction, Grand Valley)

Legend

- Trout Flow-Ecology Minimal Risk
- Warm Water Fish Flow-Ecology Minimal Risk

Cottonwood in Confined Settings
- Confined Flow-Ecology Moderate Risk

Cottonwood in Unconfined Settings
- Abundance Flow-Ecology Moderate Risk
- Recruitment Flow-Ecology Moderate Risk
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 3-10
Colorado Basin Watershed Flow Evaluation Tool

Summary of Minimal Flow-Ecology Risk Locations for Riparian, Trout, and Warm Water Fish

CDM Smith

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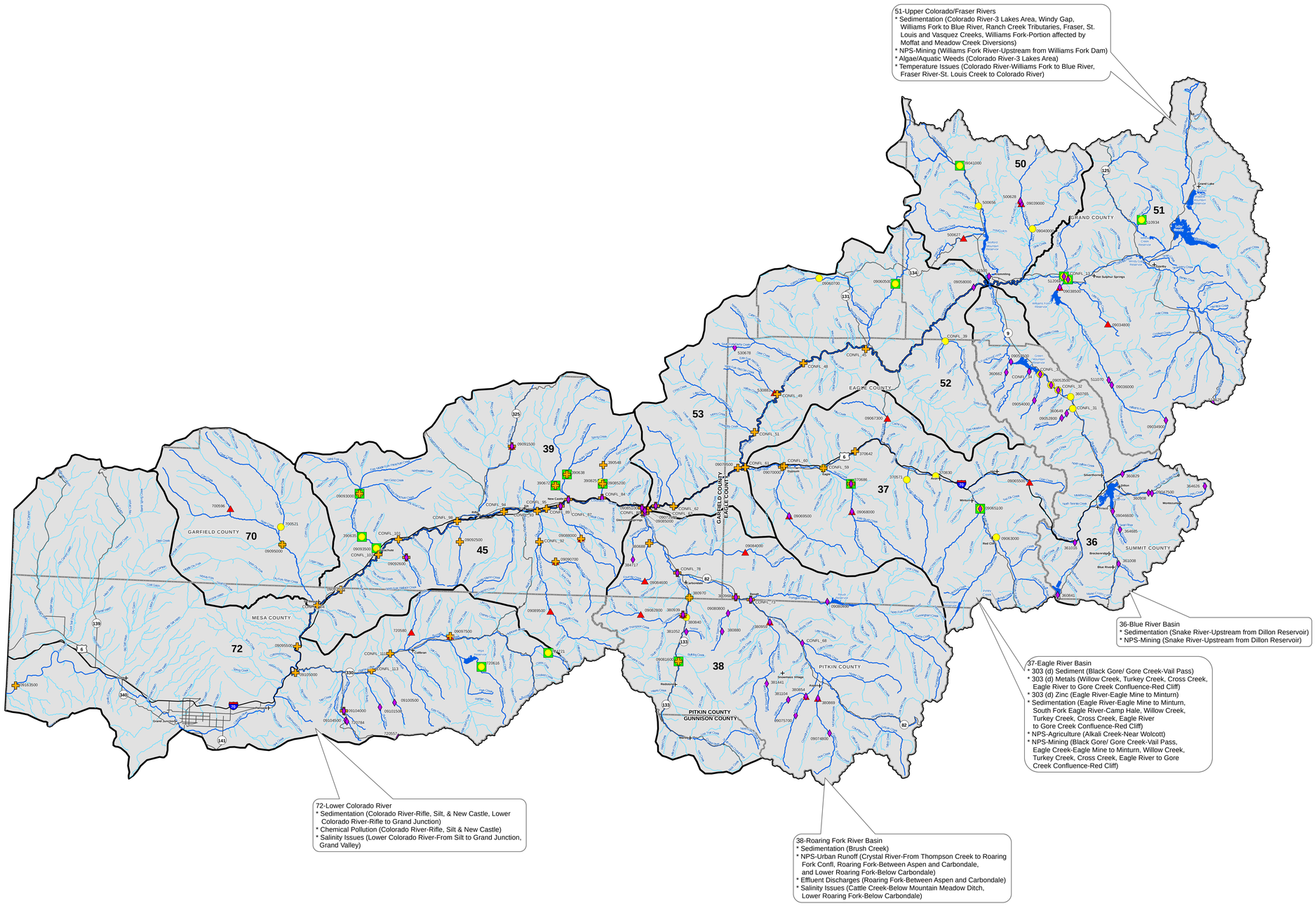

Legend

- Trout Flow-Ecology Low Risk
- Warm Water Fish Flow-Ecology Low Risk

Cottonwood in Confined Settings

- Confined Flow-Ecology Low Risk

Cottonwood in Unconfined Settings

- Abundance Flow-Ecology Low Risk
- Recruitment Flow-Ecology Low Risk
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 3-11
Colorado Basin Watershed Flow Evaluation Tool

Summary of Low Flow-Ecology Risk Locations for Riparian, Trout, and Warm Water Fish

CDM Smith

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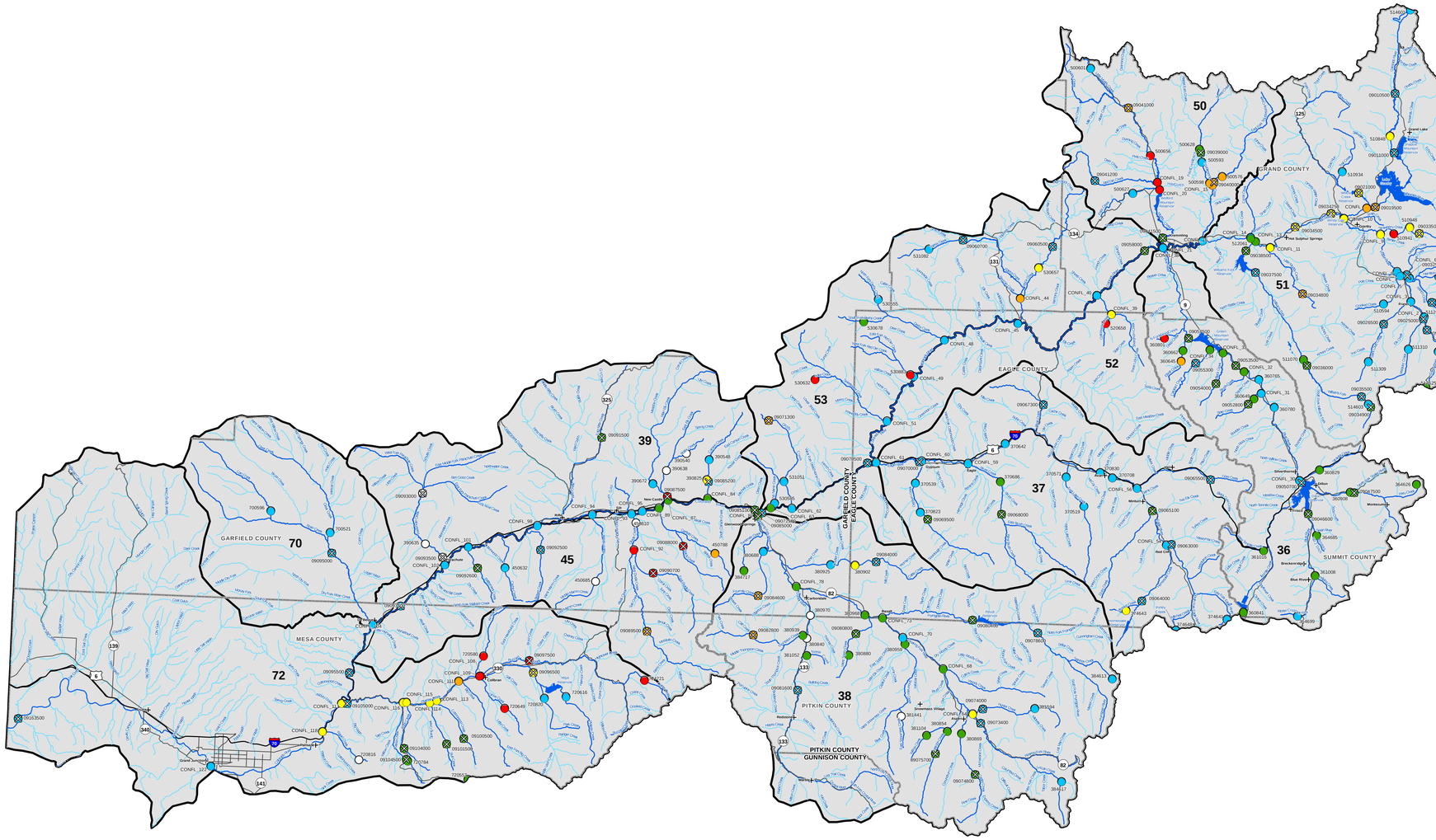

Legend

- <10% Inadequate to support trout (Very High Risk)
- 10% to 15% Inadequate to support trout (High Risk)
- 16% to 25% May severely limit trout stock every few years (Moderate Risk)
- 26% to 55% Low flow may occasionally limit trout numbers (Minimal Risk)
- >55% Low flow may very seldom limit trout (Low Risk)
- Trout metric does not apply or model data not sufficient at this location
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 3-12
Colorado Basin Watershed Flow Evaluation Tool

Trout Flow-Ecology Risk Mapping (Overview)

CDM Smith

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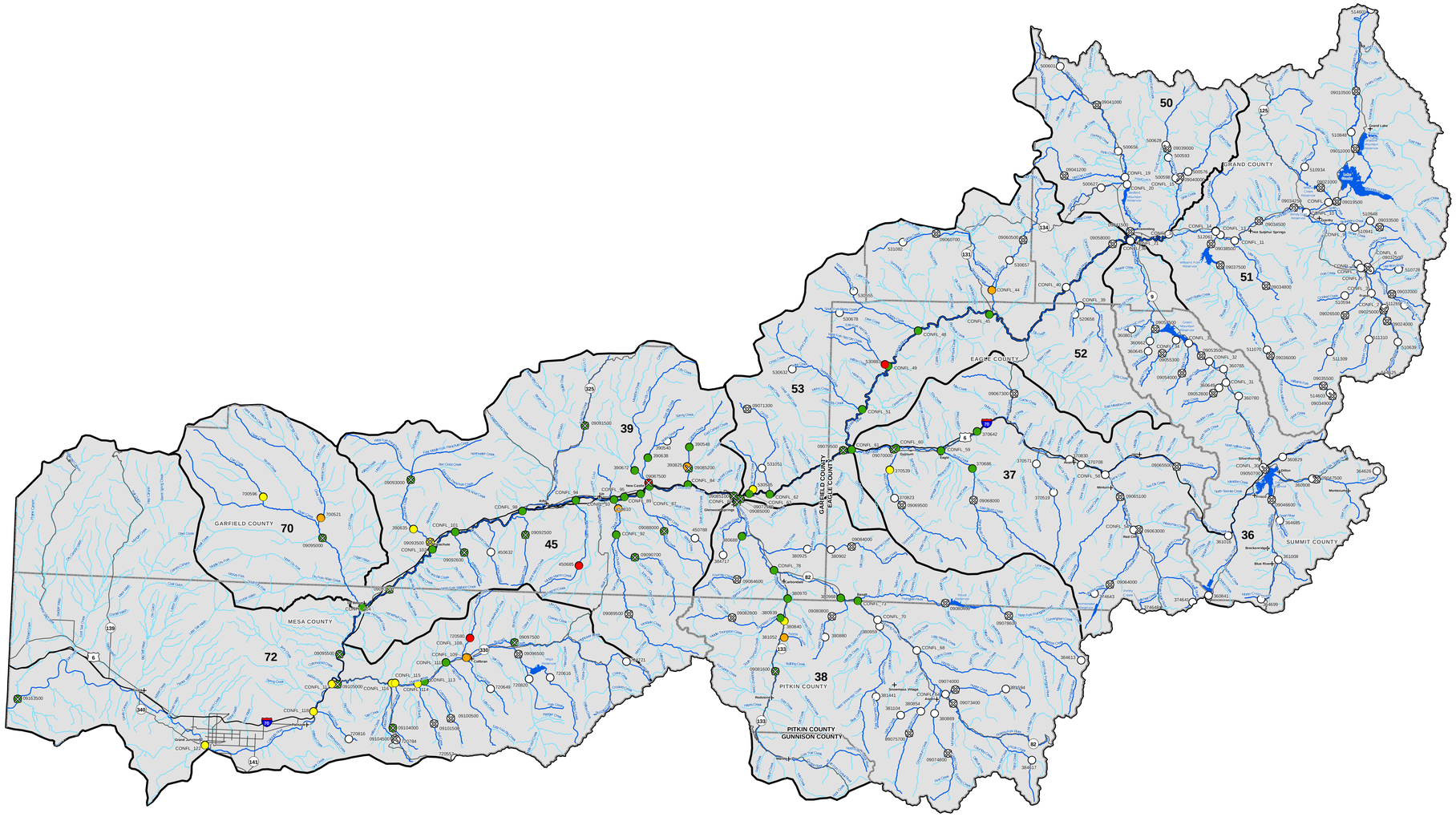


Legend

% Change in Biomass

- < 10% Low Risk
- 10% to 25% Minimal Risk
- 25% to 50% Moderate Risk
- > 50% High Risk
- Warm Water Metric does not apply
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

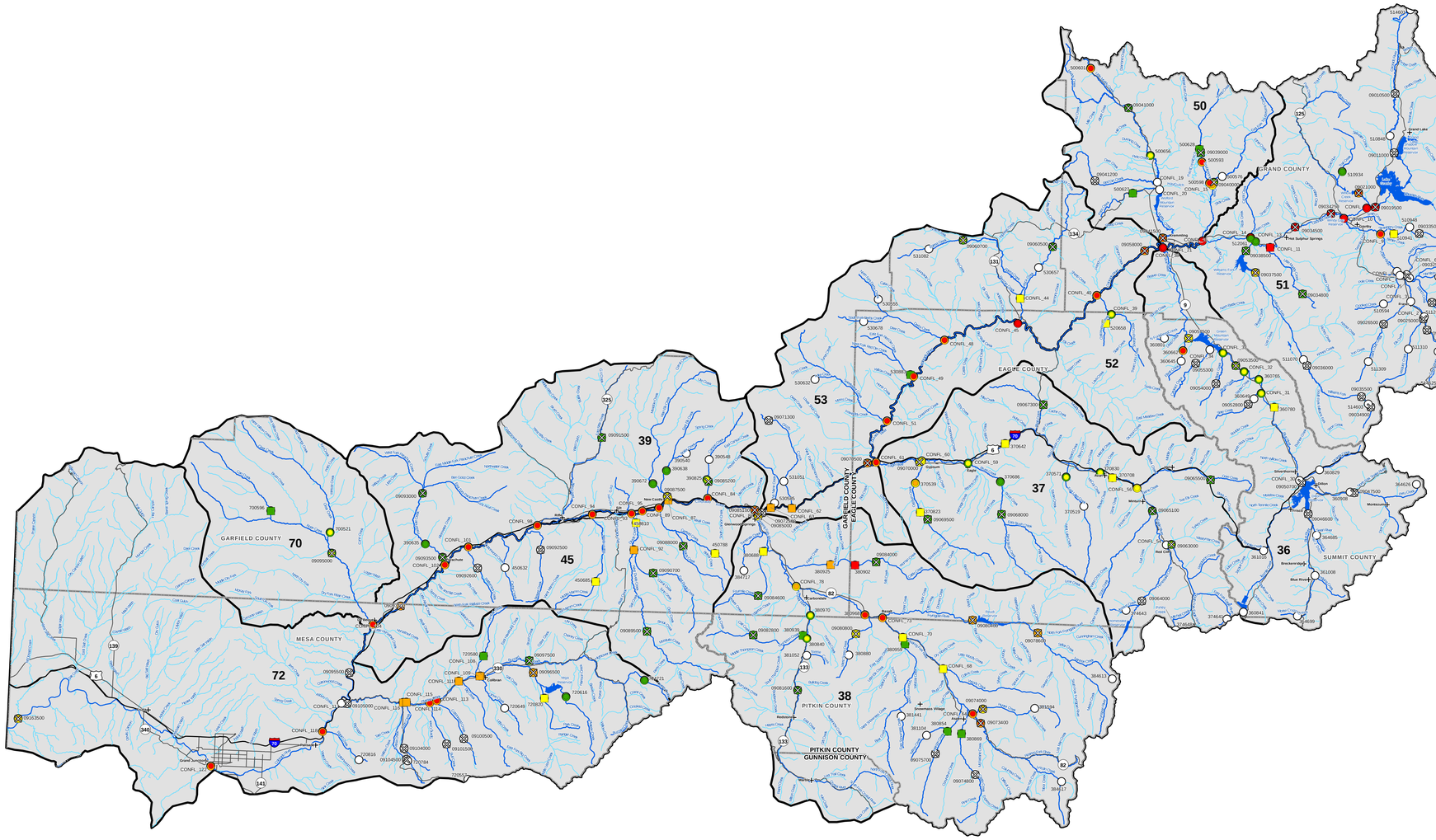
0 3 6 12 18 Miles

Figure 3-13
Colorado Basin Watershed Flow Evaluation Tool

Warm Water Fish Flow-Ecology Risk Mapping (Overview)

CDM Smith

Document: \\Dengisvr1\cdmgis\SWS\NONCONSUMPTIVE\COLORADO_WFET\MXD\Flow Metric Figures



Legend

Cottonwood in Unconfined Settings Recruitment

- -30% to -100% Very High Risk
- -18% to -30% High Risk
- -7% to -18% Moderate Risk
- 0 to -7% Low Risk

Abundance

- -50% to -100% Very High Risk
- -30% to -50% High Risk
- -15% to -30% Moderate Risk
- 0 to -15% Low Risk

Cottonwood in Confined Settings

- -42% to -100% Very High Risk
- -21% to -42% High Risk
- -8% to 21% Moderate Risk
- 0 to -8% Low Risk
- Riparian Metric does not apply
- Streamflow Gage
- Study Stream
- Stream and River
- Lake and Reservoir
- Highway
- Road
- City and Town
- County Boundary
- Colorado Basin Water District

N W E S

0 3 6 12 18 Miles

Figure 3-14
Colorado Basin Watershed Flow Evaluation Tool

Riparian Flow-Ecology Risk Mapping (Overview)

CDM Smith

Document: \\Dengisvr11\cdmgis\SWS\NONCONSUMPTIVE\COLORADO_WFETM\MXD\Flow Metric Figures

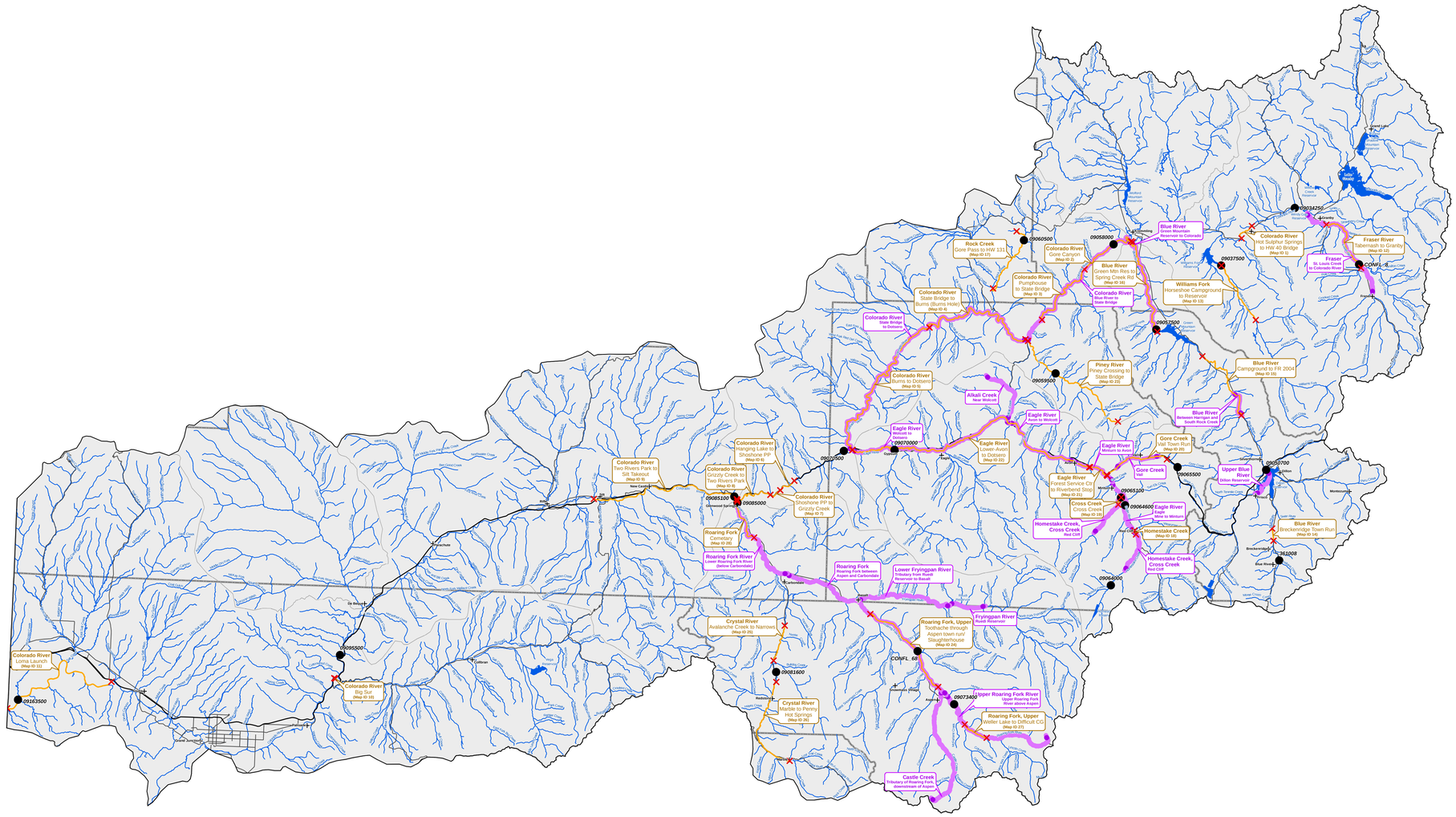


Figure 3-15
Colorado Basin Watershed Flow Evaluation Tool

Colorado River Basin Recreational Reaches and CDSS Nodes Used in Recreational Analysis

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Figure 3-16
Colorado River (Hot Sulphur Springs to Hwy 40 Bridge (Byers Canyon))
Mean Number of Useable Days by Month (1975-2005)

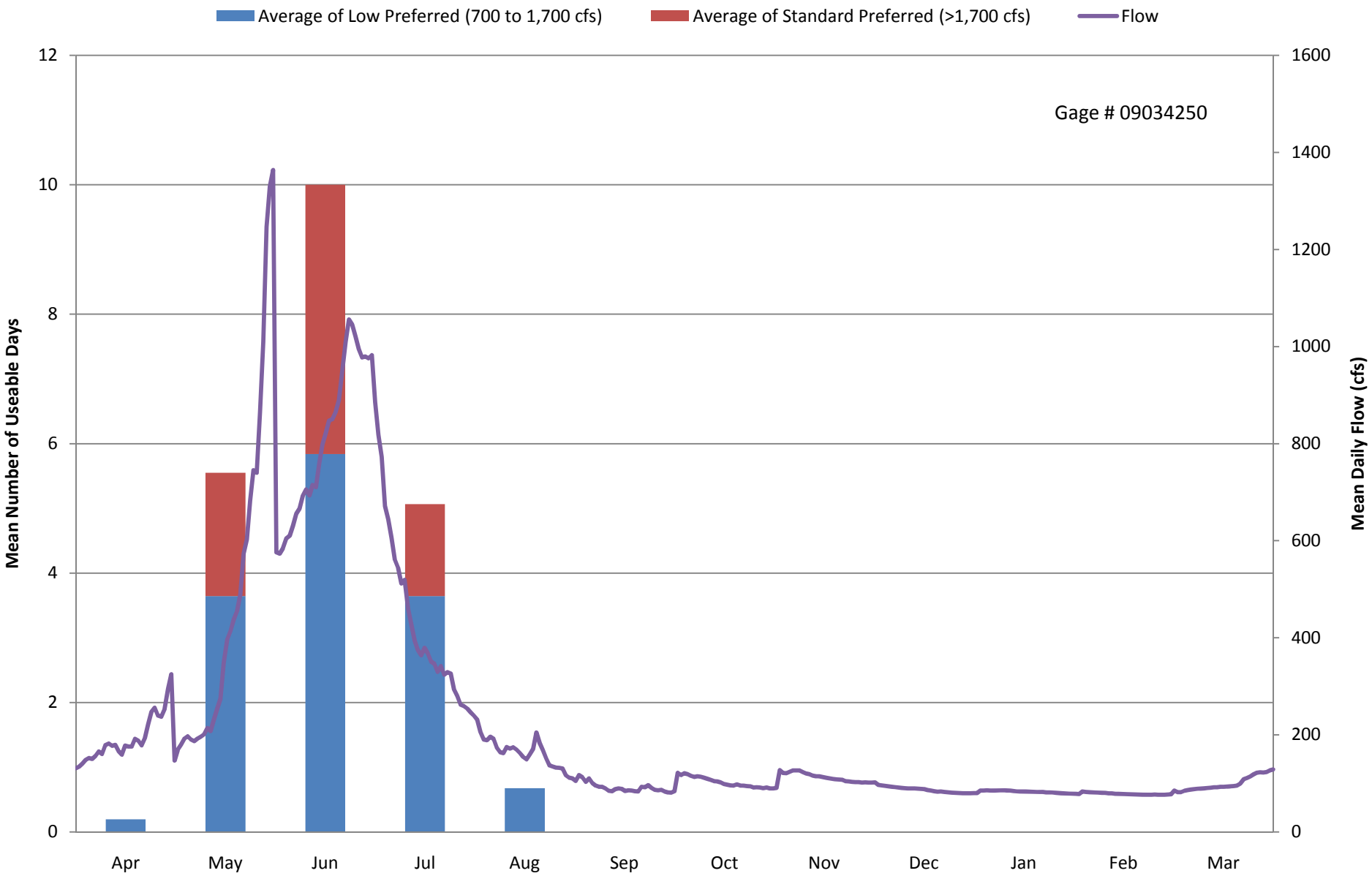


Figure 3-17
Colorado River (Gore Canyon)
Mean Number of Useable Days by Month (1975-2005)

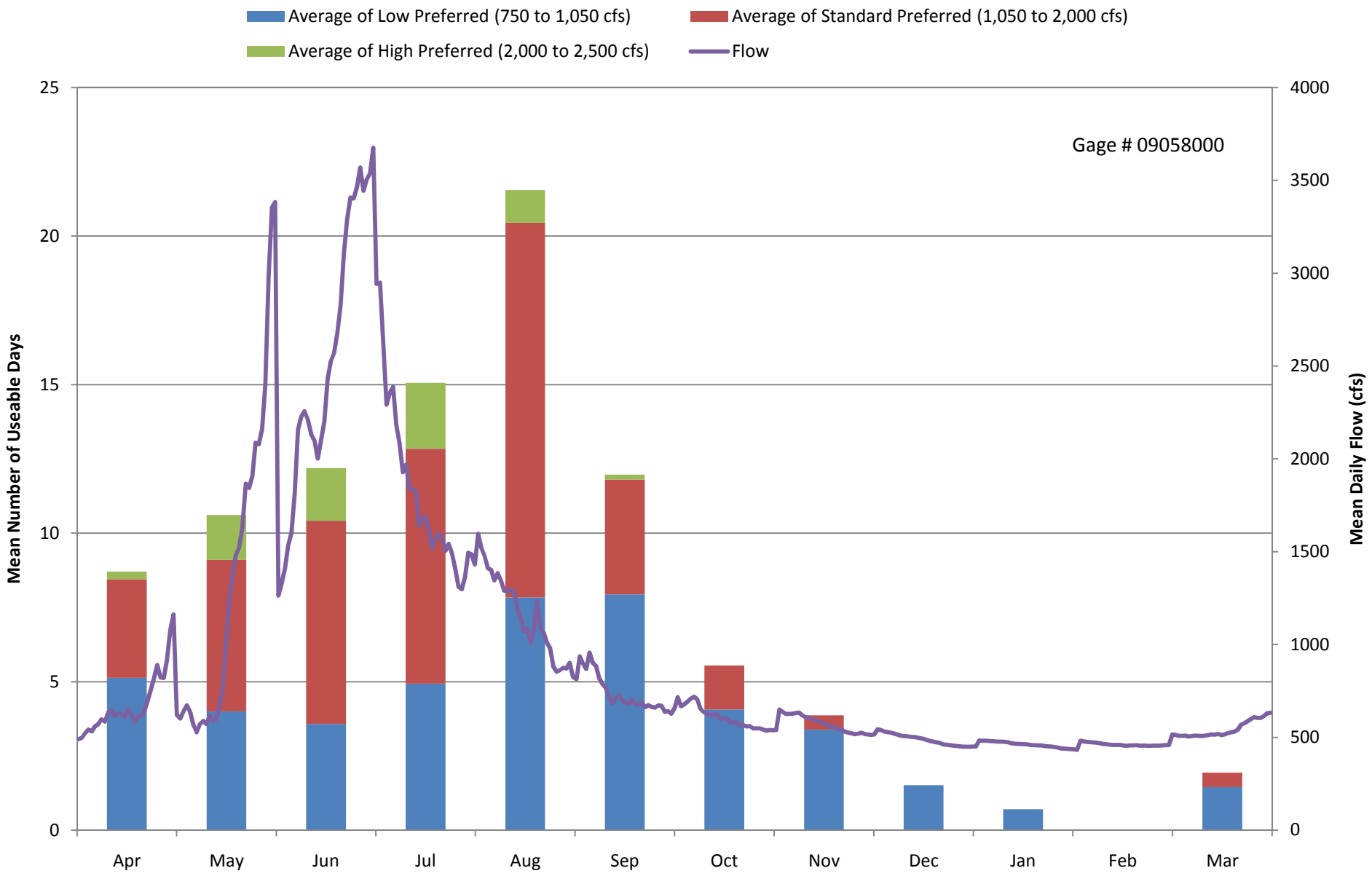


Figure 3-18
Colorado River (Pumphouse to State Bridge)
Mean Number of Useable Days by Month (1975-2005)

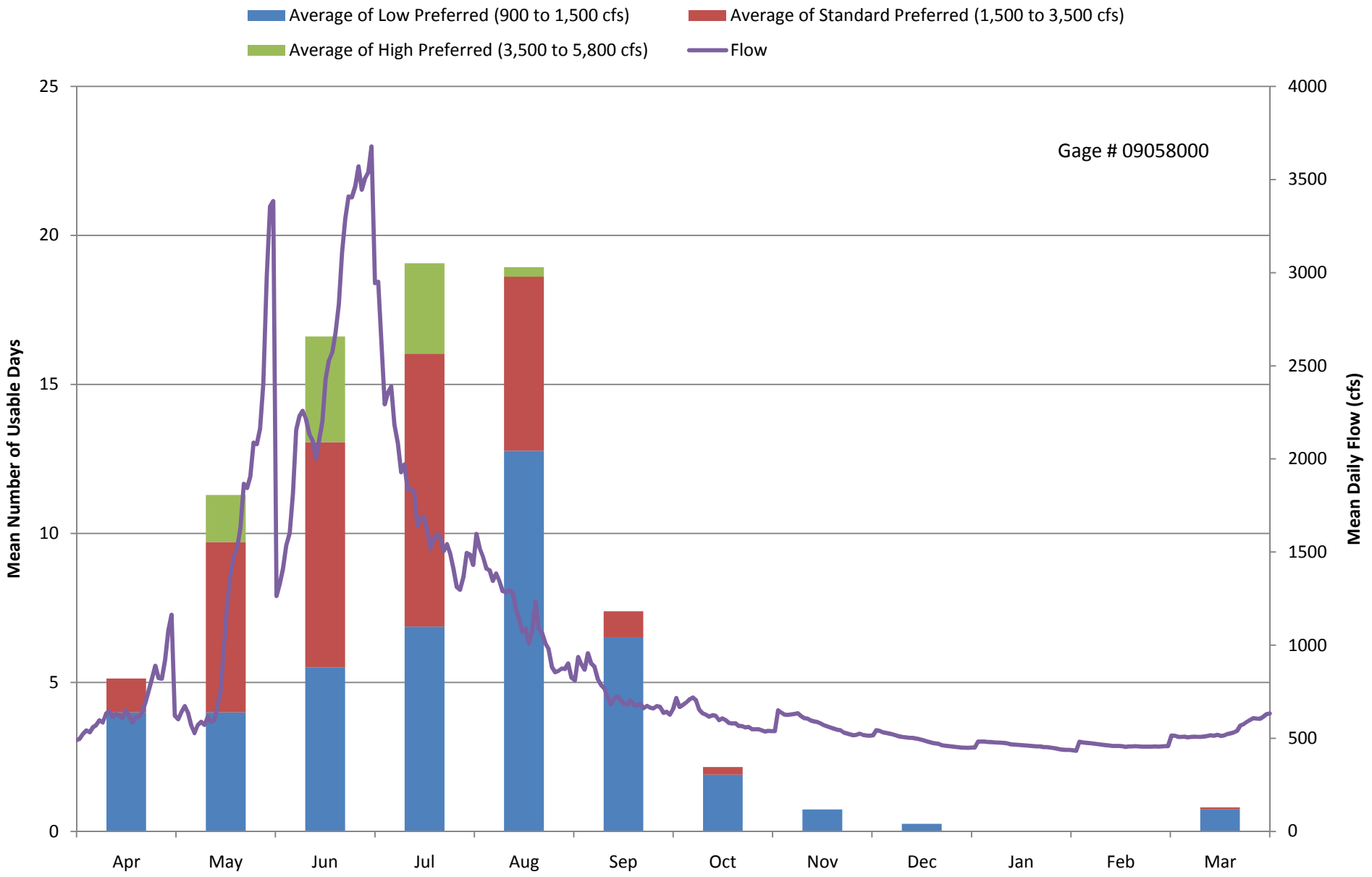


Figure 3-19
Colorado River (State Bridge to Burns (Burns Hole))
Mean Number of Useable Days by Month (1975-2005)

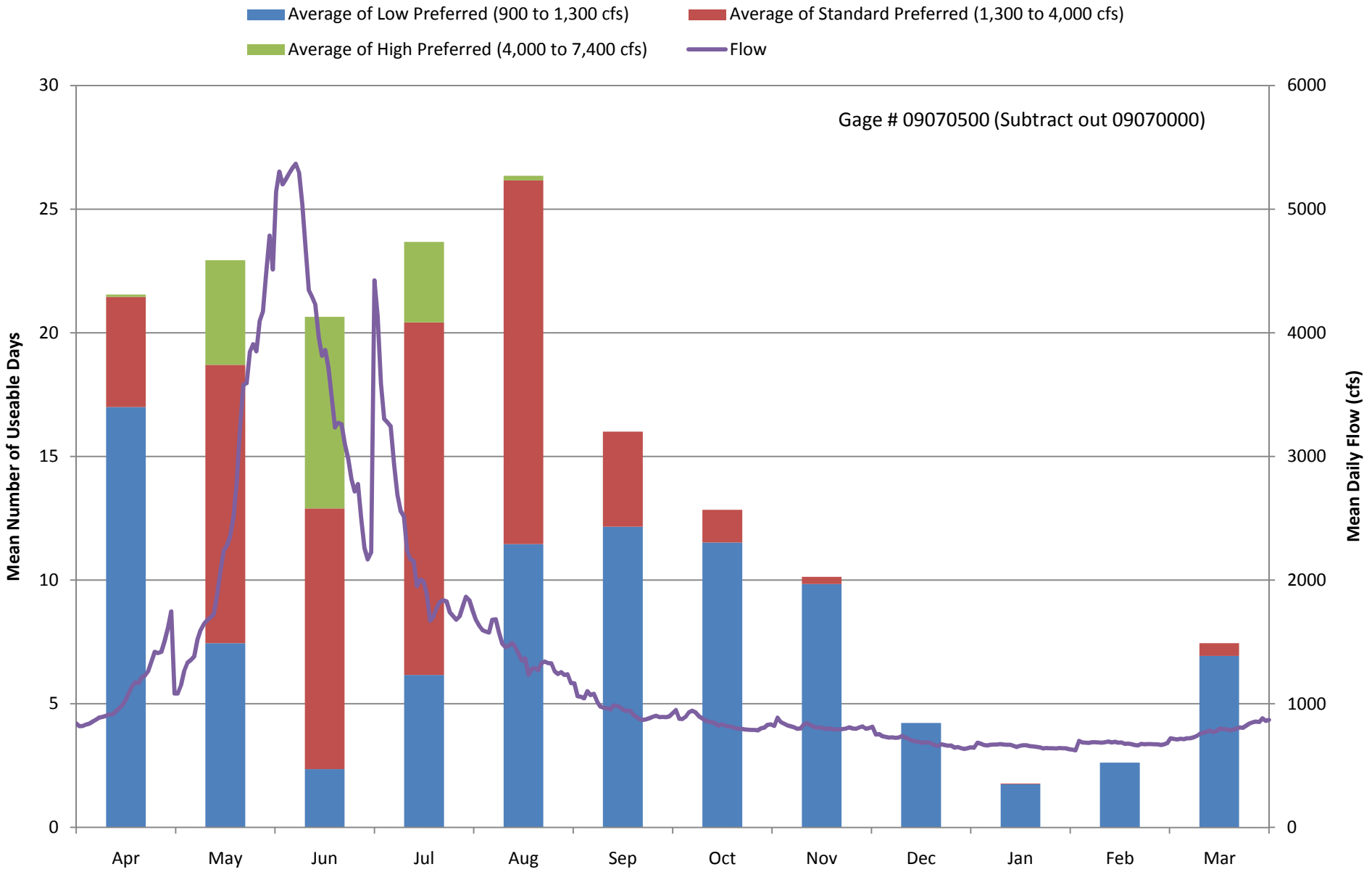


Figure 3-20
Colorado River (Burns to Dotsero (Burns Canyon))
Mean Number of Useable Days by Month (1975-2005)

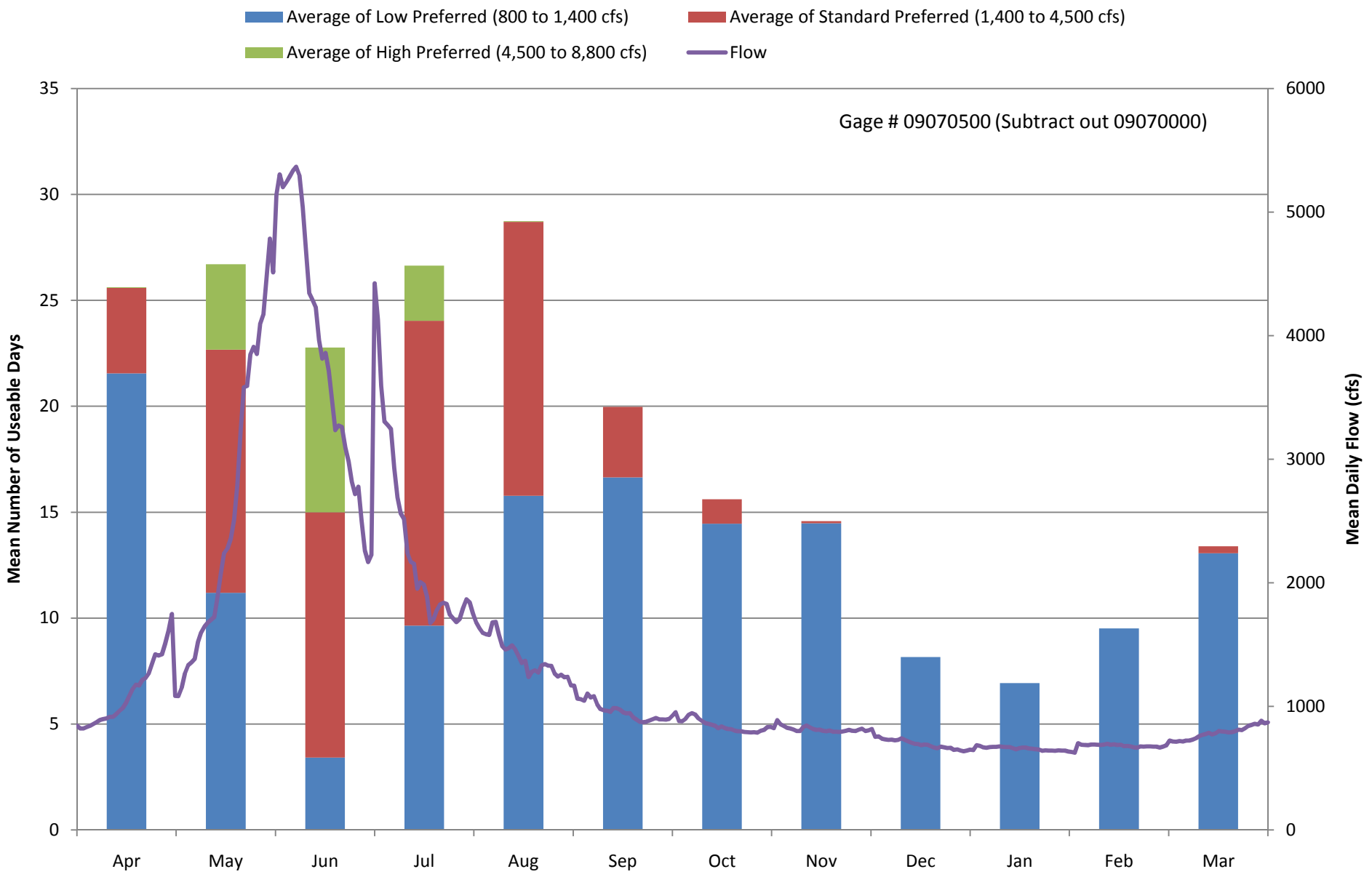


Figure 3-21
Colorado River (Hanging Lake Exit 125 (I-70) to Shoshone Power Plant Exit 123 (I-70) (Barrel Springs))
Mean Number of Useable Days by Month (1975-2005)

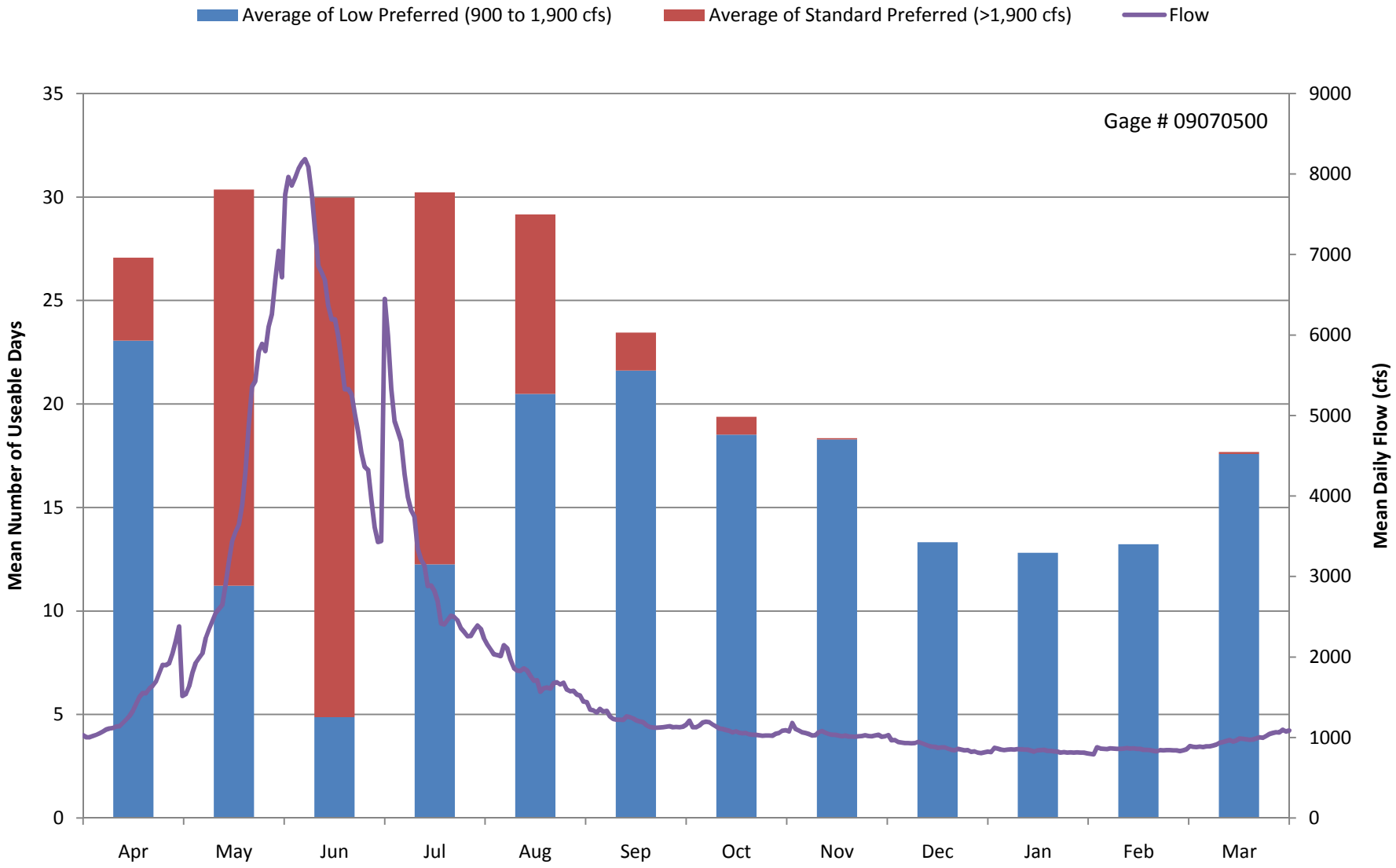


Figure 3-22
Colorado River (Shoshone Power Plant, Exit 123 (I-70) to Grizzly Creek, Exit 121 (I-70) Shosone)) Non-Commercial
Mean Number of Useable Days by Month (1975-2005)

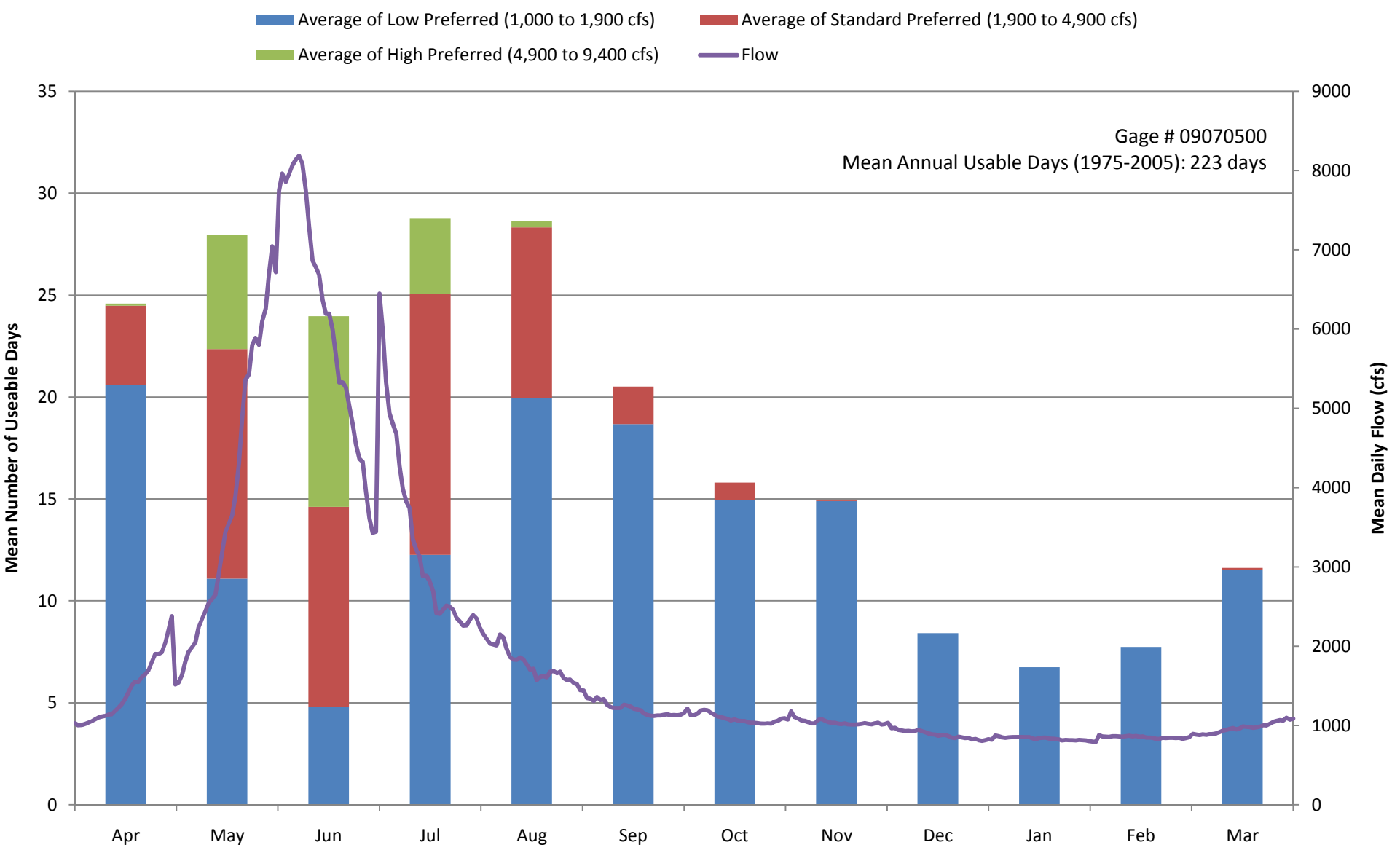


Figure 3-23
Colorado River (Grizzly Creek to Two Rivers Park)
Mean Number of Useable Days by Month (1975-2005)

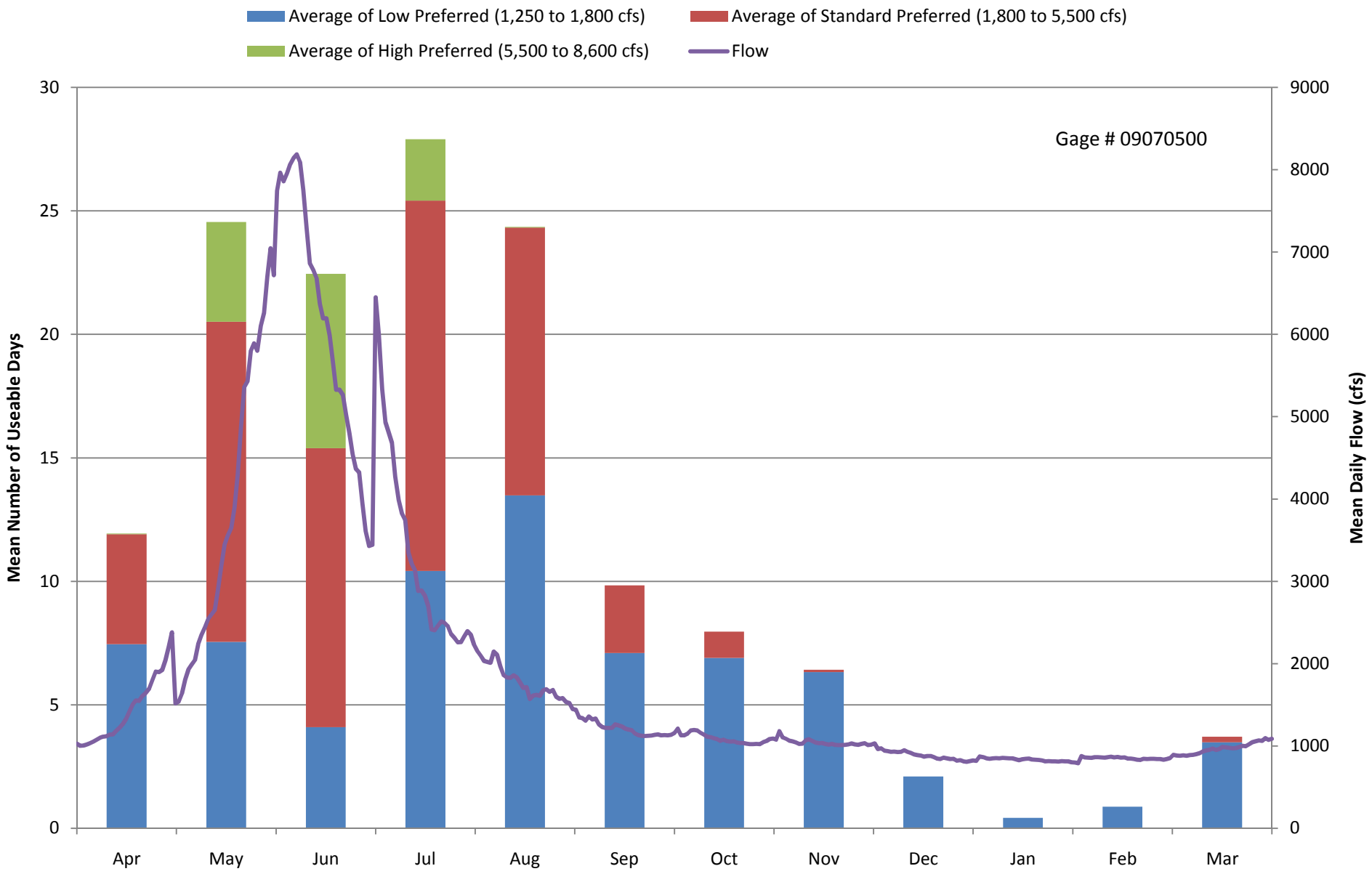


Figure 3-24
Colorado River (Two Rivers Park to Silt Takeout)
Mean Number of Useable Days by Month (1975-2005)

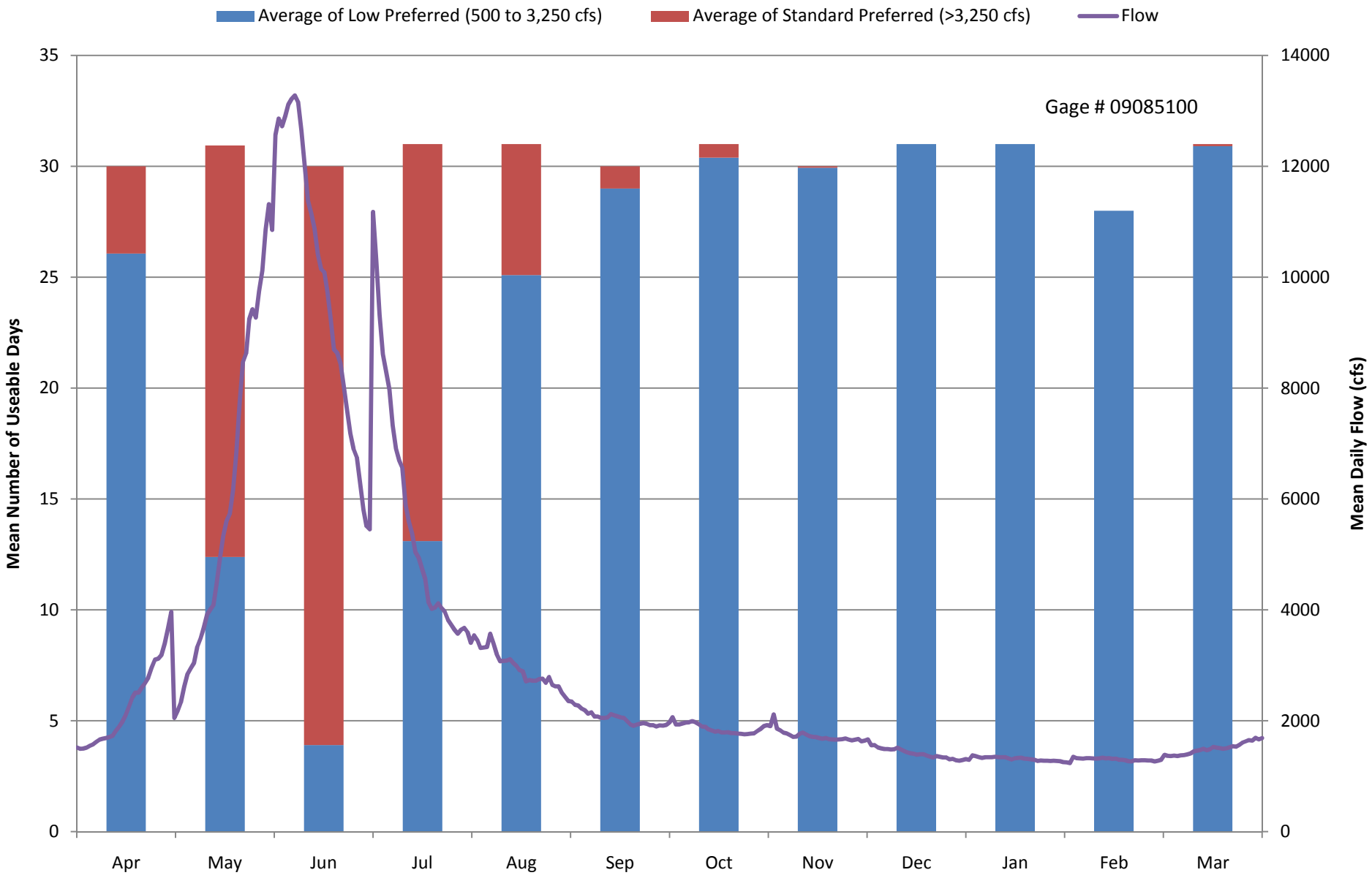


Figure 3-25
Colorado River (Big Sur)
Mean Number of Useable Days by Month (1975-2005)

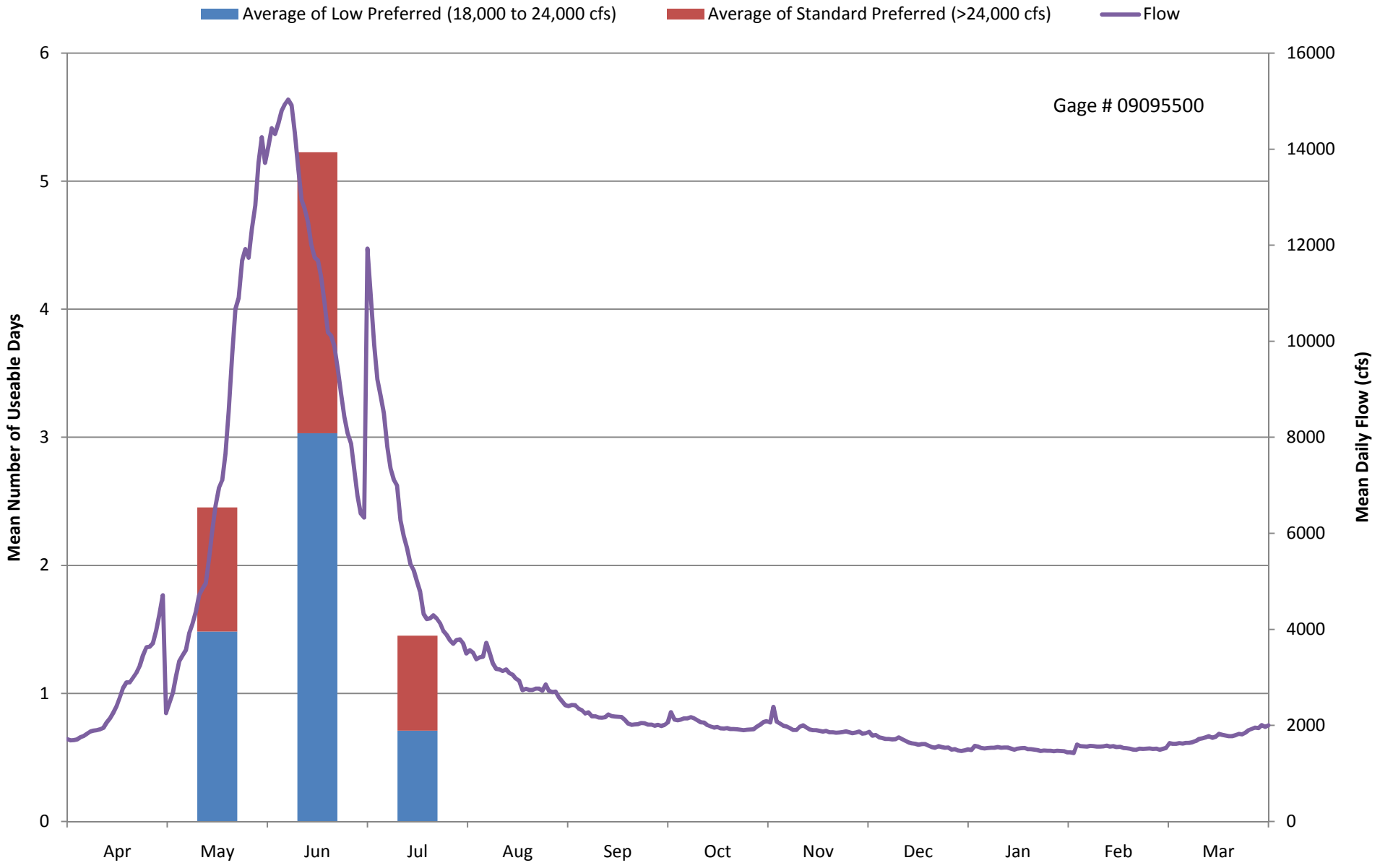


Figure 3-26
Colorado River (Loma Launch to Westwater Launch)
Mean Number of Useable Days by Month (1975-2005)

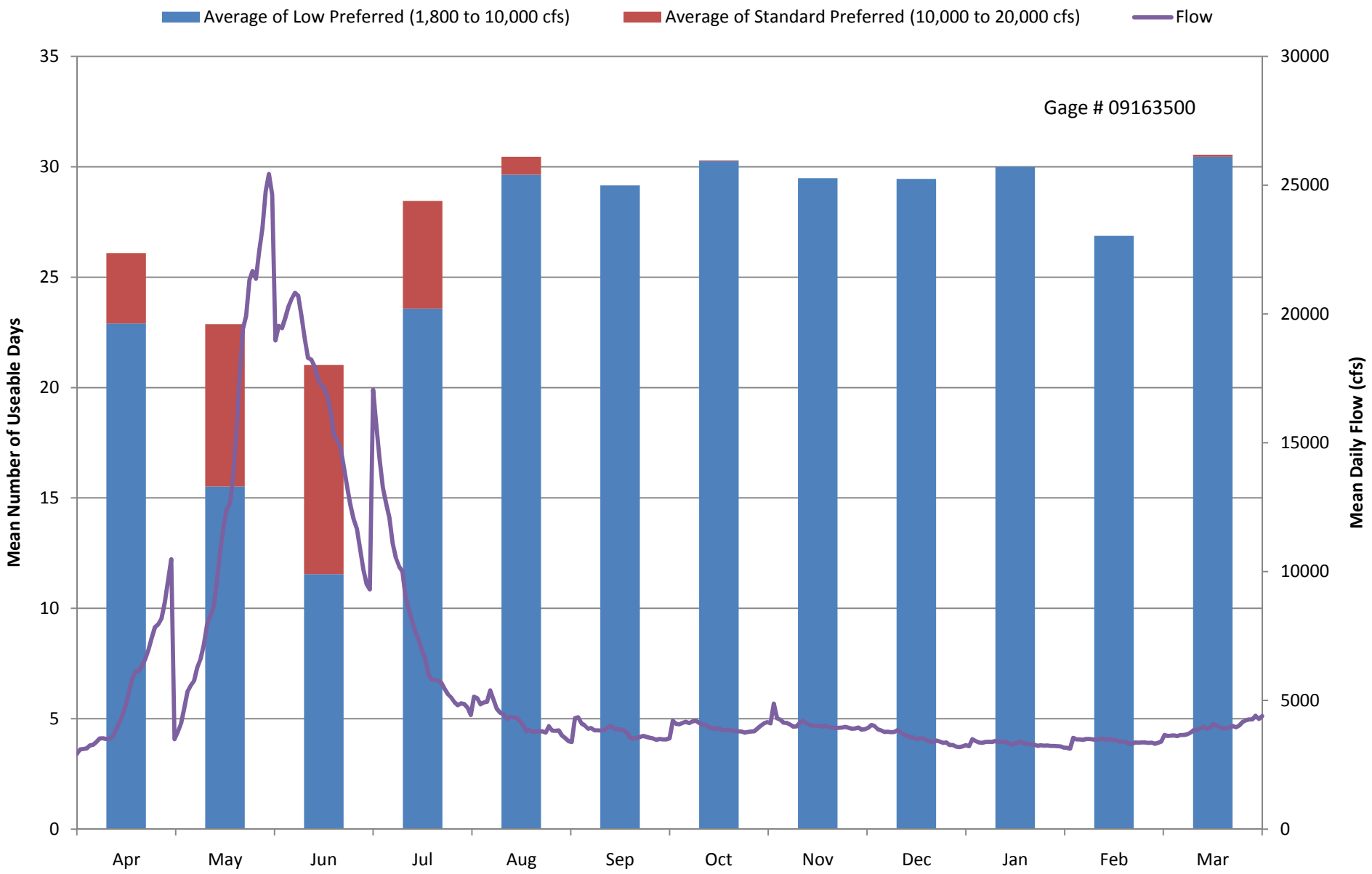


Figure 3-27
Fraser River (Tabernash to Granby)
Mean Number of Useable Days by Month (1975-2005)

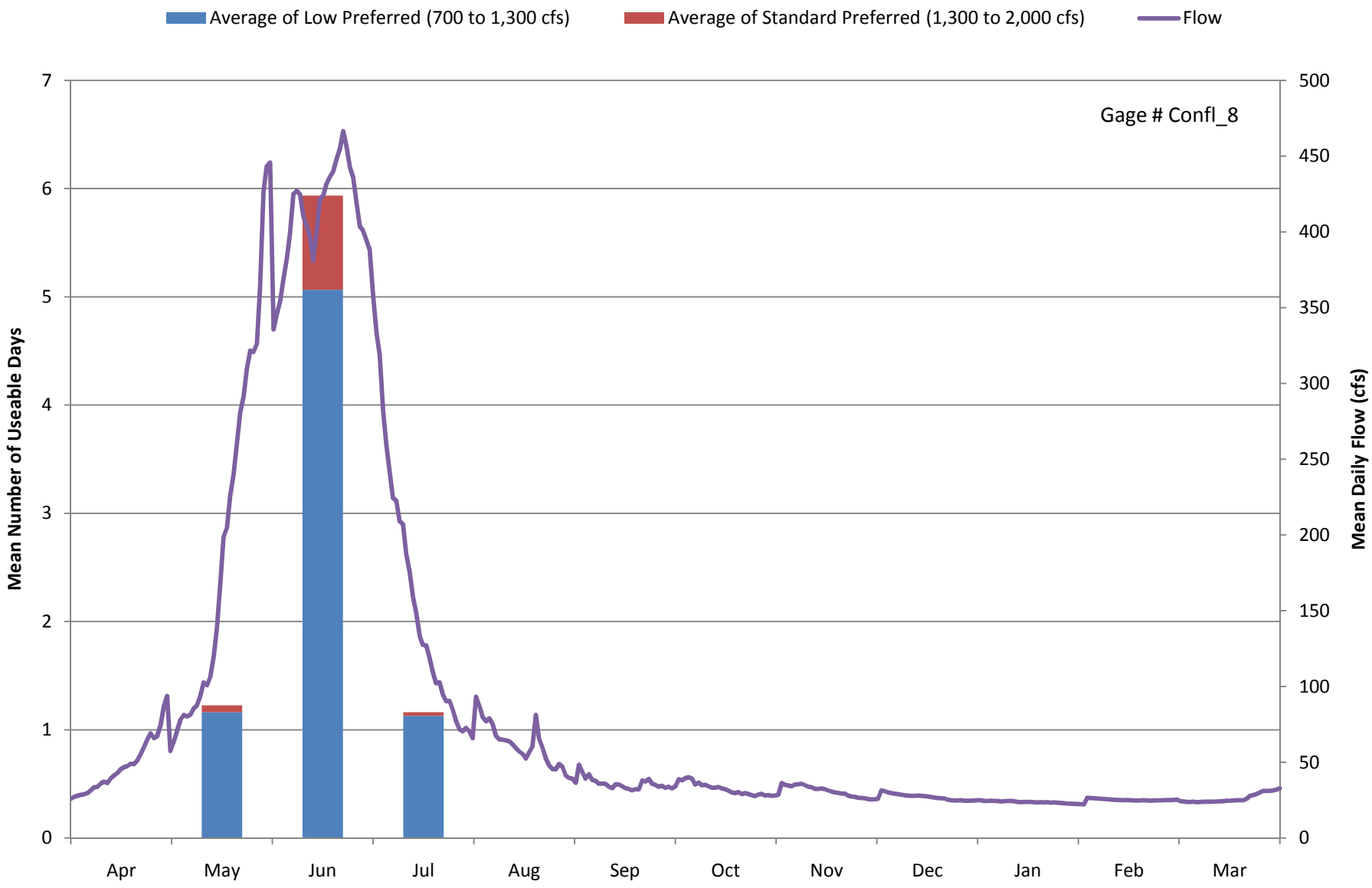


Figure 3-28
Williams Fork (Horseshoe Campground to Reservoir)
Mean Number of Useable Days by Month (1975-2005)

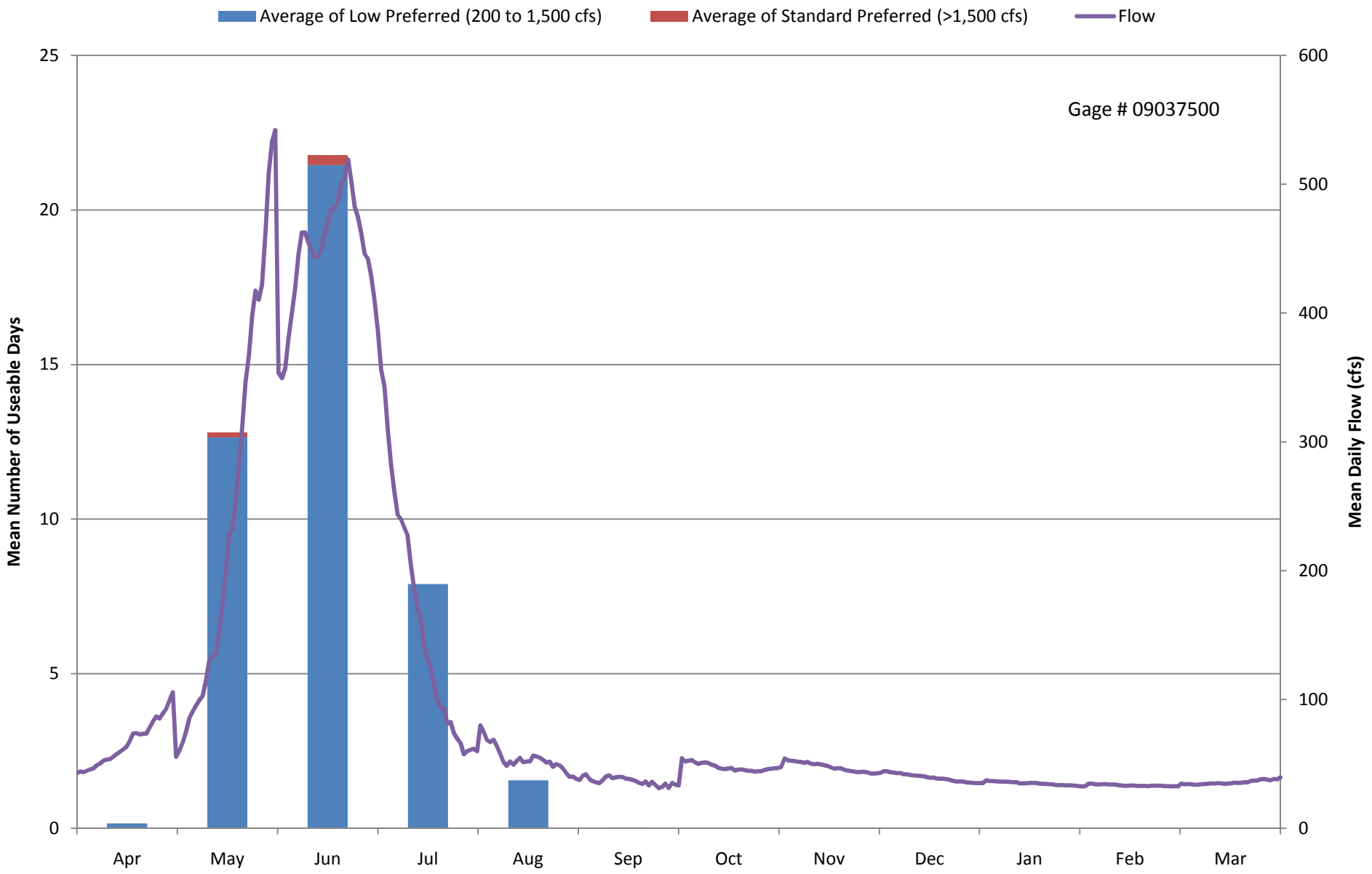


Figure 3-29
Blue River (Breckenridge Town Run)
Mean Number of Useable Days by Month (1975-2005)

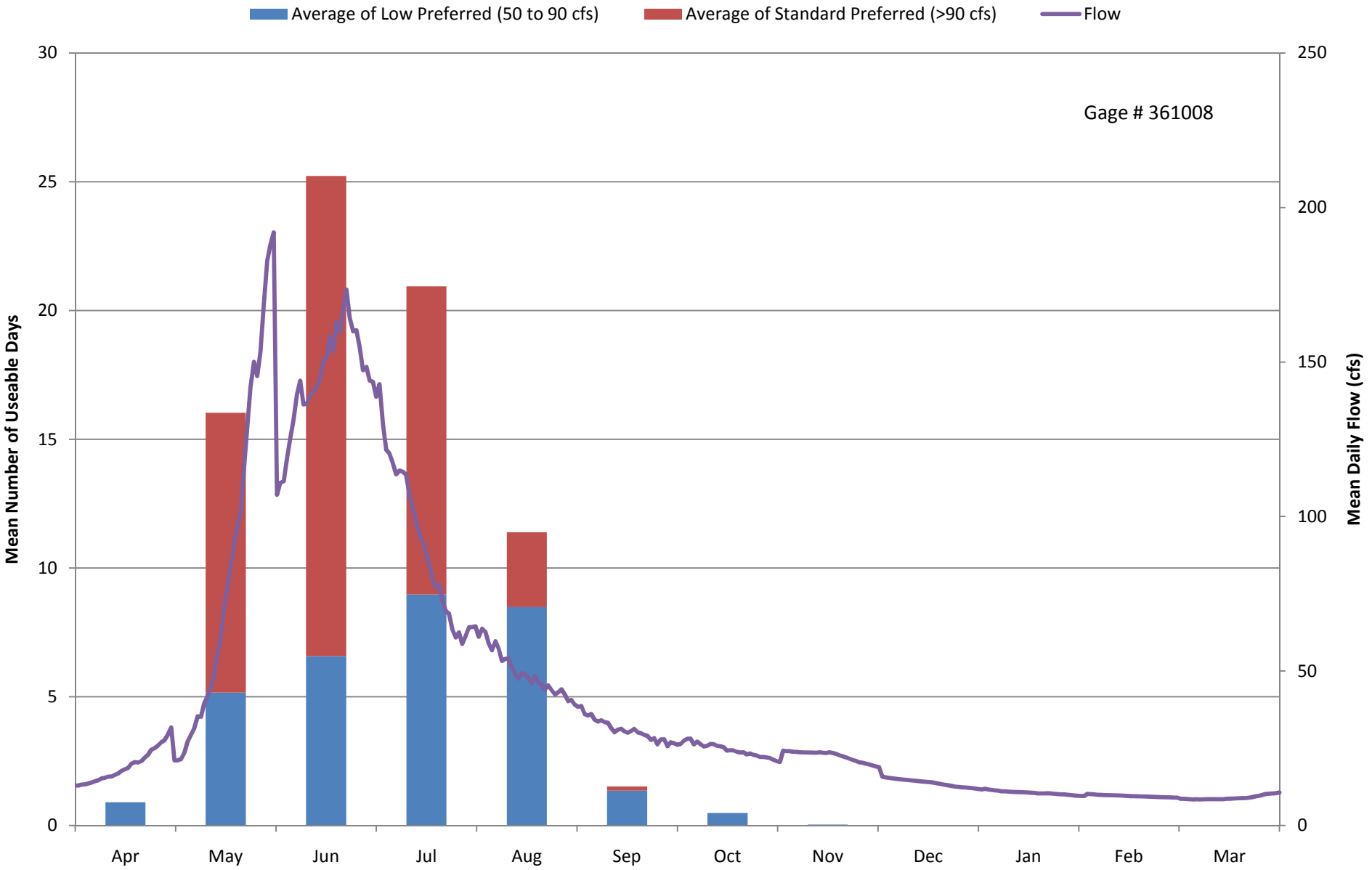


Figure 3-30
Blue River (Campground to FR 2400 (Upper Blue Dillon to Green Mountain))
Mean Number of Useable Days by Month (1975-2005)

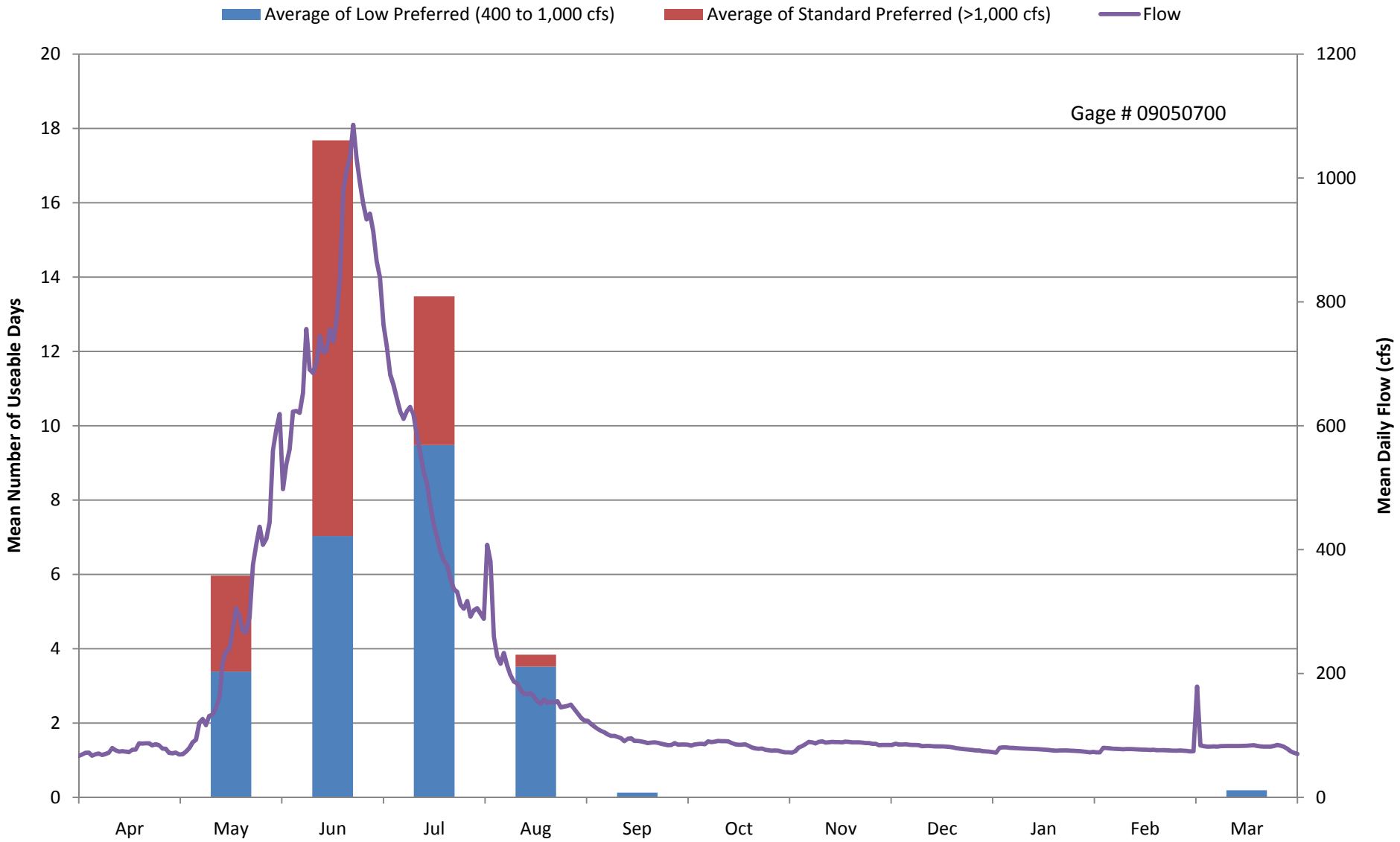


Figure 3-31
Blue River (Green Mountain Reservoir to Spring Creek (Green Mountain Canyon)) and Lower Blue River to Confluence with Colorado River
Mean Number of Useable Days by Month (1975-2005)

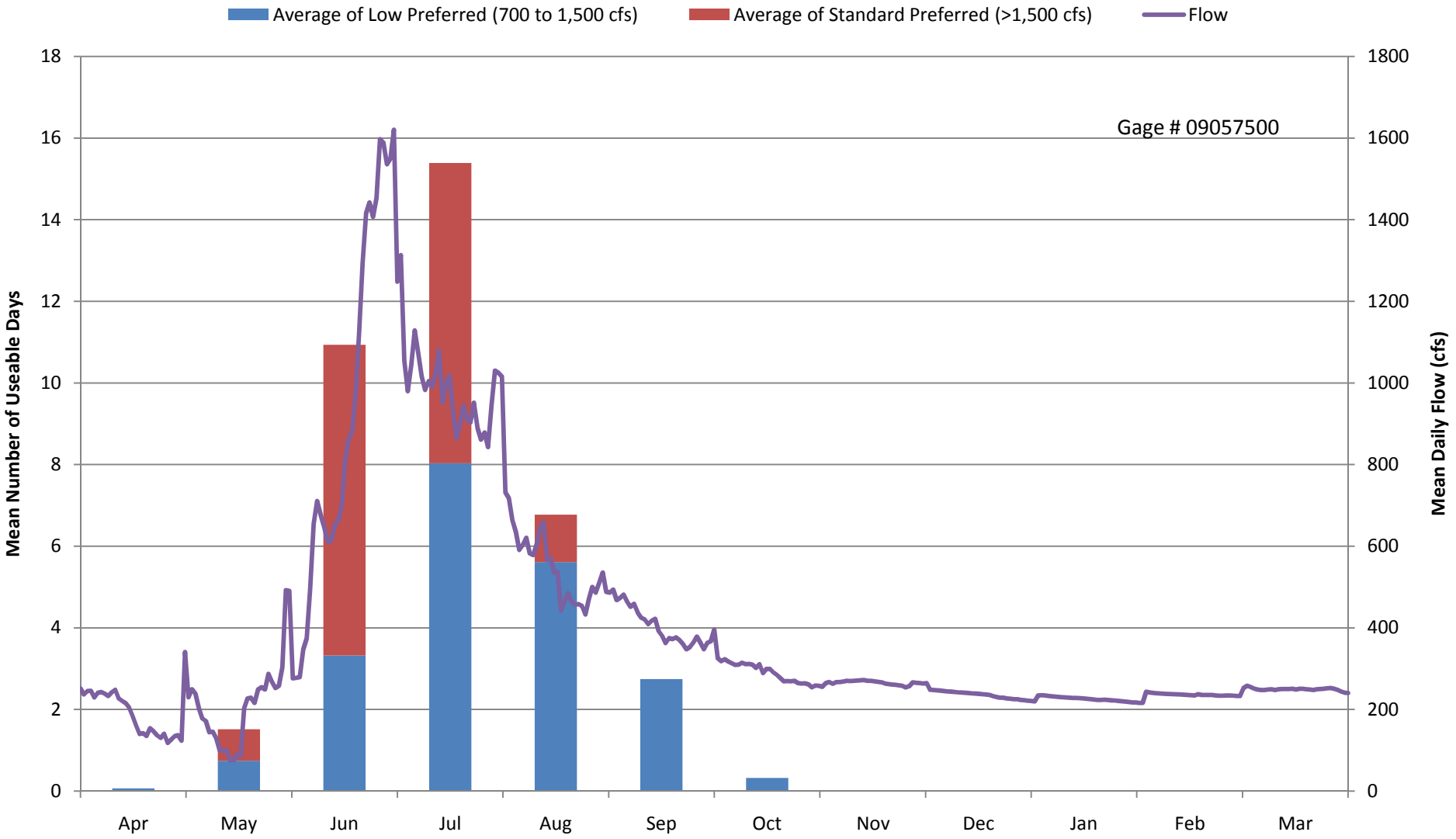


Figure 3-32
Rock Creek (Gore Pass to Highway 131)
Mean Number of Useable Days by Month (1975-2005)

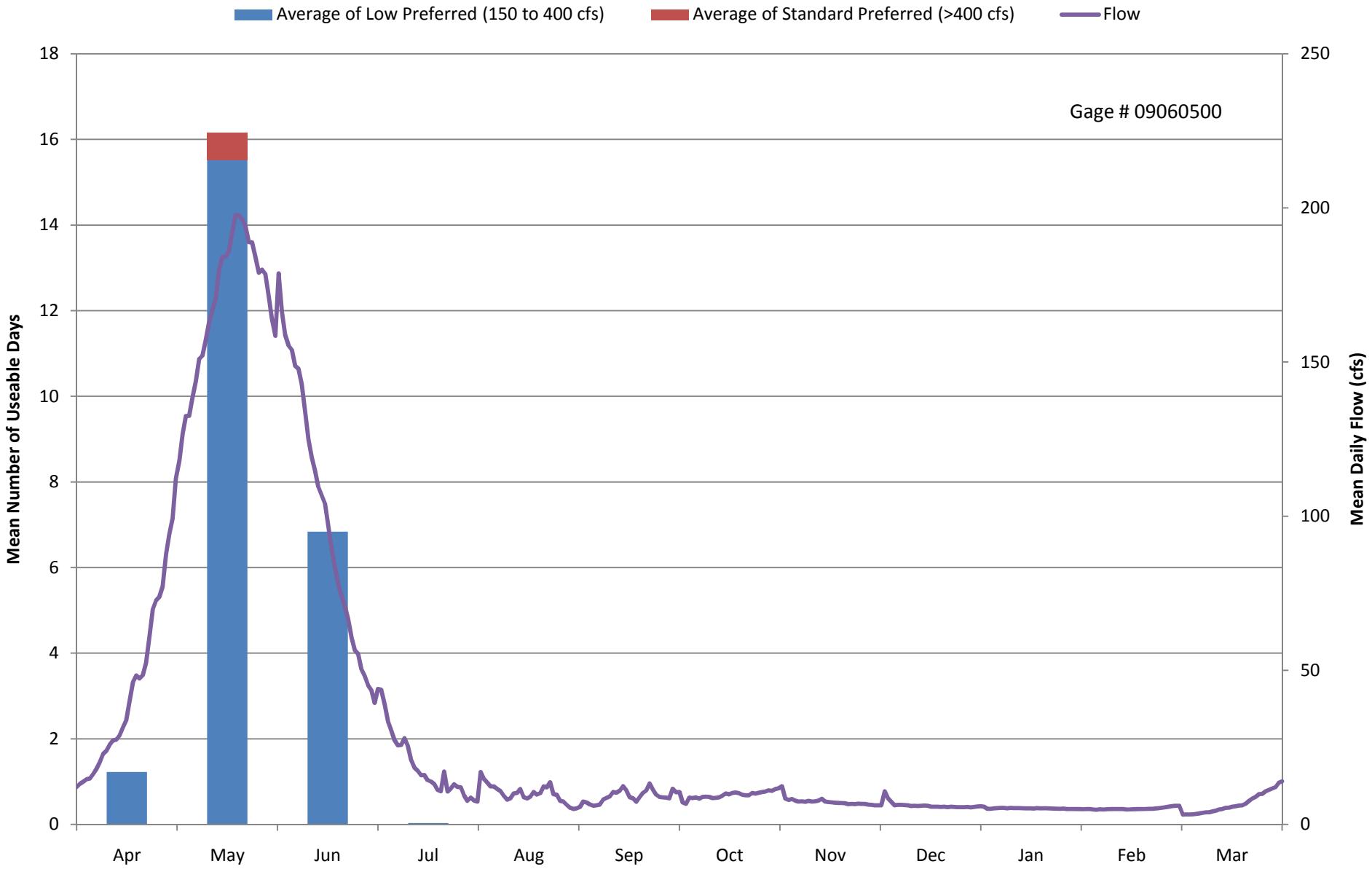


Figure 3-33
Homestake Creek
Mean Number of Useable Days by Month (1975-2005)

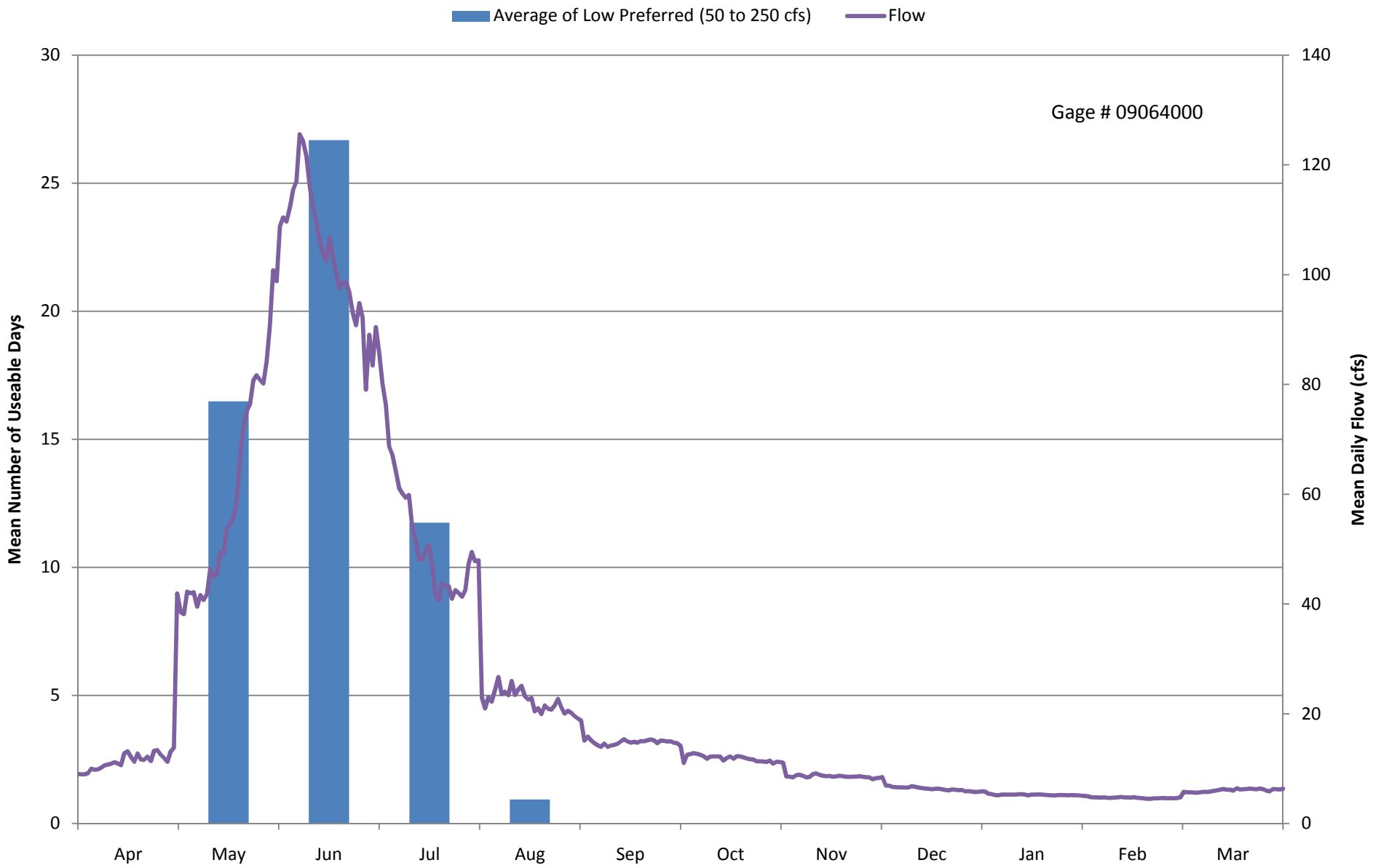


Figure 3-34
Cross Creek
Mean Number of Useable Days by Month (1975-2005)

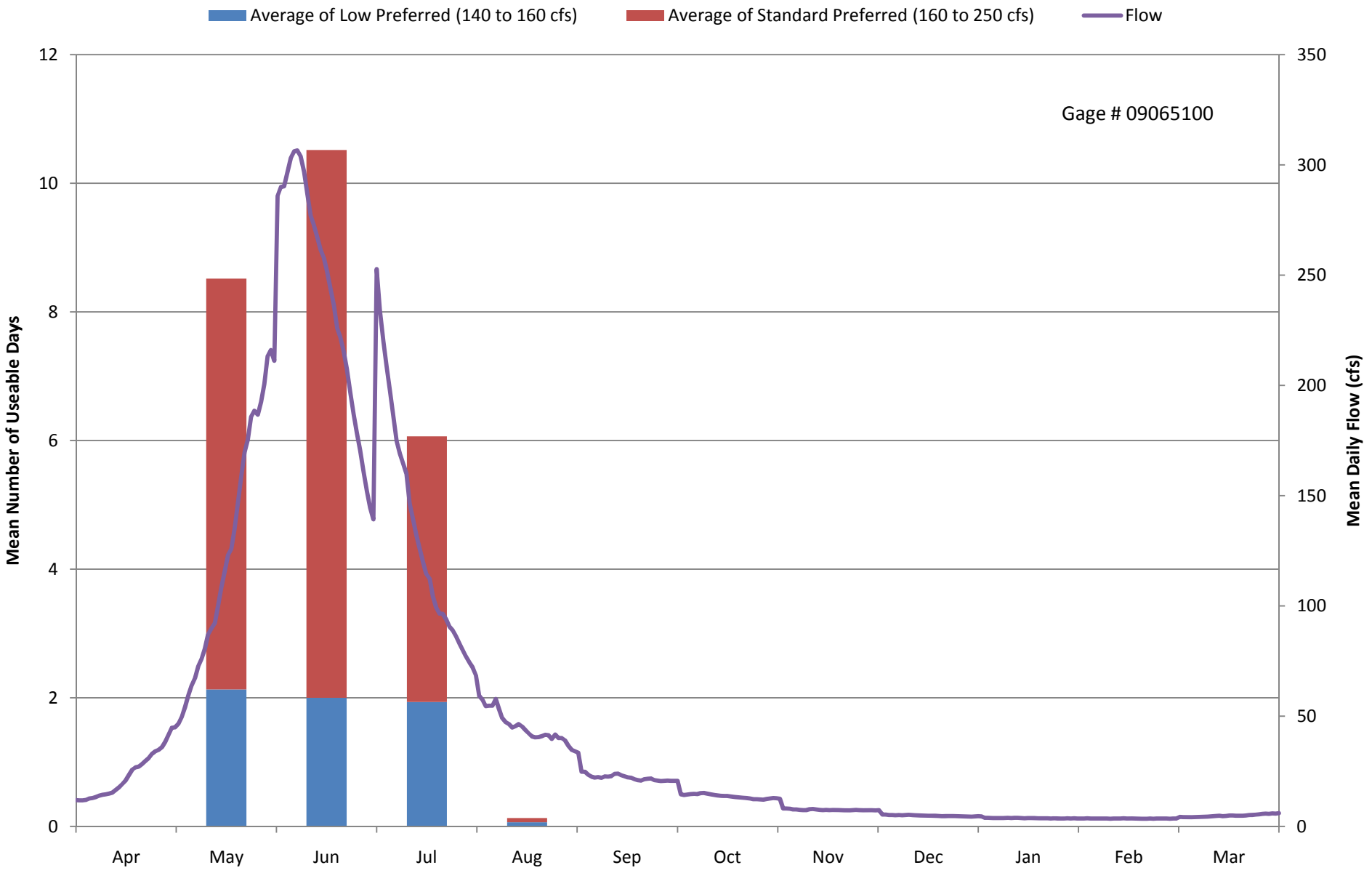


Figure 3-35
Gore Creek (Vail Town Run)
Mean Number of Useable Days by Month (1975-2005)

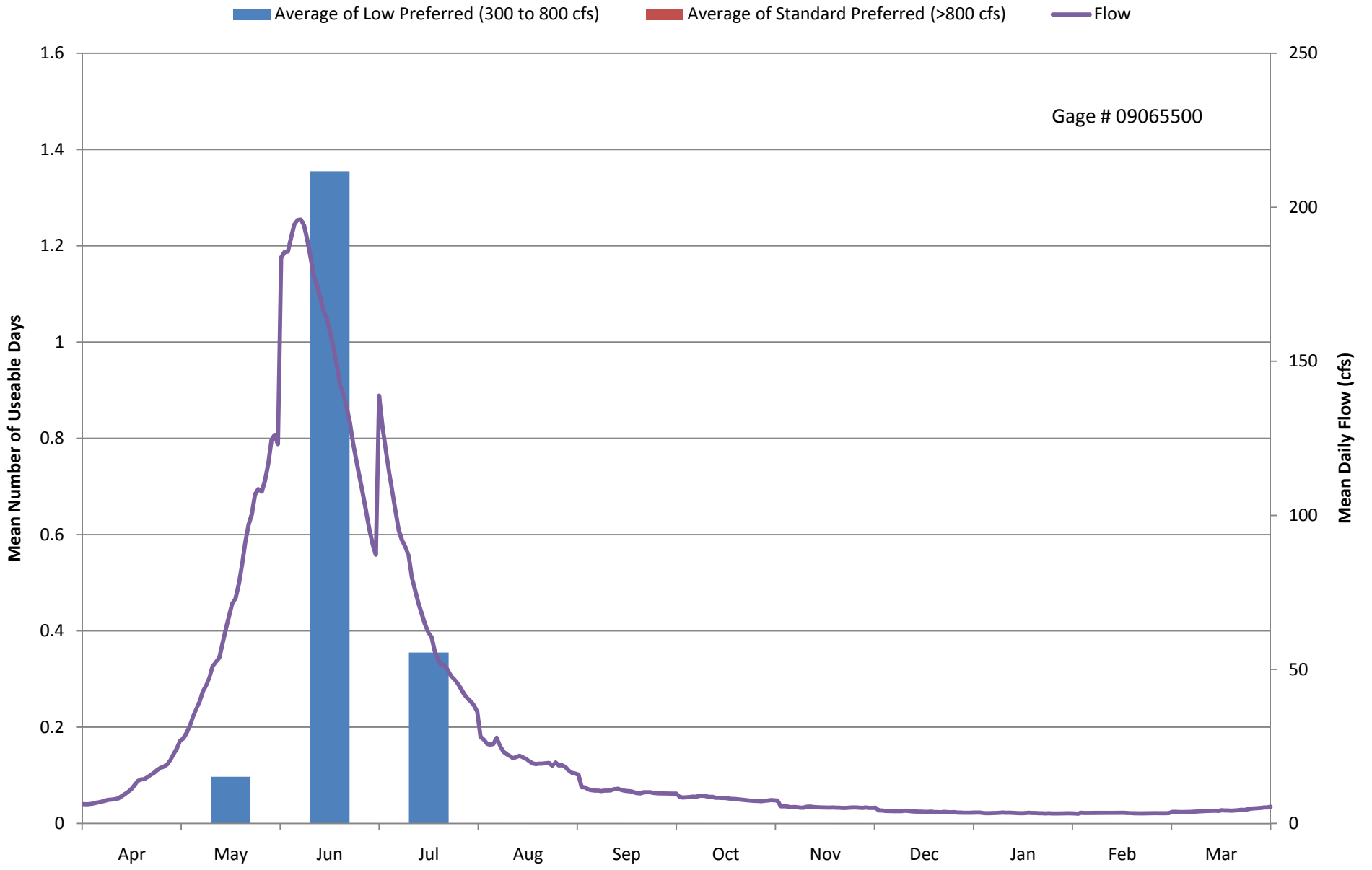


Figure 3-36
Eagle River (Forest Service Visitor Center to Riverbend Bus Stop) and Upper Eagle River (Minturn Slalom Course)
Mean Number of Useable Days by Month (1990-2001)

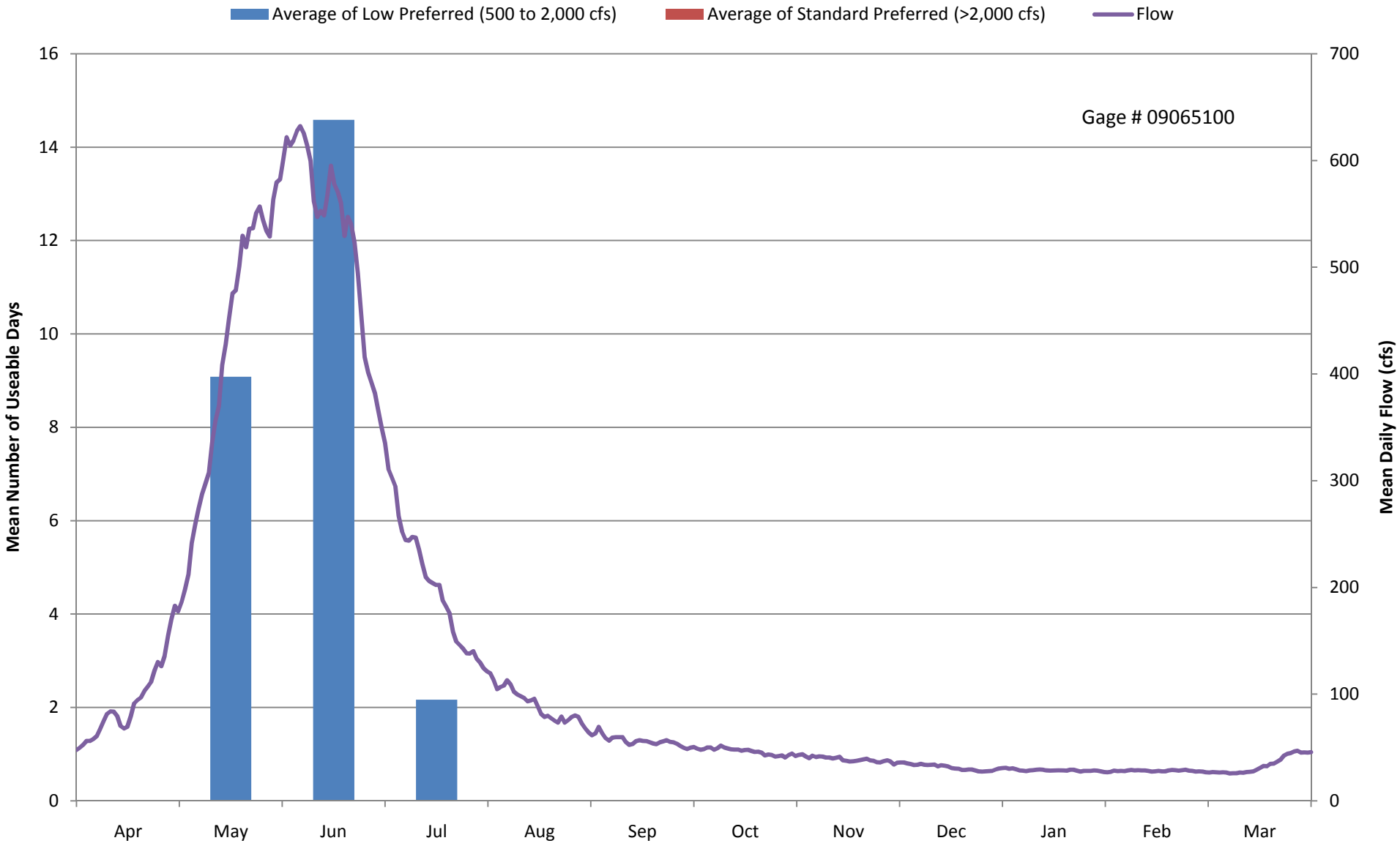


Figure 3-37
Eagle River (Avon to Dotsero)
Mean Number of Useable Days by Month (1975-2005)

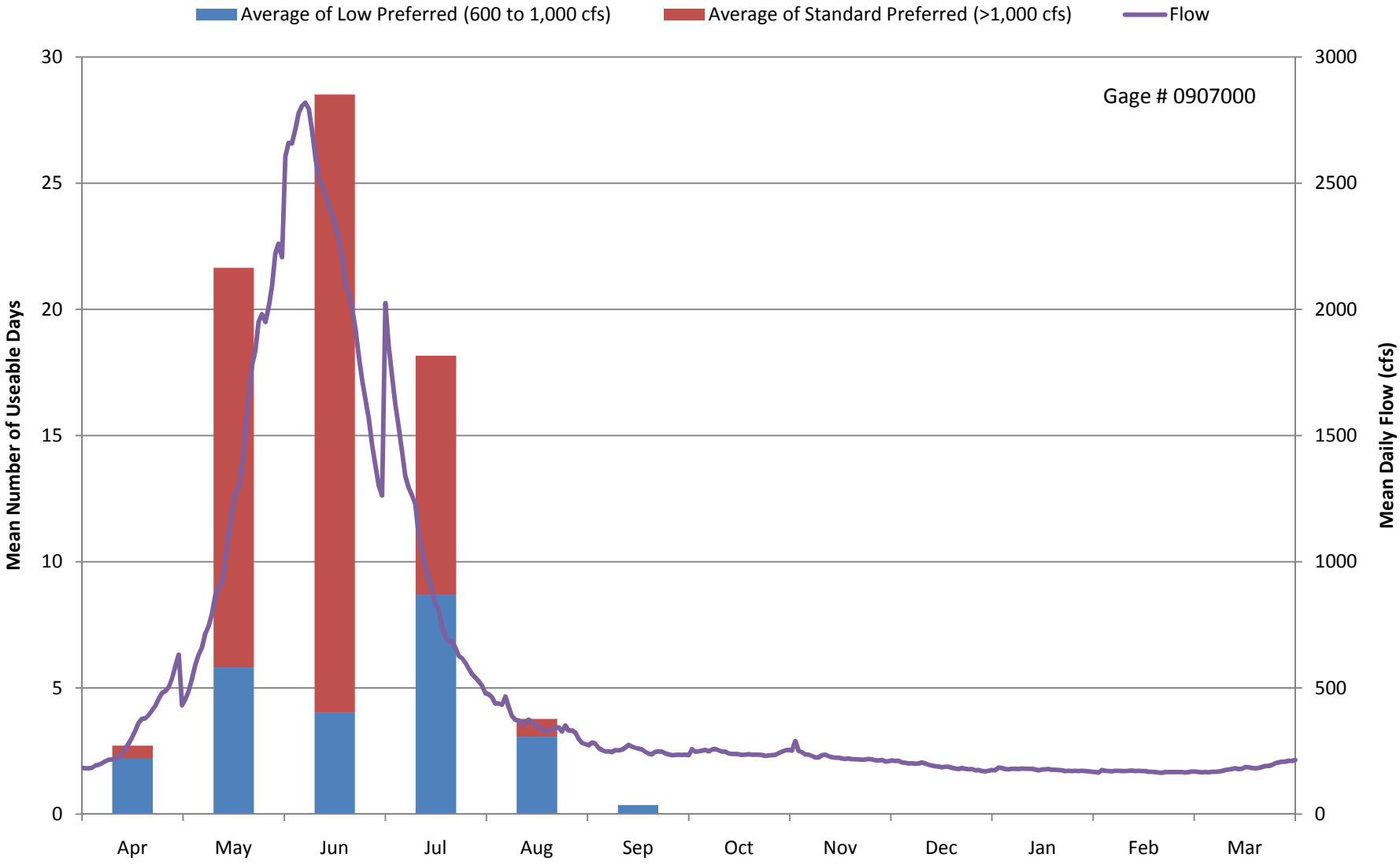


Figure 3-38
Piney River (Piney Crossing to State Bridge)
Mean Number of Useable Days by Month (1975-2005)

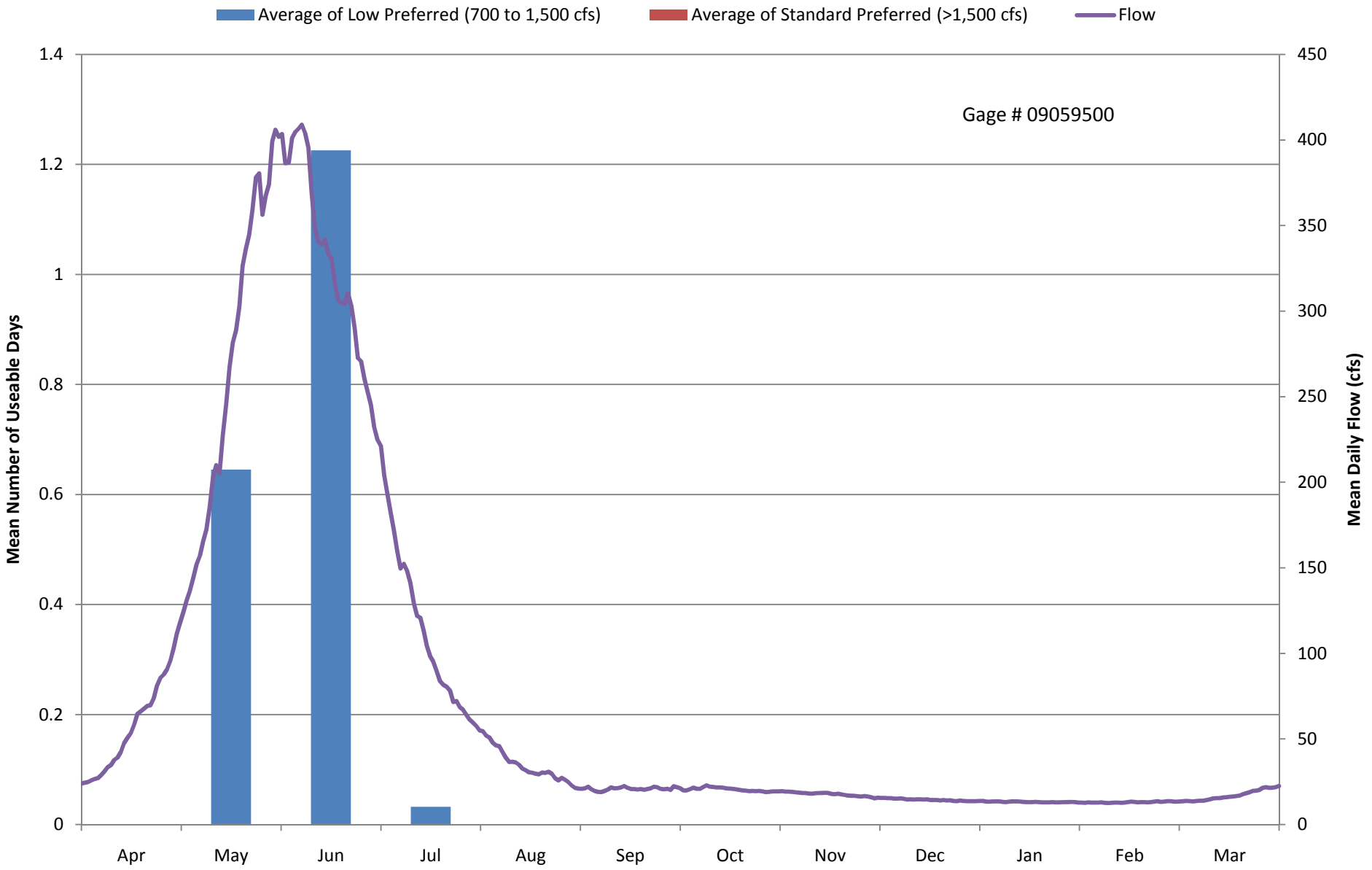


Figure 3-39
Upper Roaring Fork (Lower Woody Creek Bridge to Rte. 82 Bridge (Toothache) through Aspen Town Run (Slaughterhouse)
Mean Number of Useable Days by Month (1975-2005)

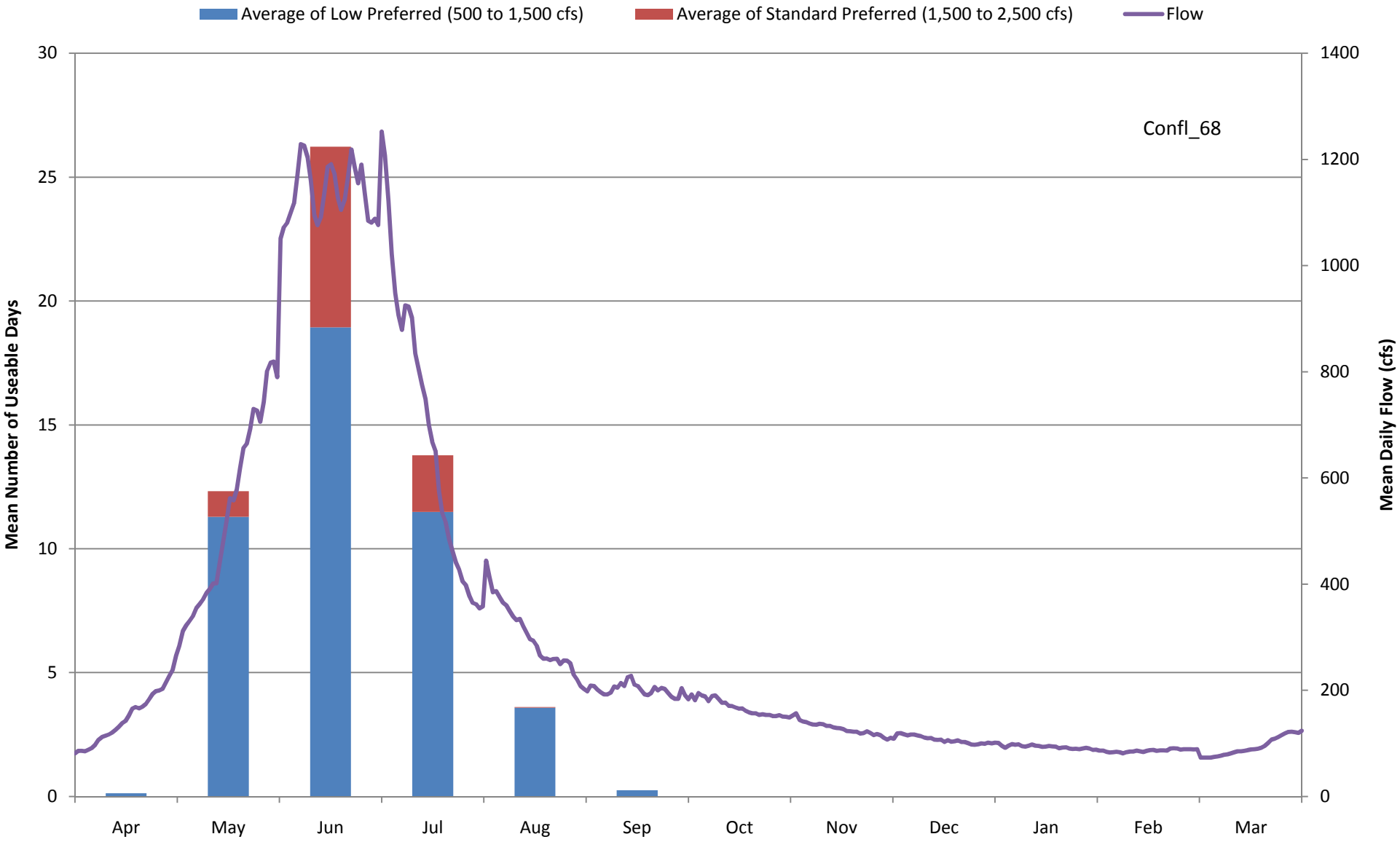


Figure 3-40
Crystal River (Avalanche Creek to Avalanche Creek (Narrows))
Mean Number of Useable Days by Month (1975-2005)

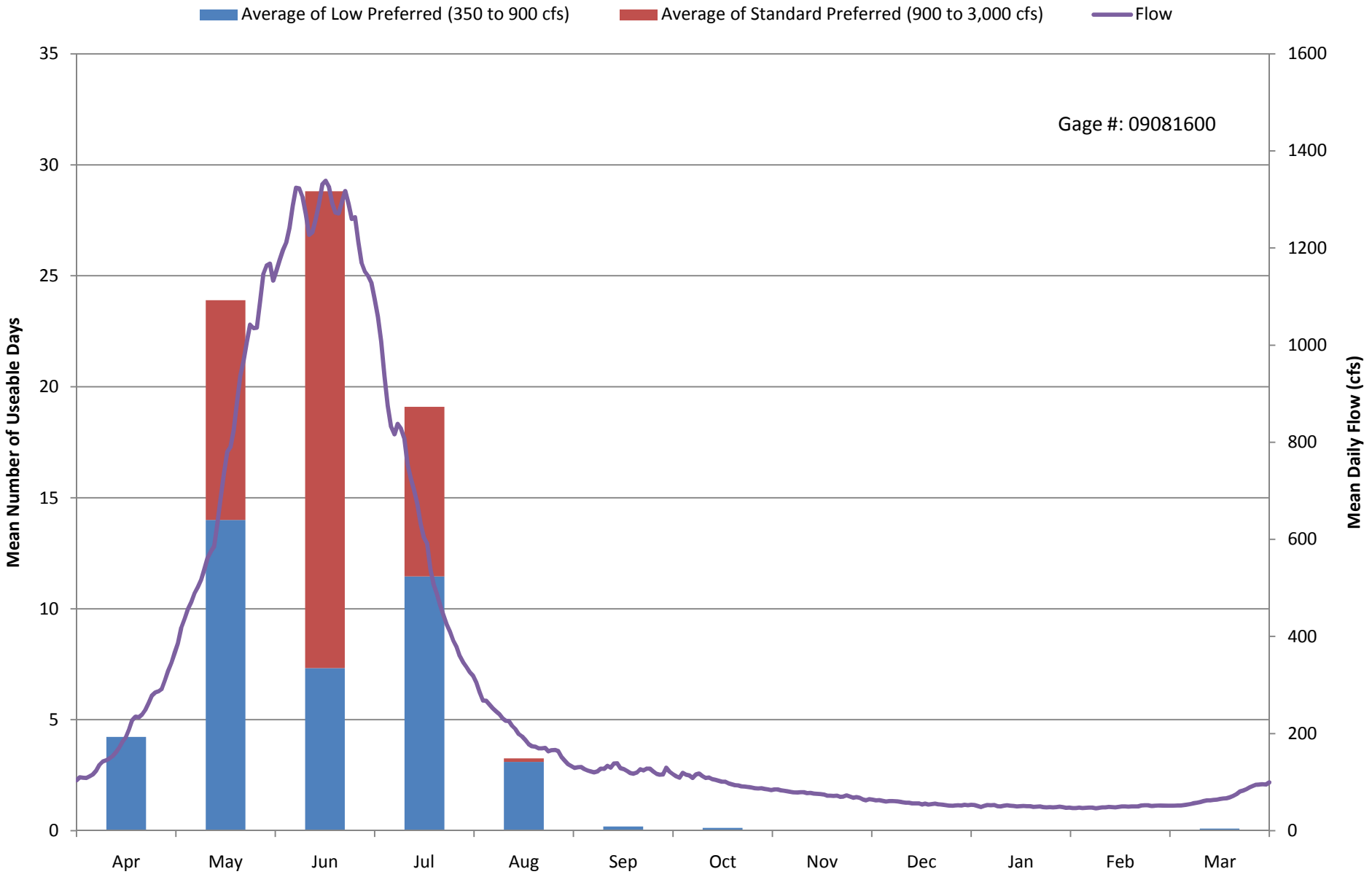


Figure 3-41
Crystal River (Marble to Penny Hot Springs (Meatgrinder))
Mean Number of Useable Days by Month (1975-2005)

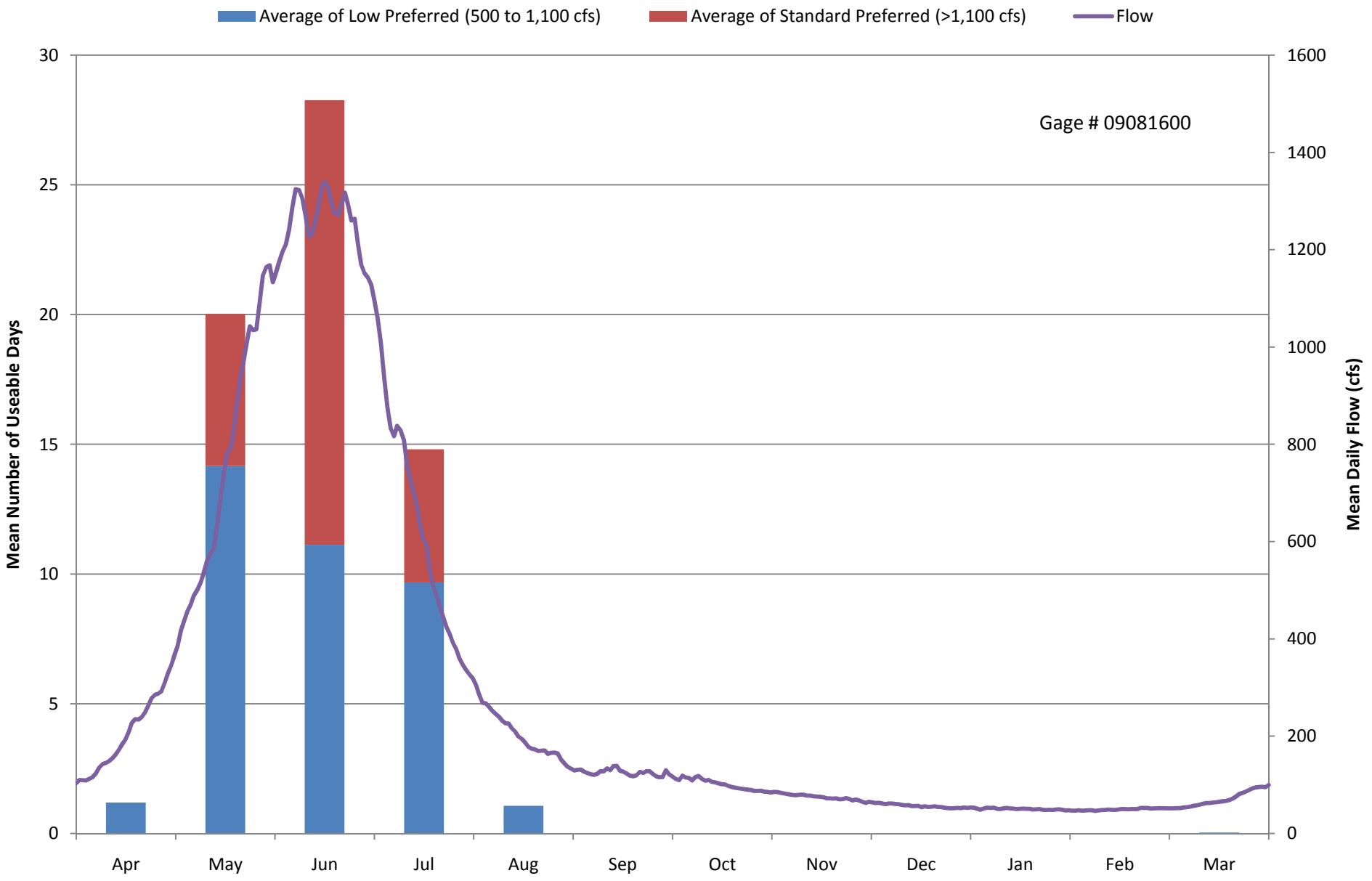


Figure 3-42
Upper Roaring Fork (Weller Lake to Difficult Camp Ground)
Mean Number of Useable Days by Month (1975-2005)

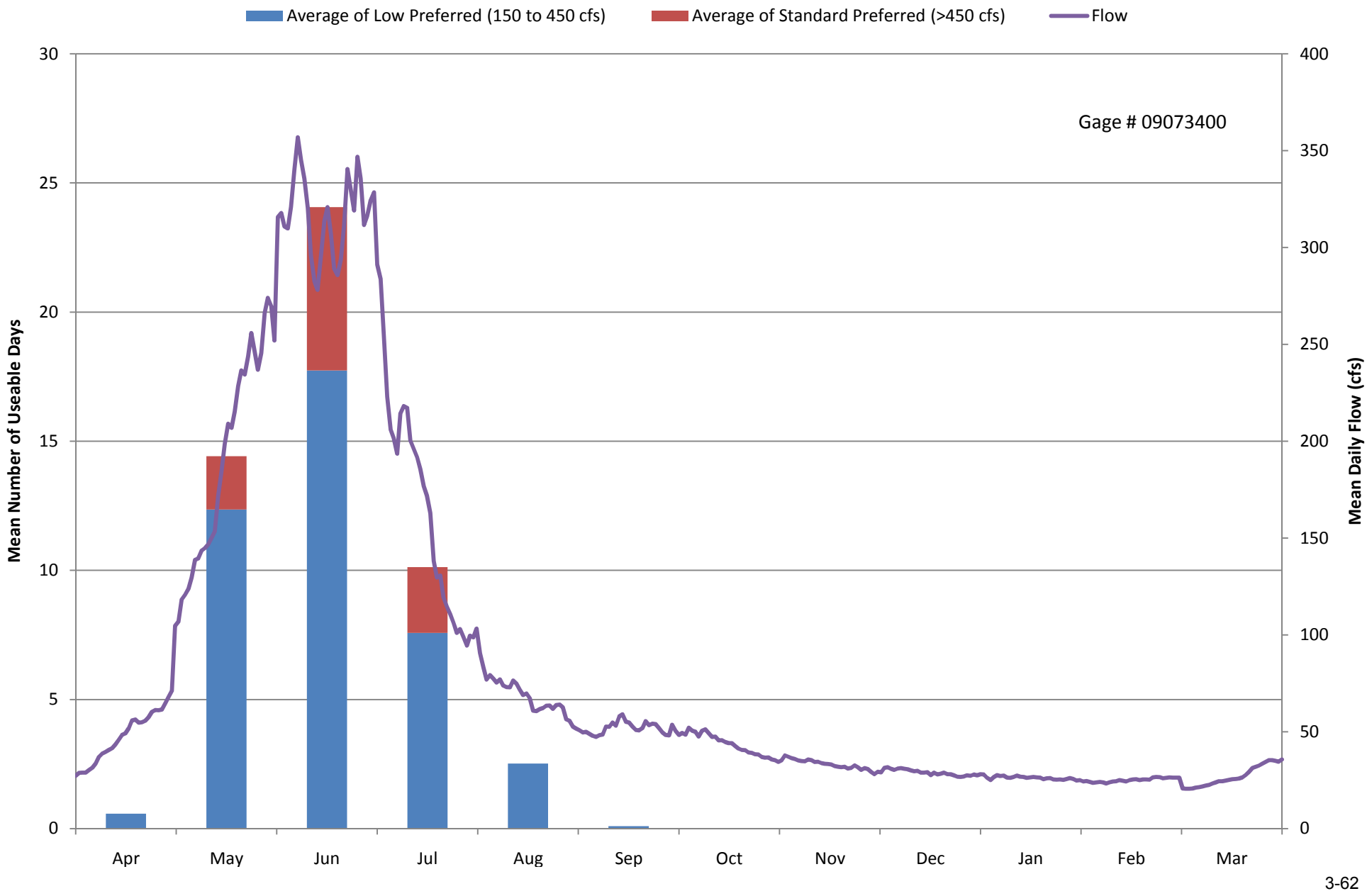
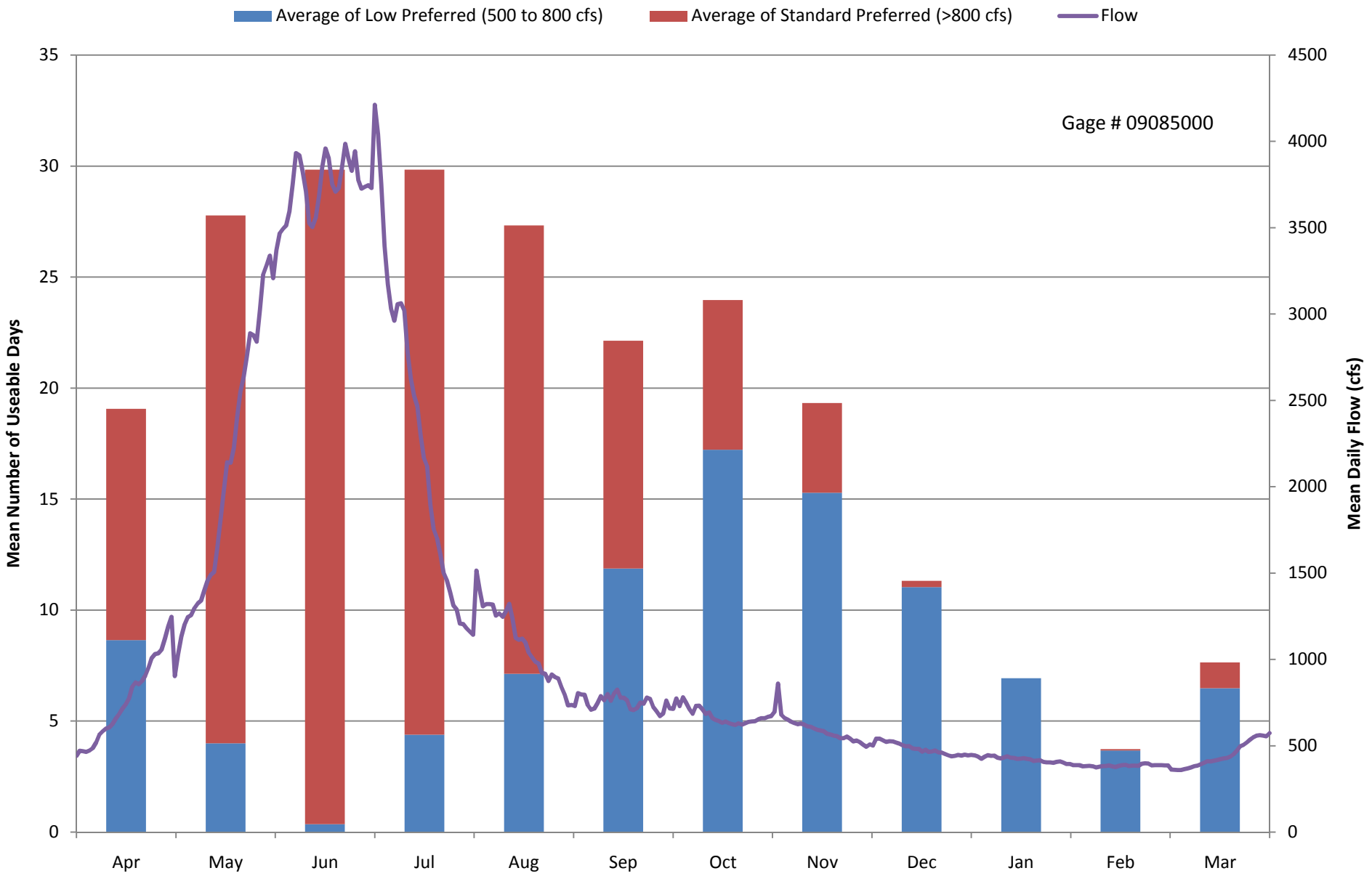


Figure 3-43
Roaring Fork (Cemetery)
Mean Number of Useable Days by Month (1975-2005)



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Section 4

Conclusions and Recommendations

4.1 Conclusions

Following are the conclusions for the Colorado Basin WFET Study based on the approach and results presented in Sections 2 and 3 of this report:

- Flow ecology relationships were developed for trout, warm water fish, and cottonwood (riparian) attributes. These flow-ecology relationships could be utilized in the future to provide a watershed scale understanding of changes in water management in the basin or changes in the hydrology related to climate change.
- The watershed scale, science-based maps of flow-related ecological risks throughout the drainage correspond well with current understanding of impacts resulting from flow management, as confirmed from quantitative site specific validation as well as qualitative review from knowledgeable project stakeholders. However, there are individual locations where WFET conclusions did not correspond with anecdotal information. The risks illustrated on these maps represent current flow conditions as of 2005. This report does not assess risks associated with future flow conditions projected following new water development projects (e.g., Moffat, Windy Gap, or any project in the concept phase).
- In general, across the entire Colorado River Basin, the majority of trout and warm water fish locations examined indicate minimal to low flow-ecology risk. Conversely, the majority of cottonwood locations examined indicate high to very high flow-ecology risk for riparian areas. Note that conclusions for "warmwater fish" do apply to endangered fish in the 15-mile reach. The endangered fish flow targets established by the Programmatic Biological Opinion are generally not currently met for either high flows or baseflows.
- Baseline information was developed for whitewater boating attributes. Whitewater recreation information was summarized for 28 river segments in the basin. This segment by segment summary describes the types of users, seasonal usage, and annual number of users if available, and flow ranges associated with user surveys and expert opinion from guidebooks. In addition, a usable days analysis was completed for each of the segments that can be utilized in the future to understand how the amount of usable days may vary in the future due to changes in water management.
- The WFET and recreational analysis conducted during the study do not address every issue affecting nonconsumptive outcomes. Flow-related decision-making should be embedded in a framework of planning for all factors affecting these outcomes.

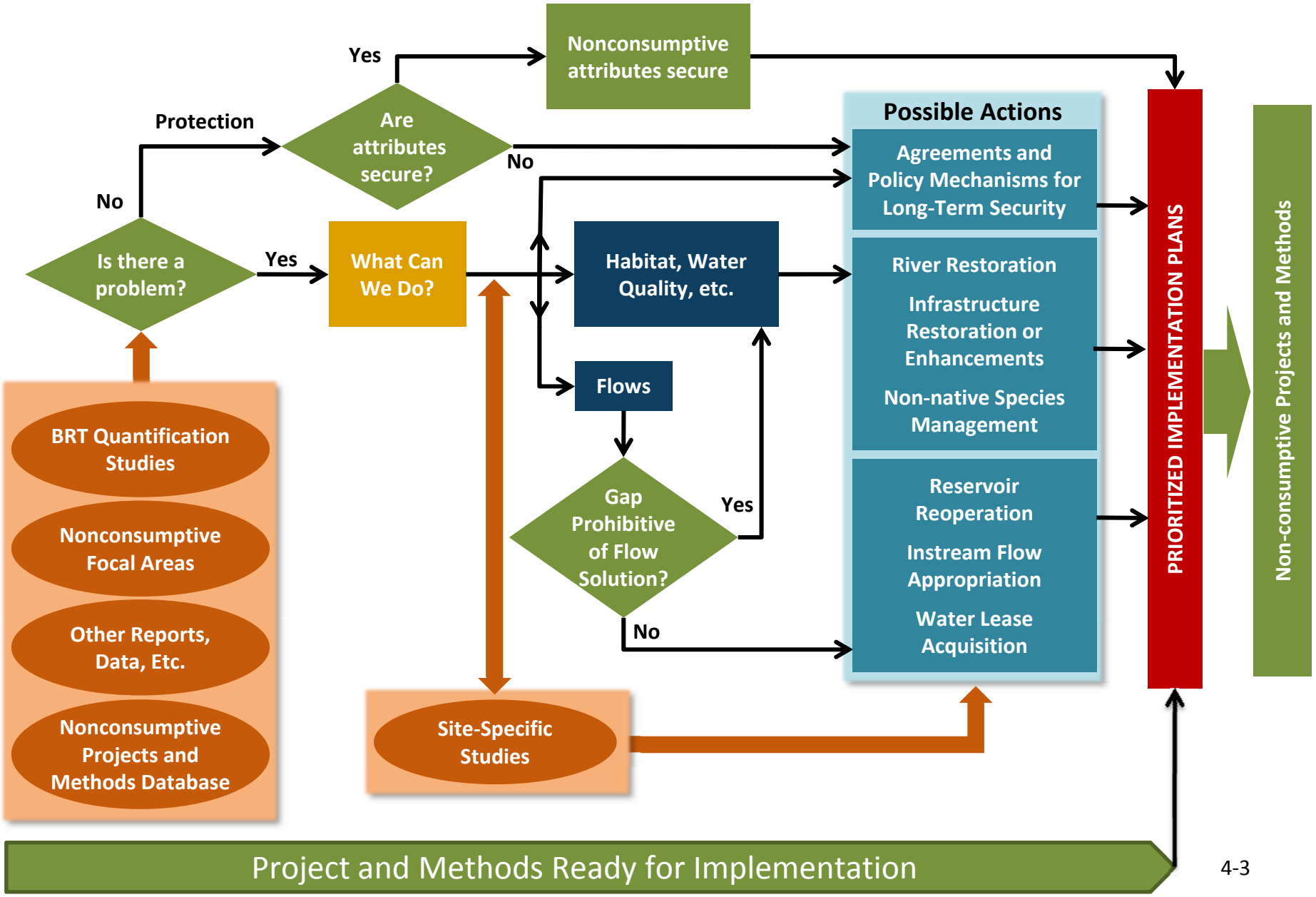
4.2 Recommendations

Figure 4-1 below summarizes the Colorado Basin Roundtable's proposed next steps for Nonconsumptive Project and Method implementation in the basin. The figure shows how the WFET study can be used to further Nonconsumptive Project and Method implementation. The WFET study results are important in addressing two key parts of the process outlined in Figure 4-1. First, study results can help the roundtable identify if there is a nonconsumptive problem that needs to be addressed, as the WFET study is a basin roundtable quantification study. Second, the WFET results can assist the roundtable in identifying early on whether flow is a realistic as part of solving a nonconsumptive problem.

Following is a summary of the process outlined in Figure 4-1:

- The Colorado Basin Roundtable's Statewide Water Supply Initiative 2010 Basin report and other studies provide a valuable starting point for addressing nonconsumptive needs. These studies and reports include: nonconsumptive focus area maps, WFET study results, site-specific quantification results, and project and methods information.
- Using existing reports and studies, the basin roundtable can ask if there is a problem with the current status of nonconsumptive attributes in specific waterbody, then:
  - If there is not a problem, the roundtable can answer if the waterbody's environmental or recreational attributes are secure into the future. If the attributes are secure, this information should be catalogued as part of the basin's project and method implementation database. If there is not a problem for a given waterbody but the attributes are not secure, agreements and policy mechanisms for long-term security of a given attribute could be explored. Examples of a policy mechanism for protection includes instream flow donations or voluntary flow agreements.
  - If there is a problem for a waterbody, there are three potential categories of actions to address the problem – policy mechanisms as described above, habitat and water quality related actions, and flow related actions. In some instances, the quantity of the flow necessary may preclude flow from being a realistic part of the long-term solution and other habitat mechanisms will need to be explored in lieu of or in combination with a flow solution.
- By using the steps above for a waterbody, specific implementation plans for the waterbody can be outlined. The implementation plan could include information about what is needed to address a given problem for a waterbody, cost estimates related to solutions, and timing for implementation.

Figure 4-1 Recommended Next Steps for Nonconsumptive Project and Methods Implementation



The Colorado Basin Roundtable Nonconsumptive Committee has used the process outlined above to examine the environmental and recreational focus areas identified during the roundtables nonconsumptive needs assessment. The results of this effort are summarized in Table 4-1. First, the committee compared the results of the WFET study with the focus area mapping results and examined whether the WFET study results confirm or provide additional information to the original focus mapping effort. Next, the committee identified if the segment was at risk for flow and if so for what attribute. Finally, if an attribute was at risk for flow the committee used the WFET results to identify whether or not flow can realistically be part of the solution for addressing the attribute's problem. To provide insight for this question, the committee identified the quantities of water that would be needed to decrease the flow-ecology risk from a higher level to a minimal condition. The committee recommends that it continue to use this matrix to further identify implementation mechanisms for its nonconsumptive needs.

In addition, the committee recommends the following actions based on the WFET study results:

- In the near term, use the WFET in conjunction with the focus area map and the process described above to identify strategies and implementation plans for long-term protections.
- In the medium and long term, use the WFET and recreational flow analysis results to analyze scale and distribution of expected flow-related risk to nonconsumptive attributes resulting from new development projects, a Compact call, and/or climate change.
- Utilize the WFET in Phase 2 of the Colorado River Water Availability Study to assess how forecast flow changes affect nonconsumptive needs.
- Initiate and support efforts to advance understanding of the relationship between flow management and both riparian vegetation and warmwater fish. Both of these aspects of river ecology are understudied in Colorado, and our management of water for long-term river health will improve as our understanding of flow-based ecological processes are better understood.

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
1	Blue River	Upper Blue River	Dillon Reservoir					X	Recreational boating (flatwater)	Ensure adequate lake levels for Frisco and Dillon Marinas July through Labor Day				Denver Water	Dillon lake levels not examined as part of WFET study.	No				Not Applicable	Not Applicable
2	Blue River	Snake River	Upstream of Dillon Reservoir		X		X		Recreational trout fishing	Aquatic life impacted by trace metals from abandoned mines and low flows in winter, channel maintenance (sediment)	Improve winter flows and upstream source control		NWCOG	Keystone Snowmaking, M&I	WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No				For trout, If reach not protected, identify mechanisms to protect reach. Perhaps retime to address winter issues could be addressed.	Not Applicable
3	Blue River	Blue River	Dillon Dam to Willow Creek		X				Gold medal fishery	Protect flows for fish; flows for fish are related to operations at Dillon	Reservoir operational considerations			Dillon Reservoir releases, M&I	WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No				For trout, if reach not protected, identify mechanisms to protect reach.	Not Applicable
4	Blue River	Blue River	Between Harrigan and South Rock Creek		X			X	Recreational boating (private and commercial) through July 4th, fishing, riparian habitat	Protect rec. flows for kayak/rafting June through July 4th, channel maintenance (sediment), fish/aquatic life needs	Reservoir operational considerations		UPCO	Dillon Reservoir releases, ag diversions	WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
5	Blue River	Blue River	Green Mountain Reservoir to Colorado		X			X	Recreational boating (private and commercial), fishing	Protect recreational flows in Green Mtn Canyon for fish and float boats, threatened by potential GMR pumpback, fish/aquatic life needs, channel maintenance (sediment)				GMR releases	WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach. Note that significant habitat improvements have occurred through a large portion of this segment, implemented by the Blue Valley Ranch.	Not Applicable
6	Upper Colorado	Colorado River	3-Lakes area		X		X		riparian habitat	Fishing and recreational boating (flatwater) threatened by water quality. algae, aquatic weeds, sediment, clarity, fish/aquatic life needs			E	CB-T, ag, local M&I	WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No				For trout, if reach not protected, identify mechanisms to protect reach.	Not Applicable
7	Upper Colorado	Colorado River	Granby Reservoir to Windy Gap	X	X				Flows for fish and habitat, overwintering fish habitat, macroinvertebrates, fishing, riparian habitat	Adequate releases from Granby for fish and habitat, temperature, sediment transport, embeddedness, cottonwood regeneration, overwintering fish habitat, macroinvertebrate habitat			E, USFWS 1950s	CB-T, ag, local M&I	WFET results indicate trout and cottonwood flow ecology risk at high levels. Warm water fish WFET metric does not apply at this location.	Yes	X		X	For trout - flows could be considered; for cottonwood, magnitude of flows likely preclude flow solution.	Trout - 6000 AF - August/September annual average increase; Cottonwood - >100,000 AF - May to July increase 1 in 3 years (150% increase over current flows)

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
8	Upper Colorado	Colorado River	Windy Gap Reservoir		X		X		Fishing	Ideal whirling disease conditions, sediment transport and deposition, fish/aquatic life needs				Windy Gap	Did not examine reservoir levels as part of WFET study.	No				Not Applicable	Not Applicable
9	Upper Colorado	Colorado River	Windy Gap Reservoir to Williams Fork	X	X				Gold Medal fishery, riparian habitat, recreational boating (seasonal)	Whirling disease, temperature, water quality, algae, fish/aquatic life needs, channel maintenance (sediment transport and deposition)			E	M&I (Windy Gap), ag	WFET results indicate trout and cottonwood flow ecology risk at high levels. Warm water fish WFET metric does not apply at this location.	Yes	X		X	For trout - flows could be considered; for cottonwood, magnitude of flows likely preclude flow solution.	Trout - 7000 AF - August/September annual average increase; Cottonwood - >100,000 AF - May to July increase 1 in 3 years (150% increase over current flows)
10	Upper Colorado	Colorado River	Williams Fork to Blue River	X	X		X		Fish, aesthetics	Temperature, sediment embeddedness, cottonwood revegetation related to upstream reservoir management, fish/aquatic life needs			E	M&I, ag	WFET results indicate trout flow ecology risk at low/minimal levels and cottonwood flow ecology risk at high levels. Warm water fish WFET metric does not apply in this location.	Yes			X	For trout, if reach not protected identify mechanisms to protect reach. For cottonwood, magnitude of flows would likely preclude flow solution.	Cottonwood - >150,000 AF - May to July increase 1 in 3 years (~50% increase over current flows)
11	Upper Colorado	Colorado River	Blue River to State Bridge		X			X	Private boating until October 31st, commercial boating until Labor Day (?)	World class recreational boating (private and commercial), fishing, sediment islands, exacerbate bank erosion, boating and fish habitat affected by reservoir operations			E		WFET results indicate trout flow ecology risk at low/minimal levels and cottonwood flow ecology risk at high levels. Warm water fish WFET metric does not apply in this location.	Yes			X	For trout, if reach not protected identify mechanisms to protect reach. For cottonwood, magnitude of flows would likely preclude flow solution.	Cottonwood - >200,000 AF - May to July increase 1 in 3 years (~50% increase over current flows)
12	Upper Colorado	Colorado River	State Bridge to Dotsero		X			X	Recreational boating	Recreational boating and float fishing under consideration as wild and scenic.					WFET results indicate low flow ecology risk for trout and warm water fish in this area and high flow ecology risk for cottonwood metrics.	Yes			X	For trout and warm water fish, if reach not protected, identify mechanisms to protect reach. Flows for lessening cottonwood flow ecology risk would preclude flow being part of the solution.	Cottonwood - >100,000 AF - May to July increase 1 in 3 years (~25% increase over current flows)
13	Upper Colorado	Colorado River	Dotsero to Glenwood Springs						Recreational boating	Recreational boating and float fishing under consideration as wild and scenic.					WFET results indicate trout and warm water flow ecology risk at low/minimal levels and cottonwood flow ecology risk at high levels.	Yes			X	For trout and warm water fish, if reach not protected identify mechanisms to protect reach. For cottonwood, magnitude of flows would likely preclude flow solution.	Cottonwood - >100,000 AF - May to July increase 1 in 3 years (~25% increase over current flows)
14	Lower Colorado	Lower Colorado River	From Silt to Grand Junction, Grand Valley		x		x		Riparian habitat; M&I and ag water supplies	Most water short for threatened and endangered fish (15-mile reach), TDS, accrete fines to banks, floodplain connection, fish/aquatic life needs, selenium, water quality					WFET results indicate low flow ecology risk for trout and warm water fish in this area and high flow ecology risk for cottonwood metrics.	Yes			X	For trout and warm water fish, if reach not protected, identify mechanisms to protect reach. Flows for lessening cottonwood flow ecology risk would preclude flow being part of the solution.	Cottonwood - >200,000 AF - May to July increase 1 in 3 years (~15% increase over current flows)

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
15	Fraser	Ranch Creek Tributaries, Fraser, St. Louis and Vasquez Creeks	Portions of Fraser and Tributaries affected by Moffat and Meadow Creek diversion system	X	X		X		Fish, riparian habitat	Sediment from road sanding, channel maintenance (sediment), fish/aquatic life needs	Flushing flows, sediment source removal		E	DW, ag, in-basin M&I	WFET results indicate trout flow ecology risk at low risk levels. WFET cottonwood and warm water fish metrics do not apply at this location.	No				For trout, if reach not protected, identify mechanisms to protect reach.	Not Applicable
16	Fraser	Fraser	St. Louis Creek to Colorado River		X	X	X	X	Fish, recreational boating (seasonal kayaking), riparian habitat	Protect kayak flows in Fraser Canyon, channel maintenance (sediment), (temps too high)-for fish			E	DW, ag, in-basin M&I	WFET results indicate trout and cottonwood flow ecology risk at high levels. Warm water fish WFET metric does not apply at this location.	Yes	X		X	For trout - flows could be considered; for cottonwood, magnitude of flows likely preclude flow solution.	Trout - 1000 AF - August/September annual average increase; Cottonwood - >30,000 AF - May to July increase 1 in 3 years (100% increase over current flows)
17	Williams Fork	Williams Fork River	Upstream of Williams Fork Dam		X		X		Excellent fishery, riparian habitat	Concern about Climax discharge, expanded WF collection system, channel maintenance (sediment) fish affecting	Excellent fishery, riparian habitat			Climax, Williams Fork Extension, Ag	WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
18	Williams Fork	Williams Fork River	Williams Fork dam to Colorado River	X	X				Excellent fishery	Reservoir operations affect prime fishery, channel maintenance (sediment) & veg encroachment				Denver Water	WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
19	Eagle	Eagle River	Eagle Mine to Minturn	X	X	X	X	X	Riparian habitat, fishing	303d listed for zinc, superfund cleanup, channel maintenance (sediment), fish/aquatic life impacts from water quality, kayaking in canyon	Metals source control, releases from Eagle Park or Homestake Creek Res. in above average years for metals dilution late March/April when res can refill before June				WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
21	Eagle	South Fork of Eagle River	Camp Hale		X	X	X			Potential well field development, channelized riparian corridor, groundwater recharge, wetland health, base flows, wildlife food sources, loss of habitat	Enforce ISF, monitor aquatic and wetland health		C		No CDSS nodes for this reach.	No				Not Applicable	Not Applicable
22	Eagle	Eagle River	Minturn to Avon	X	X			X	Recreational boating (whitewater), RICD Avon whitewater park, float fishing, sit kayak and other in lower reaches	Recreational boating (whitewater) RICD Avon whitewater park, float fishing, recreation flows for all Eagle River reaches, upstream water diversions, water quality from Eagle Mine (Homestake Reservoir)			A	RICD , Avon	No CDSS nodes for this reach.	No				Not Applicable	Not Applicable

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
23	Eagle	Eagle River	Avon to Wolcott		X	X		X	Boat fishing, recreational boating (beginner kayaking), riparian areas	Low flows/high temp late summer, temperature, low dissolved oxygen during the summer, Whirling disease habitat and temperature exceedances, low summer flows/embeddedness, flows for equilibrium sediment transport, (Edwards segment), boat fishing			A,B,C		WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
24	Eagle	Eagle River	Wolcott to Dotsero		X	X		X	Float boating	Float boating, ISF set below natural low flow occurrence even in 02 year, base flows, temperature, tamarisk			C		WFET results indicate trout, warm water fish, and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout, warm water fish and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
25	Eagle	Black Gore/ Gore Creek	Vail Pass		X	X	X		Sediment impacts to fish, Recreational boating (Class V boating in spring [realignment grade control structures mile marker 183-182.5]), aesthetics	Highway traction sand, 303(d) listed for sediment, upstream of Gold Medal reach, runoff constituents, increased native slope erosion, sedimentation smothering riparian habitat, encroachment of vegetation establishing on aggraded channel sections, loss of fish habitat by filling of pools, loss of macroinvertebrate diversity and habitat	Encourage CDOT to maintain sediment basins to collect highway maintenance waste materials.		H		WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
26	Eagle	Gore Creek	Vail		X			X	Recreational boating in spring (whitewater), wade fishing in summer-fall Gold Medal fisheries, aesthetics	Ensure ISF maintained, municipal diversion and golf course dewatering causes temp and algae problems in gold medal trout stream, nutrients and sediments			A, D	RICD Vail whitewater park	WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
27	Eagle	Homestake Creek, Sopris Creek, and Missouri Creek		X	X	X				Upper Homestake Creek tribs. dewatered					WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No				For trout, if reach not protected, identify mechanisms to protect reach.	Not Applicable
28	Eagle	Willow Creek, Turkey Creek, Cross Creek, Eagle River to Gore Creek Confluence	Red Cliff		X		X		Dilution flows for metals, impacts to aquatic life	Potential reservoir development near Cross Creek - potential diversion is just below wilderness boundary, threatens dilution flows for 303(d) listed segments for metals, nps, Sediment, lack of BMPs, sediment transport, nps stormwater and mining	Flows needed to ensure sediment transport, enforce SWMPs for developers				WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
29	Eagle	Homestake Creek, Cross Creek	Red Cliff					X	Recreational boating (Class V whitewater recreation boating on Cross Creek and Homestake Creek in spring)	Upstream diversions reduce whitewater recreation in spring					Recreation only area	No				Not Applicable	Not Applicable

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
30	Eagle	Two Elk Creek	Minturn/Vail Ski Mountain		X		X		Contribution to dilution flows for metals downstream	Potential snowmaking diversions may threaten ISF, baseflows	Maintain ISF, monitor aquatic life				No CDSS nodes for this reach.	No				Not Applicable	Not Applicable
32	Eagle	Alkali Creek	Near Wolcott					X	Recreational boating (Class IV whitewater boating during spring and later summer rain storms)	Potential Wolcott Reservoir development, agriculture nps, recreational boating (Class IV whitewater boating during spring and late summer rain storms)			A,B,C		WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
33	Eagle	Gypsum Creek	Outside of Gypsum		X	X			Riparian habitat, fishing, aesthetics	Low flows, dewatering, vegetation encroachment in channel, loss of habitat and wildlife food sources, floodplain connection, groundwater recharge			C		WFET results indicate trout, warm water fish, and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout, warm water fish and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
34	Eagle	Abrams Creek	Tributary off Brush Creek east of Town of Eagle		X	X			Class A Cutthroat Trout	Low flows, diversions,Class A Cutthroat Trout	Reduce diversions- re-locate diversion to Eagle River		BLM		No CDSS nodes for this reach.	No				Not Applicable	Not Applicable
36	Roaring Fork	New York, Lost Man, Lincoln, Tabor, Brooklyn Creeks	In the headwaters of the Roaring Fork tributaries	X	X	X			Riparian habitat, scenic values, groundwater recharge, boreal toad	Peak and baseflow issues throughout the year, riparian habitat, scenic values, groundwater recharge, boreal toad	Improve overall Independence Pass diversions and overall Fry-Ark operations			Twin Lakes diversions	WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No				For trout, warm water fish and cottonwood, if reach not protected, identify mechanisms to protect reach. No data for all of these streams with the exception of Lincoln Creek and August flows are altered by 53%. The only thing that protects Lincoln Creek is the Cameo call which calls out the IPTDS.	Not Applicable

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
37	Roaring Fork	Upper Roaring Fork River	Upper Roaring Fork River above Aspen	X	X	X		X	Willow carr, riparian habitat (rare montane riparian forests, high quality common riparian forests), Audubon important birding areas (Northstar), Colorado River cutthroat trout, boreal toads, CNHP PCA, SHI CAC, recreational boating	Roaring Fork at Aspen Gage greatest alteration is in the spring peak flow and summer baseflow (May -54%, June -67%, July -70%, August -38%) alteration is greater closer to diversion. Reduced frequency of flooding in the North Star Preserve area affects groundwater for municipal water supply to the City of Aspen (via wells). Some of the functions threatened by this reduced flood frequency are floodplain development, flood flow conveyance, channel maintenance, scour and deposition and groundwater recharge (geomorphic issues). Willow carr, riparian habitat (rare montane riparian forests, high quality common riparian forests), Audubon important birding areas (Northstar), Colorado River cutthroat trout, boreal toads, CNHP PCA, SHI CAC, recreational boating	Improve overall operation of the Fry-Ark and Independence Pass Diversions including improved stream gaging for 3000 a.f. exchange		F	Independence Pass Trans-mountain diversions	WFET results indicate trout flow ecology risk at low/minimal levels and cottonwood flow ecology risk at high levels. Warm water fish WFET metric does not apply in this location.	Yes			X	For trout, if reach not protected identify mechanisms to protect reach. For cottonwood, magnitude of flows may not preclude flow solution.	Cottonwood - 10,000 AF increase in May-Jul peak flows 1 in 3 year (5% increase over current flows)
41	Roaring Fork	Roaring Fork River	Lower Roaring Fork River (below Carbondale)	X	X	X	X	X	Flannelmouth Sucker, Bluehead Sucker, recreational boating, Gold Medal fishery, native contiguous riparian vegetation including silver buffaloberry and willow Hawthorne, SHI CAC	Reduction in peak flow (May -54%, June -45%, July -41%); increase in late fall/winter base flow (Nov 41%, Dec 26%, Jan 24%, Feb 23%, March 24%), salinity problems below confluence with Cattle Creek. Potential water quality impacts during low flow periods due to effluent discharges and stormwater runoff. Flannelmouth Sucker, Bluehead Sucker, recreational boating, Gold Medal fishery, native contiguous riparian vegetation including silver buffaloberry and willow Hawthorne, SHI CAC	Maintain fishery flow, varied sources for 10,825 water (not 100% Ruedi)		F	Municipal, irrigation, impacted by upstream diversions	WFET results indicate trout and warm water flow ecology risk at low/minimal levels and cottonwood flow ecology risk at high levels.	Yes			X	For trout and warm water fish, if reach not protected identify mechanisms to protect reach. For cottonwood, magnitude of flows likely preclude flow solution. Location of node only represents conditions at that node. The Upper RF is dewatered below the IPTDS and several undiveretd tributaries improve flow by the time it reaches this node. There is a large irrigation diversion (Salvation Ditch) immediately below this node that influences flows below the node.	Cottonwood - 50,000 AF increase in May - Jul flows 1 in 3 years (20% increase over current flows)
42	Roaring Fork	Hunter Creek, No Name, and Midway Creeks	Above Hunter Creek near Aspen gage (tributary northeast of Aspen)		X	X			Colorado River cutthroat trout and native contiguous riparian vegetation, CNHP PCA,	Reduction in spring peak flow (May - 60%, June -40%, July -50%) threatens Colorado River cutthroat trout and native contiguous riparian vegetation, CNHP PCA,	Improve overall Fry-Ark operations		F	Fry-Ark Project diversions	WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No				For trout, if reach not protected, identify mechanisms to protect reach.	Not Applicable

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
43	Roaring Fork	Hunter Creek	Below Hunter Creek near Aspen gage (tributary northeast of Aspen)		X	X			Aesthetics, native contiguous riparian vegetation, Colorado River cutthroat trout	Reduced summer and fall baseflow, CNHP PCA, Aesthetics, native contiguous riparian vegetation, Colorado River cutthroat trout.	Improve overall Fry-Ark operations, pursue dry-year lease options	Riparian and in-channel surveys	F	Irrigation	WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No					For trout, if reach not protected, identify mechanisms to protect reach.	Not Applicable
44	Roaring Fork	Castle Creek	Tributary of Roaring Fork, downstream of Aspen		X	X		X	Willow carrs, rare Rocky Mountain riparian forests, Colorado River cutthroat trout, boreal toad, recreational boating	Reduction in winter baseflow (Dec -26%, Jan -31%, Feb -29%, March -22%); water quality. Willow carrs, rare Rocky Mountain riparian forests, Colorado River cutthroat trout, boreal toad, recreational boating.	Institute water use efficiencies	Stream flow information	F	Hydropower, municipal, snowmaking	WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No					For trout, warm water fish and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
45	Roaring Fork	Maroon Creek	Maroon Creek		X	X			Willow carrs, Colorado River cutthroat trout, boreal toad, rare Rocky Mountain riparian forests; native continuous riparian vegetation, CNHP PCA	Reduction in winter baseflow (Jan -25%, Feb -21%, March -28%, April -29%). Willow carrs, Colorado River cutthroat trout, boreal toad, rare Rocky Mountain riparian forests; native continuous riparian vegetation, CNHP PCA	Institute water use efficiencies (snowmaking and municipal)		F	Hydropower, municipal, snowmaking	WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No					For trout and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
46	Roaring Fork	Snowmass Creek	Snowmass Creek		X	X			Boreal toad, CNHP PCA, native contiguous riparian vegetation, fishery (primarily browns)	Potential summer and winter baseflow issues. Boreal toad, CNHP PCA, native contiguous riparian vegetation, fishery (primarily browns)	Institute water use efficiencies, pursue dry-year lease options, revise Snowmass Water and San operations		F	Municipal, irrigation, snowmaking, diversions to Brush Creek watershed for snowmaking and municipal uses	No CDSS nodes for this reach.	No				Not Applicable	Not Applicable
47	Roaring Fork	Brush Creek	Brush Creek	X			X		scenic	sedimentation/ water quality		stream flow information		municipal, snowmkaing, irrigation, hydropower	No CDSS nodes for this reach.	No				Not Applicable	Not Applicable
48	Roaring Fork	West Sopris Creek	West Sopris Creek, near Basalt	X		X			CNHP PCA, native contiguous riparian vegetation	Reduction in summer baseflow (April -25%, May -52%, June -44%, July -45%, August -61%, Sept -67%, Oct -78%)	Pursue dry-year lease options	Stream flow information, riparian and in-channel surveys	F	Irrigation diversion to Prince Creek on the Crystal River	WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected, identify mechanisms to protect reach. On provisional 303 d list for aquatic life use; most likely not flow related.	Not Applicable
48A	Roaring Fork	East Sopris Creek	East Sopris Creek	X		X				potential flow reduction		Stream flow information, riparian and in-channel surveys		Irrigation	No CDSS nodes for this reach.	No				Unknown	Unknown

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
49	Roaring Fork	South Fork, Lily Pad, Cunningham, Mormon, Carter, Ivanhoe, Granite,North Cunningham, Middle Cunningham, South Cunningham, North Fork FP, Sawyer, Chapman Gulch, Main Stem FP	Headwaters of Fryingpan	X	X	X			high quality common montane riparian forests, cutthroat habitat, CNHP PCAs, willow carr	Loss of peak flows, high quality common montane riparian forests, cutthroat habitat, CNHP PCAs, willow carr	Re-operation of the Fry-Ark project	Riparian and in-channel surveys		Fry-Ark diversions	No CDSS nodes for this reach.	No				Not Applicable	Not Applicable; Is segment at risk box should not be no if no data. It should be unknown. South Fork Fryingpan River on provisional 303 d list for aquatic life use.
49A	Roaring Fork	Upper Fryingpan River	Above Ruedi Reservoir			X			Willow carr, CNHP PCA, riparian habitat (high quality common montane riparian forests)	Spring Peak Flow (May 33%, June 65%, July 55%), channel maintenance (sediment), Willow carr, CNHP PCA, riparian habitat (high quality common montane riparian forests)			F	Fry-Ark diversion	WFET results indicate trout flow ecology risk at low/minimal levels. Cottonwood and warm water fish WFET metrics do not apply in this location.	No				For trout, If reach not protected, identify mechanisms to protect reach. Perhaps retime to address winter issues could be addressed.	Not Applicable
50	Roaring Fork	Fryingpan River	Ruedi Reservoir					X	Maintain adequate reservoir level- reservoir is a source of recreation/hydropower	reservoir level reduction with potential impacts on rec/hydropower, maintain adequate reservoir level- reservoir is a source of recreation/hydropower	Varying sources for 10,825 water (not 100% Ruedi)			10,825 water, other contracted water	Did not examine reservoir levels as part of WFET study.	No				Not Applicable	Not Applicable
51	Roaring Fork	Fryingpan River	Upstream of Roaring Fork/Frying Pan confluence to Ruedi Reservoir		X	X			narrowleaf cottonwood/red osier dogwood riparian wetlands, native contiguous riparian vegetation with willow hawthorne, Gold Medal Fishery, SHI CAC	reduced spring peak flow and increase base flow (Oct 53%, Nov 70%, Dec 93%, Jan 110%, Feb 89%, Mar 91%, Apr 21%, May 80%, June 79%, July 34%, Aug 33%, Sept 41%), narrowleaf cottonwood/red osier dogwood riparian wetlands, native contiguous riparian vegetation with willow hawthorne, Gold Medal Fishery, SHI CAC	Maintain fishery flow, varied sources for 10,825 water (not 100% Ruedi)		F,G	Impacted by Ruedi- use of 10,825 water, other contracted water releases	WFET results indicate trout and warm water flow ecology risk at low/minimal levels and cottonwood flow ecology risk at high levels.	Yes			X	For trout and warm water fish, if reach not protected identify mechanisms to protect reach. For cottonwood, magnitude of flows would likely preclude flow solution.	Cottonwood - >50,000 AF - May to July increase 1 in 3 years (~25% increase over current flows)
52	Roaring Fork	Crystal River	Crystal River from Thompson Creekr to the Confluence with Roaring Fork		X	X	X		native contiguous riparian vegetation including silver buffaloberry and willow hawthorne, Colorado River cutthroat, SHI CAC	Reduction in summer baseflow (July -22%, Aug -49%, Sept -59%, Oct -46%), water quality, potential water quality impacts during low flow periods due to stormwater runoff, native contiguous riparian vegetation including silver buffaloberry and willow hawthorne, Colorado River cutthroat, SHI CAC	Pursue dry year lease options, institute water use efficiencies, pumpback to top of critical reach		F	Irrigation, municipal	WFET results indicate trout, warm water, and cottonwood flow ecology risk at low/minimal levels. However, stakeholders have noted areas of significant dry-up in stream not captured by current gaging records.	Unknown				Unknown	Unknown

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

				Attributes At Risk - Prioritized																	
COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
53	Crystal	Thompson Creek	Thompson Creek		X	X			rare montane riparian forests, native contiguous riparian vegetation, Colorado River cutthroat trout	Reduction in summer base flow (August -26%), rare montane riparian forests, native contiguous riparian vegetation, Colorado River cutthroat trout	Potential Wild and Scenic River designation	Stream flow information, riparian and in-channel surveys	F	Irrigation, oil and gas impacts	WFET results indicate trout, warm water, and cottonwood flow ecology risk at low/minimal levels.	No					For trout, warm water and cottonwood, if reach not protected identify mechanisms to protect reach. However, stakeholders have noted areas of significant dry-up in stream not captured by current gaging records. On proposed 303d list for iron.	Not Applicable
53B	Roaring Fork	Cattle Creek	Cattle Creek below Mountain Meadow Ditch		X	X	X		Fall passage and brown and rainbow spawning areas for Roaring Fork River Gold Medal Fishery, sedge wet meadow, Colorado River Cutthroat Trout, CNHP PCA, SHI CAC	Reduction in spring peak flow and baseflow (Oct -79%, April -49%, May -80%, June -65%, July -64%, August -71%, Sept -69%); water quality, salinity concerns. Fall passage and brown and rainbow spawning areas for Roaring Fork River Gold Medal Fishery, sedge wet meadow, Colorado River Cutthroat Trout, CNHP PCA, SHI CAC.	Designate in-stream flow; lease or acquire water rights for in-stream flows	Stream flow information	F	Irrigation, diversion to Missouri Heights	WFET results indicate trout, warm water, and cottonwood flow ecology risk at low/minimal levels except at one diversion location.	Maybe	X	X	X	Unknown; On provisional 303 d list for aquatic life use.	Unknown
54	Roaring Fork	Fourmile Creek and Threemile Creek	Tributaries west of Glenwood Ditch		X	X	X		Fall passage and brown and rainbow spawning areas for Roaring Fork Gold Medal fishery, sedge wet meadow, willow carrs, native contiguous riparian vegetation, SHI CAC	Reduction in spring peak flow and baseflow (Oct -39%, April -23%, May -38%, June -50%, July -25%, August -29%, Sept -30%), water quality. Fall passage and brown and rainbow spawning areas for Roaring Fork Gold Medal fishery, sedge wet meadow, willow carrs, native contiguous riparian vegetation, SHI CAC.	Designate in-stream flows for both streams, lease or acquire water rights for in-stream flows, water use efficiencies	Stream flow information, riparian and in-channel surveys	F	Irrigation, municipal, hydropower	WFET results indicate trout, warm water, and cottonwood flow ecology risk at low/minimal levels.	No					For trout, warm water and cottonwood, if reach not protected identify mechanisms to protect reach. However, stakeholders have noted areas of significant dry-up in stream not captured by current gaging records.	Not Applicable
55	Roaring Fork	Lower Fryingpan River	Tributary from Ruedi Reservoir to Basalt	X	X	X		X	Riparian habitat (Narrowleaf cottonwood/red osier dogwood riparian), recreational boating (whitewater in Spring), Fishing (summer-fall, Gold Medal)	Reduced spring peak flow and increased base flow (Oct 53%, Nov 70%, Dec 93%, Jan 110%, Feb 89%, March 91%, April 21%, May 80%), channel maintenance (sediment)			F	Flow controlled by Ruedi Reservoir releases	WFET results indicate trout and warm water flow ecology risk at low/minimal levels and cottonwood flow ecology risk at high levels.	Yes			X	For trout and warm water fish, if reach not protected identify mechanisms to protect reach. For cottonwood, magnitude of flows would likely preclude flow solution.	Cottonwood - >50,000 AF - May to July increase 1 in 3 years (~25% increase over current flows)
66	Roaring Fork	Woody Creek	Woody Creek	X		X			native contiguous riparian vegetation, CNHP PCAs	Flow reduction, native contiguous riparian vegetation, CNHP PCAs		Flow data	F	Irrigation	No CDSS nodes for this reach.	No				Unknown	Unknown
67	Roaring Fork	Capitol Creek	Capitol Creek	X	X				Colorado River cutthroat trout	potential flow reduction. Colorado River cutthroat trout		Flow data	F	Irrigation	WFET results indicate trout and cottonwood flow ecology risk at low/minimal levels. Warm water fish WFET metric does not apply in this location.	No				For trout and cottonwood, if reach not protected identify mechanisms to protect reach. On proposed 303d list for Selenium.	Not Applicable
59	Lower Colorado	Trapper, Northwater, 1st/2nd Anvil Creeks	East Middle Fork Parachute Creek and its tributaries, East Fork Parachute Creek and its tributaries		x	x	x		Riparian habitat	Water quality/quantity concerns from oil and gas development on Roan Plateau with 5 cutthroat populations, fish/aquatic life needs. Riparian habitat.	Fence cattle out of riparian. Keep drilling activity out of watersheds		BLM		WFET results indicate warm water and cottonwood flow ecology risk at low/minimal levels. Trout WFET metrics do not apply in this location.	No				Not Applicable	Not Applicable

Table 4-1 Colorado Basin Attributes at Risk Data Matrix and WFET Results

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COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
60	Lower Colorado	Plateau Creek Area, Middle Leon Creek, Mesa Creek	Grand Mesa National Forest between Middle Leon Creek and Mesa Creek		x	x			Riparian habitat	Fish/aquatic life needs	Maintain live creeks, coordinate stocking with storage fluctuations, optimize reservoir management for fisheries				WFET results indicate trout, warm water fish, and cottonwood flow ecology risk at low/minimum levels.	No				For trout, warm water fish and cottonwood, if reach not protected, identify mechanisms to protect reach.	Not Applicable
61	Lower Colorado	Colorado River	Rifle, Silt, and New Castle	x	x		x		Riparian habitat	Low-flow related to trans-basin diversions for energy, water quality impairment, increasing chemicals, impacts to threatened/endangered species, channel maintenance (sediment), fish/aquatic life needs					WFET results indicate low flow ecology risk for trout and warm water fish in this area and high flow ecology risk for cottonwood metrics.	Yes			X	For trout and warm water fish, if reach not protected, identify mechanisms to protect reach. Flows for lessening cottonwood flow ecology risk would preclude flow being part of the solution.	Cottonwood - >200,000 AF - May to July increase 1 in 3 years (~15% increase over current flows)
62	Lower Colorado	Colorado River	Rifle to Grand Junction	x	x		x		Riparian habitat	Water disposal pits - energy activity, WQ seepage, dam proposals (dewatering mainstem of tribs, i.e. Sulphur Gulch), riparian dynamics, eagles ospreys, neo-tropical, channel maintenance (sediment), fish/aquatic life needs					WFET results indicate low flow ecology risk for trout and warm water fish in this area and high flow ecology risk for cottonwood metrics.	Yes			X	For trout and warm water fish, if reach not protected, identify mechanisms to protect reach. Flows for lessening cottonwood flow ecology risk would preclude flow being part of the solution.	Cottonwood - >200,000 AF - May to July increase 1 in 3 years (~15% increase over current flows)
63	Lower Colorado	Roan Plateau Tributaries above Grand Valley into Colorado mainstem	Entire Roan Plateau subbasin, Roan Creek and tributaries, also Parachute Creek and its tributaries	x	x	x			Riparian habitat	Non-listed warmwater fish, cutthroat trout basin-wide (see mapped coverages), flow needs, life history/movements, headwaters to state line, fish/aquatic life needs, channel maintenance (sediment)					WFET results indicate trout and warm water flow ecology risk at higher levels and cottonwood flow ecology risk at low levels	Yes	X	X		For trout and cottonwood, if reach not protected, identify mechanisms to protect reach. For trout and warm water fish magnitude of flows not likely to preclude solution.	2500-5000 AF in late season or during low flow period on annual basis.
64	Lower Colorado	Colorado River	North of Grand Valley		x	x			Riparian habitat	Upper Colorado Fish Recovery Program, fish/aquatic life needs		Flow needs, life histories/movements, headwaters to state line			WFET used flow recovery targets as metric	Recovery Program Addressing				Recovery Program Addressing	Recovery Program Addressing
40	Roaring Fork	Roaring Fork	Roaring Fork between Aspen and Carbondale	x	x	x	x	x	Recreational boating, fishing, rare riparian forest communities, aesthetics, groundwater recharge and floodplain maintenance and native contiguous riparian vegetation including silver buffaloberry and willow hawthorne, CNHP PCA, SHI CAC	Reduced summer base flow, potential water quality impacts during low flow periods due to effluent discharges and SW runoff. Recreational boating, fishing, rare riparian forest communities, aesthetics, groundwater recharge and floodplain maintenance and native contiguous riparian vegetation including silver buffaloberry and willow hawthorne, CNHP PCA, SHI CAC	Pursue dry-year lease options, institute water use efficiencies		F	Irrigation, municipal, individual and community water systems		Yes		X	X		

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COMMENT/MAP ID	Sub-basin	Stream Name	Location	Geomorphic Functions	Aquatic Ecological Functions	Riparian/Wetland Ecological Function	Water Quality	Recreational Boating	Resource Values at Risk	Issues	Actions/Solutions	Data Gaps	Data Sources	Current Consumptive Water Uses	Does information from WFET confirm focus mapping results or provide additional information to original focus mapping work?	Is segment at risk because of flow (if yes, what attributes?)	Trout	Warm Water Fish	Cottonwood	Can flow reduce risk? (if no, additional information/monitoring will likely be needed)	Quantity of Water to Make Risk Status Minimal
**65	Any streams that showed state threatened/endangered species that wasn't covered under other comments																				
	Data Sources:																				
	A	Eagle County Recreation Enhancement Plan 2006																			
	B	Eagle County Watershed Plan 1996																			
	C	Eagle River Inventory and Assessment 2004																			
	D	Gore Creek Water Quality (USGS, Kirby Winn)																			
	E	Grand County Stream Management Plan 2008																			
	F	Roaring Fork Measures of Conservation Success, TNC, in press; Roaring Fork Conservancy's Stream Flow Survey Project, 2006; State of the Watershed Report, (In progress); Colorado Natural Heritage Program (CNHP) Roaring Fork																			
		Biological Inventory, 1999; Roaring Fork Watershed Water Quality Report, 2006; Stream Health Initiative (SHI), Catalog of stream and riparian habitat quality for the Roaring Fork River and tributaries, Central Colorado, 2007																			
	G	Roaring Fork Multi-Objective Planning Study (1999)																			
	H	TMDL 2007																			
	1Roaring Fork percentages based on comparison of pre-developed and developed medians using the Upper Colorado River Basin Water Resource Planning Model dataset (2007) developed by the CWCB and CDWR under the Colorado																			
	Decision Support System (CDSS). Only reported percentage change >20%. Also have data comparing min and max flows and flood frequency, duration and magnitude																			
	2 CNHP PCA: Colorado Natural Heritage Program Potential Conservation Area; SHI CAC: Stream Health Initiative Conservation Area of Concern																			

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Section 5
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