
DRAFT REPORT
GRAND COUNTY STREAM MANAGEMENT PLAN
PHASE 2
ENVIRONMENTAL AND WATER USERS FLOW RECOMMENDATIONS
GRAND COUNTY, COLORADO

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List of Acronyms

Acronym or abbreviation	Full Phrase
BLM	Bureau of Land Management
CDSS	Colorado's Decision Support System
CDPHE	Colorado Department of Public Health and the Environment
CDOW	Colorado Department of Natural Resources, Division of Wildlife
CNHP	Colorado Natural Heritage Program
CWCB	Colorado Water Conservation Board
DWB	Denver Water Board
Forest Service	United States Department of Agriculture, National Forest Service
GCWIN	Grand County Water Information Network
HRC	Hydrosphere Resource Consultants
IHA	Indicators of Hydrologic Alteration
ISF	Instream Flow
NCWCD	Northern Colorado Water Conservancy District
ORV	Outstanding Remarkable Value
PHABSIM	Physical Habitat Simulation
RVA	Range of Variability Analysis
TAM	Triactinomyxon (trout-infecting spore)
TU	Trout Unlimited
UPCO	Upper Colorado River Basin Study
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WQCC	Water Quality Control Commission
WUA	Weighted Usable Area

EXECUTIVE SUMMARY

Introduction

This report presents the analyses and recommendations of preferred flow regimes for streams and rivers in Grand County, Colorado, to support stream health for aquatic habitat and other non-consumptive water use. This effort is one of several phases of work required to develop a Stream Management Plan (SMP) for Grand County. Phase 1 of the SMP was completed in spring of 2007 and included inventory and review of existing pertinent data and information for streams within the County. This report, representing Phase 2, presents scientifically-based recommendations of environmental stream flow, and investigatory results of flows to support non-consumptive water uses. The flows recommended herein represent estimates that optimize conditions for a given reach and specific use. Ultimately the goal of this and subsequent phases is to develop and implement a Stream Management Plan that is protective of aquatic habitat and other non-consumptive water use, while retaining flexibility for current and future water provider operations. **It is recognized that not all recommended flows for all uses on all reaches can be achieved at all times.** Instead, these flows represent targets and a beginning for Phase 3 of the Stream Management Plan. Phase 3 will generally include the prioritization of reaches, identification of opportunities to improve existing and future flow conditions, and flow regime analyses for the development of final flow recommendations for implementation in the Stream Management Plan. This will require analyses and input from all stakeholders and will most likely be achieved through a variety of tools including stakeholder coordination of diversions and reservoir releases to achieve recommended flows and/or restoration projects that would reconfigure the channel plan-form consistent with prevailing stream flow conditions.

Two general flow conditions are being considered for this Phase of the Stream Management Plan: **environmental** flows to address aquatic issues and the physical habitat requirements of fisheries, and flow conditions for **water users**. Considered together, environmental flow and flow conditions for water users comprise the recommended, **preferred flow regime**. Within the context of this study, the term **environmental** flow regime refers to those flows that are determined to best maintain the ecological needs of the stream in relation to its fisheries. Included in these regimes are timing, frequency and quantity of stream flows. Flow regimes investigated for support of **water users** include flow requirements for irrigators, municipalities and industry, and recreation use. Other physically based parameters, or indicators of stream health, that could affect flow recommendations will be considered in subsequent analyses including **biologic** and fluvial-**geomorphic** flow-related issues.

The study area generally covers 80 miles of river in the Upper Colorado River basin, spanning the majority of the County from Winter Park to the Grand-Eagle County Line. See the **Site Location Map, Figure ES-1**. This study focuses on the Colorado and Fraser Rivers, and seven tributaries. These tributaries include Williams Fork, Blue River, Muddy Creek, and Willow Creek along the Colorado River and Vasquez, Saint Louis and Ranch Creeks along the Fraser River. The study area is divided into 27 reaches as depicted on the **Vicinity Map** appended in the plan pocket. Each reach is presented in detail in the **Reach Summaries**. Methodologies and backup data are included in the appendices.

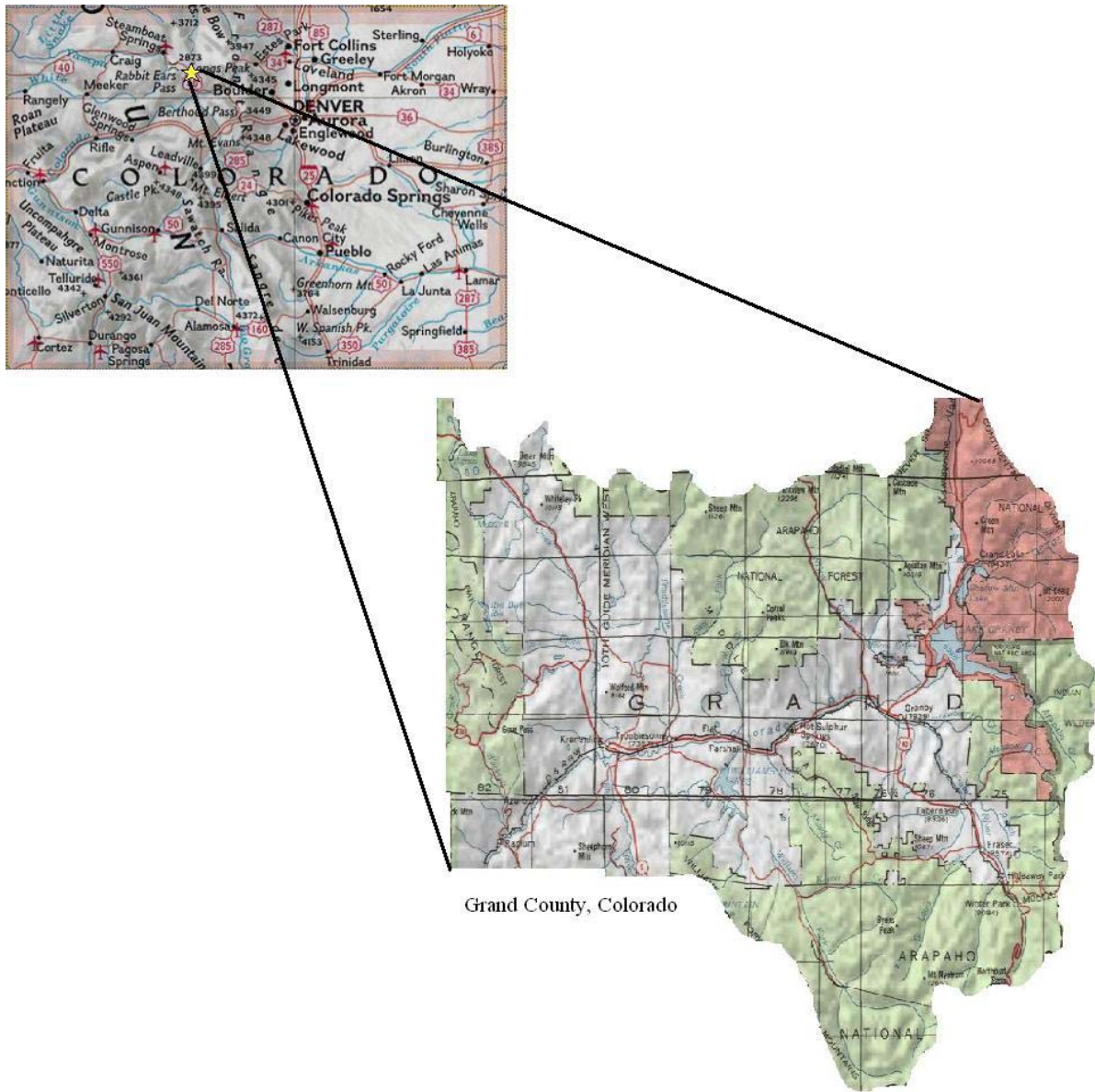


Figure ES-1. Site Location Map

Parameters and Study Objectives

Objectives

In terms of environmental flows, the primary objectives are to 1) acquire, analyze, and evaluate hydrologic data describing streamflow regimes of the study reaches; 2) acquire, analyze, and evaluate channel morphology, hydraulic geometry, and aquatic habitat information for the project reaches to describe habitat-flow relations for target fish species and life stages; 3) based upon our findings under Objectives 1 and 2, recommend a flow regime for the project reach that will likely protect critical environmental values; and 4) recommend additional studies under Phase 3 to strengthen the scientific basis for the environmental flow regime and, as needed, modify the recommendations to reflect new findings. Recommendations for environmental flows also include review of existing temperature and water quality data relative to current standards and biological limitations for the fish species of concern. In addition to determining environmental flows, flow conditions for other water users are considered and, in some cases, may govern, depending on management priorities for a given reach. Water users include irrigators, municipalities and industries, and recreational users.

Environmental Flows

Within the context of this study, the term **environmental** flow regime refers to those flows that are determined to best maintain the ecological needs of the stream in relation to its fisheries. The relationships between available trout habitat and stream flow are investigated using PHABSIM (Bovee 1997; USGS 2001) during the 2007 field season in 11 of the 27 Grand County stream reaches. The 11 reaches are selected for study based upon several guidelines, including stream flow magnitude, history of hydrologic alteration, location within the County's river drainage network, relative importance for recreational and other water uses, and in most cases, the lack of previous detailed instream flow studies. Four PHABSIM sites are located on the Fraser River and its tributaries, four on the mainstem Colorado River, and one site each on the Blue River, Williams Fork, and Muddy Creek. Detailed methods are provided in **Appendix A, Environmental Flows, Methods for Determination**.

The flow-habitat relations developed for each study site, target species (primarily brown and rainbow trout), and life stage (adult, juvenile, spawning, incubation, winter survival) are inspected to determine the recommended environmental flow ranges for two seasons of the year. Summer (April 1 to September 30) flow ranges are based primarily on the availability of adult habitat, while winter (October 1 to March 31) flows are based primarily on spawning/incubation habitat availability. The recommended environmental flow ranges, also referred to as the "preferred" flow ranges, are bounded on the upper end by the optimum flow (i.e. that flow which provides the maximum habitat for the target species and life stage) and on the lower end by the critical flow (i.e. that flow below which habitat is lost at the greatest rate).

PHABSIM, or similar, instream flow studies had previously been conducted by other investigators in five of the 27 Grand County reaches. These studies are reviewed and, where appropriate, the results used to develop environmental flow ranges. CWCBC instream flows have been established within 22 of the 27 Grand County reaches, while other instream flow requirements have been set or recommended within 11 of the reaches by the Forest Service or other agencies. Where suitable stream channel cross-section information is available, CWCBC flows are evaluated using the wetted perimeter-inflection point approach.

Flushing flow recommendations are developed where survey data is available in 14 of the 27 Grand County stream reaches. The magnitude of each flushing flow is based upon bedload transport modeling to identify the threshold flow at which spawning gravel mobilization is initiated. Flushing frequency and duration are based primarily upon a hydrologic events approach (Reiser et al 1990).

Analysis of Grand County stream flow records is primarily accomplished using the IHA approach as described in Appendix A. IHA analysis is conducted on 19 USGS and NCWCD gage records from 16 of the 27 stream reaches investigated. Of these 19, 10 stations have sufficient period-of-record to allow at

least limited temporal comparisons (i.e. historic vs. recent) of flow alteration to be made, while at the remaining nine stations, IHA is used solely to describe the hydrologic regime. Unfortunately, many of these 10 stations are not useful for quantitatively describing the hydrologic alteration which has occurred in Grand County since the first half of the 20th century. Reasons for this include 1) discontinuous years of gage operation, 2) conversion to seasonal-only operation, 3) missing data within years, and 4) inadequate period of operation either prior to or after major water development activities occurred. Of the 10 stations, only one (USGS Gage 09024000, Fraser River at Winter Park, CO) had sufficient period-of-record to allow valid (i.e. at least 20 years of complete record for each time period considered) comparisons of stream flow before and after transbasin diversions (pre and post 1936). For this station, the IHA's Range of Variability (RVA) analysis is also conducted to better describe the magnitude of hydrologic alteration which has occurred. This level of analysis is also possible for USGS Gage 09058000 (Colorado River at Kremmling, CO) to compare pre- and post-transbasin conditions (1962 - 1984 and 1985 - 2007), as well as the Green Mountain Reservoir operations change in the mid-1980's. Other hydrologic analyses included the development of daily stream flow exceedance plots and flood frequency analysis, as described in Appendix A and presented in the Reach Summaries.

Temperature

For the purposes of this study, the following guidelines are used to review temperature data for indications of elevated water temperatures: a chronic temperature of 18.2 ° C with a maximum, acute tolerance of 25 ° C along the Colorado River and along the Fraser River from the Town of Fraser to its confluence with the Colorado River; and a chronic temperature of 17 ° C with a maximum, acute tolerance of 20 ° C along the Fraser River above the Town of Fraser and all tributaries included in this study. The 2-hour and 7-day rolling temperatures are calculated to represent chronic and acute temperatures respectively. These guidelines combine considerations of the interim State temperature standards with recommendations of the U. S. Fish and Wildlife Service (USFWS).

Continuous temperature data for 2006 and/or 2007 is available at 16 locations throughout the 27 reaches of the study area for 2006 and/or 2007. Other data available for review include instantaneous readings, taken at a variety of locations. Detailed data sources and information are presented in **Appendix B, Temperature Data Review.**

Water Quality

For the purpose of this study, 14 constituents are identified as being important indicators of the health of stream habitat. These constituents include sediment, nutrients, metals, inorganic and organic parameters. In addition, algae conditions are briefly reviewed and included as appropriate.

Nonpoint source water quality issues in the study area include increased sediment and nutrient loads from urban land uses, agriculture, winter road maintenance and recreational activities. The major point source discharges in the study area include municipal or domestic wastewater treatment plants. Point source problems were extensively evaluated by the Colorado Department of Health in 1974 as part of the Colorado River Basin 303(e) Plan. This basin plan was developed and adopted to address point source problems. Since the adoption of the basin plan, the development of wastewater treatment facilities has generally proceeded in accordance with its recommendations. Most of the wastewater treatment and improvements to point source discharges occurred in the mid 1990s (NWCCG 2002). Thus, review of water quality data focuses on data collected over the last 10 to 15 years so as to best represent current conditions. A summary of the constituents, guidelines for review, and a synopsis of the results for each parameter are presented in the following Reach Summaries section of this report as well as **Appendix C, Water Quality and Algae Data Review.**

Water Users

Irrigators and Municipalities and Industry: Stream flow management for water users focus on two issues. The first is physical limitations associated with stream flow that may impact the ability of a water user to

retrieve or utilize water. The second issue is the water user's impact on flows in the stream relative to maintaining recommended flows.

Within the study reach there are hundreds of diversions. These diversions are identified so that in the future, as flow recommendations are considered, in Phase 3, there is a basis for accounting for flow reductions from diversions. A summary table and line diagram of major water diversions within Grand County is included in **Appendix D, Water Users and Recreation**.

Recreational Flows: In order to gain an understanding of recreational use within the study area, and the preferred flows for each use, rafting, kayaking, and angling commercial outfitters were contacted for their opinions. The information from this research was combined with the results of the UPCO report and is summarized in the Reach Summaries and presented in detail in Appendix D.

Water Supply

Current and future water demands, specifically municipal and domestic water supplies, are reported in the Upper Colorado River Basin Study (UPCO) (HRC 2003a). The UPCO report concludes that many of the stream reaches within the study area are experiencing occasional water shortages under current conditions and will experience water shortages on an increasingly frequent basis, based on the assumed future conditions. The UPCO report defines current conditions as those present in the year 2000, and future conditions as those assumed in the year 2030 for Denver Water with full build-out for Grand County. The purpose of including this information is to help prioritize reaches for implementing strategies. In particular, those reaches that are experiencing depleted environmental flows may be given a higher priority if they are also experiencing water supply shortages under current and/or future conditions.

Key Findings

Specific flow recommendations are presented in the Reach Summaries and summarized in **Table ES-1**. The environmental flow ranges recommended under Phase 2 are based primarily on the optimization and maintenance of trout habitat. Water user flow recommendations are based on optimal conditions for preferred uses. **Water availability** to achieve these flows will be critically examined under Phase 3 using habitat-flow time-series analysis and consideration of various alternative water operations strategies. Current and historic flows are often influenced by water operations which may or may not be reflective of what can be achieved under future operational scenarios. Thus, to examine the availability of current or historic flows to meet proposed flow recommendations may be misleading in terms of what could potentially be achieved. For reference, exceedance hydrographs depicting available gage information (and gaged flows present to date) is presented in the Reach Summaries with a graphical depiction of the recommended flows superimposed. Here again the reader should keep in mind when reviewing these plots that the hydrographs do not necessarily reflect flows that might be achieved through coordinated operations.

Table ES-1 also highlights, in red, those reaches that are considered to be the **highest priority** for consideration in Phase 3. These high priority reaches are selected based on the reaches with the largest disparity between recommended environmental flows and CWCB instream flows and/or flows currently reported by gage information, as shown on the exceedance plots. In addition, consideration is given to fishery potential, possible future development impacts, need for additional instream flow analysis, and location within the Grand County river network. These reaches also tend to coincide with the higher temperature readings based on the 2006 and 2007 continuous data, as well as reaches observed or reported with algae problems. Other reaches may be important but are not mentioned here because these will benefit indirectly if flow regimes can be achieved through management strategies. If management strategies are not successful, these priorities should be reviewed and updated.

Note that the preferred environmental flow regime for most reaches does not typically match or equal the preferred flows for water users. In many cases recreational flows exceed those recommended for environmental flows as well as for diverters. Thus, as part of future efforts for implementing management strategies, identifying **management strategies** for a reach will be necessary. For example, some reaches are highly valued for recreation, and may be managed for recreation even though flows exceed the preferred environmental flows. In other reaches management strategies may focus only on environmental flow regimes. Management strategies will be required for finalization of the Stream Management Plan and should be considered in future efforts with input from all stakeholders. This report does not identify management strategies but instead presents the preferred flow regime for the noted uses.

Finally, while these recommended flows represent **target flows** for use in implementing Phase 3, it is recognized that **flow variability** will occur over a given season. **Thus, summer flows in June may not be exactly the same as summer flows in September.** The specific range of variability is expected to be developed through the time-series analysis proposed for Phase 3.

Key findings of the analyses are presented following **Table ES-1** followed by a general discussion with highlights of the study results. Detailed information is presented in the Reach Summaries which follow, as well as the Appendices.

**TABLE ES-1. GRAND COUNTY STREAM MANAGEMENT PLAN
DRAFT FLOW RECOMMENDATIONS
(high priority reaches shown in red)**

Reach Description ¹			Recommended Environmental Flows ²					CWCB ISF Q, cfs		Other flows Q, cfs			Recommended Recreational Flows ²						
Reach ID	River	Section description	Critical/Min Q,cfs		Optimal Q,cfs		Flushing, cfs	Source	winter ³	summer ³	winter ³	summer ³	source	Kayaking Flows Q, cfs		Rafting Q, cfs		Angling Q, cfs	
			winter ³	summer ³	winter ³	summer ³	Spring runoff (3 days, 1 in 2 yrs)							min	optimal	min	optimal	min	optimal
F1	Fraser River	US 40 to DW Diversion						2.5	6										
F2	Fraser River	DW Diversion to WPWSD intake											4	10	Forest service by-pass				
F3	Fraser River	WPWSD intake to Town of WP					110-175	3.5	8	4	10	Forest service by-pass							
F4	Fraser River	Town of WP to Town of Fraser	10	20	30	30		Chadwick 1985	5	11	4.6	4.6	Brown and Caldwell 2003	250	400-700			60	100 to 200
F5	Fraser River	Town of Fraser to Fraser CWWTP						11	17					250	400 to 700			60	100 to 200
F6	Fraser River	Fraser CWWTP to Ranch Creek	40	40	50	60	250-360	Tt 2007	11	17				250	400 to 700			60	100 to 200
F7	Fraser River	Ranch Creek to mouth of Canyon							11	17				250	400 to 700			60	100 to 200
F8	Fraser River	Canyon	75	75	100	100		Chadwick 1985	19	30				350	400 to 900	500	800 to 1000	60	100 to 200
F9	Fraser River	Canyon to Granby	80	80	100	120	250-460	Tt 2007	19	30								60	100 to 200
F10	Fraser River	Granby to Colorado River at Windy Gap	80	80	100	120	250-460		19	30								60	100 to 200
F-JC	Fraser River Trib	Jim Creek							1.5/1	4			Above diversion						
F-VC	Fraser River Trib	Vasquez Creek between diversions	5	5	8	8	80-110	Tt 2007	3	6	3	8	Forest service by-pass						
F-RC	Fraser River Trib	Vasquez Creek below diversions	4	4	8	10		Chadwick 1985											
F-RC	Fraser River Trib	Ranch Creek							5	8	2	4	Forest service by-pass						
F-StL	Fraser River Trib	St. Louis Creek	5	5	10	10	50-180	Tt 2007	3.5	6	3	10	Forest service by-pass						
F-TC	Fraser River Trib	Tenmile Creek							2	4									
CR-1	Colorado River	North Fork to Shadow Mountain																	
CR2	Colorado River	Shadow Mountain to Granby Reservoirs							25	50									
CR3	Colorado River	Granby Reservoir to Windy Gap	60	100	100	200	200-370	Tt 2007	20	40	35-85 ab WC 42-100 bl WC 20	50-100 ab WC 65-130 bl WC 20-75	USFWS 1951 USFWS 1951 U.S. Dept of Interior 1961						
CR4	Colorado River	Windy Gap to Williams Fork	100	250	300	450	750-1200	Miller and CDOW	90	90 w/450 flush				300	1000 to 1600			60	200 to 300
CR5	Colorado River	Williams Fork to KB Ditch	150	250 to 270	250	500	700-880	Tt 2007; Miller 2007	135	135								60	200 to 300
CR6	Colorado River	KB Ditch to Blue River Confluence	150	250	250	500	700-900	Tt 2007	150	150								60	200 to 300
CR7	Colorado River	Blue River Confluence to pumphouse	400	600	600	1000	1800	Tt 2007						700	1200-1400	800	800-1250	450	1000
CR7	Colorado River	Pumphouse to County line												500	600-1000	700	900-1300	450	1000
WR	Williams Fork	Below reservoir to Colorado River	40	40	100	140	180-360	Tt 2007			75-150 (10/1-11/30) 50-150 (12/1-3/1)	50-150 (4/1-6/30) 50-250 (7/1-9/30)	Chadwick 1997					50	
MC1	Muddy Creek	Inflow to Wolford																	
MC2	Muddy Creek	Wolford to Colorado River	30	60	60	90	400-600	Tt 2007	20 (7/15-4/30)	70 (5/1-5/14) 105 (5/15-6/30) 70 (7/1-7/14)								20	
BR	Blue River	Green Mountain to Colorado River	150	200	200	250	na	Tt 2007	85 (7/16-4/30)	60 (5/1-7/15)				400	600-1000	550	700 to 1400	100	200 to 1200
WC	Willow Creek	Reservoir to Colorado River	7	7	10	10	60-90	Miller 1996			7 or inflow		U.S. Dept of Interior 1961						

NOTES

- (1) High priority reaches shown in red
- (2) Recommended flows may or may not be present, depending on flow operations and natural hydrology of the watershed. Presence of flows, or determination if these flows are achievable will be evaluated in Phase 3.
- (3) Specific dates defining the beginning and end of summer versus winter flows vary depending on the reach location and the source of data and analysis. See the Reach Summaries for specific dates.

Environmental Flows

The recommended environmental flows (Table ES-1) show a logical progression within the Upper Colorado River drainage with generally increasing flows in a downstream direction as contributing area and channel size increase. For the Fraser River, the preferred range for summer flows increases from 20 - 30 cfs in Reach F4, to 80 - 120 cfs at the mouth in Reaches F9 and F10. Above the Fraser River confluence, the preferred summer range for the Colorado River in Reach CR3 is 100 - 200 cfs, while below the confluence in Reach CR4 the range increases to 250 - 450 cfs. As major tributaries (Williams Fork, 40 to 140 cfs; Muddy Creek, 60 - 90 cfs; Blue River, 200 - 250 cfs) enter the Colorado, the preferred summer range increases to 600 - 1000 cfs in CR7, the most downstream reach in Grand County. A similar trend is exhibited by the preferred winter flow ranges. Such a natural progression for environmental flows from the headwaters of the county to the downstream terminus adds a measure of assurance regarding the consistency and reliability of the PHABSIM results.

The preferred summer flow ranges are based consistently on the availability of adult trout habitat throughout the Grand County river system. For all sites and flows considered, adult habitat weighted usable area is less than that available for juvenile trout. Therefore, adult habitat is considered potentially more limiting for the fishery and preferred flows are recommended to reflect this limitation. In general, adult brown trout habitat tended to be more abundant than that for adult rainbow trout and the preferred summer flows tended to agree well with the preferred angling flows.

The preferred winter flow ranges are based primarily upon the availability of trout spawning and incubation habitat. Successful natural reproduction is an indication of a healthy stream environment, reflecting not only supportive flow regimes but also high quality channel boundary and inter-gravel conditions. Brown trout spawn in the fall to early winter period and the eggs incubate in the stream gravels over the winter before hatching in the spring. Rainbow trout may begin spawning in the late winter and continue well into the spring. Thus, it is important the recommended preferred flow ranges are protective of this critical life function and stage from the time the eggs are deposited in the gravels to the time the fry emerge.

Only on the Blue River (Reach BR) are preferred winter flow ranges not based on spawning and incubation habitat. Here, the optimum spawning flow was surprisingly high, well in excess of the recommended summer flow range. Further investigation into the location of and flow requirements for spawning bars on the Blue River below Green Mountain Reservoir is recommended for Phase 3.

The flushing flows recommended in Table ES-1 range from a low of 50 cfs in St Louis Creek, a tributary of the Fraser River, to 1800 cfs for the Colorado River in Reach CR7. As with the summer and winter preferred flow ranges, the flushing flows progressively increase in a downstream direction with increasing drainage area and channel size. Flushing flow recommendations have not yet been made for the Blue River, pending the anticipated additional investigation into spawning habitat discussed above. Further, the recommended flushing flows are based on the output of hydraulic and sediment transport models and are not yet supported by empirical evidence of gravel mobilization. Further field investigation may be warranted in future phases of this work.

Streamflow regimes within Grand County are dramatically altered by water development. IHA results comparing 1911 - 1935 (pre-transbasin) with 1936 - 2007 (post-transbasin) for the Fraser River at Winter Park indicate that of the 33 hydrologic parameters evaluated, 18 were highly altered, 11 were moderately altered, and only 4 had low alteration (see Reach F3 Summary for results). Median monthly stream flows from May through November have been highly altered, with the range of monthly values reduced from 14 - 195 cfs prior to 1936 to 5.1 - 37 cfs in the post-Denver Water period. Likewise, the 1-, 3-, 7-, 30- and 90- day minimum and maximum flows have been dramatically reduced. For example, the median 3-day minimum has declined from 6 to 3.5 cfs, while the median 3-day maximum has been reduced from 273 to

145 cfs. Median flow rise and fall rates also declined substantially. Since 1971, stream flow has improved modestly on the Fraser when compared to the 1936 - 1970 period, although the regime is still substantially altered from the pre-development period.

Sufficient stream flow records are not available for the Colorado River to compare historic, pre-development conditions with more recent periods, as was done for the Fraser River.

Temperature

Overall, the temperature data indicate that temperatures are likely supportive of a cold-water fishery in the study reaches and will not result in flow requirements that exceed the values recommended for environmental flow conditions. Generally most sites have 7-day rolling average temperature below established guidelines although exceedances of the 2-hour rolling average temperatures are common in mid-July to early August along the lower reaches of the Fraser and the Colorado River between Windy Gap and Gore Canyon. As water temperatures begin to exceed these optimum ranges for trout, fish activity levels decline, stress levels increase, growth is curtailed, and mortality rates may increase dramatically, especially along popular fishing area where fish can be repeatedly stressed by angler capture and handling. Specific key findings from review of the data are summarized below.

1. Continuous data is available for 2007 at F3, F5, F6, F7, F9 and F10 of the Fraser River. The water temperatures reflected by this data are likely supportive of a cold-water fishery. The warmest months are July and August with F9 and F10 being the warmest reaches. F3 data indicates this reach is the coolest with temperatures well below 17° C. The 7-day rolling average temperatures at reaches F5, F6, F7, F9 and F10 never exceed 18.2° C in 2007. However, the 2-hour rolling average frequently exceeds 18.2° C and even 20° C during July and August with large diurnal fluctuations. Temperatures in the Fraser River tend to parallel temperatures above and below Windy Gap with little change from the Colorado River.
2. Along the Colorado River, continuous temperature information is available at 10 sites, representing 5 of the reaches. This includes CR3, CR4, CR5, CR6, and CR7. The following trends are noted:
 - i. CR3: Releases from Granby and Willow Creek Reservoirs may be keeping CR3 water temperatures relatively low and, based up on 2007 records, are supportive of a cold-water fishery.
 - ii. C4 at Windy Gap: The Colorado River above Windy Gap exceeded 18.2° C nine times between July 1 and August 9, 2007. The Colorado River below Windy Gap exceeded 18.2° C every day between July 29 and August 27, 2006. In addition during this time, the 7-day rolling average exceeded 18.2° C for four consecutive days in mid-August 2006.
 - iii. CR4: The Lone Buck gage in CR-4, just downstream of Byers Canyon near the CDOW office, is one of the warmer stations in the County, a condition which could be exacerbated by a thermal hot-spring discharge at the hot spring pools in Hot Sulphur Springs. See Reach Summaries for further discussion.
 - iv. CR5: 2007 data suggest that temperatures are likely supportive of a cold-water fishery, although on most days from mid-July to early August, the 2-hour rolling average temperatures exceeded 18.2° C. However, as with reaches along the Fraser, the 7-day rolling average temperature rarely exceeds 18.2° C. This reach of the Colorado is within the designated Gold Medal fishery and is a very popular

area for angling. Thus, repeated acute temperature exceedances in combination with the popularity of angling indicate the potential for higher than usual fish mortality rates.

- v. Temperatures measured in CR7 are comparatively cool relative to the temperatures upstream on CR6. This is most likely due to the reach being below the confluences of both the Blue River and Muddy Creek. Temperature readings in 2006 and 2007 show temperatures in the Colorado River cooling off by 1 to 3 degrees downstream of the confluence with the Blue River, based on time of year and amount of flow in the Blue. Seven-day rolling averages in 2006 for the Colorado River in CR7 never exceeded 18.2 °C. In 2007, the 7-day rolling average exceeded 18.2° C standard from July 26-August 8. Available instantaneous data shows temperatures at the Kremmling gage exceeding 18.2° C occasionally over the past 40 years.
3. Tributaries downstream of reservoirs including the Blue River, Willow Creek, Williams Fork and Muddy Creek, all have temperatures that are likely supportive of a cold-water fishery. Further monitoring is recommended to determine the effects on water temperature from reservoir flow releases.
4. CR4, being one of the warmer reaches, based on the available data, is recommended to consider for restoration opportunities to help in combating higher water temperatures, and low flows, especially at the sections noted by CDOW that appear excessively wide and shallow, including immediately upstream of Pioneer Park and downstream of the Breeze Unit (Jon Ewert, 2008). See the Reach Summaries for further discussion.

Restoration opportunities, as well as flow operations management for temperatures, would be best achieved with an improved understanding of air, water and flow temperature interface, as well as the temporal temperature relationships at specific sites. This could be achieved with a strategic system of monitoring sites measuring continuous air temperature, water temperatures and streamflows. Over future years of monitoring it will be important to connect flow temperatures with reservoir releases to track the effects. At a minimum the Colorado and Fraser Rivers from Granby to Kremmling should be monitored, as these reaches appear to be the warmest. Gages above and below key confluences are important including the Colorado and Fraser, Williams Fork and Blue River.

GCWIN is currently organizing water quality and temperature monitoring, informational, and educational programs in Grand County. All entities currently monitoring water in Grand County are being asked to participate in this newly formed organization. The Northern Water Conservation District has also initiated a relatively detailed water quality and temperature monitoring program, concentrated in and around Windy Gap. Together, these two monitoring networks may provide additional input and data to help with management-related decisions for controlling water temperatures.

Water Quality

Review of water quality data indicate that most constituents are generally within established guidelines levels. Phosphorous levels in and of themselves are not exceeding the guidelines, but are slightly elevated, which, in combination with high water temperatures, may be contributing to or exacerbating algae blooms.

Several steps may be taken to reduce algae growth in the study area. These steps may include increasing volumetric flow quantities to dilute phosphorous concentrations and increase higher velocities; and releasing water from the base of reservoirs where water is colder to lower stream temperatures. However,

developing specific stream management strategies for combating algae growth would be best achieved with an improved understanding of temperatures, particularly air-water temperature interface, and flow-temperature relationships at specific sites. This could be achieved with a strategic system of monitoring sites measuring air temperature, water temperatures and stream flows, as discussed under the previous *Temperatures* section of this report. In addition, water quality monitoring for phosphorus and other nutrients are recommended to provide improved insight along the reaches that depicted some previous exceedances of nutrients, particularly along CR 3, CR 4 and F10. Water quality monitoring, by the County (in addition to the Railroad monitoring) is also recommended downstream of the Moffat Tunnel discharge point to establish base line information and to track the impacts of reduced flows on dilution of constituents.

Water Users

Flow recommendations for water users tend to be highly variable, depending on use. Recreational flows, which tend to be the highest of the flow recommendations are subjective based on user opinion. Key findings are presented below.

Irrigators, Municipalities and Industry: In general, most users are experiencing some difficulty in retrieving or using water, especially during the recent drought. Many irrigators are constructing make-shift cobble dams to divert flows. Pumping for irrigation is also limited by the available supply as well as by nuisance clogging from algae growth. Some irrigators must clean the algae daily and in some cases up to three times per day (Thompson 2007).

Wastewater treatment plants discharge permits are based on certain minimum instream flows for determining water quality and quantity of the wastewater that can be discharged to the stream (HRC 2003a). In general the minimum flows identified for both current and future conditions for wastewater discharging are less than those recommended for environmental flows. The UPCO report indicates that sufficient flows exist for proper dilution in the Colorado River under both current and future flow conditions (HRC 2003a). However, for the Fraser River, the UPCO report states that existing conditions are occasionally below minimum flow levels but under future conditions flows are predicted to 'often' below the minimum flow levels. Current conditions are defined in the UPCO report as conditions in the year 2000. Future conditions are based on build-out for Grand County and the year 2030 for Denver Water. Site specific water user-related issues are presented in the Reach Summaries section of this report.

Recreational Flows: Reaches identified as important and/or popular for floatboating and angling are identified and associated with minimum to preferred flow ranges. These flows are presented in Table ES-1 and discussed in the Reach Summaries. An overview of recreational use for the Colorado and Fraser Rivers are presented below.

Fraser River: In terms of floatboating, the Fraser River is a relatively small river, with adequate flows limited to the spring snowmelt runoff. Below Winter Park the Fraser traverses many private properties. Anglers will fish all along the Fraser River, particularly on public lands as well the privately developed Granby Ranch.

Colorado River: The Upper Colorado, from Kremmling to the Grand-Eagle county line, has some of the most spectacular, high-quality floatboating in the west. Immediately below Kremmling, the Big Gore Canyon offers an extremely challenging class V boating experience. Downstream of the Big Gore are the Pumphouse and Radium runs with popular class III rapids that support a thriving commercial rafting industry. Byers Canyon, near Hot Sulphur Springs, is also a popular kayaking run; however the flows are often too low, and the run very short, for a high quality boating experience.

The Colorado River from the confluence of the Fraser to Troublesome Creek is a designated Gold Medal fishery by the Colorado Wildlife Commission and is known as an outstanding section for wading-anglers with excellent accessibility via public access points along Highway 40. Downstream of Pumphouse is also a very popular reach to fish with many anglers fishing from river dories and rafts, especially with the commercial guides. Here again access is excellent due to abundance of public property.

Other Considerations

Within Grand County there are several other State and Federal programs currently in progress. This includes Wild and Scenic Suitability analysis, Colorado Natural Heritage Program and CDOW Colorado Cutthroat conservation strategy program. The impacts of these programs on the Stream Management Plan are yet unknown; however, it may be that future study efforts, management strategies and/or prioritizations of reaches will consider these program recommendations. These programs are discussed below.

Wild and Scenic Rivers: In March 2007 the U.S. Department of Interior, Bureau of Land Management (BLM) completed the Final Wild and Scenic River Eligibility Report for the Kremmling and Glenwood Springs Field Offices, as part of the resource management plan revision process. Portions of the Blue River, Colorado River and Muddy Creek, within the study area have been identified as eligible for inclusion in the suitability analysis, which is currently being implemented. The reaches determined to be eligible for suitability analysis are described in the Reach Summaries including their preliminary classification.

Colorado Natural Heritage Program: In 2005 Grand County contracted with Colorado State University and the Colorado Natural Heritage Program (CNHP 2006) to survey for critical biological resources in Grand County. The goal of the project was to systematically identify the locations of rare species, significant natural plant communities and the habitat along with potential conservation areas. The results of this study included identification of Potential Conservation Areas by Biodiversity Significance Rank (CNHP 2006). Those areas that occur with the study reach of the Stream Management Plan are identified and discussed in the Reach Summaries. The identification of these sites is important in terms of protecting flows that support the unique and significant resources. In addition, these sites will become important when considering restoration opportunities.

Colorado River Cutthroat Recovery: The Colorado River cutthroat trout (CRCT) now inhabits only a few upper reaches of the Colorado River system. Native cutthroat trout require clear and cold water, naturally-fluctuating stream flows, low levels of sediment, well-distributed pools, stable streambanks, and abundant stream cover. Widespread introductions of non-native salmonids over the last century have served to limit current distributions of CRCT to isolated headwater streams and lakes. The CRCT is down to about 6% of its historic habitat within the upper Colorado River drainage. CDOW has developed a CRCT conservation strategy to assure the long-term viability of CRCT throughout their historic range (CRCT 2006). In short, aquatic habitats that currently support populations of CRCT will be maintained and additional suitable habitat areas will be managed to increase CRCT populations. In addition, new populations will be established where ecologically and economically feasible. Several tributaries within the study area are included in the CDOW conservation strategy and are noted in the Reach Summaries.

Next Steps, Phase 3

In general, the preferred approach to improving flow conditions and development of the Stream Management Plan is to target recommended preferred flows through coordination of diversions and reservoir releases, as opposed to restoration approaches. Achieving the preferred flow regimes through coordinated operations should produce flow regimes that are representative of a more natural condition, optimizing the health of the stream system in a cost effective manner, when compared to restoration. Not only is restoration expensive, but often a reconfigured stream planform poses challenges when designed for highly altered low flow conditions, while at the same time providing capacity for infrequent and more severe flood conditions. Coordination of diversions and reservoir releases will require the engagement of the water users within the watershed to work together to formulate and coordinate releases and will require expanded hydrologic modeling of the alternatives to ensure the alternatives meet water requirements.

In reaches where flow regimes can not be achieved, or there are other factors involved such as isolated problematic sub-reaches, restoration might be considered to adjust the channel planform to the altered flows. Some reaches may benefit from restoration even under improved flow conditions such as the two segments of the Colorado River noted within C4 and C5.

Tasks recommended for Phase 3 include additional study and analysis for environmental flows, development of management strategies for implementing flow recommendations through coordinated flow operations, and conduct of stream assessments for analysis of restoration opportunities.

Detailed recommendations are presented below.

1. Identify priorities for managing reaches, both in terms of uses and those reaches considered impaired under current conditions.
2. Work in collaboration with water development and management interests to perform time series analysis integrating PHABSIM habitat-flow relations with projected streamflow regimes to evaluate long-term effects of current and future water management actions on stream health and identify alternative river operation strategies which may mutually benefit all parties.
3. Assess trade-offs between physical habitat restoration and enhancement of instream flows for improving stream health using existing habitat-flow relations and PHABSIM sites to the extent possible.
4. Develop environmental flow recommendations for those reaches not studied in Phase 2. As a minimum, Phase 3 should include Ranch Creek, Troublesome Creek, Reeder Creek, and the upper reach of the Fraser River, F3. Analyses should include review of water quality and temperature data.
5. Conduct trout spawning surveys (i.e. redd surveys) in the lower Blue River during both spring and fall to identify important spawning bars for both rainbow and brown trout. Include a small-scale PHABSIM study at one such bar to develop winter environmental and flushing flow recommendations.
6. Conduct riffle stability evaluations along likely spawning bars in the vicinity of each PHABSIM site following the spring runoff season to gain better insight into the effectiveness of flushing flows to mobilize river substrates.

7. Conduct a survey to identify and evaluate potential fish passage barriers for possible future remediation. Conduct survey of headgates to identify and evaluate the potential for headgate improvements to improve diversion efficiency.
8. Assist in development of a monitoring network with GCWIN and Northern for collection of water quality, water temperature, air temperature and flows. Note that for the 2008 season monitoring should be in place by late June to capture the critical summer flow conditions. Assist in developing monitoring network with GCWIN and/or USGS and Northern for winter flows.
9. Conduct qualitative geomorphic and biological assessment, based on visual observations, to evaluate the general, existing morphological conditions of the project study reach. The assessment will provide a general description of the current stream condition as well as identification of stressors or natural factors that may have resulted in conditions that are considered to be degraded. Integrate the stream assessment findings with environmental flow recommendations and identify reaches that appear stressed under existing conditions, and could be stressed under future altered conditions. This information will also aid in supporting the decision process on coordinated flow releases, and in particular, compromises that may be required.
10. Identify opportunities and suitability of reaches, on a conceptual basis, for physical restoration such as headgate improvements or channel planform reconfiguration.
11. Work with CDOW on coordinated efforts in conjunction with the Colorado Cutthroat program.
12. Continue to follow research on algae, solicit input irrigators and discuss options for improving pump intakes.

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