RESTORATION OPPORTUNITIES

This appendix presents the initial framework for developing a restoration plan for the reaches studied in the SMP. This is the initial framework and additional design will be required as well as extensive stakeholder coordination for implementation. The primary objective here is to enhance and maintain the aquatic habitat within the study area. To begin the process, the key issues within each reach are identified as well as corresponding restoration opportunities to address these issues. Key issues identified throughout this SMP, and summarized in this appendix, include adequate flows and flow regime for support of stream health and aquatic habitat; adequate flows for local water users including diverters and recreational uses; water temperatures that are supportive of cold water fisheries; water quality; excessive sediment deposition; and the presence of algae

Restoration opportunities addressing these issues fall into one of two categories, flow enhancements and physical restoration. Flushing flows and ramping rates are also included in restoration opportunities and are presented as variations of flow enhancements. In the following sections both flow enhancements and physical restoration elements are described in a general nature and tied back to the key issue. These elements are applied to the reaches as appropriate, integrating the environmental flow recommendations, stream assessments, temperature and water quality reviews, and considerations for local water users. This forms a matrix of elements, or a restoration framework, on a reach by reach basis. Included in this analysis is a ranking system, developed to prioritize reaches and implementation.

Note that each study reach may also include specific issues and restoration opportunities that are unique to the reach and/or particular uses within the reach which are addressed both here and in the individual reach summaries.

Flow Enhancements

In 2009, Denver Water and NCWCD committed to a Mitigation/Enhancement Proposal consisting of four categories of measures: Stream Flow/Water Supply, Water Quality, Aquatic Habitat and Cooperative Measures. This proposal is shown in Figure F1. Negotiations on the details of this proposal are on-going.

The ‘Stream Flow/Water Supply’ measures (flow enhancements), include five potential sources of water, totaling 11,200 ac-ft which would be delivered through several different systems. In response to the proposal, and as requested by Grand County, Denver Water and NCWCD, Tetra Tech conducted an evaluation to address the question of whether or not the flow enhancements (11,200 ac-ft) would be beneficial to aquatic habitat. Several time series analyses were conducted based upon the PHABSIM flow-habitat relations comparing habitat availability for future flow conditions with and without the flow enhancements. These analyses are described in the following sections, including the data used, assumptions and the specific application of the flow enhancements. It should be noted that there are many other possible scenarios for use of these flows and the analyses conducted represent only several possible solutions. Flow enhancements are also only one component of ‘Restoration Opportunities’ and the final decision of where flow enhancements are applied, versus physical restoration, or a combination of both, will be determined by a stakeholder group.

Denver Water and Municipal Subdistrict, Northern Colorado
Water Conservancy District
Mitigation/Enhancement Proposal
April 2009

STREAM FLOW/WATER SUPPLY

- 2,300 AF – Firm annual water supply for Middle Park Water Conservancy District (MPWCD)
- 1,500 AF –Windy Gap pumping by MPWCD of up to 1,500 AF, providing an average annual supply of 700 AF for MPWCD
- 1,000 AF – Annual bypass of Fraser River Collection System
- 1,000 AF – Annual release from Williams Fork Reservoir resulting from Fraser System bypass
- Cooperate with Grand County on the timing of releases of 5,400 AF of "10825 water" released from Granby Reservoir to maximize benefits to Grand County, within the constraints of the Recovery Program
- **Total = 5,800 AF (11,200 AF including 10825 Water)**

WATER QUALITY

- **$ 6 million** - Improvements to the three largest wastewater treatment facilities in Grand County to reduce discharge of nutrients to Grand County streams and lakes

AQUATIC HABITAT

- **$ 2 million** – Stream channel modifications at selected locations in Grand County to improve and maintain aquatic habitat

COOPERATIVE MEASURES

- Curtail or reduce diversions in August to minimize temperature impacts to aquatic life in streams
- Allow Windy Gap pumping by Grand County for future release from Granby Reservoir
- Implement WGFP "pre-positioning" operations to moderate lake level fluctuations while reserving space in Granby Reservoir for the Municipal Subdistrict and Grand County
- Curtail Windy Gap diversions to enhance rafting and boating flows during the annual Gore Canyon Race weekend
- Implement operational changes for Big Lake Ditch, Vail Ditch, Rich Ditch, and Hammond No. 1 Ditch to enhance stream flows in Grand County
- Modify reductions in bypass flows from the Fraser River Collection System
- Coordinate diversion structure and reservoir bypasses to provide recreational flows in the Fraser and Colorado rivers
- Contribute funds for the development of a viable cutthroat trout fishery in Grand County
- Provide lands for wildlife habitat, open space or public fishing access

Figure F1. Enhancement/Mitigation Proposal prepared by Denver Water and NCWCD

Time Series Analysis - The time series analysis estimates the quantity of water required to meet target flow ranges at certain times and the changes in habitat which result. For this exercise both the Fraser and Colorado River were analyzed with several variations of flow enhancements. The sites and flow enhancement assumptions are described below. Hydrographs were supplied by Denver Water and NCWCD and reflect future conditions with both the Moffat Tunnel and Windy Gap firming projects in-

place. The analysis was conducted for future conditions with and without the flow enhancements for dry, wet and normal years.

Fraser River System

Study results conducted for the SMP on the Fraser River system indicate that in general, the upper Fraser River and Ranch Creek require additional water supply to help meet the recommended target flows under both existing and future conditions. In addition there is evidence of excessive fine sediment deposition and general lack of flow and diversity in velocity/depth regimes. Thus the upper Fraser and Ranch Creek are good candidates for application of flow enhancements. Two examples were evaluated, both being variations of the application of 1000 ac-ft of water proposed under 'Stream Flow/Water Supply' measures, 3rd bullet shown on Figure F1.

Example 1 applies the 1000 ac-ft alternating on a year-by-year basis between the Fraser River and Ranch Creek. The flow enhancements would be added to existing base flows at a rate of 8 cfs for 61 days during the months of August and September. Example 2 assumes 500 ac-ft is applied to both the Fraser River and Ranch Creek at a constant rate of 4 cfs for 61 days during August and September. A third example worthy of future analysis is application of the 1000 ac-ft to flushing flows on an alternating basis, by year, with base flow enhancements.

The time series analysis indicates that application of enhancement flows for all three examples will provide benefits and improvements as compared to future conditions without the enhancement flows. Other key findings are noted below:

- Habitat gains are greatest in dry years
- Based on the percent of habitat gained, improvements are the greatest for adult rainbow trout
- Based on habitat units (HU) gained, improvements are the greatest for juvenile trout in the Fraser and about equal between adults and juveniles in Ranch Creek
- Based on HU's, gains are greater in F6 than in RC2 under Example 1
- From a watershed and physical habitat perspective, Example 1 with all 8 cfs in the Fraser produces the greatest overall habitat unit increases
- Considering other factors such as water temperature, Example 2 with an equitable split between the Fraser and Ranch Creek is likely preferred

Colorado River System

Like the Fraser River, the study results for the Colorado River indicate that in general, the Colorado River from Granby to the confluence with Williams Fork requires additional water supply to help meet the recommended target flows under both existing and future conditions. In addition there is evidence of excessive fine sediment deposition and general lack of flow and diversity in velocity/depth regimes. Thus the Colorado River from Granby to Williams Fork is a good candidate for application of flow enhancements. One example analyzed applies all the stream flow enhancements shown under the 'Stream Flow/Water Supply' measures on Figure F1. A second example worthy of future analysis is the application of Grand County water, pumped and stored in Granby Reservoir, for augmenting flushing flows.

The time series analysis indicates that application of enhancement flows for the one example will provide benefits and improvements as compared to future conditions without the enhancement flows. Other key findings are noted below:

- Flow enhancements can produce improved habitat depending on where and how releases are operated
- Habitat gains are greatest in dry years
- Habitat gains are generally greatest for adult rainbow trout
- Habitat gains generally decline in a downstream direction
- Enhancement water could be used for improving flushing flows
- Enhancement water application could vary by years and streams
- Physical restoration can be a benefit in many reaches especially where target flows still cannot be met with application of enhancement flows

Flushing Flows

Use of flow enhancement water for augmenting flushing flows on either the Colorado or Fraser Rivers, or their tributaries, will require further evaluation and detailed consideration to ensure that it is used effectively (specifically not all used up in a single flush if late summer flows are also needed) and in a manner that does not interfere with existing water rights and water operations throughout the Upper Colorado River basin. In addition, the application of enhanced flushing flows must also consider the capacity of the downstream river reaches, most importantly hydraulic structures such as bridges and culverts, to ensure adequate conveyance of enhanced flows.

Ramping Rates

Field observations of stranded, desiccated trout redds, coupled with records of rapid stream flow changes have been identified by Tetra Tech as a possible issue below several major water storage facilities in Grand County. Stream reaches potentially affected include the Blue River below Green Mountain Reservoir, the William's Fork below William's Fork Reservoir, Muddy Creek below Wolford Mountain Reservoir, and the Colorado River below Granby Reservoir. Such flow fluctuations can adversely influence aquatic life, including fish, and also pose a human safety risk for recreationists and others along the river corridor. Rapidly rising stream flows could potentially re-locate fish and other aquatic life downstream into less favorable habitats, while rapidly declining flows can strand fish and other aquatic life in temporary habitats ultimately leading to desiccation and death (Reiser et al 2008). Also, flow reductions during important life cycle events such as spawning and incubation can lead to drying of developing embryos in redds and immobile fry attempting to emerge from the inter-gravel environment. While the magnitude of this problem in Grand County is not fully determined, desiccated trout redds have been observed on the Blue River through the Blue Valley Ranch and also downstream below the Trough Road. It is possible that this may be occurring in other tailwaters.

Ramping rates should be considered as one tool for restoration in the development of this Stream Management Plan. Three regional approaches that may be applicable have been identified:

1. The Wyoming Game and Fish Department (WGFD) recommends that for tailwater trout fisheries (Annear 2010), rising flow rates should not exceed 30% per 24 hour period, declining flow rates should not exceed 20% per 24 hour period, and during periods of extended flow reductions, observations of fish behavior should be made to assure stranding is not occurring.

2. The Colorado Division of Wildlife suggests (Uppendahl 2010) that if the existing flow is less than 100 cfs, stage change should not be greater than 0.1 ft per hour and if over 100 cfs, not more than 0.2 ft per hour, with the key factor being not to strand fish when ramping down.

3. A third approach, as yet untested, could be based upon the IHA analysis for a gage station located below the reservoir in question using the range of rise and fall rates (cfs/24 hour period) experienced historically by aquatic life within the tailwater. For example, the environmental flow components (EFC) portion of the IHA analysis presents rates, by percentile, for high flow, small

flood and large flood events from which a reach-specific recommendation could be developed. As with approaches 1 and 2, the key factor would be to avoid stranding when ramping down.

At this time, we have no basis for making a firm recommendation regarding ramping rates, but would defer to the guidance provided by CDOW. We suggest this topic be further discussed and evaluated by the stakeholders should additional, more site-specific guidance be required.

Physical Restoration

The 2009 Enhancement/Mitigation Proposal prepared by Denver Water and NCWCD (Figure F1) included one measure for improving aquatic habitat. Specifically Denver Water and NCWCD proposed to contribute funding for stream channel modifications to improve and maintain aquatic habitat. Recommendations included in this SMP for improving aquatic habitat include such things as increasing water depths under low flow conditions; providing habitat features (cover) and channel/flow diversity; restoring and protecting riparian vegetation; enhancing fish passage to increase connectivity within or between reaches; and reducing elevated water temperatures. Restoration elements designed to achieve some of these objectives are presented as follows:

In-stream habitat features - The purpose of in-stream habitat features is to create habitat and flow velocity diversity within a wide, shallow and uniform reach, and to provide pockets of protected areas with shade and deeper pools for relief during the warmer times of day in the summer. In addition these habitat features could potentially improve winter conditions by providing deeper pockets of water that are less likely to freeze.. In-stream features could include one or more of a range of techniques such as installation of large woody material, construction of channel bar enhancements, and placement of boulder structures. Examples of in-stream habitat features are provided in Exhibit F1.

Channel Bank Revegetation - The purpose of channel bank revegetation is to improve habitat, particularly cover and shade, along the channel banks while also providing to some degree, bank and/or toe stabilization. Bank stabilization will not only improve river bank habitat but it will also help in the reduction of erosion and fine sediment loading. Typically bank revegetation would be achieved using a combination of plant material and rock/boulder reinforcing. Lunker structures are another option, applicable for popular fishing areas and perhaps those locations requiring handicap access to fishing platforms. Examples of channel bank revegetation are provided on Exhibit F2.

Enhancement of Fish Passage - The goal with this type of restoration is primarily to reconnect high quality spawning reaches with the mainstem of the Colorado and Fraser Rivers. Existing fish passage barriers observed in the field are generally water diversion structures or dams. Side channels around dams could be designed to mimic small rivers, or could resemble traditional fish passage ladders such as a concrete step structure. Some fish barriers that exist at irrigation headgates are the result of river regrading under low flow conditions to divert sufficient flows into the headgate. In this case it may be possible to improve passage by permanently improving the headgate diversion, thus eliminating the need to regrade the channel bottom. Fish passage impediments were also observed in the field in 2007, 2008 and 2009 in reaches with excessively low flows resulting in wide and shallow conditions that are simply not swimmable by fish, such as CR4 upstream of Hot Sulphur Springs. The design and details required for re-connectivity will be specific to the reach, the fish species and the barrier. Examples of fish passage enhancement are provided in Exhibit F3.

Channel Restoration - Channel restoration is recommended on several reaches and would be a relatively large-scale effort including such things as reconstructing, or reconnecting channel sinuosity; construction of low-flow channels designed to accommodate the altered flow regimes; overbank riparian improvements; and/or bank stabilization. Restoration efforts will require additional study to advance the

overall concepts and planning and will be unique to the specific reach. One example of channel restoration might be construction of a by-pass channel around Windy Gap.

Irrigation Diversion Pump Intakes - Reconstruction of several irrigation diversions intakes may be warranted, particularly in CR6, to improve pumping conditions and reduce algae-related maintenance issues. Further design and study is required for these improvements including the channel morphology and issues related to the low water levels and grade controls recently installed by NCWCD to offset the low flow channel conditions.

Overbank BMPs - Some reaches within the study area are subject to high sediment loads and/or erosive conditions due to land disturbing activities in the overbanks. This includes a wide variety of issues such as winter sand operations along Highway 40, excessive erosion from construction sites, and grazing-related impacts. Site specific recommendations are presented in the reach summaries and include very general recommendations such as: construct a sediment basin, improve and encourage Best Management Practices (BMPs), and develop grazing management guidelines. The Grand County Storm Drainage Design and Technical Criteria Manual currently references the Urban Drainage and Flood Control District, Drainage Criteria Manuals for guidance on BMPs (UDFCD).

Other- Many of the reaches include recommendations that are either reach-specific or variations/combinations of the general elements listed above. Refer to the Reach Summary for further discussions.

Ranking Matrix

A ranking system is presented below. This ranking matrix is developed simply to help prioritize reaches and guide the decision process for initiating restoration efforts and resource allocation. The ranking includes consideration for flows, temperature, water quality, stream assessments, recreational use, and uses related to diversions for agricultural, municipal and industrial uses. Each parameter is assigned of value of -1, 0 or 1 depending on the criteria and the study results. Parameters included in the ranking are described below and summarized in Table F1.

1. Flow criteria: flow evaluation is based on a comparison of the 50% exceedence value of future flow conditions as reported by Denver Water's PACSM model. These are compared with the recommended target flow ranges presented in the reach summaries and described in Appendix A as well as CWCB instream flows and Forest Service by-pass flows.
2. Temperatures and water quality: information is based on available data primarily derived from GCWIN and compared to State standards as described in Appendix B.
3. Stream assessment: assessment rankings are based on results from 2008 and 2009 field work which is described in detail in Appendix A.
4. Recreational use, diverters and municipal and industrial uses: the ranking of water uses is qualitative and generally reflect whether or not there have been reported issues or problems as it relates to flow conditions.

Each reach is evaluated for the criteria outlined above. Elements not evaluated within a particular reach, are assigned a '0' so as to not skew the ranking. Note that the ranking depicts a general trend as there is typically not an absolute 'yes' or 'no' answer . The scores are added and the lowest, or most negative score reflects the reaches that should, if practical, be given the highest priority for restoration and/or flow enhancements.

Table F1. Ranking System

Based on PACSM future conditions and 50% exceedence plots	Typically Not	Yes	Typically Exceeds
Will CWCB instream flows and/or Forest Service by-pass flows be met in the summer?	-1	0	1
Will CWCB instream flows and/or Forest Service by-pass flows be met in the winter?	-1	0	1
Will target flows be met in the summer?	-1	0	1
Will target flows be met in the winter?	-1	0	1
Will flushing flows be met?	-1	0	1
Temperature and Water Quality	Frequently	Some	Rarely
Are there temperature exceedences?	-1	0	1
Is there a reported algae problem?	-1	0	1
Field assessment results:	Poor	Fair	Good
SRI/CSE assessment results:	-1	0	1
	Marginal/ Poor	Suboptimal	Optimal
EPA assessment results:	-1	0	1
Water Users	Frequently	Marginal	Rare
Is recreational use limited due to flow conditions?	-1	0	1
Are there problems or issues with diversions and M&I uses?	-1	0	1

Results indicate that the lowest scoring reaches are CR4, F2, F-RC2, and CR3. Jim Creek also scored very low but is not being considered for restoration at this time. See the Jim Creek reach summary for further discussion. These and other results are presented in Table F2.

Table F2. Ranking Matrix

Reach Description			Based on average daily flows calculated by PACSM will CWCB/FS bypass flows be met?		Based on average daily flows calculated by PACSM will target env flows be met?			Temperature exceedences	Is algae problem (reported or observed)	Pfankuch rating	EPA assessment rating	Recreational use in reach	Water User and Diverter Issues	RANKING
Reach ID	River	Section description	winter [3]	summer [3]	winter [3]	summer [3]	Spring flush (3 days, 1 in 2 yrs)							
F1	Fraser River	US 40 to DW Diversion	0	0	1	1	1	1	1	0	0	0	0	**5**
F2	Fraser River	DW Diversion to WPWSD intake	-1	0	-1	-1	-1	1	1	0	0	0	-1	**-3**
F3	Fraser River	WPWSD intake to Town of WP	-1	0	-1	-1	-1	1	1	0	0	0	0	**-2**
F4	Fraser River	Town of WP to Town of Fraser	0	1	-1	-1	-1	0	0	1	0	-1	0	**-2**
F5	Fraser River	Town of Fraser to Fraser CWWTP	1	1	0	0	0	-1	0	1	0	0	0	**2**
F6	Fraser River	Fraser CWWTP to Ranch Creek	1	1	-1	1	-1	-1	0	1	0	0	-1	**0**
F7	Fraser River	Ranch Creek to mouth of Canyon	1	1	-1	1	0	-1	0	0	0	-1	0	**0**
F8	Fraser River	Canyon	1	1	-1	0	0	-1	0	1	0	-1	0	**0**
F9	Fraser River	Canyon to Granby	1	1	-1	1	1	-1	0	0	0	-1	0	**1**
F10	Fraser River	Granby to Colorado River at Windy Gap	1	1	-1	1	1	-1	-1	1	0	0	0	**2**
F-JC	Fraser River Trib	Jim Creek	-1	-1	-1	-1	-1	0	0	1	0	0	0	**-4**
F-VC	Fraser River Trib	Vasquez Creek between diversions	1	1	0	0	0	1	0	1	0	-1	0	**3**
F-VC	Fraser River Trib	Vasquez Creek below diversions	1	1	-1	1	-1	1	-1	1	0	-1	0	**1**
F-RC1	Fraser River Trib	Ranch Creek to ds of gage	1	1	-1	-1	-1	-1	-1	1	0	0	0	**-2**
F-RC2	Fraser River Trib	Ranch Creek ds of gage to confluence	1	1	1	-1	-1	-1	-1	0	0	-1	0	**-2**
F-StL	Fraser River Trib	St. Louis Creek	1	1	0	1	1	-1	1	1	0	0	0	**5**
F-TC	Fraser River Trib	Tenmile Creek	0	0	0	0	0	0	0	0	0	0	0	**0**
CR-1	Colorado River	North Fork to Shadow Mountain			0	0	0	0	0	0	0	-1	0	**-1**
CR2	Colorado River	Shadow Mountain to Granby Reservoirs	0	0	0	0	0	0	0	0	0	0	0	**0**
CR3	Colorado River	Granby Reservoir to Windy Gap	1	1	-1	-1	0	-1	-1	0	0	-1	0	**-3**
CR4	Colorado River	Windy Gap to Williams Fork	-1	1	-1	-1	-1	-1	-1	0	0	-1	0	**-6**
CR 5	Colorado River	Williams Fork to KB Ditch	1	1	-1	0	0	0	-1	1	0	-1	0	**0**
CR 6	Colorado River	KB Ditch to Blue River Confluence	1	1	0	1	1	-1	-1	0	-1	0	-1	**0**
CR 7	Colorado River	Blue River Confluence to County Line	1	1	-1	-1	1	1	0	0	0	-1	0	**1**
WR	Williams Fork	Below reservoir to Colorado River	1	1	1	1	1	1	1	0	0	0	0	**7**
MC1	Muddy Creek	Inflow to Wolford	1	1	0	0	0	-1	0	0	0	0	0	**1**
MC2	Muddy Creek	Wolford to Colorado River	1	1	0	0	0	-1	-1	0	-1	-1	0	**-2**
BR	Blue River	Green Mountain to Colorado River	1	1	0	0	0	0	0	0	0	-1	0	**1**
WC	Willow Creek	Reservoir to Colorado River	1	1	0	0	0	-1	0	0	-1	0	0	**0**
TR	Trib	Hwy 40 to confluence	1	1	0	0	0	0	0	0	0	0	0	**2**
RE	Trib	Cty Rd 33 to confluence	1	1	0	0	0	0	0	0	0	0	0	**2**

PUTTING IT ALL TOGETHER

Table F3 provides a summary of restoration opportunities including flow enhancements and physical restoration. The table is set up with the highest-to-lowest priority reaches listed from top to bottom. Several of the reaches scored in the 'low' category but, for various reasons, have been moved to lower priorities for consideration at a later time or do not include any recommendations. The reasons for assigning a 'no recommendation' are diverse depending on the reach. See the individual reach summaries for details.

Table F3. Summary of Restoration Opportunities

Reach Description			RANKING	Restoration Opportunities										
Reach ID	River	Section description		Apply enhancement flows to low flows	Apply enhancements to flushing flows	In-stream habitat features	Channel bank revegetation	Channel restoration	Enhance fish passage	Irrigation diversion and pump intakes	Overbank BMPs	Sediment Basin	Ramping Guidelines	Notes
CR4	Colorado River	Windy Gap to Williams Fork	-6	√	√	√		√	√	√				Highly impacted reach; recommendations include both enhancements and physical restoration
F2	Fraser River	DW Diversion to WPWSD intake	-3	√	√						√	√		Flow enhancements, sediment basin and passage of spawning gravels recommended for this reach
CR3	Colorado River	Granby Reservoir to Windy Gap	-3	√	√	√				√	√		√	Previous and ongoing restoration is extensive. Additional study is recommended. Flow enhancements for CR4 will improve CR3
F-RC2	Fraser River Trib	Ranch Creek ds of gage to confluence	-2	√	√	√	√	√						F-RC2 benefits from flow enhancements recommended for F-RC1
F-RC1	Fraser River Trib	Ranch Creek to ds of gage	-2	√	√									Investigate culvert capacities downstream to accommodate increased flushing flows
F3	Fraser River	WPWSD intake to Town of WP	-2								√			Recommendations in F2 will provide benefits in F3
MC2	Muddy Creek	Wolford to Colorado River	-2	√	√			√	√		√		√	Allow stream to stabilize before developing restoration recommendations
F4	Fraser River	Town of WP to Town of Fraser	-2			√					√			Recommendations in F2 will provide benefits in F4
CR1	Colorado River	North Fork to Shadow Mountain	-1											Additional study required in conjunction with Red Top diversion changes
CR 6	Colorado River	KB Ditch to Blue River Confluence	0			√				√				Recommend additional study to address grade control structures
CR 5	Colorado River	Williams Fork to KB Ditch	0			√				√				CR5 benefits from flow enhancements in CR4
F6	Fraser River	Fraser CWWTP to Ranch Creek	0				√	√			√			Partner on existing projects
F7	Fraser River	Ranch Creek to mouth of Canyon	0			√	√							Consider public access and trail enhancements
F8	Fraser River	Canyon	0											Consider public access
F9	Fraser River	Canyon to Granby	1					√						Partner on existing projects
BR	Blue River	Green Mountain to Colorado River	1				√						√	Develop ramping and flow management strategies to support spawning
CR 7	Colorado River	Blue River to County line	1											Maintain target flows and support recommendations from Wild and Scenic alternative
F5	Fraser River	Town of Fraser to Fraser CWWTP	2								√			
F10	Fraser River	Granby to Colorado River at Windy Gap	2						√					
F-StL	Fraser River Trib	St. Louis Creek	4					√						Support efforts to restore native cut throat populations
F1	Fraser River	US 40 to DW Diversion	5								√			
WR	Williams Fork	Below reservoir to Colorado River	7										√	Monitor for and address low DO levels
F-VC	Fraser River Trib	Vasquez Creek	*						√					
F-JC	Fraser River Trib	Jim Creek	*											No recommendations made at this time
WC	Willow Creek	Reservoir to Colorado River	*											No recommendations made at this time
MC1	Muddy Creek	Inflow to Wolford	*											No recommendations made at this time
F-TC	Fraser River Trib	Tenmile Creek	*											No recommendations made at this time
CR2	Colorado River	Shadow Mountain to Granby Reservoirs	*											No recommendations made at this time
TR	Colorado Trib	Hwy 40 to confluence	*											No recommendations made at this time
RE	Colorado Trib	Cty Rd 33 to confluence	*											No recommendations made at this time

Monitoring Plan

Integral to the restoration efforts is the development of a monitoring plan. Monitoring results will allow the Stakeholder Group to evaluate the effectiveness of restoration, including the application of flow enhancements, and to help guide the decision processes for future improvements, operations and management decisions. Recommendations presented here are conceptual in nature and intended to provide a frame work for implementation. Further, monitoring recommendations for a given reach will depend on 1) the key issues being addressed by the restoration effort, and 2) the specific techniques being used to protect, restore and/or enhance environmental flow conditions.

The type and degree of monitoring could also vary from reach to reach depending upon the type and level of management actions being taken. For example in some reaches it may only be necessary to monitor fish populations while in others, monitoring of cross sections, temperature and/or flow may be recommended. The following is a general and preliminary list of potential monitoring parameters (Table F4. A monitoring plan or program will likely include a combination of these parameters, implemented over a pre-specified time period, established as needed to assure stream health and restoration success.

Table F5 provides a summary of preliminary monitoring recommendations on a reach by reach basis, presented in order of priority established for restoration implementation. Additional details are presented in the individual reach summaries. Note that some of the recommendations presented here and in the reach summaries may be accomplished by consolidating efforts to a few pre-selected, representative reaches. For example, monitoring of surface water temperatures is recommended for most of the reaches. However, it may be possible to accomplish this by monitoring temperatures in half of the reaches and interpolating in between. This would also be true of air temperatures. In addition, there is a relatively extensive effort currently already in-place for some of these parameters including surface water temperatures and water quality. Thus the implementation of some of these recommendations will require a relatively minimal effort to complete a logical basin-wide program to monitor future flow alternations and support restoration efforts. See ‘Notes and Recommendations’ under Table F4 for additional discussion.

Table F4. Preliminary List of Potential Monitoring Parameters

Parameter	Purpose	Notes and Recommendations
Surface water temperature	Are surface water temperatures meeting state standards? Is there a trend in surface water temperatures based on location and flow releases from reservoirs?	There is currently an extensive surface water temperature monitoring effort underway in Grand County. Thus only minor modifications will most likely be required to meet the recommendations made in this SMP.
Air temperatures	How does air temperature correlate with surface water temperatures?	Air temperature monitoring is recommended for many reaches in the SMP. However, it is anticipated that several key monitoring stations could provide sufficient data input for many of the reaches.
Streamflows	Are target flows being met and are flow enhancements helping with low flow conditions?	Several additional streamflow gages are recommended in this SMP. See reach summaries and Table F5 for recommendations
Intergravel fine sediment concentrations	Are flushing flows meeting their objectives? Are there other watershed factors contributing to the accumulation of fine sediments?	Sampling for intergravel fine sediments was performed in July 2010 in eight locations within the study area. The continuation of sampling at these sites and/or additional sites should be evaluated in conjunction with the development of the enhancement and mitigation plans and details.
Fish population and diversity	Are fish populations increasing or decreasing? Are they sustainable?	This effort should be coordinated with DOW to combine efforts and resources. Specific monitoring details requires additional evaluation.
Benthic macro invertebrates	Are benthic macro invertebrate populations and diversity increasing or decreasing?	This effort should be coordinated with DOW to combine efforts and resources. Specific monitoring details requires additional evaluation.
Channel cross sections and assessments	Is the river aggrading or degrading? Is stability changing?	Cross section surveys and additional assessments requires additional evaluation to determine site specific needs and to reflect needs for monitoring restoration efforts. Several site specific recommendations are included in the reach summaries.
Water quality and algae	Are improvements being accomplished? Have we correctly identified sources of pollutants?	Grand County and USGS have teamed to begin an algae monitoring program at 13 locations within the County. Site specific recommendations for water quality are included in the reach summaries.
Recreational uses	Does changes in flow effect recreational use and is use increasing or decreasing?	This effort should be coordinated with American Whitewater and the SG Wild and Scenic monitoring effort, especially for CR7. Other reaches could be monitored with the assistance of private commercial angling outfitters.

Table F5. Monitoring Recommendations by Reach

Reach Description			RANKING	Potential Monitoring Parameters									
Reach ID	River	Section description		Surface water temperatures	Air temperatures	Stream flows	Intergravel fine sediment concentrations	Fish population and diversity	Benthic macro invertebrates	Channel cross sections and assessments	Water quality and algae	Recreational Use	Special Notes
CR4	Colorado River	Windy Gap to Williams Fork	-6	√	√	√	√	√	√	√	√		Monitor for whirling disease. Replace stream gage at Hot Sulphur. Assess ramping rates. Continue to evaluate stonefly extrication.
F2	Fraser River	DW Diversion to WPWSD intake	-3			√	√			√			Install new gage at DW diversion. Monitor traction sand.
CR3	Colorado River	Granby Reservoir to Windy Gap	-3	√	√	√				√			Integrate multiple restoration efforts and designs. Collect stream flow to assess ramping rates.
F-RC2	Fraser River Trib	Ranch Creek ds of gage to confluence	-2	√	√	√	√	√		√	√	√	Install new gage
F-RC1	Fraser River Trib	Ranch Creek to ds of gage	-2	√		√							
F3	Fraser River	WPWSD intake to Town of WP	-2			√	√			√			
MC2	Muddy Creek	Wolford to Colorado River	-2	√	√	√	√	√		√	√		Monitor morphological transitions. Collect streamflow data to assess ramping rates.
F4	Fraser River	Town of WP to Town of Fraser	-2					√	√	√			Monitor Fraser River Enhancment restoration
CR-1	Colorado River	North Fork to Shadow Mountain	-1			√							New study site required for implementation of 10825
CR 6	Colorado River	KB Ditch to Blue River Confluence	0	√	√	√					√		Add stream gage at Highway 9
CR 5	Colorado River	Williams Fork to KB Ditch	0	√	√	√	√	√	√	√	√	√	
F6	Fraser River	Fraser CWWTP to Ranch Creek	0	√	√						√		Identify high pH source
F7	Fraser River	Ranch Creek to mouth of Canyon	0	√	√						√		Identify high pH source
F8	Fraser River	Canyon	0	√	√						√	√	
F9	Fraser River	Canyon to Granby	1	√	√		√	√			√		
BR	Blue River	Green Mountain to Colorado River	1			√	√						Collect streamflow data to more thoroughly assess ramping rates.
CR 7	Colorado River	Blue River to County line	1	√	√	√		√			√	√	Perform spawning surveys. Additional monitoring may be required in Wild and Scenic Alt
F5	Fraser River	Town of Fraser to Fraser CWWTP	2										No recommendations made at this time
F10	Fraser River	Granby to Colorado River at Windy Gap	2	√	√			√			√		
F-StL	Fraser River Trib	St. Louis Creek	4			√							
WR	Williams Fork	Below reservoir to Colorado River	7			√					√		Collect streamflow data to more thoroughly assess ramping rates.
F1	Fraser River	US 40 to DW Diversion	5										Track maintenance requirements for the sediment basins
F-VC	Fraser River Trib	Vasquez Creek	*			√							
F-JC	Fraser River Trib	Jim Creek	*										No recommendations made at this time
WC	Willow Creek	Reservoir to Colorado River	*										No recommendations made at this time
MC1	Muddy Creek	Inflow to Wolford	*										No recommendations made at this time
F-TC	Fraser River Trib	Tenmile Creek	*										No recommendations made at this time
CR2	Colorado River	Shadow Mountain to Granby Reservoirs	*										No recommendations made at this time
TR	Trib	Hwy 40 to confluence	*										No recommendations made at this time
RE	Trib	Cty Rd 33 to confluence	*										No recommendations made at this time

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