COLORADO RIVER RESTORATION & CONSERVATION PROJECT

WSRA FINAL GRANT REPORT

Eagle River Watershed Council
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EXECUTIVE SUMMARY

After the realization that little data existed about Eagle County's nearly 60 miles of Colorado River, Eagle River Watershed Council sought to fill these gaps in data. The resulting report will guide restoration and conservation efforts on the river. The natural starting point for this effort was to conduct a full, science-based inventory and assessment of the ecology of the river corridor outlining strategies and activities that should be undertaken to protect and enhance the health of Colorado River as it flows through Eagle County.

The WSRA grant funds, in the amount of $30,000, supported Task 2 (Data Inventory & Literature Review) and Task 3 (Inventory & Synoptic Field Survey), which are the necessary early steps in the overall Colorado River Restoration & Conservation Project.

PROJECT SCOPE

The goal for these phases of the Colorado River Restoration and Conservation Project was to understand and protect the health of the Colorado River, its inhabitants and ecosystems, by creating a defined science-based, prioritized list of restoration and conservation projects.

The objectives for the overall Colorado River Restoration & Conservation Project (CRRCP) are:

- To create a science-based, overall study of the Colorado River corridor, its inhabitants and ecosystems, that will delineate a prioritized list of needed restoration and conservation projects.
- To understand the ecological setting of the Colorado River corridor in order to preserve those values with future land-use decision making, conservation funding, enhancement and other agriculture, recreation or wildlife-based projects that benefit Eagle County and its tourism-based economy.
- To utilize the report to educate our community and state, and to help us obtain public support and funding for these projects.

The ERWC/CSU assessment will:

- Inventory channel, riparian, and upland characteristics within Eagle County that influence the ecological integrity, recreational amenities, and aesthetic values of the Colorado River and its major tributaries in the corridor.
- Analyze existing monitoring data and information to assess the status of river corridor.
- Conduct synoptic field surveys of riparian condition, chemical, physical, and biological water quality, and geomorphic attributes to supplement existing information. The spatial domain of this survey will be the Colorado River mainstem from Radium to the west Eagle County line at Glenwood Canyon.
- Identify and describe candidate rehabilitation projects (structural and non-structural) and link to current issues and likely outcomes.
- Assess current and potential recreation impact upon the river.
- Identify, describe and prioritize candidate sites best suited for recreation access.
- Prioritize rehabilitation strategies in a decision matrix based on likelihood of success, potential benefits, rough estimates of costs, and stakeholder input.
- Produce a report describing the results of the river corridor inventory and prioritized recommendations for rehabilitation projects following the updated approach and template of the 2005 Eagle River Inventory and Assessment.

PROJECT STATUS

This contract funded work on Task 2 (Data Inventory & Literature Review) and Task 3 (Inventory and Synoptic Field Survey) of the Colorado River Restoration and Conservation Project. The project is on schedule and progressing as planned.

Research began in August 2012 by conducting an extensive literature review. CSU, in coordination with ERWC, has identified and analyzed existing monitoring data and information to assess the status of the river, including the identification of any data gaps. This included a literature review of all known data for the Upper Colorado River. The draft of the Literature Review, completed in December 2013, is attached as Appendix A.

CSU, in coordination with ERWC, inventoried channel, riparian, and upland characteristics within Eagle County that influence the ecological integrity, recreational amenities, and aesthetic values of the Colorado River and its major tributaries in the reach. This included conducting synoptic field surveys in 2012 and again in the fall of 2013. The surveying in 2013 was slightly delayed due to unseasonably high flows. Information collected included pebble counts, fines and algae counts, embeddedness data, water quality and macro-invertebrate data from the mainstem and tributaries.

GIS time series animations were created for upper basin temperatures and flows for 2010-2012, 2012 and 2013 using all available temperature data from USGS temperature gages, Grand County Water Information Network (GCWIN), and the Wild & Scenic Stakeholder Group. The animations are being used to assess whether certain tributaries or sections of the mainstem are associated with elevated water temperatures downstream through the study section. These can be found in Appendices B-E.

Additionally, an outline for the report, which will be completed in the spring of 2014, has also been drafted and included in draft form as Appendix F.

More details on the results and data are provided in the following section.

PRELIMINARY RESULTS AND DATA, SCOPE TASKS 2-3

Similar results and data were shared in ERWC's Multi Sev Grant (#13000000020) submitted in June 2013. New results/data are noted with **bold text** below.

Float trip data and assessments

- Flushing flows may be a concern especially downstream of **Two Bridges Boat Ramp** where highly erodible material is naturally entering the River in relatively high amounts.
  - Caused by high intensity thunderstorms.
  - Interviews were conducted with road maintenance crews on Colorado River Road.
    - Typically fixing road issues caused by erosion from rain a couple times a year.
- Water temperatures of tributaries in study section appear colder than the mainstem including below Red Dirt Creek.
  - **Sheephorn Creek has slightly elevated temperatures compared to mainstem (~1-2°C)**
  - Tributaries not resulting in elevated temperatures in mainstem.
- Water temperature taken by the Wild & Scenic Group at Dotsero and State Bridge in 2012 show that Daily Maximum Temperatures were elevated but remained below critical levels.

- **Water temperature taken by the Wild & Scenic Group at Dotsero, State Bridge, and Below Red Dirt Creek in 2013 show that Daily Maximum Temperatures were elevated but only Dotsero had levels above standards for three days in July.**
- Below Red Dirt Creek, mainstem may be habitat limited instead of temperature limited.
  - Lack of riffles.
  - **Local fishing guides stated that fish numbers and size are less downstream of Catamount.**
    - **May be attributed to elevated sediment levels and less riffle habitat compared to upstream.**
- **Macro-invertebrates 2012-2013**
  - **Data is still being analyzed but initial preliminary findings are as follows**
    - **Salmonfly (*Pteronarcys californica*)**
      - **Abundant upstream of Catamount but only one nymph found downstream**
    - **All stoneflies**
      - **Decreasing numbers as you move downstream**
    - **Other species sensitive to sedimentation**
      - ***Orthocladiinae***
        - **Decreasing numbers as you move downstream**
      - ***Sumulidae***
        - **Decreased numbers downstream of Derby Creek**
- Riparian Area
  - The riparian zone buffer could be increased along some stretches of private property where mowing is occurring right up to the river.
    - Areas have been marked with GPS and photo points
  - Some hay production fields could also provide more of a riparian buffer, only 5ft given in areas.
    - Areas have been marked with GPS and photo points
  - Diverse age classes of Narrowleaf Cottonwood (*Populus angustifolia*) and Coyote Willow (*Salix exigua Nutt.*) are present in areas along the river.
    - Narrowleaf can propagate from roots which makes it less dependent on specific flows for recruitment.
  - Only a few mature Plains Cottonwoods were spotted which can indicate that the flows necessary for their recruitment are not occurring anymore.
    - Plains Cottonwood (*Populus deltoides*) usually only propagate from seed.
  - Tamarisk (*Tamarix ramosissima*) was spotted in **numerous** sections **below Two Bridges Boat Ramp.**
    - Plants seemed young and if taken care of now they could potentially stop spread and growth.
  - **Russian Olive (*Elaeagnus angustifolia*) was abundant in many sections below Two Bridges Boat Ramp.**

- Globally rare Narrowleaf Cottonwood/ Strapleaf Willow- Silver Buffaloberry (*Populus angustifolia/ Salix eriocephala*ar. *ligulifolia- Shepherdia argentea)* and the Narrowleaf Cottonwood- Rocky Mountain Juniper (*Populus angustifolia-Juniperus scopulorum)* associations are present within the study section.

Flushing Flows

- May be an issue, especially in the downstream section where the surrounding hillsides are highly erodible and have the potential to deliver large amounts of fine sediment into the river. Historically, high flushing flows would scour this sediment and carry it downstream, but such flows are less frequent these days.
  - Flushing flow analysis consists of estimating flows that flush surface fines as well as the higher flows associated with coarse substrate mobilization.
  - Forthcoming analysis results will provide additional insight.

GIS animation (2010-**2013**)

- A GIS time series animation was created for upper basin temperatures and flows for the years **2010-2013** to assess whether certain tributaries or sections of the mainstem are associated with elevated water temperatures downstream through the study section.
  - Important to examine upstream controls on water temperature to understand watershed context and identify opportunities for positively influencing temperatures in system-level water management
- 2010 and 2012 were exceptionally dry years and the mainstem above the study section had elevated temperatures but never surpassed the Daily Maximum Temperature (DM) level.
- Fraser River is consistently warmer and contributing more of the flow than the Colorado River upstream of their junction.
- Colorado River upstream of the Fraser and Willow Creek are consistently below critical temperatures for aquatic species but do not contribute enough flow to cool Fraser River by much.
- Consistently in summer, Hot Sulphur Springs is where the Colorado River temperature seems to increase compared to just upstream.
  - Will investigate possibility of geothermal influences.
  - Differences in flows between here and Windy Gap upstream are minimal and not likely cause of increased temps.
- Williams Fork in 2010 had no detectable influence on temperature of the Colorado because flows in the Williams Fork were not large enough compared to flows in the mainstem.
- Williams Fork in 2012 was consistently cooling the Colorado River below their junction because flows in the Colorado were low enough to make the flows in the Williams Fork actually influence temperature.
  - Flows from the Williams Fork could help keep temperatures cooler in dry years if enough water is released from the reservoir.
- Flows in the mainstem typically become elevated again by the time they reach Kremmling.
- Muddy Creek temperatures increase an appreciable amount from below Wolford Mt. Reservoir to the Colorado.
  - USGS gage is showing water temperature much higher than two other temperature sensors upstream and one downstream.

- Need to investigate why this is occurring and which sensors are accurate.

- Although actually colder than the Colorado, Muddy Creek usually does not contribute enough flow to cool the Colorado.
- The Blue River is cooling the Colorado before it enters study section.
  - Temperatures were never above critical DM level down through Radium in those years.
  - The Blue is a major tributary and contributes enough flow of cold water to cool the Colorado.
- **Towards the end of July 2013, temperatures became elevated along the Colorado mainstem. More water was released from Green Mountain Reservoir and Williams Fork Reservoir which increased flows in the Blue River and Williams Fork, and reduced temperatures in the Colorado mainstem downstream.**
  - **Flows on the Blue River increased from 100cfs to 602cfs which reduced the temperature from 19.5°C to 11.8°C.**
  - **Flows on the Williams Fork increased from 66cfs to 277cfs but no temperature data was available**
  - **Flows on the Mainstem Colorado below the confluence with the Blue River increased from 252 cfs to 515cfs which reduced the temperature from 21.8°C to 13.8°C.**

NEXT STEPS

- Finish analysis of macro-invertebrate data.
- Finish analysis of upstream temperatures and flows to determine sources of elevated water temperature and how this affects the study section.
- Create a list of potential restoration projects.
- Draft report chapters and finish report.
- Finish flushing flow analysis with the best available data.

ADDITIONAL INFORMATION

Appendix A- Literature Review DRAFT
Appendix B*- GIS Time Series Animation 2010-12
Appendix C*- GIS Time Series Animation 2012
Appendix D*- GIS Time Series Animation 2013
Appendix E*- GIS Time Series Animation Legend
Appendix F- Report Outline DRAFT

*Appendices B-E can be accessed through a shared Dropbox folder here:
(https://www.dropbox.com/l/0WlTDJVbWPx9GtSzg03sL9)

Appendix A: Literature Review DRAFT

Previous reports about the Upper Colorado River have covered issues such as water quantity, water quality, ecology, and aquatic resources. Only a few of these directly involve the Colorado River within Eagle County. However, changes in the upstream watershed directly impact the reaches within this study. A brief overview of the most relevant reports follows.

Wild and Scenic River Suitability Report (Tetra Tech, Inc., 2010)

The Bureau of Land Management (BLM) and White River National Forest Service (WRNF) have jointly assessed the suitability of designating segments of the Colorado River and some of its tributaries as a Wild and Scenic River (WSR). Six segments of the Colorado River including two through Eagle County contain outstandingly remarkable value (ORV) and could be managed as a WSR. In-stream flow protection and cooperative flow management would come with this federal designation. Some of the ORVs for the Colorado River through Eagle County are as follows.

- Scenic
    - Gore Canyon
    - Little Gore Canyon
    - Red Gorge
- Recreational
    - Fishing
    - Rafting
    - Scenic driving
- Geological
- Wildlife
    - Bald eagle nesting and winter habitat
    - River otter habitat
- Historic
    - Early hydroelectric projects
    - WWII German POW camp
    - Moffat Rd.
    - Copper mining
    - Brass Balls Mine/Cable Rapids Cabin
    - State Bridge
- Botanical
    - Riparian plant communities
- Paleontological
    - fossils

Upper Colorado River Wild and Scenic Stakeholder Group Management Plan (Wild and Scenic Stakeholder Group, 2011)

A diverse group of stakeholders was formed to develop a management plan to help protect the outstandingly remarkable values (ORVs) found on the Colorado River from Gore Canyon downstream to Glenwood Canyon. The stakeholder group management plan is being proposed as a potential alternative to federally designating the area as a Wild and Scenic River. The goal of the plan is to balance permanent protection of the ORVs while allowing flexibility for water users. Parts of the plan would include in-stream flows, ensuring water delivery to downstream senior water right holders, and delivery of endangered fish flows to the 15-Mile Reach near Grand Junction. The plan aims to protect all ORVs through focusing on recreational fishing and floating flows.

In-stream Flow Report for the Colorado River from Kremmling, Colorado downstream to Dotsero, Colorado (Miller and Swaim, 2011)

The focus of this report was to assess how fish habitat in the Colorado River between Kremmling and Dotsero responded to different flows. The results would be used to help with management decisions and determine how changes in the watershed may impact fish habitat. For the project the major fish species of interest were rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), mountain whitefish (*Prosopium williamsoni*), and flannelmouth sucker (*Catostomus latipinnis*). A River2D analysis of the study section was conducted to determine 1) the current state of the physical habitat available for the identified species and 2) the expected changes to physical habitat as a result of natural and man-made hydrologic changes. Three sites were located at Pumphouse, Rancho del Rio, and Lyons Gulch. Results show that habitat for most species and lifestages was most abundant at flows between 500 and 1500 cfs. Habitat was also shown to decrease rapidly at flows below 500 cfs. Recommendations were given for baseflows to be higher than 500 cfs and for peak flows to exceed 2000 cfs upstream and 4000 cfs downstream to maintain habitat. Peak flows double those values should happen with a recurrence interval of one to two times every ten years to create habitat and maintain riparian function.

In-stream Flow Recommendations (Colorado Water Conservation Board, 2011)

In-stream flow recommendations for the Colorado River between Kremmling and Dotsero are being put forward as part of an alternative management plan to the potential federally designated Wild and Scenic River. Two studies were conducted in order to determine 1) The existence of a natural environment and 2) The minimum amount of water necessary to preserve the natural environment to a reasonable degree. Recommendations for in-stream flows were provided by the Colorado Water Conservation Board (CWCB) and Colorado Parks & Wildlife (CPW) and are as follows:

- CWCB Recommendations
    - Confluence Blue River to confluence Piney River
        - 600 cfs (5/15-7/31)
        - 750 cfs (8/1-9/15)
        - 500 cfs (9/16-5/14)
    - Confluence Piney River to confluence Cabin Creek
        - 650 cfs (5/15-7/31)
        - 800 cfs (8/1-9/15)

        - 525 cfs (9/16-5/14)
    - Confluence Cabin Creek to confluence Eagle River
        - 650 cfs (5/15-6/15)
        - 800 cfs (6/16-9/15)
        - 525 cfs (9/16-5/14)
- CPW Recommendations
    - Confluence Blue River to confluence Piney River
        - 600 cfs (5/15-7/31)
        - 750 cfs (8/1-9/15)
        - 500 cfs (9/16-5/14)
    - Confluence Piney River to confluence Cabin Creek
        - 650 cfs (5/15-7/31)
        - 800 cfs (8/1-9/15)
        - 525 cfs (9/16-5/14)
    - Confluence Cabin Creek to confluence Eagle River
        - 650 cfs (5/15-6/15)
        - 900 cfs (6/16-9/15)
        - 800 cfs (9/16-5/14)

Colorado River Aquatic Resources Investigations Federal Aid Project F-237R-18 (Nehring *et al.*, 2011)

A study was performed to assess macro-invertebrate and mottled sculpin populations on the Upper Colorado River. Previous sampling had occurred in 1980-1981 with the same sites being resampled in 2010-2011. Pumphouse boat launch was one of the sites sampled in 2010-2011. A large portion of the study was dedicated to the stonefly *Pteronarcys californica* which is considered both an important food source for the surrounding ecosystem and an indicator species of possible negative impacts that may be occurring within the river. Results show that these stoneflies among other important macro-invertebrate species have significantly declined in areas below Windy Gap reservoir. Samples were not taken at Pumphouse in 1980-1981 so direct comparison of populations could not be conducted. However, population estimates at Pumphouse were significantly higher than any other sites upstream to Windy Gap reservoir.

Upper Colorado River Water Quality Management Plan (2012)

This report focuses on the Colorado River within Grand County. An assessment is provided about past and current water quality issues on all of the rivers and reservoirs that feed into the Colorado River. Included in this is:

- Summaries of past water quality studies
- Point source issues
    - Municipal discharges
    - Industrial
- Nonpoint source issues

  - Hydrologic modifications
  - Trans-basin diversions
  - Urban and construction
  - Recreational
  - Agricultural
- Existing watershed improvement projects
  - Clinton Reservoir Agreement
  - Berthoud Pass Sediment Control Projects
  - Three Lakes Water Quality Database
  - Three Lakes Watershed Assessment Study
  - Sheephorn Creek Riparian Improvement Project
  - Shadow Mountain Delta Formation Study
  - BOR Alternatives Study
  - Grand County Stream Management Plan
  - Grand County Water Quality Specialist
  - Grand Ditch
- Future watershed improvement projects
  - In-stream flows
  - Agricultural Best Management Practices
- Existing and future water quality monitoring
- Water Quality Standards

Grand County Stream Management Plan - Appendix B – Temperature Data Review (Tetra Tech *et al.*, 2010)

Water temperature data were analyzed for the period 2006-2009 for the Upper Colorado River and its tributaries in Grand County to determine if temperatures exceeded Maximum Weekly Average Temperature (MWAT) or Daily Maximum (DM) standards set in place by the Colorado Department of Public Health and Environment (CDPHE). For 2006-2008 gages downstream of Windy Gap often exceeded MWAT standards. Most of the sites were below DM standards except for Ranch Creek. Temperature-Discharge relationships were also analyzed at certain gaging stations. Other observations of interest are as follows:

- River temperatures in the Fraser River cool at the confluence with the Colorado River upstream of Windy Gap.
- The Colorado River warms as it travels through Windy Gap. A warming trend continues through the entire stretch from Windy Gap to Hot Sulphur Springs.
- From Hot Sulphur Springs to Williams Fork, changes in river temperatures vary. Of the five dates plotted, two days show a decrease, two days show an increase and one day, Aug 1, shows only a slight decrease.
- Flows released from Williams Fork reservoir tend to cool water temperatures below the confluence.
- From KB Ditch to Kremmling river temperatures remain relatively unchanged.

Windy Gap Firming Project EIS (Bureau of Reclamation, 2011)

Denver Water is proposing to expand Gross Reservoir to meet future water demands along the Front Range. Water would be diverted in average to wet years from the Fraser River, Williams Fork, and South Boulder Creek. The expansion would allow for an additional 72,000 AF of storage. Some possible impacts are as follows:

- Streamflow
    - Fraser River and Williams Fork would see decreased peak flows in average and wet years. This also impacts tributaries to the Fraser River.
    - Blue River would have decreased summer flows and slightly increase winter flows during average and wet years.
    - Colorado River flows would decrease during runoff during average and wet years.
- Sedimentation
    - Sediment transport capacity is expected to decrease in all affected rivers.
    - Only a small amount of localized sedimentation is expected.
- Aquatic Biology
    - There would be no changes to water quality or channel geomorphology in the Fraser, Williams Fork, Blue, and Colorado Rivers that would affect fish and other aquatic biological resources.

Colorado River Cooperative Agreement (Denver Business Journal, 2012)

An agreement has been made between west slope cities and counties, Denver Water, and other involved parties on how future water projects will be governed within the Colorado River Basin. Major points of the agreement are as follows:

- Additional water for towns, districts and ski areas in Grand and Summit counties to serve the needs of residents and to improve the health of rivers and streams.
- An agreement to operate key Denver Water facilities, such as Dillon Reservoir in Summit County, and Williams Fork Reservoir and the Moffat Collection System in Grand County, in a way that better addresses the needs and concerns of neighboring communities and enhances the river environment.
- Greater certainty for Denver Water to develop future water resources for its customers by resolving long-standing disputes over its service territory, its ability to use West Slope water, its ability to develop future water supplies in the Colorado River Basin, and other legal issues.
- Additional water and enhanced system reliability for customers of Denver Water, representing nearly 25% of the state's population, by moving forward the Moffat Collection System Project.
- Agreement by all partners to not oppose Denver's storage of its Blue River and Moffat Project water on the Front Range.
- Reinforcement of the priority and increased conservation and reuse within Denver Water's service area.

10825 Water Supply Study - Phase 1 (Grand River Consulting Corporation, 2007)

East and West Slope entities will provide a permanent supply of 10,825 acre-feet/year of water to help with the recovery of four endangered fish. The four fish (Colorado pikeminnow, razorback sucker, humpback chub, and bonytail chub) are currently present in the Colorado River near Grand Junction. The water will be used during the late summer months to help with low flow conditions. Ten alternatives to provide the water have been proposed and will be further investigated.

- Orchard Mesa Irrigation improvements
- Sulphur Gulch Reservoir
- Buzzard Creek Reservoir
- Wolford Mountain Reservoir Improvements
- Roan Creek Reservoir
- Wolcott Reservoir
- 15-Mile Reach Pumpback
- Yank Creek Reservoir
- Ruedi Reservoir (2012 Backfill) Impacts
- Synchronized Use of Multiple Facilities

Ecological and Physical Processes during Spring Peak Flow and summer Baseflows in the 15-Mile Reach of the Colorado River (Rees *et al.*, 2008)

Reductions in peak flows have negatively impacted endangered fish species present in a 15-mile Reach on the Colorado River near Grand Junction. This study focuses on determining if the current peak flow regime is in fact limiting to the native fish and the surrounding aquatic ecosystem. The investigation looked at physical and biological processes. Results indicated that a variety of factors may influence primary and secondary productivity within the 15-mile Reach including: turbidity, frequency and intensity of storm events, deposition of sediments, runoff characteristics, sediment scouring, and flow stability.

Climate Change in Colorado (Ray *et al.*, 2008)

This report synthesizes the impact of climate change on Colorado's water supply. Temperatures have increased about 2°F over the past 30 years in Colorado. Warming is expected to continue reaching a 4°F increase by 2050. Winters are expected to have less extreme cold months but more extreme warm months. No consistent long-term trend in annual precipitation can be detected. However, more precipitation is expected to fall as rain instead of snow. The peak flow on many rivers has already shown a shift to two weeks earlier that may also reduce late summer flows. A decline in snowmelt runoff is also expected. Water managers will have to adapt the way we use and distribute water as the climate continues to change.

Colorado River Water Availability Study (AECOM, 2012)

The study combined data and models developed by CWCB and DWR to look at the Colorado River water supply within Colorado. Three different water supply conditions were used in the analysis:

- Historical Hydrology – uses hydrology data from 1950-2005 to estimate water supply.
- Extended Historical Hydrology – uses tree-ring records for the past 1,200 years.
- Climate-Adjusted Hydrology – assess the magnitude of future water supply considering the effects of climate change.

Climate projections for 2040 and 2070 were used to determine resulting trends in temperature, precipitation, streamflow, reservoir storage, and consumptive use. Average monthly and annual temperatures are expected to rise. Precipitation is shown to increase in the winter months and decrease in the summer months. Temperature increases will make more precipitation fall as rain instead of snow. A decrease in annual stream flow is expected in both the 2040 and 2070 scenarios while consumptive use is expected to rise.

Colorado River Water Bank Feasibility Study (MWH, 2012)

The Colorado River Compact of 1922 states that the Upper Division (Colorado, New Mexico, Utah, and Wyoming) must curtail water use if they cause flows at Lee Ferry, Arizona to drop below 75,000,000 acre-feet during any consecutive 10-year period. Recent drought has caused conservation agencies to conduct a feasibility study of water banking within Colorado in order to avoid curtailment. Water banking works by having willing agricultural participants temporarily fallow or deficit irrigate lands using pre-1922 water rights in return for financial compensation. Different scenarios were run to try and quantify the amount of available water supply for banking. Results show that deficit irrigation is feasible for grass pasture and alfalfa in order to save ~950,000 acre-feet/year. Overall feasibility will hinge on certain legal and water right administration questions.

Agreement on Wolford Mountain Reservoir and Green Mountain Reservoir Exchange (Bureau of Reclamation, 2007)

This report is an environmental assessment of a proposed agreement between the Bureau of Reclamation (BOR), the Colorado River Water Conservation District (CRWCD), and Northern Colorado Water Conservancy District (NCWCD). The agreement states that in order to mitigate any existing shortages due to operating limits at Green Mountain Reservoir, water can be substituted from Wolford Mountain Reservoir. The investigation included a no action alternative, banking exchange, and a borrowing exchange. The effects on aquatic resources under the proposed plans are as follows:

- Blue River
    - The proposed alternatives could have an adverse impact to aquatic resources.
        - Spawning fish in Fall and Spring could be affected.
- Muddy Creek
    - The banking exchange could cause short-term negative impacts on aquatic resources but in the long-term be negligible.

  - Borrowing exchanges have the potential to cause minor negative impacts on aquatic resources.
- Macro-invertebrates
  - No impacts are expected specific to macro-invertebrates due to any decreases in flow in the Blue River and Muddy Creek are protected by in-stream flow regulations.

Wolcott Reservoir Feasibility Assessment – Phase I (Grand River Consulting Corporation and GEI Consultants, Inc., 2004)

The feasibility of building a reservoir on land owned by Denver Water is being assessed. Three reservoir scenarios have been identified and in each scenario it would be operated by east and west slope entities. The water being stored would not be diverted to the eastern slope but used on a substitution or exchange basis. Water would be diverted from both the Eagle River and Alkali Creek where the dam would be located. Water would be taken during runoff and released into the Eagle River primarily during low flows. Reservoir releases would be used primarily for the following purposes:

- Maintenance of Threatened and Endangered Fish Habitat in the lower Colorado River.
- Water Supply for Eagle River and other West Slope Water Users.
- Exchange or Substitution to Existing Trans-Mountain Diversion Facilities.
- Enhancement of environmental conditions of the Eagle and Colorado Rivers.

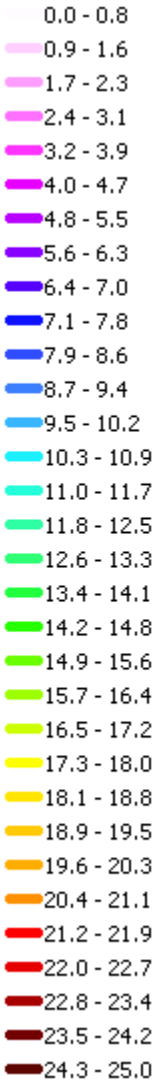
A proposed alternative to pumping water from the Eagle River into the reservoir would be to run a gravity fed tunnel from the Piney River which is the largest tributary to the Colorado River between Kremmling and Dotsero.

Appendix E: GIS Time Series Animation Legend

Temperature Standards for Colorado River in Eagle County

Daily Maximum 23.8°C

Temperature °C



Appendix F: Report Outline DRAFT

Watershed overview, history, and policy

- Watershed overview
    - Drainage Area upstream of Eagle River confluence
    - Elevation ranges
    - Precipitation
        - Annual
        - Monthly
        - SWE
    - Runoff
        - Annual Hydrograph
        - Peak Flows
            - Pre 1916
            - Post 1962
            - Average, Max, Min, Q1.5
        - Timing
        - Duration
    - Diversions
    - Land Use
        - Crops
        - Livestock
        - BLM
    - Watershed Maps
        - River System
        - Towns
        - Railroads
        - Major Roads
- Geology
    - Major formations
    - Erodibility
- Literature Review
    - Upper Colorado River Water Quality Management Plan (2012)
    - Colorado River Water Bank Feasibility Study (2012)
    - 10825 Water Supply Study (2007)
    - Ecological and Physical Processes during Spring Peak Flow and Summer Baseflows in the 15-Mile Reach of the Colorado River (2008)
    - Grand County Stream Management Plan (2010)
    - Blue River Water Quality Management Plan (2012)
    - Climate Change in Colorado (2008)

  - Colorado Basin Needs Assessment Report (2011?)
  - Colorado River Cooperative Agreement (2011)
  - Water Availability Study of the Colorado River and its Tributaries (2008)
  - Wild and Scenic River Suitability Report (2010)
  - Agreement on Wolford Mountain Reservoir and Green Mountain Reservoir Exchange (2007)
  - In-stream Flow Recommendations (2011)
  - Moffat Windy Gap Firming
  - Moffat Fraser and Williams Fork Rivers
  - Wolcott Reservoir Feasibility Study (2004)
  - Phase II Upper Colorado River Study (2003)
  - Upper Colorado River Wild and Scenic Stakeholder Group Management Plan (2011)
  - Colorado River Aquatic Resources Investigations Federal Aid Project F-237R-18 (2011)
- Historical Background
  - Early days
    - Early hydroelectric projects
    - WWII German POW camp
    - Moffat Rd.
    - Copper mining
    - Brass Balls Mine/Cable Rapids Cabin
    - State Bridge

Analysis of Watershed Characteristics

- Outstandingly Remarkable Values (ORVS) BLM
  - Scenic
    - Gore Canyon
    - Little Gore Canyon
    - Red Gorge
  - Recreational
    - Fishing
    - Rafting
    - Scenic driving
  - Geological
  - Wildlife
    - Bald eagle nesting and winter habitat
    - River otter habitat
  - Historic
    - Early hydroelectric projects
    - WWII German POW camp
    - Moffat Rd.

        - Copper mining
        - Brass Balls Mine/Cable Rapids Cabin
        - State Bridge
    - Botanical
        - Riparian plant communities
    - Paleontological
        - Fossils
- Water Use
    - Irrigation
    - Livestock
    - Consumptive
    - Recreation
- Water Rights
    - Diversions
        - Trans-mountain Diversions
            - Moffat Tunnel
            - Alva B Adams Tunnel
            - Grand Ditch
            - Eureka Ditch
            - Berthoud Pass Ditch
            - Vasquez Tunnel
            - Gumlick Tunnel
            - Straight Creek Tunnel
            - Vidler Tunnel
            - Harold D. Roberts Tunnel
            - Boreas Pass Ditch
            - East and West Hoosier Ditches
            - Hoosier Pass Tunnel
            - Arkansas Well brings water into basin
        - Future diversions
            - Increase Moffat Tunnel
            - Windy Gap Firming Project
    - Reservoir Operations
        - Green Mountain
        - Lake Granby
        - Willow Creek
        - Williams Fork
        - Wolford Mountain
        - Water banking
            - Green Mountain – Wolford Mountain swap
    - Calls

        - Cameo
        - Shoshone
        - ISF endangered species
- Hydrology
    - Overview
    - Flow Regime
    - High Flows
        - Base and Low Flows
        - Timing and Duration
        - Variability
    - Meteorological Characterization
        - Precipitation
            - Thunderstorms and erosion
            - County Roads Data
        - Temperature
    - Streamflow Metrics
        - Overview of the Statistical Analysis
        - Pre- and Post-streamflow Metrics
    - Comparison of Flow Metrics
    - Changes in High Flows
    - Changes in Low Flows
    - Timing of Low Flows
    - Variability
- Water Quality
    - Overview of Water Quality
    - Water Temperature
        - Upper Colorado Time-Series Animation (2010-2013)
        - Mainstem
        - Tributaries
    - Macroinvertebrate
        - Analysis Results
        - Sedimentation Impacts
    - Sedimentation below Catamount
        - Naturally occurring
        - Frequency of flushing
- Geomorphology of the Colorado River
    - Geomorphology, Physical Habitat, and Channel Stability
        - Confined
        - Road and train rip-rap
    - Potential Geomorphic Effects of Flow Regime Changes
    - Reduced Flows and Their Effect on Effective Discharge

- Riparian Zones
    - Ecological Significance of Riparian Zones
    - Riparian Plant Communities
        - *Populus augustifolia-Juniperus scopulorum* woodland
    - Condition of Riparian Areas
        - Riparian Vegetation Recruitment
            - Cottonwoods species
            - Willows
            - Sedges and Rushes
        - Invasive Species
            - Tamarisk
            - Russian Olive
            - Kentucky Bluegrass
- Flushing Flows
    - Introduction to Flushing Flows
    - Flushing Flows in Colorado Watershed
    - Linkages with Water Quality
    - Flushing Flows Analysis
        - Cross-sectional and channel geometry
        - Substrate characterization
        - Monte Carlo
    - Flushing Flow Results and recommendations

Potential Projects

- Future Diversions?
    - Buying water rights
    - Flushing flows
- Willow Plantings
- Stop mowing banks on private lands
- Increased riparian buffer on private lands
- Sheephorn Creek bank stabilization
- Invasive Species removal
    - Tamarisk

Recommendations

- Conclusions to come