TABLES

FIGURES

Chapter 3. Affected Environment and Environmental Consequences

3.1 Introduction

This chapter describes the affected environment and environmental consequences associated with each Windy Gap Firming Project (WGFP) alternative. Section 3.2 provides an overview of the content of the affected environment section. Section 3.3 describes the process used to determine potential environmental effects. Section 3.4 discusses the East and West Slope area of potential effect or study area used in the evaluation of resource impacts. Sections 3.5 to 3.22 present the affected environment and environmental effects for each resource of concern. Section 3.23 discusses the relationship between short-term uses and long-term productivity and Section 3.24 describes irreversible and irretrievable commitment of resources. Section 3.25 summarizes the mitigation commitments that would be implemented to reduce identified environmental effects.

Chimney Hollow valley and existing C-BT Flatiron Penstock

3.2 Description of the Affected Environment

The affected environment section for each resource describes the existing conditions for the area of potential effect associated with each alternative. Information on the affected environment was collected from a variety of sources depending on the resource, but typically included field observations and data collection, published reports and studies, modeling, and personal contacts with agencies or individuals with expertise on the resource. The affected environment reflects any ongoing or past activities that have affected the resource and that contribute to the current status of the resource. For this reason, the time periods presented for displaying historical conditions depends on-site-specific data available for each particular resource. The affected environment characterizes the existing conditions and provides a measure for comparing future changes to the resource from implementation of any of the alternatives.

3.3 Determination of Environmental Effects

In preparing the EIS, Reclamation reviewed a variety of sources and have used what we consider the best information available to predict the environmental effects of the WGFP. Potential environmental effects are identified for each alternative based on the analyses conducted for the EIS, review of relevant scientific literature, information from previous studies, and the best professional judgment of resource specialists. The effects analysis presents the scientific and analytical basis for comparison of alternatives.

Effects can be either beneficial or adverse and can be classified as direct or indirect (40 CFR 1508.8). Direct effects "are caused by the action and occur at the same place and time." Indirect effects "are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable." Cumulative effects are "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions" (40 CFR 1508.7). The terms "effect" and "impact" have the same meaning and are used interchangeably.

Effects also can be characterized by the duration of the effect. Short-term effects include actions that temporarily affect a resource, such as vegetation disturbance during construction on lands that are later reclaimed and revegetated. Short-term effects for this project are defined as those effects occurring between the beginning of construction through completion of reclamation, or a total of about 5 years. Long-term effects include those actions that would affect a resource for the duration of the project, such as the change in land use from construction of a new reservoir. NEPA requires consideration of the relationship of short-term uses and long-term productivity for each resource. Both short-term and long-term effects are included in the discussion of resource effects in Section 3.23.

NEPA also requires discussion of any irreversible and irretrievable commitments of resources that would result from implementing the alternatives. These effects are summarized for each resource in Section 3.24.

The discussion of resources potentially affected by the alternative actions includes an evaluation of the substantive issues identified during scoping at the beginning of the project as described in Section 1.9. Emphasis is given to resources of concern where measurable adverse or beneficial effects are likely to occur. Less emphasis is given to resources where the effect is likely to be minor and/or short term. For some actions there would be no resource effects. For example, Western's action of removing and relocating the transmission line for alternatives that include Chimney Hollow Reservoir would not impact surface water, ground water, geology, aquatic life, water supply, agriculture, wetlands, or floodplains.

The methods and any assumptions used to evaluate effects are described for each resource. Effects are quantified where possible using measurement indicators pertinent to the specific resource, such as changes in reservoir storage, streamflow volume, stream temperature, fish or wildlife habitat, or monetary value. Where applicable, effects are discussed in relation to regulatory standards or compliance with existing laws or commitments. Mitigation measures are identified where possible to avoid or reduce the effect of the action. A summary of unavoidable adverse effects, even with implementation of mitigation measures, is included for each resource. NEPA requires disclosure of adverse and beneficial effects, but does not require that projects have no effect or no net effect.

For some resources and some locations, the effects are similar for all alternatives and the discussion of effects is consolidated to reduce repetition. Tables 2-6 and 2-7 in Chapter 2 summarize the resource direct and cumulative effects.

> The effects analysis includes a comparison of resource impacts for each alternative. This includes a comparison of the Proposed Action and other action alternatives to the No Action Alternative, as well as a comparison to existing conditions. For Reclamation's purposes, action alternatives are compared to the No Action Alternative for determining effects. For the Corps' purpose as a regulatory agency, the effects of the alternatives are compared against existing conditions. The Corps will use this information in their evaluation of the proposed project under the 404(b)(1) guidelines and 404 regulations. Thus, the information in this EIS is presented so the reader can compare the action alternatives to either the No Action Alternative or existing conditions.

3.4 Area of Potential Effect

The area of potential effect—or study area—used in the description of the affected environment and in the evaluation of the environmental effects varies by alternative and resource. All alternatives include actions that result in effects on both the east and west sides of the Continental Divide. The West Slope study area includes areas where changes in streamflow, lake level, or water quality would occur, including Granby Reservoir and the Colorado River below Granby Reservoir through Gore Canyon below the confluence with the Blue River. Below Gore Canyon, the hydrologic effects of the alternatives diminish and potential impacts to aquatic and other resources are less likely. Also included in the West Slope portion of the study area is Willow Creek downstream from Willow Creek Reservoir. Potential effects to Grand Lake and Shadow Mountain Reservoir are limited primarily to water quality, aquatic resources and recreation because there would be no change in the water level of these reservoirs. Direct effects in the West Slope study area include the surface disturbance associated with construction of either Jasper East Reservoir or Rockwell Reservoir and the associated facilities.

On the East Slope, the study area includes areas with projected hydrologic changes, including portions of the Big Thompson River below Lake Estes, North St. Vrain Creek, St. Vrain Creek, Cache la Poudre River, Big Dry Creek, Coal Creek, and the South Platte River. Downstream effects on the South Platte River from increases in streamflow are projected to be minimal since potential changes are small in relation to the total flow in the river; therefore, the study area is limited to stream segments experiencing measurable change. Carter Lake and Horsetooth Reservoir are included in the study area because there would be a change in reservoir storage. The Chimney Hollow and Dry Creek reservoir sites are included in the East Slope study area along with the existing Ralph Price Reservoir included in the No Action Alternative. The impacts associated with removal and relocation of 3.8 miles of Western's Estes Lyon 115-kV Transmission Line are included in all appropriate resource impact discussions for the alternatives that include Chimney Hollow Reservoir.

3.5 Surface Water Hydrology

3.5.1 Affected Environment

3.5.1.1 Area of Potential Effect

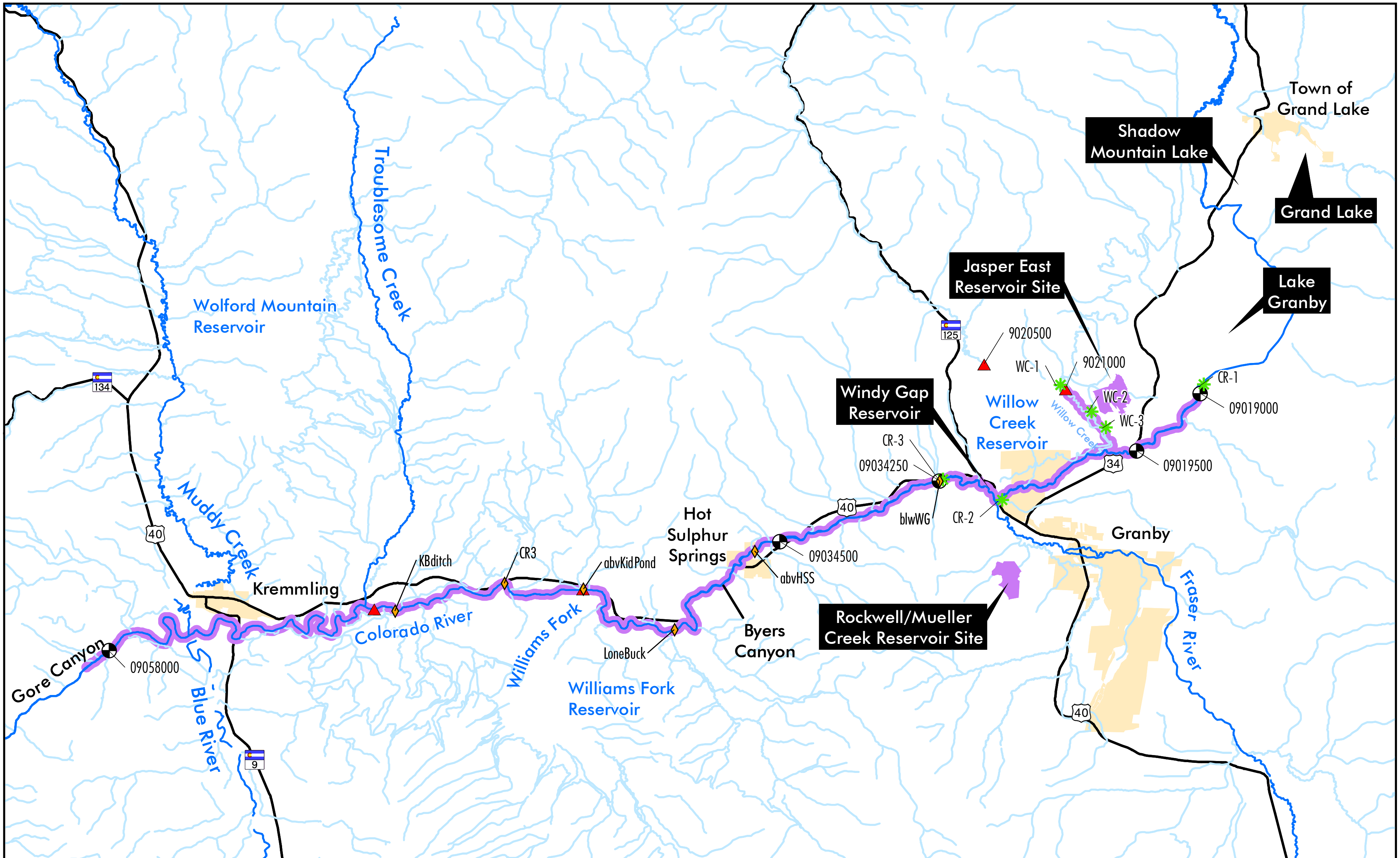
The area of potential effect used to describe hydrologic changes to streams and reservoirs comprises the Upper Colorado River basin on the West Slope where Windy Gap water is diverted (Figure 3-1) and affected tributaries on the East Slope in the South Platte River basin in northeast Colorado that receive Windy Gap water or wastewater treatment plant (WWTP) return flow following use of Windy Gap water (Figure 3-2). Stream segments and lakes and reservoirs in the study area include:

West Slope

- Colorado River below Granby Reservoir to Gore Canyon
- Willow Creek below Willow Creek Reservoir
- Granby Reservoir
- Jasper East Reservoir
- Rockwell/Mueller Creek Reservoir

East Slope

- St. Vrain and North St. Vrain creeks
- Big Thompson River below Lake Estes
- Big Dry Creek
- Cache la Poudre River below Greeley WWTP
- Coal Creek
- South Platte River
- Ralph Price Reservoir
- Carter Lake
- Horsetooth Reservoir
- Chimney Hollow Reservoir
- Dry Creek Reservoir



ERO

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NCWCD Stream Gaging Station

USGS Stream Gaging Station and Water Quality Monitoring Location

NCWCD Water Quality Monitoring Location

NCWCD 2007 Stream Temperature Measurement Site

City

Lake or Reservoir

Study Area Reservoir

Study Area Stream

Major Streams

Minor Streams

Highway

0 2 4 Miles

1 Inch = 4 Miles

N

Figure 3-1
West Slope Water Resource Study Area

Prepared for: Windy Gap Firming Project
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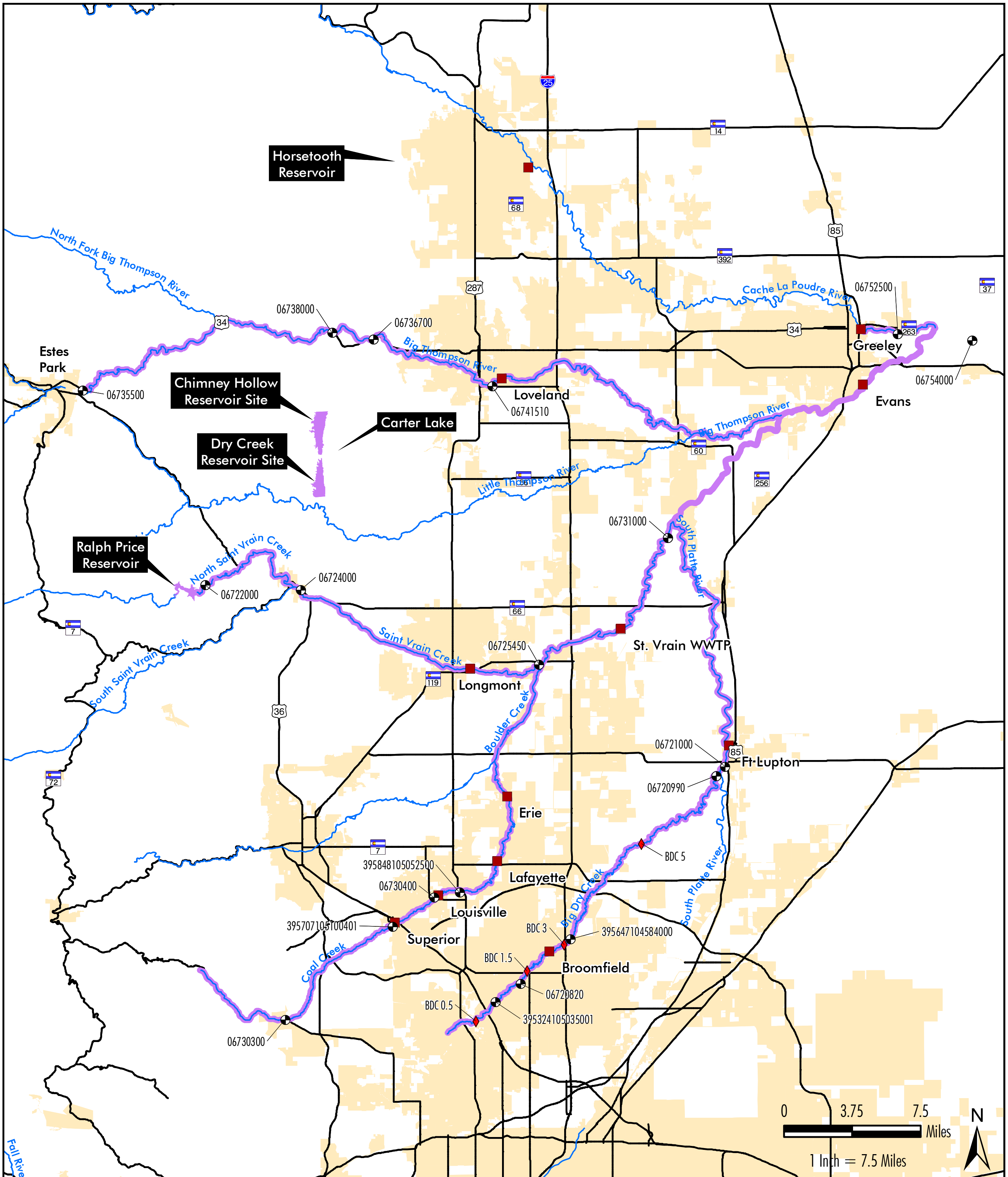

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- USGS Stream Gaging Station and Water Quality Monitoring Location
- BDCWA Water Quality Monitoring Location
- Waste Water Treatment Plant
- Lake or Reservoir
- Study Area Reservoir
- Highway
- Study Area Stream
- Major Streams
- City

Figure 3-2
East Slope Water Resource Study Area

Prepared for: Windy Gap Firming Project
File: 2390 EIS\WR_EastSlopeWaterResource.mxd (JP)

Some lakes, reservoirs, and stream segments within the study area would not be affected by alternative actions and are not discussed. Grand Lake, Shadow Mountain Reservoir, and Willow Creek Reservoir are part of C-BT's West Slope water collection and distribution system, but storage in these reservoirs would not change from existing conditions for any alternative. Operating criteria for Grand Lake and Shadow Mountain Reservoir require maintenance of stable water surface elevations in these reservoirs with fluctuations of less than 1 foot in accordance with Senate Document 80. The *Surface Water Quality* section addresses potential effects to Shadow Mountain Reservoir and Grand Lake from the passage of additional water through the system. Although potential new reservoirs would be located on ephemeral or intermittent streams, the existing downstream flows in these streams would be maintained by bypassing native flows. A substantial change in streamflow below new reservoirs would be unlikely, although seepage below dams could result in slightly increased flows and/or more consistent flow.

The downstream extent for resource evaluations on the West Slope is based on projected hydrologic changes under the alternatives. The change in the average monthly flow of the Colorado River, as a percentage of total streamflow, would decrease less than 10 percent downstream of the confluence with the Blue River due to gains from the contributing drainage basin and tributary inflow (Appendix Table A-14). The reaches of the Colorado River that would experience the highest percentage change in flow would be the Colorado River below Granby Reservoir downstream to the confluence of the Williams Fork River (Appendix Table A-8). The percentage change in flow would progressively decrease downstream of the confluence with the Williams Fork River due to additional tributary inflows and gains (Appendix Table A-13). Resource effects would likewise diminish downstream as flows increase and the percentage change from existing conditions decreases; thus, the study area for surface water hydrology does not extend below the Kremmling gage located downstream of the Blue River confluence. The Fraser River is not included in the study area because none of the alternatives would affect Fraser River flows. No WGFP diversions would occur in the Fraser River basin.

Because Windy Gap water is fully consumable, most Participants intend to reuse Windy Gap effluent and return flows either through nonpotable reuse systems, as an exchange supply, as return flow credit, or as augmentation water. Thus, there would be little to no net effect on East Slope streamflow if water is reused or if it is used to replace other diversions and depletions. There would be no change in flows in the South Platte River from Evans' and Fort Lupton's WWTP return flow discharges because these cities intend to use their Windy Gap return flows for augmentation of depletions. However, there would be minor changes in flows along the South Platte River downstream of the confluences with Big Dry Creek, St. Vrain Creek, and the Big Thompson River due to changes in WWTP return flow discharges by WGFP Participants. There would be no net change in Cache la Poudre River flows downstream of the City of Greeley WWTP because Greeley intends to use its Windy Gap return flows for augmentation of depletions and to offset return flow obligations. East Slope streams that would experience an increase in WWTP return flows are evaluated.

3.5.1.2 Data Sources

Hydrologic data from the U.S. Geological Survey (USGS), NCWCD, Reclamation, Colorado Division of Water Resources (CDWR), Denver Water Department, Colorado River Water Conservation District (CRWCD), the Upper Colorado River Basin Study, and WGFP Participants were used to describe existing conditions and estimate future conditions on affected streams and reservoirs. A computer model, described in Section 3.5.2.2, was used to project hydrologic changes for each alternative. Additional information on water resources is found in the Water Resources Technical Report (ERO and Boyle 2007).

3.5.1.3 Water Rights, Agreements, and Contracts

The WGFP would use the existing water right decrees and stipulations associated with the original Windy Gap Project constructed in 1985. The Windy Gap Project was awarded water right decrees for a total diversion of up to 600 cubic feet per second (cfs) from the Colorado River (Case Nos. 88CW169 and 89CW298).

The water rights decrees include the *Agreement Concerning the Windy Gap Project and the Azure Reservoir and Power Project* dated April 30, 1980, entered into by the Municipal Subdistrict-NCWCD and numerous West Slope parties, and the *Supplement to the Agreement of April 30, 1980* dated March 29, 1985, entered into by the Municipal Subdistrict-NCWCD, CRWCD, Northwest Colorado Council of Governments, Grand County Commissioners, and Middle Park Water Conservancy District. These agreements provide mitigation (described in Section 1.4.2.3) to West Slope entities from the transbasin diversion of water and associated impacts of the Windy Gap Project, and satisfy the Supreme Court ruling of September 14, 1979 that the conditional water right could not be granted until the Subdistrict formulated a plan to adequately mitigate any potential harm to prospective users within the Upper Colorado River basin as specified in Colorado Revised Statute (CRS) § 37-45-118(1)(b)(IV). In return for these mitigation measures, West Slope interests agreed to withdraw objections to the Windy Gap Project conditional water right decrees and cooperate with all the necessary permitting requirements for construction of the project. The Subdistrict has fulfilled the short-term obligations under these agreements, and is continuing to operate the Windy Gap Project in accordance with the long-term obligations of these agreements and Colorado state law.

The Municipal Subdistrict-NCWCD entered into an "Amendatory Contract for the Introduction, Storage, Carriage and Delivery of Water for the Municipal Subdistrict, Northern Colorado Water Conservancy District, Colorado-Big Thompson Project, Colorado," Contract No. 4-07-70-W0107 (Carriage Contract) with the United States of America and the NCWCD on March 1, 1990. The Carriage Contract defines the rights and obligations of the Municipal Subdistrict-NCWCD with respect to the use of the facilities of the C-BT Project to introduce, store, carry, and deliver water diverted by the Windy Gap Project. An amendment to the Carriage Contract or an additional contract may be required to implement one or more of the action alternatives in the WGFP.

In January 2007, the Colorado State Engineer (SEO) (Simpson 2007) indicated that the Proposed Action to deliver and store water in Chimney Hollow Reservoir using prepositioning could be administered in compliance with current water right decrees and within the priority system. The SEO also indicated that if Jasper East or Rockwell/Mueller Creek reservoirs were selected for construction, a change in the water right would be required to store water in a new West Slope reservoir.

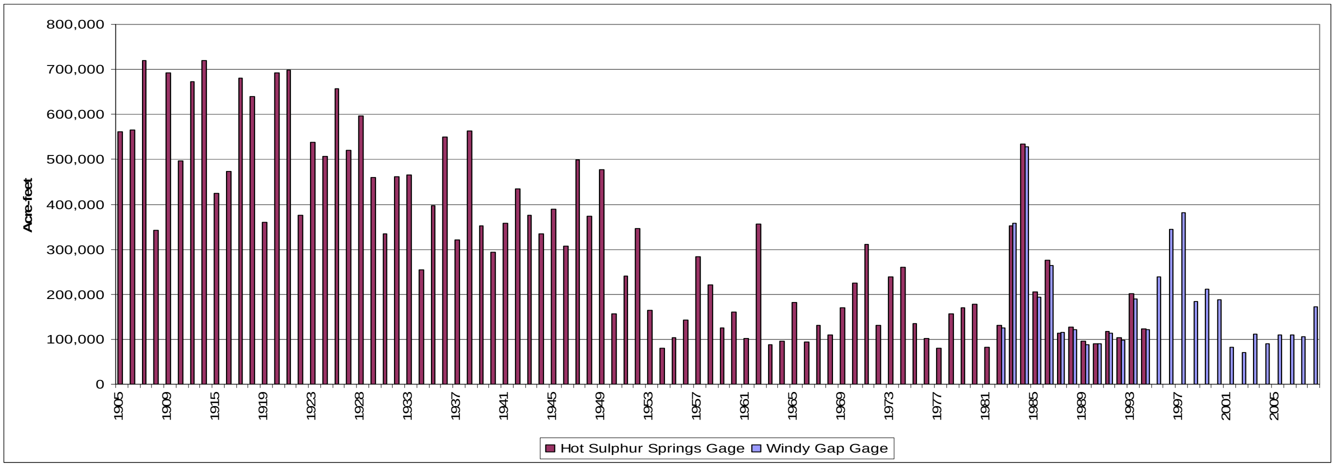
3.5.1.4 West Slope Surface Water Hydrology

Colorado River

The Colorado River study area for the hydrologic analysis starts at the outlet from Granby Reservoir and ends at the USGS gage located below the confluence with the Blue River near Kremmling, at the upstream end of Gore Canyon (Figure 3-1). The distance from Granby Reservoir to Gore Canyon is about 44 river miles and the distance from the Windy Gap Reservoir diversion to Gore Canyon is about 35 river miles. The major lakes and storage reservoirs in the Upper Colorado River watershed include Grand Lake, Shadow Mountain Reservoir, Granby Reservoir (also referred to as the Three Lakes), Willow Creek Reservoir, Williams Fork Reservoir, and Wolford Mountain Reservoir (Figure 3-1).

Average annual streamflow in the Colorado River has changed over time as a result of increased water use in the basin and transmountain diversions, as indicated by average annual historical flows at the Hot Sulphur Springs and Windy Gap USGS gages (Figure 3-3). The Hot Sulphur Springs gage was no longer operating after 1994. The Windy Gap gage is located approximately 5 miles upstream of the Hot Sulphur Springs gage; therefore, flows correlate well between those gages. For the overlapping period of record, the total annual flow at the Windy Gap gage was approximately 97 percent of the flow at the Hot Sulphur Springs gage on average. Primary water uses that have reduced Colorado River streamflow include the Denver Water Moffat Collection system, which began diversions from the Fraser River in 1937 and the C-BT Project, which included construction of Granby Reservoir and Shadow Mountain Reservoir in 1947. The Windy Gap Project began diversions from the Colorado River in 1985. Other water uses in the Upper Colorado River basin include diversions for agricultural irrigation and municipal and commercial development. Many of the irrigation diversions in Grand County and the Grand Ditch transbasin diversion began in the late 1800s. Average annual streamflow in the Colorado River at Hot Sulphur Springs between 1905 and 1949 was 486,209 acre-feet (AF) and between 1950 and 2008 streamflow averaged

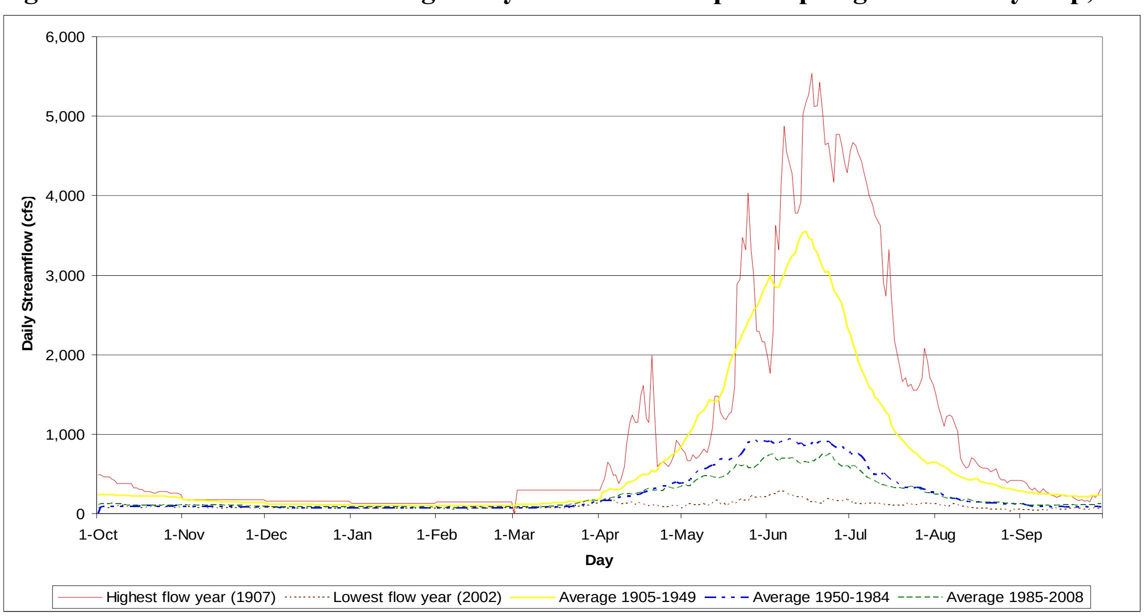
Figure 3-3. Colorado River annual flow at Hot Sulphur Springs, 1904 to 1994 and at Windy Gap from 1982 to 2008.



174,299 AF (includes Windy Gap gage data for 1995 through 2008). The lowest annual flow at the Windy Gap gage was 70,018 AF in 2002.

The Colorado River and its tributaries experience widely variable seasonal fluctuations in flows, with the largest flows resulting from snowmelt. Approximately 75 percent of the total annual flow occurs during the spring and early summer runoff period of May through mid-July. Average daily historical flow on the Colorado River at the Hot Sulphur Springs and Windy Gap gages for several time periods is shown in Figure 3-4. Averages are shown for the period prior to the C-BT Project (1905–1949), after the C-BT Project came online and prior to the Windy Gap Project (1950–1984), and after the Windy Gap Project came online (1985–2008). Average daily flow in the Colorado has decreased substantially since about 1950 as the result of the C-BT Project, the Moffat Collection System, the Windy Gap Project, and other water development in the basin. Differences in average daily flows for the different periods shown in Figure 3-4 are caused primarily by additional transbasin diversions associated with the C-BT, Windy Gap, and Moffat projects. However, there are also differences in hydrologic conditions due to irrigation, municipal, and snowmaking diversions and return flows upstream of these gages.

Figure 3-4. Colorado River average daily flow at Hot Sulphur Springs and Windy Gap, 1904 to 2008.



A number of water development and diversion projects over the past century and longer have affected flow in the Colorado River. Water use includes in-basin direct flow water uses and transbasin water export, where water from the Colorado River basin is delivered to the East Slope for municipal, industrial, and agricultural uses. Some of the existing larger water rights and uses are listed below.

In-Basin Direct Flow Water Users

- Xcel's Shoshone Hydropower Plant located downstream near Glenwood Springs, which began in 1905, with decreed rights for a total of 1,408 cfs.
- Grand County water users, most of whom began diverting water from the Fraser River, Colorado River, and Willow Creek in the early to mid-1900s, with a net absolute right for about 527 cfs on these three streams.
- The only municipal water diversion on the Colorado River within the project area is Hot Sulphur Spring's right to divert 3.34 cfs for water supply.
- Numerous diversions and water storage rights on the Williams Fork River, Muddy Creek, and Blue River, most of which began diverting water in the early to mid-1900s, with a net absolute right for about 2,400 cfs.

Transbasin Water Users

- Grand River Ditch, which began diverting in 1890, with a net absolute right for 524.6 cfs.
- The C-BT Project, which began diverting water in 1947, with decreed rights of 550 cfs at the Adams Tunnel, 1,100 cfs at Granby Pump Canal, and 400 cfs for the Willow Creek Feeder Canal.
- Denver Water, which began diverting water from the Fraser River in 1937 via the Moffat Tunnel, with a net absolute right for 928 cfs and a net conditional right for 352 cfs.
- Windy Gap, which began diverting water in 1985, with a decreed diversion right of 600 cfs.

Table 3-1 summarizes historical upstream depletions in the Colorado River at the Windy Gap gage (09034250) based on the hydrologic model study period from 1950 through 1996. Annual native Colorado River flows at the Windy Gap gage prior to water development were estimated to be 482,926 AF. Diversions by the Grand River Ditch, Moffat Tunnel, C-BT Project, Windy Gap Project, and water use in Grand County have reduced average annual flows to about 157,401 AF. Thus, about 33 percent of the native Colorado River flows at the Windy Gap gage remain following these existing diversions. Most of the diversions occur during snowmelt runoff from May to July, although some water projects divert water throughout the year.

Upper Colorado River streamflow is influenced by operation of Granby Reservoir. Completed in 1951, spills from Granby Reservoir have occurred historically from February through October, with the largest spills occurring in May and June (Reclamation 2006). The U.S. Department of the Interior developed the Principles to Govern the Release of Water at Granby Reservoir Dam to provide Fishery Flows immediately downstream in the Colorado River (Secretarial Decision Document 1961). The Principles were developed "to preserve at all times that section of the Colorado River between the reservoir to be constructed near Granby and the mouth of the Fraser River as a live stream, and also to insure an adequate supply for irrigation, for sanitary purposes, for the preservation of scenic attractions, and for the preservation of fish life." The schedule of releases from Granby Reservoir is: 20 cfs from September through April; 75 cfs from May through July; and 40 cfs in August. The bypass flow requirement may be reduced from May through September when the advanced forecast of inflow to the Three Lakes System and Willow Creek Reservoir is less than 230,000 AF (Boyle 2003, 2006a). Bypass flows were estimated to be reduced by 15 to 30 percent (as stipulated) for a portion of the period from May through August during 15 years between 1950 and 1996.

Table 3-1. Summary of average monthly depletions and flows in the Colorado River at Windy Gap for existing conditions for the model study period from 1950 through 1996 (AF).

Line #	Description	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	Native Flow at Windy Gap	13,194	9,371	8,184	7,784	6,856	8,657	28,180	113,006	172,575	73,454	26,816	14,848	482,926
2	Grand River Ditch Diversions	8	0	0	0	0	0	12	1,176	7,938	6,445	2,040	352	17,971
3	Moffat Tunnel Diversions	2,268	1,323	946	682	526	565	1,303	9,672	16,980	10,173	5,788	3,792	54,020
4	C-BT Depletions	5,096	2,531	2,428	2,570	2,101	1,991	10,326	61,245	97,609	31,767	10,788	6,128	234,579
5	Windy Gap Depletions	-9	0	0	0	0	0	4,522	17,124	-1,628	-1,168	-625	-461	17,755
6	Grand County Depletion	60	60	60	24	24	24	48	120	204	276	180	120	1,200
7	Flows at Windy Gap with Existing Conditions Depletions	5,772	5,456	4,750	4,508	4,205	6,076	11,969	23,671	51,472	25,960	8,644	4,917	157,401
8	Percent of Native Flow Volume Remaining	44%	58%	58%	58%	61%	70%	42%	21%	30%	35%	32%	33%	33%

Notes:

1. Native flow at Windy Gap was estimated to be the gaged flow at Windy Gap (1982-1996) and Hot Sulphur Springs (1950-1981) plus historical depletions (Grand River Ditch C-BT Project, Moffat Tunnel, Windy Gap, and Grand County depletions) upstream of those gages. This estimate does not include the effect of depletions associated with agricultural irrigation upstream of the Windy Gap gage.
2. Based on Hydrobase records.
3. Based on modeled diversions through Moffat Tunnel from the WGFP Model for the existing conditions scenario. Does not include Gumlick Tunnel diversions.
4. Based on data provided by the Bureau of Reclamation for 1959 through 1996. Data were not available electronically prior to 1959.
5. Based on modeled Windy Gap diversions less spills from the WGFP Model for the existing conditions scenario. Windy Gap spills include spills from Granby Reservoir and Windy Gap paper spills from Willow Creek Reservoir. Negative values occur when Windy Gap spills exceed diversions.
6. Based on existing demands of approximately 3,100 AF/yr and assumed depletion of 40% (UPCO 2003). The monthly distribution of consumptive use was estimated based on information obtained by Denver Water from Grand County water users for the UPCO Study.
7. Equals (1) - (2) - (3) - (4) - (5) - (6).
8. Equals (7)/(1).

A Memorandum of Understanding (Azure Settlement Agreement, June 23, 1980) between the Municipal Subdistrict, NCWCD, and CDOW established instream flow requirements on the 24-mile reach of the Colorado River downstream of the Windy Gap diversion to the mouth of the Blue River to support the fishery. These instream flow requirements and a periodic flushing flow include:

- From the Windy Gap diversion point to the mouth of the Williams Fork River, 90 cfs
- From the mouth of the Williams Fork River to the mouth of Troublesome Creek, 135 cfs
- From the mouth of Troublesome Creek to the mouth of the Blue River, 150 cfs
- If equivalent flows do not otherwise occur, a flushing flow release from Windy Gap Reservoir of 450 cfs for 50 consecutive hours must occur once every 3 years within the months of April, May, or June

Windy Gap Project water is diverted from the Colorado River at Windy Gap Reservoir and pumped to Granby Reservoir for storage and delivery to the East Slope via the Adams Tunnel as needed (Figure 3-1). Since Windy Gap diversions began in 1985, no water was diverted in 1986, 1996 through 2000, and 2002, and diversions occurred for only two days in 2004 because either the water rights were not in priority in dry years, or there was no storage capacity available in Granby Reservoir in wet years (Table 3-2). About 95 percent of past Windy Gap diversions occurred in May and June. The maximum Windy Gap diversion rate is 600 cfs. The greatest annual Windy Gap diversion to date was 64,200 AF in 2003, of which 90 percent of the water was diverted in May and June. The original Windy Gap Project provided for average annual diversions of 56,000 AF, with a maximum single year diversion of 90,000 AF/year and a maximum of 650,000 AF during any consecutive 10-year period. Per the 1980 Azure Settlement Agreement, these diversion limitations apply to deliveries through the Adams Tunnel, as opposed to diversions at Windy Gap Reservoir. The average annual Windy Gap diversion for 1985 through 2008 is 14,685 AF (Table 3-2). The average annual diversion for the 10-year period from 1999 through 2008 is 21,957 AF, and the average annual diversion for the period from 2001 through 2008 is 27,447 AF. Windy Gap diversions have increased in recent years because demands for Windy Gap water are higher due to growth and a greater need for reusable supplies.

Table 3-2. Historical monthly Windy Gap diversions (AF) at Windy Gap Reservoir.

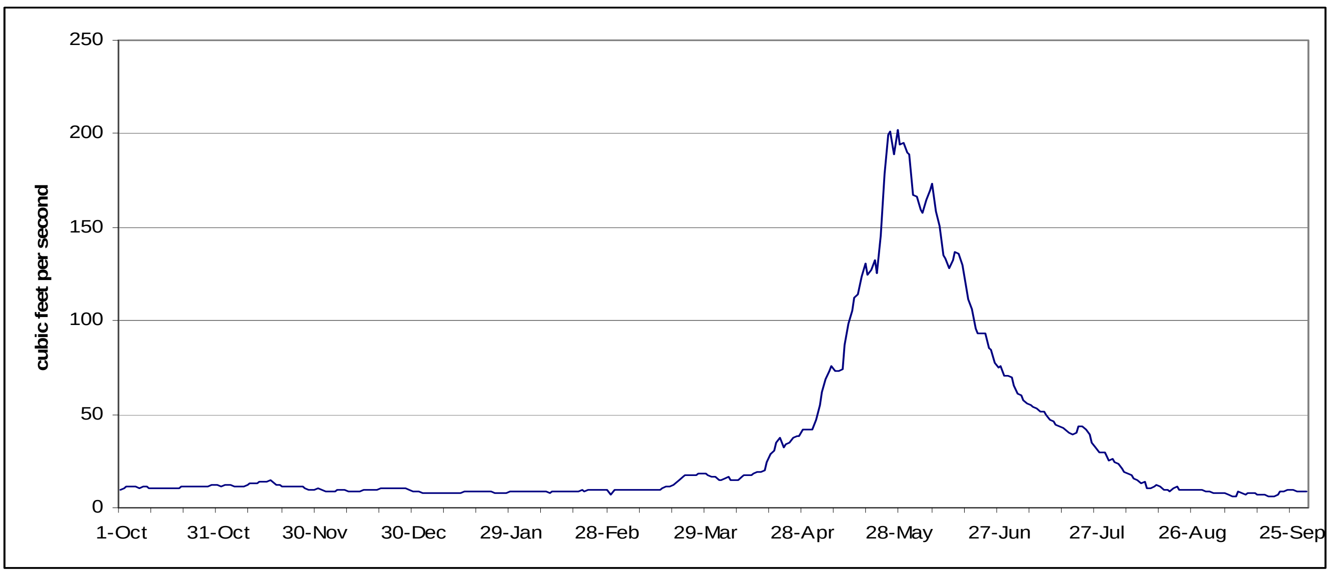
Year	April	May	June	July	Total
1985	0	488	0	2,276	2,764
1986	0	0	0	0	0
1987	0	3,730	0	0	3,730
1988	0	0	19,966	0	19,966
1989	0	0	4,036	0	4,036
1990	0	4,980	9,612	0	14,592
1991	0	0	19,303	0	19,303
1992	0	11,213	10,683	0	21,896
1993	254	11,372	10,116	0	21,742
1994	0	8,336	2,448	0	10,784
1995	0	13,620	441	0	14,061
1996	0	0	0	0	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	0	0	0	0	0
2001	58	10,300	3,892	0	14,250
2002	0	0	0	0	0
2003	6,166	27,592	30,442	0	64,200

Year	April	May	June	July	Total
2004	0	327	0	0	327
2005	3,697	18,103	19,520	0	41,320
2006		14,858	10,163		25,022
2007	7,079	21,140	12,714		40,933
2008	3,128	19,315	11,080		35,523
Minimum	0	0	0	0	0
Maximum	7,079	27,592	19,520	2,276	64,200
Average 1985-2008	886	6,891	6,851	108	14,685
Average 2001-2008					27,447

Willow Creek

Willow Creek is a tributary that enters the Colorado River about 4 miles below Granby Reservoir (Figure 3-1). The flow of lower Willow Creek is regulated by Willow Creek Reservoir, from which about 30,000 AF of water is diverted annually to Granby Reservoir via the Willow Creek Feeder Canal (WCFC) as part of the C-BT Project. Average daily flows in Willow Creek below Willow Creek Reservoir at the gage about 2.5 miles above the Colorado River confluence is shown in Figure 3-5. Four ditches are decreed to divert about 36 cfs of water from Willow Creek below the reservoir. There is a Colorado Water Conservation Board (CWCB) instream flow requirement of 7 cfs, during the nonirrigation season, for Willow Creek below Willow Creek Reservoir. However, NCWCD's current operations result in the release or bypass of at least 7 cfs below the reservoir from May 1 through September 30 to maintain a "live" stream in Willow Creek.

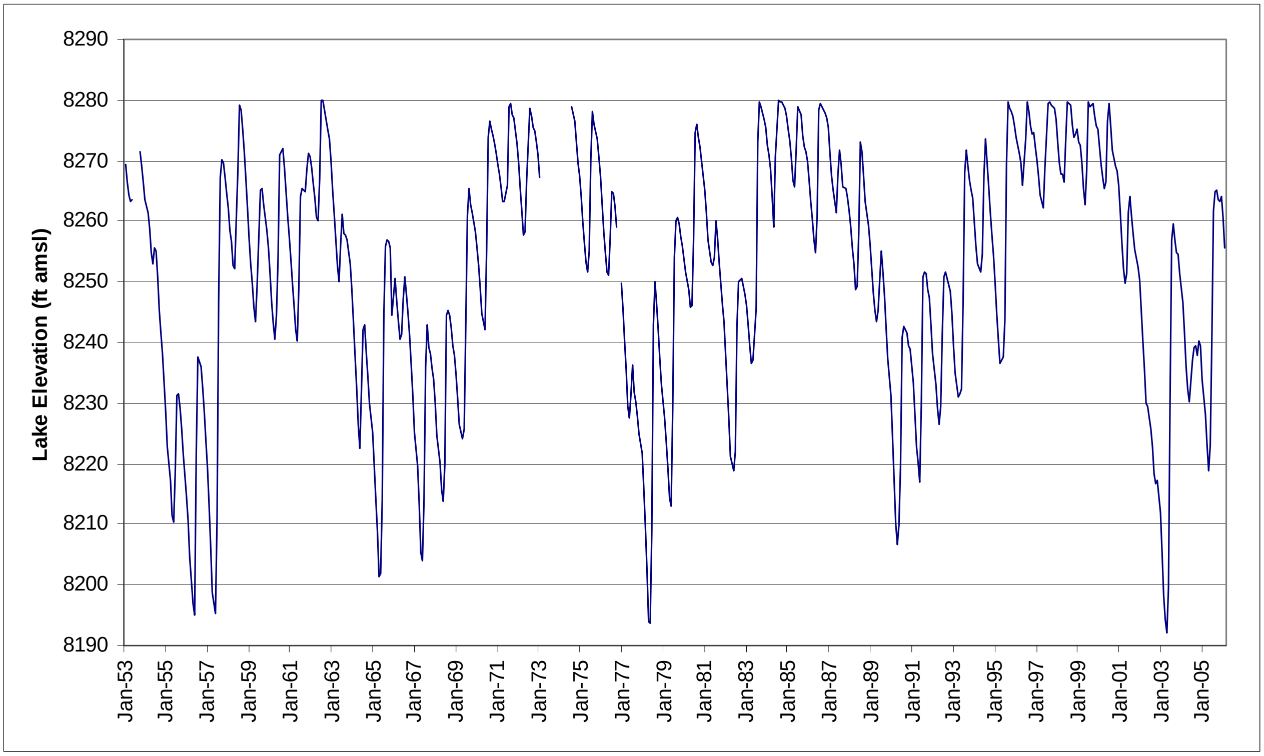
Figure 3-5. Willow Creek average daily flow, 1953 to 2004.



Granby Reservoir

With a surface area of about 7,300 acres, Granby Reservoir is the second largest reservoir in Colorado and serves as the primary storage reservoir in the C-BT system (Figure 3-1). Major tributaries flowing into the reservoir are Arapaho Creek, Stillwater Creek, Columbine Creek, and the Roaring Fork River. Water also is pumped to the reservoir from Willow Creek Reservoir and Windy Gap Reservoir. Granby Reservoir is currently the only C-BT reservoir in which Windy Gap water can be stored. Outflow is either through spills or releases to the Colorado River or to Shadow Mountain Reservoir via the Farr Pumping Plant and Granby Pump Canal and eventually through the Adams Tunnel to the East Slope. The surface water elevation of the reservoir can vary considerably depending on precipitation and operations (Figure 3-6).

Figure 3-6. Granby Reservoir historical elevations, 1953 to 2006.



Jasper East Study Area

The Jasper East Reservoir site contains an unnamed intermittent stream tributary to Church Creek, which is tributary to Willow Creek (Figure 3-1). Precipitation and snowmelt are the main sources of water supply in the 960-acre watershed, but natural flows are supplemented by irrigation return flow and seepage from the Willow Creek Pump Canal and forebay. No historical gage flow data for this drainage are available.

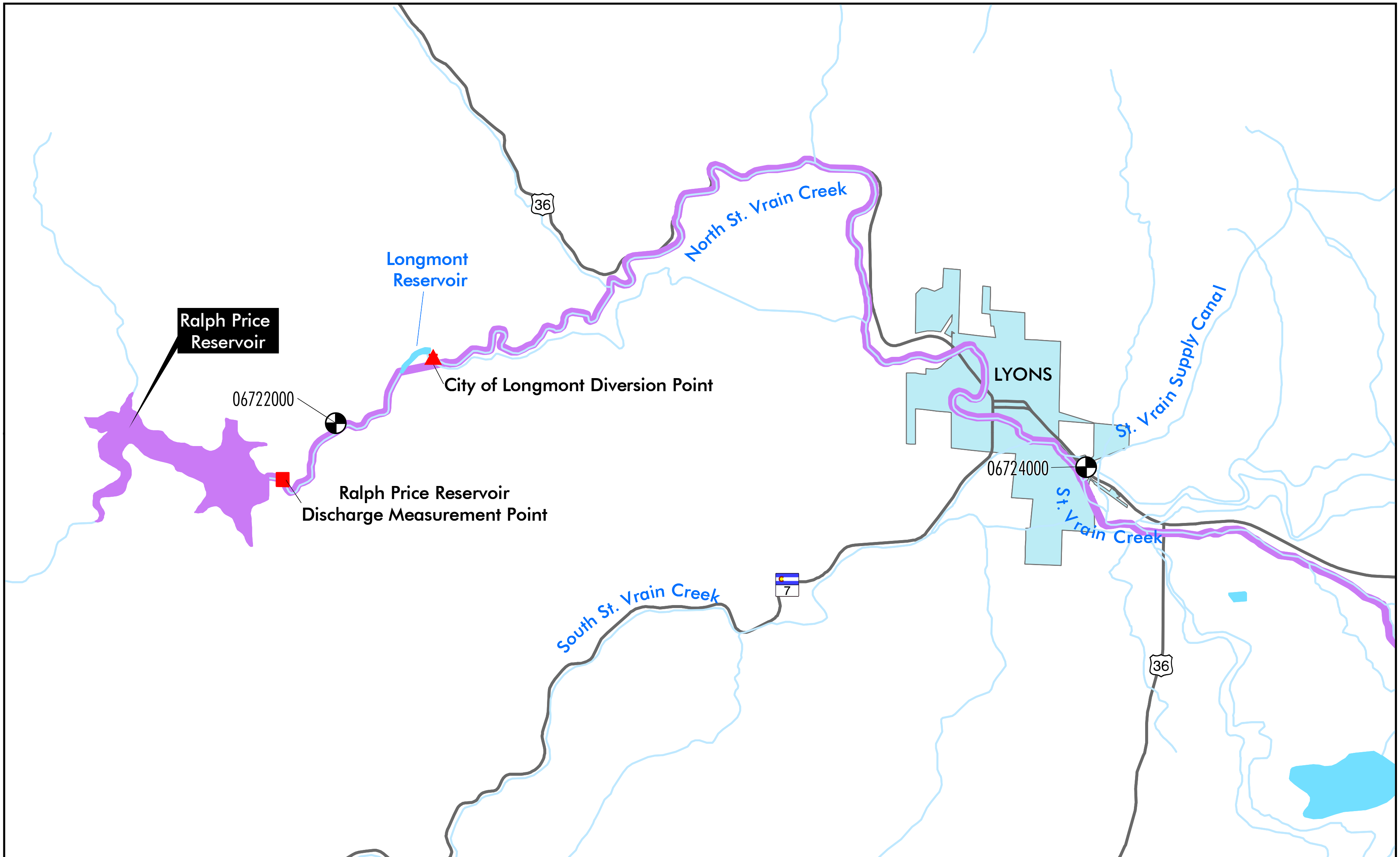
Rockwell/Mueller Creek Study Area

Rockwell and Mueller creeks flow intermittently through the Rockwell/Mueller Creek Reservoir site (Rockwell) (Figure 3-1). Precipitation and snowmelt are the main sources of water supply to these creeks in this 1,360-acre watershed. No historical gage flow data for either stream are available.

3.5.1.5 East Slope Surface Water Hydrology

North St. Vrain Creek and St. Vrain Creek

North St. Vrain and St. Vrain creeks are perennial streams with headwaters at the Continental Divide (Figure 3-7). Streamflow typically peaks in June from snowmelt runoff. North St. Vrain Creek flow is influenced by releases from Ralph Price Reservoir, diversions by the City of Longmont at Longmont Reservoir, and diversions by others downstream of these reservoirs. City diversions average about 6 to 7 cfs from November to March and 10 to 20 cfs during other months. Longmont voluntarily bypasses up to 8 cfs below Ralph Price Reservoir and there is a junior CWCB 21 cfs minimum streamflow right for all of North St. Vrain Creek (CDWR 2007). St. Vrain Creek begins at the confluence of North and South St. Vrain creeks near the Town of Lyons and flows about 40 miles to its confluence with the South Platte River.



ERO
ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: (303) 830-1199

USGS Stream Gaging Station and Water Quality Monitoring Location
Lake or Reservoir
Study Area Reservoir
Study Area Stream
Streams
City
Highway

0 0.5 1
Miles
1 Inch = 1 Mile
N

Figure 3-7
North St. Vrain and St. Vrain Creek below Ralph Price Reservoir

Prepared for: Windy Gap Firming Project
File: 2390 WR_StVrain_No_Action_Impacts.mxd (JP)

Big Thompson River

The Big Thompson River, a large tributary to the South Platte River, is a perennial stream about 75 miles long, with headwaters in Rocky Mountain National Park (Figure 3-2). The C-BT Project diverts Big Thompson River water at Lake Estes via the Olympus Tunnel and at Dille Tunnel near the canyon mouth for power generation and returns the water to the Big Thompson River at the Big Thompson Power Plant. The C-BT Project also diverts Big Thompson River water under its direct flow water rights at Olympus and Dille tunnels for storage in Carter Lake and Horsetooth Reservoir.

Coal Creek and Big Dry Creek

Coal Creek is a small perennial stream with a watershed that flows from the Continental Divide east through the communities of Superior, Louisville, Lafayette, and Erie. Coal Creek is a tributary to Boulder Creek (Figure 3-2). Big Dry Creek, a small perennial stream about 25 miles long, begins in the foothills west of Rocky Flats and flows northeast to its confluence with the South Platte River. Both of these creeks receive wastewater discharges from several WGFP Participants.

Chimney Hollow

Chimney Hollow is a small, intermittent stream located in a 3,000-acre watershed (Figure 3-2). Several ephemeral drainages, some of which contain springs and seeps, flow into Chimney Hollow. Chimney Hollow flows into Flatiron Reservoir, which is part of the C-BT Project distribution system. There are no historical gage flow data for Chimney Hollow Creek.

Dry Creek

Dry Creek is a small stream with intermittent flow from a 2,530-acre watershed (Figure 3-2). Seeps and springs, as well as rainfall and snowmelt, contribute to streamflow. Dry Creek is a tributary to the Little Thompson River. No historical gage flow data for Dry Creek are available.

Ralph Price Reservoir

Ralph Price Reservoir is the primary water supply for the City of Longmont (Figure 3-2). The reservoir stores water from North St. Vrain Creek. The 227-acre reservoir is operated so that it is typically full from June until October. The storage contents then drop to about 75 percent of capacity by March and the reservoir refills during spring runoff.

Carter Lake

Carter Lake is a 1,110-acre reservoir owned by Reclamation and operated and maintained by the NCWCD as part of the C-BT Project (Figure 3-2). The reservoir supplies water to various Front Range and eastern plains cities and water districts, and the agricultural community in Boulder, Larimer, and Weld counties. Water for the reservoir is supplied by transmountain diversions from the Upper Colorado River and the Big Thompson River. C-BT and Windy Gap water is delivered to Carter Lake by pumping water from Flatiron Reservoir. Deliveries to C-BT and Windy Gap unit holders from Carter Lake are released to the St. Vrain Supply Canal and the Southern Water Supply Pipeline.

Horsetooth Reservoir

Horsetooth Reservoir supplies water to the City of Fort Collins and the City of Greeley, as well as several other smaller cities, water districts, rural domestic suppliers, industries, and the agricultural community in the Poudre River basin (Figure 3-2). Horsetooth Reservoir is owned by Reclamation and is operated and maintained by the NCWCD as part of the C-BT Project. Transmountain water from the West Slope and Big Thompson River is delivered to Horsetooth Reservoir via the Hansen Feeder Canal. The main outlet is through Horsetooth Dam to the Poudre River via the Hansen Supply Canal.

3.5.1.6 Hydropower Generation

The C-BT Project includes six hydroelectric power generation facilities. All of the facilities are located on the East Slope except the Green Mountain Power Plant, which is below Green Mountain Reservoir on the Blue River.

The five power plants on the East Slope generate power as water is conveyed from Grand Lake via the Adams Tunnel and multiple pipelines, siphons, tunnels, forebays, and afterbays. The Marys Lake Powerplant south of Estes Park is the first East Slope facility and has a generating capacity of about 8.1 megawatts (MW). From here water is delivered through the Prospect Mountain Conduit and Tunnel to the Estes Powerplant on Lake Estes. The Estes Powerplant has a generating capacity of 45 MW. Water from Lake Estes is released through the Olympus Siphon and Tunnel and Pole Hill Tunnel and Canal to the Pole Hill Powerplant which has a capacity of 33.3 MW. Water in the Big Thompson River is also used to generate power at the Big Thompson Power Plant located about 9 miles west of Loveland. This facility has a generating capacity of 4.5 MW. From the Pole Hill Power Plant, water is conveyed to the Flatiron Power Plant located near Carter Lake. The Flatiron facility has a generating capacity of 71.5 MW.

The power produced by C-BT operations, including power generated by the additional water conveyed through the CB-T system as a result of the Windy Gap Project, is distributed and marketed by the Department of Energy's Western Area Power Administration (Western). Western sells power in Colorado, Wyoming, eastern Nebraska and northeastern Kansas to wholesale customers such as towns, rural electric cooperatives, and irrigation districts.

3.5.2 Environmental Effects

3.5.2.1 Issues

Water resource issues identified during scoping were the potential impact to the Colorado River, Fraser River, and South Platte River basins from alterations in the quantity and timing of flows. Concerns were expressed on the effect to minimum instream flows, water rights, and the amount of water remaining on the West Slope. Potential changes in existing reservoir water levels and operation and any new reservoirs were expressed as a concern. Other issues included potential changes in East Slope streamflows and reservoir operations and the ability of the WGFP to meet firm yield needs.

3.5.2.2 Method for Effects Analysis

A water allocation computer model was used to analyze the WGFP alternatives and to estimate the amount of Windy Gap water that could reliably be delivered. Two models were used—the Boyle Engineering Stream Simulation Model (BESTSM) was used in conjunction with the Upper Colorado Water Resource Planning Model from the Colorado Decision Support System (CDSS Model). BESTSM focuses on East Slope facilities and operations and the CDSS Model focuses on the representation of the Colorado River basin on the West Slope. A brief discussion on model operation is given below, but more detailed information on the model configuration, parameters, and assumptions is found in the Windy Gap Firming Project Modeling Report, the Addendum to the WGFP Modeling Report, and the WGFP Water Resources Technical Report (Boyle 2003, 2006a; ERO and Boyle 2007).

> The hydrologic model used the 47-year hydrologic record from 1950 to 1996, which contains a range of dry, wet, and average years.

A model study period of 1950 to 1996 was used. The 47-year study period contains a mixture of dry, wet, and average years, reflective of the range of historical hydrologic conditions. The study period includes the operation of the C-BT Project, which was in full operation by 1954. The study period ends in 1996 because at the time the model was developed, CDSS Model data were only available to this date. Extension of the model period through 2002, which was an extreme drought year, was evaluated, but the WGFP alternatives do not impact flows in severe drought years like 2002 because Windy Gap water rights would not be in priority. The addition of a WGFP reservoir would not change Windy Gap diversions in a dry year. The current model study period from 1950 through 1996 includes several series of dry years followed by wet years, which illustrate the effects of increased diversions to refill Windy Gap firming storage. The model study period is suitable for estimating hydrologic effects associated with the EIS alternatives for both direct effects and cumulative effects because it includes a broad range of average, wet, and dry years, and sequences of years that include dry years followed by wet years.

Three model configurations—historical, baseline, and future conditions—were developed. The historical model configuration was used to calibrate the model and accurately simulate C-BT and Windy Gap operations under historical conditions. The baseline model was used to simulate existing conditions, the No Action Alternative, and action alternatives for the direct effects analysis. The baseline model was then used to analyze the effects of each alternative and make comparisons against existing conditions. The future conditions model was used to evaluate reasonably foreseeable actions for the cumulative effects analysis.

The amount of firming storage requested by Platte River Power Authority (Platte River) and the City of Loveland changed after the modeling was completed for the Draft EIS. Platte River decreased their firming storage request by 1,000 AF from 13,000 AF to 12,000 AF and Loveland increased their firming storage request by 1,000 AF from 6,000 AF to 7,000 AF. The total firming storage requested by all Participants (not including MPWCD) remains at 87,180 AF; however, 1,000 AF of storage has been shifted from Platte River to Loveland. Because there is no change in the total storage requested by the Participants, the effects of this change on model results including Windy Gap diversions and streamflow on the East and West Slopes was negligible. The model was used to estimate streamflow and stream stage for the Colorado River, Willow Creek, and Big Thompson River below Lake Estes. The model also was used to estimate reservoir volumes, surface area, and elevation for Granby Reservoir, Carter Lake, and Horsetooth Reservoir. Similar reservoir data were generated for potential new reservoirs.

A separate analysis was used to estimate changes in streamflow for East Slope streams, including North St. Vrain and St. Vrain creeks for the No Action Alternative and other streams for all alternatives that are expected to receive additional flows below Participant WWTPs. Projected streamflow changes to North St. Vrain Creek and upper St. Vrain Creek were based on historical releases from Ralph Price Reservoir, projected exchanges of Windy Gap water from the St. Vrain Supply Canal to Ralph Price Reservoir, and the City of Longmont's projected Windy Gap water demand and associated releases from Ralph Price Reservoir (ERO and Boyle 2007). For streams projected to receive an increase in WWTP return flow from additional Windy Gap municipal water use, including the Big Thompson River, St. Vrain Creek, Big Dry Creek, and Coal Creek, estimates were made of the average and maximum streamflow increases likely to occur below Participant WWTP locations (Boyle 2006b). Should Participants change their share of storage in a new reservoir as previously described for Platte River and the City of Longmont (Section 1.8.2), the amount of return flow to the various East Slope streams below WWTPs could vary slightly from the values used in this analysis.

Existing Conditions

> Existing hydrologic conditions on the Colorado River reflect current facility operations, water rights, instream flow rights, and existing Windy Gap diversions based on current demands.

The existing conditions scenario reflects current conditions, including facilities, operations, consumptive and nonconsumptive water rights, instream flow rights, demand levels, operating rules, and other water management considerations and preferences throughout the Colorado River basin in Colorado. The existing conditions scenario reflects the existing Windy Gap Project simulated over the 47-year study period under current Windy Gap demands. The existing conditions scenario provides the basis for comparison against the action alternatives to assess hydrologic effects of the firming alternatives. The action alternatives are compared against modeled existing conditions as opposed to historical data for the following reasons:

- Demands have changed considerably over the course of the model study period,
- Certain facilities and reservoirs were not in operation for the entire model study period.
- River administration and project operations have changed over the course of the model study period.
- Model data were used for comparative purposes to better describe current operations.

As shown in Table 3-3, the total annual existing conditions demand for Windy Gap water was estimated to be approximately 21,100 AF. Each Windy Gap unit owner's current demand for Windy Gap water was based on their average Windy Gap and in-lieu deliveries[1] during the 5-year period from 2000 through 2004. Windy Gap deliveries during that period reflect the current ownership of Windy Gap units and the manner in which Windy Gap water is typically used (timing and amount) to meet each owner's water requirements. Some Participants have recently sold Windy Gap units, acquired other water supplies, developed reuse systems, or developed other uses for Windy Gap return flows. These changes were taken into account when developing the existing conditions demand for Windy Gap water.

Table 3-3. Summary of Windy Gap demands for existing conditions and the No Action Alternative.

Windy Gap Owner	Existing Conditions Demand (AF/yr)	No Action Demand (AF/yr)
Participants		
Broomfield	5,600	5,600
CWCWD	47	100
Erie	1,265	2,000
Evans	500	500
Fort Lupton	0	300
Greeley	2,982	4,400
Lafayette	0	0
LTWD	0	1,200
Longmont	3,500	8,000
Louisville	34	900
Loveland	116	4,000
Platte River	5,150	5,150
Superior	1,495	1,500
MPWCD	147	3,000
Subtotal	**20,836**	**36,650**
Non-Participants		
Boulder	100	3,700
Left Hand	63	100
Estes Park	61	300
Subtotal	**224**	**4,100**
TOTAL	**21,060**	**40,750**

No Action Alternative

The No Action Alternative reflects what is reasonably likely to occur with continuation of the existing contractual arrangement between Reclamation and the Subdistrict for the delivery of Windy Gap water through the C-BT

[1] The existing Windy Gap Amendatory "Carriage" Contract between Reclamation, and the Municipal Subdistrict, Northern Colorado Water Conservancy District provides for the delivery of C-BT water to Windy Gap allottees in-lieu of Windy Gap water, also known as "borrowing." The borrowed water must be paid back with no injury to C-BT unit holders. The borrowed water is paid back with Windy Gap water when sufficient supplies exist.

system without a new or amended contract for additional connection of new Windy Gap Firming infrastructure to C-BT facilities.

Windy Gap diversions from the Colorado River under the No Action Alternative would be higher in the future as demand increases. Windy Gap diversions can increase within existing infrastructure and the contract with Reclamation without the WGFP.

In the WGFP model, the No Action Alternative reflects the existing Windy Gap Project simulated over the 47-year study period under future Windy Gap demands. With the exception of Platte River, the average annual demand for each Windy Gap owner was based on the number of Windy Gap units owned or leased by that user multiplied by 100 AF/unit. Under the original Windy Gap Project, each unit of Windy Gap water represents a yield of up to 100 AF. Although Platte River owns 160 Windy Gap units, their average annual demand was assumed to be 5,150 AF, which is similar to their existing conditions demand because PRPA indicated that is their build-out demand for Windy Gap water. As shown in Table 3-3, the total annual demand under the No Action Alternative was estimated to be approximately 40,750 AF.

The No Action Alternative demand reflects both the Participants' future water needs and the manner in which the Windy Gap Project would operate without firming storage on-line. The Participants' demands under the No Action Alternative are higher than existing conditions and the action alternatives because Participant's water needs are anticipated to increase in the future and the Windy Gap Project can increase diversions with existing infrastructure without modification to the existing contract with Reclamation. In addition, since there is no firm yield associated with Windy Gap supplies without firming storage on-line, the Participants would maximize their Windy Gap deliveries when available because that water could be spilled from Granby Reservoir in subsequent wet years.

WGFP Model Forecasting Function

The annual decision to pump Windy Gap water takes into consideration many factors including, but not limited to, Granby Reservoir contents (C-BT and Windy Gap), Colorado River basin forecasts based on snowpack and precipitation, Big Thompson River basin forecasts, and orders for Windy Gap water. A forecasting function, which considers these factors and reduces Windy Gap diversions when Granby Reservoir is anticipated to fill, was considered for the WGFP model. However, a forecasting function was not incorporated in the model because it would require making a number of assumptions regarding the variables that influence Windy Gap pumping. Because of the variability and number of factors involved in the decision to pump Windy Gap, a forecasting function was considered impractical for incorporation in the model.

Forecasting does not eliminate Windy Gap spills as evidenced by historical Windy Gap spills in 1995 and 1996. For example, Windy Gap water was pumped in May and June of 1995, yet Granby Reservoir spilled in July that year. As the model is currently configured without a forecasting function, Windy Gap diversions occur as long as storage space in Granby Reservoir is available. Windy Gap operations were simulated in this manner to present the maximum amount of water that could be diverted with the project's current water rights to meet demands even if a portion of the water is subsequently spilled from Granby Reservoir back to the Colorado River. As a result, modeled Windy Gap diversions may be higher in some wet years than they would be under expected operations. In the model, when Granby Reservoir fills and spills in wet years, Windy Gap water pumped in April and May is often spilled in June and July. In effect, early season Windy Gap diversions are re-timed as spills later in the season. This only occurs in wet years when Granby Reservoir fills. Spills occur less frequently under the action alternatives because Windy Gap diversions would be stored in firming reservoirs as opposed to Granby Reservoir.

The lack of a forecasting function in the WGFP model may overstate Windy Gap diversions and consequently spills in some wet years primarily under existing conditions and the No Action Alternative. In addition, Willow Creek Feeder Canal diversions may be understated in some wet years under existing conditions and No Action. The stretch of the Colorado River below Granby Reservoir downstream to the Windy Gap diversion is most affected by this issue; however, the impact analysis for this reach is conservative. Flows in this reach may actually see less flow reduction than predicted by the WGFP model because of the overestimate of spills in June through August under existing conditions and No Action.

Forecasting has little effect on the impact analysis below the Windy Gap diversion. The change in streamflow below the Windy Gap diversion under the alternatives compared to existing conditions reflects the increase in net depletions due to the difference in Windy Gap diversions from the Colorado River and spills from Granby Reservoir. The net depletions to the Colorado River associated with pumping Windy Gap water equal Windy Gap diversions minus Windy Gap spills since that water is returned to the Colorado River. Pumping Windy Gap water that is later spilled is a re-timing of flows, not a depletion to the river. A considerable portion of Windy Gap water diverted from the Colorado River, primarily in wet years, is delivered back to the river via a spill under the existing conditions and No Action scenarios. Forecasting Granby Reservoir spills does not affect Windy Gap diversions in dry years; therefore, Windy Gap pumping, net depletions to the Colorado River, and associated impacts are appropriately estimated in dry years, which are typically more critical for aquatics, water quality, and other flow-related resources.

Use of Daily and Monthly WGFP Model Data for Resource Evaluations

The model operates on a monthly time step for the entire study period; however, daily data are useful for evaluation of effects for some resources. Thus, monthly data were disaggregated to daily values based on historical USGS records (Boyle 2005c), although a modified approach was used to disaggregate monthly flows below Granby Reservoir in spill months because of the variability in the amount, timing, and duration of spills. See Section 4.2.4 in the Windy Gap Firming Project Water Resources Technical Report (ERO and Boyle 2007) for a detailed discussion of the process used to disaggregate monthly model output. Daily streamflows were generated using daily disaggregation factors for the entire 47-year study period for the USGS gages on the Colorado River below Granby Reservoir, below Windy Gap, at Hot Sulphur Springs, and near Kremmling, and Willow Creek below Willow Creek Reservoir. Daily disaggregation factors were developed for each day that data were available during the study period. The percentage of flow that occurred on that day (daily percentage) was calculated as the daily flow divided by the total flow that occurred in the corresponding month. Average, wet, and dry daily hydrographs also were generated using average daily disaggregation factors. Average daily disaggregation factors were calculated for each day of the year as the average of all daily percentages available for that day.

A combination of monthly and daily hydrologic data were used for flow-related resource evaluations. A description of the hydrologic data used for each flow-related resource is provided in Table 3-4. Appendix A includes hydrologic model output and comparisons of changes in streamflow, stream stage, reservoir elevation and area, and other parameters for each of the alternatives. Average monthly summaries of flows, diversions, reservoir outflow, end-of-month storage contents, water surface elevations, and surface areas for average, wet, and dry conditions were relied on to generally characterize hydrologic changes associated with the alternatives. Daily data were used to generate flow duration curves and daily hydrographs, for flood frequency analyses, and to determine the frequency and magnitude of daily flow changes. Hydrologic analyses based on daily variations were used in resource assessments where the magnitude or value of the resources are especially sensitive to daily hydrologic changes and where the use of average, wet, and dry monthly values would mask the severity of the effects on those resources.

Table 3-4. Use of hydrologic data for the evaluation of resource impacts.

Purpose	Applications	Data Source	Period of Record or Years (POR)	Rationale	Output Examples
Hydrologic Effects	Evaluate hydrologic effects of alternatives	CDSS/BESTSM hydrologic models (monthly model output).	1950–1996	Hydrologic modeling based on historical gaged records for a period of 47 years that provides a reasonable range of average, wet and dry years.	Appendix A Tables
	Generation of daily streamflow data for the Colorado River and Willow Creek	Monthly model output was disaggregated into daily values using corresponding USGS daily records for each of the days in the period of record for gages: below Granby Reservoir, Hot Sulphur Springs, Colorado River near Kremmling, and Willow Creek. Some adjustments were needed to the below Granby Reservoir gage to account for the variability of spills from Granby Reservoir.	1950–1996	Daily values can be reasonably developed by disaggregating monthly flows in the same pattern as historical daily flows. For example, modeled flows for June 15, 1965 (or any other day in the POR) would be the same percentage of monthly flows as actually occurred on that date from historical records. These data were used to estimate the magnitude and percentage of time that flows would change on a daily basis by alternative.	Figure 3-13, Tables 3-6 to 3-8
	Average annual streamflows	Monthly model output.	1950–1996	Annual summary of monthly data provides a big picture comparison of alternatives.	Table 3-6
	Average annual dry year streamflows	Monthly model output for the five driest years in the 1950–1996 POR.	1954, 1966, 1977, 1981, 1989	Indication of hydrologic effect of alternatives in dry years.	Table 3-7
	Average annual wet year streamflows	Monthly model output for the five wettest years in the 1950–1996 POR.	1957, 1983, 1984, 1986, 1995	Indication of hydrologic effect of alternatives in wet years.	Table 3-8
	Average annual Windy Gap diversions	Water demand for WGFP Participants was based on existing demands and historical average deliveries for the 5-year period from 2000 through 2004 with adjustments specific to Participant circumstances.	2000-2004 Participant demand and deliveries	This rationale is consistent with actual water deliveries, including more recent Participant deliveries from 2005 to 2008 of 21,000 AF/year, which is representative of existing conditions.	Table 3-6, (Windy Gap diversions)
	Granby Reservoir elevation, storage, and surface area	Monthly model output.	1950–1996	Monthly data provide a reasonable representation of changes in reservoir conditions, which do not change substantially on a daily basis.	Figures 3-17; Table A-21 and A-22

Purpose	Applications	Data Source	Period of Record or Years (POR)	Rationale	Output Examples
	Streamflow changes for North St. Vrain Creek, and St. Vrain Creek	Monthly model output and historical gage records.	1950–1996	Monthly changes in streamflows below Ralph Price Reservoir are based on changes in Windy Gap exchanges to the reservoir and Windy Gap releases from the reservoir.	Table 3-15
	Streamflow changes for St. Vrain Creek at Longmont and LTWD, Big Dry Creek, Big Thompson River, and Coal Creek below Participant WWTPs	Monthly model output and historical gage records (Boyle Engineering 4-12-2006 Memorandum).	1950–1996	Increased streamflows are based on estimated increases in flow below Participant WWTPs. Streamflow increases are generally small in relation to existing flows and, hence, monthly values provide a reasonable estimate of the magnitude of change.	Tables 3-16, 3-17
	Big Thompson River below Lake Estes	Monthly model output.	1950–1996	The BESTSM output models changes in deliveries through the C-BT system including diversions into the Dille and Olympus tunnels. Because flow changes are small relative to existing streamflow, monthly data provide adequate information for comparing alternative effects.	Table A-7
	Carter Lake, Horsetooth, Chimney Hollow, Dry Creek, and Ralph Price reservoirs	Monthly model output.	1950–1996	Monthly data provided a reasonable representation of changes in reservoir conditions, which do not change substantially on a daily basis.	Figures 3-18; Tables A-17 and A-19
Stream Morphology	Evaluation of flow changes that could affect Colorado River and Willow Creek stream morphology	Monthly model output disaggregated into daily values.	1950–1996	Daily data for this period provided an indication of changes in the range of daily flows and flow frequencies.	—
	Changes in the duration and frequency for a given flow	Monthly model output disaggregated into daily values	1950–1996	Daily data were used to provide a comparison of the duration that flows of different amounts occur.	Figure 3-32 and Figure 3-33
	Changes in the frequency of flushing flows	Monthly model output disaggregated into daily values	1950–1996	Daily data indicate the frequency of days that flushing flows >450 cfs occur below Windy Gap.	Table 3-34

Purpose	Applications	Data Source	Period of Record or Years (POR)	Rationale	Output Examples
	Changes in channel maintenance flows	Monthly model output disaggregated into daily values	1950–1996	Daily data are used to evaluate the recurrence interval for Colorado River flows of various magnitudes that are needed to support channel maintenance.	Table 3-32 and Figure 3-34
Water Quality	Colorado River nutrients and metals	The EPA's QUAL2K water quality model was run under two conditions: 1) using average July 25 streamflow and 2) using WGFP diversions to the minimum flow of 90 cfs below Windy Gap Reservoir.	1950–1996 (average July 25 flow)	July 25 was used to represent conditions when streamflows are low and a time when WGFP diversions could occur in the future.	Figure 3-55 to Figure 3-63
	Colorado River temperature	Dynamic temperature model was run for June through September to evaluate effects on river temperatures.	Daily data for 1975, 1979, 1986, 1987, 1988 (simulated)	June through September was evaluated to cover the entire period of concern for river temperatures below Windy Gap.	Figure 3-48 to Figure 3-53
	Willow Creek	Hydrologic data for average flows on July 15 were used as input into the SSTEMP temperature model.	1950–1996 (average July 15 flow)	As with the Colorado River, mid- to late-July represents a period when flows are typically low and summer air and stream temperatures are high.	Section 3.8.2.4 Willow Creek
	Willow Creek	Monthly model output for water quality parameters other than temperature for mass balance calculations.	1950–1996	Average monthly flows are adequate for assessing acute and chronic water quality effects.	Table 3-99
	East Slope streams	Monthly model output for water quality parameters for mass balance calculations.	1950–1996	Average monthly flows are adequate for assessing acute and chronic water quality effects.	Table 3-79 to Table 3-83
	Grand Lake, Shadow Mountain, and Granby Reservoir water quality	Monthly model output disaggregated into daily values for a 15-year period were used as input for the Three Lakes water quality model to evaluate water quality effects.	1975–1989	The 15-year hydrologic period of record was determined to be representative of the 47-year period used for other hydrologic modeling. Daily data for this period provided a reasonable estimate of the range of potential effects to water quality parameters in the reservoirs.	Table 3-50 to Table 3-55

Purpose	Applications	Data Source	Period of Record or Years (POR)	Rationale	Output Examples
	Carter Lake, Horsetooth Reservoir, and all potential new reservoirs	Monthly model output aggregated into monthly values and water quality output from the Three Lakes Model were use as input for the BATHTUB reservoir water quality model.	1975–1989	The model is based on annual input variables to estimate potential effects to water quality.	Table 3-86 to Table 3-89
Aquatic Resources	Evaluation of changes in aquatic habitat for the Colorado River and Willow Creek	Monthly model output disaggregated into daily values were used to generate average, wet, and dry daily flows which provided input to the River 2D Model, which analyzes potential changes in fish habitat using the IFIM.	1950–1996	Daily hydrologic data are required as the input parameter for the River2D Model. Use of daily data for average, wet, and dry conditions provided an indication of the overall range and frequency of aquatic habitat changes. In addition, daily data from the five wettest and five driest years were evaluated to identify habitat impacts under those conditions.	Figure 3-98 to Figure 3-103
	Evaluation of impacts in Three Lakes, Carter Lake, Horsetooth Reservoir, Ralph Price Reservoir, and potential new reservoirs	Monthly model output.	1950–1996	Average monthly reservoir elevations and fluctuations, along with an evaluation of wet and dry year hydrologic periods provided sufficient data for assessment of potential effects to fish.	Table A-17, 19
	East slope streams	Same as for hydrologic effects for East Slope.	1950–1996	Anticipated flow changes below Participant WWTPs provided sufficient information for a qualitative evaluation of impacts to aquatic species.	—
Recreation	Evaluation of changes in preferred recreational boating flows in the Colorado River	Monthly model output disaggregated into daily values.	1950–1996	Daily hydrologic data for the 47-year period were compared to various preferred flow ranges for kayaking and rafting to determine changes in the number of preferred boating days for each of the alternatives.	Table 3-144, Table 3-146, and Table 3-147

Coordination of Hydrologic Effects Assessments for the WGFP and Denver Water's Moffat Collection System Project

The hydrologic effects assessments for the WGFP and Denver Water's Moffat Collection System Project (Moffat Project) were coordinated because these projects have overlapping study areas and affect flows in the Upper Colorado River basin. The WGFP and Moffat Project used similar surface water allocation computer models to develop hydrologic information for analysis of their respective EIS alternatives. The Platte and Colorado Simulation Model (PACSM) was used for the Moffat Project EIS, whereas the WGFP model was developed using BESTSM and the CDSS Model. PACSM, BESTSM, and the CDSS Model all incorporate a "direct solution algorithm" versus models that optimize allocation of water among competing uses. The direct solution algorithm uses the following process to allocate water to a diversion, instream flow, or reservoir based upon physically available river flow, legally available flow, decreed right, delivery capacity, and demand.

- Water availability is determined at each node.
- The most senior direct, instream, storage, well, or operational water right is identified.
- Diversions are estimated to be the minimum of the decreed water right, structure capacity, demand, and available flow in the river.
- Downstream flows are adjusted to reflect the senior diversion and its return flows.
- Return flows for future time periods are determined.
- Well depletions for future time periods are determined.
- The process is repeated by priority for each successive direct, instream, storage, well, and operational water rights for each time step of the study period.

The WGFP model operates on a monthly time step. PACSM was originally developed to operate on a monthly time step, but is now operated on a daily time step to simulate diversions and operations in a broad geographic area involving many small streams and daily modifications to operations. The change to a daily time step was in response to numerous minimum flow requirements below their diversion points, multiparty exchange agreements, and other factors. The WGFP is supplied by a single point of diversion on a larger stream that, while affected by downstream flow requirements, is not subject to the multitude of daily operational decisions that affect Moffat Project operations now and into the future. While PACSM is a daily time step model, some input to that model was derived based on a disaggregation of monthly data to daily data in a manner similar to the approach used to disaggregate monthly WGFP model output to daily data. Some model input data are unavailable (e.g., reservoir contents) or are sporadic on a daily basis. In those instances, Denver Water employed data filling and disaggregation techniques to develop daily input for PACSM prior to running the model. Depending on the amount of daily data that needs to be estimated, the overall accuracy of a daily model may not be significantly greater than a monthly model. The CDSS Model was run using a monthly time step and then monthly model output was disaggregated to daily data. This approach is less precise than running the model in a daily format primarily during the rising and falling limbs of the hydrograph (April and August). Because Windy Gap diversions during these periods are typically low, model results were reasonable for assessing hydrologic changes.

Prior to initiating the modeling of EIS alternatives for the Moffat Project and WGFP, the lead federal agencies for the EISs convened a process to compare hydrologic modeling approaches and tools. This process included review of Windy Gap diversions, Granby Reservoir operations, and Adams Tunnel, Moffat Tunnel, and Roberts Tunnel flows simulated in PACSM and the WGFP model (CDSS Model). This process also included a detailed comparison of flows in the vicinity of the projects' diversions, which was summarized in the technical memorandum, *Comparison of Fraser River flows simulated in the WGFP CDSS model with those simulated in PACSM* (Boyle 2005c). A comparison of Fraser River flows simulated in the WGFP CDSS model with those simulated in PACSM was conducted (Boyle 2005c) for the existing conditions scenario, which includes the Windy Gap Project as it currently exists without firming storage and no Moffat Collection System project online. Model results were compared in the Fraser River basin at the St. Louis near Fraser gage (USGS gage 09026500), the Fraser River near Winter Park gage (USGS gage 09024000), and the Fraser River at Granby gage (09034000). These locations reflect spatially distributed locations comprised of tributary and mainstem flows in the upper and lower portions of the Fraser River basin.

PACSM and CDSS simulated flows compare well, with excellent correlation high in the Fraser River basin, which indicates both models represent diversions, return flows, and gains and losses in a similar manner. Both models simulate virtually the same flow at the St. Louis and Fraser River near Winter Park gages. The average annual difference in simulated flows at these gages is less than 0.3 percent, with average monthly differences in simulated flows less than about 1 percent. Differences in PACSM and CDSS simulated flows are greater lower in the Fraser River basin at the Fraser River near Granby gage due primarily to the lack of available historical gage data upon which to estimate baseflows and gains and losses. However, average monthly differences at the Granby gage are still less than 4 percent during the runoff season from May through July, which are important months in relation to Moffat Project and Windy Gap diversions. The comparison of PACSM and CDSS indicates both models represent diversions, return flows, and gains and losses in the Fraser River basin in a similar manner. These models were selected due to their ability to reliably portray flows in the Fraser River basin.

The modeling approaches incorporated in the Moffat Project and WGFP for direct and cumulative effects analyses were coordinated as follows. Model data for the two projects was shared to ensure that the WGFP and Moffat Projects were reflected in a similar manner in each model.

For the WGFP, the direct effects analysis was based on a comparison of existing conditions and the hydrologic conditions simulated for each alternative. The direct effects analysis did not include the Moffat Project because it is not anticipated to be on-line until 2016 per the Moffat Project Purpose and Need Statement. Therefore, output from PACSM was used for Denver Water's Current Conditions model scenario, which includes Denver Water's average annual demand at 285,000 AF without the Moffat Project online. Monthly transbasin diversion data for the Roberts, Gumlick, and Moffat tunnels were incorporated as demands in the WGFP model at those structures. For the cumulative effects analysis, the WGFP model incorporated the Moffat Project, with 72,000 AF of additional East Slope storage online in the Moffat System and Denver Water's average annual demand at 393,000 AF.

For the Moffat Project, the direct effects analysis was based on a comparison of Full Use Existing System (2016) and the hydrologic conditions simulated for each EIS alternative. The WGFP was assumed to be online by 2016; therefore, output from the WGFP model for the Proposed Action (Chimney Hollow Reservoir with prepositioning) was incorporated in PACSM. The following WGFP model output was used in PACSM: Adams Tunnel C-BT and Windy Gap deliveries, Windy Gap demands, Windy Gap deliveries from Chimney Hollow and Granby Reservoirs to meet demands, Windy Gap pumping, Willow Creek Feeder Canal diversions, Willow Creek Reservoir end-of-month storage contents, Granby Reservoir end-of-month storage contents; and flow data at the Colorado River below Granby gage (09019500), Colorado River below the Windy Gap diversion, Willow Creek at the confluence with the Colorado River, and Fraser River at Granby gage (09034000). PACSM was configured to reflect similar Windy Gap diversions and Adams Tunnel deliveries by modifying the demands placed at the Windy Gap and Adams Tunnel structures in PACSM to match the data provided from the WGFP modeling. The cumulative effects analysis also was based on a comparison of Full Use Existing System (2016) and each alternative since reasonably foreseeable water-based actions were anticipated to occur by 2016 and, therefore, were already considered in the direct effects analysis.

The cumulative effects analyses for the WGFP and Moffat Projects also considered the same reasonably foreseeable water-based actions described in Section 2.8.2.1.

3.5.2.3 Facilities and Stream Segments Affected by Windy Gap Operations

Windy Gap Project water is diverted from the Colorado River just downstream of the confluence with the Fraser River at Windy Gap Reservoir. Once diverted, it is pumped to Granby Reservoir via a pipeline for storage. Upon introduction into the C-BT system, Windy Gap diversions are subject to a 10 percent "diversion shrink" per the

Diversion shrink is a deduction for evaporation and transit loss that Reclamation charges for Windy Gap deliveries into the C-BT system.

existing Carriage Contract between the Subdistrict and Reclamation, with the shrink amount credited to the C-BT Project. Similarly, each year at the end of March, a 10 percent carryover shrink is assessed on any Windy Gap water remaining in Granby Reservoir, with the shrink amount being stored in the Granby Reservoir C-BT account. Diversion and carryover shrink are intended to offset losses incurred by the C-BT project due to the introduction, storage, carriage, and delivery of Windy Gap water. These losses include, but are not limited to, additional evaporation associated with storing Windy Gap water in Granby Reservoir and conveyance losses associated with delivering Windy Gap water via C-BT facilities. Diversion shrink does not create an expanded use of the C-BT decree. C-BT may receive additional diversion and carryover shrink under the alternatives, due to increased Windy Gap diversions, as well as reintroduction shrink with East Slope storage alternatives; however, C-BT may incur less evaporative loss attributable to Windy Gap water because the WGFP Participants would store the majority of their Windy Gap water in new firming reservoirs as opposed to Granby Reservoir.

Instantaneous delivery allows Windy Gap water stored in Granby Reservoir to be available for immediate delivery from Carter Lake or Horsetooth Reservoir.

Windy Gap water in Granby Reservoir is delivered to the East Slope via "instantaneous delivery," which involves an exchange for C-BT water. As specified in the Carriage Contract, instantaneous delivery involves a C-BT release from Carter Lake or Horsetooth Reservoir in exchange for Windy Gap water stored in Granby Reservoir. Granby Reservoir is currently the only long-term storage facility for Windy Gap water. However, under the action alternatives, Windy Gap water also would be delivered to a firming project reservoir outside the C-BT system for storage. Instantaneous delivery will continue to be used to deliver water to Windy Gap unit owners not in the firming project, including the City of Boulder and Town of Estes Park, and possibly at times for Project Participants. Under the action alternatives, Windy Gap water would also be delivered to WGFP Participants via direct releases from firming reservoirs using C-BT conveyance facilities.

Windy Gap diversions and operations affect the C-BT Project because C-BT facilities are used for the storage and conveyance of Windy Gap water and both C-BT and Windy Gap water is stored in Granby Reservoir. Windy Gap diversions and operations also affect flows in the Colorado River below Granby Reservoir, Willow Creek below Willow Creek Reservoir, St. Vrain Creek, Big Thompson River, and several East Slope rivers that receive Participants' WWTP return flows. The sections below provide an overview of the various facilities and stream segments with projected changes in flow and the reasons for changes under the No Action and action alternatives.

Colorado River below Granby Reservoir

Flows in the Colorado River below Granby Reservoir are a function of instream flow requirements and Granby Reservoir spills. Storage of Windy Gap water in Granby Reservoir would vary for each alternative, resulting in differences in the spill of Windy Gap water. Differences in Granby Reservoir spills under the various alternatives would occur because of variations in Windy Gap operations, including the amount of shrink paid to the C-BT Project due to Windy Gap diversions and carryover storage, instantaneous deliveries, and prepositioning of water under the Proposed Action. For example, variations in the amount of shrink paid to the C-BT Project would affect C-BT contents in Granby Reservoir and consequently the timing and amount of C-BT spills.

Colorado River flows below Windy Gap Reservoir also would be affected by differences in Windy Gap diversions among the alternatives. With firming storage, Windy Gap diversions would be greater primarily in wet years because more water is available and additional storage capacity typically would be available for diversion. Under existing conditions, there is no conveyance or storage capacity in the C-BT system for Windy Gap water when Granby Reservoir fills. Therefore, under existing conditions and the No Action Alternative, Windy Gap diversions would be curtailed in most wet years after Granby Reservoir fills. Windy Gap diversions may occur in wet years prior to Granby Reservoir filling.

Willow Creek

The C-BT Project diverts water from Willow Creek for delivery to Granby Reservoir via the Willow Creek Feeder Canal (WCFC). Although WCFC diversions are a C-BT Project operation, they can be affected by Windy

Gap diversions and operations. When space in Granby Reservoir is not a limiting factor on the amount that can be diverted from Willow Creek, there would be no difference in WCFC diversions or Willow Creek flows among the alternatives. However, when Granby Reservoir fills, differences in WCFC diversions can occur. C-BT operations take precedence over Windy Gap Project operations; therefore, the first water spilled from Granby Reservoir is Windy Gap. Instead of pumping water from Willow Creek to force Windy Gap water to spill, Windy Gap water in Granby Reservoir is exchanged with C-BT water in Willow Creek Reservoir. This results in a spill of Windy Gap water from Willow Creek Reservoir. The amount of Windy Gap water exchanged to Willow Creek Reservoir is the lesser of the amount of Windy Gap water in Granby Reservoir or the amount that can be physically and legally pumped from Willow Creek. The degree to which WCFC diversions would be different among the alternatives is a function of Windy Gap storage in Granby Reservoir and the amount of Windy Gap water exchanged to C-BT in place of WCFC diversions.

Differences in WCFC diversions among the alternatives also could occur due to differences in Granby Reservoir C-BT contents. Differences in C-BT contents in Granby Reservoir among the alternatives would occur primarily from differences in Windy Gap diversions and the shrink paid to the C-BT Project, prepositioning, and instantaneous deliveries. C-BT water diverted from the Colorado River for storage in Granby Reservoir takes priority over pumping from Willow Creek. As such, WCFC diversions depend on both C-BT and Windy Gap contents in Granby Reservoir.

North St. Vrain and St. Vrain Creek

Changes in St. Vrain Creek flows due to Windy Gap operations would occur only under the No Action Alternative. Longmont's Windy Gap water would be released to St. Vrain Creek via the St. Vrain Supply Canal out of Carter Lake and exchanged upstream to the enlarged Ralph Price Reservoir. This operation would affect flows in North St. Vrain Creek below Ralph Price Reservoir and in St. Vrain Creek to the intersection with the St. Vrain Supply Canal. Windy Gap deliveries to Longmont would be conveyed using existing infrastructure.

Big Thompson River

The C-BT Project diverts water under direct flow water rights from the Big Thompson River at the Olympus and Dille tunnels for storage in Carter Lake and Horsetooth Reservoir. The C-BT Project also diverts water from the Big Thompson River for power generation. These power diversions are referred to as "skim diversions" because the water is returned to the Big Thompson River at the Big Thompson Power Plant. C-BT deliveries to Chimney Hollow under the Proposed Action and instantaneous C-BT deliveries to meet Windy Gap demands affect the available capacity in Olympus Tunnel, Carter Lake, and Horsetooth Reservoir, which in turn affect C-BT diversions from the Big Thompson River. Small changes in the flow of the Big Thompson River below Lake Estes (below the Olympus and Dille tunnels) would occur under all alternatives due to differences in C-BT diversions from the Big Thompson River for power generation.

Other East Slope Streams

With a WGFP online, use of Windy Gap water would increase and, as a result, there would be additional return flows to East Slope streams (Big Dry Creek, Big Thompson River, Coal Creek, and St. Vrain Creek) within the South Platte River watershed attributable to indoor and outdoor use of Windy Gap water. Additional Windy Gap return flows attributable to indoor use would occur primarily at Participants' WWTPs. Additional Windy Gap return flows attributable to outdoor irrigation use would occur at various locations throughout the Participants' service areas.

C-BT Deliveries

C-BT Project demands and deliveries would not change as a result of implementation of any of the WGFP alternatives. C-BT deliveries would continue to meet demands without any shortages under all alternatives and the amount of C-BT water delivered would not exceed current amounts. The WGFP would be able to continue use of C-BT facilities for the storage and delivery of Windy Gap water; however, Windy Gap operations cannot negatively impact C-BT Project operations or delivery. The WGFP is intended to use excess capacity in the C-BT system.

Loss of C-BT Water from Reservoir Evaporation

Reclamation computes evaporation values for all C-BT project facilities on a daily basis. An evaporation pan is maintained at the Farr Pumping Plant by NCWCD. The National Weather Service's Grand Lake 6 SSW station is also at the same location. District staff collects evaporation (pan water depths), temperature, and precipitation data daily, which are used to calculate gross and net evaporation for all four West Slope C-BT reservoirs (Willow Creek, Grand Lake, Shadow Mountain, and Granby Reservoir). If the C-BT Project is out of priority, the computed C-BT depletion to the Colorado River, which includes net evaporative losses, is replaced by releasing a like amount of water from Green Mountain Reservoir.

Evaporative losses charged to the C-BT Project from the major C-BT reservoirs would decrease less than 2 percent under the WGFP alternatives due to changes in operations under the alternatives. Less Windy Gap water would be stored in Granby Reservoir under the alternatives and more Windy Gap water would be stored in the WGFP reservoirs. As a result, the total evaporative losses charged to C-BT in Granby Reservoir would be lower.

Due to the integrated operations of the Three Lakes system, evaporative losses at Granby Reservoir, Shadow Mountain, and Grand Lake are replaced by C-BT diversions to storage and the Windy Gap shrink paid to the C-BT Project. The 10 percent diversion shrink and 10 percent carryover shrink paid by the WGFP to the C-BT Project are intended to offset evaporation and conveyance losses due to the introduction, storage, and delivery of Windy Gap water. Therefore, evaporative losses in all C-BT reservoirs are charged to the C-BT Project regardless of the Windy Gap contents in that facility. Evaporation losses in potential new Windy Gap reservoirs would be allocated pro rata to each account in the reservoir based on the amount stored in each account. There would be no change in evaporative losses under any alternative for Willow Creek Reservoir, Shadow Mountain Reservoir, or Grand Lake. Long-term storage of C-BT water in Chimney Hollow Reservoir would only occur under the Proposed Action. The average annual net evaporative loss at Chimney Hollow Reservoir was estimated to be 1,510 AF under the Proposed Action, of which approximately 360 AF/year would be attributed to the C-BT Project and 1,150 AF/year would be attributed to Windy Gap. This is consistent with average end-of-month C-BT contents in Chimney Hollow Reservoir, which would be 24,400 AF or approximately 27 percent of the total reservoir volume. The average annual percentage of evaporative loss attributed to the C-BT Project is slightly less than the percentage of C-BT water in Chimney Hollow on an average monthly basis because C-BT contents in Chimney Hollow would generally be higher during the winter months when evaporative losses are lower.

C-BT water could reside in Chimney Hollow or Dry Creek reservoirs under alternative 3, 4, or 5 for short periods due to reintroduction shrink; however, the amount stored would be small and the associated evaporative losses minimal.

C-BT and Windy Gap Spills

Windy Gap and C-BT spills from Granby Reservoir and Willow Creek Reservoir would change under all alternatives. Compared to existing conditions, C-BT spills from Granby Reservoir under all alternatives would change little over the long term. Small differences in the timing and magnitude of C-BT spills from Granby Reservoir would occur due to Windy Gap operations, including the amount of Windy Gap shrink paid to the C-BT project, instantaneous deliveries, and prepositioning, as well as differences in the distribution of C-BT water in Granby Reservoir, Carter Lake, and Horsetooth Reservoir due to prepositioning C-BT water in Chimney Hollow Reservoir.

> Spills of Windy Gap water from Granby Reservoir would decrease under the Proposed Action because WGFP water would be stored primarily in Chimney Hollow Reservoir. C-BT spills from Granby Reservoir would not change substantially from existing conditions.

Changes in Windy Gap spills would occur when Granby Reservoir fills and spills. Under existing conditions and the No Action Alternative, Windy Gap water is stored in Granby Reservoir; therefore, when Granby Reservoir fills, Windy Gap water is spilled. Under the action alternatives, Windy Gap water would be stored primarily in firming reservoirs; therefore, when Granby Reservoir fills, Windy Gap spills would be reduced substantially, particularly under the Proposed Action (Table 3-5). Predicted Windy Gap spills in wet years under existing conditions and the No Action Alternative may be higher than actual experience in some wet years because the

WGFP model does not forecast Granby Reservoir spills. See Section 3.5.2.2 under WGFP Model Forecasting Function for more discussion of Windy Gap diversions and spills in wet years.

Table 3-5 summarizes average annual C-BT and Windy Gap spills from Granby and Willow Creek reservoirs. Windy Gap spills from Willow Creek Reservoir would occur when Windy Gap water is exchanged with C-BT water in Willow Creek Reservoir and spilled instead of pumping C-BT water from Willow Creek Reservoir to Granby Reservoir and spilling Windy Gap water from Granby Reservoir. Actual Granby Reservoir spills may vary from model predictions because preemptive releases early in the year could occur in anticipation of future spills, which would change the timing and amount of releases.

Table 3-5. Modeled average annual C-BT and Windy Gap spills for existing conditions and the alternatives.

Alt	C-BT Spills (AF)	Windy Gap Granby Resv. Spills (AF)	Windy Gap Willow Creek Resv. Spills (AF)	Total Windy Gap Spills (AF)	Total Windy Gap and C-BT Spills (AF)
EC	19,799	14,995	3,782	18,777	38,576
Alt 1	19,320	11,424	2,375	13,799	33,120
Alt 2	21,195	4,443	620	5,063	26,258
Alt 3	19,834	7,689	1,380	9,069	28,903
Alt 4	19,841	7,702	1,390	9,092	28,933
Alt 5	19,637	7,718	1,258	8,976	28,613

Note: C-BT spills do not include the amounts required to meet the downstream instream flow requirement when Granby Reservoir is spilling.

3.5.2.4 Summary Comparison of Hydrologic Changes

Model simulations were developed to compare hydrologic changes at various locations for each alternative. A summary of annual changes in flow for the study period (1950 to 1996) at key locations on the Colorado River within C-BT system facilities and the Big Thompson River is shown in Table 3-6, Table 3-7, and Table 3-8. These summary tables present flow conditions under average, wet, and dry year conditions. Average values include the entire 47-year period of record. Dry and wet year averages are defined as the average of the five wettest and five driest years in the study period. The five driest years were 1954, 1966, 1977, 1981, and 1989 and the five wettest years were 1957, 1983, 1984, 1986, and 1995, based on the estimated virgin flow below Granby Reservoir.

The following sections provide additional discussion comparing the projected changes in hydrologic conditions under each alternative.

3.5.2.5 C-BT and Windy Gap Project Operations and Diversions

Adams Tunnel Diversions

Adams Tunnel deliveries include both C-BT and Windy Gap water and are made based on water demand on the East Slope. The tunnel diversions to the East Slope include C-BT deliveries to Carter Lake, Horsetooth Reservoir, and to meet C-BT demands, above Flatiron Reservoir and along the Big Thompson River. In addition, because Windy Gap deliveries are made via instantaneous delivery, they are reflected in the model as C-BT deliveries through the tunnel to replace corresponding releases made from Carter Lake or Horsetooth Reservoir. Windy Gap diversions from the Colorado River either go to Granby Reservoir under the Proposed Action or to Granby Reservoir and one of the new West Slope reservoirs under the other action alternatives. Windy Gap water would be moved to new East Slope storage (Chimney Hollow or Dry Creek reservoir) under all of the alternatives as soon as possible so that water would be available to meet demand.

Table 3-6. Comparison of <u>average</u> annual flow and diversion amounts (AF) at key locations.

Location	Existing Conditions	Alternative 1 No Action			Alternative 2 Proposed Action - Chimney Hollow w/Prepositioning			Alternative 3 Chimney Hollow w/Jasper East			Alternative 4 Chimney Hollow w/Rockwell/Mueller Creek			Alternative 5 Dry Creek w/Rockwell/Mueller Creek		
	Avg. Annual Flow	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percen t Diff.	Avg. Annual Flow	Diff.	Perce nt Diff.
Adams Tunnel C-BT deliveries	231,679	231,509	-170	<1%	231,196	-483	<1%	230,795	-884	<1%	230,800	-879	<1%	231,041	-638	<1%
Adams Tunnel Windy Gap deliveries	11,500	22,410	10,910	95%	31,045	19,545	170%	30,411	18,911	164%	30,433	18,933	165%	30,782	19,282	168%
Total Adams Tunnel deliveries	243,179	253,919	10,740	4%	262,240	19,061	8%	261,206	18,027	7%	261,223	18,044	7%	261,822	18,644	8%
Granby Reservoir spills	34,794	30,744	-4,050-	-12%	25,638	-9,156	-26%	27,523	-7,271	-21%	27,543	-7,251	-21%	27,355	-7,439	-21%
—C-BT spills	19,799	19,320	-479	-2%	21,195	1,396	7%	19,834	35	0%	19,841	42	0%	19,637	-162	-1%
—Windy Gap spills	14,995	11,424	-3,571	-24%	4,443	-10,552	-70%	7,689	-7,306	-49%	7,702	-7,293	-49%	7,718	-7,277	-49%
Colorado R. below Granby Resv.	59,385	55,343	-4,042	-7%	50,220	-9,165	-15%	52,071	-7,313	-12%	52,091	-7,294	-12%	51,903	-7,482	-13%
Willow Creek Feeder diversions	36,172	37,544	1,372	4%	38,760	2,588	7%	38,349	2,177	6%	38,339	2,167	6%	38,438	2,266	6%
Willow Crk. at the confluence with the Colorado R.	18,294	16,933	-1,361	-7%	15,727	-2,567	-14%	16,138	-2,156	-12%	16,148	-2,146	-12%	16,049	-2,245	-12%
Fraser R. at the confluence with the Colorado R.	91,025	91,025	0	0%	91,027	2	0%	91,028	3	0%	91,028	3	0%	91,028	3	0%
Colorado R. above the Windy Gap diversion	187,889	182,487	-5,403	-3%	176,158	-11,731	-6%	178,421	-9,468	-5%	178,451	-9,438	-5%	178,164	-9,725	-5%
Windy Gap diversions	36,532	43,573	7,041	19%	46,084	9,552	26%	48,052	11,520	32%	47,997	11,466	31%	48,483	11,951	33%
Colorado R. below Windy Gap	151,358	138,914	-12,444	-8%	130,075	-21,283	-14%	130,370	-20,988	-14%	130,453	-20,904	-14%	129,681	-21,676	-14%
Colorado R. at Hot Sulphur Spg.	156,475	144,023	-12,452	-8%	135,176	-21,299	-14%	135,472	-21,003	-13%	135,555	-20,920	-13%	134,783	-21,692	-14%
Colorado R. below confluence with Williams Fork R.	246,931	234,481	-12,450	-5%	225,634	-21,296	-9%	225,930	-21,001	-9%	226,013	-20,918	-8%	225,241	-21,690	-9%
Colorado R. above confluence with Troublesome Crk.	252,443	239,993	-12,450	-5%	231,147	-21,296	-8%	231,442	-21,001	-8%	231,526	-20,917	-8%	230,753	-21,689	-9%
Colorado R. above the confluence with the Blue R.	379,050	366,605	-12,445	-3%	357,760	-21,291	-6%	358,055	-20,995	-6%	358,139	-20,912	-6%	357,366	-21,684	-6%
Colorado R. near Kremmling	701,801	689,357	-12,444	-2%	680,512	-21,289	-3%	680,807	-20,994	-3%	680,890	-20,910	-3%	680,118	-21,683	-3%
C-BT Diversions from Big Thompson R. (Olympus & Dille)	27,990	27,632	-358	-1%	25,048	-2,942	-11%	27,062	-928	-3%	27,062	-928	-3%	26,616	-1,374	-5%
Big Thompson R. below L. Estes	66,701	67,145	444	1%	69,884	3,183	5%	67,666	965	1%	67,667	966	1%	68,146	1,445	2%
Big Thompson R. at Canyon Gage	89,367	89,725	358	0%	92,308	2,942	3%	90,294	928	1%	90,295	928	1%	90,740	1,374	2%

Note: Differences indicate a volume (AF) or percent change compared to existing conditions. A positive difference denotes an increase in flow. There is no change in tributary inflows for the Fraser River, Williams Fork, Troublesome Creek, Muddy Creek, or Blue River for any alternative.

Granby Reservoir spills do not include Windy Gap spills from Willow Creek Reservoir, which are included in Table 3-5. C-BT spills do not include the amounts bypassed to meet the instream flow requirement when Granby Reservoir is spilling.

Fraser River at the confluence with the Colorado River corresponds with outflow from the Scybert Ditch, which is the furthest downstream node on the Fraser River in the CDSS model.

Willow Creek at the confluence with the Colorado River corresponds with outflow from the Bunte Highline Ditch, which is the furthest downstream node on Willow Creek in the CDSS model.

Table 3-7. Comparison of average annual dry year flow and diversion amounts (AF) at key locations.

Location	Existing Conditions	Alternative 1			Alternative 2			Alternative 3			Alternative 4			Alternative 5		
		No Action			Proposed Action - Chimney Hollow w/Prepositioning			Chimney Hollow w/Jasper East			Chimney Hollow w/Rockwell/Mueller Creek			Dry Creek w/Rockwell/Mueller Creek		
	Avg. Annual Flow	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.
Adams Tunnel C-BT deliveries	304,061	304,299	238	<1%	304,863	802	<1%	303,636	-425	<1%	303,640	-421	<1%	304,219	158	<1%
Adams Tunnel Windy Gap deliveries	10,126	11,858	1,732	17%	28,349	18,223	180%	15,913	29,959	296%	15,968	5,842	58%	21,766	11,640	115%
Total Adams Tunnel deliveries	314,187	316,157	1,970	1%	333,210	19,024	6%	319,549	5,362	2%	319,608	5,421	2%	325,985	11,799	4%
Granby Reservoir spills	0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
—C-BT spills	0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
—Windy Gap spills	0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Colorado R. below Granby Resv.	21,946	21,946	0	0%	21,946	0	0%	21,946	0	0%	21,946	0	0%	21,946	0	0%
Willow Crk. Feeder diversions	22,200	22,200	0	0%	22,200	0	0%	22,200	0	0%	22,200	0	0%	22,200	0	0%
Willow Crk. at the confluence with the Colorado R.	3,962	3,962	0	0%	3,962	0	0%	3,962	0	0%	3,962	0	0%	3,962	0	0%
Fraser R. at the confluence with the Colorado R.	35,432	35,432	0	0%	35,432	0	0%	35,432	3	0%	35,432	0	0%	35,432	0	0%
Colorado R. above the Windy Gap diversion	74,938	74,938	0	0%	74,939	0	0%	74,938	0	0%	74,938	0	0%	74,938	0	0%
Windy Gap diversions	7,804	7,804	0	0%	7,804	0	0%	7,804	0	0%	7,804	0	0%	7,804	0	0%
Colorado R. below Windy Gap	67,134	67,134	0	0%	67,134	0	0%	67,134	0	0%	67,134	0	0%	67,134	0	0%
Colorado R. at Hot Sulphur Springs	70,656	70,656	0	0%	70,655	-1	0%	70,655	-1	0%	70,655	-1	0%	70,655	-1	0%
Colorado R. below confluence with the Williams Fork R.	147,416	147,416	0	0%	147,416	0	0%	147,416	0	0%	147,416	0	0%	147,416	0	0%
Colorado R. above confluence with Troublesome Crk.	149,898	149,898	0	0%	149,898	0	0%	149,898	0	0%	149,898	0	0%	149,898	0	0%
Colorado R. above the confluence with the Blue R.	229,222	229,222	0	0%	229,222	0	0%	229,222	0	0%	229,222	0	0%	229,222	0	0%
Colorado R. near Kremmling	450,286	450,286	0	0%	450,286	0	0%	450,286	0	0%	450,286	0	0%	450,286	0	0%
C-BT Diversions from Big Thompson R. (Olympus & Dille)	551	475	-76	-14%	0	-551	-100%	0	-551	-100%	0	-551	-100%	0	-551	-100%
Big Thompson River below L. Estes	53,535	53,611	76	0%	54,086	551	1%	54,086	551	1%	54,086	551	1%	54,086	551	1%
Big Thompson River at the Canyon Gage	67,160	67,237	76	0%	67,711	551	1%	67,711	551	1%	67,711	551	1%	67,711	551	1%

Note: Differences indicate a volume (AF) or percent change compared to existing conditions. A positive difference denotes an increase in flow. There is no change in tributary inflows for the Fraser River, Williams Fork, Troublesome Creek, Muddy Creek, or Blue River for any alternative.

Granby Reservoir spills do not include Windy Gap spills from Willow Creek Reservoir, which are included in Table 3-5. C-BT spills do not include the amounts bypassed to meet the instream flow requirement when Granby Reservoir is spilling.

Fraser River at the confluence with the Colorado River corresponds with outflow from the Scybert Ditch, which is the furthest downstream node on the Fraser River in the CDSS model.

Willow Creek at the confluence with the Colorado River corresponds with outflow from the Bunte Highline Ditch, which is the furthest downstream node on Willow Creek in the CDSS model.

Table 3-8. Comparison of average annual wet year flow and diversion amount (AF) at key locations.

Location	Existing Conditions	Alternative 1			Alternative 2			Alternative 3			Alternative 4			Alternative 5		
		No Action			Proposed Action - Chimney Hollow w/Prepositioning			Chimney Hollow w/Jasper East			Chimney Hollow w/Rockwell/Mueller Creek			Dry Creek w/Rockwell/Mueller Creek		
	Avg. Annual Flow	Avg. Annual Flow	Diff.	Per-cent Diff.	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.	Avg. Annual Flow	Diff.	Percent Diff.
Adams Tunnel C-BT deliveries	168,706	167,182	-1,524	1%	161,816	-6,890	4%	165,747	-2,959	2%	165,750	-2,956	2%	164,840	-3,866	2%
Adams Tunnel Windy Gap deliveries	12,081	29,879	17,798	147%	30,343	18,262	151%	40,085	28,004	232%	40,103	28,022	232%	37,810	25,729	213%
Total Adams Tunnel deliveries	180,787	197,062	16,274	9%	192,159	11,372	6%	205,832	25,044	14%	205,853	25,066	14%	202,650	21,863	12%
Granby Reservoir spills	118,620	110,857	-7,763	-7%	104,458	-14,162	-12%	106,764	-11,856	-10%	106,783	-11,837	-10%	105,294	-13,326	-11%
—C-BT spills	93,203	93,622	419	0%	100,104	6,901	7%	95,497	2,294	2%	95,501	2,298	2%	95,756	2,553	3%
—Windy Gap spills	25,417	17,235	-8,182	-32%	4,354	-21,063	-83%	11,267	-14,150	-56%	11,282	-14,135	-56%	9,538	-15,879	-62%
Colorado R. below Granby Resv.	144,383	136,621	-7,762	-5%	130,271	-14,112	-10%	132,355	-12,028	-8%	132,374	-12,009	-8%	130,886	-13,497	-9%
Willow Crk. Feeder diversions	33,685	39,335	5,650	17%	40,417	6,732	20%	39,953	6,268	19%	39,953	6,268	19%	39,935	6,250	19%
Willow Crk. at the confluence with the Colorado R.	52,778	47,128	-5,650	-11%	46,046	-6,732	-13%	46,510	-6,268	-12%	46,510	-6,268	-12%	46,528	-6,250	-12%
Fraser R. at the confluence with the Colorado R.	178,477	178,477	0	0%	178,477	0	0%	178,477	0	0%	178,477	0	0%	178,477	0	0%
Colorado R. above the Windy Gap diversion	403,835	390,423	-13,412	-3%	382,991	-20,844	-5%	385,539	-18,296	-5%	385,558	-18,277	-5%	384,087	-19,748	-5%
Windy Gap diversions	38,512	63,870	25,357	66%	73,923	35,411	92%	78,940	40,428	105%	78,775	40,262	105%	77,543	39,031	101%
Colorado R. below Windy Gap	365,323	326,553	-38,769	-11%	309,068	-56,255	-15%	306,599	-58,724	-16%	306,784	-58,539	-16%	306,544	-58,779	-16%
Colorado R. at Hot Sulphur Springs	369,677	330,908	-38,769	-10%	313,423	-56,254	-15%	310,954	-58,723	-16%	311,138	-58,539	-16%	310,898	-58,778	-16%
Colorado R. below confluence with the Williams Fork R.	509,758	470,989	-38,769	-8%	453,505	-56,253	-11%	451,035	-58,723	-12%	451,220	-58,539	-11%	450,980	-58,778	-12%
Colorado R. above confluence with Troublesome Crk.	519,392	480,623	-38,770	-7%	463,138	-56,254	-11%	460,669	-58,724	-11%	460,853	-58,539	-11%	460,614	-58,778	-11%
Colorado R. above the confluence with the Blue R.	706,315	667,545	-38,769	-5%	650,061	-56,253	-8%	647,591	-58,723	-8%	647,776	-58,539	-8%	647,536	-58,778	-8%
Colorado R. near Kremmling	1,217,038	1,178,269	-38,769	-3%	1,160,785	-56,253	-5%	1,158,315	-58,723	-5%	1,158,500	-58,538	-5%	1,158,260	-58,778	-5%
C-BT Diversions from Big Thompson R. (Olympus & Dille)	67,946	68,253	308	0%	67,386	-560	-1%	67,902	-43	0%	67,906	-40	0%	67,938	-8	0%
Big Thompson R. below L. Estes	72,849	72,874	25	0%	74,765	1,916	3%	72,874	25	0%	72,874	25	0%	72,874	25	0%
Big Thompson R. at the Canyon Gage	108,593	108,285	-308	0%	109,153	560	1%	108,636	43	0%	108,633	40	0%	108,601	8	0%

Note: Differences indicate a volume (AF) or percent change compared to existing conditions. A positive difference denotes an increase in flow. There is no change in tributary inflows for the Fraser River, Williams Fork, Troublesome Creek, Muddy Creek, or Blue River for any alternative.

Granby Reservoir spills do not include Windy Gap spills from Willow Creek Reservoir, which are included in Table 3-5. C-BT spills do not include the amounts bypassed to meet the instream flow requirement when Granby Reservoir is spilling.

Fraser River at the confluence with the Colorado River corresponds with outflow from the Scybert Ditch, which is the furthest downstream node on the Fraser River in the CDSS model.

Willow Creek at the confluence with the Colorado River corresponds with outflow from the Bunte Highline Ditch, which is the furthest downstream node on Willow Creek in the CDSS model.

Figure 3-8. Average annual Adams Tunnel deliveries by alternative.

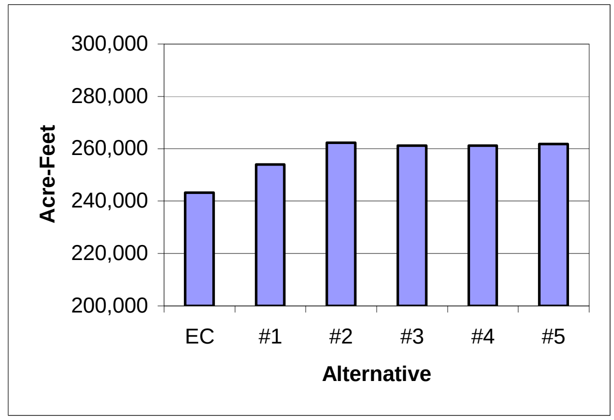


Table 3-6 through Table 3-8 show C-BT, Windy Gap, and total deliveries through Adams Tunnel. Windy Gap deliveries include: 1) instantaneous C-BT deliveries out of Carter Lake and Horsetooth Reservoir; 2) C-BT water delivered to Chimney Hollow under Alternative 2; 3) Windy Gap water delivered directly through the tunnel to meet demands; or 4) for storage in East Slope firming reservoirs under Alternatives 3 through 5. Windy Gap deliveries through the Adams Tunnel are considerably less than Windy Gap diversions because of Windy Gap spills, and because of diversion, carryover, reintroduction shrink, and evaporative losses from firming reservoirs. For example, under existing conditions, average annual Windy Gap pumping is estimated to be 36,532 AF/year; however, after spills, diversion shrink, carryover shrink, and allocations to MPWCD, approximately 11,500 AF/year of Windy Gap water is delivered through the Adams Tunnel (Table 3-6). Total annual Adams Tunnel deliveries average about 243,000 AF under existing conditions (Table 3-6). Under the No Action Alternative, average annual Adams Tunnel deliveries would increase about 10,700 AF compared to an increase of about 19,100 AF under the Proposed Action. Alternatives 3, 4, and 5 would result in average annual Adams Tunnel deliveries of about 18,000 AF to 18,600 AF greater than existing conditions. Changes in total Adams Tunnel deliveries are illustrated in Figure 3-8.

Deliveries through the Adams Tunnel for all alternatives would be greatest from December through June when C-BT water is delivered to Carter Lake, Horsetooth Reservoir, and Chimney Hollow Reservoir to refill those reservoirs and meet storage targets. Adams Tunnel deliveries under No Action would be exchanged to storage in Ralph Price Reservoir. Currently, Carter Lake is typically filled by the end of May and Horsetooth Reservoir by the end of June, after which Adams Tunnel deliveries decrease. The Adams Tunnel is typically shut down for maintenance during the last two weeks in October, first two weeks in November, last week in March and first two weeks in April. Therefore, total Adams Tunnel deliveries in those months would typically be less than other months because of these outages under existing conditions and all alternatives. In addition, it was assumed that maintenance time on the Adams Tunnel may increase by about 10 percent with a Firming Project online. This additional maintenance was assumed to occur in March.

The monthly amounts of C-BT water delivered to Chimney Hollow under the Proposed Action would be relatively constant and generally coincide with the amount of Windy Gap water released to meet Participant demands, which would range from about 1,000 AF to 2,400 AF/month throughout the year. Average monthly tunnel deliveries under the Proposed Action would be approximately 1,590 AF higher than existing conditions and 690 AF higher than No Action. However, March deliveries would be about 4,600 AF lower on average when additional tunnel maintenance would occur. Average monthly deliveries through the tunnel from September through January would be slightly higher under the Proposed Action than for the other action alternatives because of C-BT deliveries from Granby Reservoir to Chimney Hollow for prepositioning. Under the other alternatives, Windy Gap deliveries through the tunnel during the winter months would be more sporadic and only made to meet Windy Gap demands if Windy Gap water is available in either Jasper East or Rockwell reservoirs or Granby Reservoir.

Adams Tunnel deliveries are generally higher in dry years than average and wet years primarily because C-BT deliveries to the East Slope would be higher (Table 3-7). However, dry year Adams Tunnel deliveries under No Action would increase less than 2,000 AF over existing conditions because there would typically be little to no Windy Gap water in Granby Reservoir available for delivery (Table 3-7). Tunnel deliveries under the Proposed Action would be about 19,000 AF greater than existing conditions in dry years, while annual deliveries under Alternatives 3 and 4 would be about 5,400 AF greater than existing conditions and deliveries under Alternative 5 about 11,800 AF greater than existing conditions. C-BT deliveries would increase less than 1 percent under No Action, the Proposed Action, and Alternative 5 and decrease less than 1 percent under Alternatives 3 and 4 in dry years.

In wet years, C-BT deliveries are typically lower because the C-BT quota is lower (Table 3-8). Adams Tunnel wet year deliveries would be higher under all alternatives compared to existing conditions because Granby Reservoir fills by June and all Windy Gap water is spilled, resulting in little to no instantaneous Windy Gap delivery to meet demand. Wet year Windy Gap tunnel deliveries under No Action would increase about 17,800 AF compared to existing conditions to meet demand and for storage in Ralph Price Reservoir (Table 3-8). C-BT deliveries to the East Slope under No Action would decrease about 1,500 AF in wet years. Windy Gap deliveries under the Proposed Action would increase about 18,300 AF compared to existing conditions, while C-BT deliveries to the East Slope would be almost 7,000 AF lower in wet years. The greatest increase in wet year Adams Tunnel deliveries over existing conditions would occur under Alternatives 3 and 4 (25,100 AF) with a slightly lower increase of about 21,900 AF under Alternative 5. C-BT deliveries to the East Slope would decrease by about 3,000 to 4,000 AF under Alternatives 3, 4, and 5 in wet years.

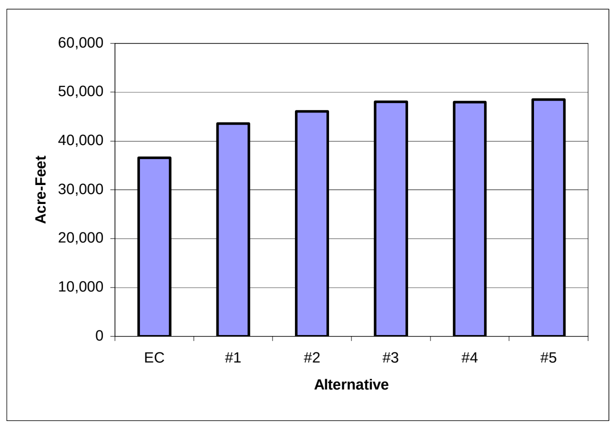
Windy Gap Diversions

All alternatives involve additional diversions from the Colorado River at the existing Windy Gap Reservoir. Windy Gap diversions would be constrained by several factors, including:

- Downstream senior water right calls and instream flow requirements
- Decree limitations
- Physical supply
- Pump station and Windy Gap pipeline conveyance limitations
- Available space in Granby Reservoir
- Available space in Firming Project reservoirs
- Available space in Adams Tunnel

The degree to which these constraints apply (timing and amount) would vary among the alternatives, resulting in differences in Windy Gap diversions. Figure 3-9 shows differences in predicted average annual Windy Gap diversions for each alternative. In an average year, Windy Gap diversions would be greatest in May and then June. Considerably smaller diversions would occur in April, July, and August.

Figure 3-9. Average annual Windy Gap diversions by alternative.



Average annual Windy Gap diversions under existing conditions would be approximately 36,500 AF/year. Under existing conditions, Windy Gap diversions are reasonably consistent with recent historical Windy Gap diversions, which reflect the Participants' need for water to meet current water demands. As discussed in Section 3.5.1.4, historical Windy Gap pumping for the 8-year period from 2001 through 2008, since Granby Reservoir last filled, averaged 27,450 AF/year.

Predicted Windy Gap diversions under existing conditions and the No Action Alternative may be high in some wet years because the WGFP model does not forecast Granby Reservoir spills. See Section 3.5.2.2 under WGFP Model Forecasting Function for more discussion of Windy Gap diversions in wet years.

Under the No Action Alternative, Windy Gap water would be delivered first to Granby Reservoir and then to Ralph Price Reservoir (for Longmont) if there is available space in Adams Tunnel and St. Vrain Supply Canal. Average annual Windy Gap diversions would be about 43,600 AF under No Action compared to 36,500 AF under existing conditions (Table 3-6). There would be no difference in Windy Gap diversions between existing conditions and No Action in years that Granby Reservoir does not fill because there would be no difference in the supply available to Windy Gap and available storage capacity would not be a constraint. However, when Granby Reservoir fills, Windy Gap cannot divert under existing conditions. Under No Action, Longmont could still divert Windy Gap water to Ralph Price Reservoir when Granby Reservoir is full as long as there is space in the Adams Tunnel and the St. Vrain Supply Canal.

Average annual Windy Gap diversions from the Colorado River would increase from about 36,500 AF under existing conditions to about 46,100 AF under the Proposed Action. Under the No Action Alternative, average annual Windy Gap diversions would increase to about 43,600 AF.

Under the Proposed Action, Windy Gap diversions would be delivered to Granby Reservoir and exchanged with C-BT water in Chimney Hollow Reservoir. This would relieve the need to deliver Windy Gap water through Adams Tunnel to Chimney Hollow during the diversion season because this operation would be accomplished via an exchange. During the fall and winter months (primarily September through January) when space is available in the Adams Tunnel, C-BT water would be delivered to Chimney Hollow Reservoir. The monthly amounts of C-BT water delivered to Chimney Hollow Reservoir would be relatively constant and generally coincide with the amount of Windy Gap water released to meet Participant demands. When Windy Gap water is diverted to Granby Reservoir from April through August, it would be exchanged with C-BT water in Chimney Hollow Reservoir. Therefore, Windy Gap water in Granby Reservoir becomes C-BT water and a commensurate amount of C-BT water in Chimney Hollow Reservoir becomes Windy Gap water. Average annual Windy Gap diversions would be about 46,100 AF under the Proposed Action or about 26 percent greater than existing conditions and about 7 percent greater than No Action (Table 3-6). The most significant additional diversions under the Proposed Action would occur in wet years following wet years, or wet years following average years. Table 3-9 summarizes Windy Gap diversions and spills, C-BT spills and the yield to Granby Reservoir from the WCFC under existing conditions and the Proposed Action in an average year to breakdown the effects on Colorado River flows.

Table 3-9. Colorado River water balance in an average year for existing conditions and the Proposed Action.

Parameter	Existing Conditions (AF)	Proposed Action - Alt. 2 (AF)	Effect on Colorado River Flows (AF)
Windy Gap Diversion	36,532	46,084	-9,552
Windy Gap Granby Spills	14,995	4,443	-10,552
Windy Gap Paper Spills from Willow Creek Reservoir[1]	3,782	620	-3,162
C-BT Granby Spills	19,799	21,195	1,396
Total WCFC Yield to Granby Reservoir[2]	39,954	39,380	574
Annual decrease in Colorado River Flow[3]			**-21,296**

[1] Windy Gap paper spills from Willow Creek Reservoir occur when Granby Reservoir fills and Windy Gap water is exchanged to C-BT instead of pumping water from Willow Creek to force Windy Gap water in Granby Reservoir to spill.

[2] The total WCFC yield to Granby Reservoir equals C-BT diversions via the WCFC plus Windy Gap exchanges to C-BT (Table 3-10).

[3] The increased depletion to the Colorado River due to Windy Gap and C-BT under the Proposed Action coincides with the difference in flows below Windy Gap under the Proposed Action (Table 3-6). However, there is a 13 AF difference between the values in the two tables due to changes in other non C-BT and Windy Gap depletions.

The net depletion to the Colorado River associated with pumping Windy Gap water equals Windy Gap diversions minus Windy Gap spills because that water is returned to the Colorado River. Pumping Windy Gap water that is later spilled is a re-timing of flows, not a depletion to the river. Thus, while the difference in average annual diversions between the Proposed Action and existing conditions is 9,552 AF/year, there also are reduced Windy

Gap spills from Granby Reservoir and less Willow Creek Reservoir paper spills under the Proposed Action. C-BT spills from Granby Reservoir would increase slightly from existing conditions, as would the yield to Granby Reservoir from the WCFC.

The average annual streamflow changes in the Colorado River for existing conditions and the Proposed Action, shows the increase in average annual net depletions to the Colorado River under the Proposed Action would be about 21,300 AF. Water diversions, changes in Colorado River flows, and East Slope deliveries for the Proposed Action are shown in Figure 3-10.

> The average annual net depletions to the Colorado River below Windy Gap Reservoir would increase about 21,300 AF under the Proposed Action compared to existing conditions.

Under Alternative 3, Windy Gap diversions would first be delivered to Chimney Hollow, limited by available space in Adams Tunnel. If the Adams Tunnel is full, Windy Gap diversions would be delivered to Jasper East and then to Granby Reservoir to the extent space is available. This configuration minimizes Windy Gap spills from Granby Reservoir and maximizes space available in Jasper East for Windy Gap diversions when Granby Reservoir and the Adams Tunnel are full. Alternative 4 would operate in a similar fashion with Rockwell Reservoir and Alternative 5 with Dry Creek and Rockwell reservoirs. Average annual Windy Gap diversions under Alternatives 3, 4, and 5 would be about 2,000 AF higher than the Proposed Action due primarily to differences in diversions in wet years in July and August and the timing and amount of spills from Granby Reservoir.

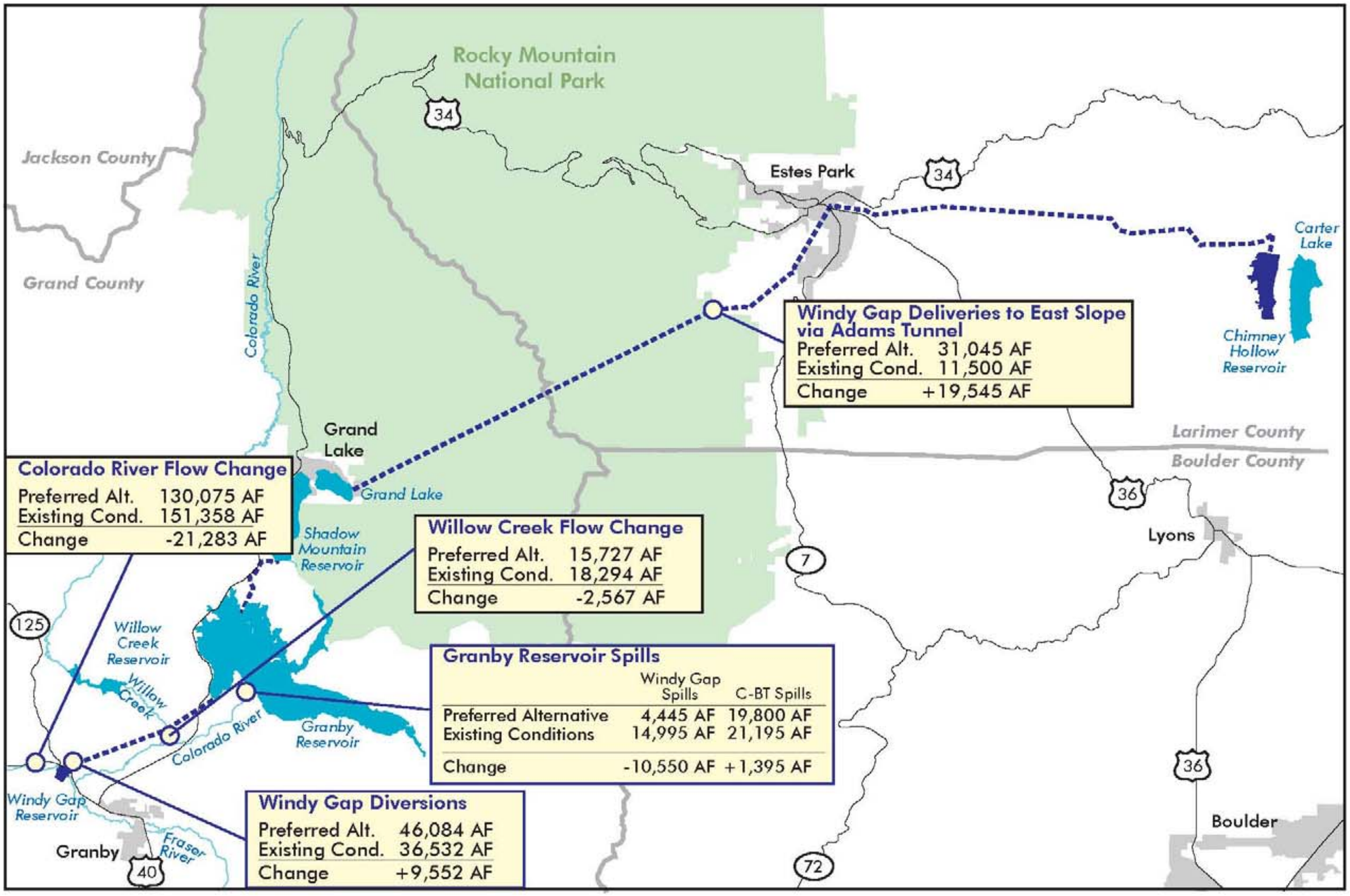
In dry years, average annual Windy Gap diversions would be relatively low in comparison with average and wet year diversions and there would be no difference among the alternatives and existing conditions (Table 3-7). Windy Gap would not divert, or would divert minimal amounts, in dry years like 1954, 1977, and 1981. Windy Gap diversions would be limited by the physically and legally available supply in the Colorado River in dry years, which would not vary among alternatives. Available space in Granby Reservoir and the firming project reservoirs would not be limiting factors. Annual Windy Gap diversions in an average dry year would be the same as existing conditions for all alternatives, or about 7,804 AF (Table 3-7). This is an average of the five driest years (1954, 1966, 1977, 1981, and 1989). In those years, Windy Gap diversions would range from approximately 300 AF in 1954 to 19,430 AF in 1989. The more severe the dry year, the less Windy Gap water would be pumped. Not all of the dry years included in the dry year average are as severe as 1954, which is the reason the average dry year diversion is greater than zero.

In wet years under existing conditions, Windy Gap diversions in May and June are often limited by available space in Granby Reservoir. Under No Action, Windy Gap diversions would continue in July and August after Granby Reservoir fills to the extent there is space available in the Adams Tunnel to deliver water to St. Vrain Creek and exchange it to Ralph Price Reservoir. Under the Proposed Action, additional Windy Gap water would be diverted to Granby Reservoir in July and August to the extent there is space in Granby Reservoir created by delivery of C-BT water to Chimney Hollow Reservoir. The additional West Slope storage space available in Alternatives 3, 4, and 5 also would allow substantially greater Windy Gap diversions in wet years. In wet years, Chimney Hollow would typically fill by the end of June or July under the Proposed Action, whereas under Alternatives 3, 4, and 5, Chimney Hollow, Jasper East or Rockwell reservoirs would typically not fill until the end of July or August, primarily due to tunnel capacity constraints. Wet year Windy Gap diversions are about 38,500 AF under existing conditions, compared to an estimated 63,900 AF under No Action, 73,900 AF under the Proposed Action, and a high of 78,900 AF under Alternative 3 (Table 3-8).

Willow Creek Feeder Canal Diversions

As described in Section 3.5.2.3, Willow Creek Feeder Canal diversions are affected by changes in Granby Reservoir storage. Average annual WCFC diversions would increase about 4 percent from existing conditions under No Action and about 7 percent under the Proposed Action (Table 3-6) primarily because of the reduction in Windy Gap water stored in Granby Reservoir under the alternatives. Alternatives 3, 4, and 5 would increase WCFC diversions about 6 percent on average. During average and wet years (Table 3-8); the increased diversions would occur primarily in June, July, and August and, thus, would decrease Willow Creek flows in the same months for all alternatives.

Figure 3-10. Diversions, deliveries, and flow changes for the Proposed Action.



When Granby Reservoir fills, Windy Gap water in Granby Reservoir is exchanged with C-BT water in Willow Creek Reservoir instead of pumping water from Willow Creek to force Windy Gap water to spill (see Section 3.5.2.3 under Willow Creek). This results in a spill of Windy Gap water from Willow Creek Reservoir at the same time C-BT contents in Granby Reservoir increase because Windy Gap water is exchanged to C-BT in place of WCFC diversions. The amount of Windy Gap water exchanged to Willow Creek Reservoir is the lesser of the amount of Windy Gap water in Granby Reservoir or the amount that can be physically and legally pumped from Willow Creek.

Table 3-10 summarizes the net yield to C-BT in Granby Reservoir due to physical diversions via the WCFC and Windy Gap exchanges to C-BT instead of pumping water from Willow Creek to force Windy Gap water in Granby Reservoir to spill. There is very little difference in the WCFC yield to the C-BT Project across the alternatives compared to existing conditions.

Table 3-10. Modeled C-BT yield from the Willow Creek Feeder Canal (WCFC).

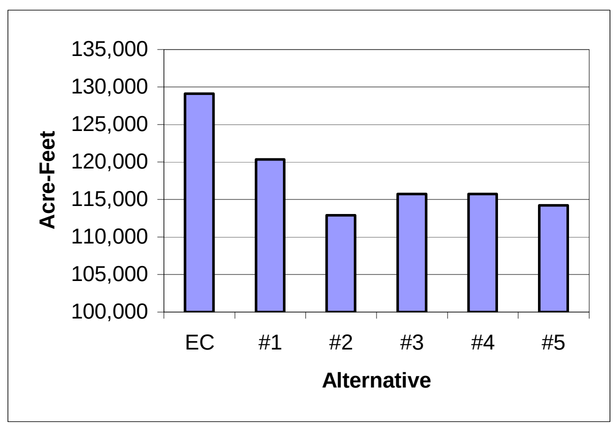
Alt	WCFC Diversions (AF)	Windy Gap Exchange to C-BT in Granby (AF)	Total WCFC Yield to C-BT in Granby (AF)
EC	36,172	3,782	39,954
Alt 1	37,544	2,375	39,919
Alt 2	38,760	620	39,380
Alt 3	38,349	1,380	39,729
Alt 4	38,339	1,390	39,729
Alt 5	38,438	1,258	39,696

Predicted changes in WCFC diversions may be higher in some wet years because the WGFP model does not forecast Granby Reservoir spills (see Section 3.5.2.2 under WGFP Model Forecasting Function). There would be no change in WCFC diversions during dry years for any alternative (Table 3-7).

Granby Reservoir Spills

C-BT storage in Granby Reservoir takes precedence over Windy Gap storage. Granby Reservoir generally only spills in wet years and the first water spilled is Windy Gap water in proportion to the amounts in each Participant's account, followed by water in the MPWCD account, and finally the C-BT account spills if necessary. Granby Reservoir spills during wet years would decrease about 7 percent under No Action, compared to a 13 percent decrease under the Proposed Action, 10 percent for Alternatives 3 and 4, and 12 percent for Alternative 5 (Table 3-8 and Figure 3-11). Table A-4 in Appendix A summarizes Granby Reservoir spill events. Under existing conditions, spills would occur in 20 years of the study period compared to 14 years under the Proposed Action. While the number of years in which spills would occur would decrease under the Proposed Action, the average duration of spills would be similar. The average daily spill under existing conditions would range from 177 cfs to 1,852 cfs compared to 236 cfs to 1,438 cfs under the Proposed Action. Average and maximum daily spill rates under the Proposed Action would decrease by about 20 percent compared to existing conditions.

Figure 3-11. Average annual wet year Granby Reservoir spills by alternative.



C-BT spills from Granby Reservoir under all alternatives would change little over the long term. As shown in Table 3-6, average annual C-BT spills under the Proposed Action would be 21,195 AF compared to 19,799 AF under existing conditions.

Windy Gap spills from Granby Reservoir would be reduced substantially, particularly under the Proposed Action, compared to existing conditions. As shown in Table 3-6, average annual Windy Gap spills from Granby Reservoir under the Proposed Action would be 4,443 AF compared to 14,995 AF under existing conditions. Windy Gap spills from Granby Reservoir would be lowest under the Proposed Action because storage of Windy

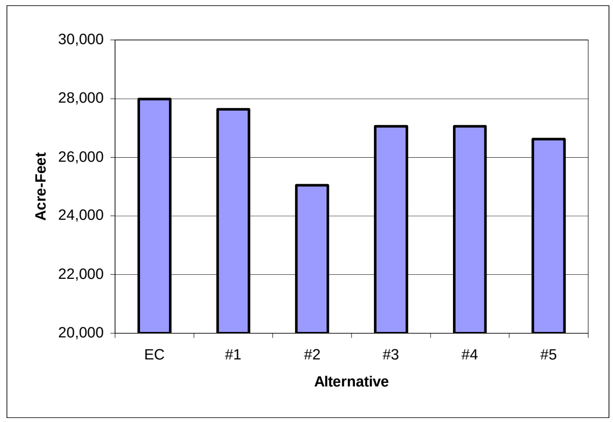
Gap water in Granby Reservoir would be protected from spilling to the degree that there is C-BT water in Participant storage accounts in Chimney Hollow. Participants could store Windy Gap water in Granby Reservoir if their Chimney Hollow account is full of Windy Gap water; however, this water is subject to spilling. When total C-BT contents in Granby Reservoir and Chimney Hollow combined reaches 539,568 AF, which is the physical capacity of Granby Reservoir, C-BT would stop storing water at Granby Reservoir. This would prevent the C-BT Project from storing more water in Granby Reservoir than it could without prepositioning and spilling "protected" Windy Gap water. Under Alternatives 3, 4, and 5, Windy Gap water would be stored in Granby Reservoir when West Slope firming storage and the Adams Tunnel are full, which is then subject to spill.

Modeled Windy Gap spills may be overstated in some wet years under existing conditions and No Action because forecasting is not incorporated in the WGFP model. See Section 3.5.2.2 under WGFP Model Forecasting Function for more discussion of Windy Gap diversions and spills in wet years.

C-BT Diversions from the Big Thompson River

Average annual C-BT diversions from the Big Thompson River for power generation would decrease slightly under all alternatives due to a reduction in the available capacity in the Olympus Tunnel. Differences in Carter Lake and Horsetooth Reservoir content among the alternatives also could cause differences in skim diversions for power. To the degree that there are differences in Carter Lake and Horsetooth contents among alternatives, C-BT deliveries to these reservoirs to meet storage targets could vary, which could cause differences in skim diversions if available capacity in Olympus Tunnel is affected and limiting. Average annual Big Thompson River diversions would decrease about 1 percent under No Action and 11 percent under the Proposed Action (Figure 3-12). Big Thompson River diversions would decrease by 5 percent or less for the other alternatives. Most of the Big Thompson diversions occur in May, June, and July. As discussed in Section 3.5.2.8, the reduction in Big Thompson diversions for power would increase streamflow in the Big Thompson River between Lake Estes and the Big Thompson Power Plant near the mouth of the canyon. Effects to power generation are discussed in the following section.

Figure 3-12. Average annual CB-T diversions from the Big Thompson River by alternative.



Hydropower Generation

The WGFP would result in energy use and energy generation from additional water conveyance in the C-BT system. Additional pumping would be needed to convey Windy Gap water from Granby Reservoir to Grand Lake and from Flatiron Reservoir to Carter Lake. Additional hydropower would be generated at the five East Slope power plants from the increased water deliveries. There would be no change in hydropower production at the Green Mountain Powerplant for any alternative.

The net change in C-BT hydropower production was calculated for each alternative based on changes in Windy Gap diversions and delivery through the C-BT system. Net C-BT Project power generation was defined as the difference between the total energy generated at Marys Lake, Estes, Pole Hill, Flatiron, and Big Thompson power plants and the total energy used for the Willow Creek Pump Canal, Granby Pump Canal, and Flatiron Unit #3. Existing conditions includes generation and pumping from an average annual delivery of 11,500 AF of Windy Gap water. Table 3-11 provides a summary comparing net hydropower generation between the alternatives and existing conditions. All alternatives would result in a net increase in annual energy production ranging from about 19 gigawatts (GW) under No Action to a maximum increase of about 30 GW under Alternative 3. The action alternatives would generate less than 2 percent more power than No Action because similar amounts of water would be delivered through the Adams Tunnel. The approximate 5 percent increase in average annual power generation from existing conditions under the action alternatives would be sold and distributed by Western.

However, the additional increase in power is still below the projected power generation expected from the original Windy Gap Project. The 5 percent increase to the C-BT generation would not affect the amount of Loveland Area Projects (LAP) energy Western markets because the increased amount of energy is already included in the currently marketed LAP resource. Since Western's total LAP firm energy commitment already includes C-BT generation based on an anticipated average Windy Gap diversion of 56,000 AF, the alternatives would reduce average annual energy purchases to support current contractual commitments and would not increase the marketable LAP energy.

Table 3-11. Comparison of net annual C-BT power generation between alternatives.

Power Generation	Existing Conditions	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Annual average (GWH)	510	529	536	540	536	536
Annual maximum (GWH)	642	645	662	664	660	660
Annual minimum (GWH)	326	343	380	386	382	382
Difference in annual average from existing conditions (GWH)	—	19	26	30	26	26
Difference in annual average from existing conditions (%)	—	3.7%	5.1%	5.8%	5.1%	5.1%

3.5.2.6 West Slope Streams and Existing Reservoirs

Colorado River

Colorado River above the Windy Gap Diversion. Flows in the Colorado River above Windy Gap Reservoir reflect the outflow from Granby Reservoir, tributary inflows from Willow Creek and the Fraser River, Colorado River mainstem irrigation diversions, and ungaged gains/losses to the river including ground water irrigation return flows. Differences in flows above Windy Gap among alternatives in average and wet years would be the result of changes in Granby Reservoir spills and changes in Willow Creek flow due to differences in WCFC diversions and Windy Gap paper spills from Willow Creek Reservoir. In dry years, flows in the Colorado River above Windy Gap would be the same for all alternatives because there would be no change in Granby Reservoir spills or WCFC diversions (Table 3-7).

Average annual Colorado River flows above Windy Gap Reservoir would decrease about 3 percent under No Action, compared to a decrease of 6 percent under the Proposed Action and 5 percent for Alternatives 3, 4, and 5 (Table 3-6). In wet years, average annual Colorado River flows above Windy Gap would decrease about 3 percent under No Action and would decrease about 5 percent for the other alternatives (Table 3-8).

For all alternatives, the majority of the changes in flow above Windy Gap would occur in average and wet years from June to August (Figure 3-13). The largest volume of flow change would occur in June, but the largest percent change in monthly flow would occur in July. Average July flows would decrease about 6 percent under No Action, 11 percent under the Proposed Action, and about a 10 percent under Alternatives 3, 4, and 5. As discussed in Section 3.5.2.2 under WGFP Forecasting Function, modeled Windy Gap diversions, and consequently spills, may be overstated in some wet years primarily under existing conditions and No Action because forecasting is not incorporated in the WGFP model. The reach of river that is most impacted by overstated spills is the Colorado River above the Windy Gap diversion; however, the impact analysis for this reach is conservative. The impact analysis is conservative for this reach because estimated flow changes based on a comparison against existing conditions and No Action will be less than predicted. In general, resource impacts would be less if the flow change is less than estimated. Flows in this reach may see less change than predicted in the model because of additional Windy Gap spills in June through August under existing conditions and No Action.

Figure 3-13. Colorado River above Windy Gap – average daily flows by alternative.

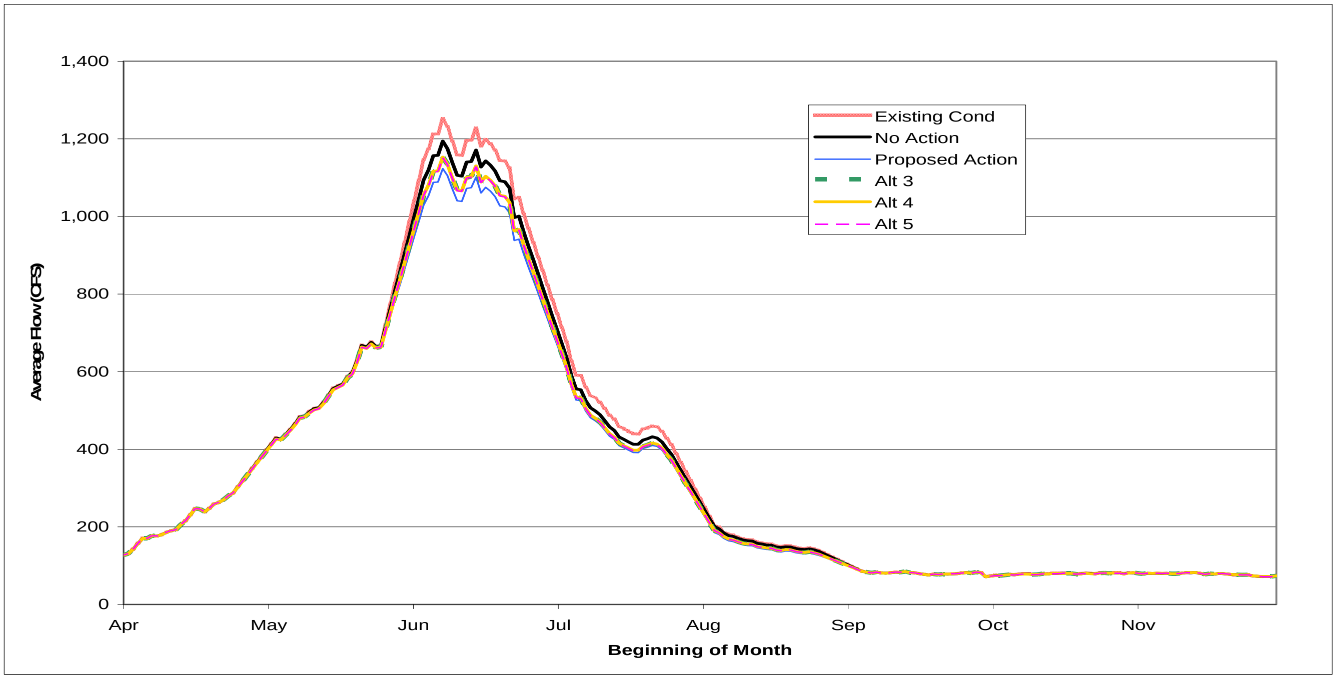


Table 3-12 illustrates the magnitude of daily flow changes from existing conditions and the percent of time that flows would change under the alternatives from May through August when most Windy Gap diversions would occur. Under the Proposed Action, Colorado River flow above the Windy Gap diversion would not change from existing conditions about 76 percent of the time. Daily flows would increase about 10 percent of the time under the Proposed Action primarily due to small differences in the timing and magnitude of C-BT spills from Granby Reservoir. Differences in Granby Reservoir C-BT contents and spills among alternatives would occur due to Windy Gap operations, including the amount of Windy Gap shrink paid to the C-BT Project, instantaneous deliveries, and prepositioning, as well as differences in the distribution of C-BT water in Granby Reservoir, Carter Lake, and Horsetooth Reservoir. Flows would decrease under the Proposed Action about 14 percent of the time from May through August. Under the Proposed Action, the maximum daily flow decrease below Granby Reservoir and above the Windy Gap diversion would be 2,398 cfs in June. Large daily flow changes would occur in wet years due to differences in the timing of spills (spills may be shifted earlier or later in the year) and reductions in the magnitude of Windy Gap spills. Flow decreases greater than 100 cfs would be infrequent and occur about 8 percent of the time. Estimated flow changes in this reach are conservative because flows in this reach may see less change than predicted in the model, as described above. Flow decreases would be similar for other action alternatives and less under No Action.

Table 3-12. Colorado River above Windy Gap – daily flow changes compared to existing conditions.

Daily Flow Changes (cfs)	Percentage of days in May through August that flow changes would occur				
	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
+1 to + 157	1.7%	9.7%	3.3%	3.3%	2.8%
0 cfs	89.4%	76.1%	84.6%	84.6%	84.2%
-1 to -10	2.4%	2.1%	1.8%	1.8%	1.5%
-11 to -100	2.7%	3.9%	3.7%	3.7%	4.7%
-101 to -200	1.6%	3.2%	2.6%	2.7%	2.7%
-201 to -300	0.7%	1.6%	1.2%	1.2%	1.2%
-301 to -500	0.3%	1.4%	1.1%	1.1%	1.2%
-501 to -1,000	0.7%	1.2%	1.1%	1.1%	0.9%
-1,001 to -2,398	0.4%	0.9%	0.6%	0.6%	0.6%

Colorado River below the Windy Gap Diversion. Colorado River streamflow below Windy Gap Reservoir to the top of Gore Canyon reflects Windy Gap diversions, irrigation and municipal diversions and return flows, ground water inflows, and tributary inflows from Williams Fork, Troublesome Creek, Muddy Creek, and the Blue River. The largest percent reduction in Colorado River streamflow for all alternatives would occur in the stream reach below the Windy Gap diversion downstream to Hot Sulphur Springs. Average annual Colorado River flows below the Windy Gap diversion would be about 8 percent lower under the No Action Alternative compared to existing conditions (Table 3-6). Average annual streamflow for the Proposed Action and other alternatives would be about 14 percent lower than existing conditions and 6 percent lower than No Action below the Windy Gap diversion. Reductions in streamflow would occur primarily from May through August for all alternatives, which coincides with the Windy Gap diversion season (Figure 3-14).

As shown in Table 3-6, the average annual flow in the Colorado River below Windy Gap would be 21,283 AF/year less under the Proposed Action compared to existing conditions. This decrease in streamflow reflects the increase in net depletion due to Windy Gap diversions from the Colorado River and spills from Granby Reservoir. The net depletion to the Colorado River associated with pumping Windy Gap water equals Windy Gap diversions minus Windy Gap spills since that water is returned to the Colorado River. Pumping Windy Gap water that is later spilled results in a re-timing of flows.

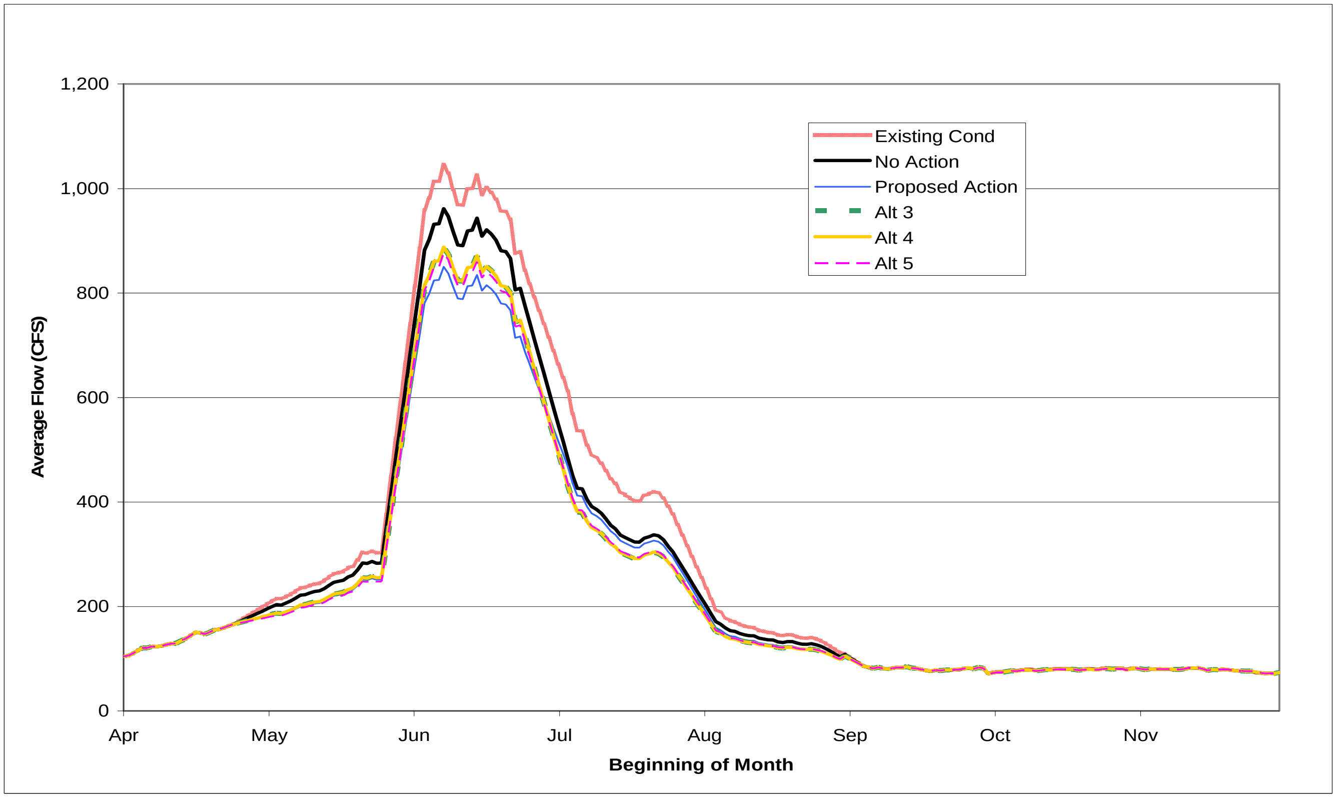
WGFP diversions from the Colorado River would occur from April to August, with the majority of diversions occurring during peak runoff in June. There would be no change in existing diversions in dry years under any of the alternatives.

The greatest volume reduction would occur during peak runoff in June, but the largest percent decrease in flow would occur in July. Reductions in Colorado River streamflow below Windy Gap in July would range from about 20 percent for No Action to 23 percent for the Proposed Action, to 28 percent for Alternatives 3, 4, and 5. There would be little to no change in flow from September to April under average (Figure 3-14) or wet years for any alternative. In dry years, there would be no change in flow from existing conditions for any alternative (Table 3-7). Similarly, the greatest reduction in river stage at the USGS gage below Windy Gap would occur during June, but the largest percent decrease in river stage would occur in July. Reductions in average monthly river stage below Windy Gap in July would range from about 11 percent for No Action to 13 percent for the Proposed Action, to 16 percent for Alternatives 3, 4, and 5. Average monthly reductions in river stage would range from 0.03 feet (0.4 inches) in August to 0.10 feet (1.2 inches) in June under No Action, and from 0.04 feet (0.5 inches) in August to 0.22 feet (2.6 inches) in June under the Proposed Action. The maximum daily decrease in river stage due to Windy Gap pumping would be approximately 1.1 feet when flows decrease from approximately 700 cfs to 100 cfs. Larger daily river stage changes may occur in wet years due to differences in the timing of spills (spills may be shifted earlier or later in the year) and reductions in the magnitude of Windy Gap spills; however, flows and consequently river stage would be much higher during spill events.

Average monthly changes in river stage, as a percent of total river stage, would decrease downstream due to gains from the contributing drainage basin and tributary inflow. Reductions in average monthly river stage for the Colorado River near Kremmling in July would range from about 2 percent for No Action to 3 percent for the Proposed Action and Alternatives 3, 4, and 5.

The frequency that the Windy Gap Project would divert from the Colorado River resulting in flows near the 90 cfs minimum flow below Windy Gap Reservoir was evaluated and compared to existing conditions. WGFP model output was used to develop daily flows for the Colorado River below Windy Gap. Monthly model output was disaggregated to daily data for the entire study period for the Colorado River below Windy Gap. Daily hydrologic data from the 47-year hydrologic period of record for May to August was tabulated to determine how many days flows below the Windy Gap diversion were less than 100 cfs (near the 90 cfs minimum flow) as a

Figure 3-14. Colorado River below Windy Gap – average daily flows by alternative.



result of Windy Gap diversions (Table 3-13). Under the No Action and action alternatives, the number of days that streamflows below Windy Gap would be reduced to near the 90 cfs minimum flow would increase, and the day at which the outflow from Windy Gap Reservoir equals the minimum flow requirement would be moved earlier in the season in some years. However, in wet years, the flow above Windy Gap is often significantly higher than 700 cfs. Under those circumstances, even if Windy Gap is diverting the full decreed amount of 600 cfs, flows below Windy Gap would still be considerably higher than the 90 cfs minimum flow.

Table 3-13. Number of days flows below the Windy Gap diversion would be less than 100 cfs over the entire 47-year study period as a result of Windy Gap pumping.

Alternative	May	June	July	August
Existing Conditions	180	13	22	84
Alt 1 – No Action	180	13	25	108
Alt 2 to 5 [1]	180	13	32	138

[1] Results indicate the effects under the Proposed Action. Alternatives 3, 4, and 5 would have a few more days because diversions are slightly greater than the Proposed Action.

In May and June there would be no change from existing conditions for any of the alternatives in the number of days that flows are below 100 cfs. In July, diversions to the minimum streamflow would increase by 3 days under the No Action Alternative compared to existing conditions and diversions to the minimum flow would increase by 10 days over the 47-year study period under the action alternatives. Under existing conditions, Windy Gap diversions reduce Colorado River streamflow to the minimum streamflow about 1.5 percent of the days in July. The additional diversions under the No Action Alternative would increase the percentage of time that flows are at the minimum streamflow about 0.2 percent and the action alternatives would increase the frequency about 0.7 percent. In August, the No Action Alternative would increase the number of days near the minimum streamflow by 24 days over the 47-year study period compared to existing conditions and days near the minimum streamflow would increase by about 54 days in 4 years over the 47-year study period under the action alternatives. Under existing conditions, Windy Gap diversions reduce flows in the Colorado River to near the minimum streamflow about 5.7 percent of the days in August. This would increase to 7.4 percent under the No Action Alternative and about 9.5 percent of the days under the action alternatives.

Additional Windy Gap diversions under the action alternatives would have little to no effect on the extent of low-flow periods and would not prolong drought conditions. Windy Gap diversions during below-average years or in the year following a drought would typically not change with additional firming storage online. The existing Windy Gap Project is able to divert water in below-average years and in wet years following dry years because storage space is typically available in Granby Reservoir. In years when Granby Reservoir has sufficient storage space, there would be no difference in the amount of Windy Gap water diverted under the action alternatives compared to existing conditions. In those years, the Participants' Windy Gap water would be stored in firming reservoirs as opposed to Granby Reservoir. For example, in the study period evaluation, there would be no difference in Windy Gap diversions between the Proposed Action and existing conditions in 1965 (wet year) following two dry years (1963 and 1964), in 1978 (wet year) following 1977 (dry year), and in 1982 (above-average year) following 1981 (dry year). In some wet years following dry years, there would be additional Windy Gap diversions under the action alternatives compared to existing conditions; however, this would not cause Colorado River streamflows to drop to dry year conditions.

The percent reduction in Colorado River streamflow decreases downstream with additional inflows from tributaries. Average annual Colorado River flow at the Kremmling gage below the confluence with the Blue River would decrease about 2 percent under No Action compared to 3 percent for the Proposed Action and other alternatives (Table 3-6). Average July streamflow near Kremmling would decrease about 5 percent under No Action, compared to 6 percent for the Proposed Action and 7 percent for the other alternatives (Figure 3-15). There would be no change in dry year flows (Table 3-7). In wet years, average annual streamflow near Kremmling would decrease 3 percent under No Action and 5 percent for other alternatives (Table 3-8).

> Colorado River average annual streamflow below the confluence with the Blue River near Kremmling would decrease about 3 percent under the Proposed Action. Average monthly streamflow would decrease up to 6 percent in July under the Proposed Action.

There would be no change in Colorado River flow below Windy Gap at Hot Sulphur Springs and Kremmling about 70 percent of the time from May through August under any of the action alternatives (Table 3-14). Daily flow decreases of 1 to 100 cfs would occur about 12 percent of the time under the Proposed Action and slightly less for other alternatives. Larger flow decreases for the action alternatives would occur about 18 to 20 percent of the time during that period. Larger flow decreases occur primarily during wet years when Windy Gap is able to divert with additional firming storage online, whereas under existing conditions, Windy Gap diversions would be curtailed in wet years when Granby Reservoir fills. Under the Proposed Action, the maximum daily flow decrease at all locations below Windy Gap due to Windy Gap pumping would be 600 cfs (from approximately 700 cfs to 100 cfs). Flow decreases greater than 600 cfs would be infrequent (less than about 5 percent of the time) and would occur in wet years due to differences in the timing and magnitude of Windy Gap spills (spills may be shifted earlier or later in the year). The No Action Alternative would experience no change in flows about 73 percent of the time.

Willow Creek

Increased WCFC diversions under all alternatives would reduce average flows in Willow Creek below Willow Creek Reservoir. Average annual flows would decrease about 7 percent under No Action compared to 14 percent for the Proposed Action and 12 percent for other alternatives (Table 3-6). Lower flows would occur from May to November with the greatest volume reductions occurring in June and the greatest percent change in July (Figure 3-16).

Figure 3-15. Colorado River near Kremmling – average daily flows by alternative.

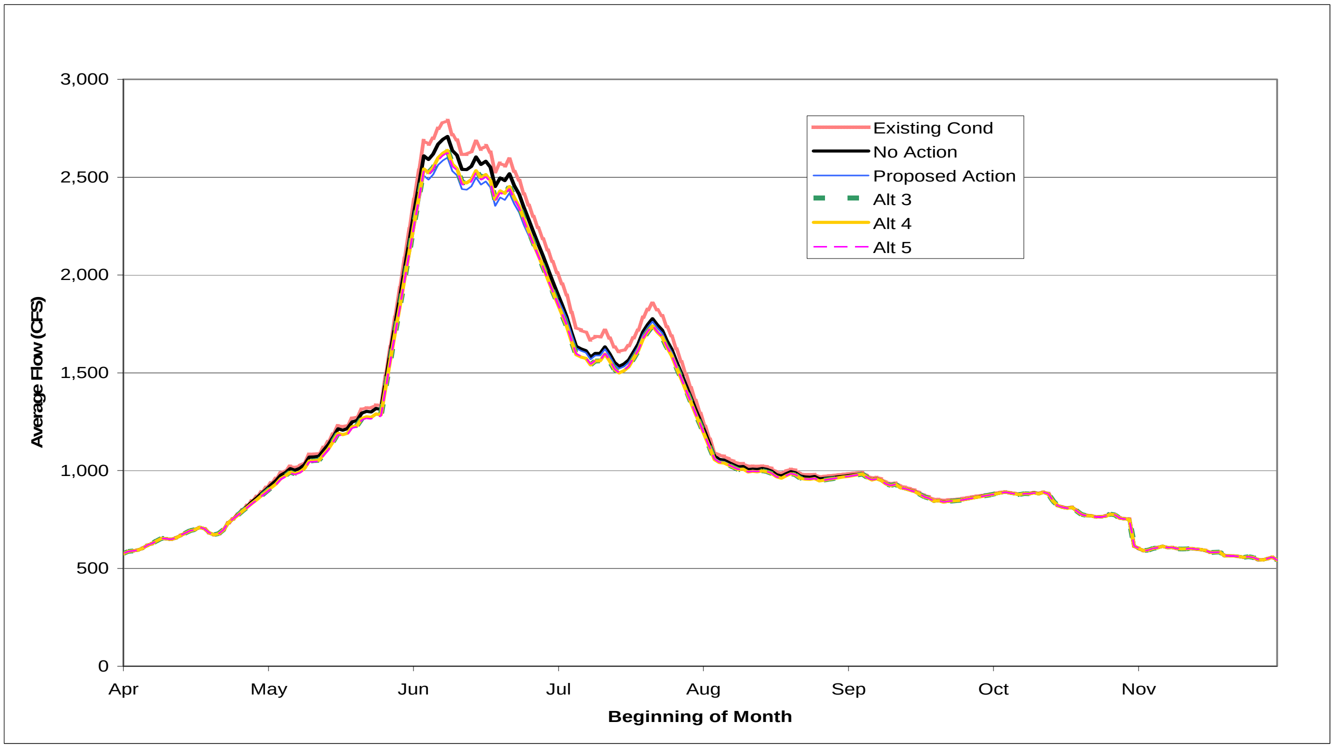
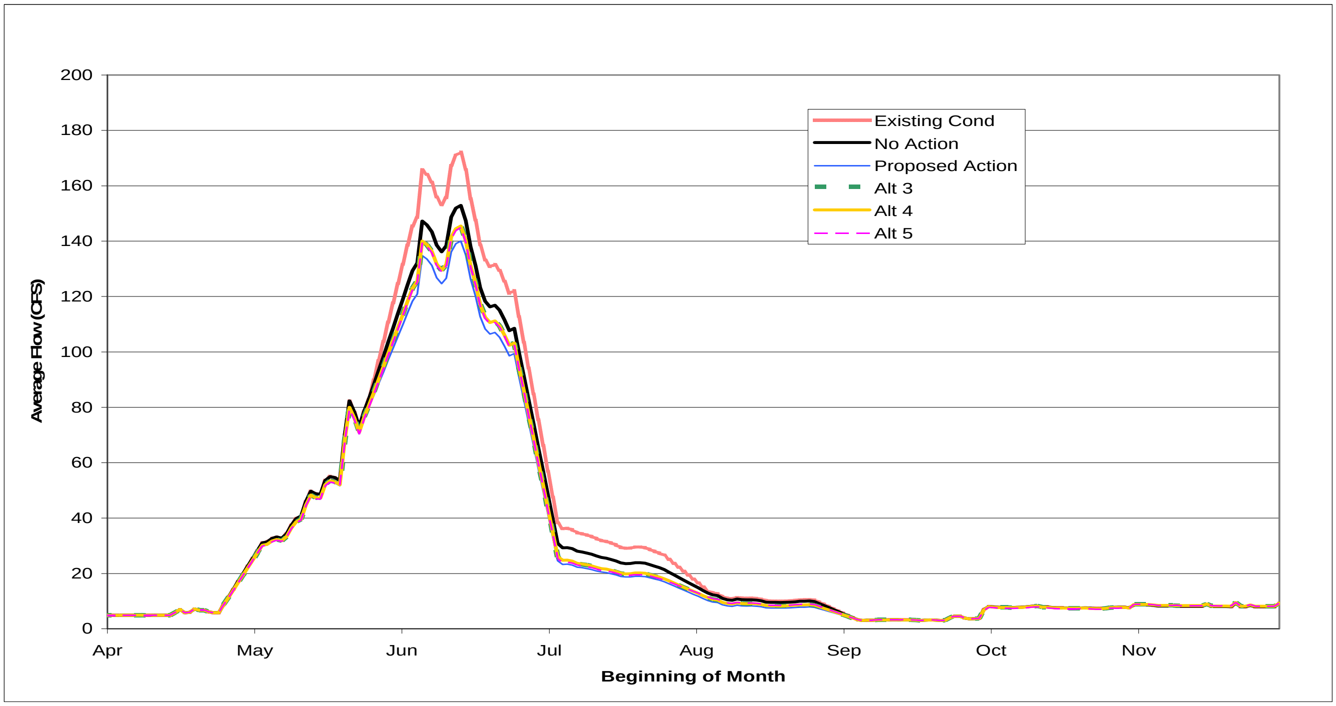


Table 3-14. Colorado River below Windy Gap (Hot Sulphur Springs to Kremmling) – daily flow changes compared to existing conditions from May to August.

Daily Flow Changes (cfs)	Percentage of days in May through August that flow changes would occur				
	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
+1 to + 24	1.6%	1.3%	0.6%	0.6%	0.5%
0	73.5%	68.8%	69.9%	70.1%	69.8%
-1 to -10	0.8%	1.9%	1.2%	1.0%	0.4%
-11 to -100	10.5%	10.4%	7.9%	8.0%	9.1%
-101 to -200	6.3%	4.8%	6.8%	6.8%	6.2%
-201 to -300	2.4%	3.7%	4.7%	4.7%	4.1%
-301 to -500	2.6%	3.5%	4.2%	4.2%	4.6%
-501 to -1,000	1.6%	4.1%	3.5%	3.5%	3.9%
-1,001 to -2,682	0.6%	1.4%	1.2%	1.2%	1.3%

Figure 3-16. Willow Creek at Colorado River – average daily flows by alternative.



Granby Reservoir

Granby Reservoir storage content would vary monthly for all alternatives in average, wet, and dry years. Differences in Granby Reservoir content between existing conditions and the alternatives occur for several reasons:

- *Differences in the storage of Windy Gap water in Granby Reservoir.* Under existing conditions, Windy Gap water can only be stored in Granby Reservoir when space is available. Under the Proposed Action, Windy Gap water diverted to Granby Reservoir would be exchanged with C-BT water in Chimney Hollow until Chimney Hollow is full of Windy Gap water, subject to volumetric limits in the decree. Any additional Windy Gap water diverted above the capacity of Chimney Hollow would be stored in Granby Reservoir. Other action alternatives would have new reservoirs in which to store Windy Gap water or an enlarged reservoir under No Action in addition to Granby Reservoir. Differences in Windy Gap storage in Granby Reservoir would result in differences in instantaneous deliveries to meet Windy Gap demands, which also would affect Granby Reservoir contents.
- *Differences in Windy Gap demand.* Differences in the magnitude and timing of Windy Gap deliveries to meet demands would affect Granby Reservoir storage content.
- *Variations in the amount of Windy Gap shrink paid to the C-BT Project.* Differences in Windy Gap diversions among alternatives affect the amount of shrink paid. The Proposed Action includes a shrink charge when Windy Gap water is initially diverted to Granby Reservoir and a reintroduction shrink when the water is delivered out of Chimney Hollow to the WGFP Participants. A diversion shrink of 10 percent is paid when Windy Gap water is introduced into the C-BT system per the Carriage Contract between the Municipal Subdistrict and Reclamation. Diversion shrink would be paid when Windy Gap water is initially diverted to Granby Reservoir and exchanged into Chimney Hollow Reservoir or delivered to Dry Creek Reservoir. Once in Chimney Hollow or Dry Creek reservoir, Windy Gap water would no longer be in the C-BT system. When Windy Gap water is released from those reservoirs for delivery to the Participants, it would be reintroduced into the C-BT

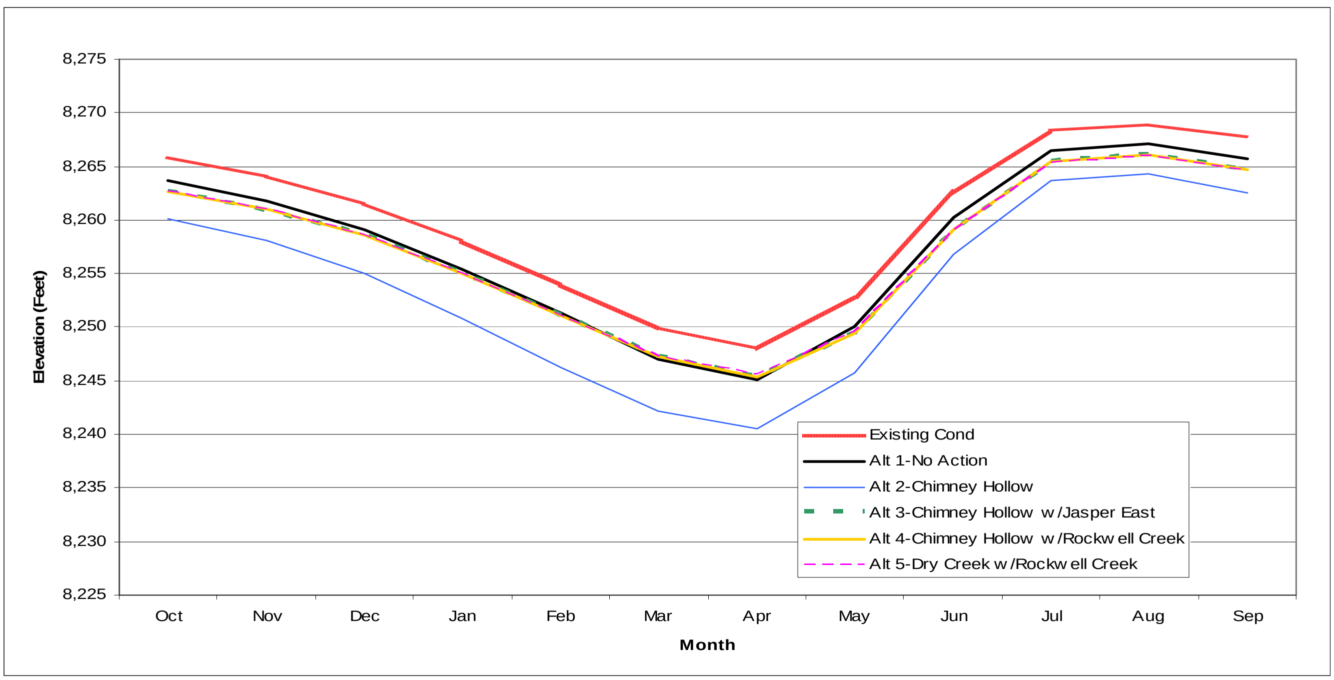
system. Therefore, Windy Gap water would be charged an additional 10 percent shrink, which was termed reintroduction shrink. East Slope firming reservoirs, such as Chimney Hollow and Dry Creek reservoirs, include a reintroduction shrink, whereas West Slope firming reservoirs, including Jasper East and Rockwell/Mueller Creek reservoirs, do not. In other words, reintroduction shrink would only be paid once when deliveries are made from West Slope firming reservoirs and introduced into the C-BT system for the first time.

- *Differences in Adams Tunnel maintenance.* A projected 10 percent increase in tunnel maintenance in March would affect C-BT and Windy Gap contents in Granby Reservoir.

Granby Reservoir average monthly content would be about 7 to 9 percent lower in the summer than existing conditions under the Proposed Action.

In an average year under the No Action Alternative, the monthly storage content in Granby Reservoir would be about 3 to 5 percent lower than existing conditions. The largest change in the monthly volume of Granby Reservoir that would occur in an average year would be under the Proposed Action, with a 13 percent decrease in content from February to April. Summer reservoir content under the Proposed Action would be about 7 to 9 percent lower than existing conditions. Other action alternatives would result in monthly decreases in Granby Reservoir content similar to No Action, but with slightly greater decreases in the spring and summer. Figure 3-17 shows changes in the average monthly surface elevation of Granby Reservoir for each alternative.

Figure 3-17. Granby Reservoir estimated average monthly surface elevation by alternative.



In dry years, the percent decrease from existing conditions in Granby Reservoir volume is generally less than average years for No Action and all the action alternatives. However, under the Proposed Action monthly storage would decrease up to 13 percent (8 feet in surface water elevation) in September of dry years. In addition, when there is a series of dry years, Granby Reservoir levels could drop as much as 23 feet under the Proposed Action. The larger changes in Granby Reservoir storage during consecutive dry years would occur primarily under the Proposed Action from delivery of C-BT water to Chimney Hollow Reservoir to replace releases to meet Windy Gap demands.

Although the amount of water stored in Granby Reservoir is substantially higher in wet years, all alternatives would result in lower storage than existing conditions. Under No Action, monthly lake storage would range from

0 to 8 percent lower than existing conditions during wet years. The Proposed Action would result in monthly storage levels of 1 to 16 percent less than existing conditions, while other alternatives would range from 1 percent to 8 percent lower in wet years. When Granby Reservoir fills with C-BT water, there would be very little difference between the alternatives because differences in C-BT operations and contents in Granby Reservoir due to Windy Gap operations would be relatively small.

3.5.2.7 Drinking Water Treatment Facilities and Wastewater Treatment Facilities

There is one drinking water treatment facility and one wastewater treatment facility within the project area, both owned by the town of Hot Sulphur Springs. The town has a right to divert 3.34 cfs for drinking water purposes. By law, diversions for the Windy Gap Project cannot impair senior water rights users. The project would not affect the wastewater treatment facility's permit to discharge to the Colorado River because the design flows used to calculate effluent limits are lower than would be experienced in the Colorado River at Hot Sulphur Springs under any of the alternatives.

3.5.2.8 East Slope Streams and Existing Reservoirs

Big Thompson River

Average flow in the Big Thompson River between Lake Estes and the canyon mouth would increase up to 9 percent in May and July under the Proposed Action.

Due to lower skim diversion for power generation, the Big Thompson River from Lake Estes to the canyon mouth would experience a slight increase in flow under all alternatives (Table 3-6). Under No Action, average streamflow below Lake Estes would increase less than 1 percent in June and July, with negligible to no change in other months (Appendix Table A-7). The Proposed Action would result in increased Big Thompson flows of up to 9 percent in May and July in average years and up to 5 percent in June of wet years. Alternatives 3, 4, and 5 would result in Big Thompson River flow increases of 4 to 5 percent in May, with less than a 2 percent change in other months in an average year. There would be no change in Big Thompson River flows during dry years for any alternative.

North St. Vrain Creek and St. Vrain Creek

Flows in North St. Vrain Creek below Ralph Price Reservoir to St. Vrain Creek near Lyons would experience increases and decreases in flow only under the No Action Alternative.

Under the No Action Alternative, the flow of North St. Vrain Creek below Ralph Price Reservoir, as well as St. Vrain Creek in the approximately 1-mile stretch from the confluence of the North and South forks to the St. Vrain Supply Canal, would change due to exchanges of Windy Gap water to storage in an enlarged Ralph Price Reservoir and Windy Gap releases from the reservoir to meet Longmont's demands. Flows in these reaches would decrease primarily in May and July, when North St. Vrain water is stored in Ralph Price Reservoir in exchange for Windy Gap deliveries to St. Vrain Creek at the St. Vrain Supply Canal. Releases from Ralph Price Reservoir to meet Longmont's Windy Gap demands would occur throughout the year (Table 3-15). Flows in these reaches would increase in September and October when releases exceed the amount exchanged to storage.

Longmont's diversions from North St. Vrain Creek at the Longmont Pipeline to meet demand would increase during most months of the year; additional diversions related to exchanging Windy Gap water upstream would occur in May, July, and August (Table 3-15). Longmont's average net diversions to storage in Ralph Price Reservoir in May, July, and August would increase by 15 cfs, 45 cfs, and 3 cfs, respectively. This would reduce the average flow of North St. Vrain Creek below Ralph Price Reservoir and Longmont's pipeline by about 10 percent in May, 25 percent in July, and 3 percent in August. The average monthly flow in June below Ralph Price Reservoir would not change because average monthly diversions to storage at Ralph Price Reservoir would be offset by Windy Gap releases to meet Longmont's demands.

Table 3-15. North St. Vrain Creek and St. Vrain Creek average monthly streamflow under the No Action Alternative.

Month	North St. Vrain between Ralph Price Reservoir and Longmont Reservoir			North St. Vrain below Longmont Reservoir			St. Vrain at Lyons USGS Gage		
	Exist. Cond. (cfs)	No Action (cfs)	% Change	Exist. Cond. (cfs)	No Action (cfs)	% Change	Exist. Cond. (cfs)	No Action (cfs)	% Change
January	24	28	18%	13	13	0%	14	14	0%
February	23	27	18%	13	13	0%	13	13	0%
March	24	28	17%	12	12	-0%	20	20	0%
April	46	48	4%	29	29	0%	91	91	0%
May	155	140	-10%	133	118	-11%	297	282	-5%
June	274	277	1%	250	250	0%	528	528	0%
July	179	134	-25%	147	107	-27%	296	256	-13%
August	89	86	-3%	59	58	-3%	135	133	-1%
September	42	60	43%	19	32	67%	67	80	19%
October	26	43	67%	8	15	90%	39	46	18%
November	23	27	18%	13	13	0%	24	24	0%
December	23	27	19%	13	13	0%	17	17	0%

Diversions by Longmont from North St. Vrain Creek at the Longmont Pipeline are limited by the pipeline's physical capacity of 28.5 cfs. From July to October, Longmont typically uses most of that pipeline capacity for its existing diversions. As a result, flow changes below Longmont's Pipeline would occur if Longmont could not divert the entire Windy Gap release from Ralph Price Reservoir at Longmont Reservoir. Longmont would divert any excess Windy Gap release that cannot be diverted at the Longmont Pipeline farther downstream above the St. Vrain Supply Canal. The flow of St. Vrain Creek would not change downstream of the St. Vrain Supply Canal because Windy Gap water would be released to St. Vrain Creek at the St. Vrain Supply Canal in exchange for diversions to storage in Ralph Price Reservoir. Also, Windy Gap releases from Ralph Price Reservoir would be diverted by Longmont upstream of this point.

Streams that Receive Windy Gap Return Flow

Under all alternatives, Windy Gap deliveries to East Slope Participants would be more reliable and there would be greater and more consistent return flows to East Slope streams. Windy Gap return flows attributable to indoor use of Windy Gap water occur primarily at Participants' WWTPs (Figure 3-2). Additional Windy Gap return flows from outdoor irrigation use would occur at various locations within Participants' service areas. However, for the purpose of analyzing affects, it was assumed that return flows attributable to outdoor irrigation use (50 percent of total) would accrue to the stream at each Participant's WWTP.

East Slope streams below Participant WWTPs would increase slightly from April to October under all of the alternatives. Because Windy Gap water is reusable to extinction, Participants may increase their reuse capabilities in the future, which would reduce return flows of Windy Gap water.

Maximum East Slope return flow increases would occur under the No Action Alternative because the demand for Windy Gap water would be highest under this alternative and, therefore, the maximum Windy Gap delivery would be greatest under No Action. However, average return flows would be less under No Action than the action alternatives compared to existing conditions because average deliveries would be less. Table 3-16 compares the average and maximum flow increases attributable to additional Windy Gap return flows under the

No Action Alternative to the existing average maximum monthly flows at the nearest USGS gage. The average and maximum flow increases attributable to Windy Gap return flows at the South Platte River near Kersey gage are the summation of increases in flows anticipated along tributaries including Big Dry Creek, Coal Creek, St. Vrain Creek, and the Big Thompson River. There would be no net change in streamflow from November to March between the No Action Alternative and existing conditions because either Participants do not intend to use their Windy Gap supplies in those months, reusable effluent is stored for use later in summer months, or reusable Windy Gap return flows are used to offset depletions or augment return flow obligations. The USGS gage flows presented are the closest measured flows to the location where additional returns would occur at Participants' WWTPs. No adjustments were made to gage flows to account for gains/losses that may occur between the gages and WWTPs. In Coal Creek and St. Vrain Creek, return flows would increase at more than one location and these flows have not been added together in Table 3-16.

Table 3-16. East Slope streamflow increases from Windy Gap return flows under the No Action Alternative.

Stream Segment	Flow Condition[1]	Apr	May	Jun	Jul	Aug	Sep	Oct
		cfs						
Big Dry Creek above Broomfield WWTP (USGS gage 06720820, adjusted for average historical Broomfield WWTP effluent, 1995-2004)	Existing average flow	13.3	28.9	51.1	41.5	38.5	23.6	10.1
	Existing maximum flow	19	40.5	73.2	86.5	49	40.3	16.2
	Average flow increase	1.5	2.6	3.1	3.7	3.7	3.1	1.5
	Maximum flow increase	3.5	5.9	7.0	8.5	8.5	7.0	3.4
Coal Creek below Superior, above Louisville, Lafayette and Erie WWTPs (USGS gage 06730400)	Existing average flow	12.3	13.1	7	2.8	4.1	2.1	2.6
	Existing maximum flow	36	35	13	4.3	15	3.1	3.8
	Average flow increases above gage	0.8	1.4	1.2	0.9	0.7	0.6	0.5
	Maximum flow increase above gage	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	Average flow increases below gage	1.5	2.8	2.3	1.8	1.3	1.2	1.0
	Maximum flow increase below gage	3.3	3.3	3.4	3.3	3.3	3.4	3.2
St. Vrain Creek below Longmont WWTP (USGS gage 06725450)	Existing average flow	76	234	348	175	148	101	68
	Existing maximum flow	259	1,155	1,227	485	185	152	159
	Average flow increase	2.2	0.8	0.9	10.7	10.5	10.3	9.3
	Maximum flow increase	3.0	0.8	0.9	11.0	11.0	11.3	10.8
St. Vrain Creek below LTWD WWTP (USGS gage 06731000)	Existing average flow	178	472	627	313	231	184	160
	Existing maximum flow	622	2,362	2,316	972	653	292	398
	Average flow increase	0.3	0.7	0.8	0.9	0.9	0.7	0.3
	Maximum flow increase	0.8	1.3	1.5	1.5	1.5	1.5	0.7
South Platte River near Kersey (USGS gage 06754000)	Existing average flow	846	2,092	2,599	821	566	618	743
	Existing maximum flow	3,894	13,065	14,517	5,784	2,783	2,079	3,388
	Average flow increase	6.4	9.7	9.5	20.1	20.6	19.8	15.4
	Maximum flow increase	12.4	14.6	16.2	29.5	32.7	34.8	29.2

[1] Existing average and maximum flow are at stream gage locations. Average and maximum flow increases are at Participants' WWTPs and dispersed return flow locations from outdoor use.

Because the yield for the Proposed Action and other action alternatives is similar, the projected increase in East Slope return flows would be similar. The maximum potential flow change in East Slope streams due to additional Windy Gap return flows under the action alternatives was compared to existing conditions and the average maximum monthly flows at the nearest USGS gage (Table 3-17). These flow changes are an estimate of the greatest possible flow changes; there would be smaller flow changes in years when the demand for Windy Gap water is lower and subsequently Windy Gap return flows would be less. Streamflow would increase during the months of April through October, but there would be no change in streamflow from November to March.

Table 3-17. East Slope streamflow increases from Windy Gap return flows under Alternatives 2, 3, 4, and 5.

Stream Segment[1]	cfs	Apr	May	Jun	Jul	Aug	Sep	Oct
Big Dry Creek above Broomfield WWTP (USGS gage 06720820, adjusted for average historical Broomfield WWTP effluent, 1995-2004)	Existing average flow	13.3	28.9	51.1	41.5	38.5	23.6	10.1
	Existing maximum flow	19	40.5	73.2	86.5	49	40.3	16.2
	Maximum flow increase	3.5	5.9	7	8.5	8.5	7	3.4
Coal Creek below Superior, above Louisville, Lafayette, and Erie WWTPs (USGS gage 06730400)	Existing average flow	12.3	13.1	7	2.8	4.1	2.1	2.6
	Existing maximum flow	36	35	13	4.3	15	3.1	3.8
	Maximum flow increase above gage	1.6	1.6	1.6	1.6	1.6	1.6	1.5
	Maximum flow increase below gage	3.5	3.7	3.9	4	4	3.9	3.3
St. Vrain Creek below Longmont WWTP (USGS gage 06725450)	Existing average flow	76	234	348	175	148	101	68
	Existing maximum flow	259	1,155	1,227	485	185	152	159
	Maximum flow increase	1.7	0.5	0.5	6.2	6.2	6.4	6.1
St. Vrain Creek below LTWD WWTP (USGS gage 06731000)	Existing average flow	177	400	535	214	164	124	103
	Existing maximum flow	856	2,256	2,203	852	410	592	286
	Maximum flow increase	0.8	1.3	1.5	1.8	1.8	1.5	0.7
Big Thompson River below Loveland WWTP (USGS gage 06741510)[2]	Existing average flow	41	251	296	129	84	37	28
	Existing maximum flow	292	2,078	1,493	418	153	84	111
	Maximum flow increase	0	0.9	1.0	1.9	3.8	5.9	5.6
South Platte River near Kersey (USGS gage 06754000)	Existing average flow	846	2,092	2,599	821	566	618	743
	Existing maximum flow	3,894	13,065	14,517	5,784	2,783	2,079	3,388
	Maximum flow increase	11.0	13.8	15.5	24.0	25.9	26.3	20.7

[1] Existing average flow and maximum flow are at stream gage locations. Maximum flow increases are at Participants' WWTPs and dispersed return flow locations from outdoor use.

[2] The average and maximum flow increases reflect the increase in firming storage of 1,000 AF requested by Loveland since the Draft EIS was released.

It is important to note that Windy Gap water is reusable to extinction. The majority of Participants reuse Windy Gap effluent either through nonpotable reuse systems, as an exchange supply, as return flow credit, or as augmentation water. Each Participant's anticipated first use and reuse of its Windy Gap supplies was taken into account when estimating Windy Gap return flows to East Slope streams. However, Windy Gap Participants may also increase their reuse capabilities in the future, which would reduce return flows.

Carter Lake

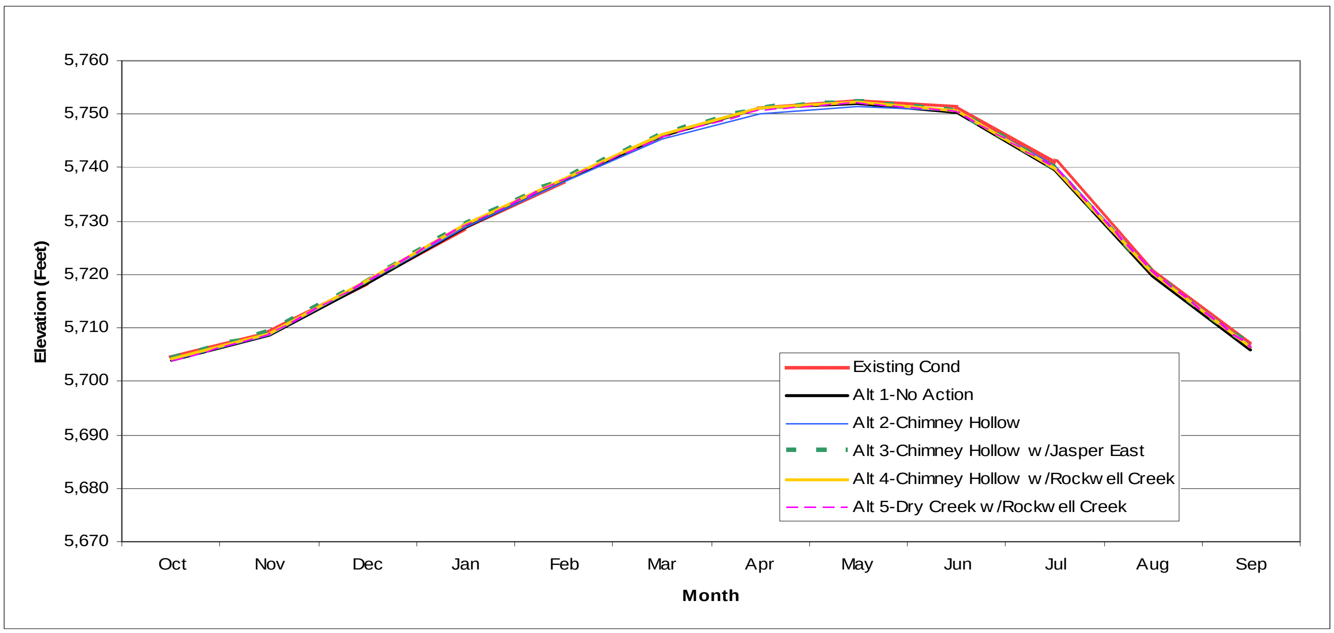
In general, Carter Lake contents would be less than existing conditions under all alternatives due primarily to differences in C-BT deliveries from Carter Lake to meet Windy Gap demands via instantaneous deliveries. Under the Proposed Action, C-BT deliveries to Chimney Hollow could reduce C-BT

> Average monthly water elevation in Carter Lake would be about 1 foot lower than existing conditions under the Proposed Action.

deliveries to Carter Lake if available capacity in the Adams Tunnel is limited or C-BT contents in Granby Reservoir are exhausted.

Average monthly Carter Lake contents under No Action would decrease by about 30 AF in February to 1,300 AF in July compared to existing conditions. The largest monthly change in the volume of water stored in Carter Lake that would occur under the No Action Alternative would be a 2 percent reduction in average years, a 1 percent reduction in dry years and a 3 percent reduction in wet years. The maximum monthly lake elevation change under No Action would be a decrease of 1 foot in average years (Figure 3-18), a decrease of less than 1 foot in dry years, and a decrease of 2 feet in wet years. Similar changes in reservoir content would occur under the Proposed Action, with a maximum monthly decrease of 1 percent in average years, a 2 percent reduction in dry years, and a 3 percent reduction in wet years. The maximum monthly lake elevation would decrease 1 foot in average and dry years and would decrease 2 feet in wet years under the Proposed Action (Appendix Table A-17). Carter Lake monthly elevations would decrease by 2 feet or less on average for Alternatives 3, 4, and 5.

Figure 3-18. Carter Lake estimated average monthly surface elevation for all alternatives.



For all alternatives, the greatest change would occur in summer months. There is little difference from existing conditions in average years under all alternatives during winter months because Windy Gap demands would be less compared to summer months and there would be less or no Windy Gap water in Granby Reservoir available for delivery. In wet and dry years under the Proposed Action, Windy Gap deliveries would be made almost exclusively from Chimney Hollow during the winter months, as opposed to instantaneous deliveries from Carter Lake under existing conditions.

During periods of consecutive dry years, Carter Lake could be as much as 7 feet lower than existing conditions under No Action due to differences in Windy Gap demands and instantaneous deliveries out of Carter Lake. In more severe dry years when C-BT contents in Granby Reservoir are exhausted, Carter Lake under the Proposed Action could be as much as 27 feet lower than existing conditions; however, the chance of a decrease in the water surface elevation at Carter Lake exceeding 4 feet in any given year would be about 6 percent. Under the Proposed Action, C-BT contents in Granby Reservoir would be exhausted earlier in dry year sequences due to C-BT deliveries to Chimney Hollow in previous years. As a result, the amount of C-BT water available for delivery to Carter Lake and Horsetooth Reservoir would be less, and consequently C-BT contents in those reservoirs would be less.

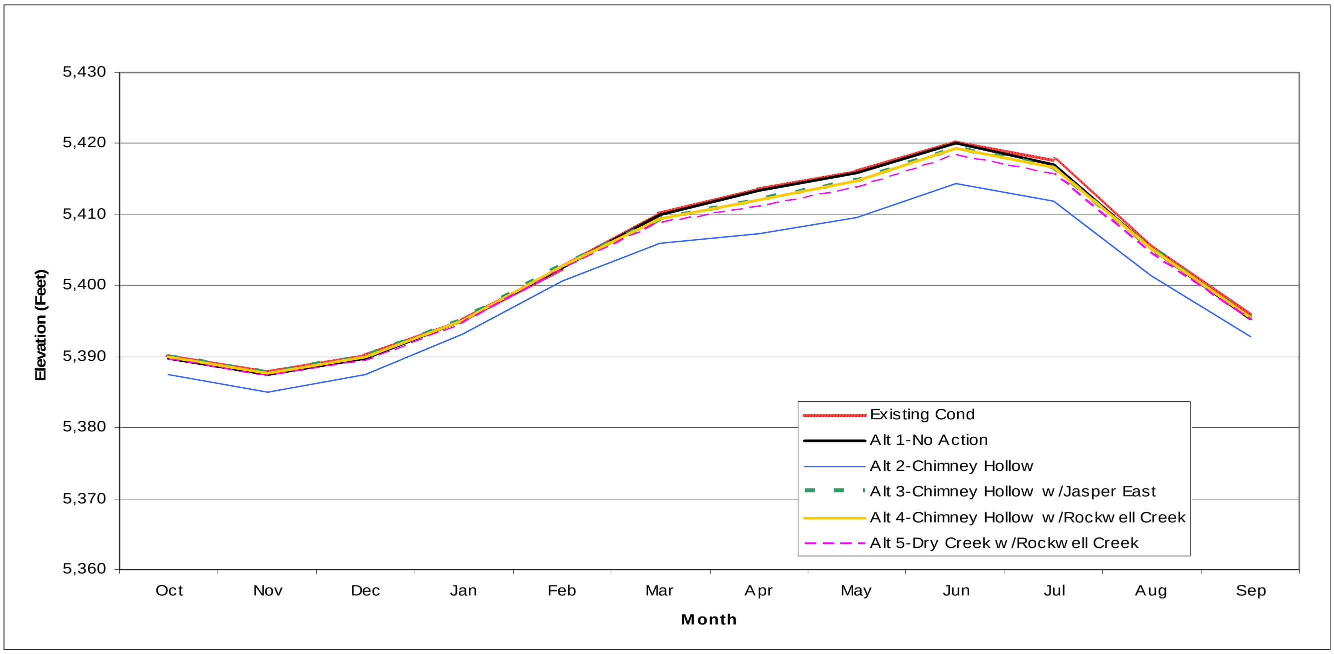
Horsetooth Reservoir

> Average monthly water elevation in Horsetooth Reservoir would decrease up to 6 feet in average years during the summer months under the Proposed Action.

As with Carter Lake, differences in Horsetooth Reservoir content for the alternatives would primarily be due to differences in instantaneous C-BT deliveries from Horsetooth to meet Windy Gap demands. This is less of a factor for Horsetooth Reservoir than Carter Lake because there is less Windy Gap demand north of Horsetooth versus south of Carter Lake. In addition, for the Proposed Action, differences in Horsetooth Reservoir content would be primarily due to C-BT deliveries to Chimney Hollow Reservoir, which could reduce C-BT deliveries to Horsetooth if available capacity in the Adams Tunnel was limiting or C-BT contents in Granby Reservoir were exhausted in more severe dry years.

The average monthly volume of water in Horsetooth Reservoir under No Action would decrease in average years by about 100 AF in February to 700 AF in July and August compared to existing conditions. This would be less than a 1 percent reduction in average, wet, and dry years. The decrease in monthly average lake elevation under No Action would be less than 1 foot in average and dry years and plus or minus 1 foot in wet years (Figure 3-19).

Figure 3-19. Horsetooth Reservoir estimated average monthly surface elevation for all alternatives.



The average monthly decrease in Horsetooth Reservoir storage under the Proposed Action would range from about 3,000 AF in January to 10,600 AF in May compared to existing conditions. The largest change in Horsetooth Reservoir average monthly volume under the Proposed Action would be an 8 percent reduction in the spring of average years, a 12 percent reduction in July during dry years, and a 9 percent reduction in the spring of wet years. The estimated maximum average monthly elevation change would occur primarily in the spring and summer (6 feet in average years, 7 feet in wet years, and 9 feet in dry years) and would be greater for the Proposed Action than other alternatives (Appendix Table A-19). The surface elevation of Horsetooth Reservoir under the Proposed Action could be up to 35 feet lower than existing conditions in successive dry years if C-BT contents in Granby Reservoir are exhausted due to C-BT deliveries to Chimney Hollow Reservoir in previous years. The chance of a decreased water surface elevation at Horsetooth Reservoir of more than 10 feet in any given year would be about 15 percent.

Average monthly Horsetooth Reservoir contents would be up to 2 percent less than existing conditions for Alternatives 3 and 4, and up to 3 percent less under Alternative 5. Average monthly content in Horsetooth

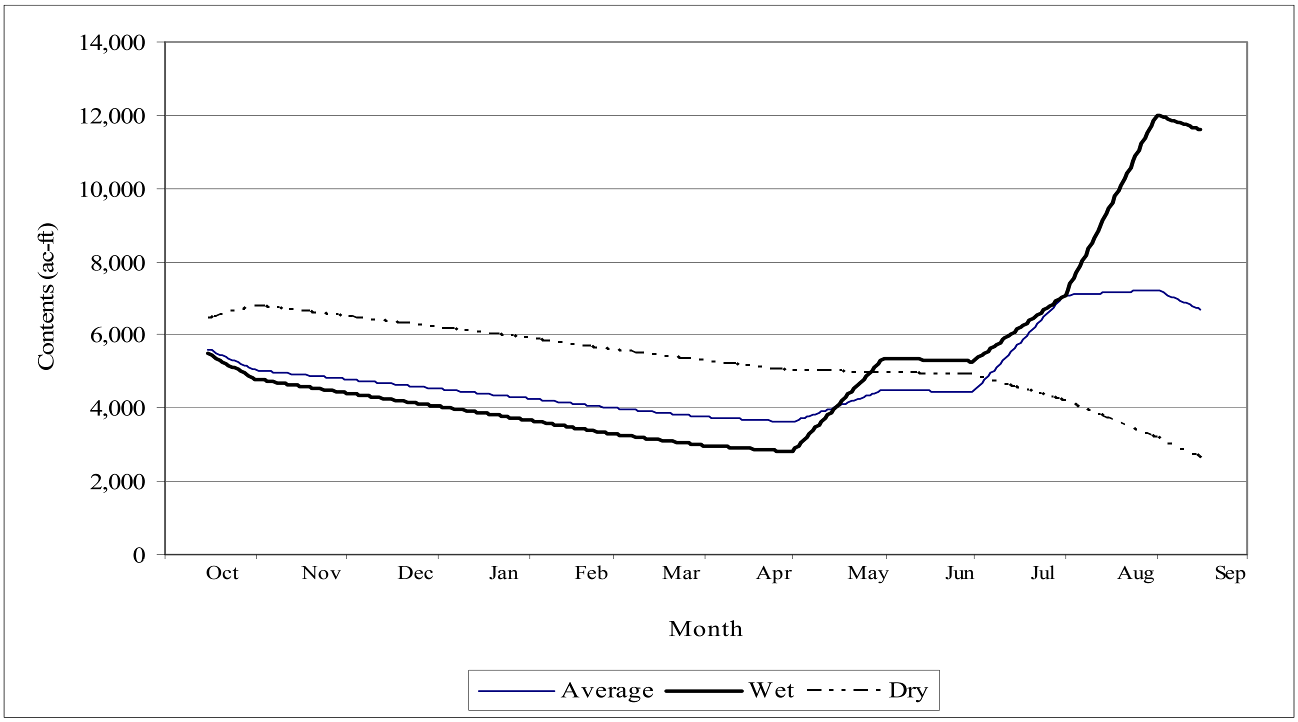
Reservoir would be higher under Alternatives 3 and 4 than other alternatives and existing conditions in winter months, particularly during wet years. Typically there would be less Windy Gap water in Granby Reservoir in the winter months under Alternatives 3 and 4; therefore, Windy Gap deliveries would be made from Chimney Hollow, Jasper East, or Rockwell in those months as opposed to instantaneous delivery from Horsetooth Reservoir.

3.5.2.9 New and Enlarged Reservoirs

Ralph Price Reservoir

Ralph Price Reservoir storage would only change under the No Action Alternative. It was assumed that operation of the existing storage of about 16,200 AF would not change (except for evaporation losses) due to the enlargement. Fluctuations in reservoir storage associated with 13,000 AF of additional storage would be due to evaporation, exchanges of Windy Gap water to storage and Windy Gap releases to meet Longmont's demands (Figure 3-20).

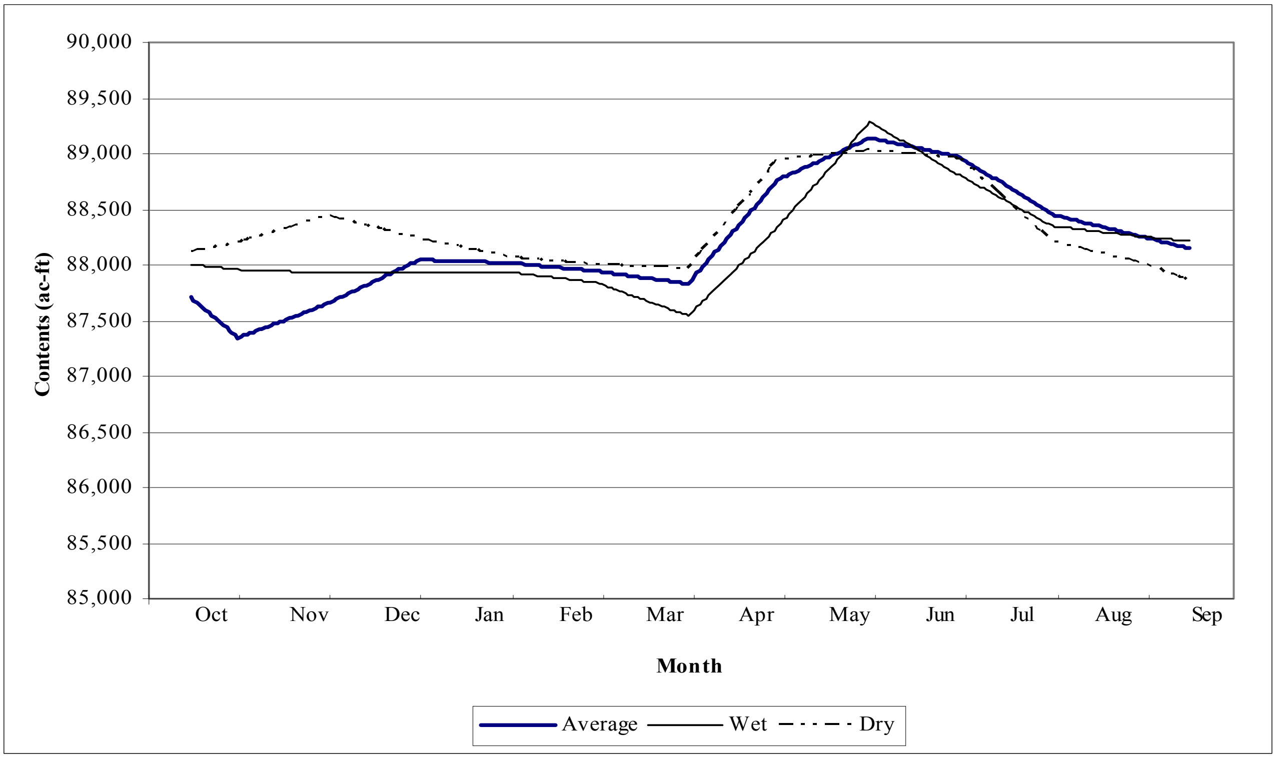
Figure 3-20. Ralph Price Reservoir daily content for 13,000 AF of new storage.



Chimney Hollow Reservoir

A 90,000 AF Chimney Hollow Reservoir would remain nearly full with both C-BT and Windy Gap water under the Proposed Action (Figure 3-21). Small fluctuations reflect evaporation losses and deliveries to meet demands. Windy Gap contents in Chimney Hollow typically would increase during the runoff season when Windy Gap water is diverted and exchanged into Chimney Hollow and would decrease through the remainder of the year as releases are made to meet Windy Gap demands. During dry year sequences, less Windy Gap water would be diverted and stored in Chimney Hollow; consequently, C-BT contents would be highest in those years under the Proposed Action.

Figure 3-21. Chimney Hollow Reservoir daily content under the Proposed Action.



Storage in a 70,000 AF Chimney Hollow Reservoir under Alternatives 3 and 4 would increase during the runoff season as Chimney Hollow fills and decrease through the remainder of the year as releases are made to meet Windy Gap demands (Figure 3-22). Chimney Hollow would fill during periods of two or more consecutive wet years. The reservoir contents appear higher at the beginning of the water year in dry years because during the model study period, the years preceding dry years were generally wetter than the years preceding wet or average years. Therefore, the reservoir contents would be higher carried over from a wet year, but would drop throughout the year under dry conditions. Chimney Hollow contents would be lowest following consecutive dry years.

Jasper East Reservoir

The volume of water in Jasper East Reservoir would fluctuate considerably throughout the year and from year to year under Alternative 3 (Figure 3-23).

In general, Jasper East would fill during the Windy Gap diversion season and then empty prior to the following diversion season as releases are made to meet Windy Gap demands. Releasing Windy Gap water from Jasper East to meet demands prior to releasing from Chimney Hollow would maximize the space available in Jasper East for Windy Gap diversions when Granby Reservoir and the Adams Tunnel are full. Jasper East Reservoir would not fill in dry year sequences because Windy Gap diversions would be limited by the physically and legally accessible supply available for diversion. However, in most average and wet years, Jasper East would fill as long as sufficient supplies remain after Windy Gap diversions to Chimney Hollow Reservoir occur. Existing downstream flows would be maintained by bypassing native flows.

Figure 3-22. Chimney Hollow Reservoir daily content under Alternatives 3 and 4.

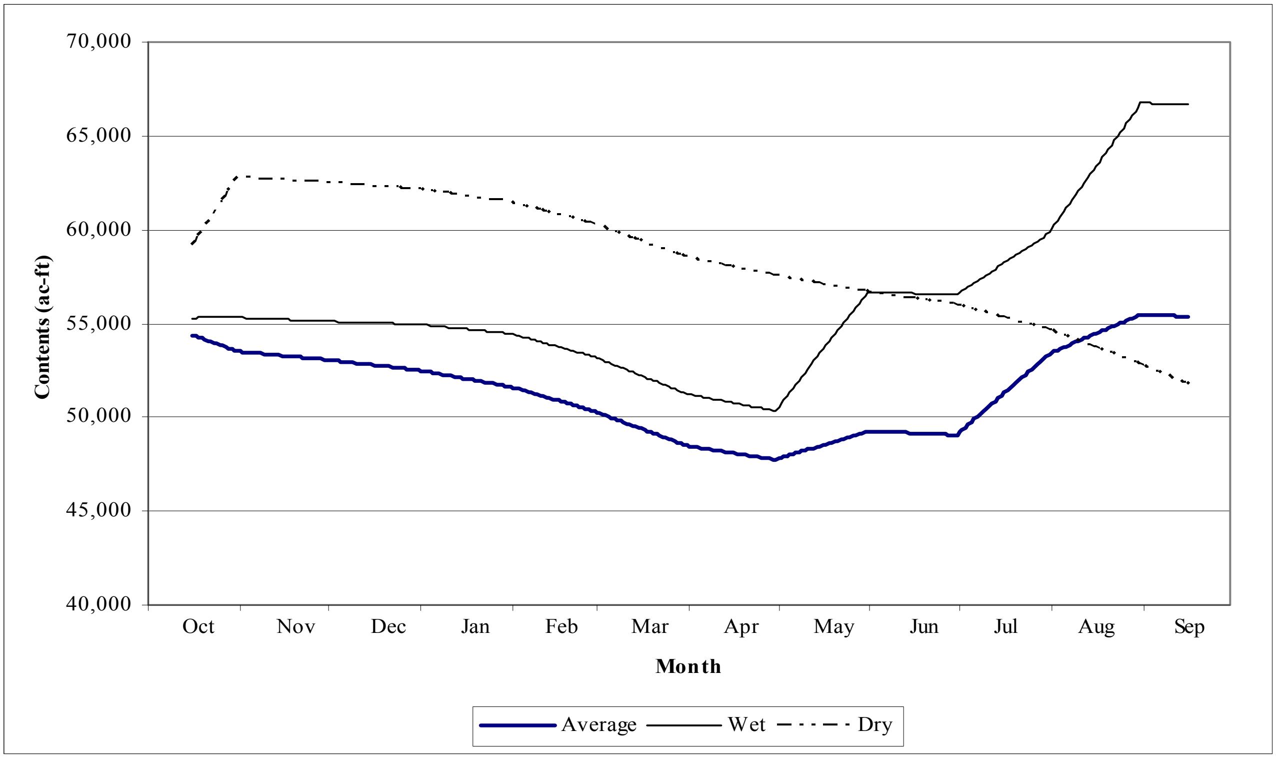
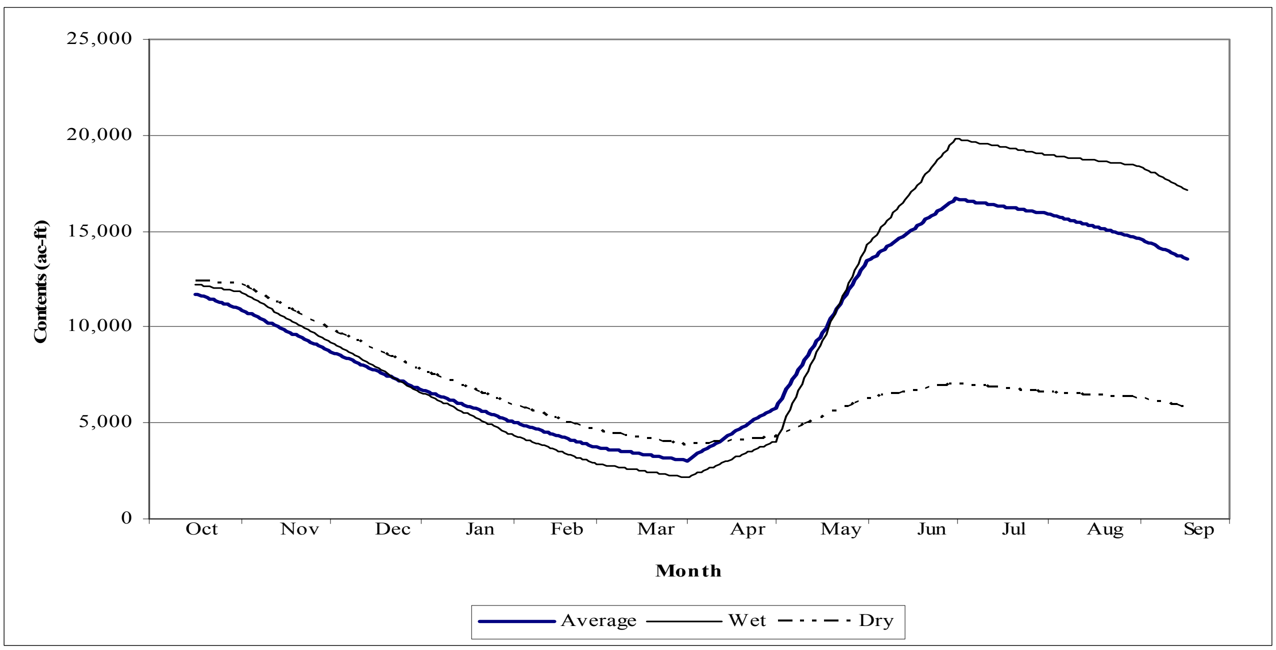


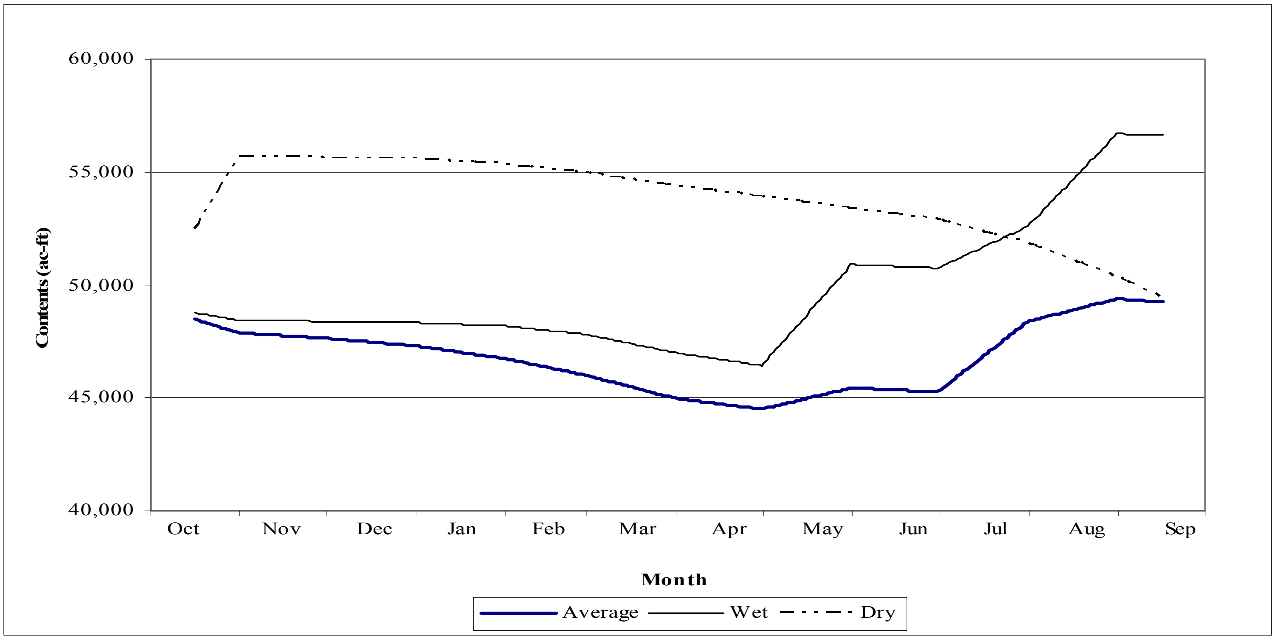
Figure 3-23. Jasper East Reservoir daily content under Alternative 3.



Dry Creek Reservoir

Dry Creek Reservoir under Alternative 5 would operate the same as Chimney Hollow Reservoir in Alternatives 3 and 4. Storage in a 60,000 AF Dry Creek Reservoir would increase during the runoff season and decrease through the remainder of the year as releases are made to meet Windy Gap demands (Figure 3-24). Dry Creek would fill during periods of two or more consecutive wet years. The reservoir contents appear higher at the beginning of the water year in dry years because, during the model study period, the years preceding dry years were generally wetter than the years preceding average or wet years. Therefore, the reservoir contents would initially be higher carried over from a wet year, but would drop throughout the year under dry conditions. Dry Creek Reservoir contents would be lowest following consecutive dry years. Existing downstream flows would be maintained by bypassing native flows.

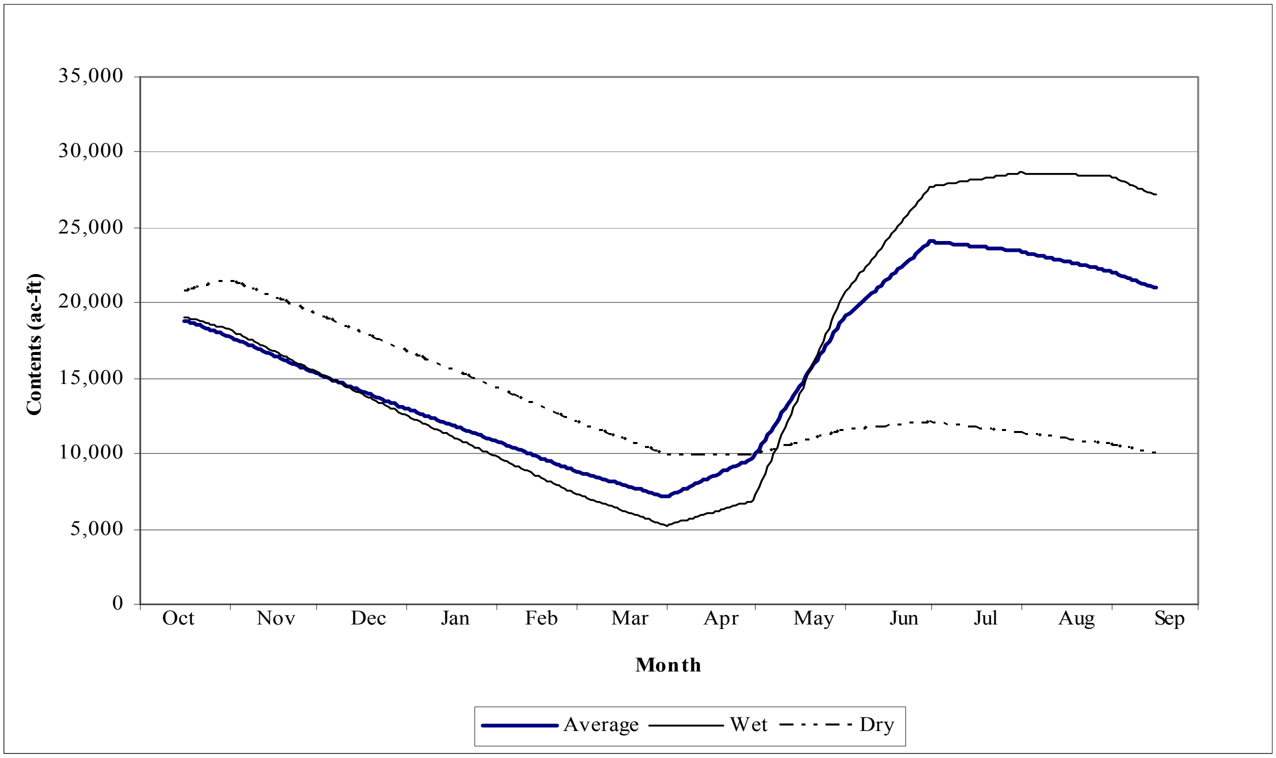
Figure 3-24. Dry Creek Reservoir daily content under Alternative 5.



Rockwell/Mueller Creek Reservoir

A 20,000 AF Rockwell Reservoir under Alternative 4 or a 30,000 AF reservoir under Alternative 5 would operate similarly to Jasper East Reservoir. Rockwell Reservoir would be more efficient in terms of storage versus surface area than Jasper East Reservoir and thus would have less evaporative loss. However, the difference in evaporation would result in a negligible difference in reservoir contents, Windy Gap diversions, and Colorado River flow between alternatives. Rockwell Reservoir would fill from Windy Gap diversions in the runoff season and then decrease over the year as water is released to meet demand. Figure 3-25 shows annual fluctuations for a 30,000 AF Rockwell Reservoir. A 20,000 AF Rockwell Reservoir would follow a similar pattern of fill and drain. Because Windy Gap water would be moved to the East Slope as soon as possible, reservoir content would fluctuate widely. Existing downstream flows would be maintained by bypassing native flows. It is possible that flows in the last approximately 2 miles of the Fraser River would increase slightly due to seepage from Rockwell Reservoir dam.

Figure 3-25. Rockwell Reservoir (30,000 AF) daily content under Alternative 5.



3.5.2.10 Windy Gap Firming Project Yield

The projected average and firm water yield to Participants in the WGFP was calculated for each alternative (Table 3-18). Windy Gap demands, firm yields, and average yields for each alternative are included in Appendix Tables A-23 to A-25.

Table 3-18. Windy Gap Participant annual demand, average, and firm yield.

Condition/Alternative	Demand	Average Yield	Firm Yield
	AF		
Existing Conditions	20,825	11,372	0
Alternative 1 No Action	36,665	21,936	1,229
Alternative 2 Proposed Action Chimney Hollow[1]	29,115	28,995	26,545
Alternative 3 Chimney Hollow and Jasper East	28,420	28,259	25,849
Alternative 4 Chimney Hollow and Rockwell	28,420	28,284	25,849
Alternative 5 Dry Creek and Rockwell	29,200	29,071	26,629

[1] The demand, average yield, and firm yield for Alternative 2 reflect an approximate 15 AF decrease as a result of the change in firming storage requests by PRPA and Loveland since the Draft EIS was released. The results for the remaining alternatives do not reflect that change; however, differences are expected to be similar to the Proposed Action.

The Participants' demands under the No Action Alternative are higher than existing conditions and the action alternatives because Participant's water needs are anticipated to increase in the future. In addition, since there is no firm yield associated with Windy Gap supplies without firming storage online, the Participants would maximize their Windy Gap deliveries when available because that water could be spilled in subsequent wet years. Firming storage allows Windy Gap water to be carried over for use in dry years because it is not at risk of being spilled from Granby Reservoir; therefore, the Participants would operate the WGFP to provide firm yield in dry years with storage online. Under the action alternatives, the Participants' demands reflect the maximum amount of Windy Gap water that could be delivered each year without any shortage, which is defined as firm yield. The demand for the action alternatives in the model is lower than under No Action because the model reflects both the Participants' needs for Windy Gap water and the manner in which they would operate the project to ensure that Windy Gap water would be available in a drought.

The Proposed Action would provide an annual firm yield of 26,545 AF to project Participants compared to 1,229 AF under the No Action Alternative and 0 AF under existing conditions.

While Windy Gap demands would be higher under No Action, average Windy Gap deliveries would be less than the action alternatives because C-BT storage space would be unavailable for Windy Gap in wet years and an enlarged Ralph Price Reservoir would provide the only additional firming storage. As a result, Windy Gap spills would be higher and there would be little to no Windy Gap water carried over to meet demands in dry years and consecutive wet years under No Action compared to the action alternatives.

The No Action Alternative would have a firm yield of about 1,229 AF/year due to the additional storage at Ralph Price Reservoir compared to firm yield of zero under existing conditions (Table 3-18). This yield would only accrue to the City of Longmont. The firm yield for other Participants would remain zero under the No Action Alternative. The No Action Alternative would not meet the purpose and need of the WGFP.

The yield for the action alternatives would be similar because the storage volumes would be the same. The Proposed Action would have an annual firm yield of 26,545 AF including the yield for MPWCD. Alternative 5 would have a slightly higher yield and Alternatives 3 and 4 would have a slightly lower yield. Individual Participant firm yield under the Proposed Action is shown in Table 3-19.

All action alternatives include 3,000 AF of storage for MPWCD's Windy Gap water. Under existing conditions, MPWCD can only store its Windy Gap water in Granby Reservoir; therefore, MPWCD's firm yield is zero. Under the No Action Alternative, the firm yield for the MPWCD would remain zero, but average yield would increase from about 100 AF to 2,000 AF because of an increase in the MPWCD's demand for Windy Gap water in the future. Under the action alternatives, the firm annual yield to the MPWCD would be 429 AF and the average yield would be about 2,900 AF.

The water demand for Windy Gap unit holders not in the Firming Project would increase in the future for all alternatives and as a result, the average yield to non-Participants would increase. Windy Gap average yield for non-Participants would increase from about 140 AF under existing conditions to about 2,200 AF for the No Action Alternative and 2,300 AF under the action

Table 3-19. Windy Gap Firming Project Participant annual firm yield for the Proposed Action.

Participant	Firm Yield (AF)[1]
Broomfield	5,600
CWCWD	93
Erie	1,840
Evans	455
Ft. Lupton	265
Greeley	2,230
Lafayette	610
Longmont	4,515
Louisville	825
Loveland[2]	2,390
LTWD	1,200
MPWCD	429
Platte River[2]	4,720
Superior	1,380

[1] Values rounded.
[2] The firm yield for Loveland and PRPA reflects the change in firming storage requests by those Participants since the Draft EIS.

alternatives. Windy Gap yield for non-Participants would increase because more storage for non-Participant water would be available in Granby Reservoir, and because the WGFP Participant's water would be stored in firming reservoir(s) and consequently non-Participant Windy Gap spills from Granby Reservoir would decrease. The firm yield to non-Participants would remain zero under all alternatives.

3.5.3 Cumulative Effects

Several water-based reasonably foreseeable actions on the West Slope were considered in the evaluation of cumulative hydrologic effects. These actions, as described in more detail in Section 2.8 of Chapter 2, are:

- Denver Water Moffat Collection System Project;
- Urban growth in Grand and Summit counties;
- Changes in releases from Williams Fork and Wolford Mountain reservoirs for endangered fish;
- Wolford Mountain Reservoir contract demand; and
- Expiration of Denver Water's contract with Big Lake Ditch.

The hydrologic effects of the above reasonably foreseeable actions were evaluated using the same hydrologic model that was used to evaluate direct effects. The results of these model runs are described beginning with Section 3.5.3.5. The year 2030 was used as the time period for the assessment of cumulative effects because it is projected that the full demand for WGFP water would occur by then, as would most of the reasonably foreseeable actions.

Several reasonably foreseeable actions were not included in the hydrologic modeling such as the 10825 Project, climate change, the periodic reduction of Xcel Energy's Shoshone Power Plant call, and *Fish and Wildlife Enhancement Plans* (FWEPs) by the Subdistrict and Denver Water, as well as Denver Water's *Fish and Wildlife Mitigation Plan* (FWMP) and *Colorado River Cooperative Agreement*, as described below.

3.5.3.1 10825 Project

The WGFP model reflects that releases of 10,825 AF would no longer be made from Williams Fork (5,412.5) and Wolford Mountain (5,412.5) reservoirs for endangered fish in the 15-Mile Reach. However, it does not include the proposed 10825 Project that would release 5,412.5 AF of water from Granby Reservoir in the late summer and fall for the Upper Colorado River Endangered Fish Recovery Program. Releases under this project would vary from year to year, but would generally occur from as early as July through September. The releases would occur during a time when streamflow is typically low. While these releases were not factored into the hydrologic modeling, they were considered in the dynamic temperature modeling and the cumulative effects to Colorado River stream temperature discussed in Section 3.8.3.1. An overview of hydrologic changes associated with the 10825 Project is found in the Colorado River discussion below (Section 3.5.3.6).

3.5.3.2 Climate Change

Climatic changes have the potential to impact water resources in the Colorado River basin in the future. Although climatic model predictions vary, the likely effects of warmer temperatures in the Colorado River basin upstream of Windy Gap, as identified by the CWCB (2010), include:

- Average annual runoff increases by about 5 percent;
- Average year-round temperature increase of about 1.8°C;
- Peak runoff in May rather than June as currently occurs;
- Higher than current average runoff in April and May;
- Lower than current average runoff in the late summer-fall months;
- Decreased baseflow from ground water in late summer;

- Reduced soil moisture in summer and longer growing seasons extended by an estimated 18 days split equally between the spring and fall;
- A shift from snow to rain in the early and late winter months due to increased temperatures; and
- Greater loss of water by evapotranspiration.

The effects of the climatic changes listed above may alter the timing and operation of the WGFP and the water supply and demand for WGFP Participants because streamflows may peak earlier, evapotranspiration may be higher, and droughts may be longer and more severe. While climate change and global warming may be considered reasonably foreseeable, there is a great deal of uncertainty in determining incremental changes in streamflow or reservoir levels associated with increasing/decreasing temperatures and precipitation. Thus, potential hydrologic effects in response to global climate change are described qualitatively.

Changes in snowpack and streamflow timing and magnitude associated with climate change may affect Windy Gap diversions and firming reservoir operations. If runoff decreases and shifts earlier in the year, Windy Gap diversions also would occur earlier and may decrease if the call on the Colorado River comes on sooner and is extended because Windy Gap water rights are relatively junior. If runoff increases and shifts earlier in the year, Windy Gap diversions could increase if the call comes on later and there is more water physically and legally available to divert. If runoff occurs earlier in the spring, the yield of the WGFP could decrease because of pipeline capacity and water rights decree constraints. To some degree, Granby Reservoir operations would buffer changes in the timing and magnitude of streamflows above Granby Reservoir due to climate change. For example, if runoff increases above Granby Reservoir, more water would likely be stored and there would potentially be little change in outflow in years the reservoir does not spill. If runoff increases on average above the reservoir, Granby Reservoir outflow would likely increase in spill years and the spill could potentially occur sooner and the inverse would occur if runoff decreases on average. Flows in the Colorado River below Windy Gap would change if there are changes in the timing and magnitude of Windy Gap diversions, spills from Granby Reservoir, and inflows from Willow Creek and the Fraser River. If evaporation rates increase, then evaporative losses at firming project reservoirs would increase. Evaporative losses could also increase or decrease if Windy Gap diversions to storage change. This could result in increased Windy Gap diversions at times to replace those additional losses and/or reduce WGFP firm yields.

Climate change was not reflected in the WGFP hydrologic model due to varied predictions in the magnitude and direction of climatic changes, and the uncertainty in determining incremental changes in streamflow or reservoir levels associated with increasing or decreasing temperatures and precipitation.

3.5.3.3 Shoshone Power Plant Call Reduction

The future operation of the Shoshone Power Plant call reduction also was not reflected in the model because it would only occur under certain conditions that are based on forecasted values for which there is limited historical data. Denver Water does not have to invoke the call reduction when the conditions of the agreement are met. Also, the agreement requires that Denver Water make available to West Slope entities 10 percent of the net water stored or diverted by Denver Water by virtue of the call relaxation. However, the West Slope beneficiaries and the timing and amount of deliveries are not specified in the agreement. Thus, the effect of this future action is discussed separately. Additional information on reasonably foreseeable actions and cumulative effects and how they were addressed in the model is found in the Water Resources Technical Report (ERO and Boyle 2007).

3.5.3.4 Fish and Wildlife Enhancement Plans, Denver Water Moffat Collection System Project Fish and Wildlife Mitigation Plan, and Colorado River Cooperative Agreement

As described in more detail in Section 2.8.2.1, the Subdistrict and Denver Water have collaboratively developed separate FWEPs that include habitat restoration measures that may change channel morphology and flow characteristics, such as stream velocity and depth from Windy Gap Reservoir downstream to about 2 miles below the Williams Fork. Denver Water's FWMP and the *Colorado River Cooperative Agreement* include measures that would bypass water from the Fraser River Collection System and increase flows downstream in the Colorado River under certain conditions. Because of the uncertainty in the timing of the various measures in these plans and agreements, it was not possible to include them in the hydrologic modeling of cumulative effects. Additional discussion on the effects of these measures is included in the sections on Stream Morphology and Floodplains (3.7.3), Surface Water Quality (3.8.3.1), and Aquatic Resources (3.9.3.1).

3.5.3.5 Summary Comparison of Hydrologic Changes

A summary of the cumulative effect to average monthly flows in the Colorado River at Windy Gap from past, present, and reasonably foreseeable actions, including WGFP alternatives for the 1950 to 1996 model period, is shown in Table 3-20. Model results indicate that the percent of native flows remaining after the various depletions ranges from less than 20 percent in May to about 60 percent in March under all of the alternatives. Model simulations of hydrologic changes with reasonably foreseeable actions in place for each alternative were generated for multiple locations and are summarized in Table 3-21, Table 3-22, and Table 3-23. These tables indicate average changes from existing conditions for the 1950 to 1996 study period and for the five wettest and five driest years similar to those presented in the direct effects discussion in Section 3.5.2.4. Because of the similarity in the effects of Alternatives 3, 4, and 5, the cumulative effects analysis used the results of Alternative 5 as representative of these three alternatives. Appendix Tables A-23 to A-45 provide additional detail on monthly hydrologic cumulative impacts.

3.5.3.6 Facilities, Streams, and Lakes Affected by Reasonably Foreseeable Actions

Four major Colorado River tributaries—the Fraser River, Williams Fork River, Muddy Creek, and Blue River—would experience changes in flow from reasonably foreseeable actions. Although WGFP alternatives would not affect flow in these tributaries, a change in the future tributary flows would have a cumulative effect to the Colorado River when combined with the WGFP. Reasonably foreseeable actions that affect tributary flows to the Colorado River are briefly discussed below, as are other future actions that could affect Colorado River flow.

Fraser River

Average annual flows in the Fraser River at the mouth has been modeled to be about 91,000 AF under existing conditions and 79,700 AF in the future for all alternatives (Table 3-21). The reduction in flow in the Fraser River in the future would be due primarily to Denver Water's (Denver) additional transbasin diversions through Moffat Tunnel and urban growth and increased water use in Grand County. Denver's average annual demand for Fraser River deliveries through the Moffat Tunnel would increase by about 9,300 AF, and depletions associated with future water use in the Fraser River basin would increase by about 1,600 AF compared to existing conditions.

Other diversions in the Fraser River basin that would be affected by reasonably foreseeable actions would reduce average annual flows at the mouth of the Fraser River by about 400 AF. Thus, the total reduction in average annual flows at the mouth of the Fraser River in the future would be about 11,300 AF (Table 3-21).

Table 3-20. Summary of average monthly depletions and flows in the Colorado River at Windy Gap for cumulative effects for the WGFP model study period from 1950 through 1996 (AF).

Line #	Description	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	Native Flow at Windy Gap	13,194	9,371	8,184	7,784	6,856	8,657	28,180	113,006	172,575	73,454	26,816	14,848	482,926
2	Flows at Windy Gap with Existing Conditions Diversions	5,772	5,456	4,750	4,508	4,205	6,076	11,969	23,671	51,472	25,960	8,644	4,917	157,401
3	Depletions for No Action (Alt 1) Including Reasonable Foreseeable Actions	111	209	262	242	183	154	-19	1,963	8,796	7,611	1,896	380	21,787
4	Depletions for Proposed Action (Alt 2) Including Reasonable Foreseeable Actions	135	183	262	242	183	154	-28	3,630	15,543	6,989	1,963	614	29,870
5	Depletions for Alternative 5 Including Reasonable Foreseeable Actions	175	197	262	242	183	154	-28	3,773	13,804	8,762	2,161	453	30,138
6	Percent of Native Flow Remaining Under Alternative 1	43%	56%	55%	55%	59%	68%	43%	19%	25%	25%	25%	31%	28%
7	Percent of Native Flow Remaining Under Alternative 2	43%	56%	55%	55%	59%	68%	43%	18%	21%	26%	25%	29%	26%
8	Percent of Native Flow Remaining Under Alternative 5	42%	56%	55%	55%	59%	68%	43%	18%	22%	23%	24%	30%	26%

Notes:

1. Native flow at Windy Gap was estimated to be the gaged flow at Windy Gap (1982-1996) and Hot Sulphur Springs (1950-1981) plus historical depletions (Grand River Ditch C-BT Project, Moffat Tunnel, Windy Gap, and Grand County depletions) upstream of those gages. This estimate does not include the effect of depletions associated with agricultural irrigation upstream of the Windy Gap gage.

2. Equals line 7 from Table 3-1, which is the native flow at Windy Gap minus existing conditions depletions (Grand River ditch, C-BT Project, Moffat Tunnel, Windy Gap, and Grand County depletions) upstream of Windy Gap.

3. Equals the change in flow below Windy Gap for the No Action Alternative (Alternative 1). The change in flow reflects additional depletions due to the Windy Gap project without the firming project plus all reasonably foreseeable future actions including Grand County growth and the Moffat Collection System Project.

4. Equals the change in flow below Windy Gap for the Alternative 2. The change in flow reflects additional depletions due to the Proposed Action plus all reasonably foreseeable actions including Grand County growth and the Moffat Collection System Project.

5. Equals the change in flow below Windy Gap for the Alternative 5. The change in flow reflects additional depletions due to Alternative 5 plus all reasonably foreseeable actions including Grand County growth and the Moffat Collection System Project.

Table 3-21. Cumulative effects – comparison of average annual year flow and diversion amounts (AF) at key locations.

Location	Existing Conditions	Alternative 1—No Action			Alternative 2—Chimney Hollow w/Prepositioning			Alternative 5—Dry Creek w/Rockwell Creek		
	Avg. Annual Flow	Avg. Annual Flow	Difference	Percent Diff.	Avg. Annual Flow	Difference	Percent Diff.	Avg. Annual Flow	Difference	Percent Diff.
Adams Tunnel C-BT deliveries	231,679	231,763	84	0%	231,069	-610	0%	231,097	-582	0%
Adams Tunnel Windy Gap deliveries	11,500	20,180	8,680	75%	28,513	17,013	148%	27,836	16,336	142%
Total Adams Tunnel diversions	243,179	251,943	8,764	4%	259,583	16,404	7%	258,933	15,755	6%
Granby Reservoir spills	34,794	28,397	-6,397	-18%	23,296	-11,498	-33%	24,840	-9,954	-29%
—C-BT spills	19,799	18,553	-1,246	-6%	20,132	333	2%	18,710	-1,089	-6%
—Windy Gap spills	14,995	9,844	-5,151	-34%	3,164	-11,831	-79%	6,130	-8,865	-59%
Colorado River below Granby Reservoir	59,385	52,976	-6,409	-11%	47,880	-11,505	-19%	49,403	-9,981	-17%
Willow Creek feeder diversions	36,172	37,828	1,656	5%	39,010	2,837	8%	38,586	2,414	7%
Willow Creek at the confluence with the Colorado River	18,294	16,685	-1,609	-9%	15,516	-2,777	-15%	15,939	-2,354	-13%
Fraser River at the confluence with the Colorado River	91,025	79,725	-11,300	-12%	79,729	-11,296	-12%	79,714	-11,311	-12%
Colorado River above Windy Gap diversion	187,889	168,544	-19,345	-10%	162,279	-25,611	-14%	164,211	-23,679	-13%
Windy Gap diversions	36,532	38,973	2,441	7%	40,791	4,259	12%	42,991	6,459	18%
Colorado River below Windy Gap	151,358	129,571	-21,787	-14%	121,488	-29,870	-20%	121,220	-30,138	-20%
Colorado River at Hot Sulphur Springs	156,475	134,095	-22,380	-14%	126,006	-30,469	-19%	125,738	-30,737	-20%
Colorado River above confluence with Williams Fork River	154,031	131,649	-22,382	-15%	123,559	-30,472	-20%	123,291	-30,740	-20%
Williams Fork River at confluence with Colorado River	90,083	95,345	5,262	6%	95,346	5,263	6%	95,346	5,263	6%
Colorado River below confluence with Williams Fork River	246,931	229,807	-17,124	-7%	221,718	-25,213	-10%	221,450	-25,481	-10%
Colorado River above confluence with Troublesome Creek	252,443	227,567	-24,876	-10%	219,479	-32,964	-13%	219,210	-33,233	-13%
Troublesome Creek at the confluence with the Colorado River	52,396	52,425	29	0%	52,425	29	0%	52,425	29	0%
Colorado River above the confluence with the Blue River	379,050	354,135	-24,915	-7%	346,048	-33,002	-9%	345,781	-33,270	-9%
Blue River at the confluence with the Colorado River	313,612	258,663	-54,949	-18%	258,677	-54,935	-18%	258,678	-54,933	-18%
Colorado River near Kremmling	701,801	621,912	-79,889	-11%	613,838	-87,963	-13%	613,572	-88,229	-13%
Colorado River above Pumphouse	696,777	616,888	-79,889	-11%	608,814	-87,963	-13%	608,548	-88,229	-13%
Muddy Creek at the confluence with the Colorado River	65,522	65,502	-20	0%	65,503	-19	0%	65,504	-18	0%
C-BT Diversions from the Big Thompson River	27,990	27,638	-352	-1%	25,154	-2,836	-10%	26,934	-1,056	-4%
Big Thompson River below Lake Estes	66,701	67,118	417	1%	69,684	2,983	4%	67,809	1,108	2%
Big Thompson River at the Canyon Gage	89,367	89,718	352	0%	92,203	2,836	3%	90,422	1,056	1%

Note: Differences indicate a volume (AF) or percent change compared to existing conditions. A positive difference denotes an increase in flow. Granby Reservoir spills do not include Windy Gap Spills from Willow Creek Reservoir. C-BT spills do not include the amount bypassed to meet the instream flow requirement when Granby Reservoir is spilling.

Fraser River at the confluence with the Colorado River corresponds with outflow from the Scybert Ditch, which is the furthest downstream node on the Fraser River in the CDSS model.

Willow Creek at the confluence with the Colorado River corresponds with outflow from the Bunte Highline Ditch, which is the furthest downstream node on Willow Creek in the CDSS model.

Table 3-22. Cumulative effects – comparison of average annual dry year flow and diversion amounts (AF) at key locations.

Location	Existing Conditions	Alternative 1—No Action			Alternative 2—Chimney Hollow w/Prepositioning			Alternative 5—Dry Creek w/Rockwell Creek		
	Avg. Annual Flow	Avg. Annual Flow	Difference	Percent Diff.	Avg. Annual Flow	Difference	Percent Diff.	Avg. Annual Flow	Difference	Percent Diff.
Adams Tunnel C-BT deliveries	304,061	304,962	901	0%	305,986	1,925	1%	305,170	1,109	0%
Adams Tunnel Windy Gap deliveries	10,126	9,923	-203	-2%	25,668	15,542	153%	19,176	9,050	89%
Total Adams Tunnel diversions	314,187	314,886	699	0%	331,654	17,468	6%	324,347	10,160	3%
Granby Reservoir spills	0	0	0	0%	0	0	0%	0	0	0%
Colorado River below Granby Reservoir	21,946	21,946	0	0%	21,946	0	0%	21,946	0	0%
—C-BT spills	0	0	0	0%	0	0	0%	0	0	0%
—Windy Gap spills	0	0	0	0%	0	0	0%	0	0	0%
Willow Creek feeder diversions	22,200	22,190	-10	0%	22,190	-10	0%	22,190	-10	0%
Willow Creek at the confluence with the Colorado River	3,962	3,962	0	0%	3,962	0	0%	3,962	0	0%
Fraser River at the confluence with the Colorado River	35,432	30,879	-4,553	-13%	30,787	-4,645	-13%	30,787	-4,645	-13%
Colorado River above Windy Gap diversion	74,938	70,377	-4,561	-6%	70,284	-4,654	-6%	70,284	-4,654	-6%
Windy Gap diversions	7,804	3,860	-3,944	-51%	3,860	-3,944	-51%	3,860	-3,944	-51%
Colorado River below Windy Gap	67,134	66,517	-617	-1%	66,424	-710	-1%	66,424	-710	-1%
Colorado River at Hot Sulphur Springs	70,656	69,494	-1,162	-2%	69,402	-1,254	-2%	69,402	-1,254	-2%
Colorado River above confluence with Williams Fork River	67,380	66,187	-1,194	-2%	66,094	-1,286	-2%	66,094	-1,286	-2%
Williams Fork River at confluence with Colorado River	77,202	80,600	3,398	4%	80,659	3,456	4%	80,659	3,456	4%
Colorado River below confluence with Williams Fork River	147,416	149,639	2,223	2%	149,605	2,188	1%	149,605	2,188	1%
Colorado River above confluence with Troublesome Creek	149,898	143,765	-6,133	-4%	143,730	-6,168	-4%	143,730	-6,168	-4%
Troublesome Creek at the confluence with the Colorado River	27,418	27,494	77	0%	27,494	77	0%	27,494	77	0%
Colorado River above the confluence with the Blue River	229,222	226,876	-2,346	-1%	226,593	-2,629	-1%	226,593	-2,629	-1%
Blue River at the confluence with the Colorado River	213,141	193,013	-20,128	-9%	192,944	-20,198	-9%	192,943	-20,198	-9%
Colorado River near Kremmling	450,286	427,728	-22,558	-5%	427,376	-22,911	-5%	427,375	-22,911	-5%
Colorado River above Pumphouse	445,113	422,555	-22,558	-5%	422,202	-22,911	-5%	422,202	-22,911	-5%
Muddy Creek at the confluence with the Colorado River	42,760	46,396	3,636	9%	46,147	3,387	8%	46,147	3,387	8%
C-BT Diversions from the Big Thompson River	551	687	136	25%	0	-551	-100%	0	-551	-100%
Big Thompson River below Lake Estes	53,535	53,399	-136	0%	54,086	551	1%	54,086	551	1%
Big Thompson River at the Canyon Gage	67,160	67,024	-136	0%	67,711	551	1%	67,711	551	1%

Note: Differences indicate a volume (AF) or percent change compared to existing conditions. A positive difference denotes an increase in flow. Granby Reservoir spills do not include Windy Gap Spills from Willow Creek Reservoir. C-BT spills do not include the amount bypassed to meet the instream flow requirement when Granby Reservoir is spilling.

Fraser River at the confluence with the Colorado River corresponds with outflow from the Scybert Ditch, which is the furthest downstream node on the Fraser River in the CDSS model.

Willow Creek at the confluence with the Colorado River corresponds with outflow from the Bunte Highline Ditch, which is the furthest downstream node on Willow Creek in the CDSS model.

Table 3-23. Cumulative effects – comparison of average annual wet year flows and diversion amounts (AF) at key locations.

Location	Existing Conditions	Alternative 1—No Action			Alternative 2—Chimney Hollow w/Prepositioning			Alternative 5—Dry Creek w/Rockwell Creek		
	Avg. Annual Flow	Avg. Annual Flow	Difference	Percent Diff.	Avg. Annual Flow	Difference	Percent Diff.	Avg. Annual Flow	Difference	Percent Diff.
Adams Tunnel C-BT deliveries	168,706	169,074	368	0%	162,366	-6,340	-4%	164,991	-3,715	-2%
Adams Tunnel Windy Gap deliveries	12,081	26,859	14,778	122%	26,961	14,880	123%	34,675	22,594	187%
Total Adams Tunnel diversions	180,787	195,934	15,147	8%	189,327	8,540	5%	199,666	18,879	10%
Granby Reservoir spills	118,620	106,539	-12,081	-10%	102,190	-16,430	-14%	102,587	-16,033	-14%
—C-BT spills	93,203	92,958	-245	0%	98,635	5,432	6%	94,765	1,562	2%
—Windy Gap spills	25,417	13,581	-11,836	-47%	3,555	-21,862	-86%	7,822	-17,595	-69%
Colorado River below Granby Reservoir	144,383	132,303	-12,080	-8%	128,133	-16,250	-11%	128,342	-16,040	-11%
Willow Creek feeder diversions	33,685	39,707	6,022	18%	40,417	6,732	20%	40,317	6,632	20%
Willow Creek at the confluence with the Colorado River	52,778	46,756	-6,022	-11%	46,046	-6,732	-13%	46,146	-6,632	-13%
Fraser River at the confluence with the Colorado River	178,477	156,645	-21,832	-12%	156,715	-21,762	-12%	156,501	-21,976	-12%
Colorado River above Windy Gap diversion	403,835	363,899	-39,935	-10%	359,091	-44,744	-11%	359,185	-44,650	-11%
Windy Gap diversions	38,512	62,118	23,606	61%	69,417	30,905	80%	71,699	33,186	86%
Colorado River below Windy Gap	365,323	301,782	-63,541	-17%	289,674	-75,649	-21%	287,486	-77,836	-21%
Colorado River at Hot Sulphur Springs	369,677	305,471	-64,206	-17%	293,363	-76,314	-21%	291,175	-78,501	-21%
Colorado River above confluence with Williams Fork River	369,268	305,065	-64,204	-17%	292,957	-76,311	-21%	290,769	-78,499	-21%
Williams Fork River at confluence with Colorado River	138,018	145,540	7,522	5%	145,541	7,522	5%	145,541	7,522	5%
Colorado River below confluence with Williams Fork River	509,758	453,068	-56,691	-11%	440,960	-68,798	-13%	438,772	-70,986	-14%
Colorado River above confluence with Troublesome Creek	519,392	455,774	-63,618	-12%	443,667	-75,725	-15%	441,479	-77,913	-15%
Troublesome Creek at the confluence with the Colorado River	92,324	92,325	1	0%	92,325	1	0%	92,325	1	0%
Colorado River above the confluence with the Blue River	706,315	642,668	-63,646	-9%	630,562	-75,752	-11%	628,373	-77,941	-11%
Blue River at the confluence with the Colorado River	493,554	412,397	-81,157	-16%	412,284	-81,271	-16%	412,393	-81,161	-16%
Colorado River near Kremmling	1,217,038	1,072,235	-144,803	-12%	1,060,014	-157,024	-13%	1,057,934	-159,104	-13%
Colorado River above Pumphouse	1,212,435	1,067,632	-144,803	-12%	1,055,411	-157,024	-13%	1,053,331	-159,104	-13%
Muddy Creek at confluence with the Colorado River	86,980	86,999	19	0%	86,999	20	0%	86,998	19	0%
C-BT Diversions from the Big Thompson River	67,946	68,058	112	0%	66,763	-1,182	-2%	67,915	-30	0%
Big Thompson River below Lake Estes	72,849	72,874	25	0%	74,701	1,851	3%	72,874	25	0%
Big Thompson River at the Canyon Gage	108,593	108,480	-112	0%	109,775	1,182	1%	108,623	30	0%

Note: Differences indicate a volume (AF) or percent change compared to existing conditions. A positive difference denotes an increase in flow. Granby Reservoir spills do not include Windy Gap Spills from Willow Creek Reservoir. C-BT spills do not include the amount bypassed to meet the instream flow requirement when Granby Reservoir is spilling.

Fraser River at the confluence with the Colorado River corresponds with outflow from the Scybert Ditch, which is the furthest downstream node on the Fraser River in the CDSS model.

Willow Creek at the confluence with the Colorado River corresponds with outflow from the Bunte Highline Ditch, which is the furthest downstream node on Willow Creek in the CDSS model.

Williams Fork River

Average annual flows in the Williams Fork River at the mouth were modeled to be about 90,100 AF under existing conditions and 95,300 AF in the future for all alternatives (Table 3-21). Changes in the quantity and timing of flows in the Williams Fork River would be primarily due to the combined effects of the following reasonably foreseeable actions;

- Denver Water would no longer release 5,412.5 AF/year from Williams Fork Reservoir for endangered fish. These releases are typically made in the fall when flows drop below the U.S. Fish and Wildlife Service (FWS) flow recommendations. Thus, fall flows would decrease compared to existing conditions. Denver's additional transbasin diversions from the Fraser, Williams Fork, and Blue rivers would result in increased exchange releases from Williams Fork Reservoir to cover Denver's out-of-priority depletions and increased substitution releases to cover Denver's out-of-priority storage in Dillon Reservoir when Green Mountain Reservoir does not fill. The net effect of additional exchange releases and reductions in fish flow releases would be offset by a corresponding change in the amount of water stored in Williams Fork on average. As a result, changes in Williams Fork Reservoir operations (storage and releases) would affect the timing of flows below the reservoir, but the change in the average annual quantity of flow due to these future actions would be relatively small.
- Denver's future growth and implementation of the Moffat Collection System Project would result in about 2,000 AF of additional transbasin diversions from the Williams Fork River basin in the future.
- Big Lake Ditch diversions would decrease, deliveries to the Reeder Creek drainage for irrigation would be curtailed, and all Big Lake Ditch return flows would accrue to the Williams Fork River. These changes would result in approximately 8,800 AF/year less diversion and a corresponding increase in flows on average in the Williams Fork River basin compared to existing conditions. The reduction in Big Lake Ditch diversions would not increase the physical supply available to Denver Water to divert through Jones Tunnel, but would increase the supply available for storage in Williams Fork Reservoir. Depending on the year type, this change may increase or decrease the overall gain of water to the Williams Fork River and Colorado River below the confluence with the Williams Fork River. Also, the timing of flows would change. At times, especially in dry years, this would allow Denver Water to divert water that would otherwise be "called out" at Williams Fork Reservoir when the reservoir water rights are in priority. The additional water stored in Williams Fork Reservoir does not result in increased diversions to the East Slope through the Moffat Tunnel by Denver Water because Denver Water operates its system to retain water in Williams Fork Reservoir to fully exchange to the Moffat Collection System. The additional supplies in Williams Fork Reservoir could increase Denver Water's ability to exchange to Roberts Tunnel and Dillon Reservoir. At other times, because the Big Lake Ditch is no longer diverting and consuming as much water, this practice creates a net increase in flows to the Colorado River below the confluence with the Williams Fork River.

Other diversions in the Williams Fork River basin also would be affected due to reasonably foreseeable actions. The combined effect of the future actions described above would increase average annual flows at the mouth of Williams Fork River by approximately 5,300 AF compared to existing conditions. Average annual flows in the Colorado River downstream of the Reeder Creek drainage would decrease by about 7,750 AF/year due to reduction in Big Lake Ditch return flows. This difference in flows in the Colorado River would occur below the confluence of the Williams Fork River and above the confluence with Troublesome Creek.

Muddy Creek

Average annual flows in Muddy Creek at the mouth are about 65,500 AF under existing conditions and would be the same in the future for all alternatives (Table 3-21). Flows in Muddy Creek are influenced by Wolford Mountain Reservoir operations. Wolford Mountain Reservoir's primary operations include releases to cover Denver's and Colorado Springs' substitution requirements for out-of-priority diversions when Green Mountain Reservoir does not fill, releases to cover contract demands, and releases for endangered fish flow requirements.

The following reasonably foreseeable actions would have the greatest effect on Wolford Mountain Reservoir operations:

- Endangered fish flow releases of 5,412.5 AF/year would no longer be made from Wolford Mountain Reservoir, which would reduce flows in the fall. However, less water would be stored during the runoff season to replace these releases, so flows during runoff would increase on average below the reservoir due to differences in the amounts stored and the timing and quantity of spills.
- The future demand for contract water from Wolford Mountain Reservoir is anticipated to increase to about 11,100 AF/year by 2030 (Boyle 2006a). Releases from Wolford Mountain Reservoir would be required to cover future monthly depletions if the depletions are out of priority. The specific entities that would contract for this water in the future and the locations of the depletions have not been identified. Of the total future contract demand, the average annual modeled release from Wolford Mountain Reservoir to meet this demand would increase about 7,325 AF/year primarily during winter months and in summer months of dry years versus existing conditions. However, more water would be stored during the runoff season to replace these releases, so flows during runoff decrease on average below the reservoir compared to existing conditions.
- Wolford Mountain Reservoir's substitution releases for Denver and Colorado Springs also would be affected by reasonably foreseeable actions that would reduce flows in the Blue River and Colorado River and increase the call on the Colorado River. The amount of water diverted out of priority by Denver and Colorado Springs in relation to Green Mountain Reservoir would increase in the future. As a result, substitution releases from Wolford Mountain would increase in the future in dry years compared to existing conditions.

The future actions would have little net effect on average annual Muddy Creek flows for any alternative (Table 3-21). There would be changes in the timing of flows below the reservoir, but minimal change in the quantity of flows on an average annual basis. In the future, flows generally would increase on average from August through March. In these months, additional reservoir releases to meet increased contract demands and substitution requirements would, on average, exceed the reduction in releases to meet fish flow requirements. On average, flows would generally decrease during the runoff season because more water would be stored to replace releases and spills would be reduced. Average annual dry year flows in Muddy Creek would increase about 8 to 9 percent under the alternatives compared to existing conditions (Table 3-22); however, there would be no change in average annual wet year flows (Table 3-23).

Blue River

Average annual flow in the Blue River at the Colorado River confluence is about 313,600 AF under existing conditions and would be about 258,700 AF in the future for all alternatives (Table 3-21). The reduction in flows in the Blue River in the future would be due primarily to Denver's additional transbasin diversions through Roberts Tunnel and increased depletions due to urban growth in the Blue River basin. Denver's average annual delivery through the Roberts Tunnel would increase by about 54,000 AF and average annual depletions associated with urban growth in Summit County would increase by about 3,000 AF in the future compared to existing conditions. Additional diversions in Summit County due to growth in outdoor water use and snowmaking demands would result in both additional depletions and changes in return flows. There also would be some effect on other diversions in the Blue River basin, and Dillon Reservoir and Green Mountain Reservoir operations due to reasonably foreseeable actions. The net effect would be an average annual reduction in flow of about 55,000 AF at the mouth of the Blue River (Table 3-21).

> Reductions in Colorado River streamflow below the confluence with the Blue River are overstated by about 30,000 AF in the WGFP cumulative effects modeling due to recent changes in Denver Water projected demand.

However, since the completion of the WGFP Draft EIS additional information on the Moffat Project indicates that the reduction in Blue River flows are overstated in the WGFP hydrologic analysis as the following background information explains. In 2005, Denver provided output from its Platte and Colorado Simulations Model (PACSM) run that puts Denver's total system demand at about 393,000 AF/year, which would be full use of its existing system including the 30,000 AF/yr safety factor, plus 18,000 AF of new firm yield generated by the Moffat Collection System Project. Denver's current demand is 285,000 AF/year; therefore, an increase in demand of 108,000 AF/year was considered for the WGFP cumulative effects analysis. Following completion of the hydrologic analysis for the WGFP, Denver completed their modeling for the Moffat Collection System Project EIS and considered a total system demand of 363,000 AF/year, which does not include use of the 30,000 AF/year safety factor. Thus, Denver's diversions, primarily from the Blue River and to a lesser degree from the Fraser River and Williams Fork River, are overstated in the cumulative effects hydrology used in the WGFP analysis.

Colorado River

Modeled streamflow changes along the Colorado River due to reasonably foreseeable actions reflect differences in the outflow from Granby Reservoir, Windy Gap diversions, growth in Grand and Summit counties, changes in tributary inflows discussed above, and reductions in return flows to the Colorado River from the Big Lake Ditch on Williams Fork River as previously described. Average annual flow in the Colorado River at Kremmling is about 701,800 AF under existing conditions and would be about 614,000 AF in the future for all alternatives (Table 3-21). The combined effect of reasonably foreseeable actions would decrease average annual flows at Kremmling by approximately 87,960 AF under the Proposed Action. As discussed above in the Blue River section, Denver's diversions, primarily from the Blue River and to a lesser degree from the Fraser and Williams Fork rivers, are overstated in the cumulative effects hydrology due to the manner in which Denver Water's demand was modeled. Streamflow changes due to reasonably foreseeable actions that were not reflected in the WGFP model, including the Shoshone call reduction and 10825 releases for endangered fish, are discussed below.

Streamflow changes in the Colorado River are possible in some dry years from implementation of the Shoshone call reduction. The triggers to invoke a relaxation of the Shoshone call are based on forecasts of Denver's total system storage and the March 1 NRCS forecast for Colorado River flows at Kremmling or Dotsero. The relaxation of the Shoshone call would allow diversions that would otherwise be called out to divert water in-priority even if they are junior to the Shoshone Power Plant water rights. Because more diversions would be made in-priority, releases from reservoirs such as Green Mountain, Wolford Mountain, and Williams Fork for exchange or substitution purposes would also be less. In-priority diversion increases and reduced reservoir releases for exchange and/or substitution would decrease flows in the Upper Colorado River basin during the relaxation period. Colorado River flows at Dotsero would not be affected outside of the relaxation period.

The magnitude and timing of flow reductions attributable to a Shoshone call relaxation could vary widely from year-to-year and would depend on many factors including streamflows, reservoir storage contents, project operations, and bypass/instream flow requirements. The Shoshone call reduction was not included in the WGFP model because information on the conditions under which it would occur was not available for a significant portion of the study period. Streamflow forecasts for the Colorado River at Kremmling were not available and streamflow forecasts for the Colorado River at Dotsero did not exist prior to 1969. In addition, Denver Water does not have to invoke the call reduction when the conditions of the agreement are met. Last, the agreement requires that Denver Water make available to West Slope entities 10 percent of the net water stored or diverted by Denver Water by virtue of the call relaxation. However, the West Slope beneficiaries and the timing and amount of deliveries are not specified in the agreement. Due to the difficulty in incorporating this action in the model, the evaluation of potential hydrologic effects was based on historical data.

Based on historical July 1 storage contents in Denver's reservoirs and available streamflow forecast data for the Colorado River at Dotsero, the Shoshone call relaxation may have been invoked in about 8 to 10 years during the period from 1947 through 2002, or roughly 1 out of every 6 to 7 years.

The key projects/water rights that would benefit from a Shoshone call relaxation include the Continental-Hoosier Project, Green Mountain Reservoir (this includes gains to the C-BT Project that occurred as a result of diversions under the C-BT direct flow and storage rights at Adams Tunnel and Granby Reservoir that did not require replacement by the C-BT pool in Green Mountain Reservoir due to the relaxation), Wolford Mountain Reservoir, Denver (Moffat Tunnel, Williams Fork Reservoir, Roberts Tunnel, and Dillon Reservoir), Windy Gap, and the Homestake Project. These projects/facilities would be able to divert more water in-priority even though they are junior to the Shoshone Power Plant water rights. Because more diversions would be made in-priority, releases from reservoirs such as Green Mountain, Wolford Mountain, and Williams Fork for exchange or substitution purposes would be less. Increased in-priority diversions and reduced reservoir releases for exchange and/or substitution would decrease flows in the Upper Colorado River basin primarily in the Williams Fork River, Muddy Creek, Blue River, and Colorado River mainstem below the Windy Gap diversion during the relaxation period.

The only changes in flows outside of the relaxation period would be due to differences in substitution releases from Wolford Mountain and Williams Fork reservoirs. However, differences in substitution releases would not change flows in the Colorado River below the confluence with the Blue River because these releases are made to pay back Green Mountain Reservoir in lieu of Green Mountain Reservoir Historic User's Pool releases. Flows in the Fraser River basin during the relaxation period would likely not be affected because Denver diversions occur regardless of the Shoshone call. Denver exchanges cover out-of-priority diversions in the Fraser River basin with releases from Williams Fork Reservoir. In 2003 and 2004, the flow reductions due to a relaxation of the Shoshone call totaled 21,234 AF and 26,841 AF, respectively. Flow reductions in 2003 and 2004 were quantified by Denver Water, and were reviewed and agreed to by Reclamation, the River District, and other West and East Slope entities. The quantification of flow reductions relied on call data, diversion data for the projects that benefited due to the call reduction, and historical flow data at the USGS gage at Dotsero. While Windy Gap diversions may increase under a Shoshone call reduction, diversions with or without the firming project would be the same because available storage capacity in Granby Reservoir would not be a limiting factor in dry years when the Shoshone call reduction would likely be invoked.

The WGFP model reflects that releases of 5,412.5 AF would no longer be made from Williams Fork and Wolford Mountain reservoirs for endangered fish in the 15-Mile Reach. An alternative to supply 10,825 AF of water was identified by East and West Slope water providers and is being evaluated by Reclamation in an Environmental Assessment (Reclamation 2011). The proposed alternative would release 5,412.5 AF of water from Ruedi Reservoir each year and an additional 5,412.5 AF from Granby Reservoir during the late summer and fall, at agreed-upon schedules designed to optimize flows for endangered fish and aquatic life in the upper Colorado River below Granby Reservoir.

The Granby Reservoir releases would be made possible by the dry-up of a portion of the land currently irrigated by the Redtop Valley Ditch. Irrigation on two major ranches served by the Redtop Valley Ditch would be permanently curtailed. The Redtop Valley Ditch water that was previously used to irrigate these two ranches would accrue to, and be stored in, Granby Reservoir. Occasionally, scheduled releases from Granby Reservoir may occur when Recovery Program water deliveries to the 15-Mile Reach are not desired. To ensure that Granby Reservoir releases benefit the Recovery Program, an excess capacity contract (if-and-when storage account) would be secured in Green Mountain Reservoir from Reclamation. This excess capacity contract in Green Mountain Reservoir would facilitate the re-timing of Granby Reservoir releases to meet the 15-Mile Reach streamflow objectives of the Recovery Program. If Granby Reservoir releases occur when water is not desired for Recovery Program use in the 15-Mile Reach, the water may be exchanged up the Blue River into the Green Mountain Reservoir account. The water stored by exchange in Green Mountain Reservoir would be released at a subsequent time, pursuant to objectives of the Recovery Program and the FWS.

The proposed 10825 Project is not included in the WGFP cumulative effects modeling, but the proposed project calls for releases of 5,412.5 AF from Granby Reservoir from July to September.

Under the 10825 Project, Granby Reservoir releases would occur in late summer and fall (commonly from August to September and possibly July) at rates that are determined to be beneficial to aquatic habitat for downstream endangered fish and fish populations below Granby Reservoir. The release patterns would typically result in the delivery of 10,825 AF of water at a time when the Recovery Program desires additional streamflow in the 15-Mile Reach. Granby Reservoir releases would be determined by an Operations Group comprised of representatives from the water users, the FWS, Reclamation, and the State Division Engineer. The schedule and volume of releases would differ for dry, average, and wet years. In average years, 50 cfs would be released from August 1 to September 15 and 29 cfs would be released from September 16 to 30. In dry years, releases vary between 22 to 55 cfs from mid-July through September. In wet years, releases would range from 24 to 70 cfs and would occur from August 1 to September 30. Early season releases in July could occur in some years to help reduce stream temperatures.

3.5.3.7 C-BT and Windy Gap Project Operations and Diversions

Windy Gap Diversions

WGFP diversions would be lower in the future following implementation of reasonably foreseeable actions such as the Moffat Collection System Project, increased municipal demand in Grand County, and downstream calls.

In general, the reason for the differences in streamflow, reservoir content, diversions, and operations between existing conditions, No Action, and the action alternatives in the future are similar to those discussed in detail for direct effects in Section 3.5.2.5. Windy Gap diversions would generally be less in the future under all alternatives for several reasons:

- The amount of water available for diversion at Windy Gap would decrease in the future because the Fraser River inflow to the Colorado River would decrease on average. Denver's increased demand and the Moffat Collection System Project would increase Denver's diversions from the upper Fraser River basin. In addition, growth in Grand County would increase water use and diversions in the Fraser River basin. Denver's and Grand County's increased diversions and depletions in the Fraser River basin are located upstream of the Windy Gap diversion site on the Colorado River and are senior in priority to Windy Gap; therefore, these future actions would reduce the amount of water available for diversion at Windy Gap.
- Additional diversions in Grand County due to growth in outdoor use and snowmaking demands would result in both additional depletions and changes in return flows. For example, additional snowmaking diversions would decrease flows in winter months but increase flows in the summer months due to return flows. Therefore, the change in flows available at Windy Gap would be a combination of the effect of additional diversions and changes in the timing and quantity of return flows.
- The amount of water available for diversion at Windy Gap would change due to differences in Granby Reservoir spills and WCFC diversions in the future. However, differences in spills and WCFC diversions would typically occur in wet years when Windy Gap diversions are often constrained by other factors (decree limitations and available space in the C-BT system and the firming project reservoirs), as opposed to the physical supply at Windy Gap.
- The amount of water legally available for diversion at Windy Gap would decrease in the future because of downstream calls. In average and wet years, Windy Gap diversions are typically controlled by the 90-cfs minimum downstream flow requirement. In dry years, the amount Windy Gap must bypass to satisfy downstream senior rights is often controlled by the Shoshone Power Plant water rights. The reasonably foreseeable actions could at times change the call on the Colorado River downstream of Windy Gap. In this case, the amount of water legally available to Windy Gap would change. The largest effect from foreseeable actions would be Denver's additional diversions through Roberts Tunnel and depletions associated with urban growth in Summit County. These actions would

reduce the amount of Blue River inflow to the Colorado River, which is upstream of the Shoshone Power Plant diversion. As a result, the amount of flow at the Shoshone Power Plant would decrease in the future. The flow that Windy Gap must bypass to satisfy downstream senior rights would be higher on average because the flow available to meet the Shoshone call would decrease in the future. Larger increases in flow below Windy Gap would generally be caused by an increase in administrative calls in the future, which would require that Windy Gap bypass additional water. However, there would frequently be small flow increases of less than 5 cfs below Windy Gap at Hot Sulphur Springs due to additional bypasses for diversions associated with future municipal growth along the Colorado River.

As a result of reasonably foreseeable actions and the effects on the WGFP, several changes in C-BT operations would occur compared to the direct effects discussed in Section 3.5.2.5. Adams Tunnel deliveries to the East Slope would be less for all alternatives compared to direct effects because of lower Windy Gap diversions. Willow Creek Feeder Canal diversions would be higher in the future because there would be more space available in Granby Reservoir in wet years. Granby Reservoir spills would decrease in the future primarily because less Windy Gap water would be pumped and, therefore, Windy Gap spills would be less. There would be minor differences in C-BT Big Thompson River diversions in the future compared to direct effects with lower Windy Gap diversions and deliveries to the East Slope. Streamflows in the Colorado River and elsewhere would also change as discussed below for each location.

Hydropower Generation

Increased net hydropower generation with reasonably foreseeable actions in place would be slightly less than under direct effects because less Windy Gap water would be delivered through the C-BT system. The No Action Alternative would result in a net annual increase in power generation of about 15 GW compared to 21 GW for the Proposed Action and about 25 GW for other alternatives (Table 3-24). The Proposed Action would result in about a 4 percent increase in power production compared to existing conditions, and about 1 percent more power than the No Action Alternative.

Table 3-24. Comparison of net C-BT hydropower generation between alternatives—cumulative effects.

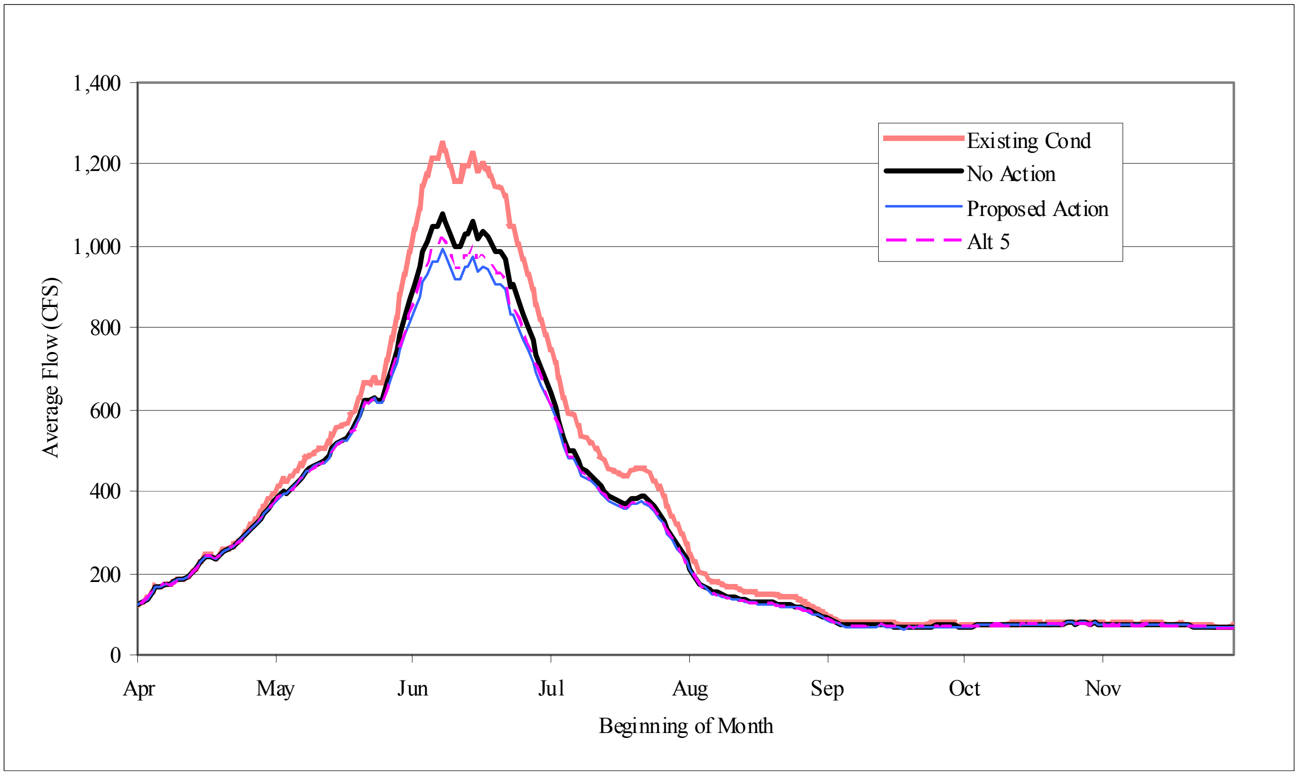
Power Generation	Existing Conditions	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Annual Average (GWH)	510	526	532	535	531	531
Annual Maximum (GWH)	642	640	661	663	658	659
Annual Minimum (GWH)	326	343	375	380	376	376
Difference in Annual Average from Existing Conditions (GWH)	—	15	21	25	21	21
Difference in Annual Average from Existing Conditions (%)	—	3%	4.2%	4.8%	4.1%	4.1%

3.5.3.8 West Slope Streams and Existing Reservoirs

Colorado River

Colorado River above the Windy Gap diversion. Average annual Colorado River flows above Windy Gap Reservoir would decrease about 10 percent under No Action compared to a decrease of about 14 percent for the Proposed Action and 13 percent for other alternatives (Table 3-21). There would be no change in flow about 79 percent of the time under No Action and about 77 percent of the time for the action alternatives. Decreases in flow would occur about 15 percent of the time and the remainder of the time small increases in flow would occur under all alternatives. Changes in Granby Reservoir spills, WCFC diversions, and additional diversions on the Fraser River from the Moffat Collection System Project and Grand County water use would contribute to changes in streamflow. Average daily flows on the Colorado River above Windy Gap are shown in Figure 3-26. During December through March, there would be no differences in flows between existing conditions and the alternatives. Below 200 cfs, the differences in flows between existing conditions and the alternatives would be 1 to 2 cfs, except in August (when differences would be up to 15 cfs), and September (when differences would be up to 7.5 cfs). Monthly changes in Colorado River flows below Granby Reservoir and above Windy Gap are shown in Appendix Tables A-30 and A-31.

Figure 3-26. Colorado River above Windy Gap – average daily flows with reasonably foreseeable actions.



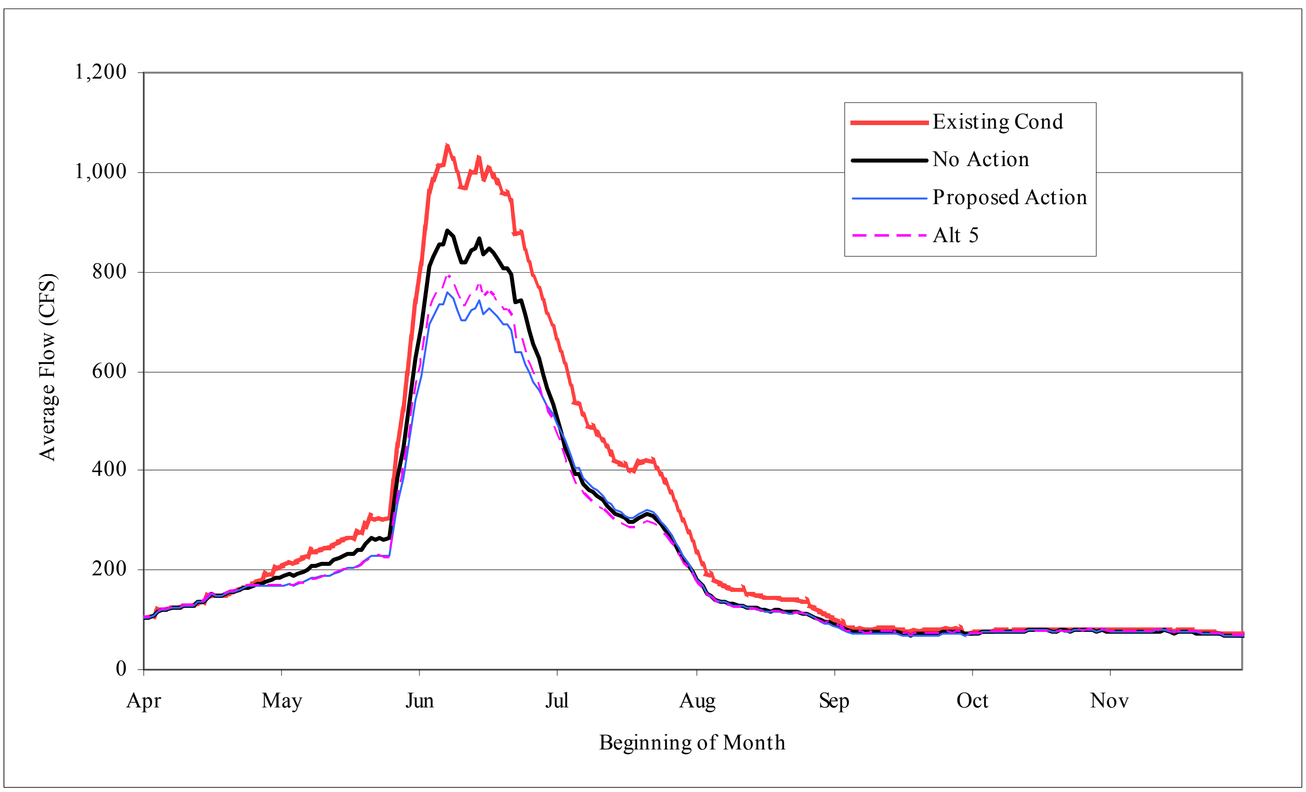
Average annual Colorado River streamflow below Windy Gap Reservoir would decrease about 20 percent under the Proposed Action with reasonably foreseeable future actions. Below the Blue River confluence, the effect would be a 13 percent decrease in average annual flows.

Colorado River below the Windy Gap diversion. Average annual streamflow on the Colorado River immediately below the Windy Gap diversion would decrease about 14 percent under No Action and about 20 percent for the Proposed Action and other alternatives (Table 3-21). Reasonably foreseeable future actions would account for about 38 percent of the change in streamflow from existing conditions and the remainder would be from Windy Gap diversions, and changes in the timing and amount of Granby Reservoir spills, and WCFC diversions. In dry years, there would be about a 1 percent decrease in average annual flow for all alternatives (Table 3-22). Wet year flow reductions would be about 10 percent under No Action and 11 percent for the action alternatives (Table 3-23). All alternatives indicate similar changes in the percentage of days that flows change from May to August. There would be no change in Colorado River flows at Hot Sulphur Springs about 13 percent of the time, a decrease in flows about 66 percent of the time, and an increase in flows about 21 percent of the time (Table 3-25). At times, flows would increase under the alternatives due to changes in the timing of spills from Granby Reservoir and because Windy Gap would have to bypass more water to satisfy senior downstream water rights and instream flow requirements. Additional depletions due to the WGFP, Moffat Collection System Project, and growth in Grand and Summit counties would reduce water supplies available to the Shoshone Power Plant and increase administrative calls at times in the future. Decreases in flow of less than 100 cfs would occur about 45 percent of the time. Average daily flows on the Colorado River below Windy Gap are shown in Figure 3-27. During December through March, there would be no differences in flows between existing conditions and the alternatives. Below 200 cfs, the differences in flows between existing conditions and the alternatives would be 1 to 2 cfs, except in early May (when differences in flows would be as much as 40 cfs), August (when flow differences would be as much as 30 cfs), and September (when flow differences would be up to 7.5 cfs).

Table 3-25. Colorado River below Windy Gap (Hot Sulphur Springs) – daily flow changes compared to existing conditions from May to August.

Daily Flow Changes (cfs)	Percentage of days in May through August that flow changes would occur		
	No Action	Proposed Action	Alternatives 3 to 5
+1 to +159	22.0%	21.1	20.1%
0	12.5%	13.3%	12.9%
-1 to -10	20.4%	20.9%	20.3%
-11 to -100	24.6%	23.6%	22.5%
-101 to -200	7.7%	5.3%	6.9%
-201 to -300	4.3%	3.5%	4.2%
-301 to -500	4.0%	5.1%	5.5%
-501 to -1,000	3.0%	4.1%	4.9%
-1,001 to -2,977	1.6%	3.0%	2.7%

Figure 3-27. Colorado River below Windy Gap – average daily flows with reasonably foreseeable actions.



Average annual streamflow in the Colorado River below the Blue River confluence near Kremmling would decrease about 11 percent under No Action and about 13 percent under the Proposed Action and other alternatives (Table 3-21). About 79 percent of the reductions in flows near Kremmling would be related to reasonably foreseeable actions, including changes in Blue River flows from Denver's future increases in demand, additional Summit County water use, the elimination of flow releases for endangered fish, additional contract deliveries from Wolford Mountain Reservoir, and other upstream reasonably foreseeable actions. The Windy Gap Project would account for the remainder of the flow change. In dry years, both the Proposed Action and No Action would result in annual flows about 5 percent less than existing conditions (Table 3-22). Wet year average annual flow reductions under the Proposed Action would be about 13 percent less than existing conditions and about 1 percent less than No Action (Table 3-23). Daily Colorado River streamflow decreases from May to June at the Kremmling gage would occur about 85 percent of the time under all alternatives (Table 3-26). Average daily flows on the Colorado River below Windy Gap are shown in Figure 3-28. Appendix Tables A-32 to A-39 show streamflow changes below Windy Gap Reservoir.

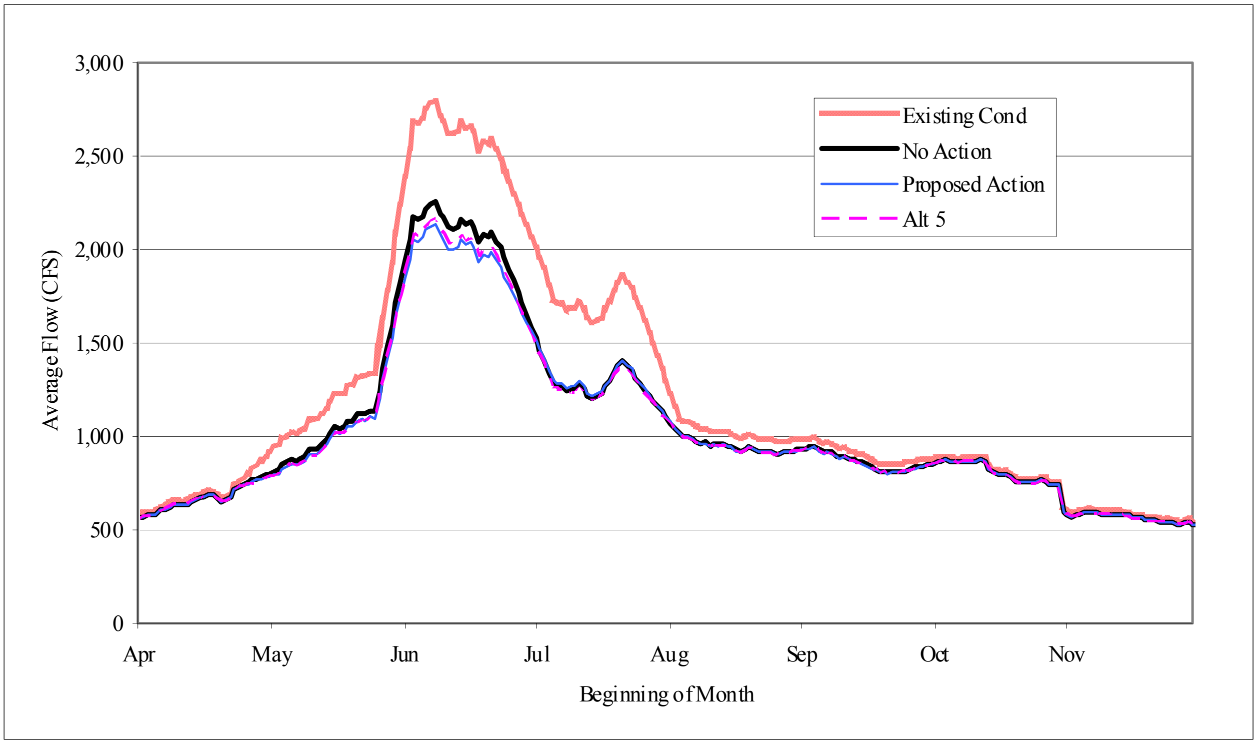
Willow Creek

Average annual flows in Willow Creek would decrease about 9 percent under No Action, 15 percent under the Proposed Action, and 13 percent under other alternatives (Table 3-21). Reasonably foreseeable actions do not directly affect Willow Creek flow, but changes in Windy Gap diversions and contents in Granby Reservoir as a result of future actions would affect WCFC diversions and, therefore, Willow Creek flows.

Table 3-26. Colorado River below Windy Gap (Kremmling) – daily flow changes compared to existing conditions from May to August.

Daily Flow Changes (cfs)	Percentage of days in May through August that flow changes would occur		
	No Action	Proposed Action	Alternatives 3 to 5
+1 to +242	14.2%	13.1%	13.1%
0	1.5%	1.5%	1.5%
-1 to -10	2.0%	1.7%	1.7%
-11 to -100	27.0%	28.2%	27.8%
-101 to -200	16.4%	15.3%	14.6%
-201 to -300	7.0%	7.1%	8.1%
-301 to -500	10.8%	11.1%	10.6%
-501 to -1,000	14.3%	13.1%	13.5%
-1,001 to -3,465	6.8%	8.9%	9.1%

Figure 3-28. Colorado River near Kremmling – average daily flows with reasonably foreseeable actions.



Granby Reservoir

Average monthly Granby Reservoir water elevation would decrease up to 9 feet in the summer under the Proposed Action with reasonably foreseeable future actions.

Reasonably foreseeable actions would indirectly affect Granby Reservoir storage by reducing Windy Gap diversions and, therefore, Windy Gap storage in Granby Reservoir. C-BT contents in Granby Reservoir would be lower than direct effects because shrink payments would be less. The average monthly storage in Granby Reservoir would be about 4 to 17 percent lower than existing conditions under the No Action Alternative, compared to about 9 to 16 percent lower under the Proposed Action and 6 to 8 percent lower under other alternatives. In dry years, monthly storage would be up to 7 percent less under the No Action Alternative and Alternatives 3, 4, and 5, and from 7 to 17 percent less under the Proposed Action. Consecutive dry years could result in a decrease in the reservoir surface elevation of up to 33 feet and a decrease in surface area of approximately 1,680 acres under the Proposed Action, with less of a decrease under other alternatives. Appendix Tables A-44 and A-45 show monthly changes in Granby Reservoir elevation and surface area.

3.5.3.9 East Slope Streams and Existing Reservoirs

Big Thompson River

Average annual Big Thompson River flows below Lake Estes would increase about 1 percent under No Action compared to 4 percent for the Proposed Action and 2 percent for other alternatives (Table 3-21) due to changes in skim diversions. Dry year flow increases would be less than 1 percent under all alternatives (Table 3-22). Average monthly flows would increase less than 9 percent for the Proposed Action and less for other alternatives (Appendix Table A-29).

North St. Vrain Creek and St. Vrain Creek

Changes in flow in North St. Vrain Creek below Ralph Price Reservoir and in St. Vrain Creek to the St. Vrain Supply Canal would only occur under the No Action Alternative. Changes in streamflow in these reaches would be slightly smaller with reasonably foreseeable actions than under direct effects shown in Table 3-15 because of lower Windy Gap diversions and conveyance to the East Slope.

Streams that Receive Windy Gap Return Flow

East Slope streamflows below Participant WWTPs on Big Dry Creek, Coal Creek, St. Vrain Creek, and the Big Thompson River would increase from existing conditions, but would be slightly less than those described for direct effects because of lower Windy Gap imports. Under the No Action Alternative, average and maximum streamflows would decrease by less than 1 cfs from the values shown for direct effects in Table 3-16. For the Proposed Action and other action alternatives, East Slope return flows would decrease by less than 2 cfs compared to the values shown in Table 3-17.

Carter Lake

Average monthly storage in Carter Lake would decrease less than 1 percent or less than 1 foot under all alternatives compared to existing conditions (Appendix Table A-40). Dry year changes in reservoir storage would be similar and wet year storage would decrease less than 3 percent for all alternatives. Occasionally, in severe dry years when C-BT contents in Granby Reservoir are exhausted, Carter Lake contents under the Proposed Action would be as much as 29 feet lower than existing conditions and No Action. C-BT contents in Granby Reservoir would be exhausted earlier in dry year sequences due to C-BT deliveries to Chimney Hollow in previous years. As a result, the amount of C-BT water available for delivery to Carter Lake would be less.

Horsetooth Reservoir

Average year and dry year monthly storage in Horsetooth Reservoir would decrease less than 1 percent under the No Action Alternative compared to existing conditions. Wet year storage would decrease up to 2 percent under No Action. The Proposed Action would reduce average monthly reservoir storage by 2 to 7 percent with up to a 10 percent decrease in dry years and up to an 8 percent decrease in wet years. A decrease in average monthly reservoir water levels of up to 6 feet would occur in April and May under the Proposed Action, with less change for other action alternatives (Appendix Table A-42). Alternatives 3 through 5 would reduce average monthly reservoir storage less than 2 percent, dry year storage would decrease up to 6 percent, and wet year storage would decrease less than 1 percent. Similar to Carter Lake, consecutive dry years could occasionally result in a decrease in Horsetooth Reservoir water levels of 35 feet under the Proposed Action.

3.5.3.10 New and Enlarged Reservoirs

Ralph Price

The additional 13,000 AF of storage in Ralph Price Reservoir under the No Action Alternative would fluctuate with exchanges of Windy Gap water storage and releases to meet the City of Longmont's demand. The amount of water stored in the future would be less than under direct effects because there would be less Windy Gap water diverted.

Chimney Hollow Reservoir

Chimney Hollow Reservoir would operate as described for direct effects, although less Windy Gap water would be available for storage with reasonably foreseeable actions in place. While Chimney Hollow remains near full most of the year, a greater percentage of the water would be C-BT storage.

Dry Creek Reservoir

Dry Creek Reservoir would operate similar to that described for direct effects, with slightly greater fluctuations in the future with less Windy Gap water available for diversion.

Jasper East and Rockwell Reservoirs

These reservoirs would operate in a similar manner as described for direct effects. Reservoir storage would fluctuate widely seasonally and from year to year depending on available Windy Gap water and water demand.

3.5.3.11 Windy Gap Firm Yield

The yield for the action alternatives would be similar because the storage volumes would be the same. Firm yield would be about 20 percent lower than direct effects for the action alternatives because less Windy Gap water would be diverted with reasonably foreseeable actions in place. The Proposed Action would have a slightly higher firm yield of 24,030 AF than Alternatives 3 through 5 (24,012 AF) (Table 3-27). The No Action Alternative would have a firm yield of 579 AF because of the additional storage at Ralph Price Reservoir. The firm yield under existing conditions is zero. Individual Participant firm yields for the Proposed Action are shown in Table 3-28. Tables of Windy Gap demands, firm yields, and average yields for each alternative are included in Appendix Tables A-23 to A-25.

Table 3-27. Windy Gap Participant demand, average yield, and firm yield—cumulative effects.

Condition/ Alternative	Demand	Average Yield	Firm Yield
	AF		
Existing Conditions	20,825	11,372	0
Alt 1 – No Action	36,665	20,071	579
Alt 2 – Proposed Action[1]	26,600	26,360	24,030
Alt 3 – 5	26,583	26,340	24,012

[1] The demand, average yield, and firm yield for Alternative 2 reflect an approximate 15 AF decrease as a result of the change in firming storage requests by PRPA and Loveland since the Draft EIS was released. The results for the remaining alternatives do not reflect that change; however, differences are expected to be similar to the Proposed Action).

Table 3-28. Windy Gap Firming Project Participant firm yield for the Proposed Action—cumulative effects.

Broomfield	4,995
CWCWD	75
Erie	1,500
Evans	395
Ft. Lupton	235
Greeley	2,125
Lafayette	515
Longmont	4,315
Louisville	675
Loveland[2]	2,280
LTWD	1,035
MPWCD	429
Platte River[2]	4,330
Superior	1,125

[1] Values rounded.
[2] The firm yield for Loveland and PRPA reflects the change in firming storage requests by those Participants since completion of the Draft EIS.

Under the No Action Alternative, the firm yield for the MPWCD would remain zero. Under the action alternatives, the firm annual yield to MPWCD would be 429 AF. The average yield to MPWCD for each of the action alternatives would be close to 3,000 AF.

The demand for Windy Gap unit holders not in the Firming Project would increase in the future for all alternatives and, as a result, the average yield to non-Participants would increase from about 140 AF/year under existing conditions to about 2,000 AF for all alternatives. The firm yield to non-Participants would remain zero under all alternatives.

3.5.4 Surface Water Hydrology Mitigation

3.5.4.1 Granby Reservoir

To maintain higher water levels in Granby Reservoir under the Proposed Action, the Subdistrict would modify prepositioning operations as described in the FWMP (Appendix E). Under the originally proposed version of prepositioning Granby Reservoir storage content and water surface elevations would be lower than existing conditions, particularly during consecutive dry years due to the delivery of C-BT water to Chimney Hollow Reservoir. To maintain greater storage in Granby Reservoir, the Subdistrict would reduce, and in some instances curtail, C-BT deliveries to Chimney Hollow Reservoir when water levels in Granby Reservoir are projected to fall below an elevation of 8,250 feet (about 340,000 AF of storage). If projections indicate Granby Reservoir would fill, C-BT water would be delivered to Chimney Hollow Reservoir to maintain that reservoir full to the extent possible. C-BT water in Chimney Hollow Reservoir would then be exchanged with Windy Gap water diverted to Granby Reservoir, as described under the originally proposed version of prepositioning. Details of this measure would be developed by the Subdistrict and incorporated into a proposed agreement between Reclamation and the Subdistrict with review by the U.S. Army Corps of Engineers (Corps). The objective is to minimize the adverse effects of prepositioning on water levels in Granby Reservoir. This measure would minimize any potential negative effects on aquatic resources and recreation in Granby Reservoir that may be caused by reduced water levels from prepositioning.

To evaluate the potential reduction in water fluctuations at Granby Reservoir due to modified prepositioning operations, the Proposed Action was simulated using the WGFP model assuming C-BT deliveries to Chimney Hollow would be curtailed when Granby Reservoir contents drop below 8,250 feet in elevation. Actual operations may vary from this simulation of modified prepositioning depending on specific hydrologic conditions and runoff projections. Appendix Tables B-1 to B-9 show average, wet, and dry monthly changes in storage contents, water surface elevations, and surface areas for Carter Lake, Horsetooth Reservoir, and Granby Reservoir with modified prepositioning.

> Modified prepositioning under the Proposed Action would reduce drawdowns in Granby Reservoir. Average monthly summer water elevations would decrease less than 5 feet from existing conditions, with a maximum reduction of about 15 feet.

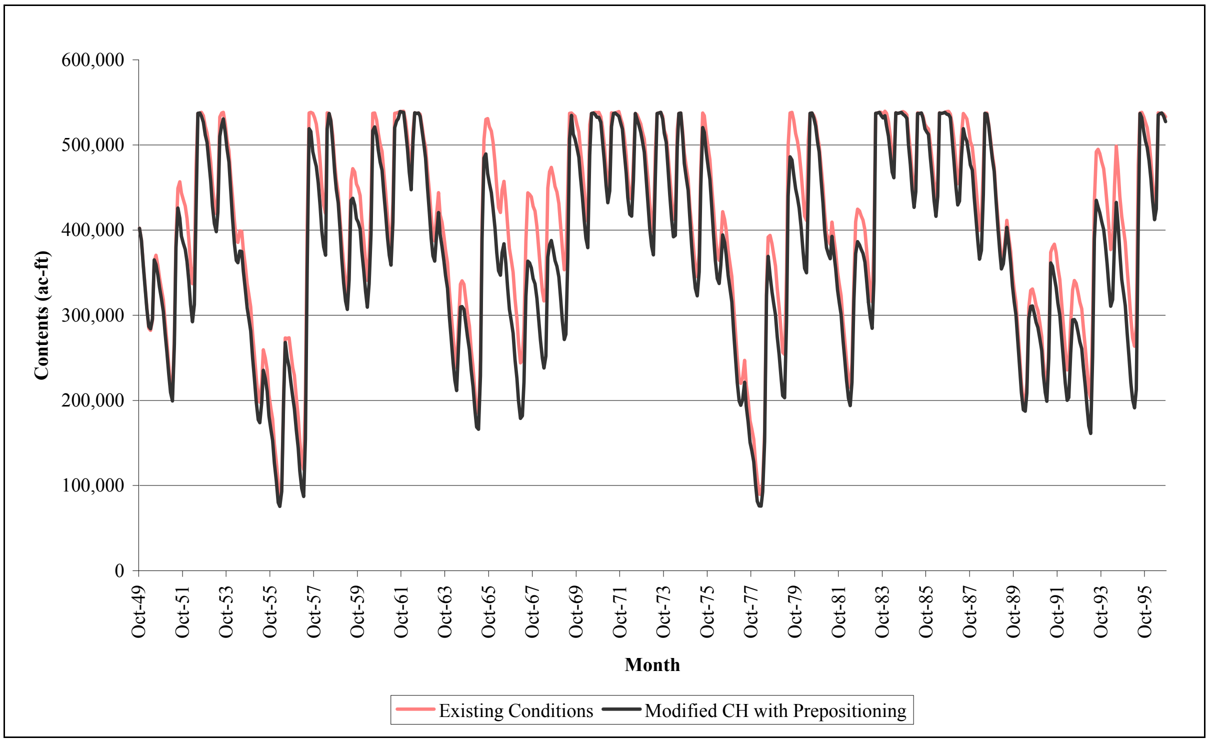
With modifications to prepositioning, the maximum reduction in water surface elevation at Granby Reservoir from May to September would be about 15 feet compared to existing conditions, versus 23 feet under the originally proposed version of prepositioning (Table 3-29). Figure 3-29 shows the difference in Granby Reservoir surface elevations compared to existing conditions under the modified prepositioning for the entire study period. Reductions in water surface elevations are much less in dry year sequences such as 1954–1956, 1963–1967, 1977–1979, and 1981–1982 than under original prepositioning. In some periods, there are still relatively large decreases in water elevations at Granby Reservoir compared to existing conditions (such as April 1995); however, those changes are due to differences in Windy Gap contents in Granby Reservoir as opposed to C-BT deliveries to Chimney Hollow Reservoir.

Table 3-29. Comparison of the change from existing condition in content, maximum surface area, and water level decrease in Granby Reservoir for the Proposed Action under original prepositioning and modified prepositioning.

	Original Prepositioning Granby Reservoir					Modified Prepositioning Granby Reservoir				
Date [1]	Content (AF)	Area (ac)	Change (ac)	Level (ft)	Change (ft)	Content (AF)	Area (ac)	Change (ac)	Level (ft)	Change (ft)
May	215,684	4,608	-1,142	8,226	-23	252,054	5,003	-747	8,233	-15
June	331,668	5,742	-902	8,248	-19	368,236	6,038	-606	8,254	-12
July	349,400	5,888	-894	8,251	-18	382,472	6,148	-634	8,257	-13
August	353,908	5,924	-897	8,252	-18	387,832	6,189	-632	8,257	-13
Sept.	342,271	5,830	-918	8,250	-19	376,636	6,103	-644	8,256	-13

[1] Maximum monthly change in Granby Reservoir area and elevation over the 47-year study period.

Figure 3-29. Comparison of monthly Granby Reservoir elevation for existing conditions and modified prepositioning under the Preferred Alternative.



Average monthly Granby Reservoir water elevations during the summer would be about 3 to 5 feet lower than existing conditions under modified prepositioning or about 2 feet higher than original prepositioning (Table 3-30). The largest change in monthly water elevation in average, wet, and dry years at Granby Reservoir would be a 6-foot reduction in the winter or early spring compared to existing conditions (Appendix Table B-2).

Table 3-30. Average monthly changes in Granby Reservoir elevation and surface area for the Proposed Action, with and without modified prepositioning.

Alternative	May	June	July	August	September
	Surface Elevation (feet)				
Existing Conditions	**8,253**	**8,263**	**8,268**	**8,269**	**8,268**
	Changes in Lake Elevation from Existing Conditions (feet)				
Alt 2 – Proposed Action	-7	-6	-5	-5	-5
Alt 2 – Proposed Action – Modified Prepositioning	-5	-4	-3	-3	-4
	Surface Area (acres)				
Existing Conditions	**5,970**	**6,440**	**6,722**	**6,750**	**6,691**
	Changes in Lake Surface Area from Existing Conditions (acres)				
Alt 2 – Proposed Action	-351	-281	-225	-226	-251
Alt 2 – Proposed Action – Modified Prepositioning	-245	-186	-150	-165	-192

There would be little to no change in Carter Lake storage contents, water surface elevations, and surface areas under the modified version of prepositioning compared to existing conditions (Appendix Tables B-4 to B-6). Water level fluctuations would be about 1 foot lower or higher than existing conditions under modified prepositioning.

Modified prepositioning would reduce water level changes in Carter Lake and Horsetooth Reservoir. Under the Proposed Action with modified prepositioning, the average monthly water level in Carter Lake would decrease less than 1-foot and the water level in Horsetooth Reservoir would decrease less than 2 feet compared to existing conditions.

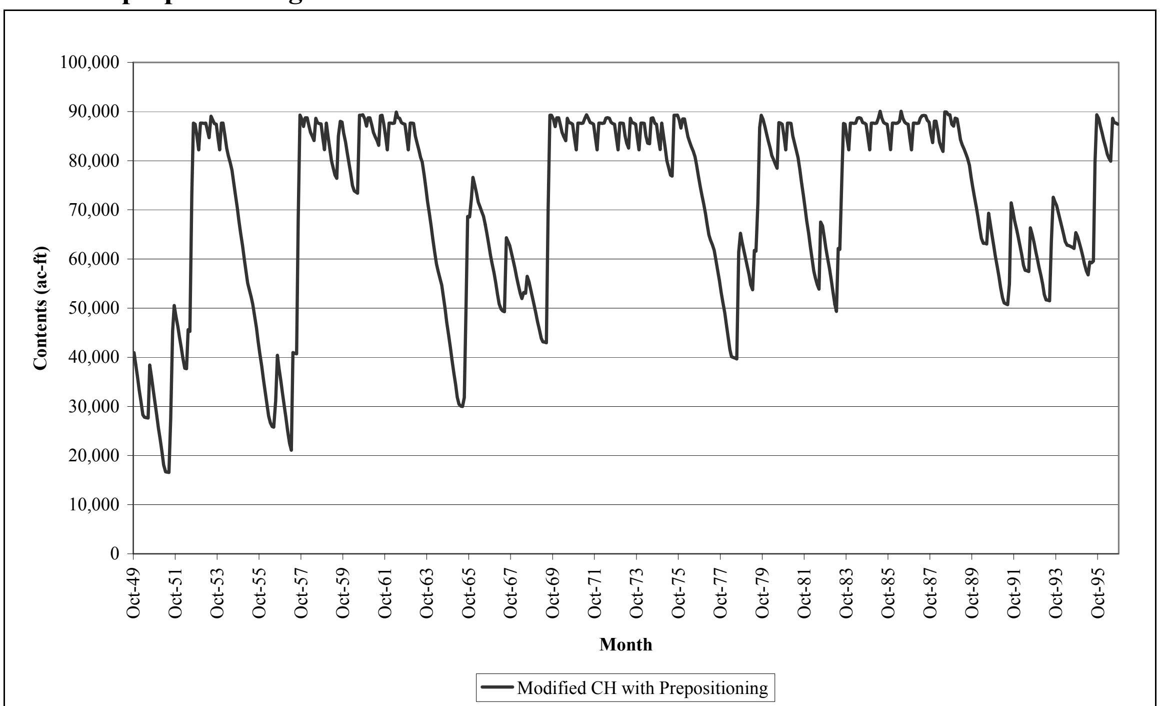
Differences in storage contents, water surface elevations, and surface areas at Horsetooth Reservoir would be less under modified prepositioning compared to original prepositioning. C-BT deliveries to Chimney Hollow Reservoir could reduce C-BT deliveries to Horsetooth Reservoir if available capacity in Adams Tunnel is limited or C-BT contents in Granby Reservoir were exhausted in dry years. Because C-BT deliveries to Chimney Hollow Reservoir would be reduced in dry years under the modified version of prepositioning, differences to Horsetooth Reservoir also would be less. Reductions in water surface elevations would be much less in dry year sequences. The maximum average monthly water surface elevation decrease from existing conditions in the summer months would be 2 feet (Table 3-31). Average monthly water surface elevations would be about 3 to 4 feet higher than under original prepositioning. Horsetooth Reservoir elevations would decrease less than 2 feet for all months in average, wet, and dry years (Appendix Table B-8). With modifications to prepositioning, the maximum reduction in water surface elevation in Horsetooth Reservoir compared to existing conditions would be about 10 feet compared to 40 feet under the originally proposed prepositioning.

Figure 3-30 shows the expected content of Chimney Hollow Reservoir under modified prepositioning for the entire study period. Chimney Hollow Reservoir would be drawn down in dry year sequences, whereas under the originally proposed prepositioning, Chimney Hollow Reservoir was maintained full. During dry years, when Granby Reservoir is not forecasted to fill, C-BT deliveries to Chimney Hollow Reservoir would be reduced, and in some instances curtailed, and as a result, storage contents in Chimney Hollow Reservoir would decrease as Windy Gap water is delivered to the Participants. During dry years, there would be limited to no Windy Gap water diverted to refill Chimney Hollow Reservoir.

Table 3-31. Average monthly changes in Horsetooth Reservoir elevation and surface area for the Proposed Action, with and without modified prepositioning.

Alternative	May	June	July	August	September
	Surface Elevation (feet)				
Existing Conditions	**5,416**	**5,420**	**5,418**	**5,406**	**5,396**
	Changes in Lake Elevation from Existing Conditions (feet)				
Alt 2 – Proposed Action	-6	-6	-6	-4	-3
Alt 2 – Proposed Action – Modified Prepositioning	-2	-2	-2	-1	-1
	Surface Area (acres)				
Existing Conditions	**1,834**	**1,892**	**1,854**	**1,703**	**1,579**
	Changes in Lake Surface Area from Existing Conditions (acres)				
Alt 2 – Proposed Action	-83	-79	-74	-55	-38
Alt 2 – Proposed Action – Modified Prepositioning	-23	-25	-25	-18	-15

Figure 3-30. Chimney Hollow Reservoir operation for the Proposed Action with modified prepositioning.



Modified prepositioning would have little to no impact on Windy Gap diversions. Windy Gap spills increase slightly because in some instances, Windy Gap water stored in Granby Reservoir would be spilled before it can be delivered to the East Slope. These differences are small, however, and flows in the Colorado River would be similar to the originally proposed prepositioning.

Modifications to prepositioning would have little to no impact on the firm yield to the Participants. Granby Reservoir contents would generally be above 340,000 AF for all or portions of average and wet years, in which case sufficient C-BT water could be delivered to Chimney Hollow Reservoir to exchange with Windy Gap water.

In dry years, when storage contents would be below 340,000 AF, Windy Gap water could be stored in Granby Reservoir with little to no risk that it would be spilled prior to delivery through the Adams Tunnel. Generally, Granby Reservoir takes at least 2 years to fill after a drought, so that Windy Gap water remaining in Granby Reservoir could be delivered to the East Slope, and sufficient C-BT water could be prepositioned in Chimney Hollow Reservoir after Granby Reservoir contents exceed 340,000 AF. Windy Gap yield could be affected in sequences of very dry years like 1954 through 1956, followed by an extremely wet year like 1957, if Granby Reservoir fills too quickly before sufficient C-BT water could be prepositioned in Chimney Hollow Reservoir.

3.5.4.2 Colorado River

Windy Gap Diversions. As described in *Surface Water Quality Mitigation* (Section 3.8.4), the Subdistrict prepared a FWMP in cooperation with the Colorado Division of Parks and Wildlife (CDPW) that includes curtailment of WGFP diversions during periods when chronic or acute stream temperature standards are exceeded as a result of the WGFP. The FWMP also includes a modification in flushing flows from the original Windy Gap Project (1980 MOU) from 450 cfs to 600 cfs in any year when flows below Windy Gap have not exceeded 600 cfs for at least 50 consecutive hours in the previous two years, and total Subdistrict water supplies in Chimney Hollow and Granby reservoirs exceed 60,000 AF on April 1, the Subdistrict would cease all Windy Gap pumping for at least 50 consecutive hours to enhance peak flows below Windy Gap. This mitigation measure is discussed in more detail in *Stream Morphology and Floodplains Mitigation* (Section 3.7.4). The above mitigation measure would periodically increase Colorado River streamflows by reducing diversions at Windy Gap.

3.5.5 Unavoidable Adverse Effects

All alternatives would result in an increase in water diversions from the Colorado River below the Windy Gap Reservoir. Streamflow on the Colorado River would generally decrease below the diversion and streamflow on Willow Creek below Willow Creek Reservoir also would decrease during the spring and summer. Spills of water to the Colorado River from Granby Reservoir would decrease under all alternatives. Granby Reservoir water levels would be lower, as would Carter Lake, and Horsetooth Reservoir at times. Streamflow on the East Slope would increase slightly on the Big Thompson River below Lake Estes and on St. Vrain Creek, Big Dry Creek, and Coal Creek below Participant WWTPs. Monthly streamflow increases and decreases would occur on the North St. Vrain Creek and St. Vrain Creek under the No Action Alternative.

3.6 Ground Water

3.6.1 Affected Environment

3.6.1.1 Area of Potential Effect

Areas of potential effect to ground water hydrology and ground water quality are shallow alluvial aquifers located along East and West Slope streams and reservoirs and hydraulically connected bedrock aquifers that could be affected by the project alternatives.

3.6.1.2 Data Sources

Information on the hydrogeology, ground water use and ground water quality for the study areas was obtained from the U.S. Geological Survey, Colorado Geological Survey, Colorado Division of Water Resources, and Chronic (1980). More detailed information is provided in the Water Resources Technical Report (ERO and Boyle 2007), Stream Water Quality Technical Report (ERO and AMEC 2008a), and Lake and Reservoir Water Quality Technical Report (AMEC 2008a).

3.6.1.3 West Slope Ground Water Hydrology and Quality

Hydrogeology and Ground Water Use

The geology of the Colorado River from Granby Reservoir to Gore Canyon is variable and relatively complex (ERO and Boyle 2006). Geologic units exposed at the surface include Quaternary-aged alluvium, colluvium, landslide deposits, and glacial outwash, Tertiary-aged sediments, Cretaceous-aged sedimentary rocks and volcanic rocks, and Precambrian-aged igneous and metamorphic rocks. In general, the width of the floodplain and the thickness of the alluvium are controlled by the bedrock geology. In reaches of the river that flow through areas of erosionally resistant bedrock units, the floodplain tends to be narrow, relatively straight, and contains little if any alluvium. In areas of less resistant bedrock geology, the floodplain is relatively wide, meandering, and contains areas of alluvium greater than 100 feet thick.

Because the Colorado River drainage is the lowest area topographically, the river is most likely a discharge area for aquifers or water-bearing zones in bedrock formations that are crossed by the river. Surficial deposits along the Colorado River, such as alluvium, are usually connected hydraulically to the river. There may be areas where older alluvial terraces may no longer be directly connected to the river because of more recent erosion and downcutting by the river, isolating the older units. Alluvium also may receive water from underlying or adjacent bedrock aquifers. In addition to alluvium, other small surficial aquifers include glacial outwash or other similar unconsolidated deposits. Numerous wells are located near the Colorado River within the study area, most less than 100 feet deep and completed in the alluvium.

The Jasper East and Rockwell study areas are underlain by the Troublesome Formation, except in the narrow valleys associated with Willow, Rockwell, and Mueller creeks, where limited Quaternary-aged alluvium is present, and in other areas where Quaternary-aged terrace gravels and landslide deposits are present (ERO and Boyle 2006). The Troublesome Formation, about 1,000 feet thick, consists of interbedded siltstone and mudstone or shale, with less abundant sandstone and conglomerate, and minor amounts of limestone. This formation is the primary water-yielding unit in the study area. In addition, alluvial deposits may yield water in useable quantities, particularly downstream of the proposed Rockwell Reservoir on the south side of the Fraser River valley. Most of the bedrock wells in the study areas are completed at depths exceeding 100 feet.

The general geology of the Granby Lake area is Precambrian-aged granitic and metamorphic rocks to the east side, and Tertiary-aged sedimentary rocks, primarily the Troublesome Formation, underlying the reservoir and to the west. In various areas these rocks are overlain by Quaternary-aged alluvium and glacial drift. Hundreds of water supply wells are located along the lake, most of which are more than 100 feet deep and are screened at a depth of 50 feet or greater.

Ground Water Quality

Reported water quality data results (Apodaca and Bails 2000; Bauch and Bails 2004; Earthinfo, Inc. 2008; Topper et al. 2003) indicate that alluvial ground water along the Colorado River has low nutrient concentrations, low dissolved solid concentration (average of 120 mg/L), low alkalinity (less than 100 mg/L) and low hardness (average of 50 mg/L). Compared to bedrock ground water quality in this area, alluvial ground water is lower in calcium, bicarbonate, chloride, sodium and sulfate. Bedrock ground water along the Colorado River has much higher total dissolved solids, iron, and manganese concentrations than alluvial ground water. At the Jasper East and Rockwell reservoir sites, Troublesome Formation ground water is typically a calcium bicarbonate water with a total dissolved concentration of 200 mg/L and a hardness of less than 90 mg/L (Bauch and Bails 2004; Topper 2003). Water wells located near Granby Reservoir are used for domestic purposes and are assumed to be of potable quality.

3.6.1.4 East Slope Ground Water Hydrology and Quality

The western portion of the Chimney Hollow and Dry Creek study areas are underlain by Precambrian age metamorphic bedrock. The eastern half of the study areas are underlain by sedimentary rocks that consist of conglomerate, sandstone, siltstone, shale, and minor amounts of limestone. Within both study areas, a thin layer of Quaternary-aged alluvium and and/or colluvium occurs along the banks of Dry Creek and Chimney Hollow (ERO and Boyle 2006).

The occurrence of ground water in the Dry Creek and Chimney Hollow study areas is limited to fractures in the well-cemented sedimentary rocks and Precambrian-age bedrock. Limited quantities of ground water also may exist in the relatively thin and limited unconsolidated alluvial and colluvial deposits, but it is unlikely that the thin surficial deposits yield sufficient ground water for domestic or stock water use. Very few existing wells are located within the Dry Creek and Chimney Hollow reservoir footprints; only one well is shallower than 200 feet.

The hydrogeology and availability of ground water at Carter Lake and Horsetooth Reservoir is similar to that of the Dry Creek and Chimney Hollow study areas. Only one well is located within 100 feet of Horsetooth Reservoir and it is screened more than 150 feet below ground surface. No wells are located within 100 feet of Carter Lake or Ralph Price Reservoir. The Ralph Price Reservoir area is composed of Precambrian-aged granitic rocks; useable quantities of ground water occur in fractured Precambrian-aged crystalline metamorphic rocks.

Ground water quality at the potential reservoir locations on the East Slope is unknown due to a lack of data. However, Topper et al. (2003) reports that fractured crystalline rocks along the Front Range generally produce good quality ground water with total dissolved solids less than 500 mg/L. The bedrock ground water in these areas is typically calcium bicarbonate water, but varies somewhat as a result of local mineralization.

3.6.2 Environmental Effects

3.6.2.1 Issues

Ground water issues of concern identified during scoping were the potential effects to ground water wells near reservoir sites and ground water aquifer recharge along the Colorado River.

3.6.2.2 Method for Effects Analysis

Potential effects to ground water resources could occur where there is a hydraulic connection between ground water and affected streams and reservoirs. Impacts to ground water hydrology and quality were evaluated by reviewing expected changes in stream stage, reservoir levels as discussed in Section 3.5, and changes in the water quality of streams and existing reservoirs, as well as the expected water quality of new reservoirs as discussed in Section 3.8.

3.6.2.3 Ground Water Hydrology

Ground water along streams, existing reservoirs, and potential new reservoirs may be affected by the WGFP as a result of the following:

- Changes in existing reservoir elevations
- Water storage in new reservoirs
- Changes in stream stage

Lake surface elevations in Granby Reservoir, Carter Lake and Horsetooth Reservoir would be lowered during some months under all alternatives. However, at all of the reservoir locations, the ground water flow direction is controlled by topography, which in general slopes toward the reservoirs. With the exception of areas below the dams, ground water is most likely moving toward the reservoirs and would, in general, be only slightly affected by changes in reservoir elevation. The occasional large decreases in reservoir elevations during a series of dry years could result in temporary changes in ground water levels near the reservoirs. Seepage from the reservoirs is mostly controlled by the nature of the geology and the engineering design of the impoundment. The anticipated changes in the elevations of existing reservoirs would not significantly change the rate of seepage below dams.

The historical variation in the lake surface elevation of Granby Reservoir (nearly 90 feet) is larger than the expected change due to any alternative.

There are hundreds of private water wells around the perimeter of Granby Reservoir. Of the 632 State Engineer's Office (SEO) wells listed as having been constructed, 138 are domestic water wells, 23 are commercial wells, 446 are household water use wells, 10 are municipal water wells, 5 are listed as "other" use, and 10 have no listing associated with use. Of these 632 wells, 44 were installed with the top of the well screen at less than 50 feet below ground surface, and 200 wells have no screen depth information listed. Of the 200 wells with no screen information listed, 59 have a listed total well depth of less than 100 feet.

Because Granby Reservoir is the lowest local topographic feature, ground water would move toward the lake. Therefore, the water level in many wells is not subject to fluctuation as a result of reservoir level, but rather is due to typical seasonal changes in recharge. Based on a review of water level information for three USGS wells immediately bordering the reservoir, the ground water table elevation is higher than that of the reservoir, indicating that ground water is flowing toward the reservoir (i.e., the reservoir is gaining water from the surrounding aquifers).

Depending on the geology, however, there may be areas around the lake where ground water levels are controlled by reservoir levels because they are in low-lying areas or in alluvium connected to the lake. The lake currently experiences substantial changes in elevation from artificial and natural causes. During the 2002 drought period, the lake was reported to be at its lowest level since filling in 1950. No published reports were identified from this period to indicate a shortage in water supplies from wells near the lake. If this is correct, it is confirmation that most local water supplies are from deeper formations that are somewhat buffered from short-term variations in recharge from precipitation and are not affected by large changes in reservoir water levels. Water levels in wells may decrease during periods of drought or lowered reservoir levels, but water apparently can still be pumped to the surface for use.

There would be no change in water surface elevations at Grand Lake, Shadow Mountain, or Willow Creek reservoirs for any of the WGFP alternatives; hence, ground water near these reservoirs would not be affected.

Potential effects to ground water levels at new reservoirs are unlikely because the direction of ground water flow is generally toward reservoir sites and the relatively low hydraulic conductivity of the bedrock units would limit the influence of a new reservoir. The potential new reservoirs are located in areas of relatively low topography that are typically the discharge areas for bedrock aquifers. Therefore, ground water levels would not be affected by new water storage because ground water would be, in general, moving toward the reservoirs. Even if a new reservoir is located in a bedrock recharge area, impounding additional surface water may result in positive effects, such as reducing typical seasonal variability in recharge, thereby increasing ground water availability. Seepage losses through or beneath new impoundment(s) could raise ground water levels below the dams. Depending on current ground water conditions and actual seepage losses, higher ground water levels below the dam are possible.

> WGFP diversions would have minimal effects on alluvial ground water levels and wells along the Colorado River because of the small changes in stream stage.

The average June change in Colorado River stream stage under the Proposed Action would be a decrease of about 2.6 inches in the river below Windy Gap Reservoir and about 3.4 inches in the river near Kremmling compared to decreases of less than 2 inches under No Action and with other alternatives falling between these values (ERO and Boyle 2007). These stage changes are smaller than the natural variability of existing stage changes in the river due to seasonal flow changes. Alluvial wells located along the river currently pump during stage changes of as much as several feet. Other months would see smaller decreases in river stage. It is unlikely that small changes in stream stage would measurably affect alluvial ground water levels beyond tens of feet horizontally from the river or impact water production from nearby alluvial aquifers or wells. Changes in recharge to the alluvial aquifer would be small and would be measurable (in inches of water elevation decline) only close to the river. However, it may be difficult to separate the changes in river stage due to Windy Gap diversions from the natural seasonal variability in river stage. Similar small decreases in stream stage on Willow Creek would unlikely measurably affect any nearby wells.

Because of the nature of ground water hydraulics, which are controlled by resistance to flow of the granular alluvium, any change in river stage would be reduced to smaller changes in ground water levels as a function of the permeability (hydraulic conductivity) of the alluvial material and distance from the river. Also, because much of the Colorado River system receives recharge from adjacent bedrock units, head changes some distance from the river would likely be much less than the river stage change, and may not be measurable.

Data are not available to quantify potential impacts to every alluvial well along the Colorado River. However, several generalizations can be made with respect to potential impacts to alluvial wells. A 1-foot or less change in river stage would not change the water supply available to a well, but it would change the total saturated thickness and, therefore, the total available water column that can be drawn down during pumping, which could affect the pumping rate under some conditions. The greater the distance a well is from the river, the less the impact would be from a change in river stage. For alluvial wells near the river in permeable (high hydraulic conductivity) alluvium typical of coarse-grained material and with reasonable saturated thicknesses (meaning that the saturated thickness is more than adequate to supply the well demand at the site specific hydraulic conductivity), a 1-foot or smaller change in river stage would be unlikely to have any impact on the well's productivity (pumping rate). For a well completed in moderately permeable material, but with a reasonable saturated thickness (as defined above), a 1-foot stage change would likely result in unmeasurable changes in well production. For alluvial wells located near the river in low to moderate permeability material and a relatively thin saturated thickness, which are unlikely to exist because they would be poor producers, a stage change could further reduce the productivity of the well. Thus, impacts to the amount of water or productivity of alluvial wells along the Colorado River are unlikely from the small predicted changes in stream stage under all of the alternatives.

Projected increases in streamflow for several East Slope streams from additional water imports would be unlikely to affect stream stage by more than a few inches because the water in these streams spreads out within wide alluvial channels. Therefore, nearby alluvial ground water levels would not be expected to change more than a few inches.

3.6.2.4 Ground Water Quality

As discussed in *Surface Water Quality* (Section 3.8), the predicted change in water quality in the existing reservoirs under all alternatives is relatively small. In addition, there would be small predicted changes in ground water levels adjacent to the reservoirs. It is, therefore, unlikely that ground water quality would be affected by any alternative. The predicted water quality of the new reservoirs under the various alternatives is expected to be similar to that of existing reservoirs. Because seepage from the new reservoirs is expected to be small, and surface water quality is generally better relative to typical background ground water quality, it is unlikely that ground water quality near the potential new reservoirs would be negatively affected.

Colorado River water quality model results for the various alternatives indicate that there may be some changes in stream water quality, such as specific conductance, ammonia, and inorganic phosphorus concentrations that could increase slightly in some parts of the Colorado River. The largest increases in specific conductance would occur downstream of the Williams Fork River, and the largest change in nutrient concentrations would occur downstream of the Hot Sulphur Springs WWTP (see Section 3.8.2.4). Similar changes in alluvial ground water quality immediately adjacent to the Colorado River would be expected. The change of other modeled water quality parameters is predicted to be minor. Because the alluvial water adjacent to the Colorado River is a mixture of water from upgradient sources (surface water recharge, shallow ground water, and bedrock groundwater) and water from the river, it is likely that the effects of Windy Gap diversions from the Colorado River would have effects to alluvial water quality that may not be measurable within the natural variability of ground water quality, even within a few feet of the river.

> The small predicted changes in surface water quality as a result of the WGFP are unlikely to measurably affect ground water quality.

In the Upper Colorado River basin, bedrock water quality is much poorer than the alluvial water it flows toward. The predicted changes in Colorado River stage during Windy Gap diversions would slightly reduce the water level in the alluvium, thus increasing the percentage of bedrock water versus water from the river that recharges the alluvial aquifer. The bedrock ground water flow (or flux) that discharges to the Colorado River alluvium, and ultimately the river, is not controlled by river stage. The driving head for bedrock ground water discharging to the river is generally much higher than the possible range of river stage between high and low flows, and as a result controls the rate of discharge along with other hydraulic parameters such as hydraulic conductivity and saturated thickness. Changes in river stage may affect bedrock hydraulic gradient in the immediate vicinity of the river, but the rate of ground water discharge to the river does not change (as a result of changes in river stage).

The predicted maximum stage change that would result from Windy Gap diversions to the minimum streamflow of 90 cfs, in combination with effects due to changes in Granby Reservoir spills as a result of the project, is about 0.75 feet. Stage reductions would occur only for short periods, typically 2 weeks or less, but rarely up to 1 month. Also, stage reductions under this flow scenario would occur only during about 15 percent of all years. Current surface and ground water users already experience larger natural stage changes on an annual basis and, therefore, infrequent stage changes of 0.75 feet would not be expected to impact those users. Also, the water level changes would attenuate farther from the river. Therefore, it is expected that any changes to alluvial water quality as a result of reduced stream levels during Windy Gap diversions would not be measurable. Bedrock aquifers would not likely be affected by changes in river flow or quality.

Hydrologic modeling of Willow Creek showed that ground water inflow is a source of water to Willow Creek below Willow Creek Reservoir. It is unlikely that changes in the water quality of Willow Creek predicted for the WGFP alternatives described in Section 3.8 would affect ground water quality near the creek because the creek is not losing water to ground water.

The water quality of North St. Vrain Creek is expected to improve from existing conditions under the No Action Alternative due to releases from Ralph Price Reservoir, which would have slightly improved water quality because of its increased volume and depth. Therefore, there would be no negative effects to ground water quality at Ralph Price Reservoir or along North St. Vrain Creek and St. Vrain Creek. Water quality changes to the Big Thompson River between Lake Estes and the Hansen Feeder Canal are predicted to be very small and are not expected to affect ground water quality near the river.

For the other East Slope streams where small water quality changes are predicted to occur under all alternatives due to changes in Participants' WWTP return flows, there may be minor changes to alluvial ground water quality near the streams. This includes the Cache la Poudre River below Greeley's WWTP, the Big Thompson River below Loveland's WWTP, St. Vrain Creek below Longmont's and the Little Thompson Water District's WWTPs, Big Dry Creek below Broomfield's WWTP and Coal Creek below Superior's, Louisville's, Lafayette's and Erie's WWTPs.

3.6.3 Cumulative Effects

The effects to ground water from the combined hydrologic effects of the WGFP and reasonably foreseeable future actions would be very similar to those expected under direct effects for all alternatives. Changes in ground water levels and ground water quality are expected to be minor to unmeasurable. The average June decrease in Colorado River stage would be about 4 inches downstream from Windy Gap Reservoir and about 1 foot near Kremmling under the Proposed Action, and less for other alternatives. This would not result in a substantial change to water production from nearby alluvial water aquifers or wells. The expected changes in ground water levels due to a 1-foot decrease in stream stage would not be measurable beyond tens of feet horizontally from the river. Increased late summer and fall releases from Granby Reservoir as part of the 10825 Project would have a slightly positive effect on ground water levels adjacent to the Colorado River. Periodic bypass flows as part of Denver Water's FWMP for the Moffat Project and the *Colorado River Cooperative Agreement* would have minimal effect on ground water in the Colorado River.

Section 2.8.2.1 in Chapter 2 summarizes possible climate changes for the north-central Rocky Mountains and how these changes could affect precipitation and runoff. With respect to the regional ground water resources, possible increases in average temperature could result in higher rates of evaporation, which would result in less water available for ground water recharge. Less recharge would result in lower ground water levels and less ground water discharge to streams and rivers. In addition, due to changing precipitation patterns, with less rainfall predicted during April through October, there may be decreased baseflow in streams from ground water in late summer. Because of the uncertainty in quantifying potential impacts from climate change, it is not possible to measure potential impacts to ground water resources. However, any decrease in ground water discharge to rivers would be proportional to decreases in ground water recharge as a result of climate change.

3.6.4 Ground Water Mitigation

Because no significant effects to ground water hydrology or quality for any alternative are expected; no specific mitigation is proposed for ground water aquifers in the project area. Curtailment of WGFP diversions as part of temperature mitigation would result in later summer increases in Colorado River flow and minor changes in stream stage that would have a minimal effect on ground water. Nutrient mitigation measures described in Section 3.8.4 would improve water quality on the lower Fraser River, Colorado River, and Willow Creek and thus ground water quality immediately adjacent to these streams.

3.6.5 Unavoidable Adverse Effects

Changes in existing reservoir elevations, storage in new reservoirs, and changes in stream stage expected to occur under the project alternatives would have negligible to no effect on nearby ground water hydrology. The predicted minor changes in stream or reservoir water quality under the all alternatives is unlikely to adversely affect nearby ground water quality.

3.7 Stream Morphology and Floodplains

3.7.1 Affected Environment

3.7.1.1 Regulatory Framework

Executive Order (EO) 11988 requires agencies to avoid developments that result in adverse impacts to floodplains. The purpose of the order is to prevent increased flood risk and minimize the impact of floods on human safety, health, and welfare and the preserving the beneficial values of floodplains.

3.7.1.2 Area of Potential Effect

The area of potential effect used to describe morphological changes to stream channels and banks is composed of the streams that would experience changes in flows as a result of the alternatives. On the West Slope, this includes the Colorado River from below Granby Reservoir to Gore Canyon, as well as Willow Creek below Willow Creek Reservoir. On the East Slope, this includes the Big Thompson River below Lake Estes and North St. Vrain Creek and St. Vrain Creek below Ralph Price Reservoir for the No Action Alternative. Hydrologic flow changes would also occur below Participant WWTPs on St. Vrain Creek, the Big Thompson River, Big Dry Creek, and Coal Creek. All of these streams have an associated floodplain. The existing diversion from the Colorado River at Windy Gap Reservoir is located within the river's floodplain. Proposed new reservoir sites are located on small intermittent streams in small watersheds that likely flood infrequently.

3.7.1.3 Data Sources

Information on streamflow and stream morphology for the study areas was obtained from the USGS, CDWR, USDA Forest Service, Colorado State University, previous relevant studies of the Colorado River completed for the 1981 Windy Gap Project EIS, the Grand County Stream Management Plan (SMP) (Tetra Tech et al. 2008, 2010), and analysis of sediment transport conducted for the WGFP and Moffat EISs. Additional information is provided in the Water Resources Technical Report (ERO and Boyle 2007).

3.7.1.4 West Slope Stream Morphology and Floodplains

The flow of the Colorado River is affected by storage in Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake; stream diversions; return flows; tributary and ground water inflows; and natural precipitation events. There are numerous diversions for agricultural and domestic water needs. Although the flow of the Colorado River has been quite variable over time, due in part to diversions and storage, only minor changes in river morphology (form and structure) other than the addition of Windy Gap Reservoir, are evident in aerial photos taken between 1938 and 2005 below Granby Reservoir and below Windy Gap Reservoir (Ward and Eckhardt 1981; ERO and Boyle 2007). In addition, river cross-sectional analyses completed for the aquatic resource analysis, located 8 to 10 miles downstream of Windy Gap Reservoir, showed no evidence of recent changes to stream morphology, sediment deposition, or scouring in the Colorado River near Parshall (Miller Ecological Consultants 2010).

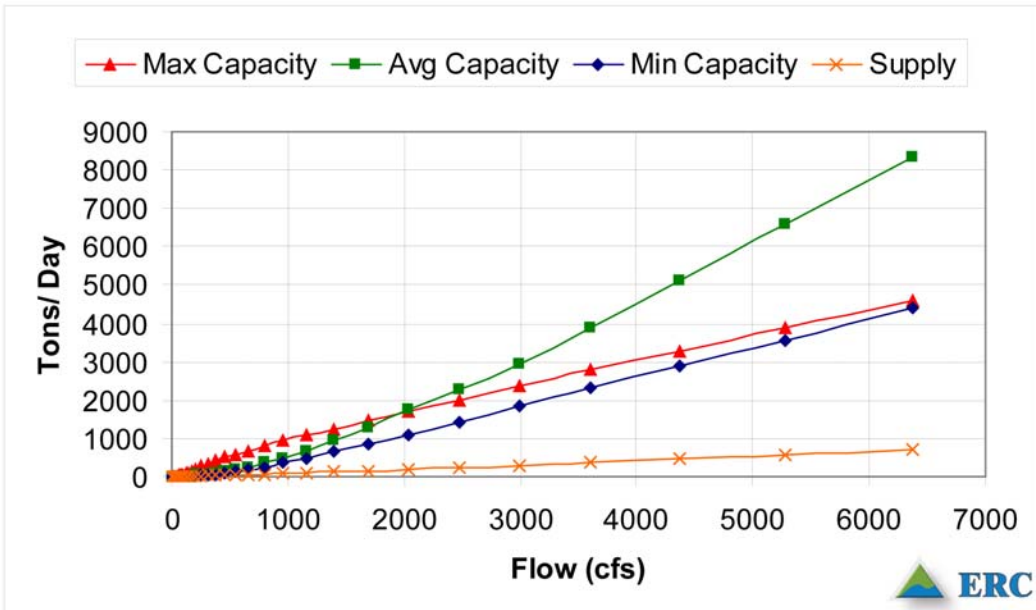
Streamflow in the Colorado River changed substantially after construction of the C-BT Project and Granby Reservoir began storing water in 1947. However, over the last six decades, the river channel has remained stable despite changes in the timing and quantity of flows. The form and structure of the channel, banks, and floodplain have changed very little. The river has continued to convey sediment without aggradation or degradation of the stream channel. As the following discussion indicates, the upper Colorado River is a morphologically stable stream.

Sediment discharges to the Colorado River in the project area are derived from upstream sources, tributary inflows, overland flow, or the channel bed and banks (Ward and Eckhardt 1981). The igneous and metamorphic rocks of the Colorado River headwaters are fairly resistant to weathering and, therefore, contribute little sediment to the river from natural sources. Other sources of sediment include agricultural runoff, road sanding, unpaved roads, timber harvest, and land-clearing developments. A previous study showed that the Colorado River channel bed and banks are well armored (Ward and Eckhardt 1981). This study determined that the largest tributary source of sediment in the study area is Troublesome Creek, with minor contributions from other tributary sources. The sediment supply was found to be low, and the transport capacity of the river greatly exceeds supply (Ward and Eckhardt 1981). A recent study completed on the Colorado River above Parshall also found that the transport capacity of the Colorado River at this location greatly exceeds supply (Figure 3-31) (Corps 2010). The sediment supply, as represented by the orange supply line in Figure 3-31 indicates a relatively low volume of available sediment across a range of flow volumes. At a flow of about 200 cfs, sediment supply is the same as the transport capacity of the river, and at flows greater than 200 cfs, the capacity of the river to transport sediment exceeds sediment supply. The three transport capacity lines represent the minimum, maximum, and average sediment transport capacities derived by modeling 14 river cross-sections above Parshall. Thus, the transport capacity of the Colorado River even at relatively low flows exceeds the volume of available sediment.

Although there has been growth and development in the upper Colorado River watershed since 1981, no major wildfires, flash floods, or alterations to the river channel have occurred that have substantially increased sediment loading to the Colorado River other than short-term perturbations such as those that occur due to large localized storm events. Human activities near the Colorado River that might increase sediment supply to the river in the study area have not changed substantially in recent decades. Construction of Windy Gap Reservoir has decreased sediment loading to the river below the dam by capturing sediment. Twenty-five years of accumulated sediment (5,600 tons) in Windy Gap Reservoir required dredging in 2010 to prevent further damage to facilities.

Channel maintenance flows are considered necessary to maintain the physical characteristics of a stream channel and are critical to ensuring unimpaired flow and sediment conveyance. A range of channel maintenance flows provide the benefits of conveying water and eroded materials from tributaries without aggradation (raising of the streambed by deposition of sediment) or degradation (lowering of the streambed), preventing vegetation encroachment and narrowing of the channel, sustaining aquatic ecosystems, temporarily storing flood flows on the floodplain, and maintaining healthy streambank and floodplain vegetation (Schmidt and Potyondy 2004). Channel maintenance flows can be related to various ecological functions, such as the maintenance of fish

Figure 3-31. Comparison of sediment supply vs. transport capacity at CR-1, Colorado River above Parshall.



Source: Corps 2010.

spawning beds and the scouring of periphyton (organisms attached to rocks in the stream) growth in a river channel. Previous studies have defined a range of channel maintenance flow from a lower limit of 80 percent of the 1.5-year discharge to an upper limit of the 25-year instantaneous peak flow (Potyondy 2007; Schmidt and Potyondy 2004). The lower limit is the flow rate at which coarse sediment transport begins and the upper limit is the flow above which valley rather than channel maintenance occurs and when property damage may occur (Potyondy 2007). Gravel-bed channels such as the Colorado River tend to transport bed and bank material only at the largest annual flows for a few days a year (Whiting 2002).

Willow Creek

The 2.5-mile segment of Willow Creek from Willow Creek Reservoir to the Colorado River has a sinuous channel that flows across gently sloping topography. Streamflow in Willow Creek is primarily a function of Willow Creek Reservoir operations, although two small tributaries are below the reservoir. The baseflow of Willow Creek is about 10 cfs, which occurs 7 months of the year. Scouring flows exceeding 1,000 cfs have occurred infrequently. Sediment supply in Willow Creek is limited due to the reservoir and because alluvium and soils underlying the creek and its tributaries are shallow, overlying exposed bedrock in much of the Willow Creek watershed below the reservoir.

Floodplain

The width of the Colorado River floodplain, as indicated by unconsolidated deposits from geologic mapping, is variable within the study area, depending on the location of resistant bedrock units; in general, it varies between ¼ to ½ mile wide (Izett 1968; Izett and Barclay 1973; Schroeder 1995). The floodplain of Willow Creek is about ¼ mile wide (Izett 1974). The floodplains of the intermittent streams at the proposed new reservoir sites (Jasper East and Rockwell) are narrow (250 feet or less) (Izett 1974; Schroeder 1995). The Colorado River has overflowed its banks occasionally during snowmelt events. At the gage near Kremmling, the largest flood occurred in June 1912 (20,000 cfs), and other flood flows equal to or exceeding 15,000 cfs occurred in June 1909, 1914, 1917, and 1918 (EarthInfo 2010). The most recent high flood flow was in May 1984 (12,700 cfs) (EarthInfo 2010).

3.7.1.5 East Slope Stream Morphology and Floodplains

East Slope streamflows, stream morphology, and sediment loads have been thoroughly altered by land use practices that began with the 1859 gold rush (Wohl et al. 1998). The primary influences are flow regulation and diversions, which have reduced seasonal flood peaks and increased baseflows. Irrigation of agricultural fields has raised the regional water table. Urban development and the increase in impervious surfaces have influenced the timing and delivery of stormwater runoff to streams. Reduced peak streamflows have resulted in greater sediment deposition and considerable narrowing of channels. These changes in surface and subsurface flows facilitated the growth of riparian vegetation. Damming of streams has reduced the amount of sediment carried by streams. Stream channels and banks along the Front Range urban corridor are generally unstable and considered by hydrologists and stream morphologists to be in a state of disequilibrium (Wohl et al. 1998). Channel patterns continue to change, channels and banks are actively eroding and scouring, and channel downcutting and excessive sediment deposition is occurring.

The width of the alluvial floodplain based on geologic mapping for the East Slope streams is generally less than ¼ mile in the foothills (North St. Vrain Creek and the Big Thompson River below Lake Estes to the base of the foothills) and about 1 mile wide on the plains. At the proposed Chimney Hollow and Dry Creek Reservoir sites, through which small streams flow intermittently, the floodplain ranges from 500 to 1,000 feet wide (Braddock et al. 1988), although flooding outside of the streambank is expected to be infrequent.

3.7.2 Environmental Effects

3.7.2.1 Issues

The potential for changes in streamflow in the Colorado River and other streams to affect stream channel characteristics, sediment deposition, and transport are an issue of concern. Hydrologic changes that could affect the potential for flooding were also a concern.

3.7.2.2 Method for Effects Analysis

Potential effects to stream morphology were evaluated for each alternative. Significant changes in the frequency and magnitude of channel maintenance flows could affect the morphology of a stream channel and alter sediment transport and the rate of sediment deposition in a stream. In addition, such changes may affect the distribution of riparian vegetation along streams. Decreases in streamflow could result in the reduction of the sediment transport capacity of the river and could cause aggradation and vegetation encroachment into the stream channel. Increases in streamflow could result in increased streambed and bank erosion, degradation, and increased sediment transport. Increases in streamflows also could flood and potentially diminish or scour riparian vegetation along the edges of a stream. Changes in stream morphology also have the potential to impact habitat for aquatic life.

Stream morphology, including its channel, banks, floodplain, and drainage area, can be altered by natural activities such as flooding, erosion, vegetation encroachment, or mud and debris flows. Human actions, such as dam construction and reservoir regulation, water diversions, return flows, land use changes, and structural features constructed in the floodplain, also can alter stream morphology. Factors affecting channel dynamics include changes in streamflow (i.e., frequency, magnitude, and duration); bed and bank material size and distribution; stream channel vegetation; and sediment supply and transport capacity. As water flows over the channel bed and along the banks, it exerts a force in the direction of flow that, if large and frequent enough, will move the bed and bank material. This may cause the channel to become unstable and move laterally. If the force of the water is too small to move bed and bank material, or is too infrequent and causes movement only rarely, then the channel will be stable (Leopold et al. 1995).

Sediment particles are transported in flowing water by rolling or sliding along the streambed, moving above the bed with resting periods on the bed, or in suspension in the water. The first two processes help shape the bed and influence bed roughness and channel stability. The amount of material transported or deposited in a channel under a given set of conditions depends on variables that influence the quantity and type of sediment transported in the channel, and on variables that influence the capacity of the channel to transport sediment. Deposition of sediment eroded and transported from upstream can raise the streambed (aggradation). Lowering of the streambed (degradation) can occur from scouring of sediments during high streamflows.

Potential impacts to stream morphology and sedimentation were examined for the Colorado River by evaluating changes in the frequency of existing Windy Gap flushing flow requirements, comparing changes in the range of channel maintenance flows for different recurrence intervals and ecological functions, calculating sediment transport capacity, and analyzing flow duration curves (changes in the volume of flow over time). For Willow Creek, the flow duration curve was developed and evaluated. For East Slope streams, the changes in streamflow were compared to existing flows to qualitatively assess potential effects to morphology and flooding.

3.7.2.3 West Slope Streams

Colorado River

Historical Aerial Photographs of the Colorado River Channel. Diversions from the Colorado River began in the late 1800s, including the transbasin Grand Ditch diversion, which began in 1890. Regulation of the Colorado River, which began in 1947 with construction of Granby Reservoir, has not substantially altered the observed stream morphology of the Colorado River below the dam from preregulation conditions; this conclusion is based on review of a series of aerial photographs taken since 1938. Studies have indicated that a man-made disturbance within a watershed, such as an online reservoir, will impact stream channel stability by affecting the interrelationships between hydrology, sediment sources and yields, and channel processes (Leaf 1998). The relationship of channel stability to these elements is a matter of thresholds. In a morphologically stable stream, the sediment material supplied to and/or stored in the stream channel is balanced with the energy available to transport the material. Channel adjustments can occur, but the channel will remain stable as long as changes in streamflows, slope, and sediment stay below the threshold. This appears to be the case for the Colorado River in the study area, which may be at least in part due to the fact that transport capacity greatly exceeds sediment supply in the river. In addition, the Fraser River and other unregulated tributaries below the confluence with the Fraser River provide substantial flows to the Colorado River.

Changes in Flow Duration. Flow duration curves were constructed for the USGS gages at Hot Sulphur Springs and near Kremmling (Figure 3-32 and Figure 3-33). The curves show the differences in the frequency of a range of flows for existing conditions and the alternatives for the 47-year model period. Changes in flow duration for different volumes would be similar under all action alternatives for the Colorado River at Hot Sulphur Springs. The following flow changes are predicted to occur under the action alternatives:

- The number of days flow is less than 150 cfs would increase 3.5 percent;
- 200 cfs flows would occur about 10.5 percent of the time compared to 14 percent of the time under existing conditions;
- 500 cfs flows would occur slightly more than 5 percent of the time compared to slightly more than 7 percent of the time under existing conditions;
- 1,000 cfs flows would occur 3 percent of the time compared to slightly more than 4 percent of the time under existing conditions;
- Flows of 2,000 cfs or greater would occur 1.6 percent of the time compared to 2 percent of the time under existing conditions; and
- Flows of 4,600 cfs or greater would occur less than 0.1 percent of the time under both existing conditions and the action alternatives.

For the Colorado River near Kremmling, under all action alternatives the following is predicted to occur:

- The number of days flow is less than 1,200 cfs would increase less than 1 percent;

- 1,600 cfs flows would occur 9.5 percent of the time compared to 10.5 percent of the time under existing conditions;
- 3,000 cfs flows would occur slightly less than 4 percent of the time compared to slightly more than 4 percent of the time under existing conditions; and
- Flows of 5,000 cfs or greater would occur about 1.5 percent of the time compared to 1.9 percent of the time under existing conditions.

Figure 3-32. Flow duration curve—Colorado River at Hot Sulphur Springs.

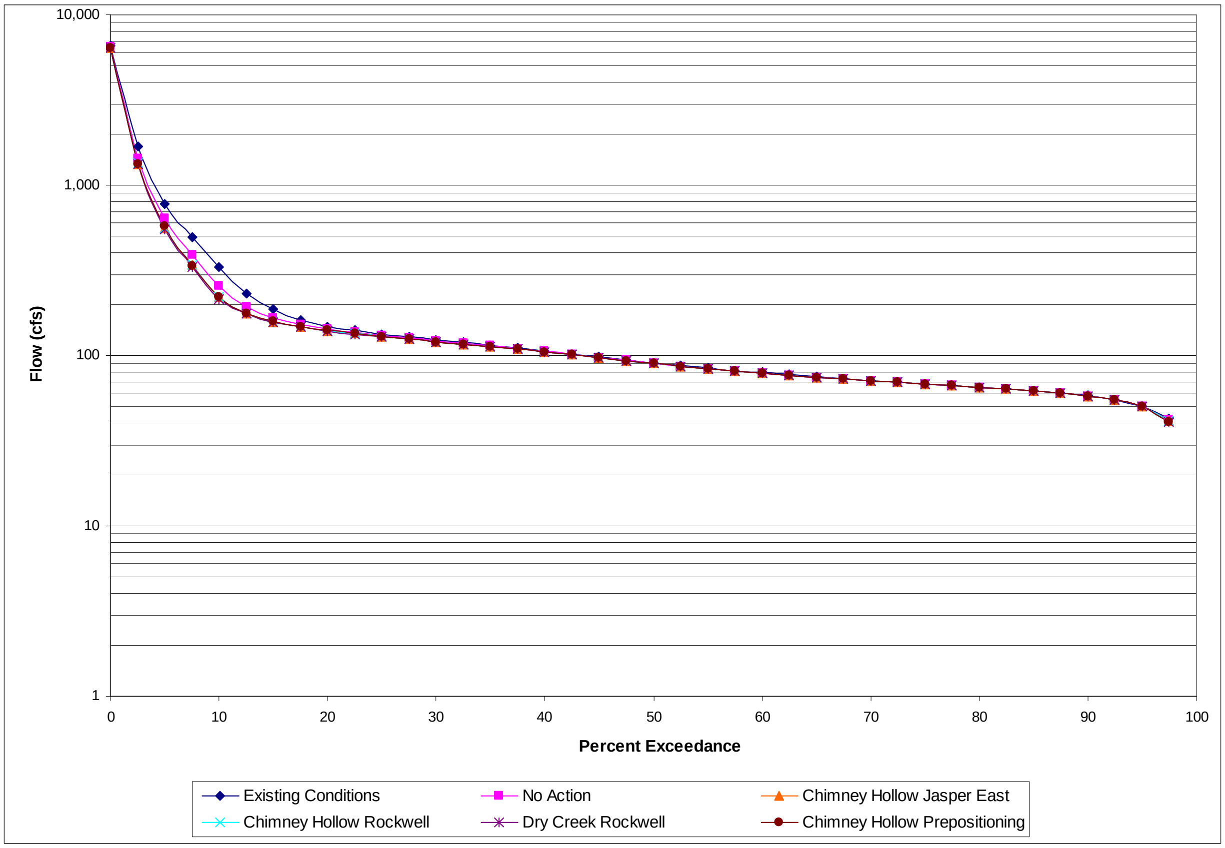
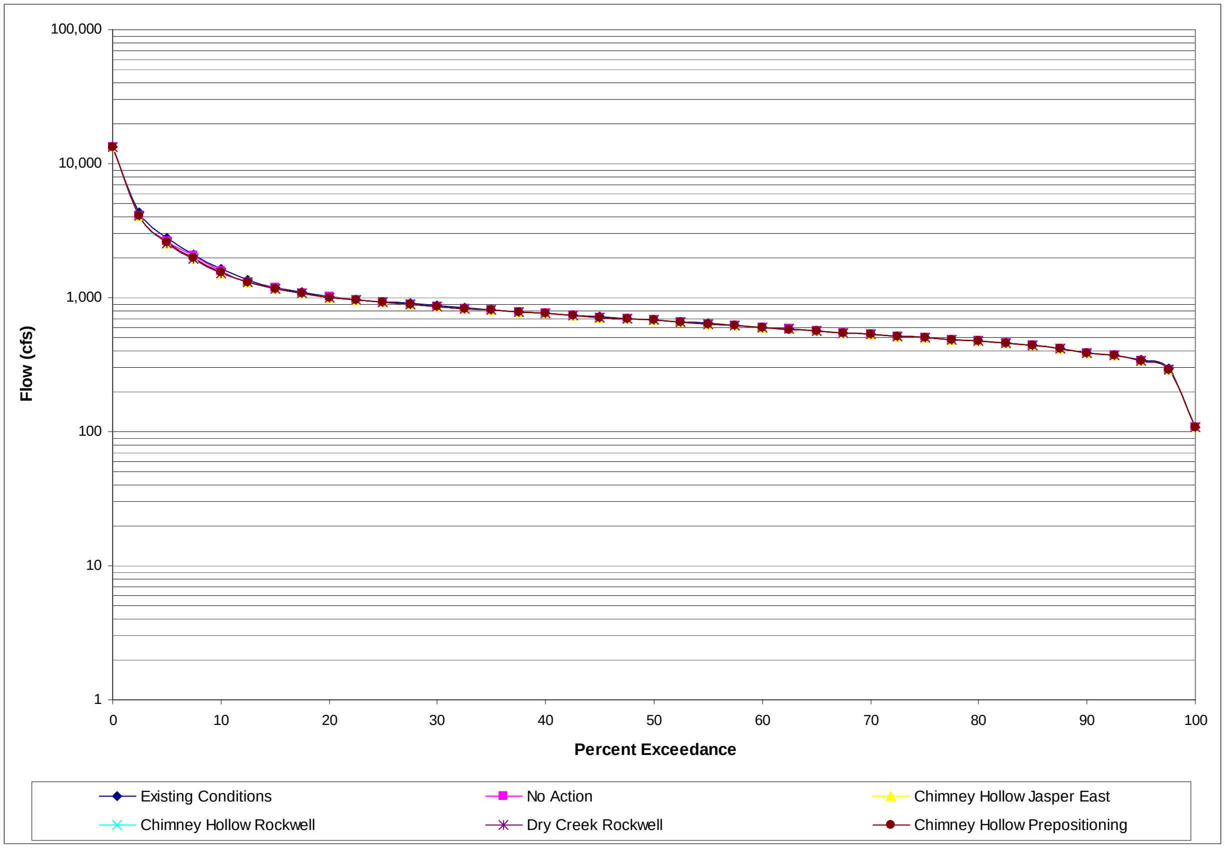


Figure 3-33. Flow duration curve—Colorado River at Kremmling below Blue River.



Effects to Sediment Transport. Previous evaluation and modeling of the Colorado River for the original Windy Gap Project EIS (USDI 1981) indicated that no significant increases in sediment transport or the rate of sediment deposition would occur downstream of the Windy Gap diversion with a proposed average withdrawal of 56,000 AF/year (Ward and Eckhardt 1981). Ward and Eckhardt's study (1981) is still relevant because the average annual reductions in streamflow that were anticipated for the original Windy Gap Project are greater than would occur under any of the WGFP alternatives, including No Action. In addition, Ward and Eckhardt's study (1981) and a recent study completed for the Moffat Project of the Colorado River above Parshall indicate the sediment transport rate of the river continues to far exceed the sediment supply to the river and no aggradation of the channel is likely (Figure 3-31) (Corps 2010). While the reductions in flow under all of the alternatives would decrease the sediment transport capacity of the stream below Windy Gap Reservoir, the projected flow changes and existing flushing flow requirements would not substantially affect sediment transport processes. Sediment transport capacity would remain substantially higher than the available sediment supply.

A recent evaluation was completed of available streamflow versus shear stress data at the Colorado River Breeze station, a riffle site located downstream of the confluence with the Williams Fork (ERC 2009). This analysis provides a generalized relationship between sediment mobilization and streamflows in the Colorado River. The results showed that fine sediments (sand and silt, 2 mm or finer) would be mobilized at this riffle site at flows of less than 50 cfs. Fine gravel (8 mm) would require a flow of 200 cfs, medium gravel (16 mm) would require a flow of about 400 cfs, and coarse gravel (32 mm) would require a flow of about 850 cfs to be mobilized. In Ward's 1981 study, his results at four locations from below Windy Gap to above the Blue River showed that fine sediments (sand and silt, 2 mm or finer) would be mobilized at discharges ranging from 140 to 240 cfs (depending on location, with the highest flow at the lowest site above the Blue River). The flow duration curve for Hot

Sulphur Springs shows minimal changes in flows of 150 cfs or less under the action alternatives. Colorado River flow at the Kremmling gage would likewise have minimal changes in flow below 1,200 cfs.

Effects to Channel Maintenance Flows. An evaluation was completed for the Colorado River at the Hot Sulphur Springs gage below the Windy Gap diversion to compare changes in the timing and frequency of various channel maintenance flows under the alternatives (Table 3-32, Figure 3-34, and Figure 3-35). The percent of years within the low channel maintenance flow range of 510 cfs to 1,240 cfs would decrease from 62 percent under existing conditions to about 51 percent for the Proposed Action and 53 percent for No Action. The duration of flows for the 510 to 1,240 cfs flow range, during years when such flows occur, would decrease from 2 to 4 days for all alternatives compared to existing conditions. The percent of years with flows in the 2- to 5-year recurrence interval range would decrease about 4 percent for the action alternatives and 2 percent for the No Action Alternative compared to existing conditions. Flows within the recurrence interval of 5 to 10 years would decrease about 13 percent for the Proposed Action, 11 percent for other action alternatives, and 2 percent for No Action. However, the duration of flows in this range would increase slightly (by up to 2.5 days for the Proposed Action) from existing conditions. The percent of years with flows in the 10- to 25-year recurrence interval would occur about 7 percent less under the action alternatives compared to existing conditions, but with a slightly greater duration (up to 2 days longer for the Proposed Action). Changes in the frequency and duration of channel maintenance flows from existing conditions of this magnitude are unlikely to measurably alter stream morphology or sediment transport at Hot Sulphur Springs.

Table 3-32. Changes in Colorado River channel maintenance flows at Hot Sulphur Springs (1950-1996 hydrology).

Recurrence Interval	Flow Range cfs	Percentage of Years Flow Range Occurs				Duration of Flows when Flow Range Occurs (days)			
		Existing Conditions	No Action	Proposed Action	Alternatives 3-5	Existing Conditions	No Action	Proposed Action	Alternatives 3-5
0.8x1.5-yr to 2-yr flow	510 to 1,240	62%	53%	51%	51-53%	23	21	20	19
2- to 5-yr flow	1,240 to 3,160	38%	36%	34%	34%	24	22	22	21-22
5- to 10-yr flow	3,160 to 4,600	30%	26%	17%	19%	10.5	10	13	11
10- to 25-yr flow	4,600 to 6,520	13%	11%	6%	6%	4	4	6	5.3

Bankfull storage is defined as a flow condition where the streamflow completely fills the stream channel up to the top of the bank before overflowing onto the floodplain. The USGS has determined that the current bankfull flow volume at the Windy Gap gage, based on monthly measurements, is 765 cfs, plus or minus 10 percent (Craig 2010). This is similar to the 1.5-year flow (640 cfs) at Hot Sulphur Springs (Table 3-32). Many of the morphological characteristics of a channel are formed at its bankfull discharge, which may be equivalent to the 1.5- to 2-year flow (Rosgen 1996). The Grand County SMP derived a bankfull flow volume of 1,250 cfs for the Lone Buck site just below Byers Canyon and 880 cfs between the Williams Fork and Troublesome Creek (Tetra Tech et al. 2008). Bankfull flows are very site-specific, depending on channel and bank dimensions as well as the channel gradient, but the range of measured values is near or within the 1.5- to 2-year modeled peak flow range of 640 to 1,240 cfs for Hot Sulphur Springs.

Figure 3-34. Duration of channel maintenance flows in years when such flows occur at Hot Sulphur Springs.

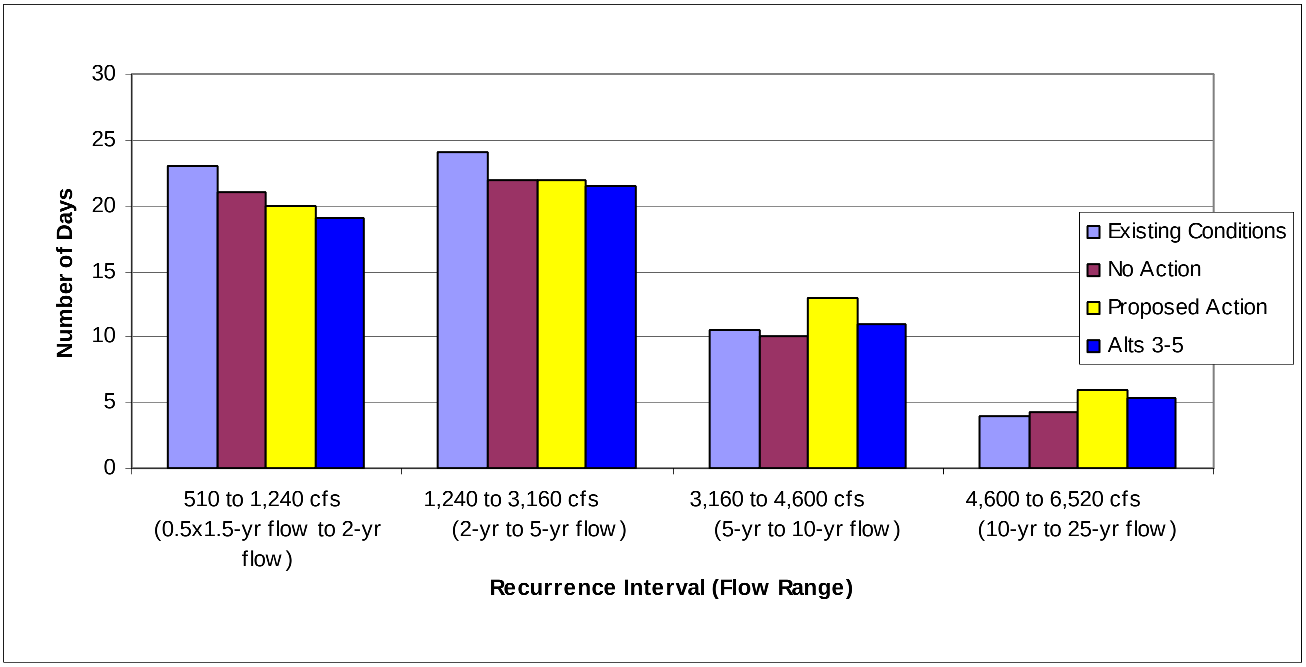
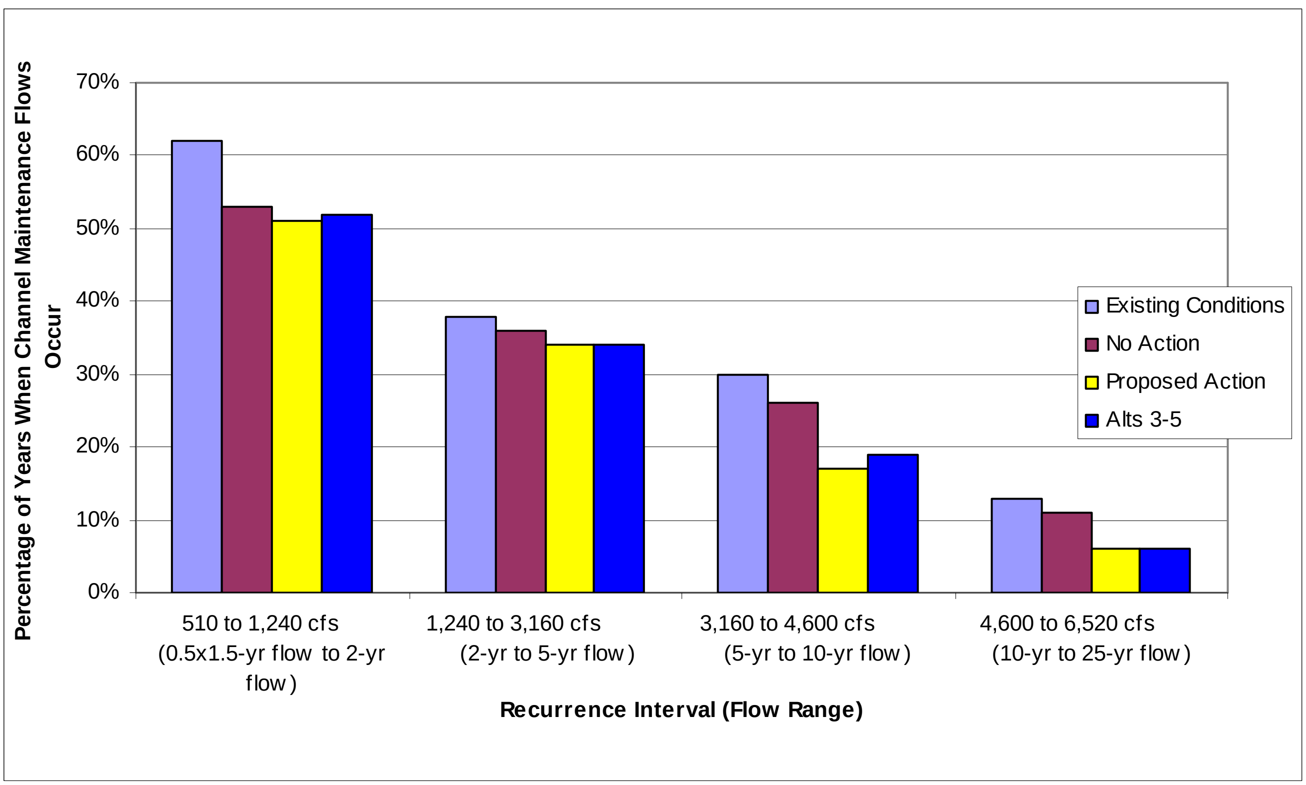


Figure 3-35. Percent of years when channel maintenance flows occur at Hot Sulphur Springs.



Changes in channel maintenance flows may affect certain ecological functions. Substrates up through medium to coarse gravel are used by spawning trout. Fine sediments may smother spawning beds and other habitats. As discussed previously in *Effects to Sediment Transport*, flows smaller than the 2-year peak flow are shown to move up to medium-sized gravel, and flows roughly equivalent to the 2-year peak flow will move coarse gravel. Table 3-32 shows that flows of this duration would continue to occur under the action alternatives and should maintain aquatic habitat. Flows sufficient to scour periphyton can occur at less than the 2-year peak flow (Pitlick and Wilcock 2001) and the removal of encroaching riparian vegetation occurs at about the 2-year peak flow (Whiting 2002). Larger flows may be needed to remove more established vegetation that may colonize after several low-flow years. Modeled flows with reasonably foreseeable actions would remain sufficient to prevent vegetation encroachment and periodically scour periphyton from the river channel under all alternatives. However, once periphyton is established, it frequently returns within a few weeks following a scour event (Rees et al. 2008). Based on numerous studies, the full transport of the bedload up to boulder size has been shown to occur at flows greater than the 50-year peak flow (Whiting 2002). The Hot Sulphur Springs flow duration curves with the WGFP alternatives indicate the frequency of flows equal to or greater than the 10-year peak flow (4,600 cfs) would occur about 0.1 percent of the time under both existing conditions and the alternatives. High flows that would fully transport the bedload of the river, although occurring rarely, would continue to occur under the action alternatives. Table 3-32 shows the percentage of years that flows equal to or greater than the 10-year peak flow would decrease by 11 to 13 percent under the action alternatives, but would still occur during 6 in 100 years and for a duration of 11 to 13 days when such flows occur. This is within the expected frequency of these high flows.

An evaluation was also completed for the Colorado River near Kremmling gage to compare changes in the timing and frequency of channel maintenance flows under the alternatives (Table 3-33, Figure 3-36, and Figure 3-37). The percent of years within the low channel maintenance flow range of 1,650 to 2,850 cfs would decrease from 70 percent under existing conditions to about 66 percent for the Proposed Action. The duration of flows for the 1,650- to 2,850-cfs flow range, during years when such flows occur, would increase by one day under the Proposed Action compared to existing conditions. The percent of years with flows in the 2- to 5-year recurrence interval range would decrease about 2 to 4 percent for the action alternatives and 2 percent for the No Action Alternative compared to existing conditions, and the duration of flows would increase by about 2 days under the Proposed Action. Flows in the 5- to 10-year recurrence interval would decrease about 4 percent for the action alternatives and 2 percent for No Action. The duration of flows in this range would decrease by 3 days from existing conditions. The percent of years in the 10- to 25-year recurrence interval would occur about 3 percent less under the action alternatives compared to existing conditions, but the duration would increase by 2 days. The slight difference in channel maintenance flows between existing conditions and the alternatives is unlikely to measurably alter stream morphology or sediment transport near Kremmling.

The magnitude, timing, and frequency of channel maintenance flows in the Colorado River below Granby Reservoir also would change as a result of changes in spills. When spills are not occurring, the river flow below Granby Reservoir is controlled by instream flows; therefore, it is difficult to define a range of channel maintenance flows based on peak flow events. An analysis of the changes in the magnitude, timing, and frequency of spills that would occur under the alternatives show that fewer spills from Granby Reservoir would occur, but average spills of 560 cfs or more would continue to occur for periods of 1 to 4 months. Spills of this magnitude or greater would occur during 30 percent of all years under existing conditions and in 23 percent of all years under the Proposed Action. The changes in spills are not expected to alter channel morphology or sediment movement in the Colorado River below Granby Reservoir because the spills that would occur under all alternatives would continue to provide flows sufficient to maintain channel capacity, provide periodic scouring, and transport sediment.

Table 3-33. Colorado River at Kremmling channel maintenance flows (1950-1996).

Recurrence Interval	Flow Range cfs	Percentage of Years Flow Range Occurs				Duration of Flows When Flow Range Occurs (days)			
		Existing Conditions	No Action	Proposed Action	Alternatives 3-5	Existing Conditions	No Action	Proposed Action	Alternatives 3-5
0.8 x 1.5- to 2-yr flow	1,650 to 2,850	70	70	66	66	27	26.5	28	27
2- to 5-yr flow	2,850 to 6,550	49	47	45	45-47	29	29	31	29-30
5- to 10-yr flow	6,550 to 7,920	19	17	15	15	10	8	7	7
10- to 25-yr flow	7,920 to 11,900	9	6	6	6	13	16	15	15

Figure 3-36. Duration of channel maintenance flows in years when such flows occur near Kremmling.

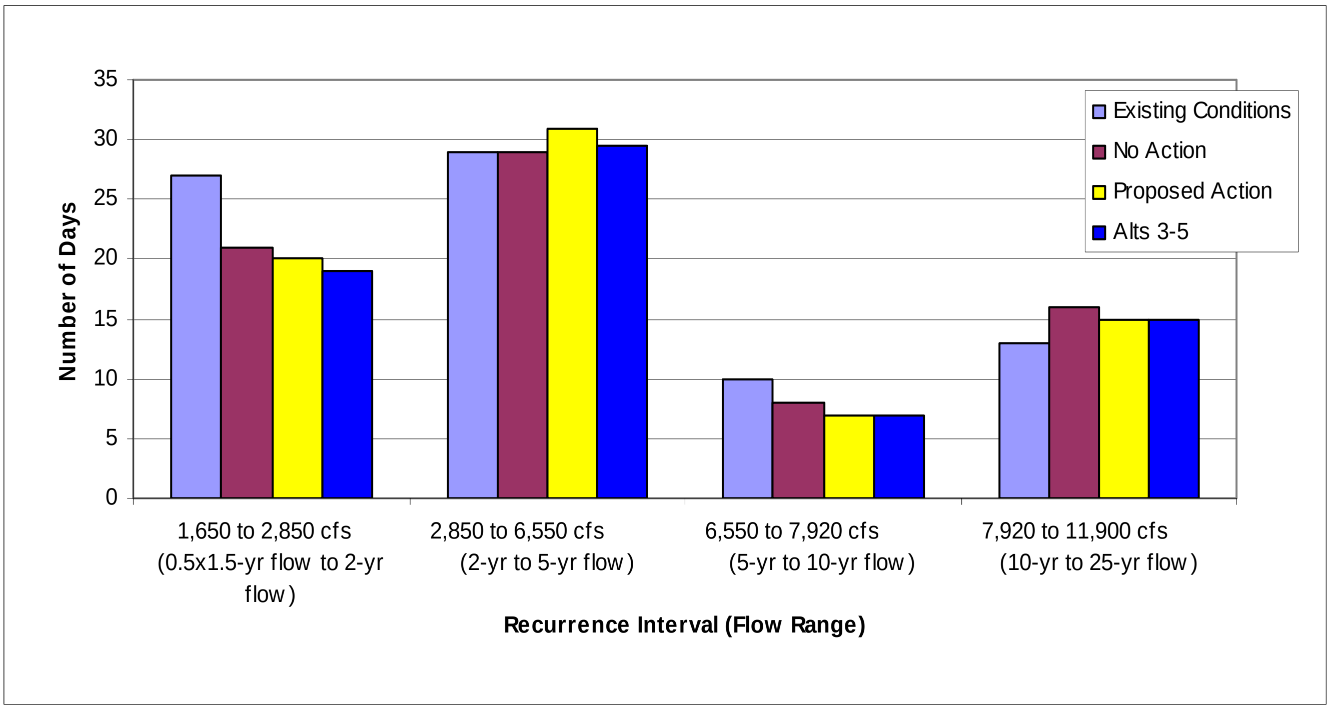
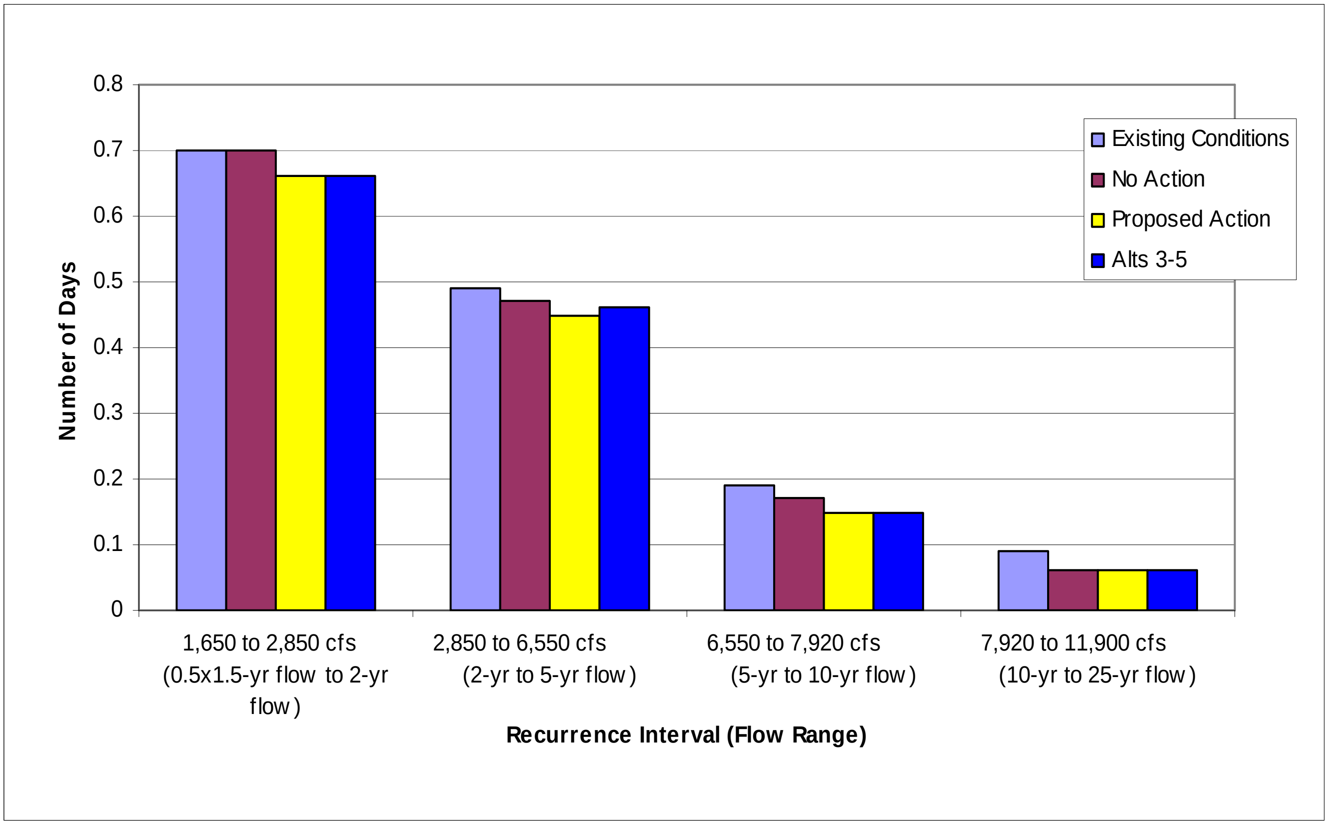


Figure 3-37. Percent of years when channel maintenance flows occur near Kremmling.



> The frequency of 450 cfs flushing flows in the Colorado River below Windy Gap Reservoir would decrease under all of the alternatives. However, streamflow would remain sufficient to transport sediments without channel aggradation.

Effects to Flushing Flows. As part of the original Windy Gap Project and a 1980 MOU between the Municipal Subdistrict, Northern Colorado River Water Conservancy District, NCWCD, and CDOW, flushing flows of 450 cfs for 50 consecutive hours are required at least every 3 years below Windy Gap Reservoir. The Windy Gap Project would curtail diversions if necessary to meet flushing flow requirements under the agreement. Ward and Eckhardt's study of bed materials and movement concluded that the required flushing flow of 450 cfs below Windy Gap Reservoir during the period from April 1 to June 30 every 3 years should be sufficient to transport fine sediments and prevent aggradation (Ward 1981). Under existing conditions, Colorado River flows at Hot Sulphur Springs equal to or greater than 450 cfs are estimated to occur for 3 consecutive days or more for 1,314 days over the 47-year period of record or an average of 28 days per year under existing conditions (Table 3-34). Under the No Action Alternative, flows of greater than 450 cfs are estimated to occur for 3 consecutive days or more for 1,075 days, or 23 days per year on average. For the Proposed Action, flows of 450 cfs are estimated to occur for 3 consecutive days or more for 961 days over the 47-year period of record, or about 20 days per year on average. The other action alternatives would have a similar frequency of flushing flows. All alternatives would reduce the frequency of flows greater than 450 cfs, but flushing flows would remain adequate to transport fine sediment. During four 3- to 4-year periods under existing conditions (1953-1956, 1966-1968, 1976-1978, and 1989-1992) in the 47-year model period, flows did not exceed 450 cfs. In similar conditions in the future, the WGFP would have to curtail diversions, if in priority, to meet the every 3-year 450-cfs flushing flow requirement.

The 2010 Grand County SMP (TetraTech et al. 2010) recommended flushing flows for the Colorado River. These flushing flows were included as part of the "recommended environmental target flows," which were defined as "flows… determined to best maintain the ecological needs of the stream in relation to its fisheries."

The SMP also states that "the magnitude of each flushing flow was based upon bedload transport modeling to identify the threshold flow at which spawning gravel mobilization is initiated." Thus, these flushing flows were developed for providing aquatic habitat rather than for all of the physical and biological aspects of channel maintenance flows. Flushing flows were based on the "output of hydraulic and sediment transport models [and] are not yet supported by empirical evidence of gravel mobilization and spawning success." The flushing flow recommendations in the SMP are 600 cfs for the Windy Gap to the Williams Fork reach and 800 to 850 cfs for the Williams Fork to the Blue River reach, with a minimum duration of 3 days during 50 percent of all years. This range of flows is within the lowest channel maintenance flow range shown for Hot Sulphur Springs in Table 3-32. Under the action alternatives, such flows would continue to occur during 50 percent of all years for on average of 19 or 20 days during those years, which meets the SMP flushing flow recommendations.

Table 3-34. Flushing flows in Colorado River below Windy Gap Reservoir as measured at Hot Sulphur Springs gage.

Alternative	Number of days in 47-year model period when flows are 450 cfs or greater for at least 3 consecutive days[1]
Existing Conditions	1,314
Alt 1 – No Action	1,075
Alt 2 – Proposed Action	961
Alternative 3	964
Alternative 4	965
Alternative 5	937

Note: The Hot Sulphur Springs gage was used because daily flows for the complete period of record are available. Flows below Windy Gap Reservoir are typically slightly higher than at Hot Sulphur Springs.

[1] Per previous mitigation commitments for the original Windy Gap Project, flushing flows of greater than 450 cfs are required once every 3 years for 50 consecutive hours (just more than 2 days). To provide a conservative estimate of future flows equal to or greater than 450 cfs, the calculation was based on 3 consecutive days (i.e., 72 hours).

Willow Creek

The 2-year peak discharge of 80 cfs for Willow Creek was estimated to be exceeded about 5 percent of the time under existing conditions. Under all alternatives, the 2-year peak discharge was estimated to be exceeded slightly less than 5 percent of the time. It is unlikely this small change would measurably affect stream morphology or change sediment transport or deposition in Willow Creek.

West Slope Floodplains

The project would reduce the magnitude of peak snowmelt runoff flows in the Colorado River during years when the WGFP could divert water, resulting in a decrease in flood risk below Windy Gap Reservoir. Potential new reservoirs would capture flood flows that might occur within their watersheds. The narrow floodplains associated with the intermittent streams at the Jasper East and Rockwell reservoirs sites (Alternatives 3, 4, and 5) would be altered by reservoir construction. There would be no new facilities or improvements within any other floodplains.

3.7.2.4 East Slope Streams

North St. Vrain Creek and St. Vrain Creeks

Under the No Action Alternative, streamflows in the reach between Ralph Price Reservoir and the St. Vrain Supply Canal would change due to exchanges of Windy Gap water to storage in Ralph Price Reservoir and releases from Ralph Price Reservoir to meet Longmont's future Windy Gap demands. Although there would be both increases and decreases in flow during several months of the year (Table 3-15), the volume of changes would be well within the historical range of flows. In addition, the North St. Vrain Creek channel, like many foothill creeks, has a channel that is stabilized by bedrock or boulders. For these reasons, it would be unlikely that changes in flow would alter the morphology of the stream or affect sediment movement.

Big Thompson River below Lake Estes

Under all alternatives, minor flow increases in the Big Thompson River from Lake Estes to the Hansen Feeder Canal would occur in April through November, with the greatest increases in May and July. It is not expected that the flow increases (a maximum of 18 cfs in July) would measurably alter stream morphology or sediment transport and deposition. The estimated change in flow would be well within the historical range of flows, which exceed 500 cfs during high flows.

Streams that Receive Windy Gap Return Flows

> Flow changes to East Slope streams conveying WGFP water or return flows would not substantially affect stream morphology or sediment transport because the changes in flows under all of the alternatives would be well within the historical range of flows.

The predicted streamflow increases for the East Slope stream segments that receive Windy Gap return flows (Big Dry Creek, Coal Creek, St. Vrain Creek, and Big Thompson River) are unlikely to substantially alter stream morphology or the rate of sediment transport. The increased flows would be small compared to the spring and early summer flows and would be well within the capacity of the stream channels. In addition, streams on the East Slope have not experienced natural streamflow conditions for more than 100 years, and are not in equilibrium with respect to channel forming and channel moving processes, erosion, or sediment loading, movement and deposition. Given the magnitude of the flow increases (less than 12 cfs under all alternatives), it would be difficult to measurably differentiate changes to stream morphology and sedimentation due to changes in Participants' WWTP return flows from the many other ongoing actions influencing East Slope streamflow conditions.

East Slope Floodplains

The small changes in streamflows that would occur under all alternatives to East Slope streams could increase the potential for flooding; however, the estimated flow increases would be small compared to flood flows caused by snowmelt runoff or large storm events. Potential new reservoirs would capture flood flows that might occur within their watersheds. The only floodplains that would be altered by the project alternatives are those that would be within the footprints of proposed new reservoirs (Chimney Hollow, Dry Creek, or the enlarged Ralph Price Reservoir). There would be no new facilities or improvements within other floodplains.

3.7.3 Cumulative Effects

The effects to stream morphology and sediment transport would be very similar to those expected under direct effects. As with direct effects, changes in streamflow under cumulative effects for all alternatives are not expected to substantially affect stream morphology or change sediment transport or deposition. Windy Gap diversions would be less under the cumulative effects evaluation, but streamflow reductions by other reasonably foreseeable actions would result in less flow in the Colorado River, particularly downstream of the Blue River. The change in the frequency and duration of channel maintenance flows at Hot Sulphur Springs is shown in Table 3-35 and near Kremmling is shown in Table 3-36. Channel maintenance flows at Hot Sulphur Springs ranging from 510 cfs (0.8 x 1.5- to 2-year recurrence interval) to the 6,520 cfs (25-year recurrence interval) are estimated to occur from up to 4 days less to up to 4 days longer during years when such flows occur when comparing existing conditions to the alternatives. The percentage of years such flows are estimated to occur would decrease by 6 to 15 percent. Under the action alternatives channel maintenance flows ranging from 1,650 to 11,900 cfs at Kremmling are estimated to occur from 5 days less to up to 1 day longer during years when such flows occur compared to existing conditions. The percentage of years such flows would occur would decrease by 3 to 17 percent. The magnitude of the change in the frequency of channel maintenance flows is unlikely to substantially change stream morphology or change sediment transport and deposition.

The potential for flooding on the Colorado River would be slightly less with the additional diversions from other reasonably foreseeable actions. East Slope streamflow increases would be less than direct effects because less Windy Gap water would be delivered with reasonably foreseeable actions in place (Table 3-6 and Table 3-21);

thus, cumulative effects would be slightly less than described for direct effects. Lower WGFP diversion under cumulative effects would reduce East Slope deliveries and WWTP return flows, which would slightly reduce the potential for contributing to flood flows for tributaries receiving return flows.

Table 3-35. Colorado River at Hot Sulphur Springs channel maintenance flows, cumulative effects (1950-1996).

Recurrence Interval	Flow Range	Percentage of Years Flow Range Occurs				Duration of Flows When Flow Range Occurs (days)			
	cfs	Existing Conditions	No Action	Pro-posed Action	Alt 5	Existing Conditions	No Action	Proposed Action	Alt 5
0.8x1.5- to 2-yr flow	510 to 1,240	62%	34%	47%	47%	23	28	21	19
2- to 5-yr flow	1,240 to 3,160	38%	34%	32%	32%	24	21	21	21
5- to 10-yr flow	3,160 to 4,600	30%	25.5%	17%	17%	10.5	8	9	9.5
10- to 25-yr flow	4,600 to 6,520	13%	4%	4%	4%	4	8	8	7.5

Table 3-36. Colorado River at Kremmling channel maintenance flows, cumulative effects (1950-1996).

Recurrence Interval	Flow Range	Percentage of Years Flow Range Occurs				Duration of Flows When Flow Range Occurs (days)			
	cfs	Existing Con-ditions	No Action	Pro-posed Action	Alt 5	Existing Con-ditions	No Action	Proposed Action	Alt 5
0.8x1.5- to 2-yr flow	1,650 to 2,850	70%	55%	53%	53%	27	23	23	22
2- to 5-yr flow	2,850 to 6,550	49%	36%	36%	36%	29	29	28.5	28
5- to 10-yr flow	6,550 to 7,920	19%	13%	8.5%	11%	10	6	9	7
10- to 25-yr flow	7,920 to 11,900	9%	6%	6%	6%	13	15	13	14

The 10825 Project would provide additional flows from the release of 5,412.5 AF of water from Granby Reservoir in the late summer. The timing of releases would not affect peak flow or contribute substantially to channel maintenance flows, but would occur at a time when flows are typically low. The Moffat FWMP (Denver Water 2011b) also includes bypassing flows from the Fraser River system for temperature mitigation that would increase flows in the late summer. Additional bypass flow by Denver Water as part of the *Colorado River Cooperative Agreement* (Denver Water 2011c) could also increase Colorado River flows in the late summer. All of these potential flow increases would contribute toward maintaining the channel.

The WGFP and Moffat Collection System Project FWEPs (Municipal Subdistrict 2011a; Denver Water 2011a) include funding for implementation of a stream restoration project on the Colorado River between Windy Gap Reservoir and the Kemp-Breeze State Wildlife Area below the confluence with the Williams Fork. While the details of this project would be determined at a later date by CDPW, it is anticipated to include physical changes to the stream channel to enhance fish passage, create a low-flow channel, and restore streambank vegetation. Specific effects from these stream restoration activities are unknown at this time, but actions are likely to reduce the width of the existing stream channel, increase water depth, create deeper pools, increase the flow rate, and reduce the volume of flow required to reach bankfull discharge. Stream channel restoration work would be conducted in phases in a Learning By Doing cooperative effort so that the effectiveness of measures in meeting biological goals can be evaluated. The long-term effects of these actions on channel morphology are unknown.

Due to the uncertainty in the magnitude and timing of hydrologic changes related to climate change, the effects on stream morphology and sediment transport are qualitatively described. Although average annual runoff for the upper Colorado River basin at Grand Lake is predicted to increase about 5 percent by 2040, the distribution of flows may change. Climate change that results in shorter seasons for snow accumulation and less snowpack could result in smaller and shorter peak flows. If climate change results in earlier and/or reduced peak flows and lower river flows due to decreased baseflow from ground water, less water would be available for Windy Gap diversions from the Colorado River. The range and timing of flows for channel maintenance could change if runoff occurs earlier in the year or if precipitation changes. Specific cumulative effects on stream morphology and sediment transport are difficult to estimate due to the differences in climate model predictions and the uncertainty in estimating future conditions. However, because the evidence indicates that the Colorado River is morphologically stable within the study area, climate change effects to river flows may need to be very significant to noticeably alter stream morphology and sediment transport; an average annual increase in runoff of 5 percent would likely not result in noticeable changes.

3.7.4 Stream Morphology and Floodplain Mitigation

The FWMP (Municipal Subdistrict 2011a) developed by the Subdistrict and adopted by the CDPW and CWCB includes provisions for increasing the volume of periodic flushing flows from the current requirement. The Windy Gap Project is currently required to bypass 450 cfs for 50 hours once in every 3 years, if such flows are naturally available in accordance with the *Memorandum of Understanding Between Municipal Subdistrict, NCWCD, and Division of Wildlife, Colorado Department of Natural Resources, Relating to Minimum Stream Flow in Association with the Windy Gap Diversion Project*, dated June 23, 1980. The Subdistrict would modify project operations as follows:

- The flushing flow provision of the 1980 MOU would be modified to increase the required flushing flow from 450 to 600 cfs.
- In any year when flows below Windy Gap have not exceeded 600 cfs for at least 50 consecutive hours in the previous 2 years, and total Subdistrict water supplies in Chimney Hollow and Granby reservoirs exceed 60,000 AF on April 1, the Subdistrict would cease all Windy Gap pumping for at least 50 consecutive hours to enhance peak flows below Windy Gap.

The intent of this measure is to enhance peak flows below Windy Gap. The Subdistrict will coordinate with CDPW and other water suppliers, including Denver Water, to maximize benefits of the higher flows and minimize any potential negative impacts to aquatic resources.

Temperature mitigation measures as described in *Water Quality* (Section 3.8.4.2) would result in periodic bypass of Windy Gap diversions after July 15 that would contribute to baseflows and sediment transport.

The construction of new reservoirs (Chimney Hollow, Dry Creek, Jasper East, or Rockwell/Mueller) would occur within the floodplains of these small watersheds, capturing potential flood flows. No mitigation to the floodplain is needed or proposed.

3.7.5 Unavoidable Adverse Effects

The WGFP would reduce the volume of water available for channel maintenance functions in the Colorado River below Granby Reservoir and below Willow Creek Reservoir. The import of water to the East Slope would increase the volume of water for channel maintenance functions for several streams. Streamflow changes for all of the alternatives are not expected to significantly alter stream morphology or sediment transport in any of the East or West Slope streams in the project area.

3.8 Surface Water Quality

3.8.1 Affected Environment

3.8.1.1 Area of Potential Effect

The area of potential effect for evaluating surface water quality is essentially the same as described for water resources in Section 3.5. Changes in streamflow or reservoir operation have the potential to impact the chemical, physical, and biological properties of water.

Streams evaluated in the West Slope study area (Figure 3-1) are the Colorado River downstream of Granby Reservoir to Gore Canyon below the confluence with the Blue River, and Willow Creek below Willow Creek Reservoir. Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir are included in the study area, as well as potential new reservoirs at the Jasper East and Rockwell reservoir sites. Windy Gap Reservoir is a small in-channel reservoir and has water quality similar to that of the Colorado River; so it was not evaluated separately. The East Slope study area (Figure 3-2) includes the Big Thompson River below Lake Estes (where additional Windy Gap deliveries would increase flow), and downstream of Participant WWTPs on Big Dry Creek, Coal Creek, St. Vrain Creek, the Big Thompson River, and the Cache la Poudre River. North St. Vrain Creek below Ralph Price Reservoir also could be affected under the No Action Alternative (Figure 3-7). East Slope reservoirs in the study area are Carter Lake, Horsetooth Reservoir, and Ralph Price Reservoir, along with potential new reservoirs at Chimney Hollow and Dry Creek.

Water quality effects to other small reservoirs in the C-BT system were not specifically evaluated because the reservoirs have very short residence times and the water quality would be similar to the major inflows. The other reservoirs in the C-BT system are Marys Lake, Lake Estes, Pinewood Reservoir, and Flatiron Reservoir. Because water quality effects at Carter Lake would be minor, impacts to Boulder Reservoir, which receives water from Carter Lake, should be minimal. Green Mountain Reservoir and Willow Creek Reservoir were not included in the study area because they would not be affected by any alternative.

3.8.1.2 Data Sources

Data used for the evaluation of water quality effects were obtained from the USGS, Reclamation, Big Dry Creek Watershed Forum, Dry Creek Watershed Association, Colorado Department of Public Health and Environment, National Weather Service, U.S. EPA, University of Colorado, Grand County, NCWCD, and WGFP Participants. Various reports and studies on existing water quality also were reviewed to characterize existing water quality and model or estimate future water quality under the alternative actions. Section 3.8.2.3 provides information on the methods used for analyzing water quality effects. More information on the stream and reservoir water quality analysis is found in two technical reports—Stream Water Quality Technical Report (ERO and AMEC 2008a), the Lake and Reservoir Water Quality Report (AMEC 2008a), and the Upper Colorado Dynamic Temperature Modeling Report (Hydros 2011c).

3.8.1.3 West Slope Affected Environment

Colorado River

Colorado River water is generally of good quality throughout the study area. Both natural and man-made activities influence the river's quality. Weathering and erosion of geologic material contributes salts and trace elements to the river. Ground water flowing to the river from underlying bedrock contributes dissolved solids, calcium, sulfate, iron, and manganese to the river. The hot springs at Hot Sulphur Springs discharge about 50 gallons per minute to the Colorado River at a temperature of about 105°F and a total dissolved solids (TDS) concentration of 1,200 mg/L (Barrett and Pearl 1978). According to the Hot Sulphur Resort and Spa, their pools are fed with over 200,000 gallons per day (140 gpm) of spring water ranging from 104 to 126ºF (HSSRAS 2007).

Troublesome Creek, a tributary to the Colorado River near Kremmling, contributes elevated concentrations of iron and suspended sediment to the Colorado River from erodible geologic formations (NWCOG 2002).

Other influences to the Colorado River that affect water quality include various water uses and changes in the hydrologic regime such as diversions by the C-BT Project, Windy Gap, Moffat Collection System, municipal, commercial, and irrigation water uses as described in Section 3.5.1.4. Effluent discharges from WWTPs also affect water quality. The Hot Sulphur Springs WWTP has a capacity to discharge up to 90,000 gallons per day (gpd) (0.139 cfs) to the Colorado River (EPA 2006). This is the only WWTP source of discharge directly to the Colorado River in the study area, but discharges to tributaries also influence Colorado River water quality. The Kremmling WWTP discharges to Muddy Creek, a tributary to the Colorado River. The Fraser River has elevated sediment and nutrient concentrations due to human activities in the basin, including four municipal WWTP discharges to the Fraser River:

- Winter Park Water and Sanitation District (up to 0.45 million gpd or 0.696 cfs)
- Fraser Sanitation District (up to 1 million gpd or 1.547 cfs)
- Tabernash Meadows Water and Sanitation District (up to 0.1 million gpd or 0.155 cfs)
- Granby Sanitation District (up to 0.995 million gpd or 1.539 cfs)

Nonpoint sources of discharge that affect Colorado River water quality are surface runoff from roads, developed areas, irrigation return flows, rangeland supporting livestock, and agricultural lands. Irrigation return flows may contribute to higher temperatures, as well as additional sediment, nutrient, and pesticide loadings and mineral leaching from the soils (Spahr et al. 2000).

Table 3-37 summarizes the range and average water quality for several parameters at three locations along the Colorado River. There have been few measured water quality exceedances, but several samples have had dissolved oxygen (DO) concentrations that were below the standard at sites below Windy Gap Reservoir and near Kremmling.

Table 3-37. Colorado River historical water quality values at three locations.

Parameter	Upstream of Fraser River[1]		Below Windy Gap Reservoir[2]		Near Kremmling[3]	
	Range	Avg.	Range	Avg.	Range	Avg.
Temperature (°C)	3.1 - 17.6	9.3	0 - 22	7.7	0 - 22	9.9
Specific conductivity (µS/cm)	85 - 239	146	61 - 277	129	150 - 428	238
Suspended sediment (mg/L)	3.2 - 46.4	14.8	2.8 - 26	12.4	NA	NA
Dissolved oxygen (mg/L)	3.3 - 12.1	8.9	4.3 - 12.1	9.1	5.3 - 11.4	8.3
pH	6.6 - 8.5	7.7	6.6 - 9.5	8.2	7.4 - 8.6	8.2
Ammonia (mg/L)	0.02 - 0.11	0.06	0.005 - 0.14	0.04	0.003 - 0.11	0.02
Nitrate and nitrite (mg/L)	0.019 - 0.2	0.08	0.03 - 0.85	0.14	0.01 - 0.24	0.09
Total phosphorus (mg/L)	0.03 - 0.76	0.08	0.01 - 0.99	0.14	0.01 - 0.27	0.04
Sodium (mg/L)	3.3 - 9.9	6.4	0.2 - 8.7	5.8	5 - 25	9.7
Total iron (µg/L)	32 - 1,100	709	210 - 1,600	682	233 - 2,650[4]	870
Dissolved Manganese (µg/L)	6 - 200	79	1 - 92	38	10.8 - 143	37.3
Dissolved Selenium (µg/L)	NA	NA	0.05 - 0.4[4]	0.15	<1 - 0.6[4]	0.35
Total Selenium (µg/L)	NA	NA	<1 - 0.3[4]	<1	<1 - 1	<1

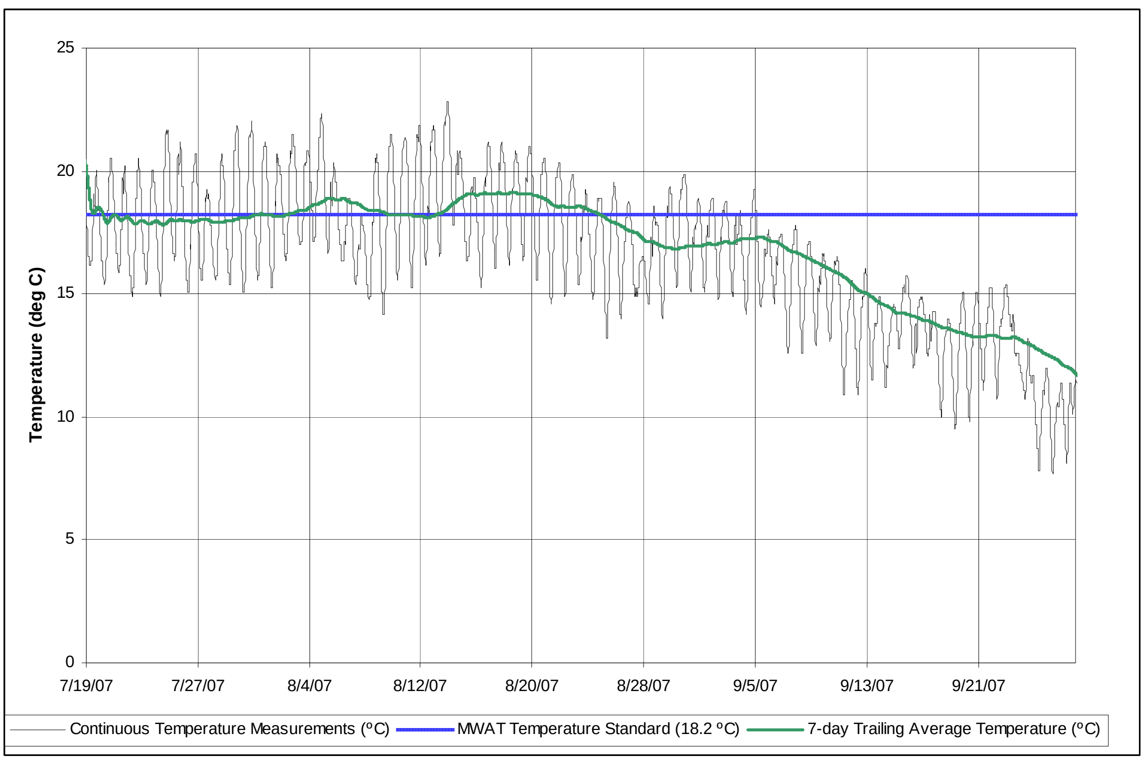
[1] Data from 1991 to 2004.
[2] Data from 1981 to 2004.
[3] Data from 1976 to 2004.
[4] Data from 1976 to 2006.
Source: Earthinfo 2006; NCWCD 2006.

The establishment of the diatom *Didymosphenia germinata* (didymo) in the Colorado River has been a concern because of the potential effect on nutrient cycling, food web dynamics, and invertebrate populations (Velarde, pers. comm. 2008). There are also potential impacts on irrigators and water diverters as didymo can plug pumps and intakes. Didymo is a nonnative single-celled organism (algae) that can create thick mats of biomass that grow on rock and plants with the potential for periodic nuisance blooms (Spaulding 2007). Its spread is not well understood, but the transfer of cells from fishing equipment, boots, and waders is thought to be one mechanism (Id.).

> Under existing conditions, the maximum weekly average temperature standard is occasionally exceeded during the summer in the Colorado River downstream of Windy Gap Reservoir and above the Williams Fork confluence.

The USGS has collected temperature samples for many years on the Colorado River, usually at intervals of once or twice per month and less frequently during the winter (Earthinfo 2006). It is not possible from these data to determine if the chronic temperature standards have been exceeded. However, in 2007 Grand County collected stream temperatures every 15 minutes during July, August, and September at six locations on the Colorado River (Clements 2007). The most upstream sample location was below Windy Gap Reservoir and the lowest location was at the KB Ditch above the confluence with Troublesome Creek (Figure 3-1). The results of this data collection indicate that the maximum weekly average temperature (MWAT) standard of 18.2ºC was exceeded in late July and August 2007 above the Williams Fork River confluence. Colorado River water temperatures at the Lone Buck site upstream of the Williams Fork in 2007 are shown in Figure 3-38. The 7-day trailing average temperature is a calculated average temperature of all continuous temperature data collected during the previous week up to a particular point in time. Figure 3-38 shows that the average weekly temperature of the Colorado River in 2007 exceeded the temperature standard during much of the period between late July and late August. The daily maximum (DM) temperature standard of 23.8ºC was exceeded at only one location (at Hot Sulphur Springs) during one day in mid-August 2007.

Figure 3-38. Colorado River temperatures at Lone Buck in 2007.



Source: Clements 2007.

Willow Creek

Water quality characteristics for Willow Creek below Willow Creek Reservoir to the confluence with the Colorado River are shown in Table 3-38. Dissolved oxygen concentrations have been below the standard on a few occasions; the lowest values occurred anomalously in mid-spring when stream temperatures were quite low. Occasional exceedances of the water quality standard for temperature, pH, ammonia, total iron, and copper have occurred; however, water quality has generally been good. No algae or chlorophyll data were available for Willow Creek at the time of this study. The Three Lakes Water and Sanitation District operates a recently upgraded WWTP (Three Lakes WWTP) with a 2 million gpd (3,094 cfs) capacity that discharges to Church Creek, a tributary to Willow Creek. Effluent from the Three Lakes WWTP is likely the primary source of ammonia in Willow Creek; however, other nutrient sources may include natural erosion, ground water, roads, recreation, agriculture, and timber harvesting above Willow Creek Reservoir.

Table 3-38. Willow Creek historical water quality values.

Parameter	Range[1]	Average
Stream temperature (°C)	0 - 27	7.2
Specific conductivity (µS/cm)	65 - 240	124
Suspended sediment (mg/L)	3.2 - 50	20.7
Dissolved oxygen (mg/L)	3.7 - 12	8.7
pH	6.3 - 8.8	7.7
Ammonia (mg/L)	0.01 - 0.44	0.1
Nitrate and nitrite (mg/L)	0.025 - 2.9	0.5
Total phosphorus (mg/L)	0.03 - 0.59	0.14
Sodium (mg/L)	3.9 - 17	8.7
Iron, total (µg/L)	62 - 1,600	775
Dissolved iron (µg/L)	3 - 160	92.5
Dissolved manganese (µg/L)	38 - 180	100
Dissolved copper (µg/L)	1 - 12	3.4

[1] Data collection ranges from 1956 to 2002.
Source: Earthinfo 2006; NCWCD 2006.

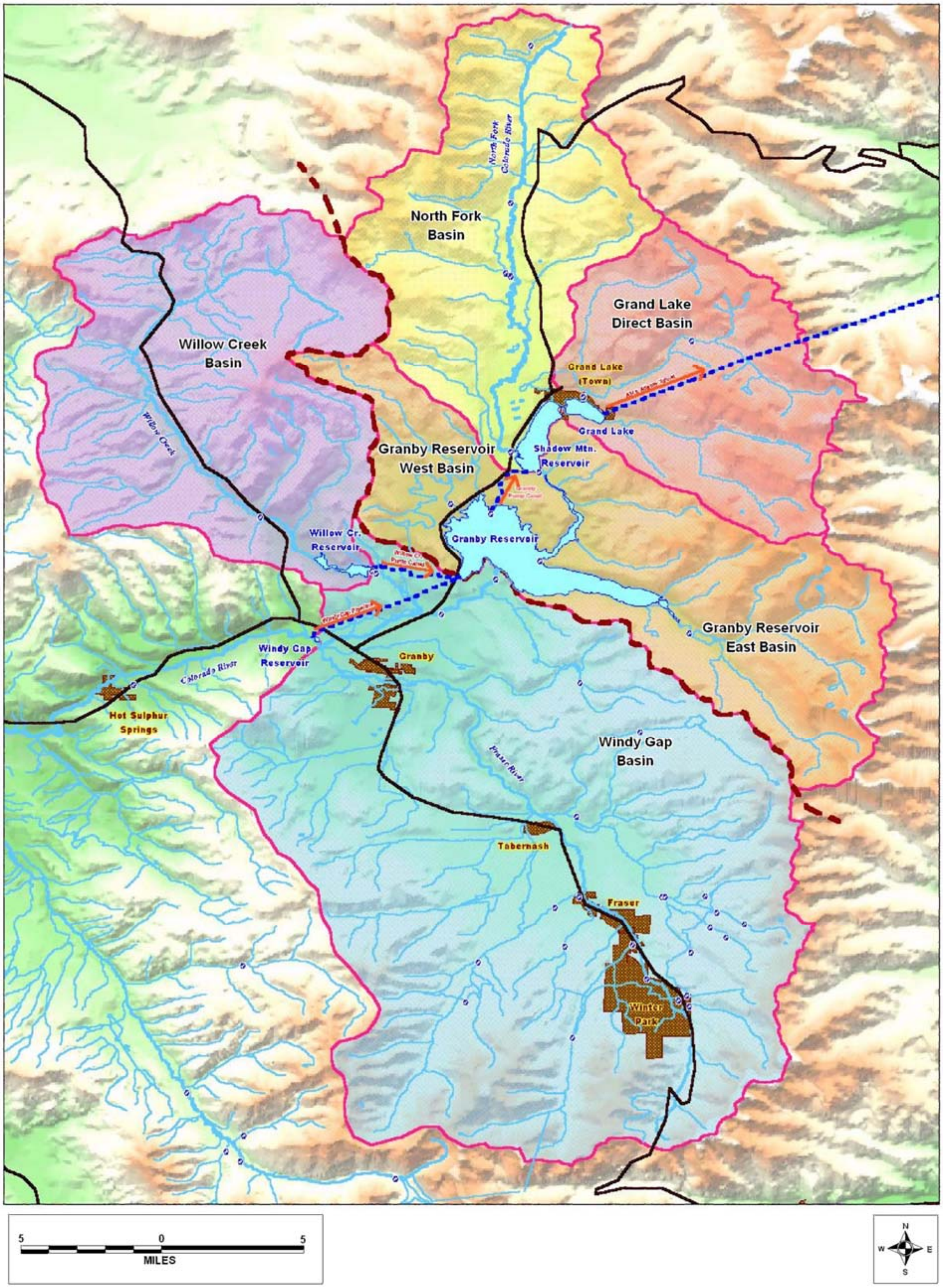
Streams at New Reservoir Sites

No water quality data are available for the unnamed tributary that flows through the proposed Jasper East Reservoir site or for Rockwell and Mueller creeks, which flow through the Rockwell Reservoir site. Water quality at the Jasper Reservoir site is influenced by livestock grazing, hay production, and irrigation return flows. Water quality in Rockwell and Mueller creeks may be influenced by roads, development, and livestock grazing.

The Three Lakes System

Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir are often referred to as the Three Lakes System (Figure 3-39). These three water bodies are operated together as part of the C-BT Project. During the runoff season, water flows from Grand Lake through Shadow Mountain Reservoir, and is stored in Granby Reservoir. When water is needed on the East Slope, water is pumped up from Granby Reservoir through Shadow Mountain Reservoir to Grand Lake, and then flows east through the Adams Tunnel. Because water can flow either direction, the entire watershed has an impact on all three water bodies. Additional input to the Three Lakes System comes via pumping from Windy Gap Reservoir on the Colorado River below the confluence with the Fraser River and from Willow Creek Reservoir via the Willow Creek Pump Canal. Thus, water input from the Fraser River (Windy Gap basin) and Willow Creek basin also influence water quality in the Three Lakes System. The existing conditions for each of the Three Lakes are discussed separately below.

Figure 3-39. Three Lakes System watersheds.



Granby Reservoir

Granby Reservoir is the second largest reservoir in Colorado and serves as the primary storage reservoir in the C-BT Project. Major tributaries include Arapaho Creek, Stillwater Creek, Columbine Creek, and the Roaring Fork River. Water is also pumped to Granby Reservoir from Willow Creek Reservoir and Windy Gap Reservoir. Outflow is to the Colorado River and to Shadow Mountain (via the Farr Pumping Plant). Granby Reservoir's physical characteristics and hydrology are described in Table 3-39.

Table 3-39. Physical characteristics of Granby Reservoir.

Metric	Value
Volume	539,758 AF
Surface Area	7,256 acres
Mean Depth	74 feet
Maximum Depth	221 feet
Shoreline	40 miles
Hydraulic Residence Time	0.9 to 1.8 years

Note: Values at maximum capacity. Residence time based on annual average content and total annual outflow.
Source: Hydrosphere 2003a; NCWCD 2007a.

Table 3-40 provides a summary comparison of water quality in Granby Reservoir for 2000 to 2007 with applicable standards. Following is a brief discussion of the existing water quality in Granby Reservoir for key parameters.

Major Ions and Trace Elements. The median concentrations of major ions (calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonate) are typical of nonpolluted watersheds. Together, they make up most of the TDS, which is closely approximated by specific conductance. Copper is of concern for aquatic life; however, insufficient data are available to evaluate whether the standard is being met. Available data indicate an exceedance of the acute standard on one day. Dissolved iron and dissolved manganese concentrations, which can be a problem for water providers at elevated concentrations, show higher values in the hypolimnion (lower layer) versus the epilimnion (upper layer). This is common in lakes and reservoirs that experience low DO concentrations in the hypolimnion.

Algae and Trophic State. Since 2000, the average chlorophyll *a* concentration was about 5.5 to 6.0 µg/L, with a maximum of 15.5 µg/L. There is no clear seasonal pattern for chlorophyll *a*, although most often the highest concentrations occur in the early part of the year (January to May). Chlorophyll *a* concentrations are indicative of a mesotrophic lake (intermediate amount of plant and animal life).

Recent monitoring in Granby Reservoir includes microcystin toxicity testing along with cell counts of dominant cyanobacteria (blue-green algae) (GCWIN 2007). Microcystin is a hepatotoxin that targets the liver and can be produced by some cyanobacteria. The presence or excessive abundance of toxin-producing algae does not translate into the presence of toxins in the water column. In 2007, a water advisory was posted for Grand Lake for two weeks by the Grand County Public Health Nursing Service. This was based on a microcystin measurement of 1.48 µg/l on August 6, 2007 analyzed using the ELISA method. Two follow-up tests using another method (HPLC) on the August 6 samples indicated values of 0.85 and 0.87 µg/l. All microcystin results received through 2009 for Granby Reservoir have been below the detection limit (Clements 2007; Tollett, pers. comm. 2010). Microcystin toxin levels of more than 1 µg/L in drinking water have been identified as a concern because of the associated health risk and potential for liver damage (WHO 1998). There are currently no drinking water standards for microcystin toxins. The highest microcystin test value for 2004, 2005, 2006, 2008, and 2009 was 0.334 µg/l. The relationships between the abundance of toxin-producing algae and levels of microcystin are unclear and are the subject of research efforts. Current research indicates that microcystin production is not only controlled by environmental factors (such as light, nutrients, and grazing pressure) but also by genetic composition (Zurawell et al. 2005). There are toxic and non-toxic strains of microcystin producing cyanobacteria. Although cell counts are sometimes used to assess the magnitude of a bloom or when to start testing for toxins, they are not an accurate measure of bloom toxicity. Thus, a water body could have optimum environmental conditions for microcystin production (which are not well understood) and a high microcystin-producing cyanobacteria cell count, and no microcystin production.

Table 3-40. Comparison of key water quality standards for Granby Reservoir under existing conditions.

Use Classification	Parameter Category	Parameter	Unit	Applicable Standard[1]	In-Lake Value	Standard Met?
Aquatic Life	Physical	Dissolved oxygen (elsp)	mg/L	6.0	6.9	Yes
		pH (epilimnion)	SU	6.5 - 9.0	7.1 - 8.2	Yes
		pH (hypolimnion)	SU	6.5 - 9.0	6.6 - 7.8	Yes
		Temperature standard	°C	9 (ch winter)	1.7 - 2.1	Yes
				13 (ac winter)	2.1 - 2.8	Yes
				19.42(ch summer)	16.5 - 19.3	Yes
				23.8 (ac summer)	16.9 - 19.9	Yes
	Inorganic	Ammonia	mg/L as N	ch (varies)	varies	Yes
				ac (varies)	varies	Yes
	Metals	Cadmium, dis	µg/L	ac (varies)	not enough data	—
				ac (varies)	varies	Yes
		Copper	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Iron, Trec	µg/L	1,000 (ch)	no data	—
		Lead, dis	µg/L	ac (varies)	not enough data	—
				ac (varies)	varies	Yes
		Manganese, dis	µg/L	ch (varies)	varies	Yes
				ac (varies)	varies	Yes
		Silver, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
Water Supply	Physical	Dissolved oxygen	mg/L	3.0	5.6 (42)	Yes
		pH	SU	6.5 - 9.0	7.1 - 8.2	Yes
	Inorganic	Nitrate	mg/L	10 (1-day)	max = 0.3 (80)	Yes
	Metals	Cadmium, dis	µg/L	5.0 (1-day)	not enough data	—
		Iron, dis	µg/L	300 (30-day)	0 - 80	Yes
		Lead, Trec	µg/L	50 (1-day)	no data	—
		Manganese, dis	µg/L	50 (30-day)	0 - 160	No
		Silver, Trec	µg/L	100 (1-day)	no data	—
Recreation	Physical	Dissolved oxygen	mg/L	3.0	5.6 (42)	Yes
		pH	SU	6.5 - 9.0	7.1 - 8.2	Yes
Agriculture	Physical	Dissolved oxygen	mg/L	3.0	5.6 (42)	Yes
	Inorganic	Nitrate	mg/L as N	100	max = 0.3 (80)	Yes
	Metals	Cadmium, Trec	µg/L	10 (30-day)	no data	—
		Lead, Trec	µg/L	100 (30-day)	no data	—
		Manganese, Trec	µg/L	200 (30-day)	no data	—

[1] Source: CDPHE 2011a.
- ac= acute, ch-chronic, dis=dissolved, Trec=total recoverable.
- Water quality data for the 5 years beginning with September 2002 was evaluated against standards applicable to the reservoir according to Colorado water quality regulations.
- Values in parenthesis in "In-Lake Value" column are numbers of samples or daily average values evaluated for the parameter.
- D.O. "In-Lake Values" are 15th percentile of daily average epilimnion profile results (elsp = early life stage present). In addition, per the WQCD, if all measurements in the epilimnion and metalimnion on any one day were below the standard, the reservoir was found to be out of attainment.
- pH range is 15th percentile - 85th percentile value of daily average profile sample results.
- "Large Lake" temperature criteria applied. Temperature "In-Lake Values" are for epilimnion layer min - max of MWAT (ch) (lake equivalent of MWAT) and DM (ac).
- Nitrate "In-Lake Value" is the maximum of all discrete Nitrate + Nitrite results.
- Water Supply "In-Lake Value" is min - max range of 30-day averages of hypolimnion samples (insufficient data points to evaluate epilimnion layer).
- For acute computations, evaluated all data. For all other computations, evaluated only if at least 12 data points (per WQCD guidelines).
- 'no data' includes instances where there are no hardness data available to evaluate the standard.

Nutrients. Phosphorus and nitrogen concentrations are lower in the epilimnion (upper layer) and higher in the hypolimnion (lower layer). Inorganic nitrogen concentrations (ammonia, nitrate, and nitrite), which are bioavailable for phytoplankton growth are low (Wetzel 2001). Orthophosphate concentrations (the form available to algae) are also low. Ammonia and nitrate concentrations in Granby Reservoir meet water quality standards (Table 3-40).

There are no standards for phosphorus; however, for lakes or reservoirs, the EPA-recommended total phosphorus concentration to prevent or control eutrophication is 25 µg/L (EPA 1986). The mean epilimnetic total phosphorus concentration in Granby Reservoir (2004-2009) is 13.2 µg/L.

Lake analyses sometimes include an investigation to determine which nutrient is limiting the growth of algae. Increases in the limiting nutrient can cause increases in algae growth. Increases of the nonlimiting nutrient will not cause increases in algae growth because there is more available than the algae can take up. Previous bioassays have shown nitrogen limitation (EPA 1970, 1977a) or primarily nitrogen limitation (there were a few periods of phosphorus limitation and/or the need to increase both phosphorus and nitrogen) (Morris and Lewis 1988). Lieberman (2007b) concluded that the reservoir is mainly phosphorus limited with periods of co-limitation based on nutrient concentrations.

Water Clarity. The mean Secchi-disk depth value (a measure of clarity) during the period 2000-2007 is 3.9 meters and the range is 1.6 to 8.0 meters. An analysis of Secchi-disk depth values indicates a statistically significant increasing trend in clarity between May and October using data from 1989 to 2006.

Dissolved Oxygen. Typical of large deep lakes, DO concentrations are lower in the hypolimnion than the epilimnion because the hypolimnion is essentially cut off from DO additions at the lake's air-water interface. Also, there can be significant demands of DO at the bottom of a lake due to decomposition of organic matter and other reactions. Low dissolved oxygen concentrations at the bottom are of concern because of the potential for the release of orthophosphate, ammonia, iron, and manganese from the sediments under anoxic conditions. DO at the reservoir bottom in March and October of 2006 was low (<3 mg/L). There was also the development of low DO concentrations at the elevation of the metalimnion (middle layer) in summer 2006. Possible causes for this drop in DO at the metalimnion include 1) decomposition of oxidizable material in the metalimnion, 2) significant concentrations of zooplankton in the metalimnion that respire and drop the DO concentration, and 3) reservoir morphometry or the shape of the reservoir basin (Wetzel 2001). Inflowing water could be entering the reservoir at the metalimnion and supplying organic matter (Lieberman 2007a).

Temperature. Temperature in the epilimnion ranges from 1.7 to 19.3°C and does not exceed the acute or chronic standards (Table 3-40).

Quagga Mussels. In summer 2008, Granby Reservoir tested positive for quagga mussel veligers, an aquatic invasive species. Veligers are the larval stage of quagga mussels. No veligers were detected in 2009 or 2010 and no adult mussels have been found in the reservoir. Quagga mussels are a concern in many areas including water supply and delivery, power generation, recreation, and in-reservoir water quality and ecology.

Shadow Mountain Reservoir

Shadow Mountain Reservoir serves to maintain a constant water surface elevation in Grand Lake and is a conduit for flow between Granby Reservoir and Grand Lake. The North Fork of the Colorado River is the major tributary flowing into Shadow Mountain Reservoir. The reservoir also receives and discharges water to Grand Lake and Granby Reservoir depending on C-BT operations. Shadow Mountain Reservoir's physical characteristics and hydrology are described in Table 3-41. This shallow reservoir typically does not strongly stratify during the summer months due to a high level of mixing (from wind and flow).

Table 3-41. Physical characteristics of Shadow Mountain Reservoir.

Metric	Value
Volume	17,354 AF
Surface Area	1,852 acres
Mean Depth	9.4 feet
Shoreline	8 miles
Hydraulic Residence Time	2.7 to 3.3 weeks

Note: Values at maximum capacity. Residence time based on annual average content and total annual outflow.
Source: Hydrosphere 2003a; NCWCD 2007b.

Table 3-42 provides a summary comparison of water quality in Shadow Mountain for the years 2000 to 2007 with applicable standards. Following is a brief discussion of the existing water quality in Shadow Mountain Reservoir for key parameters.

Major Ions and Trace Elements. The median concentrations of major ions are typical of nonpolluted watersheds. Together, they make up most of the TDS concentration, which is closely approximated by specific conductance. Although sufficient data are not available to evaluate if copper standards are being met for Shadow Mountain Reservoir, available data indicate an exceedance of the acute standard on two days. Dissolved iron and dissolved manganese concentrations are higher in the hypolimnion than in the epilimnion. Manganese concentrations currently exceed the water supply standard. Dissolved iron concentrations meet water supply standards.

Algae and Trophic State. Since 2000, chlorophyll *a* concentrations have averaged 5.1 µg/L and peak chlorophyll *a* concentrations have reached 32.7 µg/L. There is no clear seasonal pattern for chlorophyll *a*, although most often the highest concentrations occur in September. Average summer values of chlorophyll *a* concentrations (2000 to 2007) are indicative of a mesotrophic lake, with higher summer peak concentrations. Recent monitoring in Shadow Mountain Reservoir includes microcystin toxicity testing along with cell counts of dominant cyanobacteria (blue-green algae) (GCWIN 2007).

All microcystin results received through 2009 for Shadow Mountain Reservoir have been below the detection limit, with the exception of a sample collected on August 6, 2007. Using the HPLC method, 1.15 µg/L of microcystin were detected. Using the ELISA method, results indicated less than 0.1 µg/L (Clements 2007; Tollett, pers. comm. 2010).

Aquatic Vegetation and Sediment. Excessive growth of aquatic vegetation in the reservoir has been a problem since the reservoir was filled (Sisneros 2007). Reservoir drawdowns occurred in 1990 and again in 2006 to help mitigate the problem. In addition, sediment has been accumulating where the North Fork enters the reservoir, forming a 15-acre delta. This delta interferes with recreation in that area of the reservoir. Studies have been conducted to assess the delta, identify potential restoration alternatives, and identify strategies for sediment management (e.g., HDR 2003; Barclay 2000).

Nutrients. Total phosphorus and total nitrogen concentrations are similar near the bottom of the reservoir and at the surface. Inorganic nitrogen concentrations (ammonia, nitrate, and nitrite), which are bioavailable for phytoplankton growth, are low and typical of an oligotrophic system (Wetzel 2001). Orthophosphate concentrations are also low. Ammonia and nitrate concentrations in Shadow Mountain Reservoir meet water quality standards. Previous bioassays have shown that nitrogen may be the primary limiting factor for algae growth (EPA 1970; EPA 1977a). Although a few periods of phosphorus limitation and/or the need to increase both phosphorus and nitrogen have occurred (Morris and Lewis 1988), no recent bioassays have been conducted to determine if this situation has changed.

Water Clarity. The mean Secchi-disk depth (a measure of clarity) is 2.4 meters with a range between 1 and 4 meters. Based on a statistical analysis of historical data from 1989 to 2006 the lake is clearest during the months of July and August.

Dissolved Oxygen. Although Shadow Mountain Reservoir is considered to be relatively well mixed, low DO concentrations near the bottom have occurred. Low DO concentrations can cause the potential release of orthophosphate, ammonia, iron, and manganese from the sediments. In addition, the aquatic life standard for dissolved oxygen has been exceeded and the reservoir is listed on the Colorado Water Quality Control Commission's (WQCC) 303(d) List for dissolved oxygen.

Table 3-42. Comparison of key water quality standards for Shadow Mountain Reservoir under existing conditions.

Use Classification	Parameter Category	Parameter	Unit	Applicable Standard[1]	In-Lake Value	Standard Met?
Aquatic Life	Physical	Dissolved oxygen (elsp)	mg/L	6.0	6.7 (40)	Yes
		pH (epilimnion)	SU	6.5 - 9.0	7.0 - 8.3	Yes
		pH (hypolimnion)	SU	6.5 - 9.0	6.9 - 8.2	Yes
		Temperature standard	°C	9 (ch winter)	1.7 - 2.2	Yes
				13 (ac winter)	2.1 - 2.4	Yes
				19.3 (ch summer)	14.6 - 19.3	Yes
				23.8 (ac summer)	15.5 - 19.7	Yes
	Inorganic	Ammonia	mg/L as N	ch (varies)	varies	Yes
				ac (varies)	varies	Yes
	Metals	Cadmium, dis	µg/L	ch (varies)	not enough data	—
				ac (tr) (varies)	varies	Yes
		Copper	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Iron, Trec	µg/L	1,000 (ch)	no data	—
		Lead, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Manganese, dis	µg/L	ch (varies)	varies	Yes
				ac (varies)	varies	Yes
		Silver, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
Water Supply	Physical	Dissolved oxygen	mg/L	3.0	6.7 (40)	Yes
		pH	SU	6.5 - 9.0	7.0 - 8.3	Yes
	Inorganic	Nitrate	mg/L	10 (1-day)	max = 0.1 (61)	Yes
	Metals	Cadmium, dis	µg/L	5.0 (1-day)	not enough data	—
		Iron, dis	µg/L	300 (30-day)	13 - 220	Yes
		Lead, Trec	µg/L	50 (1-day)	no data	—
		Manganese, dis	µg/L	50 (30-day)	0 - 210	No
		Silver, Trec	µg/L	100 (1-day)	no data	—
Recreation	Physical	Dissolved oxygen	mg/L	3.0	6.7 (40)	Yes
		pH	SU	6.5 - 9.0	7.0 - 8.3	Yes
Agriculture	Physical	Dissolved oxygen	mg/L	3.0	6.7 (40)	Yes
	Inorganic	Nitrate	mg/L as N	100	max = 0.1 (61)	Yes
	Metals	Cadmium, Trec	µg/L	10 (30-day)	no data	—
		Lead, Trec	µg/L	100 (30-day)	no data	—
		Manganese, Trec	µg/L	200 (30-day)	no data	—

[1] Source: CDPHE 2011a.

- ac= acute, ch-chronic, dis=dissolved, Trec=total recoverable.
- Water quality data for the 5 years beginning with September 2002 was evaluated against standards applicable to the reservoir according to Colorado water quality regulations.
- Values in parenthesis in "In-Lake Value" column are numbers of samples or daily average values evaluated for the parameter.
- D.O. "In-Lake Values" are 15th percentile of daily average epilimnion profile results (elsp = early life stage present). In addition, per the WQCD, if all measurements in the epilimnion and metalimnion on any one day were below the standard the reservoir was found to be out of attainment.
- D.O. standard evaluation was based on WQCD D.O. standard evaluation methodology prior to the June 7-8, 2010 Rulemaking Hearing, which modified the methodology of definition of the "upper portion" of a lake. Because the revised criteria are less stringent (assesses a narrower zone at the surface), the evaluation was not revised for the FEIS.
- pH range is 15th percentile - 85th percentile value of daily average profile sample results.
- "Large Lake" temperature criteria applied. Temperature "In-Lake Values" are for epilimnion layer min - max of MWAT (ch) (lake equivalent of MWAT) and DM (ac).
- Nitrate "In-Lake Value" is the maximum of all discrete Nitrate + Nitrite results.
- Water Supply "In-Lake Value" is min - max range of 30-day averages of hypolimnion samples (insufficient data points to evaluate epilimnion layer).
- For acute computations, evaluated all data. For all other computations, evaluated only if at least 12 data points (per WQCD guidelines).
- 'no data' includes instances where there are no hardness data available to evaluate the standard.

Temperature. Temperature in the epilimnion ranges from 1.7 to 19.7°C. Although the chronic summer standard criterion has been exceeded, the standard was met for the period analyzed since the MWAT was not exceeded more than once in three years.

Quagga Mussels. In September 2008, Shadow Mountain Reservoir tested positive for quagga mussel veligers, an aquatic invasive species. Veligers are the larval stage of quagga mussels. No veligers were detected in 2009 or 2010 and no adult mussels have been found in the reservoir. Quagga mussels are a concern in many areas including water supply and delivery, power generation, recreation, and in-reservoir water quality and ecology.

Grand Lake

Grand Lake is the largest natural lake in Colorado. Its major tributaries are the East Inlet and North Inlet, which emanate from Rocky Mountain National Park. As part of the C-BT Project, Grand Lake also receives flow from Shadow Mountain Reservoir. The majority of the lake's outflow is via the Adams Tunnel, although some water also flows back to Shadow Mountain Reservoir, depending on operations. The water surface elevation of the lake is maintained within a 1-vertical-foot range as part of the C-BT system operations.

Grand Lake's physical characteristics and hydrology are described in Table 3-43. The lake has a small surface area relative to its depth. The hydraulic residence time (the average amount of time water spends in the reservoir) is short due to the operation of the C-BT Project and varies according to operations. The lake strongly stratifies during the summer, forming an epilimnion, a metalimnion, and a hypolimnion.

Table 3-43. Physical characteristics of Grand Lake.

Metric	Value
Volume	68,621 AF
Surface Area	507 acres
Mean Depth	135 feet
Maximum Depth	265 feet
Hydraulic Residence Time	2 to 3 months

Note: Values at maximum capacity. Residence time based on annual average content and total annual outflow.

Table 3-44 provides a summary comparison of water quality at the Grand Lake monitoring site on the west side of the lake for the years 2000 to 2007 with applicable standards. Following is a brief discussion of the existing water quality in Grand Lake for key parameters.

Major Ions and Trace Elements. The median concentrations of major ions are typical of nonpolluted watersheds. Although no sufficient data are available to evaluate if copper standards are being met, available data indicate no exceedances. Likewise, there is insufficient data available to evaluate whether the dissolved manganese standard is being met for Grand Lake, but existing data show values in the hypolimnion above the water supply standard.

Algae and Trophic State. Since 2000, chlorophyll *a* has averaged 7.3 µg/L while peak chlorophyll *a* concentrations have risen to 16.0 µg/L. There is no clear seasonal pattern for chlorophyll *a* although most often, the highest concentrations occur in September. Average chlorophyll *a* concentrations (2000 to 2005) are indicative of a mesotrophic lake.

Recent monitoring in Grand Lake includes microcystin toxicity testing along with cell counts of dominant cyanobacteria (blue-green algae) (GCWIN 2007). All microcystin results received through 2007 for Grand Lake have been below the detection limit except for two August 2007 samples with concentrations of 0.85 µg/l and 0.87 µg/l (Clements 2007).

Sediment. One area of concern among Grand Lake users does not become evident by analyzing the concentrations of water-quality constituents. Sediment that has accumulated on the east side of Grand Lake at the channel entrance has formed a delta. It is very difficult to quantitatively describe the factors influencing the development of this delta given the existing problems with sediment in Shadow Mountain Reservoir. While it is possible that the Farr pumping contributes to the formation of the delta, there is insufficient information to determine the cause of the delta.

Table 3-44. Comparison of key water quality standards for Grand Lake under existing conditions.

Use Classification	Parameter Category	Parameter	Unit	Applicable Standard[1]	In-Lake Value	Standard Met?
Aquatic Life	Physical	Dissolved oxygen (elsp)	mg/L	6.0	6.7 (25)	Yes
		pH (epilimnion)	SU	6.5 - 9.0	6.8 - 8.4	Yes
		pH (hypolimnion)	SU	6.5 - 9.0	6.4 - 7.1	No
		Temperature standard	°C	9 (ch winter)	1.5 - 2.2	Yes
				13 (ac winter)	2 - 2.3	Yes
				18.2 (ch summer)	15.5 - 16.2	Yes
				23.8 (ac summer)	16.2 - 16.9	Yes
	Inorganic	Ammonia	mg/L as N	ch (varies)	varies	Yes
				ac (varies)	varies	Yes
	Metals	Cadmium, dis	µg/L	ac (varies)	not enough data	—
				ac (tr)(varies)	varies	Yes
		Copper	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Iron, Trec	µg/L	1,000 (ch)	no data	—
		Lead, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Manganese, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Silver, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	—
Water Supply	Physical	Dissolved oxygen	mg/L	3.0	6.7 (25)	Yes
		pH	SU	6.5 - 9.0	6.8 - 8.4	Yes
	Inorganic	Nitrate	mg/L	10 (1-day)	max = 0.2 (50)	Yes
	Metals	Cadmium, dis	µg/L	5.0 (1-day)	not enough data	—
		Iron, dis	µg/L	300 (30-day)	not enough data	—
		Lead, Trec	µg/L	50 (1-day)	no data	—
		Manganese, dis	µg/L	50 (30-day)	not enough data	—
		Silver, Trec	µg/L	100 (1-day)	no data	—
Recreation	Physical	Dissolved oxygen	mg/L	3.0	6.7 (25)	Yes
		pH	SU	6.5 - 9.0	6.8 - 8.4	Yes
Agriculture	Physical	Dissolved oxygen	mg/L	3.0	6.7 (25)	Yes
	Inorganic	Nitrate	mg/L as N	100	Max = 0.2 (50)	Yes
	Metals	Cadmium, Trec	µg/L	10 (30-day)	no data	—
		Lead, Trec	µg/L	100 (30-day)	no data	—
		Manganese, Trec	µg/L	200 (30-day)	no data	—

[1] Source: CDPHE 2011a.

- ac= acute, ch-chronic, dis=dissolved, Trec=total recoverable.
- Water quality data for the 5 years beginning with September 2002 was evaluated against standards applicable to the reservoir according to Colorado water quality regulations.
- Values in parenthesis in "In-Lake Value" column are numbers of samples or daily average values evaluated for the parameter.
- D.O. "In-Lake Values" are 15th percentile of daily average epilimnion profile results (elsp = early life stage present). In addition, per the WQCD, if all measurements in the epilimnion and metalimnion on any one day were below the standard the reservoir was found to be out of attainment.
- D.O. standard evaluation was based on WQCD D.O. standard evaluation methodology prior to the June 7-8, 2010 Rulemaking Hearing, which modified the methodology of definition of the "upper portion" of a lake. Because the revised criteria are less stringent (assesses a narrower zone at the surface), the evaluation was not revised for the FEIS.
- pH range is 15th percentile - 85th percentile value of daily average profile sample results.
- "Large Lake" temperature criteria applied. Temperature "In-Lake Values" are for epilimnion layer min - max of MWAT (ch) (lake equivalent of MWAT) and DM (ac).
- Nitrate "In-Lake Value" is the maximum of all discrete Nitrate + Nitrite results.
- Water Supply "In-Lake Value" is min - max range of 30-day averages of hypolimnion samples (insufficient data points to evaluate epilimnion layer).
- For acute computations, evaluated all data. For all other computations, evaluated only if at least 12 data points (per WQCD guidelines).
- 'no data' includes instances where there are no hardness data available to evaluate the standard.

Nutrients. Orthophosphate concentrations are low. Inorganic nitrogen concentrations (ammonia, nitrate, and nitrite) that are bioavailable for phytoplankton growth are also low. Previous bioassays have shown that nitrogen may be the primary limiting factor for algae growth (EPA 1970, 1977a). Although a few periods of phosphorous limitation and/or the need to increase both phosphorus and nitrogen occurred (Morris and Lewis 1988), no recent bioassays have been conducted to determine if this situation has changed.

Clarity. Secchi-disk depths since 2000 have ranged from 1.8 to 5.7 meters, with a mean of 3.5 meters. Water clarity in Grand Lake is a concern among stakeholders in Grand County. Northwest Colorado Council of Governments (NWCCOG), Grand County, and the Greater Grand Lake Shoreline Association recently proposed a Secchi-disk depth standard for the lake of 4 meters (WQCC 2008). In June 2008, the WQCC established a narrative clarity standard for Grand Lake effective December 31, 2008. This narrative standard is "the highest level of clarity attainable, consistent with the exercise of established water rights and the protection of aquatic life." The WQCC also established a numeric clarity standard of a 4-meter Secchi-disk depth for the months of July through September, with an effective date of January 1, 2014. Local communities and other water utilities are evaluating ways to improve water clarity. Reclamation and the NCWCD are experimenting with operation of the C-BT by altering pumping from Granby Reservoir to Grand Lake during critical periods to determine impacts on Grand Lake clarity.

Dissolved Oxygen. DO concentrations are lowest at the bottom of the lake just before fall turnover. Low dissolved oxygen concentrations at the bottom are of concern because of the potential for the release of orthophosphate, ammonia, iron, and manganese from the sediments under anoxic conditions. Water quality standards for DO are currently met in Grand Lake.

> Local government entities are proposing to improve clarity in Grand Lake. A numeric clarity standard of a 4-meter Secchi-disk depth for July to September was established by the WQCC with an effective date of January 1, 2014.

Temperature. Temperature values range from 1.5 to 16.2°C and are within current standards (Table 3-44).

pH. Values for pH range from 6.4 to 7.1 in the hypolimnion and from 6.8 to 8.4 in the epilimnion. Existing data for the monitoring station on the west side of Grand Lake indicate pH values are below the aquatic life standard of 6.4. pH is a measure of the acidity or alkalinity of water. Values below 7 are more acidic and those above 7 more basic or alkaline.

Quagga and Zebra Mussels. In summer 2008, Grand Lake tested positive for quagga and zebra mussel veligers, which are aquatic invasive species. Veligers are the larval stage of quagga and zebra mussels. No veligers were detected in 2009 or 2010 and no adult mussels have been found in the reservoir. Quagga and zebra mussels are a concern in many areas including water supply and delivery, power generation, recreation, and in-reservoir water quality and ecology.

3.8.1.4 East Slope Affected Environment

Big Thompson River

The water quality of the Big Thompson River in Rocky Mountain National Park is typical of high altitude mountain streams (Figure 3-2). Water quality characteristics for the Big Thompson River at locations below Lake Estes, upstream of the City of Loveland, and downstream near the confluence with the South Platte River are shown in Table 3-45. Iron concentrations are somewhat elevated during higher flows, indicating a natural source within the upper drainage area. Specific conductivity increases downstream near Loveland; and nitrogen, phosphorus, calcium, magnesium, sodium, chloride, and sulfate concentrations also are somewhat higher near Loveland. As the river flows through Loveland and east to its confluence with the South Platte River, the water quality continues to decline, with specific conductivity indicative of increasing salt concentrations and increased concentrations of nutrients, minerals, and metals. Potential sources of these constituents to the river include natural erosion, runoff from roads and urban development, agricultural return flows, septic systems, WWTP return flows, irrigation return flows, and ground water discharge.

In the upper Big Thompson River, pH values have infrequently been below the pH standard. Below Loveland, the acute and chronic ammonia standard has occasionally been exceeded during winter months. Effluent discharges from the Loveland WWTP and other WWTPs are a likely source of some of the elevated ammonia concentrations.

Table 3-45. Big Thompson River historical water quality.

Parameter	Below Lake Estes, Above Dille Tunnel[1]		At Loveland[1]		At the Confluence with South Platte River[2]	
	Range	Avg.	Range	Avg.	Range	Avg.
Temperature (°C)	0 - 20	8.8	0.5 - 22.5	12.4	0 - 29	12.5
Specific conductivity (µS/cm)	27 - 151	57	60 - 1,950	857	355 - 3,000	1,813
TDS (mg/L)	26 - 64	43	120 - 1,200	529	NA	NA
Dissolved oxygen (mg/L)	7.5 - 13.9	10.1	6.1 - 14.2	9.6	6.5 - 12.5	9.1
pH	7.1 - 9.1	7.8	7.5 - 8.7	8.1	7.7 - 8.4	8.0
Ammonia (mg/L)	0.001 - 1.77	0.1	<0.002 - 0.75	0.11	0.22 - 4.6	1.66
Nitrate and nitrite (mg/L)	0.015 - 0.62	0.23	<0.05 - 0.72	0.22	0.51 - 5.0	2.9
Total phosphorus (mg/L)	0.011 - 0.155	0.05	0.004 - 0.19	0.03	0.16 - 0.68	0.44
Sodium (mg/L)	1.6 - 9.27	3.5	5 - 132	37.3	17 - 220	137
Total iron (µg/L)	5 - 130	57.6	20 - 7,100	528	20 - 50	30
Dissolved manganese (µg/L)	0.75 - 10.4	3.7	9.1 - 159	35	10 - 510	144
Total selenium (µg/L)	NA	NA	1 - 21	6.2	NA	NA
Dissolved selenium (µg/L)	0.05 - 0.4	0.14	0.64 - 20	3.9	NA	NA

[1] Data from 2000 to 2006.
[2] Data from 1980 to 2001.
Source: Earthinfo 2006.

North St. Vrain Creek and St. Vrain Creek

North St. Vrain Creek and St. Vrain Creek at Lyons are high quality mountain streams that appear to be little affected by human activities within their watersheds. Water quality characteristics for North St. Vrain Creek at Longmont Dam, St. Vrain Creek at Lyons, and St. Vrain Creek at the confluence with Boulder Creek (Figure 3-2) are shown in Table 3-46.

Table 3-46. North St. Vrain and St. Vrain Creek historical water quality.

Parameter	North St. Vrain Creek at Longmont Dam[1]		St. Vrain Creek at Lyons[2]		St. Vrain Creek at the Confluence with Boulder Creek[3]	
	Range	Avg.	Range	Avg.	Range	Avg.
Temperature (°C)	0 - 17.5	7.7	0 - 22	8.9	0.4 - 24	12.3
Specific conductivity (µS/cm)	18 - 73	29	34 - 140	76	261 - 1,900	1,226
Suspended sediment (mg/L)	NA	NA	1 - 48	8.7	15 - 3,370	273
Dissolved oxygen (mg/L)	7.6 - 11.4	9.5	7.3 - 13.5	10	6.4 - 14	9.3
pH	5.4 - 8.3	7.3	6.6 - 7.6	7.1	7.5 - 8.7	8.03
Ammonia (mg/L)	NA	NA	0 - 0.12	0.037	0.05 - 2.5	0.5
Nitrate and nitrite (mg/L)	0 - 0.45	0.07	0.07 - 0.5	0.27	0.52 - 5.4	3.1
Total phosphorus (mg/L)	NA	NA	0.02 - 0.67	0.1	0.22 - 1.5	0.7
Sodium (mg/L)	1 - 4	1.9	1.7 - 5.8	3.6	15 - 160	99.7
Dissolved iron (µg/L)	30 - 270	104	20 - 200	69	3 - 160	28
Dissolved manganese (µg/L)	0 - 160	16.6	<10 - 20	10.3	10 - 460	95

[1] Data from 1971 to 1978.
[2] Data from 1980 to 2002.
[3] Data from 1980 to 2001.
Source: Earthinfo 2006.

Manganese concentrations exceeded the water supply standard in North St. Vrain Creek one time; this is likely due to discharge from bedrock units containing manganese. Phosphorus concentrations were occasionally elevated above background concentrations in St. Vrain Creek at Lyons during periods of very low flows; this may be due to discharge from Lyons' WWTP. East of Longmont, the water quality of St. Vrain Creek declines substantially, with specific conductivity values about 20 times higher and suspended sediment concentrations about 25 times higher than measured at Lyons. Nutrient concentrations also increase downstream, with ammonia concentrations occasionally above the chronic standard below Longmont. St. Vrain Creek from Lefthand Creek to I-25 has a Total Maximum Daily Load (TMDL) for ammonia to help attain ammonia standards. Potential sources of contaminants to St. Vrain Creek are natural erosion, runoff from roads and developed areas, WWTP return flows, irrigation return flows, and ground water (especially from bedrock sources, such as the Pierre shale, which outcrops at the west edge of the plains and is a source of dissolved salts and suspended sediment).

Big Dry Creek

Big Dry Creek is primarily a plains stream located in areas of urban and agricultural development (Figure 3-2). Water quality characteristics for Big Dry Creek at locations west of Highway 36, below the Broomfield WWTP, and downstream of Weld County Road 4 near Fort Lupton are shown in Table 3-47. Big Dry Creek water quality is affected by WWTP return flows, runoff from roads and urban areas, and irrigation return flows. Specific conductivity values are high, especially at low flows, and nitrogen and phosphorus concentrations are often elevated. The total ammonia standards are occasionally exceeded. Total iron concentrations exceed the standards below the Broomfield WWTP and farther downstream.

Table 3-47. Big Dry Creek historical water quality.

Parameter	West of Highway 36[1]		Below Broomfield WWTP[2]		Below Weld County Road 4[1]	
	Range	Avg.	Range	Avg.	Range	Avg.
Temperature (°C)	0 - 19.9	9	7.3 - 25.3	15	0 - 27.3	13.7
Specific conductivity (µS/cm)	214 - 3,794	1,314	407 - 1,460	1,021	367 - 1,904	1,234
TDS (mg/L)	138 - 2,197	886	346 - 885	660	368 - 1,288	823
Suspended sediment (mg/L)	1 - 170	13	8 - 300	41.2	3.2 - 560	70
Dissolved oxygen (mg/L)	6.2 - 16.5	10.0	7.5 - 11.7	9.5	7.2 - 17	10.5
pH	6.79 - 8.76	7.74	7.11 - 8.31	7.76	7.13 - 9.15	8.00
Ammonia (mg/L)	<0.01 - 1.4	0.1	0.025 - 8.2	1.05	<0.01 - 12	0.9
Nitrate and nitrite (mg/L)	<0.02 - 3	0.87	2.5 - 20.4	10.85	0.77 - 19.3	8.5
Total phosphorus (mg/L)	<0.01 - 0.22	0.05	0.38 - 3.48	1.98	0.22 - 5.3	1.5
Sodium (mg/L)	16.3 - 539.4	164	62 - 171	120	69 - 240	149
Total iron (µg/L)	5 - 1,044	337	30 - 10,072	1,090	8.85 - 8,358	1,490
Dissolved manganese (µg/L)	NA	NA	8 - 221	80	NA	NA
Dissolved manganese, (fraction unspecified) (µg/L)	2 - 1,930	300	NA	NA	2 - 168	48.6

[1] Data from 2000 to 2005.
[2] Data from 1994 to 2005.
Source: Earthinfo 2006; BDCWA 2007.

Coal Creek

Water quality characteristics for Coal Creek near Plainview and Louisville/Lafayette (Figure 3-2) are shown in Table 3-48. At the base of the foothills, Coal Creek is fairly pristine, although specific conductivity values and iron concentrations have been elevated at times. Nutrient concentrations in Coal Creek increase downstream with effluent discharges from several WWTPs, plus additional urban and agricultural nonpoint sources. There is an ammonia TMDL on Coal Creek.

Table 3-48. Coal Creek historical water quality.

Parameter	Near Plainview west of Highway 93[1]		At Louisville and Lafayette[2]	
	Range	Avg.	Range	Avg.
Temperature (°C)	0 - 24	9.1	0 - 24	12.5
Specific conductivity (µS/cm)	95 - 600	233	229 - 2,800	931
Suspended sediment (mg/L)	NA	NA	3 - 4	3.5
Dissolved oxygen (mg/L)	5.9 - 12.2	9.1	8.1 - 9.4	8.8
pH	6.9 - 8.6	7.5	7.21 - 8.07	7.71
Ammonia (mg/L)	<0.02 - 0.13	0.08	<0.04 - 0.12	0.07
Nitrate and nitrite (mg/L)	0 - 1.8	0.21	<0.06 - 1.9	0.6
Total phosphorus (mg/L)	0 - 0.04	0.02	0.016 - 0.018	0.017
Sodium (mg/L)	5.6 - 67	20.4	150	NA
Total iron (µg/L)	34 - 1,200	584	34 - 1,200	490
Dissolved manganese (µg/L)	<4 - 140	23	10 - 30	16.5

[1] Data from 1980 to 2003.
[2] Data from 1987 to 2003.
Source: Earthinfo 2006.

Cache la Poudre River

The Cache la Poudre River, with headwaters at the Continental Divide, flows through Fort Collins and Greeley to its confluence with the South Platte River near Greeley (Figure 3-2). Water quality characteristics for the Cache la Poudre River downstream of Fort Collins and near Greeley are provided in Table 3-49. Water quality decreases downstream from Fort Collins as a result of urban development, WWTP discharges, agricultural runoff, and natural sources, such as the Pierre shale. Average nutrient, specific conductivity, and mineral concentrations increase between Fort Collins and Greeley. The dissolved oxygen concentration has been below the standard near Greeley on a couple of occasions in the spring, which can affect warm water biota. The total ammonia standard also has occasionally been exceeded below Fort Collins and farther downstream.

Chimney Hollow and Dry Creek

No water quality data are available for the intermittent Chimney Hollow and Dry Creek where potential reservoirs would be located. Water quality in these small watersheds is influenced primarily by natural sources of sediment, organic matter, and inorganic compounds because development is minimal. The llama operation in the Dry Creek watershed may introduce nutrients to periodic runoff.

Table 3-49. Cache la Poudre River historical water quality.

Parameter	Below Fort Collins[1]		Near Greeley[2]	
	Range	Avg.	Range	Avg.
Temperature (°C)	0 - 25	11	1.5 - 25.5	14
Specific conductivity (µS/cm)	49 - 1,330	527	370 - 2,140	1,599
Dissolved oxygen (mg/L)	6.5 - 20	11.4	4.3 - 15.8	9.15
Ammonia (mg/L)	0.006 - 2.7	0.2	0.24 - 1.2	0.66
pH	7.4 - 9.6	8.4	7 - 8.3	7.8
Nitrate and nitrite (mg/L)	0.005 - 4.4	1.2	0.77 - 8.5	4.8
Total phosphorus (mg/L)	0.01 - 1.5	0.31	0.24 - 1.1	0.6
Sodium (mg/L)	2.6 - 62.4	24.6	15 - 150	110
Total iron (µg/L)	10 - 6,000	416	NA	NA
Dissolved iron (µg/L)	NA	NA	10 - 270	32
Dissolved manganese (µg/L)	4 - 90	24.8	20 - 540	171

[1] Data from 1980 to 2004.
[2] Data from 1980 to 2001.
Source: Earthinfo 2006.

Ralph Price Reservoir

Ralph Price Reservoir is located within the Button Rock Preserve and is the primary water supply for the City of Longmont (Figure 3-7). Ralph Price Reservoir stores water from North St. Vrain Creek, which emanates from the Wild Basin Area of Rocky Mountain National Park. Ralph Price Reservoir's physical characteristics are described in Table 3-50.

No water quality data are available to describe reservoir conditions, although some water quality data were collected downstream of Ralph Price Reservoir (below Longmont Dam) in the 1970s (USGS 2007). These data indicate relatively pristine conditions, which are expected given the nature of the upstream watershed. Ralph Price Reservoir is not impaired, nor is it a concern from a water quality standpoint.

Table 3-50. Physical characteristics of Ralph Price Reservoir.

Metric	Value
Volume	16,197 AF
Surface Area	227 acres
Mean Depth	71.3 feet
Average Annual Outflow	48,600 AF/year
Hydraulic Residence Time	1.1 years

Note: Values at maximum capacity. Residence time based on annual average content and total annual outflow.
Source: Boyle 2006c.

Carter Lake

Carter Lake is a C-BT Project reservoir that supplies water to various Front Range and eastern plains cities and agricultural areas (Figure 3-40). Water for the reservoir comes from Grand Lake and the Big Thompson River through a series of pipelines, conduits, and reservoirs. Reservoir releases are delivered through the St. Vrain Supply Canal and the Southern Water Supply Project. Carter Lake's physical characteristics and hydrology are described in Table 3-51.

Table 3-51. Physical characteristics of Carter Lake.

Metric	Value
Volume	112,230 AF
Surface Area	1,110 acres
Mean Depth	101 feet
Maximum Depth	180 feet
Hydraulic Residence Time	1 year

Note: Values at maximum capacity. Residence time based on annual average content and total annual outflow.
Source: NCWCD 2007c; Jassby and Goldman 1999.

Figure 3-40. Carter Lake.

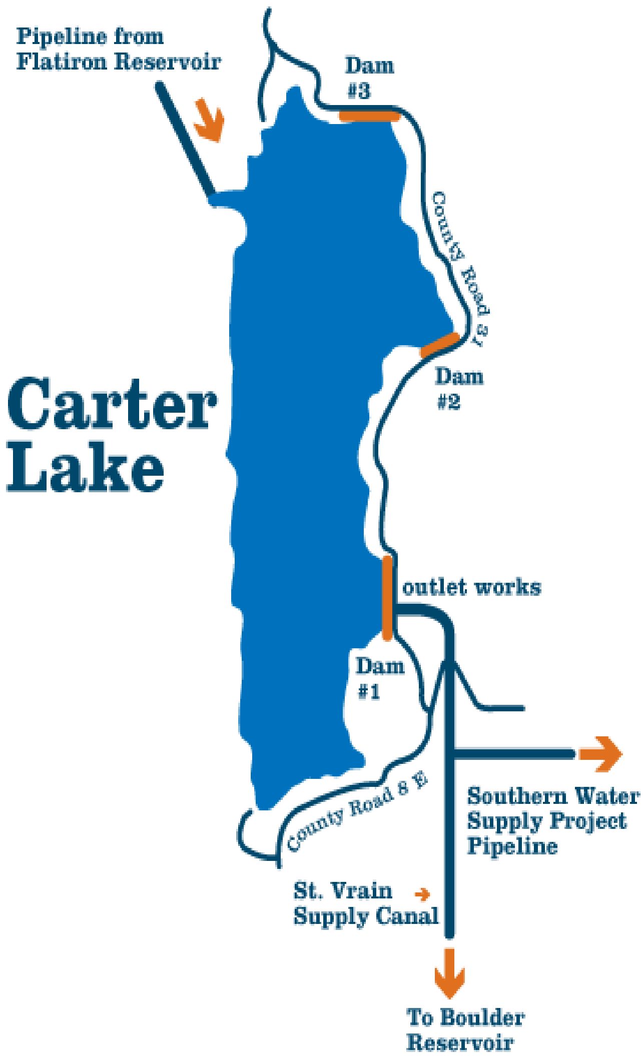


Table 3-52 provides a summary comparison of water quality in Carter Lake for 2000 to 2007 with applicable standards. Following is a brief discussion of the existing water quality in Carter Lake for key parameters.

Major Ions and Trace Metals. The median concentrations of major ions are typical of nonpolluted watersheds. Although no sufficient data are available to evaluate if copper standards are being met, available data indicate an exceedance of the standard on one day. Dissolved iron and dissolved manganese concentrations show higher values in the hypolimnion versus the epilimnion. Manganese concentrations are relatively low with the exception of a spike in September 2006, and currently meet standards.

Algae and Trophic State. Since 2000, the peak chlorophyll *a* concentration was 4.7 µg/L. Peak concentrations tend to occur in the spring and/or fall. The average chlorophyll *a* concentrations translate to a mesotrophic state.

Nutrients. Orthophosphate concentrations are low. Inorganic nitrogen concentrations (ammonia, nitrate, and nitrite) are low. Ammonia and nitrate concentrations are within water quality standards. No bioassays have been conducted to determine which nutrient is limiting the growth of algae. Estimates based on inorganic nutrient concentrations are uninformative due to the high number of results below the detection limits. Jassby and Goldman (1999) concluded that the reservoir was co-limited by nitrogen and phosphorus.

Water Clarity. Since 2000, the range in Secchi-disk depth has been from 1.6 to 5.1 meters with a mean value of 2.9 meters.

Dissolved Oxygen. DO concentrations in Carter Lake meet water quality standards. DO concentrations increase in the spring and early summer at a depth of 5 to 10 meters. This typically occurs because of large algal populations that develop more rapidly than are sinking out of this stratum (Wetzel 2001).

Temperature. Surface temperatures in the summer range from 20.8°C to 22.7°C, which meets the current temperature standard.

Table 3-52. Comparison of key water quality standards for Carter Lake under existing conditions.

Use Classification	Parameter Category	Parameter	Unit	Applicable Standard[1]	In-Lake Value	Standard Met?
Aquatic Life	Physical	Dissolved oxygen (elsp)	mg/L	6.0	7.2 (26)	Yes
		pH (epilimnion)	standard	6.5 - 9.0	7.6 - 8.5	Yes
		pH (hypolimnion)	standard	6.5 - 9.0	7.0 - 8.4	Yes
		Temperature standard	°C	9 (ch winter)	no data	—
				13 (ac winter)	no data	—
				22.7 (ch summer)	20.8 - 22.7	Yes
				23.8 (ac summer)	21.3 - 22.9	Yes
	Inorganic	Ammonia	mg/L as N	ch (varies)	varies	Yes
				ac (varies)	varies	Yes
	Metals	Cadmium, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Copper	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Iron, Trec	µg/L	1,000 (ch)	no data	—
		Lead, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Manganese, dis	µg/L	ch (varies)	varies	Yes
				ac (varies)	varies	Yes
		Silver, dis	µg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
Water Supply	Physical	Dissolved oxygen	mg/L	3.0	7.2 (26)	Yes
		pH	standard	6.5 - 9.0	7.6 - 8.5	Yes
	Inorganic	Nitrate	mg/L	10 (1-day)	max = 0.3 (53)	Yes
	Metals	Cadmium, dis	µg/L	5.0 (1-day)	not enough data	—
		Iron, dis	µg/L	300 (30-day)	0 - 40	Yes
		Lead, Trec	µg/L	50 (1-day)	no data	—
		Manganese, dissolved	µg/L	50 (30-day)	0 - 37.8	Yes
		Silver, Trec	µg/L	100 (1-day)	no data	—
Recreation	Physical	Dissolved oxygen	mg/L	3.0	7.2 (26)	Yes
		pH	standard	6.5 - 9.0	7.6 - 8.5	Yes
Agriculture	Physical	Dissolved oxygen	mg/L	3.0	7.2 (26)	Yes
	Inorganic	Nitrate	mg/L as N	100	max = 0.3 (53)	Yes
	Metals	Cadmium, Trec	µg/L	10 (30-day)	no data	—
		Lead, Trec	µg/L	100 (30-day)	no data	—
		Manganese, Trec	µg/L	200 (30-day)	no data	—

[1] Source: CDPHE 2011a.
- ac= acute, ch-chronic, dis=dissolved, Trec=total recoverable.
- Water quality data for the 5 years beginning with September 2002 was evaluated against standards applicable to the reservoir according to Colorado water quality regulations.
- Values in parenthesis in "In-Lake Value" column are numbers of samples or daily average values evaluated for the parameter.
- D.O. "In-Lake Values" are 15th percentile of daily average epilimnion profile results (elsp = early life stage present). In addition, per the WQCD, if all measurements in the epilimnion and metalimnion on any one day were below the standard the reservoir was found to be out of attainment.
- D.O. standard evaluation was based on WQCD D.O. standard evaluation methodology prior to the June 7-8, 2010 Rulemaking Hearing, which modified the methodology of definition of the "upper portion" of a lake. Because the revised criteria are less stringent (assesses a narrower zone at the surface), the evaluation was not revised for the FEIS.
- pH range is 15th percentile - 85th percentile value of daily average profile sample results.
- "Large Lake" temperature criteria applied. Temperature "In-Lake Values" are for epilimnion layer min - max of MWAT (ch) (lake equivalent of MWAT) and DM (ac).
- Nitrate "In-Lake Value" is the maximum of all discrete Nitrate + Nitrite results.
- Water Supply "In-Lake Value" is min - max range of 30-day averages of hypolimnion samples (insufficient data points to evaluate epilimnion layer).
- For acute computations, evaluated all data. For all other computations, evaluated only if at least 12 data points (per WQCD guidelines).
- 'no data' includes instances where there are no hardness data available to evaluate the standard.

Horsetooth Reservoir

Horsetooth Reservoir is a C-BT Project reservoir that supplies water to Fort Collins as well as several rural domestic suppliers, industries, and agricultural lands in the Cache la Poudre River basin (Figure 3-41). Water is supplied from Flatiron Reservoir and the Dille Tunnel via the Hansen Feeder Canal. The main outlet is through Horsetooth Dam to the Poudre River via the Hansen Supply Canal. Horsetooth Reservoir's physical characteristics and hydrology are described in Table 3-53.

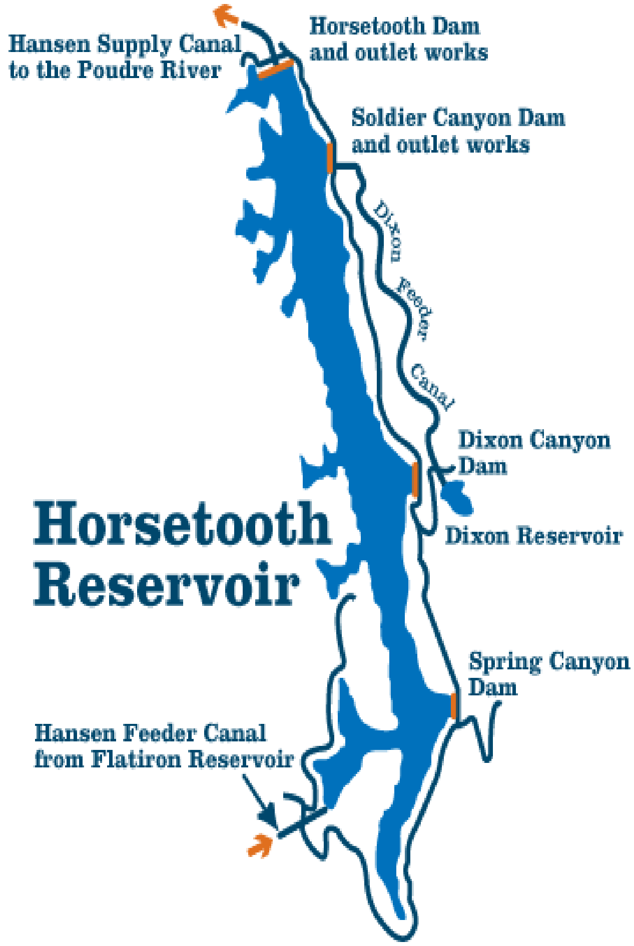
Table 3-53. Physical characteristics of Horsetooth Reservoir.

Metric	Value
Volume	156,735 AF
Surface Area	2,143 acres
Mean Depth	73.1 feet
Maximum Depth	188 feet
Hydraulic Residence Time	1 year+

Note: Values at maximum capacity. Residence time based on annual average content and total annual outflow.
Source: NCWCD 2007d; Jassby and Goldman 1999.

Table 3-54 provides a summary comparison of water quality in Horsetooth Reservoir for the years 2004 to 2007 with applicable standards. Following is a brief discussion of the existing water quality in Horsetooth Reservoir for key parameters at the Soldier Canyon Dam water quality monitoring site.

Figure 3-41. Horsetooth Reservoir.



Major Ions and Trace Elements. The median concentrations of major ions are typical of nonpolluted watersheds. Although no sufficient data are available to evaluate whether copper standards are being met, available data indicate an exceedance of the acute standard on one day. Low dissolved oxygen concentrations in the hypolimnion result in increased dissolved iron and dissolved manganese concentrations. Manganese concentrations currently exceed the water supply standard.

Algae and Trophic State. Since 2004, peak chlorophyll *a* concentrations have been as high as 6.8 µg/L. There is no clear seasonal pattern for chlorophyll *a*, although most often the highest concentrations occur during the summer months. Average chlorophyll *a* concentrations for 2004-2006 are indicative of a mesotrophic state.

Constituents of Concern for Water Treatment. Several constituents are a concern to drinking water facilities. The Fort Collins Water Treatment Facility and the Tri-District Soldier Canyon Filter Plant withdraw water directly from Horsetooth Reservoir for treatment. Elevated levels of total organic carbon, geosmin (and other taste and odor compounds), and dissolved manganese are of specific concern. High concentrations of TOC are associated with increased levels of disinfection byproducts. If WTP influent TOC concentrations exceed 2.0 mg/L, Safe Drinking Water Act regulations require the removal of TOC. Concentrations in Horsetooth Reservoir (see Tables 22 and 23 in the Lake and Reservoir Water Quality Technical Report (AMEC 2008a)) show median and mean concentrations above 3.0 mg/L. In addition, Haby and Loftis (2007) recently found a significantly statistical positive trend in TOC concentrations in the reservoir.

Table 3-54. Comparison of key water quality standards for Horsetooth Reservoir (Soldier Canyon Dam) under existing conditions.

Use Classification	Parameter Category	Parameter	Unit	Applicable Standard[1]	In-Lake Value	Standard Met?
Aquatic Life	Physical	Dissolved oxygen (elsp)	mg/L	5.0	6.9	Yes
		pH (epilimnion)	SU	6.5 - 9.0	7.0 - 8.1	Yes
		pH (hypolimnion)	SU	6.5 - 9.0	6.7 - 7.6	Yes
		Temperature standard	°C	13.2 (ch winter)	no data	—
				14.8 (ac winter)	no data	—
				26.3 (ch summer)	21.4 - 22.8	Yes
				29.5 (ac summer)	22.3 - 23.7	Yes
	Inorganic	Ammonia	mg/L a N	ch (varies)	not enough data	—
				ac (varies)	not enough data	—
	Metals	Cadmium, dis	μg/L	ch (varies)	no data	—
				ac (varies)	no data	—
		Copper, dis	μg/L	ch (varies)	no data	—
				ac (varies)	no data	—
		Iron, Trec	μg/L	1,000 (ch)	not enough data	—
		Lead, dis	μg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
		Manganese, dis	μg/L	ch (varies)	no data	—
				ac (varies)	no data	—
		Silver, dis	μg/L	ch (varies)	not enough data	—
				ac (varies)	varies	Yes
Water Supply	Physical	Dissolved oxygen	mg/L	3.0	5.5 (28)	Yes
		pH	SU	6.5 - 9.0	7.0 - 8.1	Yes
	Inorganic	Nitrate	mg/L	10 (1-day)	max = 0.3 (28)	Yes
	Metals	Cadmium, dissolved	μg/L	5.0 (1-day)	no data	—
		Iron, dissolved	μg/L	300 (30-day)	20 - 237.5	Yes
		Lead, Trec	μg/L	50 (1-day)	no data	—
		Manganese, dis	μg/L	50 (30-day)	0 - 140	No
		Silver, Trec	μg/L	100 (1-day)	no data	—
Recreation	Physical	Dissolved oxygen	mg/L	3.0	5.5 (28)	Yes
		pH	SU	6.5 - 9.0	7.0 - 8.1	Yes
Agriculture	Physical	Dissolved oxygen	mg/L	3.0	5.5 (28)	Yes
	Inorganic	Nitrate	mg/L as N	100	max = 0.3 (28)	Yes
	Metals	Cadmium, Trec	μg/L	10 (30-day)	no data	—
		Lead, Trec	μg/L	100 (30-day)	no data	—
		Manganese, Trec	μg/L	200 (30-day)	no data	—

[1] Source: CDPHE 2011b.
- ac= acute, ch-chronic, dis=dissolved, Trec=total recoverable.
- Water quality data for the 5 years beginning with January 2004 was evaluated against standards applicable to the reservoir according to Colorado water quality regulations.
- Values in parenthesis in "In-Lake Value" column are numbers of samples or daily average values evaluated for the parameter.
- D.O. "In-Lake Values" are 15th percentile of daily average epilimnion profile results (elsp = early life stage present). In addition, per the WQCD, if all measurements in the epilimnion and metalimnion on any one day were below the standard the reservoir was found to be out of attainment.
- D.O. standard evaluation was based on WQCD D.O. standard evaluation methodology prior to the June 7-8, 2010 Rulemaking Hearing, which modified the methodology of definition of the "upper portion" of a lake. Because the revised criteria are less stringent (assesses a narrower zone at the surface), the evaluation was not revised for the FEIS.
- pH range is 15th percentile - 85th percentile value of daily average profile sample results.
- "Large Lake" temperature criteria applied. Temperature "In-Lake Values" are for epilimnion layer min - max of MWAT (ch) (lake equivalent of MWAT) and DM (ac).
- Nitrate "In-Lake Value" is the maximum of all discrete Nitrate + Nitrite results.
- Water Supply "In-Lake Value" is min - max range of 30-day averages of hypolimnion samples (insufficient data points to evaluate epilimnion layer).
- For acute computations, evaluated all data. For all other computations, evaluated only if at least 12 data points (per WQCD guidelines).
- 'no data' includes instances where there are no hardness data available to evaluate the standard.

Geosmin is a taste and odor compound that can be produced by certain species of algae. Concentrations greater than 5 mg/L can be detected by some individuals. Geosmin has been a problem in Horsetooth Reservoir and is the focus of a detailed monitoring program. Concentrations peaked at 25 mg/L in October 2008. The cause of this increase is unknown (Billica 2009).

Dissolved manganese concentrations can increase, resulting in increased chemical and operating costs at a WTP. As noted above, manganese concentrations at Horsetooth Reservoir currently exceed the water supply standard.

Nutrients. More than 70 percent of the orthophosphate concentrations are below the detection limit. Inorganic nitrogen concentrations (ammonia, nitrate, and nitrite) are low and typical of an oligotrophic system (Wetzel 2001). There are not enough data to determine if ammonia concentrations are within water quality standards. Nitrate concentrations are within applicable standards. Due to the high nutrient detection limits, it is difficult to determine the limiting nutrient for algae growth. Jassby and Goldman (1999) concluded that Horsetooth Reservoir was co-limited by nitrogen and phosphorus.

Water Clarity. Since 2004, the mean Secchi-disk depth has ranged from 1.5 to 4.8 meters and has averaged 2.9 meters.

Dissolved Oxygen. Low DO concentrations occur at a depth of about 10 meters during the summer months, similar to Granby Reservoir. Possible causes for this drop in DO in the metalimnion include 1) decomposition of oxidizable material, 2) significant concentrations of zooplankton that respire and drop the DO concentration, and 3) reservoir morphometry (shape) (Wetzel 2001). It is possible that an interflow from the Hansen Feeder Canal results in an increased loading of organic material, causing a reduction in DO concentrations (Lieberman 2007b). Horsetooth Reservoir is currently on the 2010 Monitoring and Evaluation List for dissolved oxygen.

Temperature. Summer temperatures, which range from 21.4 to 23.7°C, currently meet water quality standards.

Summary of Lake and Reservoir Water Quality Concerns

Regulatory water quality concerns for existing lakes and reservoirs in the study area are summarized in Table 3-55.

3.8.2 Environmental Effects

3.8.2.1 Issues

Several water quality issues were identified during the scoping process. Concern was expressed about potential impacts to Colorado River water quality from nutrient loadings, changes in selenium and salinity concentrations, temperature, and sediment. The transport of additional water through the Three Lakes System was a concern because water from the Fraser River, a tributary to the Colorado River above the Windy Gap diversion, includes discharges from several WWTPs that may increase nutrient loading. Nutrient loadings and water quality in existing East Slope reservoirs, as well as new reservoirs, and streams were also an issue of concern.

3.8.2.2 Regulatory Requirements

The Federal Clean Water Act (33 U.S.C. 1251, et seq.) is a set of laws that govern and regulate surface and ground water quality and improve watersheds nationwide. This Act requires states to adopt water quality criteria for waters and develop a plan to implement and enforce the criteria (CDPHE 2002). The WQCC (the administrative agency) and the Water Quality Control Division (WQCD) (the implementing and enforcing agency) govern water quality in Colorado. This includes 1) assigning use classifications to state water segments, 2) establishing water quality standards for each water segment, and 3) reporting on attainment of water quality standards. The WQCC has adopted water use classifications for streams, lakes, and reservoirs that identify the uses to be protected on a stream segment or in a lake or reservoir and has adopted numerical standards for specific pollutants to protect these uses.

Table 3-55. Reservoir status on meeting water quality standards and status on the 2010 303(d) List of Impaired Waters and Monitoring and Evaluation List.

Reservoir	Segment	Water quality standards met (using data from this analysis)?	On 2010 303(d) List?[1]	On 2010 M&E List?[2]
Granby Reservoir	Upper Colorado River Segment 2 COUCUC02	No [dissolved manganese]	Yes [Aquatic Life Use- mercury and fish consumptive advisory due to mercury in fish tissue]	No
Shadow Mountain Reservoir	Upper Colorado River Segment 2 COUCUC02	No [dissolved manganese, dissolved oxygen]	Yes [dissolved oxygen]	No
Grand Lake	Upper Colorado River Segment 2 COUCUC02	No [pH, dissolved manganese]	No	No
Carter Lake	COSPBT11	Yes	Yes [Aquatic Life Use-fish consumption advisory due to mercury in fish tissue]	Yes [copper and arsenic]
Horsetooth Reservoir	COSPCP14	No [dissolved manganese]	Yes [Aquatic Life Use-fish consumption advisory due to mercury in fish tissue]	Yes [dissolved oxygen, copper and arsenic]
Ralph Price Reservoir	COSPSV02	—	No	No

[1] The term "303(d) list" is short for the list of impaired and threatened waters that the Clean Water Act requires all states to submit for EPA approval every two years. The states identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards, and establish priorities for development of total maximum daily loads (TMDLs) based on the severity of the pollution and the sensitivity of the uses to be made of the waters.
[2] Colorado's Monitoring and Evaluation List identifies water bodies where there is reason to suspect water quality problems, but there is also uncertainty regarding one or more factors, such as the representative nature of the data. Water bodies that are impaired, but it is unclear whether the cause of impairment is attributable to pollutants as opposed to pollution, are also placed on the Monitoring and Evaluation List. This M&E list is a state-only document that is not subject to EPA approval.
Source: CDPHE 2010a, Colorado's Section 303(D) List of impaired waters and monitoring and evaluation list.

The nonattainment of water quality standards is reported every 2 years via the State's 303(d) List. When segments on the 303(d) List are considered impaired for one or more water quality parameters, a TMDL effort occurs to resolve the impairment. If impairment is suspected and data are insufficient to draw a conclusion, the water segment is placed on the Monitoring and Evaluation (M&E) List. In 2010, the CDPHE added the Colorado River segment from County Road 578 Bridge below Windy Gap Reservoir to just above the confluence with the Blue River to the 303(d) list of impaired water for temperature.

The following sections discuss water quality regulations and standards for the West and East Slope rivers, lakes, and reservoirs in the study area.

West Slope

The Colorado River from the outlet of Granby Reservoir to the Roaring Fork River and Willow Creek below Willow Creek Reservoir are designated "reviewable water" by the WQCD. This means these streams must be maintained and protected at their existing quality unless it is determined that poorer water quality is necessary to accommodate important economic or social development. Regulated activities, such as construction of a new

West Slope reservoir, would require a 404 Permit from the Corps and 401 Certification from the WQCD. The WQCD would determine the need for an antidegradation review of the selected alternative.

The Colorado River and its tributaries from below Granby Reservoir to the confluence with the Roaring Fork River are classified by the Colorado Department of Public Health and Environment (CDPHE) (2011a) for the following uses:

- Aquatic Life Cold 1 (currently capable of sustaining a wide variety of cold water biota, including sensitive species).
- Recreation 1a (existing primary contact, where the ingestion of small quantities of water is likely to occur, such as swimming or kayaking).
- Water Supply (suitable or intended to become suitable for potable water supplies after receiving standard treatment).
- Agriculture (suitable or intended to become suitable for irrigation of crops and not hazardous for livestock drinking water).

Numeric standards established by the CDPHE (2011a) for the Colorado River mainstem and its tributaries in the study area are provided in Table 3-56. CDPHE has adopted aquatic life acute and chronic criteria for total ammonia (CDPHE 2011c). The stream use classifications and the numeric standards do not apply to the mainstem of Church Creek from its headwaters to the confluence with Willow Creek. Due to existing water quality degradation in Church Creek, the creek is classified as not capable of sustaining a wide variety of cold water biota, not suitable for primary contact recreation use, and not suitable for water supply (CDPHE 2011c). Church Creek is designated as Use-Protected. This means it is not subject to the antidegradation review process. There are numeric standards for Church Creek above the Willow Creek Reservoir Road, except for ammonia, chlorine, chloride, sulfate, or iron. Metal numeric standards are not hardness-based. Below the Willow Creek Reservoir Road to Willow Creek, numeric standards for Church Creek are the same as those shown in Table 3-56, except there is no standard for nitrate.

The WQCD has a Hydrologic Modification Nonpoint Source Management Program with a goal to identify and develop programs to minimize adverse nonpoint source water quality impacts associated with hydrologic modifications (CDPHE 2000). Implementation of best management practices (BMPs) to correct identified nonpoint source water quality problems is voluntary in Colorado. Section 208 of the Clean Water Act requires plans for coordinated regional approaches to water quality management. The Northwest Colorado Council of Governments (NWCCOG) is the designated regional water quality management agency responsible for water quality planning in Grand County and surrounding counties. When a federal 401/404 permit is required for a Hydrologic Modification, such as construction of a new reservoir on the West Slope, NWCCOG is authorized to review and comment on the federal permit.

East Slope

The tributaries to the South Platte River in the study area are the Big Thompson River, Big Dry Creek, Coal Creek, North St. Vrain Creek, St. Vrain Creek, and the Cache la Poudre River. These streams, with the exception of the Big Thompson River upstream of Big Barnes Ditch and North St. Vrain Creek, are classified for the following uses:

- Aquatic Life Warm 2 (currently not capable of sustaining a wide variety of warm water biota, including sensitive species, due to physical habitat, flows, or water quality conditions).
- Recreation 1a or 1b (existing or potential primary contact, where the ingestion of small quantities of water is likely to or might occur, such as swimming or kayaking).
- Agriculture (suitable or intended to become suitable for irrigation of crops and not hazardous for livestock drinking water).

- Water supply (suitable or intended to become suitable for potable water supplies after receiving standard treatment), applies only to Big Dry Creek, St. Vrain Creek above Hygiene Road (west of Longmont), and the Big Thompson River above the Greeley-Loveland Canal.

Table 3-56. Numeric standards for the Upper Colorado River and its tributaries, from below Granby Reservoir to the Roaring Fork River.

Parameter	Standard	Parameter	Standard
Physical		**Metals[1] (µg/L)**	
Dissolved oxygen (mg/L)	6.0	Arsenic	0.02
Dissolved oxygen, spawning (mg/L)	7.0	Cadmium (acute, trout/chronic)	0.9/0.25
pH	6.5-9.0		
Temperature, °C, MWAT, April-Oct/Nov-March [2]	18.2/9	Chromium III (acute/chronic)	323/42
Temperature, °C, DM, April-Oct/Nov-March [2]	23.8/13	Chromium VI (acute/chronic)	16/11
Inorganic (mg/L)		Copper (acute/chronic)	7/5
Total ammonia[3] (acute/chronic for early life stages/chronic without early life stages present)		Iron (chronic, dissolved, water supply)	300
Chlorine (acute)	7.02/2.87/3.87	Iron (chronic, total rec., aquatic)	1,000
Chlorine (chronic)	0.019	Lead (acute,/chronic)	30/1.2
Cyanide	0.011	Manganese (chronic, water supply)	50
Sulfide as H_2S	0.005	Manganese (acute/chronic, aquatic)	2,370/1,310
Boron	0.002	Mercury (chronic, total)	0.01
Nitrite	0.75	Nickel (acute/chronic)	260/90
Nitrate	0.05	Selenium[4] (acute/chronic)	18.4/4.6
Chloride	10	Silver (acute/chronic, trout)	0.62/0.02
Sulfate	250	Zinc (acute/chronic)	85/65

[1] Most metals standards are hardness dependent; values provided above assume a hardness of 50 mg/L, based on hardness data collected from the Colorado River near the Windy Gap diversion. At distances farther downstream where hardness is greater than 50 mg/L, metal standards would be higher (less stringent).
[2] The MWAT (maximum weekly average temperature) chronic standard defined by the WQCC as the largest mathematical mean of multiple evenly spaced daily temperatures over a 7-day consecutive period, with a minimum of 3 data points spaced evenly through the day. The DM (daily maximum) acute temperature standard defined by the WQCC as the highest 2-hour average water temperature.
[3] Ammonia standards are lower when stream temperature and/or pH are higher. Listed standards are for an average pH of 7.88 and temperature of 9.9°C for the Colorado River near Windy Gap.
[4] Selenium is a bioaccumulative metal, subject to a range of toxicity values depending on numerous site-specific variables.
Source: CDPHE 2011a.

North St. Vrain Creek and the Big Thompson River from the boundary of Rocky Mountain National Park to Big Barnes Ditch in Loveland are classified for the following uses:

- Aquatic Life Cold 1 (currently capable of sustaining a wide variety of cold water biota, including sensitive species).
- Recreation 1a (existing primary contact, where the ingestion of small quantities of water is likely to occur, such as swimming or kayaking).
- Agriculture (suitable or intended to become suitable for irrigation of crops and not hazardous for livestock drinking water).
- Water Supply (suitable or intended to become suitable for potable water supplies after receiving standard treatment).

The Big Thompson River from the Home Supply Canal near Loveland to its confluence with the South Platte River has different use classifications above and below the Greeley-Loveland Canal diversion. Above the

Greeley-Loveland Canal diversion, the Big Thompson River is classified as Aquatic Life Cold 2 (currently not capable of sustaining a wide variety of cold water biota, including sensitive species, due to physical habitat, flows, or water quality conditions), while below the Greeley-Loveland Canal diversion, the Big Thompson River is classified as Aquatic Life Warm 2 (currently not capable of sustaining a wide variety of warm water biota, including sensitive species, due to physical habitat, flows, or water quality conditions). Below the Greeley-Loveland Canal diversion, the Big Thompson River loses its Water Supply classification. Below Big Barnes Ditch in Loveland, the classification of Recreation 1a throughout the year changes to Recreation 2 (not suitable for primary contact uses, but suitable for secondary contact, such as wading or fishing) from mid-October through April 30.

Numeric standards for stream segments on Colorado's East Slope classified for use as Aquatic Life Warm 2, Recreation 1a or 1b, and Agriculture are provided in Table 3-57. Numeric standards for North St. Vrain Creek and the Big Thompson River to Big Barnes Ditch in Loveland are provided in Table 3-58.

Table 3-57. Numeric standards for the East Slope streams (except North St. Vrain Creek and the Big Thompson River above Home Supply Canal).

Parameter	Standard	Parameter	Standard
Physical		**Metals[1] (µg/L)**	
Dissolved oxygen (mg/L)	5.0	Arsenic	0.02
pH	6.5-9.0	Cadmium (acute/chronic)	9.1/1.2
Temperature, °C, MWAT, March-Nov/Dec-Feb [2]	24.2/12.1		
Temperature, °C, DM, March-Nov/Dec-Feb [2]	29/14.5	Chromium III (agriculture)	100
		Chromium VI (acute/chronic)	16/11
Inorganic (mg/L)		Copper (acute/chronic)	50/29
Total ammonia[3] (acute/chronic Apr 1 to Aug 31/chronic Sep 1 to Mar 31)	5.6/2.43/2.86	Iron (chronic, dissolved, water supply)	-
Chlorine (acute)	0.019	Iron (chronic, total rec., aquatic)	1,000
Chlorine (chronic)	0.011	Lead (acute, chronic)	281/10.9
Cyanide	0.005	Manganese (chronic, water supply)	-
Sulfide as H_2S	0.002	Manganese (agriculture)	200
Boron	0.75	Mercury (chronic, total)	0.01
Nitrite	4.5	Nickel (chronic, aquatic/agriculture)	168/200
Nitrate	10	Selenium[4] (acute/chronic)	18.4/4.6
Chloride	250	Silver (acute/chronic)	22/3.5
Sulfate (water supply)	250	Zinc (acute/chronic)	565/428

[1] Most metals standards are hardness dependent; values provided above assume a hardness of 400 mg/L, based on hardness data collected from affected East Slope streams.
[2] The MWAT (maximum weekly average temperature) chronic standard defined by the WQCC as the largest mathematical mean of multiple, evenly spaced daily temperatures over a 7-day consecutive period, with a minimum of 3 data points spaced evenly through the day. The DM (daily maximum) acute temperature standard defined by the WQCC as the highest 2-hour average water temperature recorded during a given 24-hour period.
[3] The aquatic life ammonia standards are pH and temperature dependent; an average pH of 8 and an average stream temperature of 12°C was used based on data collected from affected East Slope streams. Ammonia standards are lower when stream temperature and/or pH are higher.
[4] Selenium is a bioaccumulative metal, subject to a range of toxicity values depending on numerous site-specific variables.
Source: CDPHE 2011b, 2011c.

Table 3-58. Numeric standards for North St. Vrain Creek and the Big Thompson River above Big Barnes Ditch.

Parameter	Standard	Parameter	Standard
Physical		**Metals[1] (µg/L)**	
Dissolved oxygen (mg/L)	6.0	Arsenic	0.02
Dissolved oxygen, spawning (mg/L)	7.0	Cadmium (acute trout/chronic)	0.5/0/15
pH	6.5-9.0		
Temperature, MWAT, April-Oct/Nov-Mar [2]	18.2/9	Chromium III (acute/chronic)	183/24
Temperature, DM, April-Oct/Nov-Mar [2]	23.8/13	Chromium VI (acute/chronic)	16/11
Inorganic (mg/L)		Copper (acute/chronic)	3.6/2/7
Total ammonia[3] (acute/chronic for early life stages/chronic without early life stages present)	17.5/5.08/7.73	Iron (chronic, dissolved, water supply)	300
Chlorine (acute)	0.019	Iron (chronic, total rec., aquatic)	1,000
Chlorine (chronic)	0.011	Lead (acute, chronic)	14/0.5
Cyanide	0.005	Manganese (water supply)	50
Sulfide as H_2S	0.002	Manganese (agriculture)	200
Boron	0.75	Mercury (chronic, total)	0.01
Nitrite	4.5	Nickel (chronic, aquatic/water supply)	16/100
Nitrate	10	Selenium[4] (acute/chronic)	18.4/4.6
Chloride	250	Silver (acute/chronic)	0.19/0.01
Sulfate	250	Zinc (acute/chronic)	45/34

[1] Most metals standards are hardness dependent; values provided above assume a hardness of 25 mg/L, based on hardness data collected from the Big Thompson River and St. Vrain Creek.
[2] The MWAT (maximum weekly average temperature) chronic standard defined by the WQCC as the largest mathematical mean of multiple, evenly spaced daily temperatures over a 7-day consecutive period, with a minimum of 3 data points spaced evenly through the day. The DM (daily maximum) acute temperature standard defined by the WQCC as the highest 2-hour average water temperature recorded during a given 24-hour period.
[3] The aquatic life acute ammonia standard is pH and temperature dependent; an average pH of 7.3 was used and an average stream temperature of 8°C was used based on data collected from North St. Vrain Creek and the Big Thompson River. Ammonia standards are lower when stream temperature and/or pH are higher.
[4] Selenium is a bioaccumulative metal, subject to a range of toxicity values depending on numerous site-specific variables.
Source: CDPHE 2011b, 2011c.

3.8.2.3 Method for Effects Analysis

Rivers and Streams

Colorado River. The Draft EIS used the QUAL2K model to simulate potential impacts to Colorado River temperature and other water quality parameters. Since completion of the Draft EIS, additional stream temperature data for the Colorado River became available allowing use of a dynamic temperature model to better predict the effect of stream diversions for the alternative actions. Following is a discussion of the revised methods used for the temperature analysis in the Final EIS and the QUAL2K model that was used for the analysis of other water quality parameters.

Dynamic Temperature Model

The River Modeling System version 4.5 (Hauser et al. 2008), a dynamic surface water temperature model, was used to simulate the flow and river temperature in the upper Colorado River to evaluate the potential effects of WGFP alternatives and the No Action Alternative on river temperature. A review of historical river temperature data indicated that the reach below Windy Gap Reservoir to the Williams Fork confluence is the most vulnerable to a temperature increase from WGFP diversions. Below the Williams Fork, the river is cooled by inflows from

Williams Fork and other major tributaries, including Troublesome, Blue, and Muddy creeks. As noted previously in the *Affected Environment* section, this reach of the Colorado River from Windy Gap Reservoir to Williams Fork currently experiences exceedances in the state temperature standard primarily in July and August of some years. Thus, the focus of the temperature modeling effort was the 24-mile reach of the Colorado River from Windy Gap Reservoir to Williams Fork for the months June to September. Temperature model output was generated for three locations on the Colorado River: 1) Colorado River 1 mile downstream of Windy Gap Reservoir (WGD), 2) Colorado River above the town of Hot Sulphur Springs (HSU), and 3) Colorado River upstream of the confluence with Williams Fork (WFU) (Figure 3-42).

Figure 3-42. Colorado River dynamic temperature modeling sites.

Hydrologic input data to the model for calibration and validation included flows from Granby Reservoir; three major tributaries (Willow Creek, Fraser River, and Williams Fork); stream diversions including Windy Gap pumping; Hot Sulphur Springs wastewater treatment plant discharge; Hot Sulphur Springs Resort flows; and gains and losses across four subreaches. The source data for all daily hydrologic inputs to the temperature model runs were from the BESTSM and CDSS models developed for the WGFP as described in Section 3.5.2.2. The dynamic temperature model used hourly river temperature data available from the Grand Water Information Network (GCWIN) and NCWCD records for multiple locations on the Colorado River.

The dynamic temperature model requires meteorological data on an hourly basis. Hourly meteorological data for the area was only available for the years 2005 to 2010. The year 2007 was used for model calibration and for each of the model runs to evaluate the effect from the WGFP alternatives. The year 2007 represents one of the hottest July and August periods on record (Figure 3-43). Records indicate that July 2007 was the sixth hottest in the 62 years of record for that month (1949-2010) at the Grand Lake Weather Station 6SSW[2]. The 2007 average July temperature was 1.6°C warmer than the 62-year average. August 2007 was the hottest in the 63 years of record for that month (1948-2010). The 2007 average August temperature was 2.0°C warmer than the 63-year average. The Colorado River in 2007 also experienced the highest recorded number of river temperature standard exceedances (acute and chronic) and relatively low-flow rates. Thus, use of 2007 meteorological data for

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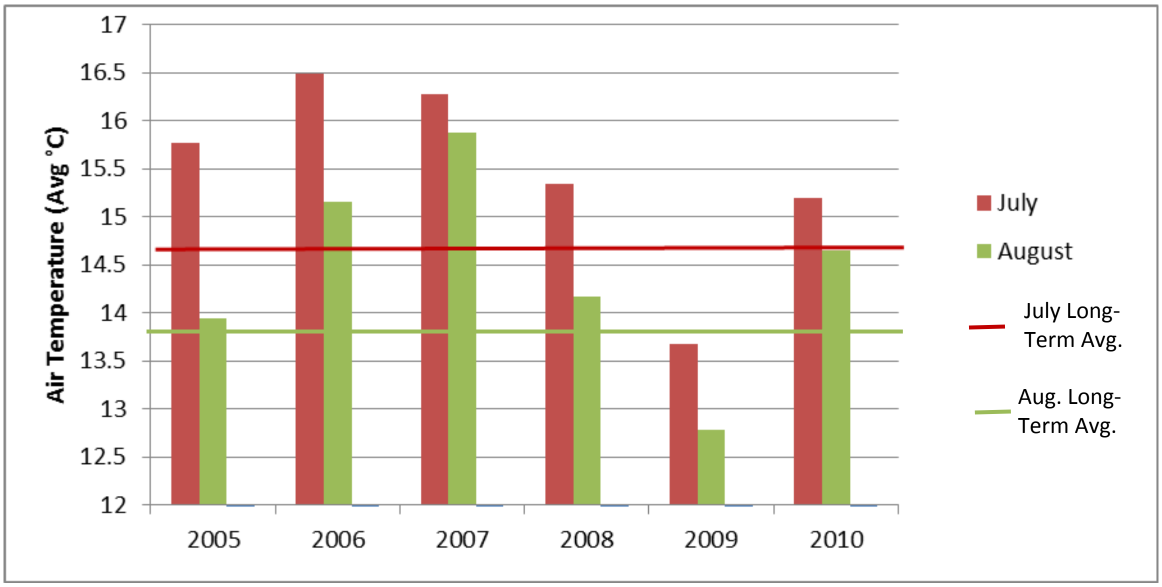
[2] The Grand Lake Weather Station 6SSW was used for this analysis because it had the most complete long-term records in the vicinity. The station is located just north of Granby Reservoir, between Shadow Mountain Reservoir and Granby Reservoir. Data from the Grand Lake Weather Station track well with data from the Kremmling airport, with an R^2 value 0.94 in a linear correlation. As such, patterns in this data set are expected to be applicable to the focus area from Windy Gap to Williams Fork.

temperature model runs show the potential for temperature exceedances with the WGFP under some of the warmest climate conditions on record. Because of the strong influence of air temperature on stream temperature, stream temperatures would be lower under average climatic conditions than those used in the temperature model runs with 2007 meteorological data. Meteorological data used in the model included hourly air temperature, dew point temperature, wind speed, cloud cover, and solar radiation data. Hourly meteorological data were obtained from the NCWCD Irrigation Management Service weather station located near Windy Gap Reservoir. Data were available for all input parameters from this station, with the exception of cloud cover, which was taken from the weather station near the Kremmling airport.

Figure 3-43. Mean monthly air temperature at Grand Lake Weather Station (6SSW).



At EPA's request, a supplemental analysis was conducted to determine if bank storage or ground water recharge processes would be affected by WGFP diversions and hence, reduce the cooling effect of these waters returning to the river following periods of high flow. The EPA was concerned that a reduction in peak flows could diminish the subsequent release of bank storage and ground water to the river at times when the WGFP is not pumping and thus reduce the contribution of this cooler water to the river. Bank storage refers to the river water that flows into the porous material along the banks of the river channel during high river stages. Bank storage is typically cooled by the soil matrix in the warmer months and subsequently released back to the river as the river stage lowers. In a similar pattern, ground water recharge to the river is driven by the pressure head of the adjacent water table. In gaining reaches, like most of the Colorado River during runoff, the stream receives ground water that is typically cooler than surface water during the summer months. A reduction in ground water recharge as a result of WGFP pumping, which would lower peak river stage, could reduce ground water flow back to the river and any cooling effect.

Separate analyses were conducted for bank storage (Hydros 2011a) and ground water recharge (Hydros 2011b) to determine whether the potential decrease in bank storage and ground water cooling effects from operation of the WGFP would have a substantial effect on river temperature. The analyses were conducted using existing information and very conservative assumptions that tend to overestimate the volume of bank and ground water storage, hydraulic conductivity of bank material, evaporative loss, and other variables. Even so, the results of the analyses indicated that the greatest reduction in the bank storage cooling effect for the Proposed Action compared to existing conditions during July and August would only be 0.076°C. The maximum lost cooling effect from reduced ground water recharge under the Proposed Action was estimated at 0.08°C. The effect of the WGFP on bank storage and ground water recharge cooling even under very conservative assumptions would have a negligible effect on river temperature. This matches the findings of the calibrated dynamic temperature model that shows the key variable factors controlling river temperatures across simulations are not long-term delayed effects, but instead river flow rate, air temperature, and solar radiation.

The dynamic temperature model was calibrated to observed data for the period from June 1, 2007 through September 30, 2007 and then validated against observed data for the period from June 1, 2008 to September 30, 2008. Both the calibration and validation model runs met the statistical targets that were set in consultation with the EPA prior to model development. The model was then used to evaluate the potential effects on Colorado River temperature for the No Action, Proposed Action, and Alternative 5 (representative of Alternatives 3 to 5), along with a comparison to existing conditions. Model runs focused on five key years of simulated daily hydrology within the 15-year model period used for other water quality analysis. In agreement with the EPA, the years selected were 1975, 1979, 1986, 1987, and 1988. These five years represent the only years in the 15-year simulated daily hydrology that were likely to result in a temperature increase due to the WGFP alternatives. Other years in the 15-year period would either experience no change in river flows from WGFP pumping or streamflow was so high during the critical summer months that exceedance of the temperature standards was unlikely. Model output allowed calculation of the estimated MWAT and the DM temperature to determine if, and how frequently, values would exceed state chronic and acute temperature standards. The Upper Colorado Dynamic Temperature Model Report provides additional information on model development (Hydros 2011c).

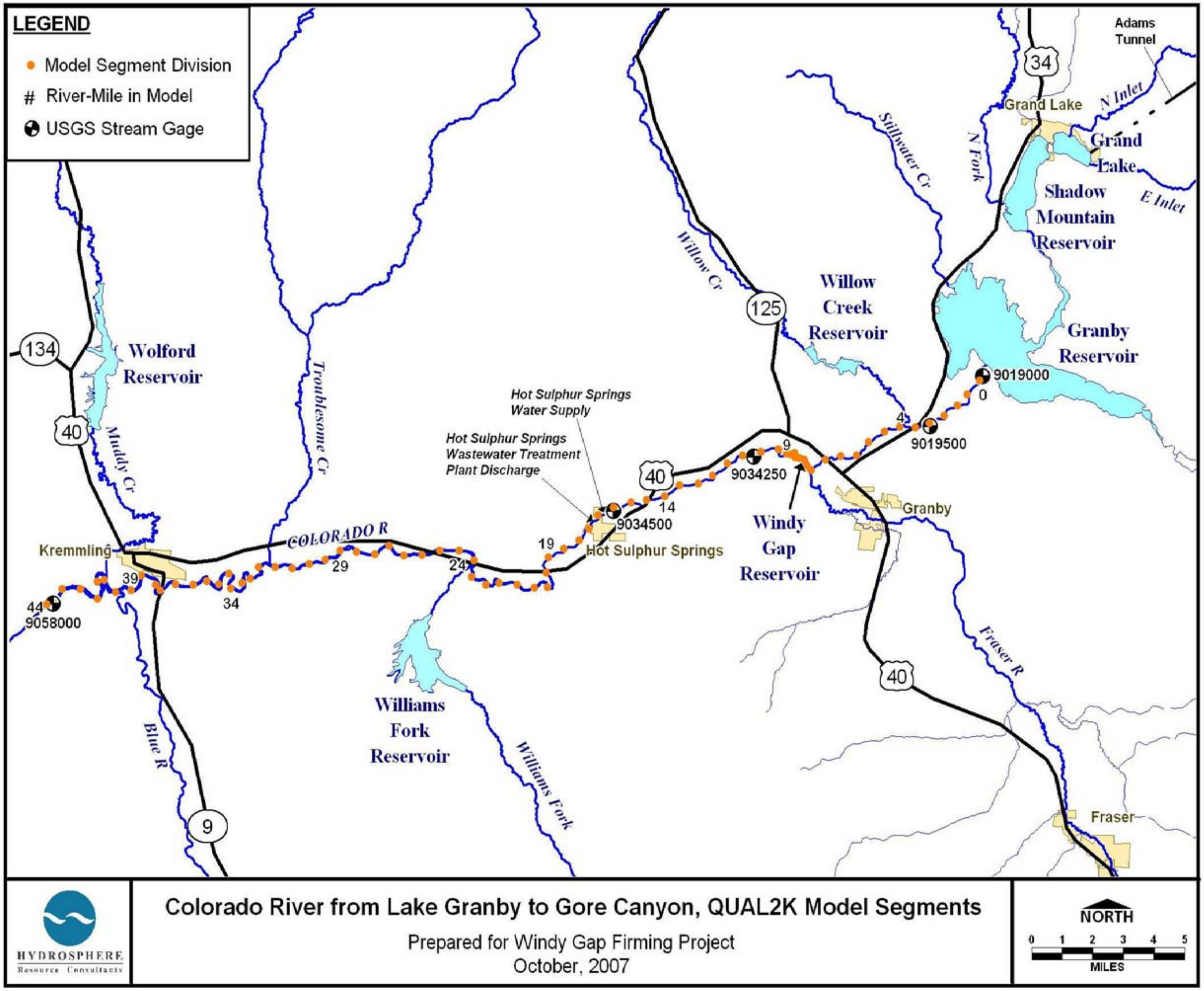
QUAL2K Steady State Model

The simulation of several chemical and physical water quality parameters in the Colorado River was performed using the QUAL2K numerical model (Chapra et al. 2006). The QUAL2K model is a one-dimensional, steady state model that simulates flow and water quality along a river reach. For the alternatives analysis, the model was used to predict instream flows, conductivity, concentrations of DO, nutrients (total ammonia and inorganic phosphorus), selenium, and pH. Output from the model provides a prediction of the flow and water quality at locations along the river as influenced by upstream water quality and quantity, water inflows and diversions, and chemical reactions that occur as water flows downstream. This modeling tool effectively simulates the water quality in the Colorado River reach below Granby Reservoir to the top of Gore Canyon. The model considers tributary inflows from Willow Creek, Fraser River, Williams Fork, Troublesome Creek, Muddy Creek, and Blue River; municipal withdrawals for drinking water and the WWTP outfall at the Town of Hot Sulphur Springs; and diversions from the river at Windy Gap Reservoir. The model extent, segment boundaries, and tributaries are shown in Figure 3-44.

The QUAL2K simulations were conducted for July 25 to offer a view of the Colorado River during conditions when flows are typically low and additional WGFP diversions would further reduce flows in some years. The model was run under two hydrologic conditions for July 25. One simulation was based on average stream discharge for July 25. The other simulation assumed that Windy Gap diversions would reduce streamflow to the minimum streamflow requirement of 90 cfs below the Windy Gap diversion. The second analysis demonstrates the potential bounds of river water quality for the lowest allowable flow conditions. Wet and dry hydrologic conditions for the alternatives were not simulated because WGFP dry year diversions would not change from existing conditions and higher flows in wet years would have less impact than the simulated conditions. Complete descriptions of modeling assumptions, model calibration, data used and sensitivity analyses are presented in the Stream Water Quality Technical Report and Modeling Report (ERO and AMEC 2008a and 2008b).

Willow Creek. Effects to water quality on Willow Creek were estimated using two methods. A USGS stream temperature model, called SSTEMP, was used to predict changes in stream temperature due to a decrease in releases to Willow Creek from Willow Creek Reservoir (Bartholow 2002). The maximum average monthly decrease in the flow of Willow Creek would occur during July of an average year under all of the alternatives. Thus, July 15 was chosen to evaluate Willow Creek water quality to determine worst case conditions for aquatic life in the stream. Wet and dry hydrologic conditions for the alternatives were not simulated because decreases in flow would be less in wet years and dry year flows would not change stream temperature from existing conditions.

Figure 3-44. QUAL2K model segments, Colorado River from Granby Reservoir to Gore Canyon.



A mass balance analysis of ammonia, copper, and iron concentrations in Willow Creek was completed for the month of July to evaluate effects to these water quality parameters. Ammonia, copper, and iron were chosen as indicators of effects to water quality because the Three Lakes WWTP effluent discharge to Church Creek could result in more frequent standard exceedances as a result of reduced flows in Willow Creek.

East Slope Streams. For East Slope streams in which flow would change under one or more of the alternatives, several methods were used to evaluate water quality changes. For the Big Thompson River below Lake Estes to the Hansen Feeder Canal, flow increases would occur during high-flow months as a result of smaller C-BT skim diversions from the river. The Three Lakes model results for water quality for the Adams Tunnel water and existing water quality data for the Big Thompson River above the Dille Tunnel were used as input for mass balance calculations to determine changes in nitrogen and phosphorus concentrations.

For North St. Vrain Creek and St. Vrain Creek at Lyons, where both flow increases and decreases under the No Action Alternative would occur, historical water quality data for different flow volumes and months were analyzed to predict relative water quality changes.

The lower Big Thompson River, Big Dry Creek, Coal Creek, and the Cache la Poudre River would receive increased Participant WWTP return flows under all of the alternatives. For these streams, ammonia, iron, copper, and manganese were chosen as examples of water quality parameters that are measured in WWTP effluent discharge that could have more frequent standard exceedances as a result of additional effluent return flows. A mass balance analysis was completed for the month with the largest increase in WWTP return flow.

Lakes and Reservoirs

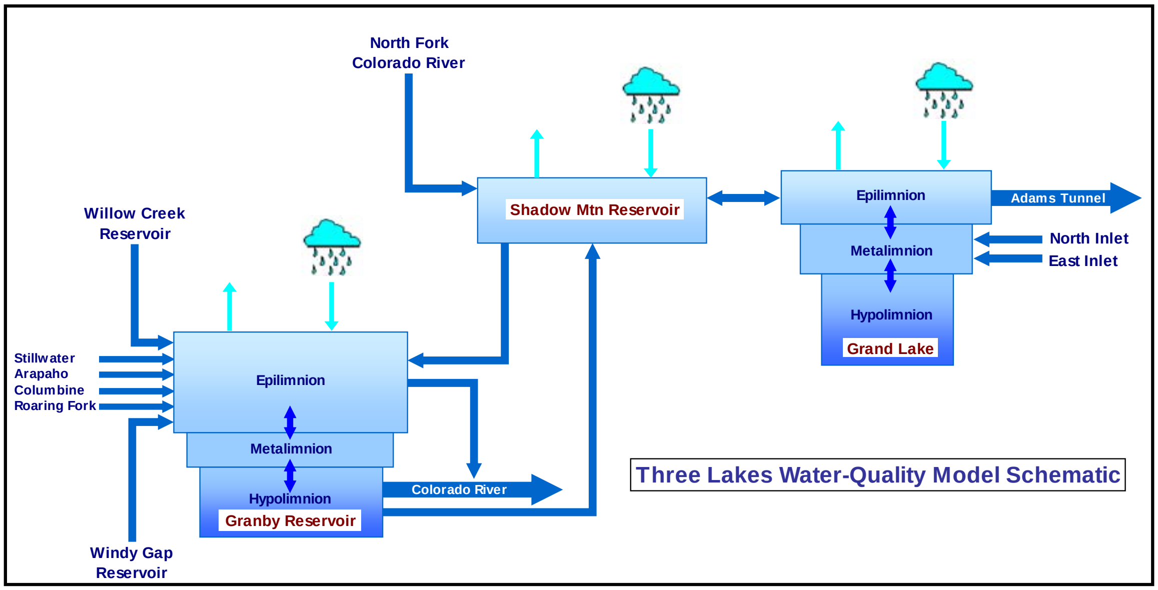
After the Draft EIS was issued, it was discovered that historic water quality data from an incorrect location on Willow Creek were used for the analysis upstream of Windy Gap Reservoir. Since loading computations were affected, the loading analysis needed to be redone. In order to best reflect current conditions, data from 2005–2010 were used. The frequency of data collection was also greater during this period. Although the loading computations were corrected (results presented later in this section), the Three Lakes Model was not rerun because the change would have minimal effect on displayed impacts or differences between alternatives.

Three Lakes. The method used for the prediction of water quality for Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir was based on the Three Lakes water quality model (Hydrosphere 2003b). This is a dynamic process-based model that simulates results over time and can be used to predict water quality based on changes in hydrologic conditions and water quality input variables.

The Three Lakes Model characterizes Grand Lake and Granby Reservoir as three-layer lakes. Therefore, both have an epilimnion, a metalimnion, and a hypolimnion during the stratified period, and the water quality is assumed to be uniform throughout each layer. The model mixes the three layers during other portions of the year. Shadow Mountain Reservoir is characterized as a single well-mixed layer in the model because it is shallow and does not strongly stratify.

The Three Lakes Model was calibrated using measured data from October 1, 2005 to September 30, 2006. The calibrated model was used to predict future water quality conditions for each alternative using anticipated flow under each alternative. The model simulates the water quality of each layer over time on a daily basis. A schematic of the Three Lakes water quality inflows and outflows by segment is illustrated in Figure 3-45. Model runs were based on daily hydrology from the 15-year period (water years 1975 to 1989), which was determined to be representative of the 47-year period used for hydrologic modeling described in Section 3.5. The model is successful at computing average chlorophyll *a* concentrations (a measure of algae) with changes in hydrology; however, peak annual chlorophyll *a* concentrations may be underestimated if unanticipated nutrient loads occur. The Three Lakes Water Quality Model Documentation Report provides additional detail on model calibration and assumptions (AMEC 2008b).

Figure 3-45. Three Lakes water quality model schematic.



Model results for each alternative were compared to predictions made for existing conditions. Alternative comparisons were made for total phosphorus (TP) and nitrogen, chlorophyll *a*, Secchi-disk depth (SD), trophic state, minimum DO, and total suspended solids (TSS). The trophic state index is computed using the Carlson Trophic State Index (TSI) (Table 3-59). The reported TSI is based on the average value from May 1 to November 15 for the Three Lakes and on the average annual value for the reservoirs modeled with a Corps' Water Quality Model called BATHTUB (East Slope reservoirs and potential new reservoirs). Trophic state indices were also computed on a monthly basis for the reservoirs modeled using the Three Lakes Water Quality Model. Trophic state indices are based on an average chlorophyll *a* value rather than peak values because there can be significant variations within the averaging period.

Table 3-59. Common chlorophyll *a*, Secchi-disk, and total phosphorus values by trophic state.

Condition	Chlorophyll *a* (µg/L)	Surrogate Metrics	
		SD (m)	TP (µg/L)
Oligotrophic	<0.95	>8	<6
Oligotrophic-Mesotrophic	0.95-2.6	8-4	6-12
Mesotrophic	2.6-7.3	4-2	12-24
Eutrophic	7.3-20	2-1	24-48
Eutrophic-Hypereutrophic	20-56	0.5-1	48-96
Hypereutrophic	56-155	0.25-0.5	96-192
Extremely Hypereutrophic	>155	<0.25	192-384

Note: Values based on average summer values (June 15 to September 1).
Phosphorus-Limited North American Temperate Lakes www.nalms.org, reproduced with permission from NALMS.

The LAKE2K model (Chapra and Martin 2004) was used to simulate temperature in Granby Reservoir for each alternative. Model results showed that there were no discernable changes in the temperature of Granby Reservoir between existing conditions and any of the alternatives.

Carter Lake, Horsetooth Reservoir, Ralph Price Reservoir, and Potential New Reservoirs. Carter Lake, Horsetooth Reservoir, Ralph Price Reservoir, and the four potential new reservoirs were evaluated using the

Corps' BATHTUB model. This steady-state model contains several empirical relationships to translate nutrient loading into in-reservoir conditions. Results from the Three Lakes Water Quality Model were used to develop input files for the BATHTUB model runs. The alternatives were evaluated by comparing annual predicted in-reservoir changes from existing conditions using BATHTUB model output for nutrients, chlorophyll *a*, Secchi-disk depth, hypolimnetic oxygen demand (HOD), metalimnetic oxygen demand (MOD), and trophic state.

As with all models, BATHTUB has some limitations. Since BATHTUB assumes steady state conditions, the focus is on average conditions in the epilimnion; thus short-term responses cannot be explicitly evaluated. In addition, responses to variables other than nutrients and flow cannot be predicted. The empirical relationships used in the model were developed based on data from 299 Corps' reservoirs. As with all empirical models, use of the model for a particular site assumes the reservoir being analyzed behaves similarly to the aggregated behavior of the reservoirs in the BATHTUB database.

The BATHTUB model does not provide a direct prediction of DO concentration. However, the relative magnitudes of HOD and MOD predictions were used to compare existing conditions and the alternatives to provide insight on the relative potential impact on the DO concentration in the metalimnion or hypolimnion. Larger HOD or MOD values, as compared to existing conditions, indicate a potential for lower DO in the reservoir. Quantification of the likelihood of the DO concentration to be below the current water quality standards for an alternative is not possible based on the BATHTUB model predictions. Potential changes in manganese concentrations were based on relative HOD. Low DO concentrations in the hypolimnion can result in the conversion of manganese in the reservoir sediments to a soluble form.

The BATHTUB model does not simulate water temperature; therefore, it was assumed that if there was no change in temperature at Granby Reservoir then temperature in East Slope reservoirs would not change.

3.8.2.4 West Slope Effects

Colorado River

The magnitude of influence of tributary inflows on Colorado River water quality varies as a result of the volume of water and tributary concentration compared to the in-river concentration. The largest changes in water quality at tributary inflow points occur where large inflows with different water quality from the Colorado River enter, providing a strong dilution or concentrating effect on the river. The decrease in Colorado River flow under all alternatives enhances the influence of tributary inflows.

> WGFP diversions would increase temperatures in the Colorado River in some years and the frequency of exceedances of the chronic and acute temperature standards. Other parameters including specific conductivity, ammonia, and inorganic phosphorus would increase slightly. Dissolved oxygen concentrations would remain similar to existing conditions.

Model output indicates the following general influences on Colorado River water quality and the various tributary contributions to those changes. The Fraser River increases water temperatures, whereas the Williams Fork, Blue River, and Muddy Creek decrease temperatures. Specific conductivity is increased most by Willow Creek, the Williams Fork, Blue River, and Muddy Creek. Troublesome Creek offers a dilution effect on specific conductivity. DO concentrations are not influenced greatly by tributary inflows. The Fraser River and Hot Sulphur Springs WWTP provide sources of ammonia and inorganic phosphorus that increase in-river concentrations. The low flow of the natural hot springs near the Town of Hot Sulphur Springs has a very small influence on the water quality of the Colorado River (even if the hot spring flow were nearly 3,000 gpm, which is greater than typical 140 gpm discharges, the discharge would only be 2 percent of the typical July flow of the river and would increase the river temperature immediately below the hot springs by only 1ºC). Downstream of the Hot Sulphur Springs WWTP, when Colorado River concentrations of ammonia and inorganic phosphorus are highest, the Williams Fork offers a dilution effect. To lesser degrees, the Blue River and Muddy Creek increase ammonia concentrations in the Colorado River and Willow Creek is a source of inorganic phosphorus. Muddy Creek provides elevated dissolved selenium concentrations, raising the concentration in the Colorado River slightly.

The following sections provide the results of the dynamic temperature model analyses for the Colorado River and the QUAL2K model analyses that were conducted for other chemical and physical constituents.

Dynamic Temperature Model. As previously described in the *Method for Effects Analysis* (Section 3.8.2.3), the temperature model was run for 5 years when the WGFP would divert flows during the summer months and temperature impacts could be expected. Results were compiled for three locations on the reach of the Colorado River between Windy Gap Reservoir and the confluence with the Williams Fork, where temperature changes are of greatest concern–downstream of Windy Gap Reservoir (WGD), at Hot Sulphur Springs (HSU), and upstream of the Williams Fork (WFU) (Figure 3-42). All model runs for each of the 5 years were run using 2007 meteorological data, which as previously stated, included the sixth hottest July on record and the hottest August in the 62-year record. Thus, results indicate the upper range of likely impacts to stream temperature from the alternative actions. Detailed information on model results is presented for the hydrologic model year 1975, which is representative of a year with average flows and the largest WGFP diversions in July and August of the 5 years modeled and thus, potentially some of the greatest impact on stream temperature. Also included in this section is a summary of the predicted exceedances of the chronic and acute temperature standards, which are used to evaluate effects on fisheries and aquatic life, for all 5 years under existing conditions, No Action, and WGFP alternatives. Alternative 5 was used to represent the result of Alternatives 3 to 5, since diversion amounts would be similar among these alternatives. The Upper Colorado Dynamic Temperature Model Report (Hydros 2011c) provides model output for all of the model scenarios.

Temperature Model Results using 1975 Hydrology

Windy Gap pumping in a hydrologic year like 1975 would occur in June, July, and August for the No Action Alternative, Proposed Action, and Alternative 5 (representative of Alternatives 3 through 5) (Table 3-60). Under existing conditions, the Windy Gap Project would pump similar volumes of water in June and August, but would not pump water in July. As noted in Figure 3-46, Colorado River flows below Windy Gap Reservoir would differ from existing conditions only during the month of July and streamflow would be reduced to just over 100 cfs.

Table 3-60. Windy Gap pumping volumes using 1975 hydrology.

Alternative	1975- Monthly Pumping Totals (AF/month)			
	June	July	August	September
Existing Conditions	18,700	0	2,693	0
No Action	18,700	7,271	2,693	0
Alternative 2	18,700	18,032	2,670	0
Alternative 5	18,700	18,032	2,670	0

Temperature model results on the Colorado River upstream of the Williams Fork show the hourly fluctuations in temperature for July 1975 under existing conditions, no action, and action alternatives (Figure 3-47). The Proposed Action and Alternative 5 have similar results because they divert about the same volume of water. Both of these alternatives show an increase in daytime temperatures above existing conditions and the No Action Alternative. The reduction in streamflow from Windy Gap diversions causes a greater relative increase in the upper range of daytime temperatures, with only a small change in nighttime temperatures. This reflects the strong influence of water depth on heating by solar radiation during the day. In contrast, the small changes to water depth do not have as much of an effect on temperatures at night, when river temperatures are more a function of the heat capacity of the streambed and air temperature.

The weekly average temperature (WAT) and DM temperatures were calculated using the three focus locations on the Colorado River to determine the potential for exceedance of water temperature standards. The chronic temperature standard of 18.2°C is based on the MWAT. A MWAT is calculated for each day based on the average from that day and the previous six days. Exceedance of the MWAT standard is presented in terms of weeks, however, a one-week MWAT exceedance is indicated if even only one day in a given week has a seven day rolling average WAT greater than 18.2°C. The DM temperature standard is 23.8°C and is based on the highest two-hour average water temperature recorded during a given 24-hour period.

Figure 3-46. Colorado River flow below Windy Gap Reservoir (WGD) using 1975 hydrology.

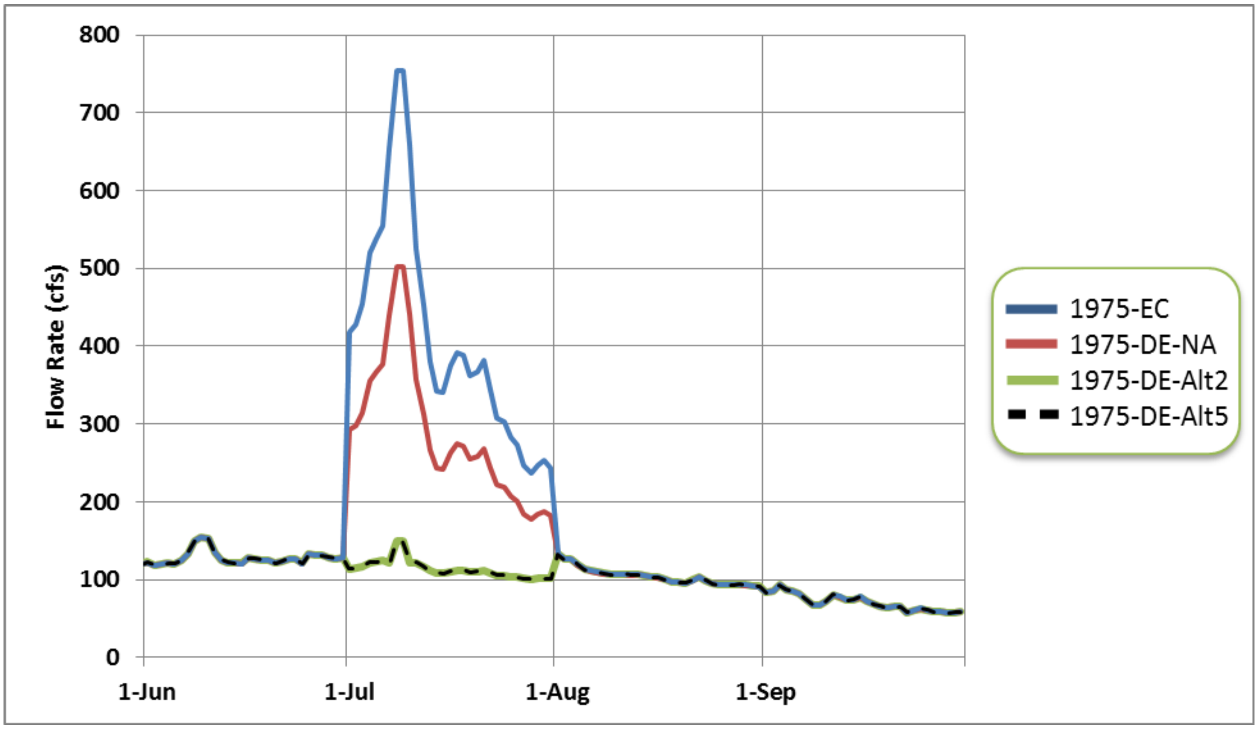
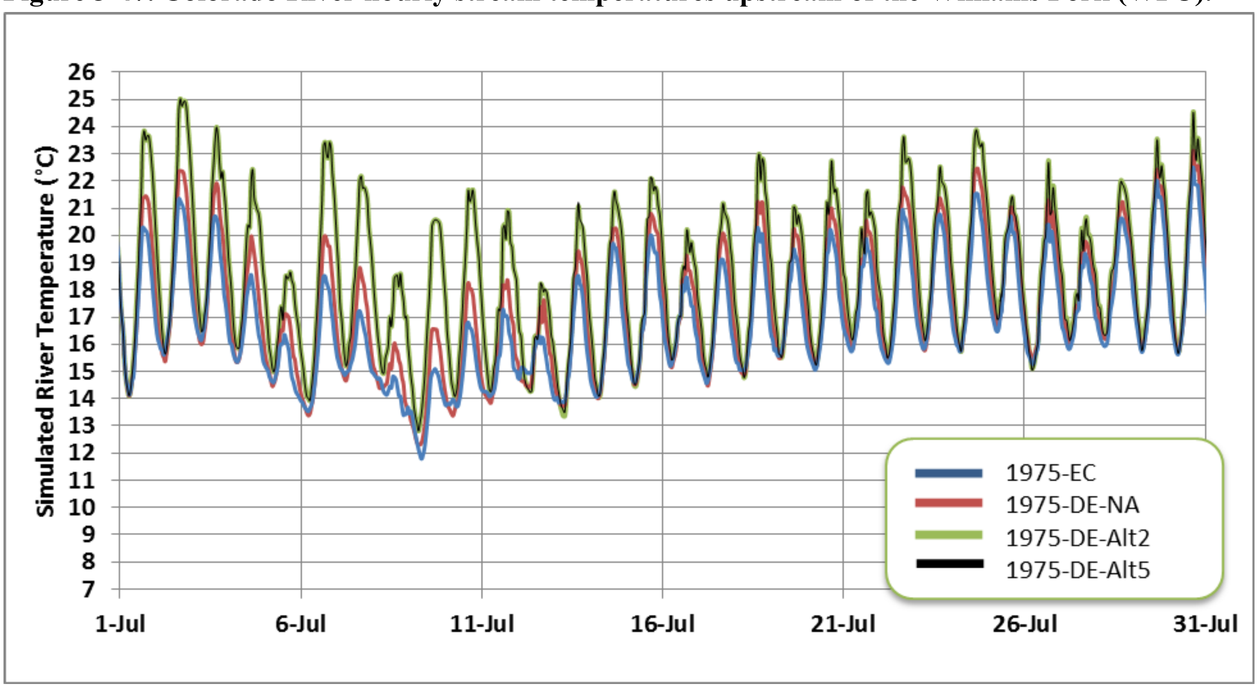


Figure 3-47. Colorado River hourly stream temperatures upstream of the Williams Fork (WFU).



Simulated Colorado River WATs for the alternatives are plotted for the June to September, 1975 period below Windy Gap Reservoir (Figure 3-48), at Hot Sulphur Springs (Figure 3-49), and above the Williams Fork (Figure 3-50). Model results indicate that only the Proposed Action would result in an exceedance of the MWAT at the WGD location in July (Table 3-61). Farther downstream at HSU and WFU, the No Action Alternative would exceed the MWAT for one week in July and the Proposed Action and Alternative 5 would exceed the MWAT for 3 weeks. In August, existing conditions and all of the alternatives would exceed the MWAT for 3 to 4 weeks at all locations and there would be no difference between existing conditions and any of the alternatives. The highest MWAT for the entire study period, relative to existing conditions was 0.1°C higher at WGD for the No Action and Proposed Action/Alternative 5 and was unchanged at HSU and WFU (Table 3-3).

Figure 3-48. WAT at Colorado River downstream of Windy Gap Reservoir (WGD), June to September 1975.

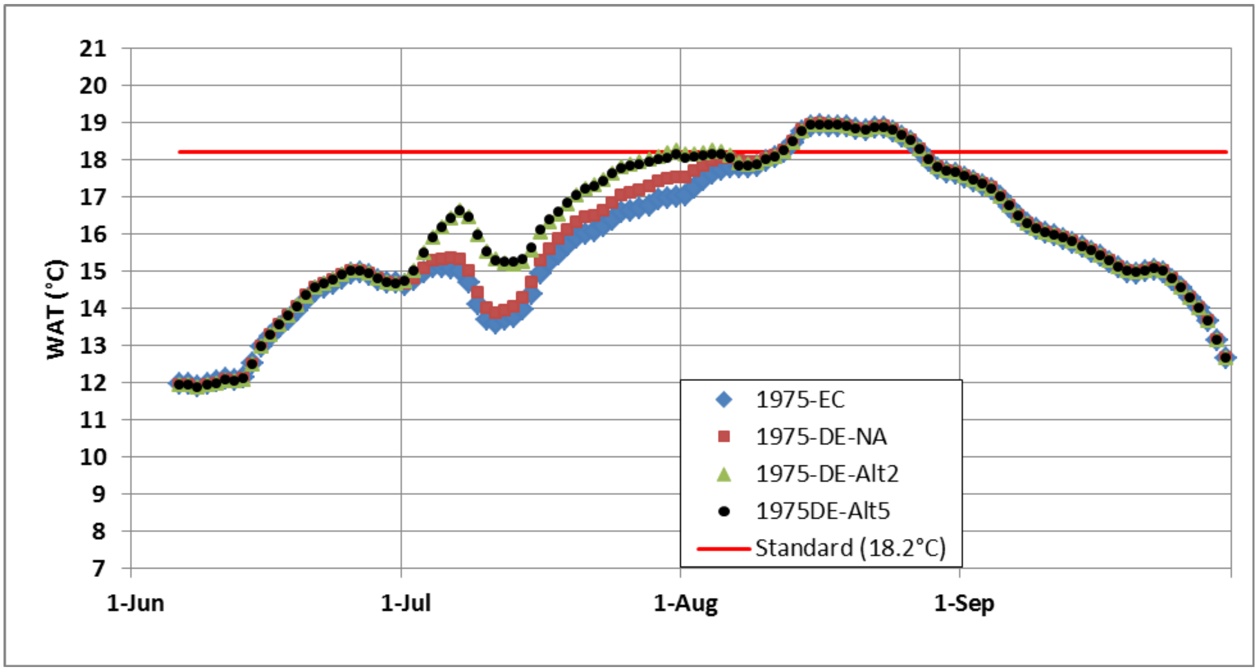


Figure 3-49. WAT at Colorado River at Hot Sulphur Springs (HSU), June to September 1975.

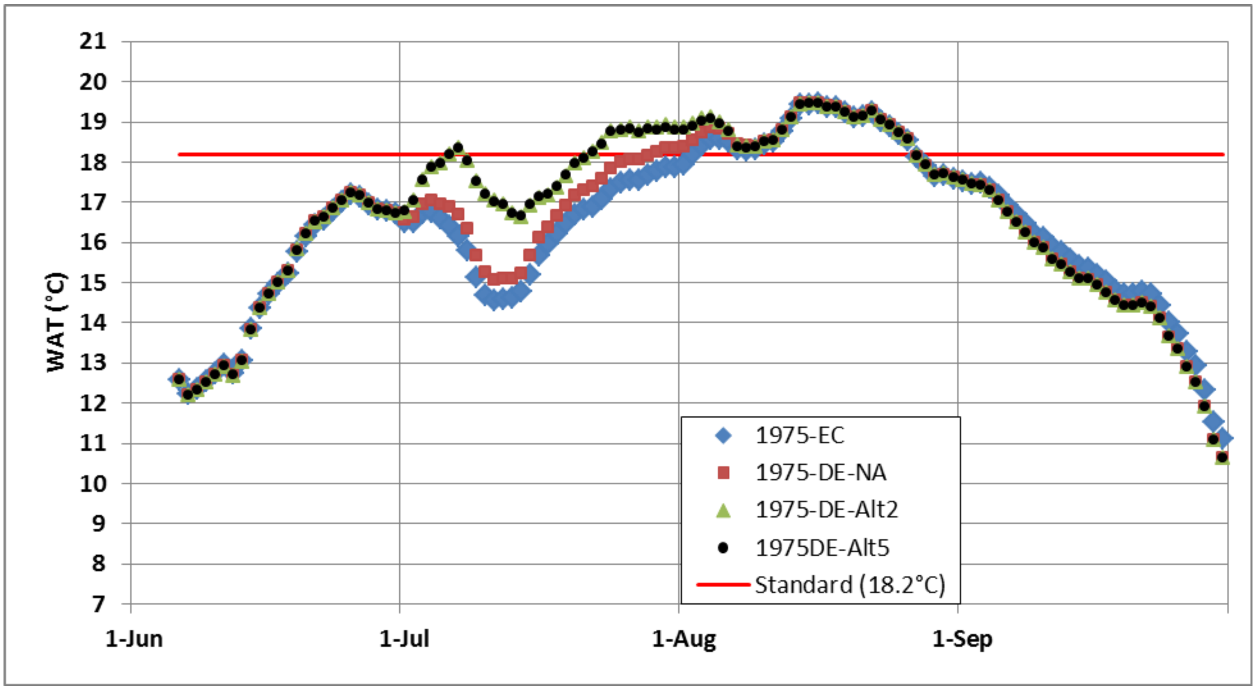


Figure 3-50. WAT at Colorado River upstream of the Williams Fork (WFU), June to September 1975.

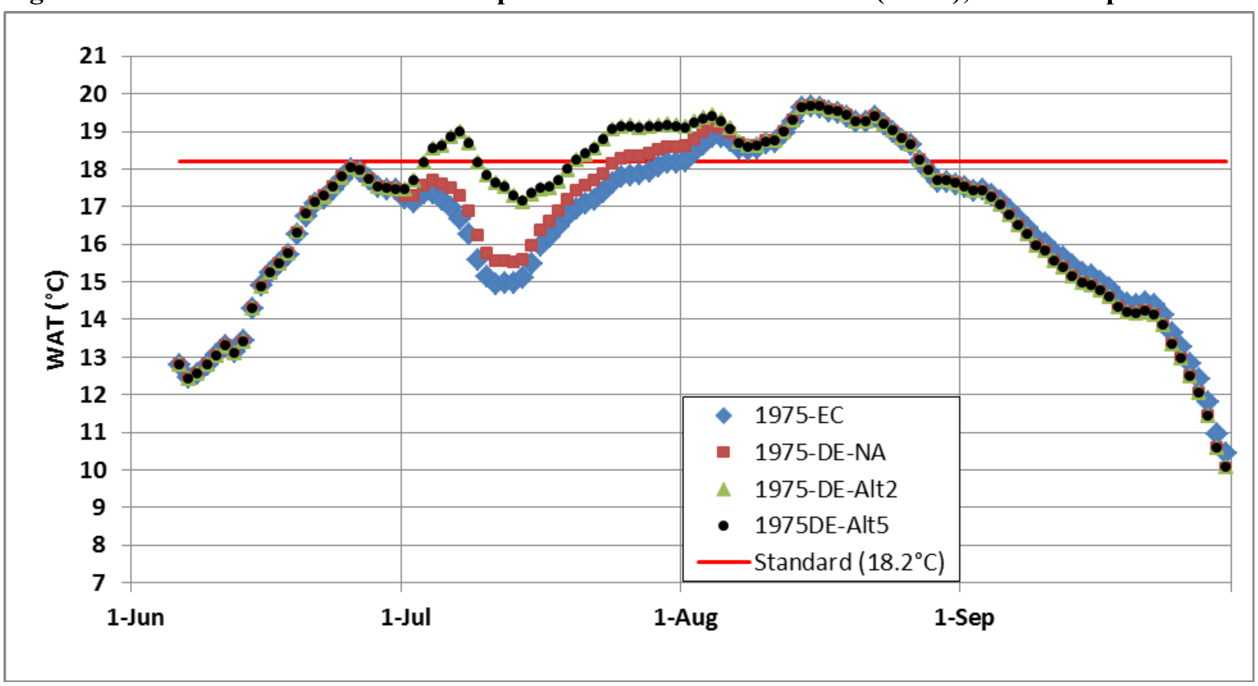


Table 3-61. Exceedance of the chronic and acute temperature standards in 1975.

Temperature Standards	1975-WGD				1975-HSU				1975-WFU			
	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5
Chronic												
MWAT (°C)	18.9	19.0	19.0	19.0	19.5	19.5	19.5	19.5	19.7	19.7	19.7	19.7
June # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0
July # weeks > 18.2°C	0	0	1	0	0	1	3	3	0	1	3	3
August # weeks > 18.2°C	3	3	3	3	4	4	4	4	4	4	4	4
Sept. # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0
Acute												
Max DM (°C)	20.8	20.8	20.8	20.8	24.4	24.4	24.8	24.8	23.5	23.5	24.9	24.9
June # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0
July # days > 23.8°C	0	0	0	0	0	0	3	3	0	0	1	1
August # days > 23.8°C	0	0	0	0	5	6	6	6	0	0	0	0
Sept. # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0

Graphs of the DM temperatures for 1975 and all three of the modeled locations are presented in Figure 3-51, Figure 3-52, and Figure 3-53. The highest simulated DM for existing conditions and all alternatives was 20.8°C at the CR-WGD site, with no exceedances of the standard (Table 3-61). The highest DMs were simulated to occur at the Hot Sulphur Springs site (24.4°C for existing conditions and the No Action Alternative and 24.8°C for the Proposed Action and Alternative 5). This resulted in exceedance of the DM standard for three days in July for the Proposed Action and Alternative 5. In August the DM was exceeded for five days under existing conditions and six days for No Action, the Proposed Action, and Alternative 5.

Table 3-62 provides a comparison of relative changes in the simulated WAT and DM for the Proposed Action and Alternative 5 compared to existing conditions. There was no difference in temperature value changes between the Proposed Action and Alternative 5. Both alternatives would result in up to a 2.7°C increase in the WAT at the CR-WFU location compared to existing conditions. Average July WAT temperature increases were up to 1.5°C above existing conditions, but there was only a 0.1°C difference in average August WAT temperatures for the Proposed Action over existing conditions. The largest one-day increase in DM (6.0°C) occurred at the Hot Sulphur Springs site in early July for the Proposed Action as compared to existing conditions.

Table 3-63 provides a comparison of the action alternatives to the No Action Alternative. Differences between the Proposed Action/Alternative 5 and the No Action Alternative are simulated to occur primarily in July. The largest simulated WAT increase relative to No Action was 2.1°C at WFU. The largest simulated DM increase relative to No Action was 4.6°C at Hot Sulphur Springs.

Figure 3-51. Daily Maximum Temperature at Colorado River downstream of Windy Gap Reservoir (WGD), June to September 1975.

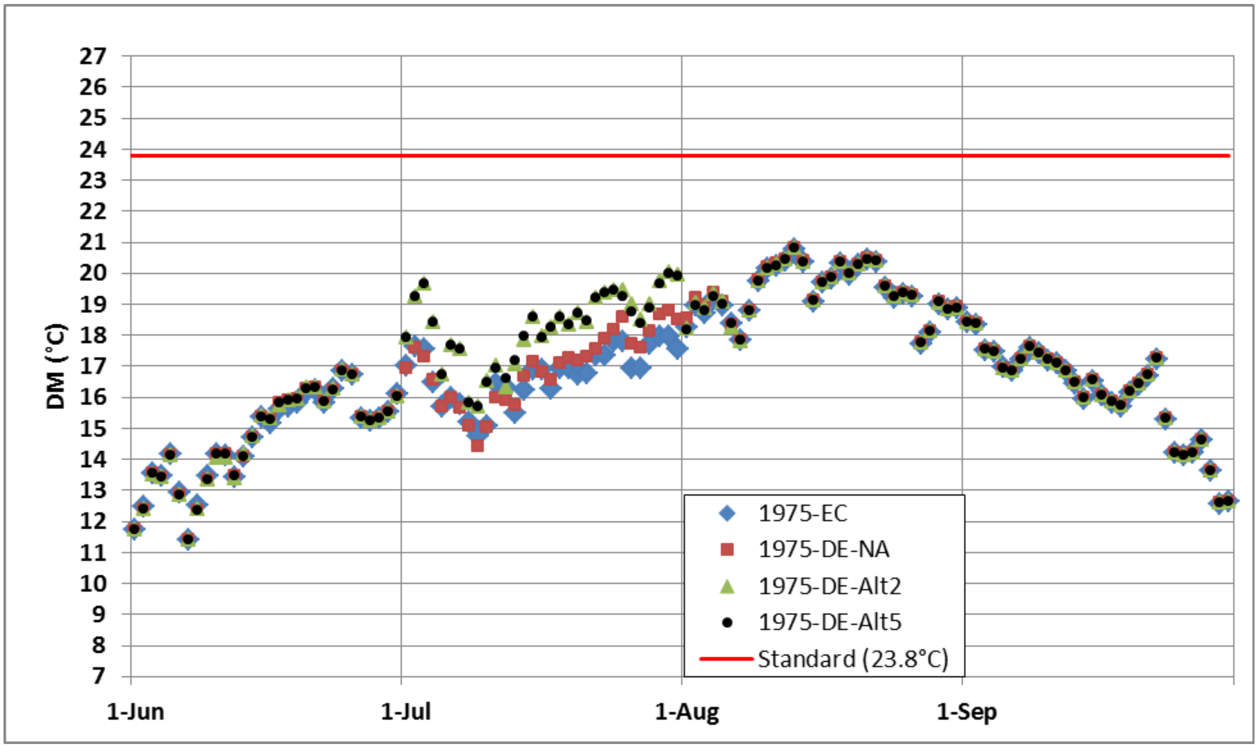


Figure 3-52. Daily Maximum Temperature at Colorado River at Hot Sulphur Springs (HSU), June to September 1975.

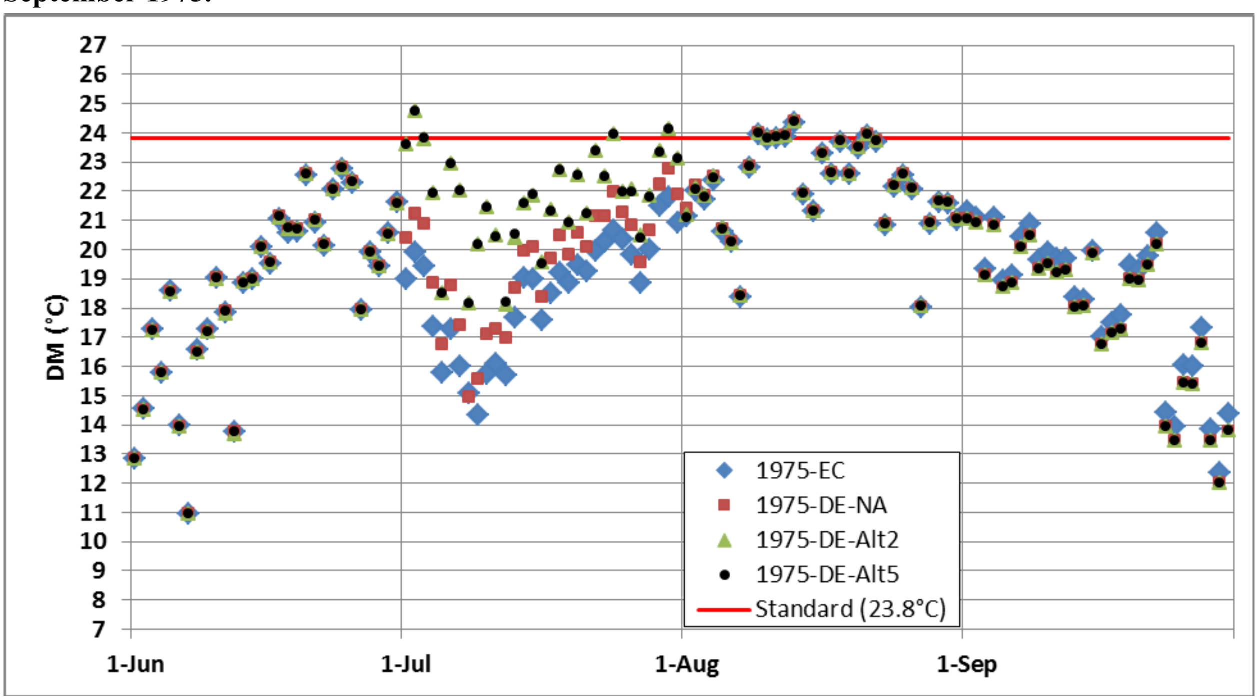


Figure 3-53. Daily Maximum Temperature at Colorado River upstream of the Williams Fork (WFU), June to September 1975.

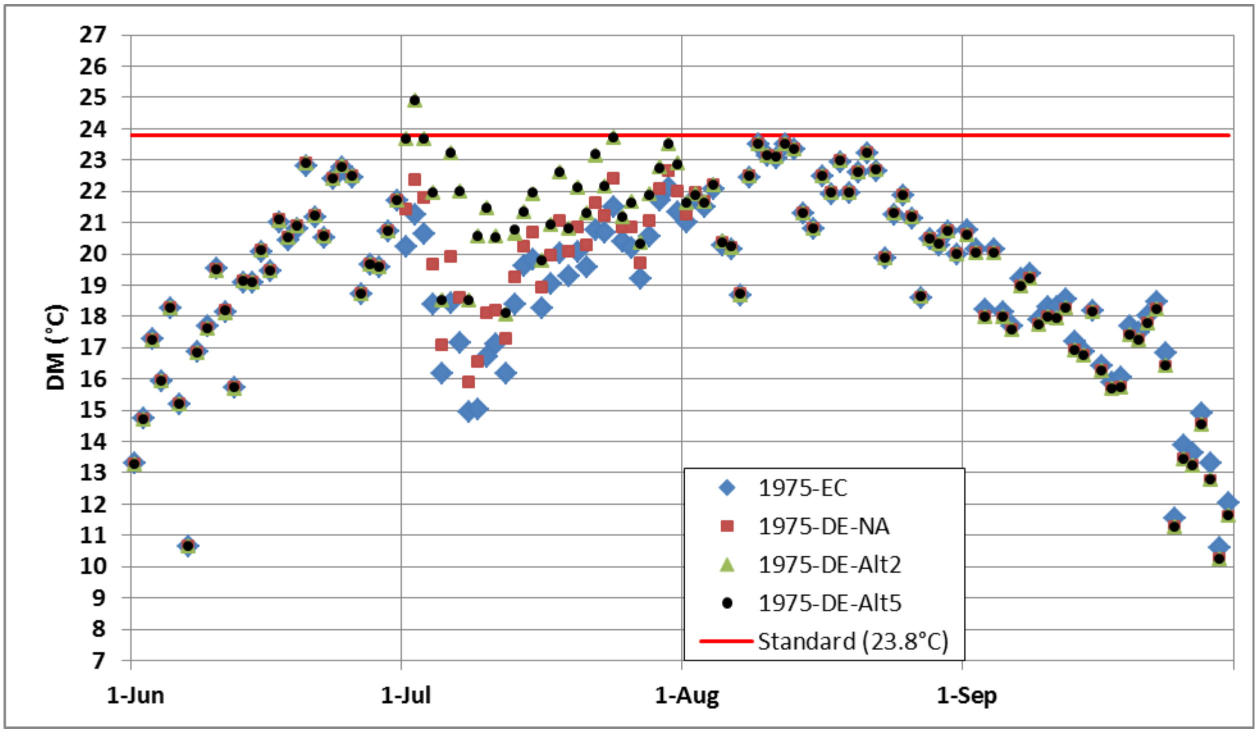


Table 3-62. Simulated Weekly Average Temperature (WAT) and Daily Maximum (DM) increases compared to existing conditions.

Temperature Standards	1975-WGD		1975-HSU		1975-WFU	
	Increase Relative to Existing Conditions (°C)		Increase Relative to Existing Conditions (°C)		Increase Relative to Existing Conditions (°C)	
	Alt2	Alt5	Alt2	Alt5	Alt2	Alt5
Chronic						
Largest WAT Increase (°C)	1.9	1.9	2.5	2.5	2.7	2.7
Avg. July WAT Increase (°C)	1.2	1.2	1.5	1.5	1.5	1.5
Avg. Aug. WAT Increase (°C)	0.2	0.1	0.1	0.1	0.2	0.1
Acute						
Largest DM Increase (°C)	2.4	2.4	6.0	6.0	5.5	5.5
Avg. July DM Increase (°C)	1.5	1.5	3.2	3.2	2.5	2.5
Avg. Aug. DM Increase (°C)	0.0	0.0	0.0	0.0	0.1	0.0

Table 3-63. Simulated Weekly Average Temperature (WAT) and Daily Maximum Temperature (DM) increases compared to the No Action Alternative.

Temperature Standards	1975-WGD Increase Relative to No Action (°C)		1975-HSU Increase Relative to No Action (°C)		1975-WFU Increase Relative to No Action (°C)	
	Alt2	Alt5	Alt2	Alt5	Alt2	Alt5
Chronic						
Largest WAT Increase (°C)	1.5	1.5	2.0	2.0	2.1	2.1
Avg. July WAT Increase (°C)	0.9	0.9	1.0	1.0	1.1	1.1
Avg. Aug. WAT Increase (°C)	0.0	0.0	0.1	0.0	0.1	0.1
Acute						
Largest DM Increase (°C)	2.3	2.3	4.6	4.6	4.0	4.0
Avg. July DM Increase (°C)	1.3	1.3	2.2	2.2	1.6	1.6
Avg. Aug. DM Increase (°C)	0.0	0.0	0.0	0.0	0.0	0.0

Summary of Temperature Model Results for all Modeled Years and Locations

Of the 15-year period of simulated daily hydrology used for the water quality analysis, only five years were identified that could potentially show temperature effects downstream of Windy Gap Reservoir in response to increased pumping under the WGFP. Other years in the 15-year period either exhibit no differences in pumping from Windy Gap or have very high flow rates during critical months and would not be expected to have temperature concerns. The five years provided a range of conditions over which to assess potential effects of the alternatives ranging from relatively dry (1987) to wet (1986) conditions. Of the five years simulated, flow rates below Windy Gap Reservoir ranged from 334 cfs to 4,250 cfs. The lowest flow rate during July and August was 84 cfs in 1979. The results of dynamic temperature modeling for 1975, 1979, 1986, and 1988 are shown in Table 3-64, Table 3-65, and Table 3-66. Bolded values in these tables indicate a simulated increase in exceedance of the standards, as compared to existing conditions or the No Action Alternative. The greatest simulated increase in MWAT and DM exceedances over existing conditions occurred in 1975 and 1979 when WGP diversions were largest relative to the amount of flow available for diversion. Model runs for all five years used 2007 climatic data, so differences between modeled years are primarily a function of the water remaining in the river following Windy Gap diversions. As noted previously, 2007 average July and August air temperatures were some of the highest values recorded, so under average climatic conditions, the number of exceedances of the temperature standards would likely be lower. The greatest number of temperature exceedances for MWAT occurred at the location above Williams Fork. The greatest number of temperature exceedances for DM occurred at Hot Sulphur Springs. Of the five years simulated, there were no increases in exceedance of the temperature standard in 1986 compared to existing conditions. However, 1987 had the greatest frequency of July and August MWAT and DM exceedances of the modeled years; although there were no Windy Gap diversions in July and August.

As described in Section 3.8.2.3, a review of historical river temperature data indicated that the reach below Windy Gap Reservoir to the Williams Fork confluence is the most vulnerable to a temperature increase from WGFP diversions. Below Williams Fork, temperature effects from the Proposed Action are not a concern due to river cooling by inflows from Williams Fork and other major tributaries, including Troublesome, Blue, and Muddy creeks.

QUAL2K Water Quality Model. The following sections provides the result of water quality modeling based on average flow conditions on July 25 as well as when Windy Gap diversions reduce the flow to near 90 cfs below Windy Gap Reservoir. The water quality analysis evaluated potential impacts to specific conductivity, dissolved oxygen, ammonia, inorganic phosphorus, and selenium in the Colorado River under each alternative. The WGFP would not introduce contaminants to the Colorado River; however, changes in flow volume can affect the concentration of nutrients, metals, and other parameters.

Table 3-64. Temperature model results for the Colorado River downstream of Windy Gap Reservoir (WGD).

Temperature Standards	1975				1979				1986				1987				1988			
	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5
Chronic																				
MWAT (°C)	18.9	19.0	19.0	19.0	18.7	19.1	19.1	19.1	16.1	16.4	16.4	16.6	19.4	19.5	19.5	19.5	18.8	18.8	18.8	18.8
June # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # weeks > 18.2°C	0	0	**1**	0	0	2	**2**	**1**	0	0	0	0	2	2	2	2	0	2	**2**	**2**
August # weeks > 18.2°C	3	3	3	3	2	3	**3**	**4**	0	0	0	0	4	4	4	4	2	2	**3**	**3**
September # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acute																				
Max DM (°C)	20.8	20.8	20.8	20.8	20.6	21.1	21.1	21.1	17.2	17.7	17.9	18.2	21.4	21.5	21.5	21.5	20.6	20.6	20.6	20.6
June # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-65. Temperature model results for the Colorado River at Hot Sulphur Springs (HSU).

Temperature Standards	1975				1979				1986				1987				1988			
	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5
Chronic																				
MWAT (°C)	19.5	19.5	19.5	19.5	19.4	19.7	19.7	19.7	17.3	17.6	17.7	17.8	20.0	20.0	20.0	20.0	19.4	19.4	19.4	19.4
June # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # weeks > 18.2°C	0	1	**3**	**3**	1	2	**2**	**2**	0	0	0	0	4	4	4	4	2	2	2	2
August # weeks > 18.2°C	4	4	4	4	4	4	4	4	0	0	0	0	5	5	5	5	3	4	**4**	**4**
September # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acute																				
Max DM (°C)	24.4	24.4	24.8	24.8	24.3	24.8	24.8	24.8	21.5	22.1	22.3	22.5	25.4	25.4	25.4	25.4	24.2	24.2	24.5	24.5
June # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # days > 23.8°C	0	0	**3**	**3**	0	2	**2**	**2**	0	0	0	0	1	1	1	1	0	1	**2**	**2**
August # days > 23.8°C	5	6	**6**	**6**	2	7	**7**	**7**	0	0	0	0	12	12	12	12	4	4	4	4
September # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-66. Temperature model results for the Colorado River upstream from the Williams Fork (WFU).

Temperature Standards	1975				1979				1986				1987				1988			
	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5	EC	NA	Alt2	Alt5
Chronic																				
MWAT (°C)	19.7	19.7	19.7	19.7	19.6	19.9	19.9	19.9	17.7	18.0	18.1	18.2	20.0	20.0	20.0	20.0	19.6	19.6	19.6	19.6
June # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # weeks > 18.2°C	0	1	**3**	**3**	2	2	2	2	0	0	0	0	4	4	**5**	**5**	2	3	**3**	2
August # weeks > 18.2°C	4	4	4	4	3	4	**4**	**4**	0	0	0	0	4	4	4	4	4	4	4	4
September # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acute																				
Max DM (°C)	23.5	23.5	24.9	24.9	23.4	23.9	23.9	23.8	21.5	21.9	22.0	22.1	24.3	24.3	24.4	24.4	23.5	23.7	23.9	23.9
June # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # days > 23.8°C	0	0	**1**	**1**	0	1	**1**	**1**	0	0	0	0	1	1	1	1	0	0	**1**	**1**
August # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0	0	0
September # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Streamflow

Colorado River flows would decrease below Windy Gap Reservoir as a result of additional diversions under all alternatives. Figure 3-54 indicates the Colorado River streamflow for existing conditions and the alternatives from Granby Reservoir at River Mile 0 to the Kremmling gage at the top of Gore Canyon at about River Mile 45. Alternatives 3 and 4 would have the greatest decrease in streamflow, but all of the action alternatives are similar. The No Action Alternative would result in the smallest decrease in streamflow.

Figure 3-54. Colorado River average July 25 streamflow.

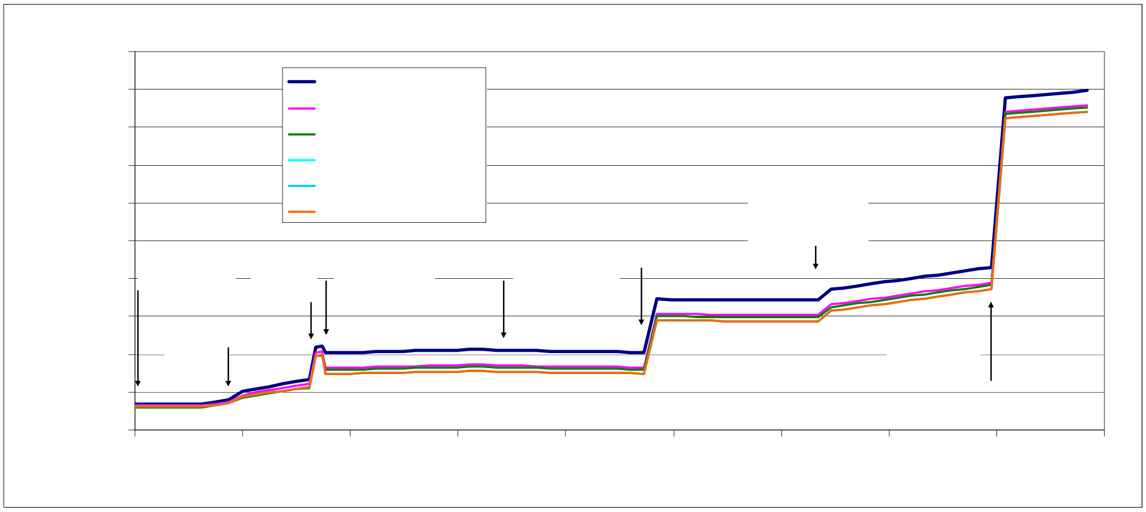


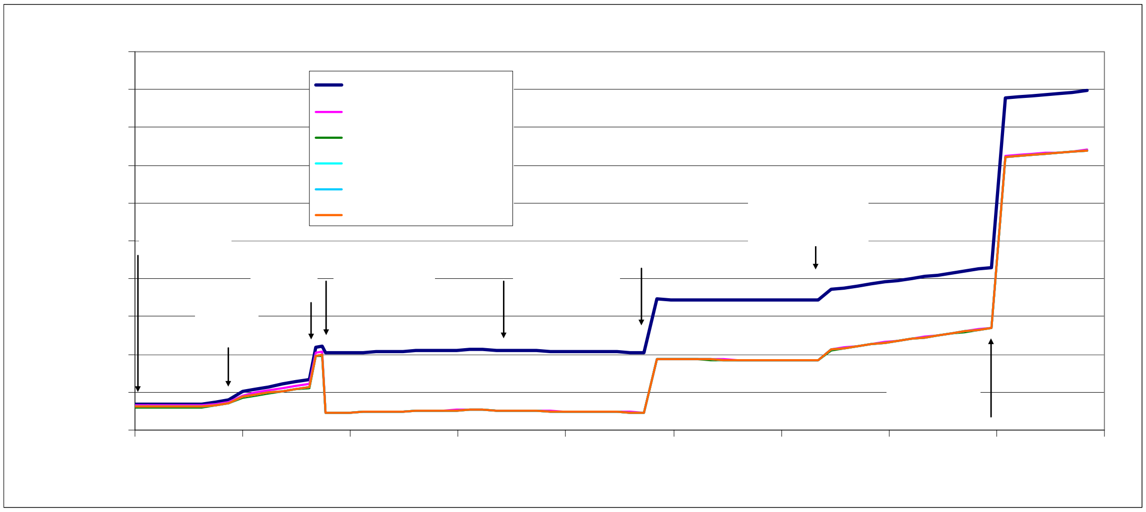
Figure 3-55 indicates what Colorado River flows would look like if Windy Gap diversions reduce flows for July 25 to the minimum streamflow requirement of 90 cfs. Diversions to 90 cfs could occur under all alternatives; therefore, the flow in Figure 3-55 is the same for all alternatives. Based on daily model results for the 47-year study period, diversions in July to the minimum streamflow would increase by less than one day per year on average under the Proposed Action compared to existing conditions. Streamflow of 90 cfs or less already occur in the Colorado River when Windy Gap is not diverting as the result of upstream diversions by others and/or low surface runoff or ground water discharge to the river. There would be no change in the current minimum flows available for the Town of Hot Sulphur Springs' potable water treatment plant or dilution flows for its WWTP discharges.

Specific Conductivity

Specific conductivity values for the Colorado River, which are an indicator of the TDS[3] concentration, increase slightly below the Williams Fork (Figure 3-56). Conductivity increases below the Williams Fork because there would be less Colorado River water to dilute higher conductivity inflows from the Williams Fork. Alternatives 3, 4, and 5 would increase specific conductivity up to about 10 percent over existing conditions. Conductivity would increase a maximum of about 7 percent under the No Action Alternative and about 8 percent under the Proposed Action. Conductivity would increase up to 45 percent under all alternatives with diversions to the 90 cfs minimum streamflow (Figure 3-57).

[3] Total dissolved solids (mg/L) = 0.6 x conductivity (µS/cm) based on measured data for the Colorado River.

Figure 3-55. Colorado River July 25 streamflow assuming diversion to the minimum instream flow below Windy Gap Reservoir.



Note: Flow rates for No Action, the Proposed Action, and Alternatives 3 through 5 are very similar and follow the Alt5 line, which plots "on top" from roughly River Mile 8 through River Mile 44.

Figure 3-56. Colorado River specific conductivity for July 25.

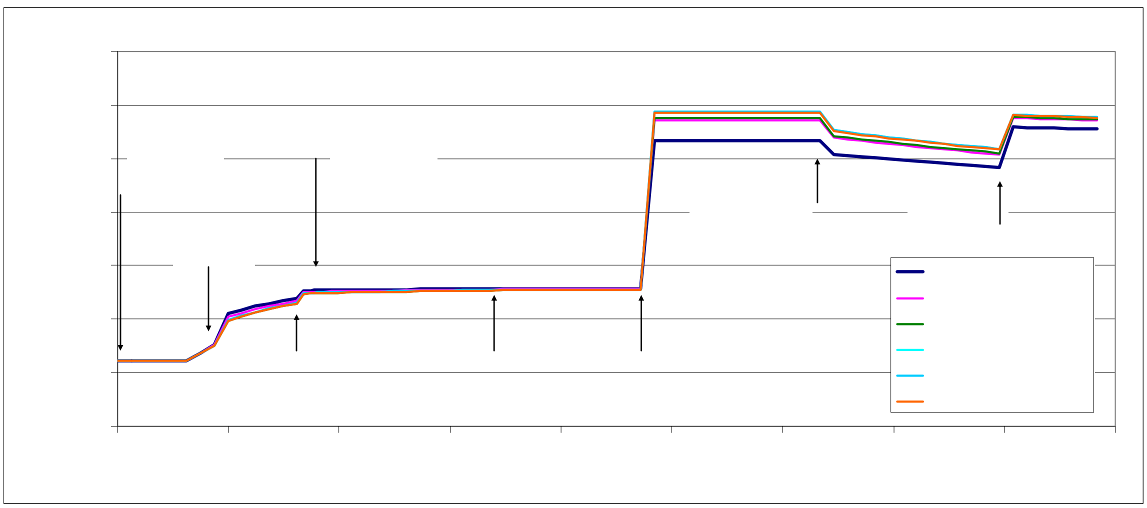
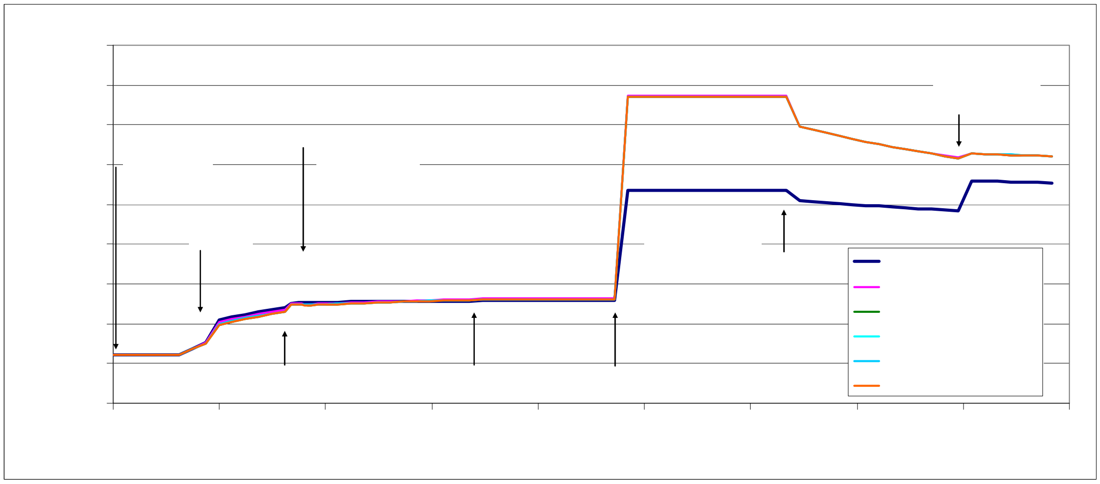


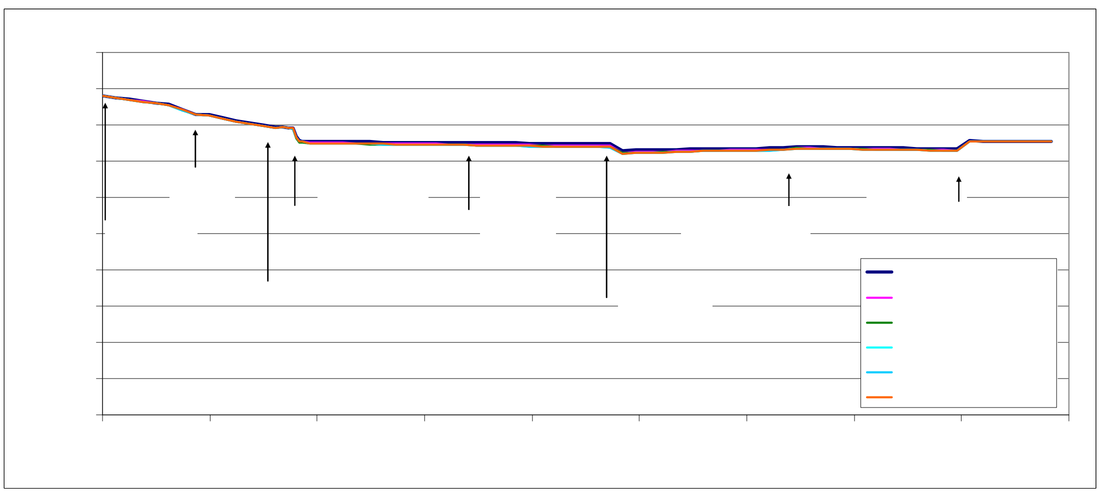
Figure 3-57. Colorado River specific conductivity for July 25 assuming diversion to the minimum streamflow below Windy Gap Reservoir.



Dissolved Oxygen

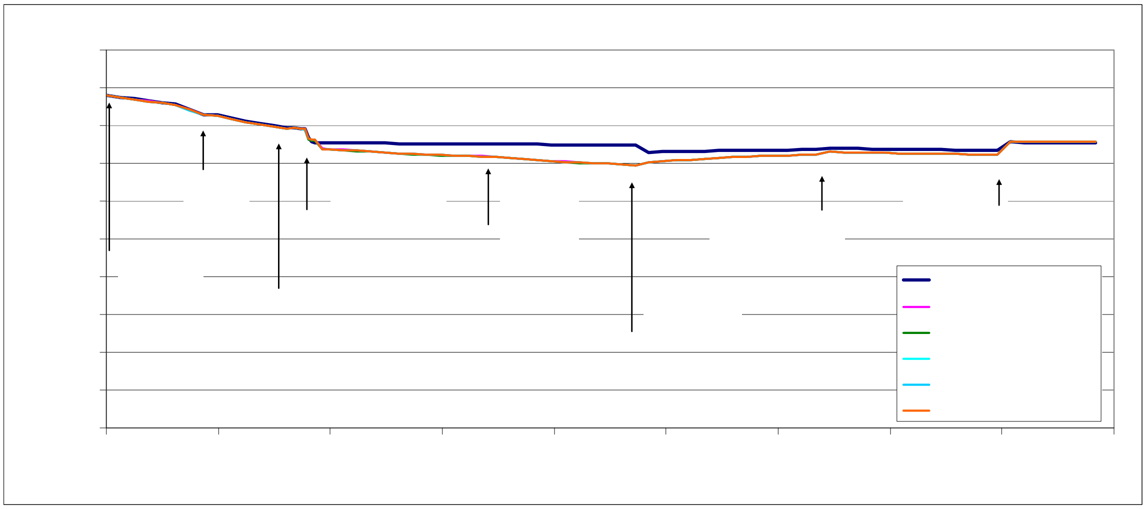
DO concentrations would remain relatively constant as water moves downstream from Granby Reservoir under all alternatives (Figure 3-58). A maximum DO reduction of about 0.1 mg/L below Windy Gap Reservoir is predicted under all alternatives compared to existing conditions. The aquatic life nonspawning standard of 6.0 mg/L of DO and the spawning standard would be met throughout the study reach.

Figure 3-58. Colorado River dissolved oxygen concentrations for July 25.



DO concentrations would decrease up to 0.6 mg/L under the Proposed Action and decrease up to 0.5 mg/L for all the other alternatives when flows are at the 90 cfs minimum flow below Windy Gap Reservoir (Figure 3-59). DO concentrations as low as 6.9 mg/L are predicted for a short reach just above the Williams Fork confluence under all alternatives. This is just below the spawning standard of 7.0 mg/L; however, reduced DO below the spawning standard is expected to occur only during the summer months outside of the spring and fall spawning seasons. DO would gradually increase below Williams Fork to 7.6 mg/L at the top of Gore Canyon.

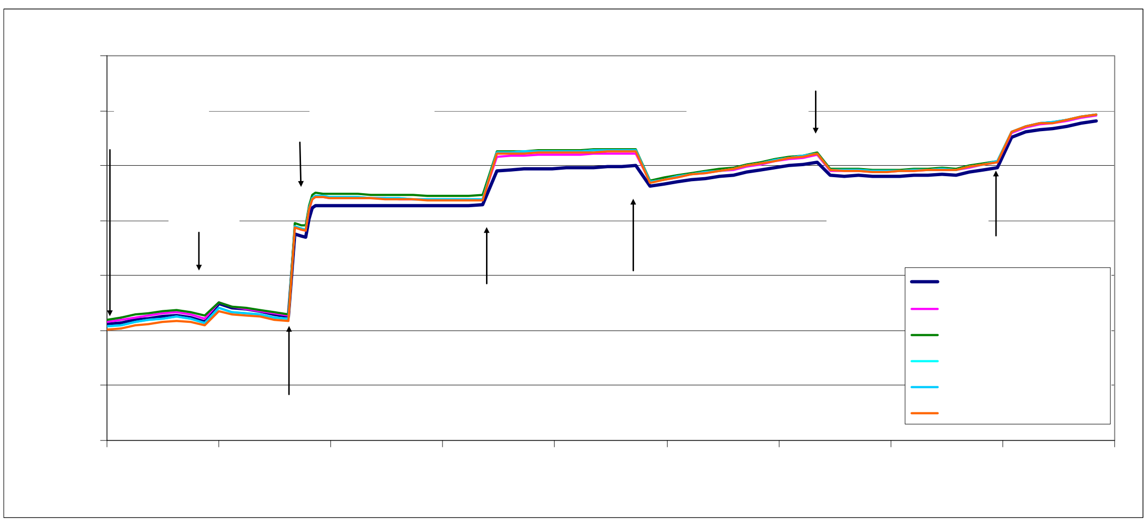
Figure 3-59. Colorado River dissolved oxygen concentrations for July 25 assuming diversion to the minimum streamflow below Windy Gap Reservoir.



Ammonia

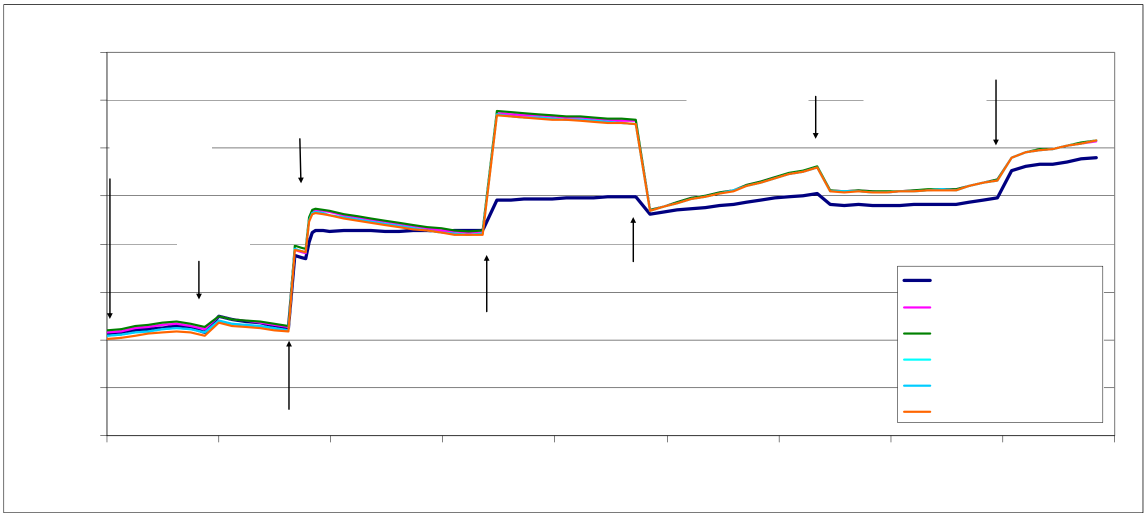
Ammonia concentrations would increase slightly below the Windy Gap diversion (Figure 3-60). The largest increase would occur below the Hot Sulphur Springs WWTP (HSS WWTP) because of less dilution of WWTP effluent discharges. The maximum increase in ammonia concentrations from existing conditions would be 1.7 µg/L under the Proposed Action, compared to 1.3 µg/L under No Action, with the other alternatives falling between these values. Ammonia concentrations would be below chronic and acute standards throughout the study reach for all alternatives.

Figure 3-60. Colorado River ammonia concentrations for July 25.



Predicted Colorado River ammonia values for the simulation of minimum streamflow would result in a greater increase in ammonia concentrations (Figure 3-61). The Proposed Action would increase ammonia concentrations up to 9.3 µg/L below the HSS WWTP compared to 9.1 µg/L for the No Action Alternative, and slightly less for the other alternatives. Ammonia concentrations would remain below standards for all alternatives at minimum flows.

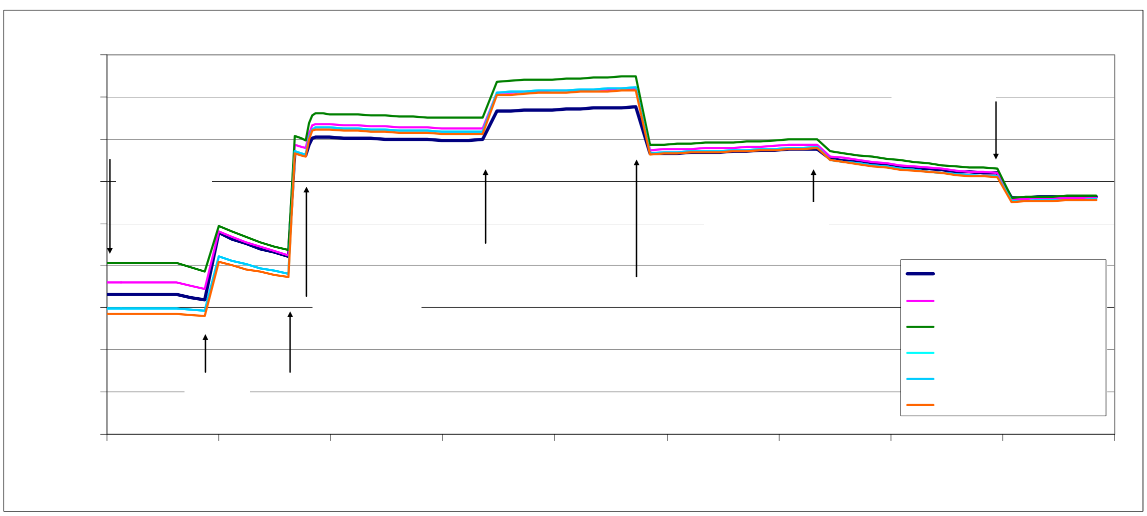
Figure 3-61. Colorado River ammonia concentrations for July 25 assuming diversion to the minimum streamflow below Windy Gap Reservoir.



Inorganic Phosphorus

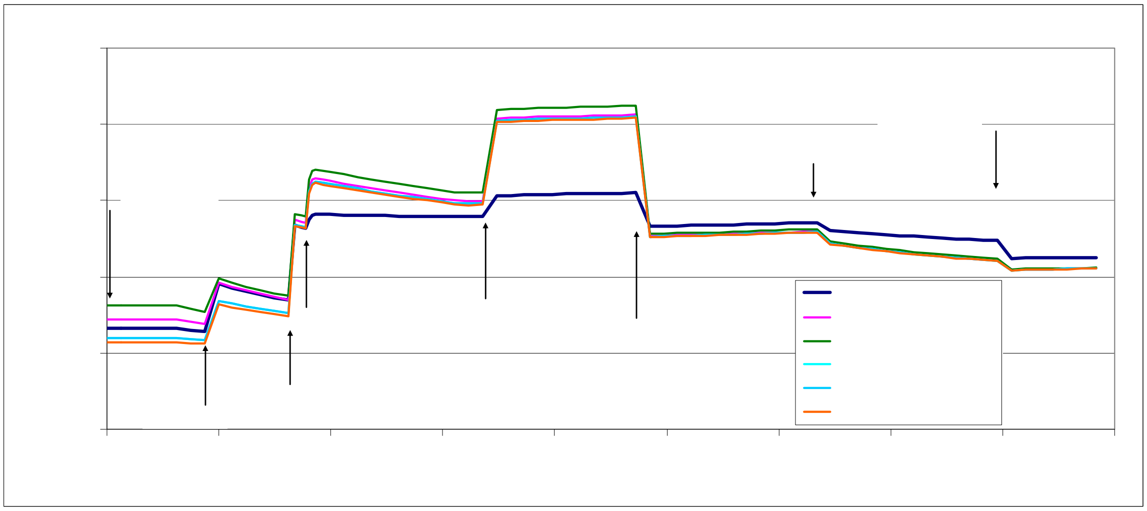
Inorganic phosphorus concentrations would vary from existing conditions throughout the study reach (Figure 3-62). Phosphorus concentrations would increase by up to 1.5 µg/L under the Proposed Action below Granby Reservoir and below the HSS WWTP. Other alternatives, including the No Action Alternative, would result in an increase of up to 0.9 µg/L in inorganic phosphorus concentrations. Slight reductions in inorganic phosphorus would occur upstream of Willow Creek under Alternatives 4 and 5. There is currently no water quality standard for phosphorus; however, the EPA-recommended concentration for streams is 100 µg/L (EPA 1986).

Figure 3-62. Colorado River inorganic phosphorus concentrations for July 25.



Inorganic phosphorus concentrations would increase primarily between Windy Gap Reservoir and the Williams Fork at the 90 cfs minimum streamflow (Figure 3-63). The increase in inorganic phosphorus concentrations would be similar among alternatives; however, the Proposed Action would have the greatest increase (5.7 µg/L) and Alternative 5 would have the least (4.9 µg/L). Inorganic phosphorus concentrations would decrease below the Williams Fork for all alternatives because the low phosphorus concentrations in the Williams Fork would contribute a greater percentage of flow to the Colorado River.

Figure 3-63. Colorado River inorganic phosphorus concentrations for July 25 assuming diversion to the minimum streamflow below Windy Gap Reservoir.



Selenium

Existing dissolved selenium concentrations in the Colorado River are very low and would increase only slightly near Kremmling under all alternatives. An increase in selenium of up to 0.002 µg/L below Muddy Creek would be the result of the reduction in Colorado River flows relative to naturally higher selenium concentrations in Muddy Creek. Under minimum streamflows of 90 cfs, selenium concentrations would increase up to 0.04 µg/L below Muddy Creek for all alternatives. Selenium concentrations would remain well below the chronic and acute standard for all alternatives for average or minimum flow conditions.

Aquatic Plant Growth

For all alternatives, an increase in aquatic plant growth could occur as a result of an increase in nutrient (ammonia and phosphorus) concentrations. Didymo is an aquatic organism tolerant of a wide range of stream chemical and physical conditions and none of the predicted water quality and flow changes under the alternatives are expected to adversely contribute to the spread or development of didymo populations that are currently present in the river.

Colorado River Drinking Water Treatment Facilities and Wastewater Treatment Facilities

There is one drinking water treatment facility and one wastewater treatment facility along the Colorado River project area below Windy Gap, both are owned and operated by the Town of Hot Sulphur Springs. As part of the mitigation measures implemented for the original Windy Gap Project, the town was paid $150,000 to improve its water treatment facility and $270,000 to improve its wastewater treatment facility. The analysis of Colorado River water quality showed increases in ammonia concentrations at Hot Sulphur Springs under all of the alternatives, but values would remain well below the standard. Hot Sulphur Springs experienced high turbidity levels at their intake in 2008 that affected their ability to treat drinking water. Current and future Windy Gap diversions upstream from Hot Sulphur Springs would not be expected to increase turbidity levels in the Colorado River as evidenced by the relatively small increase in specific conductivity previously discussed. Changes in water quality as a result of the WGFP should not impair Hot Sulphur Springs' drinking water treatment facility's ability to meet drinking water standards or increase its cost for treatment. The project is not anticipated to affect effluent limits for Hot

Sulphur Springs' WWTP because the acute and chronic design flows used to calculate effluent limits (38 and 59 cfs, respectively) are much lower than would be experienced in the Colorado River at Hot Sulphur Springs (90 cfs) under any of the alternatives (CDPHE 2008a). Changes in ambient water quality could potentially change effluent limits, but it is likely that the WQCD would initiate changes to the WWTP permit only if the Colorado River were to become 303(d) listed for a water quality parameter, or if a total maximum daily load (TMDL) were to be completed for that segment of the river.

Willow Creek

Streamflow would decrease in Willow Creek below Willow Creek Reservoir under all alternatives as discussed in Section 3.5.2.3. Water quality changes are possible due to increases in the relative contribution of ground water and inflow from Church Creek, which carries effluent discharge from the Three Lakes WWTP. The majority of changes in streamflow would occur from June to August; therefore, the evaluation focused on this period.

Under the No Action Alternative, model results indicate the change in flow would not measurably affect the water temperature in Willow Creek. For all action alternatives, a decrease in water temperature of 0.2°C or less is predicted. The decrease in water temperature is likely the result of an increase in the influence of cooler ground water discharges to Willow Creek. Because temperature changes would be so small, it is not expected that dissolved oxygen concentrations would be reduced substantially.

Potential changes to ammonia, iron, and copper concentrations in Willow Creek were evaluated because these constituents sometimes have elevated concentrations in Willow Creek and could exceed standards more frequently at lower streamflows. To evaluate impacts, a mass balance analysis was completed using the maximum discharge from the Three Lakes WWTP that occurred between 2005 and 2010. Results indicate ammonia concentrations in Willow Creek would increase under all alternatives during the summer (Table 3-67). The greatest increase would occur under the Proposed Action. Acute and chronic aquatic life ammonia standards would not be exceeded under any alternative. Given the lack of algae and chlorophyll data for Willow Creek, it is not known whether the predicted increases in ammonia concentrations would result in algal growth problems in the creek. Dissolved iron concentrations would decrease slightly from existing conditions for all alternatives, and would be below the water supply standard. Dissolved copper concentrations would increase about the same amount for all alternatives, but would remain below the acute and chronic aquatic life standard.

Table 3-67. Willow Creek average monthly ammonia, iron, and copper concentrations.

Standard/Alternative	Ammonia (mg/L)			Iron, dis (µg/L)			Copper, dis (µg/L)		
	June	July	Aug.	June	July	Aug.	June	July	Aug.
Standard[1]	2.87	2.87	2.45	300	300	300	10	10	10
WWTP[2]	1.4	2.7	1.7	43	75	70	11.4	14.5	16.2
EC	0.03	0.03	0.03	92.5	92.5	92.5	3.4	3.4	3.4
Alt 1 – No Action	0.032	0.173	0.25	92.4	91.56	89.5	3.41	4	5.23
Alt 2 – Proposed Action	0.035	0.212	0.295	92.4	91.3	89	3.53	4.15	5.57
Alt 3	0.034	0.203	0.27	92.4	91.36	89.3	3.52	4.12	5.4
Alt 4	0.034	0.203	0.27	92.4	91.36	89.3	3.52	4.12	5.4
Alt 5	0.034	0.212	0.27	92.4	91.3	89.3	3.41	4.15	5.4

[1] Copper standard based on mean hardness of 112 mg/L (CDPHE 2011a).

[2] Effluent concentrations from the Three Lakes WWTP discharge to Church Creek, a tributary to Willow Creek (WQCD 2010).

Jasper East Drainage

The unnamed drainage below the Jasper East Reservoir site would receive seepage or discharge from the new reservoir in Alternative 3. Water quality would be similar to the reservoir, as discussed below. Water quality is predicted to meet standards for all parameters, except manganese. Manganese concentrations may range from 20 to 100 µg/L, occasionally exceeding the water supply standard of 50 µg/L (Hydrosphere 2007).

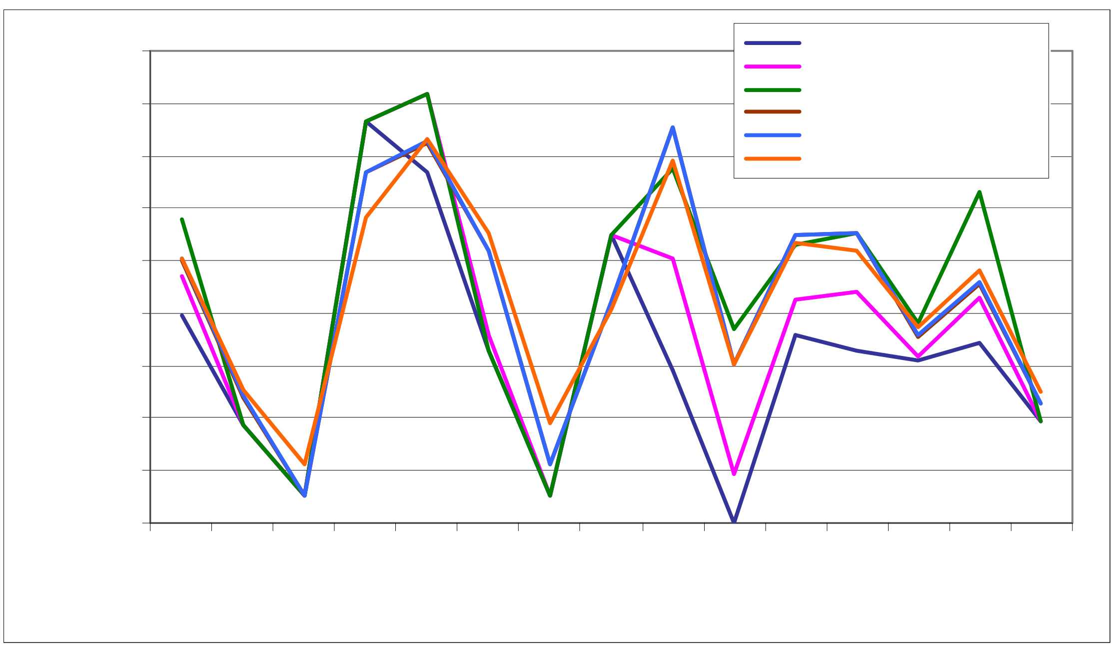
Rockwell and Mueller Creeks

Release or seepage to Rockwell and Mueller creeks below the new reservoir under Alternatives 4 and 5 would have water quality similar to the new reservoir, as described below. There would be slight differences in the water quality based on the size of the reservoir. No exceedance of water quality standards is predicted, except possibly for manganese, which could occasionally exceed the water supply standard (Hydrosphere 2007).

Water Delivery to Three Lakes System

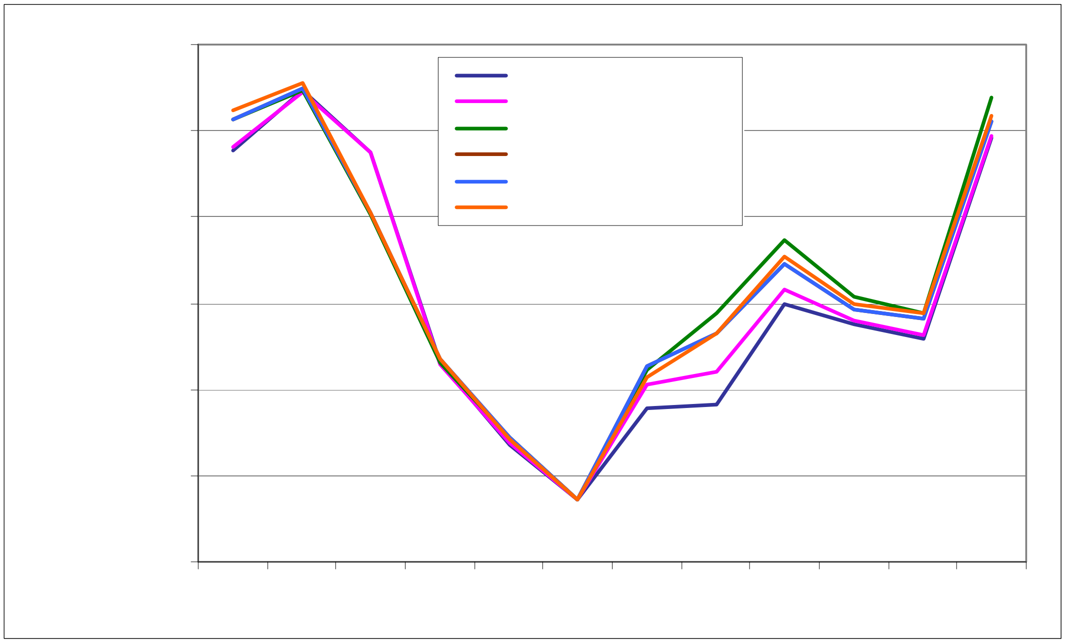
All alternatives would deliver additional water to Granby Reservoir and then to Shadow Mountain Reservoir and Grand Lake via the Farr Pumping Plant. The Proposed Action and No Action Alternative would deliver water to Granby Reservoir directly from Windy Gap Reservoir. Alternative 3 would deliver water from both Windy Gap Reservoir and Jasper East Reservoir. Alternatives 4 and 5 would deliver water from Windy Gap Reservoir and Rockwell Reservoir. The Proposed Action and No Action Alternative would only deliver water to the Three Lakes from April to August, while the other alternatives, with new West Slope storage, would deliver water year round. The annual volume of delivery to Granby Reservoir varies by year. Figure 3-64 shows estimated annual pumping from Windy Gap Reservoir to Granby Reservoir based on the hydrology for the 1975 to 1989 period. The timing and amount of water pumped from Granby Reservoir into Shadow Mountain Reservoir is shown in Figure 3-65.

Figure 3-64. Estimated pumping from Windy Gap Reservoir, proposed Jasper East Reservoir (Alternative 3), and proposed Rockwell Creek Reservoir (Alternatives 4 and 5) into Granby Reservoir by water year.



Source: Boyle 2006.

Figure 3-65. Estimated pumping from Granby Reservoir to Shadow Mountain Reservoir via the Farr Pumping Plant.



Source: Boyle 2006.

Nutrient loading into the Three Lakes under existing conditions comes from several sources as shown in Table 3-68. Primary contributors of the phosphorus and nitrogen loading into the Three Lakes are Willow Creek, Windy Gap, and Stillwater Creek. Arapaho Creek is the largest source of nitrogen to the Three Lakes. The change in phosphorus and nitrogen load into the Three Lakes for the alternatives is shown in Table 3-69 and Table 3-70. The Proposed Action has the highest additional nutrient loadings. Alternatives 3, 4, and 5, which include a new West Slope reservoir, would retain a portion of the nutrients in the new reservoir, which would reduce contributions to the Three Lakes System. The following sections focus on the effects to the individual reservoirs in the Three Lakes System.

Table 3-68. Estimated average annual nutrient load into the Three Lakes System for existing conditions (based on 1975 to 1989 hydrology).

Location	Average Total Phosphorus Load (kg/yr)	Percent of Total Phosphorus Load	Average Total Nitrogen Load (kg/yr)	Percent of Total Nitrogen Load
Willow Creek Pumping	1,128	15.5	9,455	8.7
Windy Gap Pumping	2,158	29.6	15,966	14.8
Arapaho Creek	503	6.9	20,578	19.0
Stillwater Creek	1,566	21.5	7,023	6.5
North Fork of the Colorado	596	8.2	7,962	7.4
North Inlet	355	4.9	10,717	9.9
East Inlet	225	3.1	6,819	6.3
Roaring Fork	92	1.3	3,784	3.5
Columbine Creek	62	0.8	2,523	2.3
Precipitation	377	5.2	13,671	12.6
Miscellaneous Gains	218	3.0	9,756	9.0
Total	7,280	100	108,254	100

Table 3-69. Estimated additional total phosphorus load into the Three Lakes System for alternatives over existing conditions (based on 1975 to 1989 hydrology).

Alternative	TP Load from Willow Creek Reservoir (kg/yr)	TP Load from Windy Gap Reservoir (kg/yr)	TP Load from Jasper East Reservoir (kg/yr)	TP Load from Rockwell Creek Reservoir (kg/yr)	Total (kg/yr)
Alt 1 – No Action	+84	+237			+321
Alt 2 – Proposed Action	+97	+681			+778
Alt 3	+97	-536	+509		+70
Alt 4	+97	-531		+485	+51
Alt 5	+98	-737		+552	-87

Table 3-70. Estimated additional total nitrogen load into the Three Lakes System for alternatives over existing conditions (based on 1975 to 1989 hydrology).

Alternative	TN Load from Willow Creek Reservoir (kg/yr)	TN Load from Windy Gap Reservoir (kg/yr)	TN Load from Jasper East Reservoir (kg/yr)	TN Load from Rockwell Creek Reservoir (kg/yr)	Total (kg/yr)
Alt 1 – No Action	+653	+2,169			+2,822
Alt 2 – Proposed Action	+758	+5,370			+6,128
Alt 3	+753	-3,092	+5,243		+2,904
Alt 4	+753	-3,037		+4,927	+2,643
Alt 5	+764	-4,713		+5,856	+1,907

Model results for existing conditions and the Proposed Action were examined to understand the fate of nutrients entering the Three Lakes system and the differences predicted to occur if the Proposed Action were implemented. Treating all three water bodies (Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake) as a whole, the fate of total phosphorus and total nitrogen is shown in Figure 3-66 and Figure 3-67. The boxes on the left-hand side indicate the average annual starting mass of nutrients in the system over the 15-year period of simulation (WY75–WY89) while the boxes on the right show the average annual ending mass.

Average annual additions and subtractions from the water column are shown in the middle graphics. The ‘Inflow’ box is the amount of nutrients entering the Three Lakes system under existing conditions and is the sum of the contributions from all tributaries, precipitation, pumping, and miscellaneous gains to the system. The “Int. Load” box is the amount of nutrients entering the water column from the sediments (internal loading). The value listed is computed within the model and is based on the amount of organic particulate matter sinking from the water column to the sediments and dissolved oxygen concentrations (AMEC 2008b). The ‘Settling’ box shows the amount of nutrients lost from the water column to the sediments due to particulate settling. Settling rates used in the model were determined during model calibration and are consistent with values reported in the literature. The ‘Outflow’ box shows the mass of nutrients leaving the system via the Adams Tunnel and releases to the Colorado River from Granby Reservoir. Thus, beginning with the starting mass, adding in the inflows and internal loads, subtracting out the settling and outflows, the ending condition is reached.

Figure 3-66. Fate of total phosphorus (TP) for the Three Lakes system (average annual kg/yr, WY75-WY89).

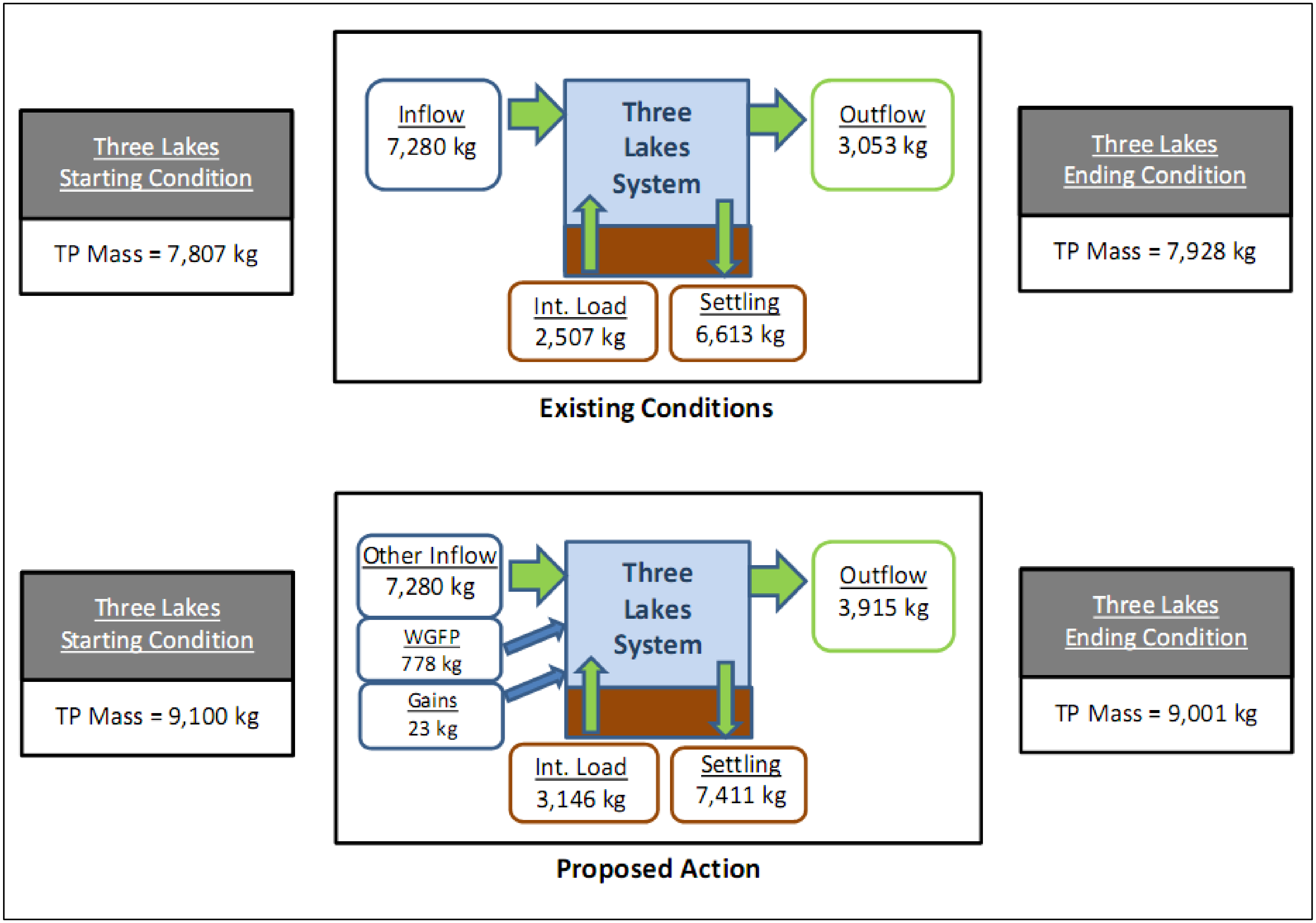
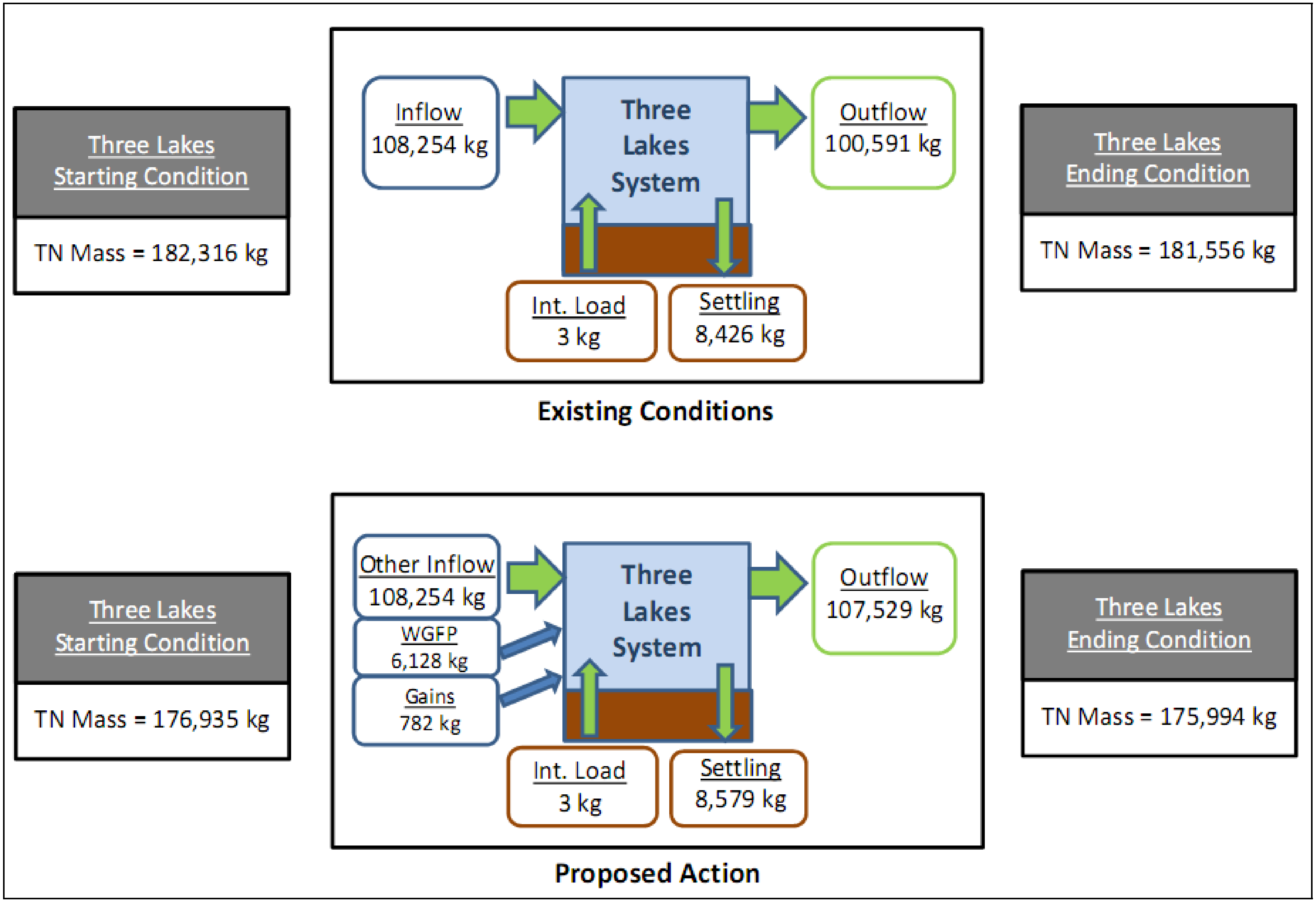


Figure 3-67. Fate of total nitrogen (TN) for the Three Lakes system (average annual kg/yr, WY75–WY89).



For the Proposed Action, the total 'Inflow' is broken down to indicate the additional load that can be anticipated to contribute to the system because of the WGFP. Note that a small amount of nutrients enters the system via additional gains for the Proposed Action in the model. The additional gains were required to ensure the mass of water balanced, given the flows provided by the hydrologic model. In addition, the total system storage differs between existing conditions and the Proposed Action.

Implementation of the Proposed Action is predicted to result in increased settling of nitrogen and phosphorus in the Three Lakes, as well as increased release of these nutrients to the Adams Tunnel and the Colorado River. Settling for both the Proposed Action and existing conditions is approximately the same percentage of inflow mass plus starting mass. However, since the outflow increases more than the inflow increases for Proposed Action (relative to existing conditions) and there is no increase in internal loading (as there is in the case of phosphorus), there is a larger reduction in mass for the Proposed Action than for existing conditions.

Granby Reservoir

> Phosphorus, nitrogen, chlorophyll *a*, and total suspended solid concentrations in the Three Lakes would increase, and dissolved oxygen concentrations would decrease under the Proposed Action.

Predicted average annual and the range in daily water quality for Granby Reservoir under existing conditions and all alternatives is summarized in Table 3-71. Table 3-72 shows the percent change in water quality for each alternative compared to existing conditions. There would be no change in the average trophic status or clarity as measured by the Secchi-disk depth under any alternative. Average chlorophyll *a* concentrations would increase about 2.4 percent under the Proposed Action and would not change under the other alternatives. Peak chlorophyll *a* concentrations are difficult to accurately model, but changes are predicted to be minor. Phosphorus concentrations would increase under all alternatives because of the additional Windy Gap water pumped into the reservoir. Nitrogen concentrations would increase slightly under No Action and the Proposed Action, and decrease under the other alternatives. Although more water would be flowing through Granby Reservoir, there would be a decrease in residence time and more flushing of the reservoir content. The reduced residence time offsets some of the additional nitrogen loading. The shorter residence time is not enough to substantially diminish the increased phosphorus loading. Chlorophyll *a* data for Granby Reservoir indicate a growing season of May to July. Average total phosphorus concentrations for the growing season are predicted to be 14.5 µg/l for existing conditions and 16.3 µg/l for the Proposed Action. For total nitrogen, the values are 303 µg/l for existing conditions and 305 µg/l for the Proposed Action. Minimum hypolimnetic DO concentrations would remain unchanged for Alternatives 3, 4, and 5, but would decrease slightly for No Action and the Proposed Action. DO concentrations would be lowest during the years when the reservoir contents are lowest. Under these conditions, the volume of the hypolimnion decreases and does not hold as much DO to meet hypolimnetic demands. TSS concentrations would increase slightly for all action alternatives. None of the alternatives would result in a discernable change in the epilimnetic temperature.

The daily time series of simulated total phosphorus, total nitrogen, chlorophyll *a*, Secchi-disk depth, and hypolimnetic DO for Granby Reservoir are presented in Figure 3-68 through Figure 3-72.

The alternatives were evaluated to determine if water quality standards would be met. Granby Reservoir would continue to meet ammonia and nitrate standards under all alternatives. Manganese concentrations are anticipated to increase because of lower DO concentrations in the hypolimnion under No Action and the Proposed Action; therefore, the manganese water supply standard may continue to be exceeded for all alternatives. DO concentrations would continue to exceed the spawning standard because there is no improvement in DO concentrations for any alternative. Predicted increased drawdowns in Granby Reservoir would expose greater areas of reservoir sediment that may increase suspended sediments in the reservoir during windy conditions or storm events.

The Proposed Action could lead to an increase in reservoir erosion, turbidity, suspended sediment, and phosphorus to Granby Reservoir, although the reservoir currently experiences large swings in contact, so the effect is likely not measurable. This is not accounted for in the Three Lakes Model.

Table 3-71. Average predicted water quality for Granby Reservoir.

Parameter	Average Annual Values Over the 15-Year Model Period and the Range in Daily Values (min – max)					
	Existing Conditions	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (µg/L)	12.6 (4.5 - 25.2)	13.4 (4.5 – 26.3)	14.2 (4.5 – 26.5)	13.1 (4.8 – 22.2)	13.0 (4.8 – 22.1)	12.8 (4.9 - 21.7)
Total nitrogen (µg/L)	289 (228 – 375)	290 (229 - 380)	291 (229 -379)	282 (229 – 360)	281 (229 – 359)	279 (229 - 358)
Chlorophyll *a* (µg/L)	4.2 (2.0 – 7.3)	4.2 (2.0 – 7.2)	4.3 (2.0 – 7.2)	4.2 (2.0 – 7.4)	4.2 (2.0 – 7.4)	4.2 (2.0 - 7.3)
Peak chlorophyll *a* (µg/L)	6.6	6.6	6.5	6.6	6.6	6.6
Secchi-disk depth (m)	3.6 (2.1 – 5.3)	3.6 (2.0 – 5.3)	3.6 (2.0 – 5.3)	3.6 (2.1 – 5.2)	3.6 (2.1 – 5.2)	3.6 (2.1 – 5.1)
Trophic state (Index)	Mesotrophic (46)	Mesotrophic (46)	Mesotrophic (46)	Mesotrophic (46)	Mesotrophic (46)	Mesotrophic (46)
Minimum DO (mg/L)	4.5	4.4	4.3	4.5	4.5	4.5
TSS (mg/L)	2.3 (1.1 – 5.9)	2.3 (1.1 – 6.2)	2.4 (1.1 – 6.3)	2.4 (1.2 – 5.7)	2.4 (1.2 – 5.7)	2.4 (1.1 – 5.7)

Note: All concentrations are for the epilimnion with the exception of minimum DO, which is for the hypolimnion.

Table 3-72. Granby Reservoir predicted water quality changes by alternative compared to existing conditions.

Parameter	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (µg/L)	+6.3%	+12.7%	+4.0%	+3.2%	+1.6%
Total nitrogen (µg/L)	+0.3%	+0.7%	-2.1%	-2.8%	-3.5%
Chlorophyll *a* (µg/L)	No Change	+2.4%	No Change	No Change	No Change
Peak chlorophyll *a* (µg/L)	No Change	-1.5%	No Change	No Change	No Change
Secchi-disk depth (m)	No Change	No Change	No Change	No Change	No Change
Trophic state	No Change	No Change	No Change	No Change	No Change
Minimum DO (mg/L)	-2.2%	-4.4%	No Change	No Change	No Change
TSS (mg/L)	No Change	+4.3%	+4.3%	+4.3%	+4.3%

Figure 3-68. Simulated daily total phosphorus concentrations in Granby Reservoir (existing conditions and all alternatives).

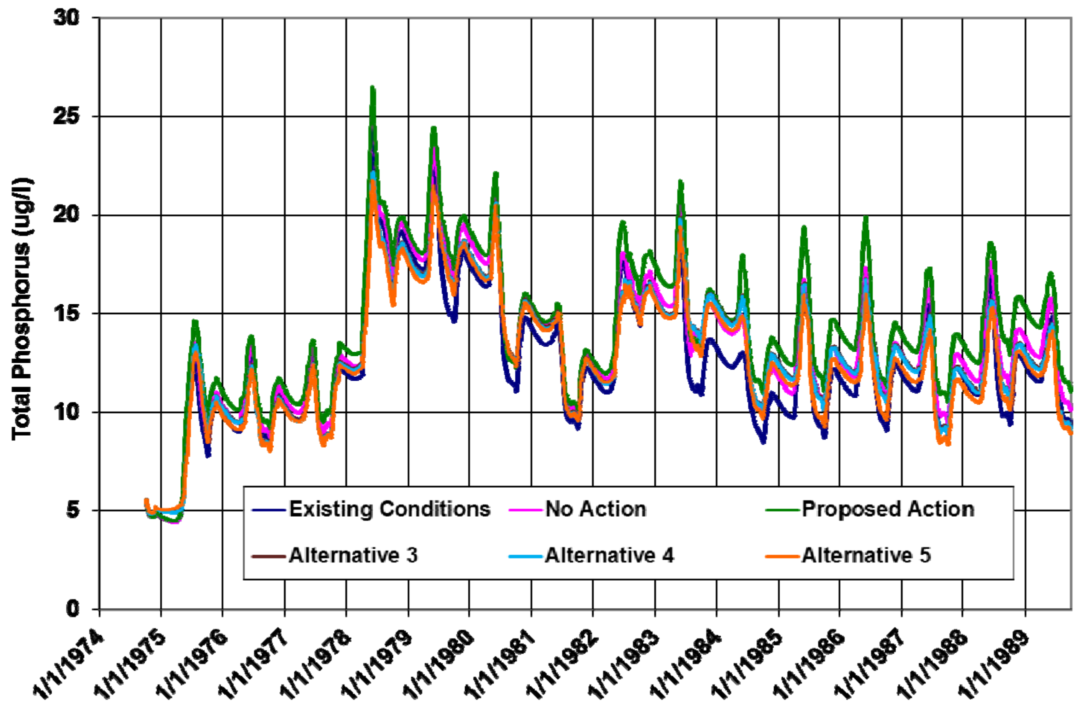


Figure 3-69. Simulated daily total nitrogen concentrations in Granby Reservoir (existing conditions and all alternatives).

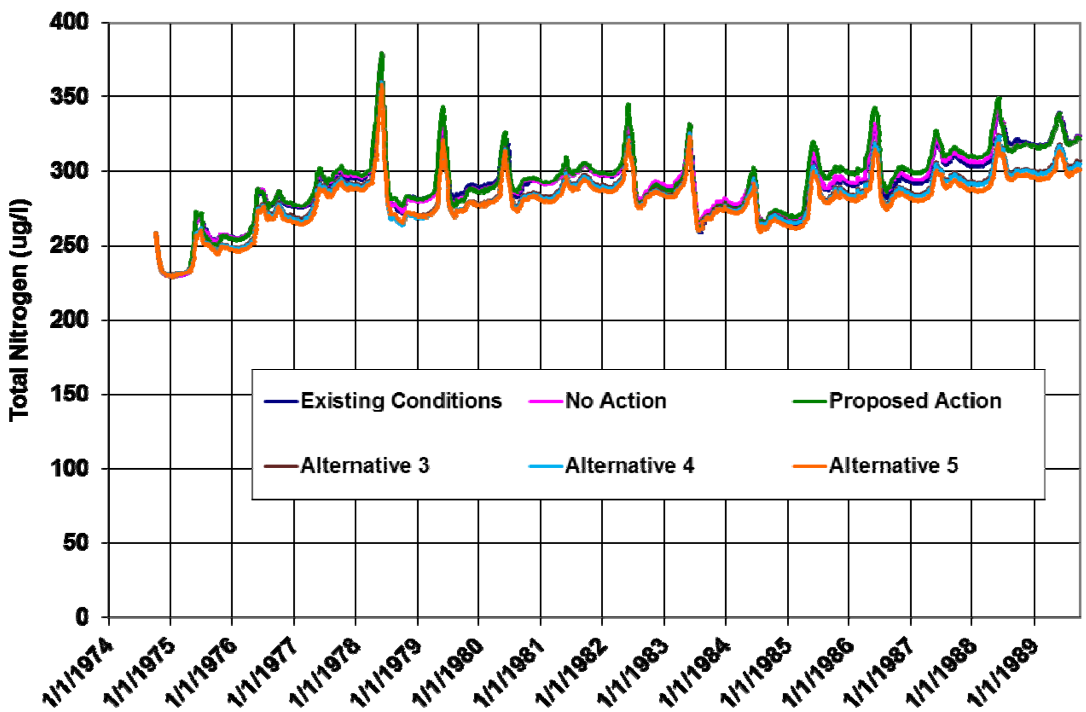


Figure 3-70. Simulated daily chlorophyll a concentrations in Granby Reservoir (existing conditions and all alternatives).

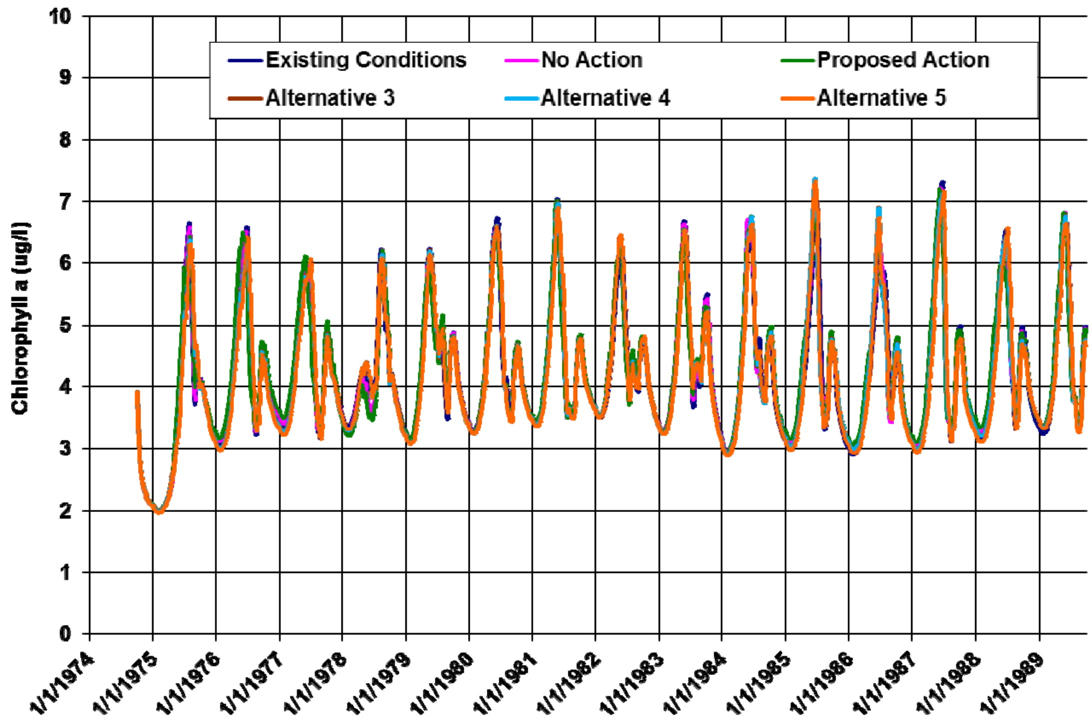


Figure 3-71. Simulated daily Secchi depth in Granby Reservoir (existing conditions and all alternatives).

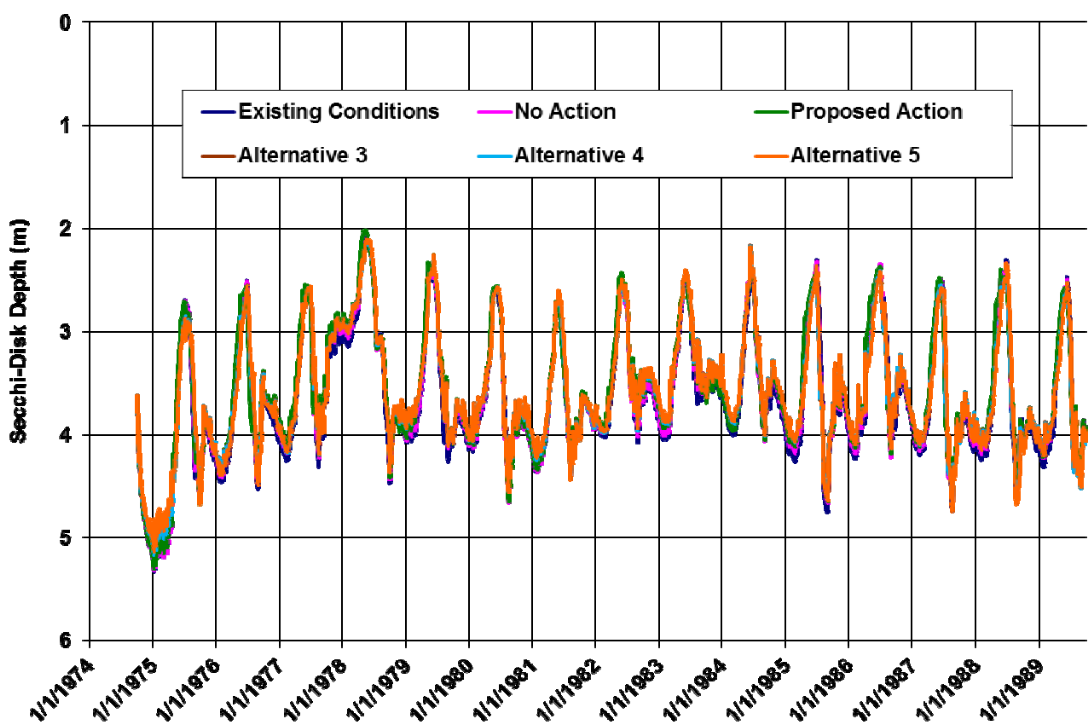
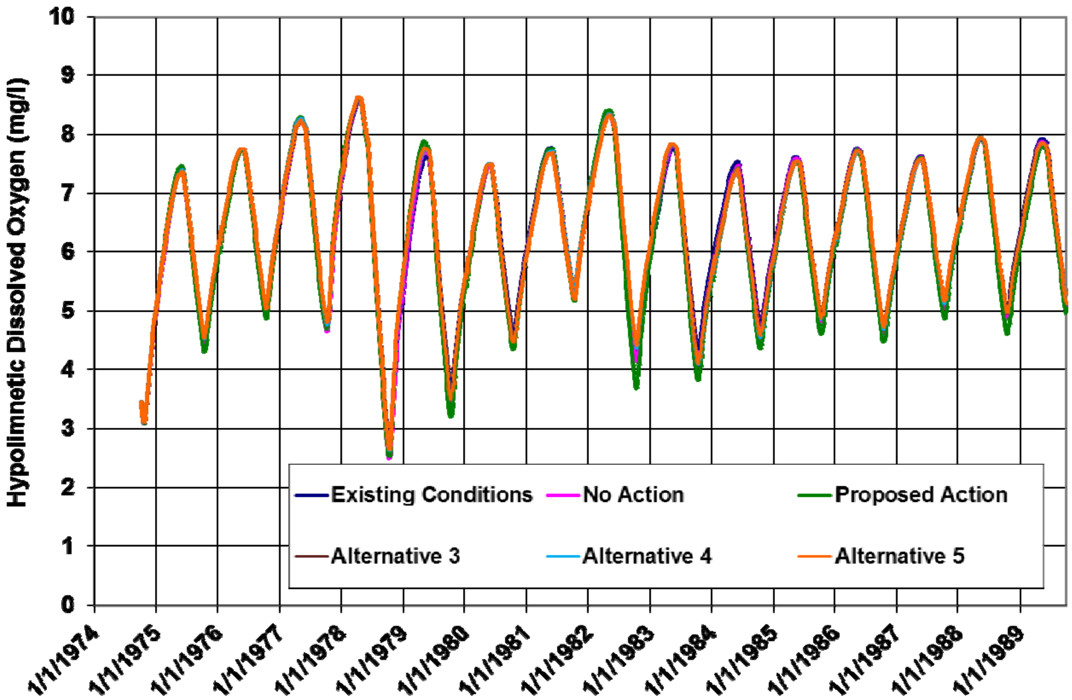


Figure 3-72. Simulated daily hypolimnetic dissolved oxygen in Granby Reservoir (existing conditions and all alternatives).



Although quagga mussel veligers were detected in Granby Reservoir in 2008, there is uncertainty as to whether or not a reproducing adult population can establish in the reservoir due to very low calcium concentrations. Reservoir operations under the alternatives should not impact the potential establishment of quagga mussel populations in the reservoir.

Shadow Mountain Reservoir

Predicted average annual and the range in daily water quality for Shadow Mountain Reservoir under existing conditions and all alternatives are summarized in Table 3-73. Table 3-74 shows the percent change in water quality for each alternative compared to existing conditions. Based on annual averages, Shadow Mountain Reservoir would remain in a mesotrophic state for all alternatives, although on a monthly basis, the trophic state would range between oligotrophic–mesotrophic and eutrophic. Seasonal variations in trophic state for existing conditions and the alternatives show that Shadow Mountain borders on eutrophic conditions during summertime. Average chlorophyll *a* concentrations would increase slightly for all alternatives except Alternatives 4 and 5. Total phosphorus and nitrogen concentrations would increase under all alternatives, with the greatest increase under No Action and the Proposed Action. Peak chlorophyll *a* concentrations would increase the most under the Proposed Action. Chlorophyll *a* data for Shadow Mountain Reservoir indicate a growing season of July to September. Average total phosphorus concentrations for the growing season are predicted to be 11.5 µg/l for existing conditions and 13.1 µg/l for the Proposed Action. For total nitrogen, the values are 256 µg/l for existing conditions and 264 µg/l for the Proposed Action. DO would decrease slightly under the Proposed Action, but would not change under other alternatives. TSS concentrations would increase about 5 percent under all alternatives. The maximum summer temperature would not increase with any of the action alternatives and may be cooler. Potentially lower temperatures could occur as a result of the additional volume of water flowing through the reservoir. The largest potential decrease in temperature would be in August, the month when exceedance of temperature standards is most likely. The Proposed Action, which has the greatest pumping through the Farr Pumping Plant in August, is most likely to reduce temperatures.

Table 3-73. Average predicted water quality for Shadow Mountain Reservoir.

Parameter	Average Annual Values Over the 15-Year Model Period and the Range in Daily Values (min - max)					
	Existing Conditions	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (µg/L)	12.4 (1.9 -20.3)	13.1 (4.9 – 22.5)	13.8 (4.9 -23.8)	13.4 (5.2 -21.7)	13.0 (5.2 -21.7)	12.8 (5.3 – 20.9)
Total nitrogen (µg/L)	275 (190 – 330)	278 (198 – 332)	280 (197 -333)	276 (197 -316)	273 (197 – 315)	272 (197 - 314)
Chlorophyll *a* (µg/L)	5.7 (1.8 – 10.5)	5.8 (1.7 – 11.2)	5.8 (1.7 – 11.2)	5.8 (1.6 – 11.1)	5.7 (1.6 – 11.0)	5.7 (1.6 – 11.4)
Peak chlorophyll *a* (µg/L)	8.8	9.1	9.4	8.9	8.8	8.7
Secchi-disk depth (m)	2.0 (1.4 – 3.0)	2.0 (1.3 – 3.0)	2.0 (1.3 – 3.1)	2.0 (1.3 - 3.1)	2.0 (1.3 - 3.2)	2.0 (1.3 – 3.2)
Trophic state (Index)	Mesotrophic (48)	Mesotrophic (48)	Mesotrophic (48)	Mesotrophic (48)	Mesotrophic (48)	Mesotrophic (48)
Minimum DO (mg/L)	7.1	7.1	7.0	7.1	7.1	7.1
TSS (mg/L)	2.0 (1.1 – 5.3)	2.1 (1.1 – 5.5)	2.1 (1.1 – 5.5)	2.1 (1.1 – 5.5)	2.1 (1.1 – 5.5)	2.1 (1.1 – 5.4)

Note: All concentrations are for the epilimnion with the exception of minimum DO, which is for the hypolimnion.

Table 3-74. Shadow Mountain Reservoir predicted water quality changes by alternative compared to existing conditions.

Parameter	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (µg/L)	+5.6%	+11.3%	+8.1%	+4.8%	+3.2%
Total nitrogen (µg/L)	+1.1%	+1.8%	+0.4%	-0.7%	-1.1%
Chlorophyll *a* (µg/L)	+1.8%	+1.8%	+1.8%	No Change	No Change
Peak chlorophyll *a* (µg/L)	+3.4%	+6.8%	+1.1%	No Change	-1.1%
Secchi-disk depth (m)	No Change	No Change	No Change	No Change	No Change
Trophic state	No Change	No Change	No Change	No Change	No Change
Minimum DO (mg/L)	No Change	-1.4%	No Change	No Change	No Change
TSS (mg/L)	+5.0%	+5.0%	+5.0%	+5.0%	+5.0%

The daily time series of simulated total phosphorus, total nitrogen, chlorophyll *a*, Secchi-disk depth, and hypolimnetic DO for Shadow Mountain Reservoir are presented in Figure 3-73 through Figure 3-77.

Figure 3-73. Simulated daily total phosphorus concentrations in Shadow Mountain Reservoir (existing conditions and all alternatives).

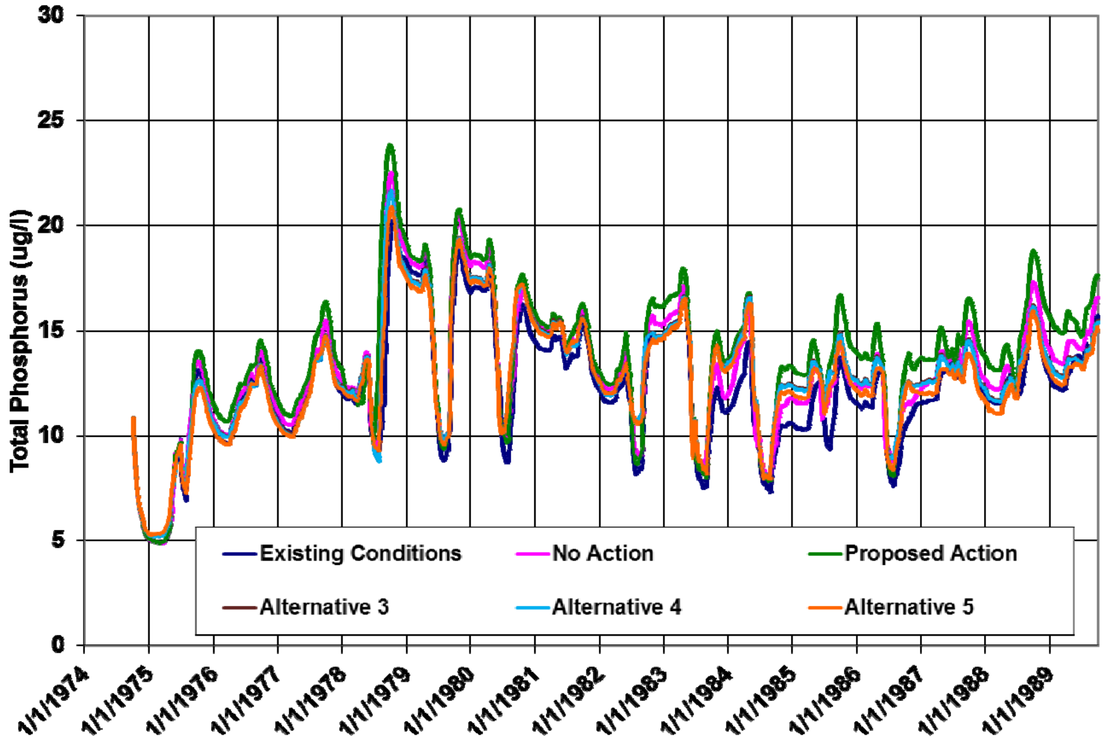


Figure 3-74. Simulated daily total nitrogen concentrations in Shadow Mountain Reservoir (existing conditions and all alternatives).

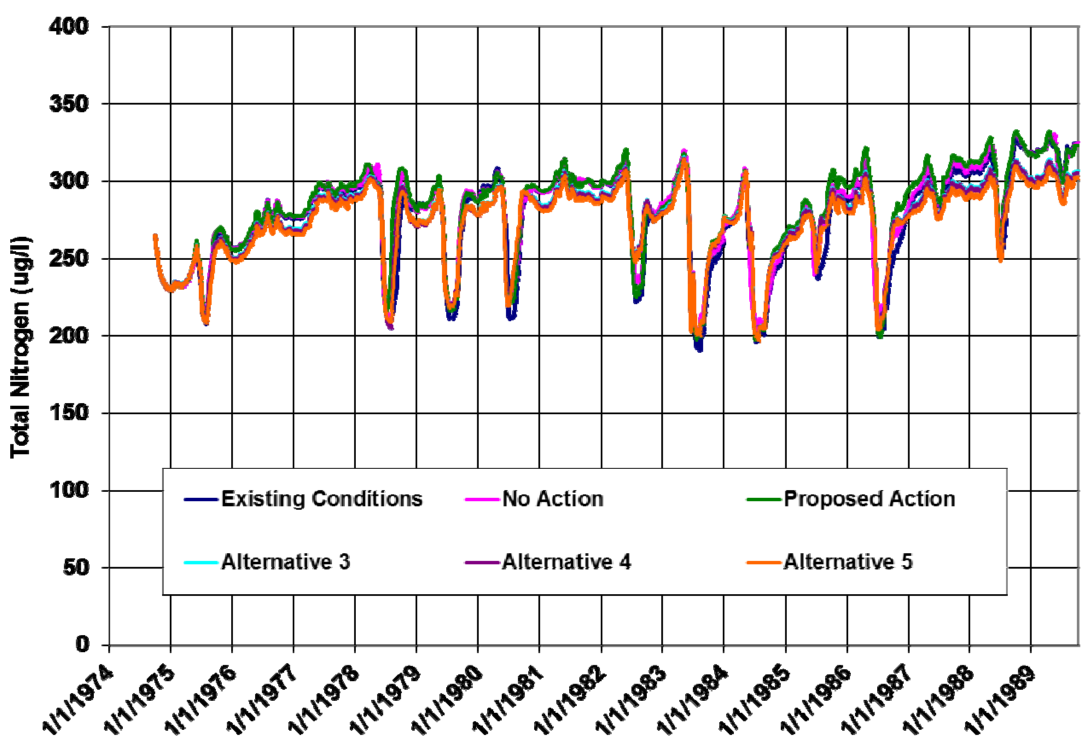


Figure 3-75. Simulated daily chlorophyll *a* concentrations in Shadow Mountain Reservoir (existing conditions and all alternatives).

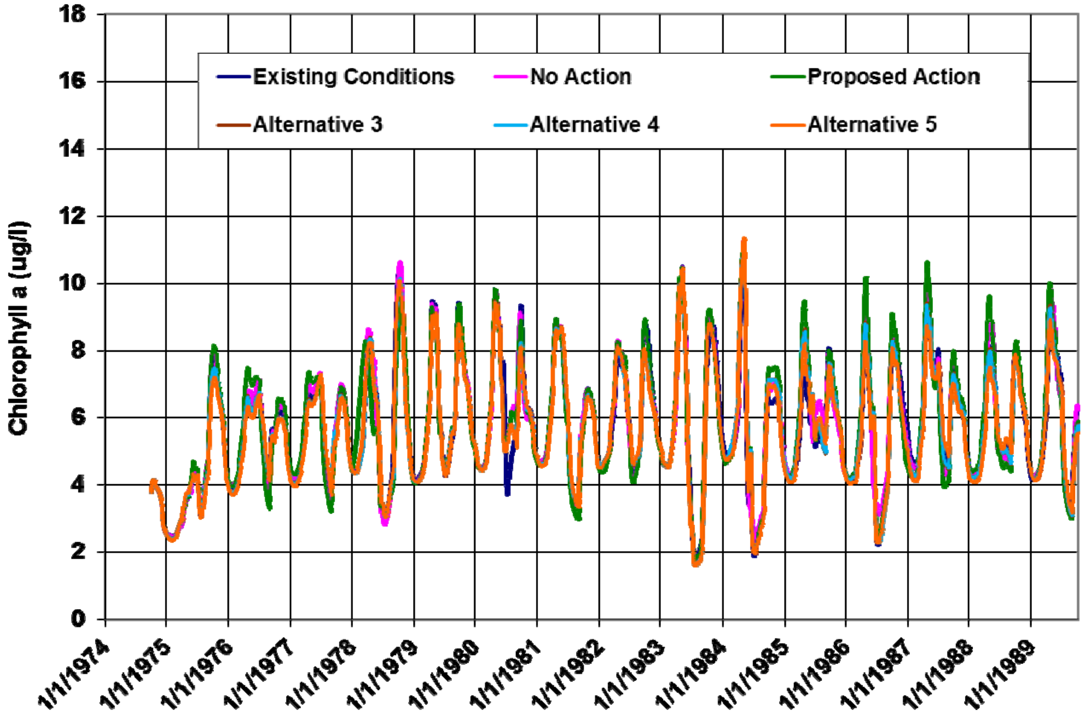


Figure 3-76. Simulated daily Secchi depth in Shadow Mountain Reservoir (existing conditions and all alternatives).

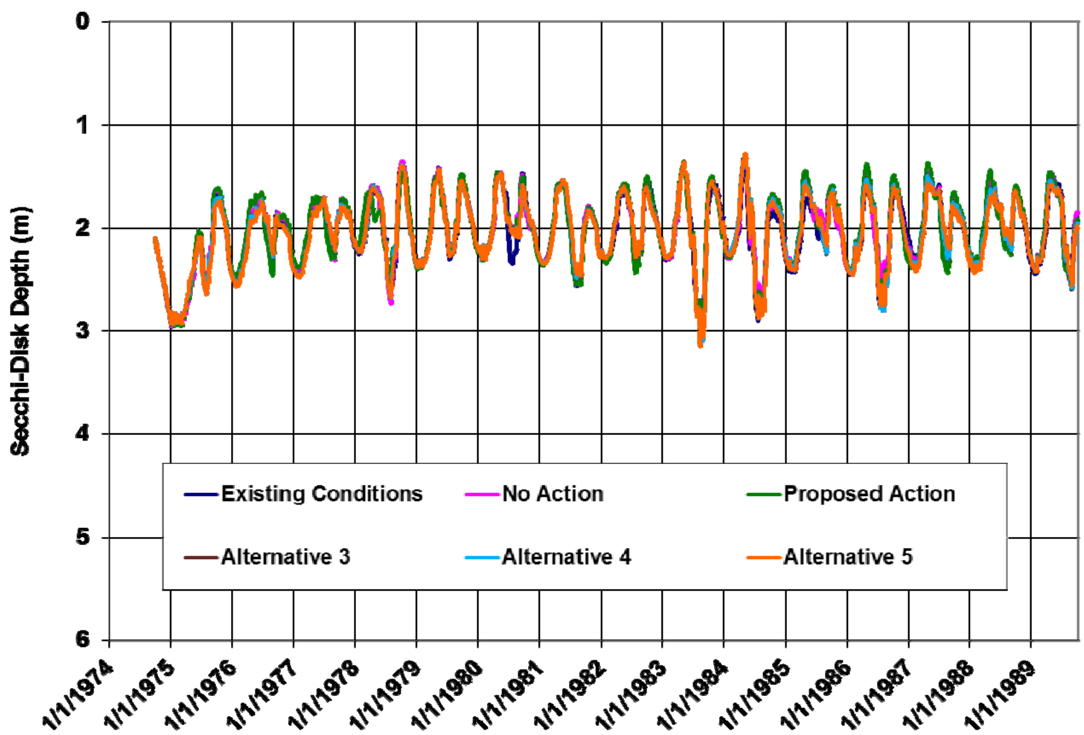
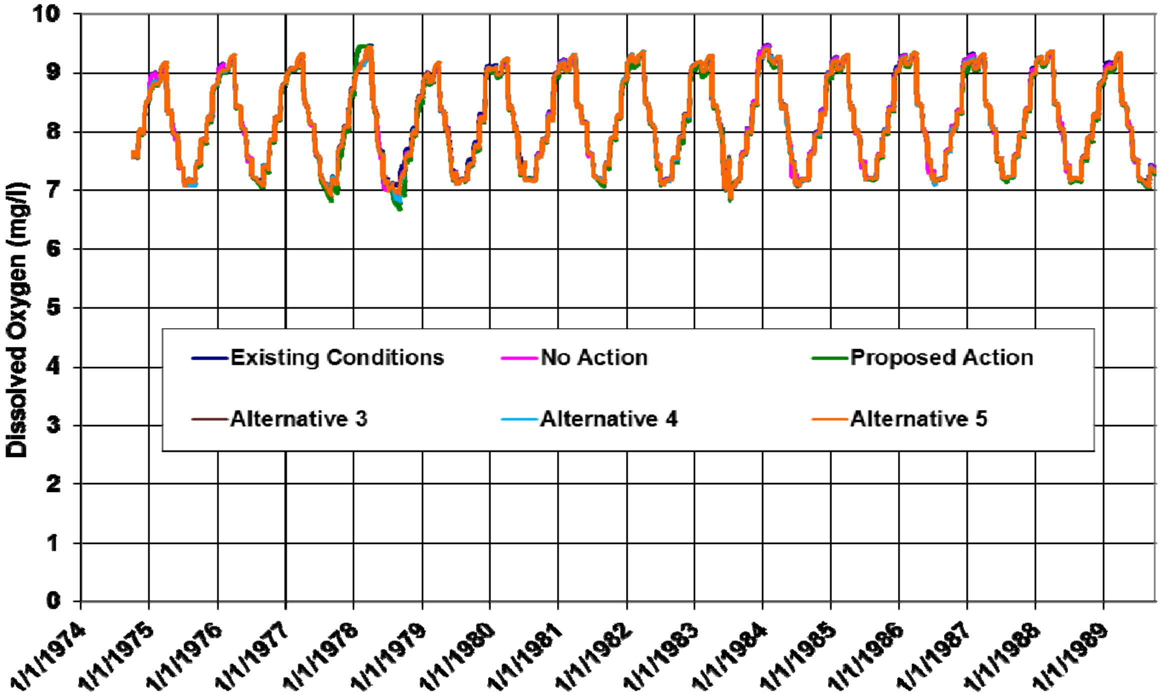


Figure 3-77. Simulated daily dissolved oxygen in Shadow Mountain Reservoir (existing conditions and all alternatives).



Because the change in nutrient concentrations would be very low for all alternatives, no change in the amount and type of aquatic vegetation (macrophytes) in Shadow Mountain Reservoir is likely. Rooted aquatic plants generally meet their nutrient needs directly from the sediments (Barko et al. 1986). Thus, they can thrive even in oligotrophic systems (Cooke et al. 2005). Therefore, changes in nutrient concentrations cannot be expected to result in changes in macrophyte growth and biomass (Cooke et al. 2005) and although there are anticipated changes in nutrient concentrations associated with the alternatives, it is not anticipated that these changes would aggravate the macrophyte problem.

Shadow Mountain Reservoir would continue to meet DO, ammonia, and nitrate standards. It is anticipated that manganese concentrations would stay about the same for each alternative with the exception of the Proposed Action, which is predicted to result in slightly increased manganese concentrations based on the minimum DO concentrations in the hypolimnion. Thus, the manganese water supply standard may not be met under any alternative, similar to existing conditions. The temperature standard would continue to be met under all alternatives.

Although quagga mussel veligers were detected in Shadow Mountain Reservoir in 2008, there is uncertainty as to whether or not a reproducing adult population can establish in the reservoir due to very low calcium concentrations. Reservoir operations under the alternatives should not impact the potential establishment of quagga mussel populations in the reservoir.

Grand Lake

Predicted water quality for Grand Lake under existing conditions and all alternatives is summarized in Table 3-75. Table 3-76 shows the percent change in water quality for each alternative compared to existing conditions. The average trophic state would remain mesotrophic under all alternatives. Secchi-disk depth would decrease about 0.1 meter under all alternatives except Alternative 5, which would not change. Average and peak chlorophyll *a* concentrations would increase under all alternatives, except peak chlorophyll *a* would not change under Alternative 5. The No Action Alternative and Proposed Action would result in the highest peak chlorophyll *a* concentrations. Phosphorus concentrations would increase under all alternatives. The Proposed Action would increase the phosphorus concentrations the most, with a 12 percent increase over existing conditions. There would be a slight increase in total nitrogen concentrations under No Action and the Proposed Action, and a slight decrease under Alternatives 3, 4, and 5. The higher flushing rate would offset some of the increased nitrogen loading. Chlorophyll *a* data for Grand Lake indicate a growing season of July to September. Average total phosphorus concentrations for the growing season are predicted to be 7.7 μg/l for existing conditions and 9.2 μg/l for the Proposed Action. Total nitrogen concentrations are predicted to be 239 μg/l for existing conditions and 248 μg/l for the Proposed Action. Hypolimnetic DO concentrations would decrease under all alternatives, with the greatest change under the No Action Alternative. TSS concentrations would increase 5.6 percent for the Proposed Action and Alternatives 3 and 4, and would not change for the other alternatives. None of the alternatives are predicted to increase the temperature of the epilimnion.

Table 3-75. Average predicted water quality for Grand Lake.

Parameter	Average Annual Values Over the 15-Year Model Period and the Range in Daily Values (min - max)					
	Existing Conditions	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (μg/L)	8.3 (4.3 – 13.7)	8.8 (4.1 – 17.0)	9.3 (4.2 – 19.9)	8.8 (4.2 – 16.7)	8.8 (4.2 – 16.7)	8.7 (4.2 – 15.6)
Total nitrogen (μg/L)	247 (174 – 330)	248 (157 – 348)	251 (156 – 329)	246 (164 – 334)	246 (163 -334)	245 (163 - 333)
Chlorophyll *a* (μg/L)	4.9 (2.1 – 10.2)	5.1 (2.2 – 10.5)	5.2 (2.2 – 9.7)	5.1 (2.2 – 10.2)	5.0 (2.1 – 10.2)	5.0 (2.1 – 10.2)
Peak chlorophyll *a* (μg/L)	7.4	7.7	7.8	7.5	7.5	7.4
Secchi-disk depth (m)	2.6 (1.3 – 4.3)	2.5 (1.3 – 3.9)	2.5 (1.4 – 4.3)	2.5 (1.3 – 4.2)	2.5 (1.3 – 4.2)	2.6 (1.3 – 4.2)
Trophic state (Index)	Mesotrophic (47)	Mesotrophic (47)	Mesotrophic (47)	Mesotrophic (47)	Mesotrophic (47)	Mesotrophic (47)
Minimum DO (mg/L)	5.4	4.8	5.0	5.1	5.1	5.1
TSS (mg/L)	1.8 (1.0 – 4.1)	1.8 (1.1 – 4.3)	1.9 (1.1 – 4.2)	1.9 (1.2 – 4.2)	1.9 (1.2 – 4.2)	1.8 (1.2 – 4.2)

Note: All concentrations are for the epilimnion with the exception of minimum DO, which is for the hypolimnion.

Table 3-76. Grand Lake predicted water quality changes by alternative compared to existing conditions.

Parameter	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (μg/L)	+6.0%	+12.0%	+6.0%	+6.0%	+4.8%
Total nitrogen (μg/L)	+0.4%	+1.6%	-0.4%	-0.4%	-0.8%
Chlorophyll *a* (μg/L)	+4.2%	+6.1%	+4.2%	+2.0%	+2.0%
Peak chlorophyll *a* (μg/L)	+4.1%	+5.4%	+1.4%	+1.4%	No Change
Secchi-disk depth (m)	-3.8%	-3.8%	-3.8%	-3.8%	No Change
Trophic state	No Change	No Change	No Change	No Change	No Change
Minimum DO (mg/L)	-11.1%	-7.4%	-5.6%	-5.6%	-5.6%
TSS (mg/L)	No Change	+5.6%	+5.6%	+5.6%	No Change

The daily time series of simulated total phosphorus, total nitrogen, chlorophyll *a*, Secchi-disk depth, and hypolimnetic DO for Grand Lake are presented in Figure 3-78 through Figure 3-82.

Figure 3-78. Simulated daily total phosphorus concentrations in Grand Lake (existing conditions and all alternatives).

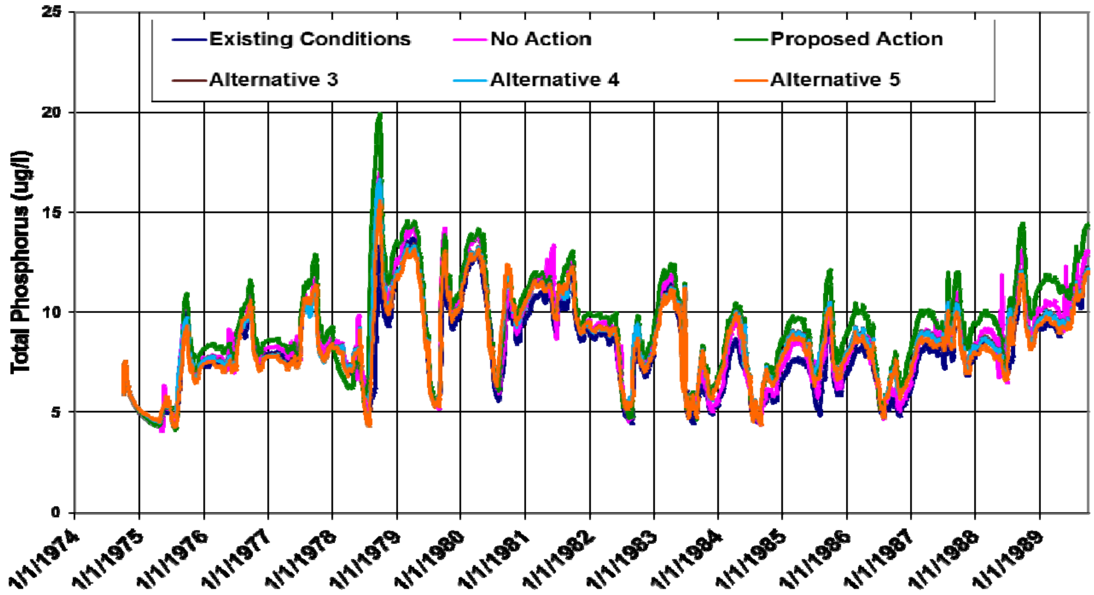


Figure 3-79. Simulated daily total nitrogen concentrations in Grand Lake (existing conditions and all alternatives).

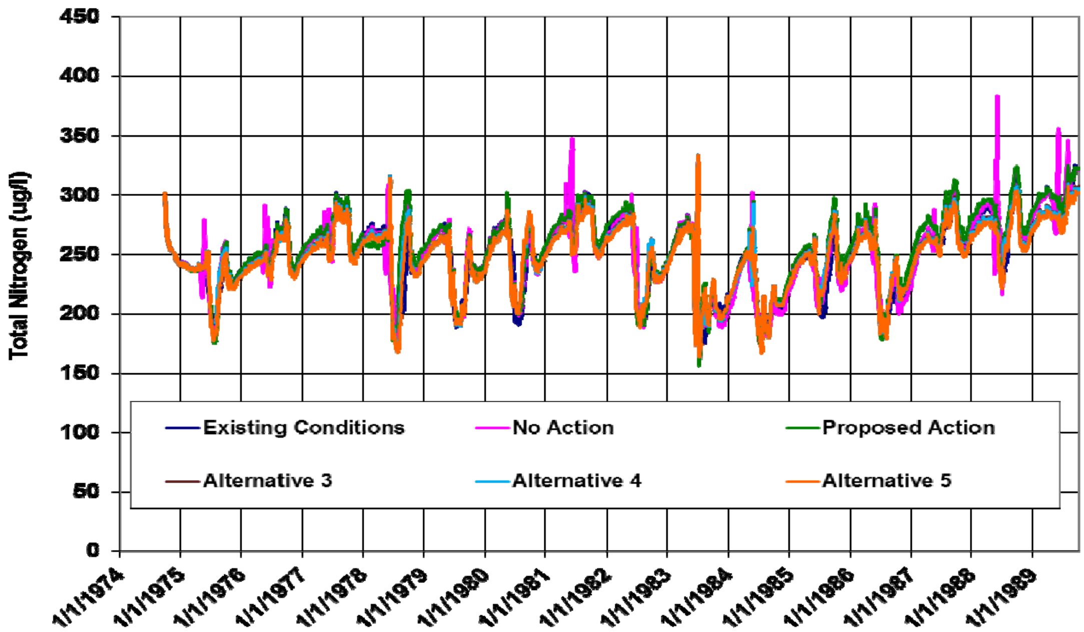


Figure 3-80. Simulated daily chlorophyll *a* concentrations in Grand Lake (existing conditions and all alternatives).

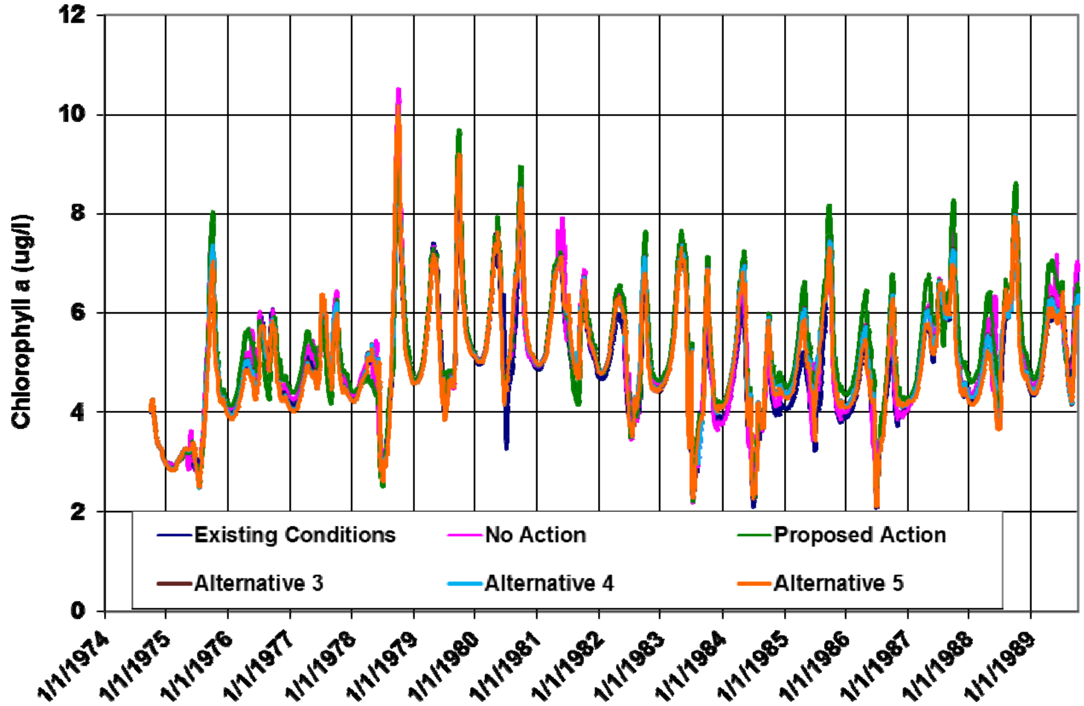


Figure 3-81. Simulated daily Secchi depth in Grand Lake (existing conditions and all alternatives).

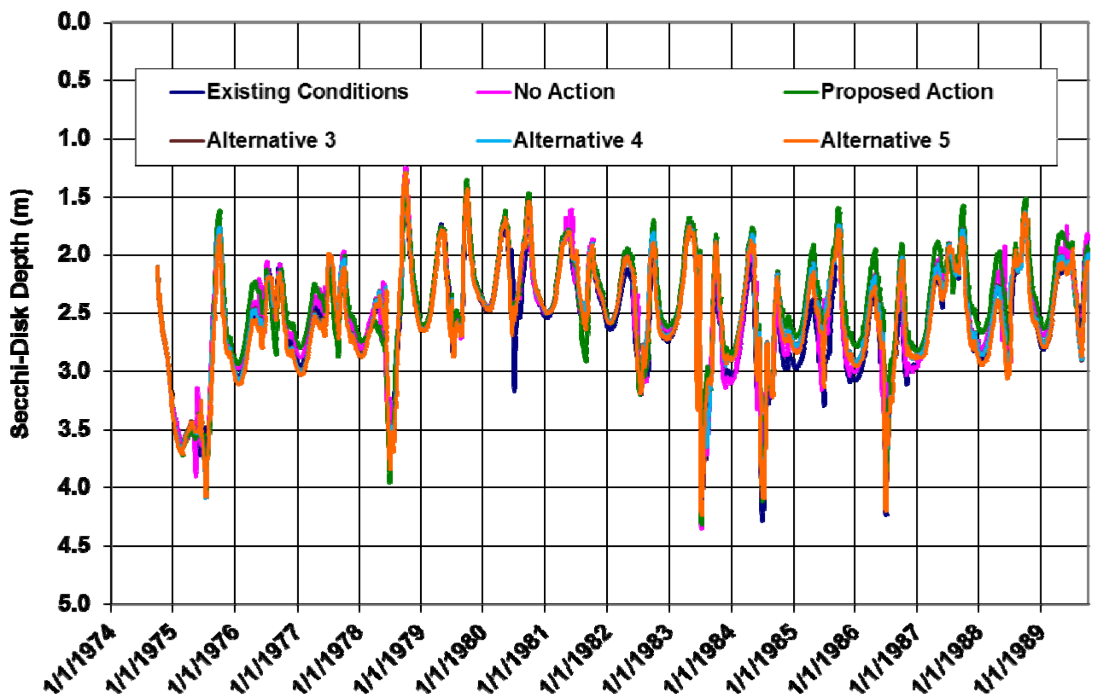
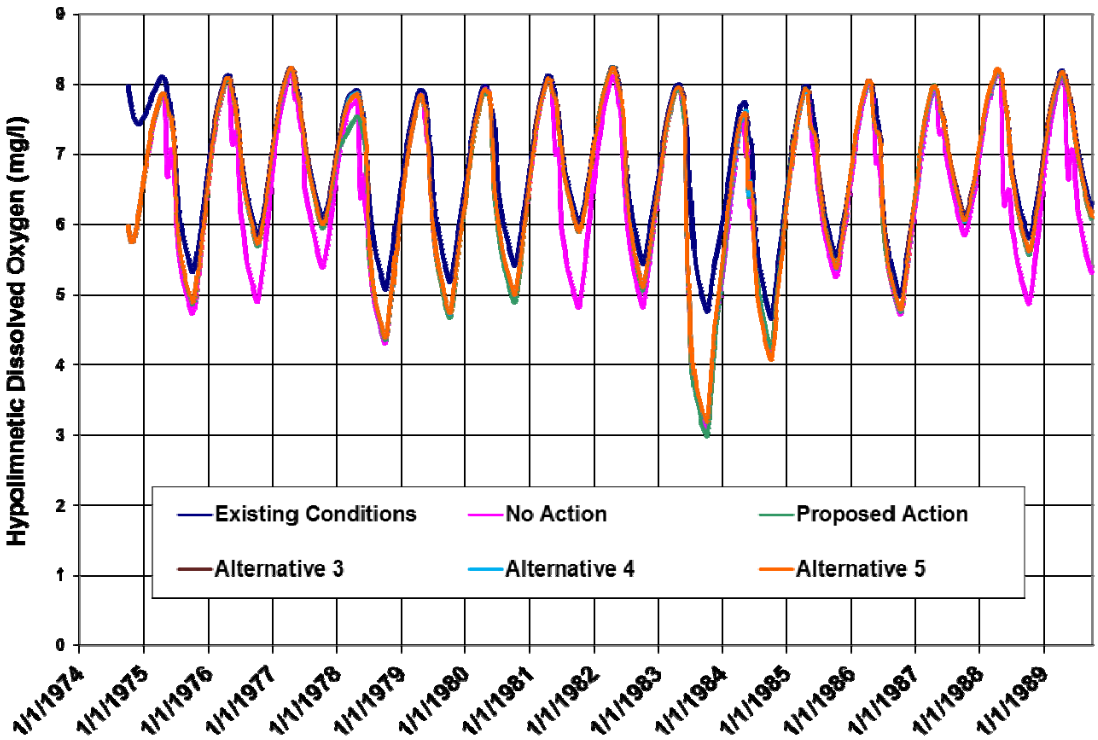


Figure 3-82. Simulated daily hypolimnetic dissolved oxygen in Grand Lake (existing conditions and all alternatives).



Grand Lake would continue to meet DO, ammonia, and nitrate standards. It is anticipated that manganese concentrations would increase over existing conditions due to lower DO concentrations in the hypolimnion. It is predicted that the No Action Alternative would result in the highest manganese concentrations and the Proposed Action alternative would result in the second highest concentrations and would likely exceed standards. There is no indication that temperature standards would be exceeded. In addition, there is no evidence to suggest that pH would decrease more under any alternative; therefore, the pH standard is predicted to be exceeded under all alternatives, similar to existing conditions.

Although quagga and zebra mussel veligers were detected in Grand Lake in 2008, there is uncertainty as to whether reproducing adult populations can establish in the lake due to very low calcium concentrations. Operations under the alternatives should not impact the potential establishment of quagga and zebra mussel populations in the lake.

Jasper East

The water quality for Jasper East Reservoir under Alternative 3 was predicted using the BATHTUB model. The reservoir is predicted to be oligotrophic to mesotrophic (Table 3-77). Jasper East Reservoir would retain some nitrogen and phosphorus; therefore, nutrient deliveries to Granby Reservoir would be reduced. Rapid filling and drawdown could lead to an increase in reservoir erosion, turbidity, and suspended sediment delivery to Granby Reservoir.

Table 3-77. Average predicted water quality for Jasper Reservoir.

Parameter	Average Annual Values Over the 15-Year Model Period
Total phosphorus (µg/L)	30
Total nitrogen (µg/L)	246
Chlorophyll *a* (µg/L)	2.3
Secchi-disk depth (m)	3.3
Trophic state (Index)	Oligotrophic - Mesotrophic (39)

Rockwell/Mueller Creek Reservoir

A 20,000 AF Rockwell Reservoir under Alternative 4 and a 30,000-AF reservoir under Alternative 5 would have similar water quality (Table 3-78). The trophic state is predicted to be oligotrophic to mesotrophic for either size of reservoir. Nutrient and chlorophyll *a* concentrations would be slightly lower for Alternative 5 than Alternative 4, primarily due to a higher flushing rate for Alternative 5. Rockwell Reservoir would retain some nitrogen and phosphorus, thereby reducing nutrient deliveries to Granby Reservoir. Rapid filling and drawdown could lead to an increase in reservoir erosion, turbidity, and suspended sediment delivery to Granby Reservoir.

Table 3-78. Average predicted water quality for Rockwell Reservoir.

Parameter	Average Annual Values Over the 15-Year Model Period	
	Alternative 4	Alternative 5
Total phosphorus (µg/L)	28	26
Total nitrogen (µg/L)	229	214
Chlorophyll *a* (µg/L)	1.8	1.4
Secchi-disk depth (m)	3.4	3.5
Trophic state (Index)	Oligotrophic-Mesotrophic (36)	Oligotrophic-Mesotrophic (34)

3.8.2.5 East Slope Effects

Big Thompson River

Additional Windy Gap deliveries to the East Slope would increase flows in the Big Thompson River below Lake Estes as described in Section 3.5.2.3. A maximum average monthly flow increase in the Big Thompson River of 9 percent under the Proposed Action would result in a slight increase in nitrogen and phosphorus concentrations from the Adams Tunnel deliveries (<0.01 mg/L). Other alternatives, including No Action, would import less water and would have slightly lower increases in nitrogen and phosphorus concentrations. The small increases in flow under all alternatives would have minimal effects on stream temperatures.

Big Thompson River flows also would increase farther downstream due to additional discharges from the Loveland WWTP (Figure 3-2). Increases in flow would occur from May to October, with the greatest percent increase in October. Given that ammonia concentrations occasionally exceed the chronic and acute standard under existing low flow, potential changes in ammonia concentrations were calculated for the alternatives. Because data on copper concentrations were available for stream and effluent discharge, changes to copper concentrations were also evaluated. Under all alternatives, ammonia concentrations in the Big Thompson River would decrease slightly from existing conditions because effluent ammonia levels are, on average, lower than in the river. Additional WWTP discharges would have a greater influence on stream concentrations, thus reducing ammonia concentrations (Table 3-79). A slight reduction in the potential for exceeding the ammonia standard is possible under all alternatives. Copper concentrations would increase under all alternatives, but would not exceed water quality standards.

Table 3-79. Big Thompson River average ammonia and copper concentrations in October below the Loveland wastewater treatment plant (WWTP).

Parameter	Standard	Existing Conditions	WWTP Effluent Concentrations[1]	No Action		All Other Alternatives	
		Average	Average	Average	Change	Average	Change
Ammonia (mg/L)	2.86	1.44	1.4	1.06	-0.38	1.21	-0.23
Copper (µg/L)	29.0	2.94	8.06	4.57	1.63	4.87	1.93

[1] Data are from EPA Envirofacts (http://www.epa.gov/enviro).

North St. Vrain Creek

Streamflow in North St. Vrain Creek below Ralph Price Reservoir would experience both increases and decreases in average monthly flows under the No Action Alternative. As discussed later, water quality in a larger Ralph Price Reservoir is expected to improve and, therefore, releases to the North St. Vrain Creek would also improve stream water quality. Projected decreases in flow in May and July are estimated to increase stream temperatures in North St. Vrain Creek by up to 1°C from existing July temperatures of about 12°C, which is well below the MWAT and DM temperature standards. Increased North St. Vrain Creek streamflows in September and October would decrease stream temperatures up to 5°C.

DO concentrations in North St. Vrain Creek under the No Action Alternative are predicted to decrease by less than 0.5 mg/L during months with reduced flow and increase from 0.5 to 2 mg/L during months with higher flows. A slight reduction in the DO concentration as a result of reduced flow would not reduce the DO concentrations to below the standard of 6 mg/L.

Manganese concentrations in North St. Vrain Creek have exceeded drinking water standards only during very low flows (<15 cfs). The No Action Alternative would not reduce flows below 15 cfs during any month. Given that other water quality constituents have low concentrations during all flow levels under existing conditions and that predicted changes in flow are well within the historical range, water quality in North St. Vrain Creek is expected to be similar to historical conditions.

St. Vrain Creek

Under the No Action Alternative, the changes in flow in North St. Vrain Creek would affect flow in St. Vrain Creek to the St. Vrain Supply Canal near Lyons (Figure 3-7). Based on the magnitude of these flow changes in relation to existing water quality; temperature, DO, and other water quality parameters would be minimally affected and would not result in any exceedances of water quality standards.

St. Vrain Creek flow would increase from April to October from additional effluent discharges below Longmont's WWTP and the St. Vrain Sanitation District WWTP under all alternatives (Figure 3-2). The largest percent increase above existing flow would occur in October. Impacts to ammonia concentrations in St. Vrain Creek were evaluated for October because the chronic ammonia standard is occasionally exceeded during existing conditions at low flows during that month. Predicted increases in ammonia concentrations for October under all of the alternatives approach, but do not exceed the standard (Table 3-80). The No Action Alternative would result in higher ammonia concentrations than the other alternatives because of higher potential maximum WWTP discharges. Under all alternatives, the potential for exceedance of the ammonia standard would increase.

Table 3-80. St. Vrain Creek average changes in ammonia concentrations in October below the Longmont wastewater treatment plant (WWTP) under all of the WGFP alternatives.

Parameter	Standard	Existing Conditions	WWTP Effluent Concentrations[1]	No Action		All Other Alternatives	
		Average	Average	Average	Change	Average	Change
Ammonia (mg/L)	2.86	1.3	5.2	2.71	1.41	2.5	1.2

[1] Data are from EPA Envirofacts (http://www.epa.gov/enviro).

A similar evaluation was conducted for ammonia for St. Vrain Creek below the St. Vrain Sanitation District WWTP (Figure 3-2). Existing ammonia concentrations in the stream are low. Ammonia concentrations would increase under the alternatives, but would not exceed the standard (Table 3-81).

Table 3-81. St. Vrain Creek average changes in ammonia concentrations in October below the St. Vrain wastewater treatment plant (WWTP) under the No Action Alternative.

Parameter	Standard	Existing Conditions	WWTP Effluent Concentrations[1]	All Alternatives	
		Average	Average	Average	Change
Ammonia (mg/L)	2.86	0.155	1.05	0.161	0.006

[1] Data are from EPA Envirofacts (http://www.epa.gov/enviro).

Big Dry Creek

Increased WWTP return flows to Big Dry Creek below Broomfield's WWTP from April to October would occur under all alternatives (Figure 3-2). Changes in ammonia, iron, and manganese concentrations, which already occasionally exceed standards, were calculated for October, the month when the largest percent flow increase would occur. The predicted increase in the ammonia concentrations would not exceed the ammonia standard, but the potential for exceedances would increase (Table 3-82).

Ammonia concentrations in St. Vrain Creek, Big Dry Creek, Coal Creek, and the Cache la Poudre River would increase slightly as a result of additional discharges from Participant WWTPs under all of the alternatives. No exceedances of the stream standard are predicted.

Iron concentrations would decrease under all alternatives because WWTP discharges have lower concentrations than the stream (Table 3-82). Manganese concentrations would likewise decrease for all alternatives.

Table 3-82. Big Dry Creek average changes in ammonia, iron, and manganese concentrations in October below the Broomfield wastewater treatment plant (WWTP) under all of the WGFP alternatives.

Parameter	Standard	Existing Conditions	WWTP Effluent Concentrations[1]	All Alternatives	
		Average	Average	Average	Change
Ammonia (mg/L)	2.86	1.05	2	2.41	1.36
Iron (µg/L)	1,000	1,090	161	461	-629
Manganese (µg/L)	200	80	9.74	31.4	-48.6

[1] Data are from EPA Envirofacts (http://www.epa.gov/enviro).

Coal Creek

From April to October, streamflow in Coal Creek would increase by a monthly average maximum of about 5 cfs from additional WWTP discharges for Superior, Louisville, Lafayette, and Erie under all alternatives. Currently WWTP discharges provide the majority of Coal Creek flow for this portion of the creek. A quantitative analysis of effects to water quality was not conducted because of a lack of baseline data. Available data indicate low existing ammonia concentrations in Coal Creek (0.07 mg/L), while the ammonia concentrations in the four WWTP effluent discharges range from less than 0.03 mg/L to occasionally greater than 10 mg/L. A higher volume of WWTP discharges would increase ammonia concentrations in Coal Creek and would increase the potential for exceeding the ammonia standard, particularly during low flows.

Cache la Poudre River

The Cache la Poudre River average monthly streamflows would increase up to 8.4 cfs from November to March under the No Action Alternative, and up to 7 cfs under the other alternatives from additional discharges below Greeley's WWTP (Figure 3-2). For the No Action Alternative, the largest flow increase would occur in November. For the other alternatives, the largest increase would occur in January. Ammonia concentrations would increase about the same amount under all alternatives, but would not exceed the standard (Table 3-83). Copper concentrations would increase slightly, but would remain below the standard for all alternatives.

Table 3-83. Cache la Poudre River average changes in ammonia and copper concentrations below Greeley's wastewater treatment plant (WWTP) under all of the WGFP alternatives.

Parameter	Standard	Existing Conditions	WWTP Effluent Concentrations[1]	No Action (November)		Alternatives 2 to 5 (January)	
		Average	Average	Average	Change	Average	Change
Ammonia (mg/L)	2.86	0.66	4.79	1.4	0.74	1.37	0.71
Copper (µg/L)	29	2	11.1	3.64	1.64	3.56	1.56

[1] Data are from EPA Envirofacts (http://www.epa.gov/enviro).

Currently, the average annual Windy Gap delivery to Greeley on the Poudre River is 725 AF; under the WGFP, the total firm yield exchanged into the Poudre River via Horsetooth Reservoir would be 1,115 AF. However, on the way to the Poudre River, the Windy Gap water would be commingled several times and would be dominated by a much greater volume of C-BT water. It is expected that water quality effects to the Poudre River at Greeley would be minor due to the commingling of a relatively small amount of WGFP water.

Existing Wastewater Treatment Facilities

WQCC regulations for domestic wastewater treatment facilities require the permitted facility to initiate engineering and financial planning for expansion of the wastewater treatment facility whenever the treatment volume reaches 80 percent of the 30-day average design capacity identified in the facility's certification to discharge. Expansion of the wastewater treatment facility must begin when the treatment volume reaches 95 percent of the existing 30-day average design capacity. As Participant water use and water treatment increases in the future, wastewater facility upgrades would be required with or without the WGFP. In addition, wastewater facility discharge permits must be renewed on a regular basis; such renewals and possible associated upgrades would occur with or without the WGFP.

Chimney Hollow and Dry Creek

Streamflow in the short reach of Chimney Hollow below the new reservoir would be composed primarily of seepage from the reservoir and would have water quality characteristics similar to the new reservoir, as discussed later. Dry Creek water quality would be similar to that described below for Dry Creek Reservoir. All water quality parameters are predicted to meet standards below both reservoirs (Hydrosphere 2007).

Ralph Price Reservoir

A summary of estimated water quality changes for the enlargement of Ralph Price Reservoir under the No Action Alternative is shown in Table 3-84. Ralph Price Reservoir would remain in an oligotrophic state with a slight improvement in water quality from a larger and deeper reservoir. Nutrient and chlorophyll *a* concentrations would decrease slightly from existing conditions. Metalimnetic and hypolimnetic oxygen demands are expected to decrease; therefore, DO concentrations would likely increase. The larger reservoir would likely have slightly lower temperatures. Ralph Price Reservoir would continue to meet DO, ammonia, nitrate, dissolved manganese, and temperature standards.

Table 3-84. Average predicted water quality for Ralph Price Reservoir.

Parameter	Average Annual Values Over the 15-Year Model Period	
	Existing Conditions	No Action
Total phosphorus (µg/L)	5.1	4.9
Total nitrogen (µg/L)	188	177
Chlorophyll *a* (µg/L)	0.6	0.4
Secchi-disk depth (m)	3.8	3.8
Trophic state (Index)	Oligotrophic (26)	Oligotrophic (22)

Water Delivery to East Slope Reservoirs

Changes in Carter Lake, Horsetooth Reservoir, Chimney Hollow, and Dry Creek Reservoir would be affected not only by changes in hydrology, but also by changes in loading to the East Slope from Adams Tunnel deliveries. The average annual nutrient loads delivered through the Adams Tunnel, as predicted by the Three Lakes Model are listed in Table 3-85. The highest loading occurs for the Proposed Action and the least for the No Action Alternative.

Table 3-85. Average nutrient load through the Adams Tunnel.

Alternative	Average Phosphorus Load	Average Nitrogen Load
	(kg/yr)	
Existing Conditions	2,480	75,484
Alt 1 – No Action	2,738	78,303
Alt 2 – Proposed Action	3,058	82,328
Alt 3	2,782	79,894
Alt 4	2,773	79,739
Alt 5	2,744	79,627

Carter Lake

WGFP deliveries to Carter Lake under the Proposed Action would increase phosphorus, nitrogen, and chlorophyll *a* concentrations. Dissolved oxygen concentrations may decrease slightly. No temperature change or violation in water quality standards is predicted.

Predicted water quality for Carter Lake under existing conditions and all alternatives is summarized in Table 3-86. Table 3-87 shows the percent change in water quality for each alternative compared to existing conditions. No change in the trophic status of Carter Lake is predicted for any alternative. Clarity would decrease by about 0.1 meter in Secchi-disk depth for all alternatives. The No Action Alternative, Proposed Action, and Alternative 5 would result in an increase in chlorophyll *a*. Nutrient concentrations would increase under all alternatives. Model predictions indicate that all alternatives may slightly reduce DO concentrations in both the metalimnion and hypolimnion. The oxygen demand predictions indicate that the Proposed Action alternative would likely result in the lowest DO concentrations among the alternatives for both the metalimnion and hypolimnion. No change in temperature is anticipated for any alternative.

Table 3-86. Average predicted water quality for Carter Lake.

Parameter	Average Annual Values Over the 15-Year Model Period					
	Existing Conditions	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (µg/L)	9.9	10.4	10.8	10.2	10.2	10.2
Total nitrogen (µg/L)	226	230	235	229	229	230
Chlorophyll *a* (µg/L)	1.8	1.9	2.0	1.8	1.8	1.9
Secchi-disk depth (m)	2.9	2.8	2.8	2.8	2.8	2.8
MOD (mg/[m3-day])	24	25	26	25	25	25
MOD Range (mg/[m^3-day])	23-25	23-27	23-30	23-26	23-26	23-26
HOD (mg/[m3-day])	22	23	24	23	23	23
HOD Range (mg/[m^3-day])	20-23	21-25	20-29	21-24	21-24	20-24
Trophic state (Index)	Oligotrophic-Mesotrophic (36)	Oligotrophic-Mesotrophic (37)	Oligotrophic-Mesotrophic (37)	Oligotrophic-Mesotrophic (37)	Oligotrophic-Mesotrophic (37)	Oligotrophic-Mesotrophic (37)

Table 3-87. Carter Lake predicted water quality changes by alternative compared to existing conditions.

Parameter	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (µg/L)	+5.1%	+9.1%	+3.0%	+3.0%	+3.0%
Total nitrogen (µg/L)	+1.8%	+4.0%	+1.3%	+1.3%	+1.8%
Chlorophyll *a* (µg/L)	+5.6%	+11.1%	No Change	No Change	+5.6%
Secchi-disk depth (m)	-3.6%	-3.6%	-3.6%	-3.6%	-3.6%
Trophic state (Index)	No Change	No Change	No Change	No Change	No Change

Carter Lake would continue to meet DO, ammonia, and nitrate standards. Temperature standards are not predicted to be exceeded. Dissolved manganese concentrations may increase due to decreased hypolimnetic DO concentrations, but it is unlikely that the standard would be exceeded for any alternative.

As noted above, quagga and zebra mussel veligers were detected in the Three Lakes in 2008. Established populations of quagga and zebra mussels can have significant impacts in the areas of water supply and delivery, power generation, recreation, and reservoir water quality and ecology. A number of researchers (Hincks and Mackie 1997; Cohen and Weinstein 2001; Jones and Ricciardi 2005; Whittier et al. 2008) have noted that calcium is a key limiting factor and there is uncertainty as to whether the Three Lakes could sustain reproducing adults due to very low calcium concentrations. It may be possible for veligers to survive being transported from the Three Lakes system through the Adams Tunnel and the C-BT delivery system to Carter Lake. If this were the case, it may be very difficult for mussel populations to establish in Carter Lake, again due to very low calcium concentrations (~9 mg/L). In addition, veliger mortality is likely high between the Three Lakes system and Carter Lake. These conditions exist with and without the WGFP and it is unlikely the project would alter the risk of infestation.

Horsetooth Reservoir

WGFP deliveries to Horsetooth Reservoir under the Proposed Action would increase phosphorus, nitrogen, and chlorophyll *a* concentrations. Dissolved oxygen concentrations may decrease slightly, which could result in continued exceedance of the manganese standard. No change in temperature is predicted.

Predicted water quality for Horsetooth Reservoir under existing conditions and all alternatives is summarized in Table 3-88. Table 3-89 shows the percent change in water quality for each alternative compared to existing conditions. Trophic state and Secchi-disk depth would remain unchanged from existing conditions for all alternatives, except for a slight decrease in clarity for the Proposed Action. The Proposed Action also has the highest nutrient loading from the Adams Tunnel and results in the highest nutrient and chlorophyll *a* concentrations. All alternatives may slightly reduce DO concentrations in both the metalimnion and hypolimnion. No change in temperature is predicted for any alternative.

Table 3-88. Average predicted water quality for Horsetooth Reservoir.

Parameter	Average Annual Values Over the 15-Year Model Period					
	Existing Conditions	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (µg/L)	9.9	10.4	11.0	10.3	10.3	10.2
Total nitrogen (µg/L)	274	281	290	285	284	284
Chlorophyll *a* (µg/L)	3.5	3.7	3.9	3.7	3.7	3.7
Secchi-disk depth (m)	2.6	2.6	2.5	2.6	2.6	2.6
MOD (mg/[m^3-day])	44	45	49	45	45	46
MOD Range (mg/[m^3-day])	41-46	42-48	44-67	43-49	43-49	42-48
HOD (mg/[m^3-day])	46	47	54	48	48	49
HOD Range (mg/[m^3-day])	43-51	44-53	46-86	44-53	44-53	44-54
Trophic state (Index)	Mesotrophic (43)	Mesotrophic (43)	Mesotrophic (44)	Mesotrophic (43)	Mesotrophic (43)	Mesotrophic (43)

Table 3-89. Horsetooth Reservoir predicted water quality changes by alternative compared to existing conditions.

Parameter	No Action	Proposed Action	Alternative 3	Alternative 4	Alternative 5
Total phosphorus (µg/L)	+5.1%	+11.1%	+4.0%	+4.0%	+3.0%
Total nitrogen (µg/L)	+2.6%	+5.8%	+4.0%	+3.6%	+3.6%
Chlorophyll *a* (µg/L)	+5.7%	+11.4%	+5.7%	+5.7%	+5.7%
Secchi-disk depth (m)	No Change	-3.8%	No Change	No Change	No Change
Trophic state	No Change	No Change	No Change	No Change	No Change

Horsetooth Reservoir would continue to have reduced DO concentrations. The reservoir would continue to meet ammonia, and nitrate standards. The increases in chlorophyll *a* concentrations could result in increases in total organic carbon and taste and odor compounds, such as geosmin. Increases in these constituents could result in increased chemical, monitoring, and operating costs for the Fort Collins Water Treatment Facility and the Tri-District's Soldier Canyon Filter Plant. Temperature standards are not predicted to be exceeded. Dissolved manganese concentrations may increase due to decreased hypolimnetic DO concentrations, which could result in continued exceedance of the standard under any of the alternatives.

As noted above, quagga and zebra mussel veligers were detected in the Three Lakes in 2008. Established populations of quagga and zebra mussels can have significant impacts in the areas of water supply and delivery, power generation, recreation, and reservoir water quality and ecology. A number of researchers (Hincks and Mackie 1997; Cohen and Weinstein 2001; Jones and Ricciardi 2005; Whittier et al. 2008) have noted that calcium is a key limiting factor and there is uncertainty as to whether the Three Lakes could sustain reproducing adults due to very low calcium concentrations. It may be possible for veligers to survive being transported from the Three Lakes system through the Adams Tunnel and the C-BT delivery system to Horsetooth Reservoir. If this were the case, it may be very difficult for mussel populations to establish in Horsetooth Reservoir, again due to very low calcium concentrations (~9 mg/L). In addition, veliger mortality is likely high between the Three Lakes system and the reservoir. These conditions exist with and without the WGFP, and it is very unlikely that the project would alter the risk of infestation.

Chimney Hollow Reservoir

The predicted water quality for Chimney Hollow Reservoir for the Proposed Action and Alternatives 3 and 4 is summarized in Table 3-90. Water quality for both the 70,000-AF and 90,000-AF reservoirs would be similar. The Proposed Action would have slightly higher nutrient and chlorophyll *a* concentrations due to a higher residence time with less flushing. The reservoir would be oligotrophic under all alternatives.

Table 3-90. Average predicted water quality for Chimney Hollow Reservoir.

Parameter	Average Annual Values Over the 15-Year Model Period		
	Proposed Action	Alternative 3	Alternative 4
Total phosphorus (µg/L)	8.7	7.2	7.3
Total nitrogen (µg/L)	183	158	158
Chlorophyll *a* (µg/L)	0.7	0.2	0.2
Secchi-disk depth (m)	3.8	3.9	3.9
Trophic state (Index)	Oligotrophic (24)	Oligotrophic (13)	Oligotrophic (13)

Dry Creek Reservoir

Predicted water quality for Dry Creek Reservoir under Alternative 5 is shown in Table 3-91. The reservoir is expected to be oligotrophic. Reservoir water quality changes would be related to changes in inflow volumes and reservoir storage content.

Table 3-91. Average predicted water quality for Dry Creek Reservoir.

Parameter	Average Annual Values Over the 15-Year Model Period
Total phosphorus (µg/L)	9.3
Total nitrogen (µg/L)	204
Chlorophyll *a* (µg/L)	1.1
Secchi-disk depth (m)	3.6
Trophic state (Index)	Oligotrophic (26)

3.8.3 Cumulative Effects

The dynamic temperature and QUAL2K models also were used to evaluate stream temperature and water quality impacts on the Colorado River based on future hydrologic conditions and nutrient loading. A mass balance model of nutrient load contributions throughout the Fraser River basin was developed for nitrogen and phosphorus concentrations, based on predicted future growth in the basin. Assumptions for future conditions were as follows: lower flow in the Fraser River, a greater population utilizing WWTPs that discharge to the Fraser River, and implementation of advanced wastewater treatment in the Fraser River basin above current levels of treatment. Under these assumptions, the model predicted higher nitrogen concentrations and lower phosphorus concentrations in the Fraser River inflow to the Colorado River (Table 3-92).

Table 3-92. Fraser River nutrient concentration outflow for July 25—cumulative effects.

Alternative	Organic N	Ammonia	Nitrate and Nitrite	Organic P	Inorganic P
	(µg/L)				
Existing Conditions	106	32	87	34	22
All Alternatives	209	63	172	20	13

As with direct effects, the QUAL2K model runs were conducted for both average July 25 flows and Windy Gap diversions that would reduce river flow to the minimum streamflow of 90 cfs. Because of the similarity in results between Alternatives 3, 4, and 5, only Alternative 5 was used in the model runs to represent the effect of all three alternatives.

For streams other than the Colorado River, mass balance calculations, the SSTEMP model, and other calculations, as discussed in Section 3.8.2.3, were used for the impact assessment.

Lake water quality for the cumulative effects analysis used the same models and methods as described for direct effects based on future hydrologic conditions. In addition, future water quality conditions of each of the inflows into the Three Lakes System were estimated. It was assumed that the water quality of East Inlet, North Inlet, Arapaho Creek, Stillwater Creek, Roaring Fork, the North Fork of the Colorado River, and the water quality of the water pumped from Willow Creek Reservoir would remain unchanged from existing conditions. For pumping from Windy Gap and new West Slope reservoirs, assumptions were made about future water quality in the Fraser River basin due to anticipated growth, including WWTP upgrades with nutrient removal. The resulting anticipated nutrient loads from Windy Gap Reservoir and Rockwell Creek Reservoir are summarized in Table 3-93 and Table 3-94. Loads from Willow Creek pumping are also included in the model. Alternative 5 was used to represent the results of Alternatives 3 and 4 because of the similarity between these alternatives. Nutrient loads from Jasper East Reservoir under Alternative 3 would be similar to Rockwell Reservoir.

Table 3-93. Average annual total phosphorus load delivered to Granby Reservoir from Willow Creek Reservoir, Windy Gap Reservoir, and Rockwell Creek Reservoir—cumulative effects.

Alternative	TP Load From Willow Creek Reservoir	TP Load From Windy Gap Reservoir	TP Load From Rockwell Creek Reservoir	Total
	(kg/yr)			
Existing Conditions	1,128	2,158	—	3,286
Alt 1 – No Action	1,214	1,999	—	3,213
Alt 2 – Proposed Action	1,242	2,351	—	3,593
Alt 5	1,226	1,237	320	2,783

Table 3-94. Total nitrogen load delivered to Granby Reservoir from Willow Creek Reservoir, Windy Gap Reservoir, and Rockwell Creek Reservoir—cumulative effects.

Alternative	TN Load from Willow Creek Reservoir	TN Load from Windy Gap Reservoir	TN Load from Rockwell Creek Reservoir	Total
	(kg/yr)			
Existing Conditions	9,455	15,966	—	25,421
Alt 1 – No Action	10,123	20,859	—	30,982
Alt 2 – Proposed Action	10,330	23,866	—	34,196
Alt 5	10,217	11,310	4,670	26,197

3.8.3.1 West Slope Cumulative Effects

Colorado River

Dynamic Temperature Model

The dynamic temperature model was used to assess potential impacts to Colorado River stream temperatures in the future from the hydrologic changes associated with reasonably foreseeable actions (Section 3.5.3). The dynamic temperature model was run for the same five model years (1975, 1979, 1986, 1987, and 1989) as conducted for the direct effects analysis. These were the only years within the 15-year period of record for water quality modeling where adverse impacts to temperature as a result of WGFP pumping are likely. Reasonably foreseeable actions included in the cumulative effects simulation, which affect the simulated hydrology used in the dynamic temperature model, include:

- Denver Water Moffat Collection System Project,
- Increased water use from population growth in Grand and Summit counties,
- Changes in releases from Williams Fork (related to changes to recommended releases for fish flows and the expiration of Denver Water's contract with Big Lake Ditch), and
- 5,412 AF releases from Granby Reservoir, per the release schedule presented in the 10825 Project Environmental Assessment (BOR 2011).

The 5,412 AF releases from Granby Reservoir are a component of the 10825 Project to improve flows for Colorado River endangered fish near Grand Junction with secondary benefits to aquatic life below Granby Reservoir. Granby Reservoir releases are variable depending on the type of water year, but could occur from mid-July through September according to the schedule shown in Table 3-95. Actual schedule releases for average and wet years would be determined by an Operations Group comprised of representatives from the water users, the FWS, Reclamation, and the State Division Engineer. Four out of five of the years simulated were average years (1975, 1979, 1987, and 1988). 1986 was considered a wet year, and correspondingly simulated applying the wet year release schedule. In addition, because exceedance of the temperature standard often occurs in mid-July, the early season release scheduled also was modeled for the 1975 hydrologic model year to evaluate the effectiveness of earlier releases on stream temperature.

Results were compiled for three locations on the reach of the Colorado River between Windy Gap Reservoir and the confluence with the Williams Fork where temperature changes are of greatest concern – downstream of Windy Gap Reservoir (WGD), at Hot Sulphur Springs (HSU), and upstream of the Williams Fork (WFU). Meteorological data from 2007, a year with very warm July and August air temperatures, was applied to all simulations. The analysis focused on existing conditions, the No Action Alternative, and the Proposed Action (Alternative 2). Impacts to Alternatives 3 to 5 would be similar to the Proposed Action since diversion amounts are similar.

Table 3-95. Granby Reservoir 5,412 AF release schedule under the 10825 Project.

Date	Granby Reservoir Releases (cfs)			
	Dry	Average	Wet	Example Early Season Release
July 15-31	22	0	0	45
August 1-14	47	50	35	40 (Aug 1-15)
August 15-31	47	50	50	39 (Aug 16-31)
September 1	55	50	70	25
September 2-9	38	50	70	25
September 10-15	38	50	50	25
September 16-20	21	29	50	25
September 21-30	21	29	24	25

The results of dynamic temperature modeling using cumulative effects hydrologic conditions for 1975, 1979, 1986, 1987, and 1988 are shown in Table 3-96, Table 3-97, and Table 3-98. Bolded values in these tables indicate a simulated increase in exceedance of the standards, as compared to existing conditions or the No Action Alternative. The greatest simulated increase in MWAT and DM standard exceedances over existing conditions occurred in 1975 and 1979 when WGP diversions were largest relative to the amount of flow available for diversion. Model runs for all five years used 2007 climatic data which, as previously discussed in Section 3.8.2.3, included the hottest August on record and the sixth hottest July on record.

The increase in regulatory exceedances is limited to three years out of the 15-year period. No exceedances were simulated for any scenario or year in June or September. No changes in exceedances, relative to existing conditions, were simulated in August with the 5,412 AF releases from Granby Reservoir. Simulated annual increases in chronic exceedances were as high as 3 additional weeks above the MWAT standard relative to existing conditions and 2 additional weeks relative to No Action. Simulated annual increases in acute exceedances were as high as 4 additional days above the DM standard relative to existing conditions and 4 additional days relative to No Action. As with the direct effect analysis, use of the 2007 meteorological data with very high July and August air temperatures resulted in more exceedances than is likely to occur in years with average climatic conditions.

The 5,412 AF releases from Granby Reservoir beginning August 1 exhibit a strong cooling effect on river flows. In some years and locations, the No Action Alternative and Proposed Action had fewer exceedances of the MWAT and DM in August than existing conditions as a result of the 5,412 AF releases. Based on separate runs for 1975 using an earlier start date (July 15 instead of August 1) for 5,412 AF releases, July exceedance of the MWAT standard at WGD would be eliminated and the exceedances at WFU would decrease by 1 week.

QUAL2K Water Quality Model. The following sections provide the results of water quality modeling based on average flow conditions on July 25 as well as when Windy Gap diversions reduce the flow to near 90 cfs below Windy Gap Reservoir.

Streamflow

Predicted changes in average Colorado River flow for July 25 are shown in Figure 3-83. Streamflows would be reduced throughout the study reach due to Windy Gap diversions, as well as a reduction in tributary inflows to the Colorado River from reasonably foreseeable future actions. Streamflows calculated for the minimum instream flow simulations would be similar for all of the alternatives and are shown in Figure 3-84. Streamflow changes immediately below Windy Gap Reservoir would be the same as for direct effects, but changes in tributary inflows in the future would reduce flows farther downstream.

Table 3-96. Temperature model results for the Colorado River downstream of Windy Gap Reservoir (WGD), cumulative effects.

	1975			1979			1986			1987			1988		
	EC	**NA**	**Alt2**	**EC**	**NA**	**Alt2**	**EC**	**NA**	**Alt2**	**EC**	**NA**	**Alt2**	**EC**	**NA**	**Alt2**
Chronic															
MWAT (°C)	18.9	18.0	18.3	18.7	18.9	18.8	16.1	15.3	15.3	19.4	18.9	18.9	18.8	17.7	18.1
June # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # weeks > 18.2°C	0	0	**1**	0	**2**	**2**	0	0	0	2	**3**	**3**	0	0	0
Aug. # weeks > 18.2°C	3	0	0	2	0	0	0	0	0	4	0	0	2	0	0
Sept. # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acute															
Max DM (°C)	20.8	19.5	20.2	20.6	20.6	20.6	17.2	16.3	16.5	21.4	20.6	20.6	20.6	18.9	19.4
June # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug. # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sept. # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-97. Temperature model results for the Colorado River downstream at Hot Sulphur Springs (HSU), cumulative effects.

	1975			1979			1986			1987			1988		
	EC	**NA**	**Alt2**	**EC**	**NA**	**Alt2**	**EC**	**NA**	**Alt2**	**EC**	**NA**	**Alt2**	**EC**	**NA**	**Alt2**
Chronic															
MWAT (°C)	19.5	18.8	19.0	19.4	19.4	19.3	17.3	16.8	16.8	20.0	19.3	19.3	19.4	18.5	18.8
June # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # weeks > 18.2°C	0	2	**3**	1	2	**3**	0	0	0	4	4	4	2	2	2
Aug. # weeks > 18.2°C	4	1	2	4	2	2	0	0	0	4	2	2	3	0	0
Sept. # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acute															
Max DM (°C)	24.4	23.6	24.8	24.3	24.5	24.5	21.5	20.8	21.1	25.4	24.2	24.2	24.2	23.1	23.3
June # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # days > 23.8°C	0	0	**4**	0	3	**3**	0	0	0	1	4	**4**	0	0	0
Aug. # days > 23.8°C	5	0	0	2	0	0	0	0	0	12	0	0	4	0	0
Sept. # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-98. Temperature model results for the Colorado River upstream of Williams Fork (WFU), cumulative effects.

	1975			1979			1986			1987			1988		
	EC	NA	Alt2	EC	NA	Alt2	EC	NA	Alt2	EC	NA	Alt2	EC	NA	Alt2
Chronic															
MWAT (°C)	19.7	19.0	19.3	19.6	19.5	19.5	17.7	17.2	17.3	20.0	19.5	19.5	19.6	18.8	18.9
June # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # weeks > 18.2°C	0	3	**3**	2	4	**4**	0	0	0	4	5	**5**	2	2	2
Aug. # weeks > 18.2°C	4	3	3	3	2	2	0	0	0	4	2	2	4	2	2
Sept. # weeks > 18.2°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acute															
Max DM (°C)	23.5	23.9	24.9	23.4	24.1	24.2	21.5	21.0	21.2	24.3	24.6	24.6	23.5	23.0	23.3
June # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July # days > 23.8°C	0	1	**1**	0	2	**2**	0	0	0	1	2	**2**	0	0	0
Aug. # days > 23.8°C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Sept. # days > 23.8°C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3-83. Colorado River average July 25 streamflow—cumulative effects.

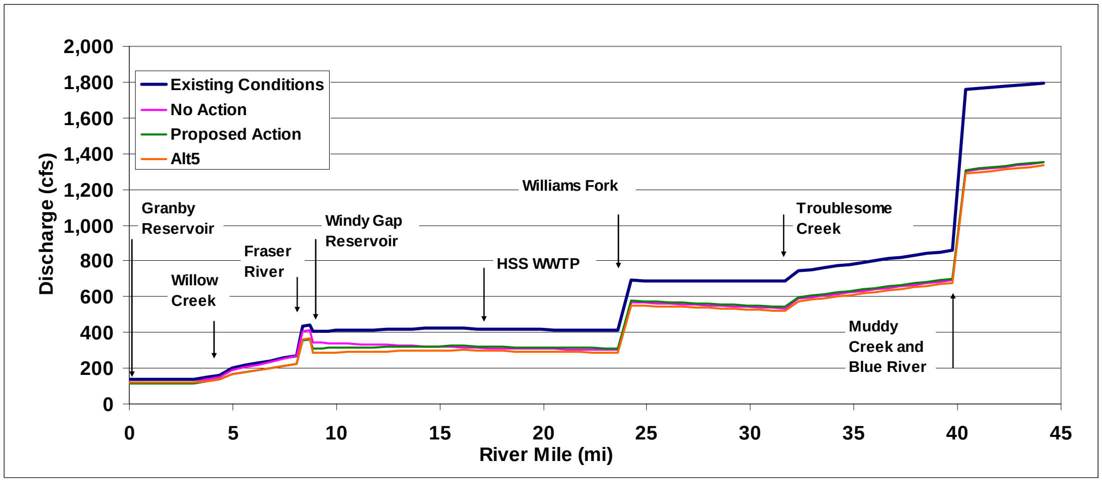
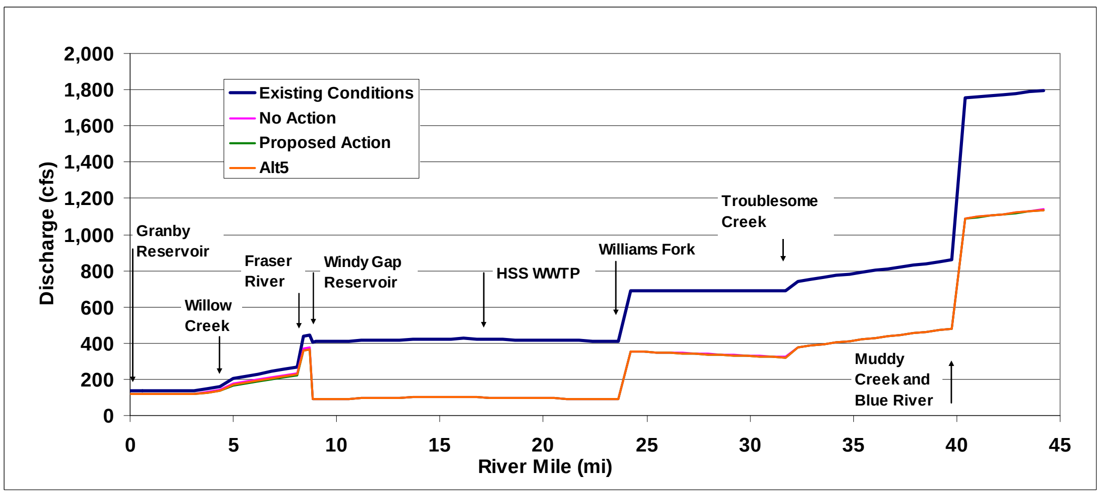


Figure 3-84. Colorado River July 25 streamflow assuming diversion to the minimum instream flow below Windy Gap Reservoir.



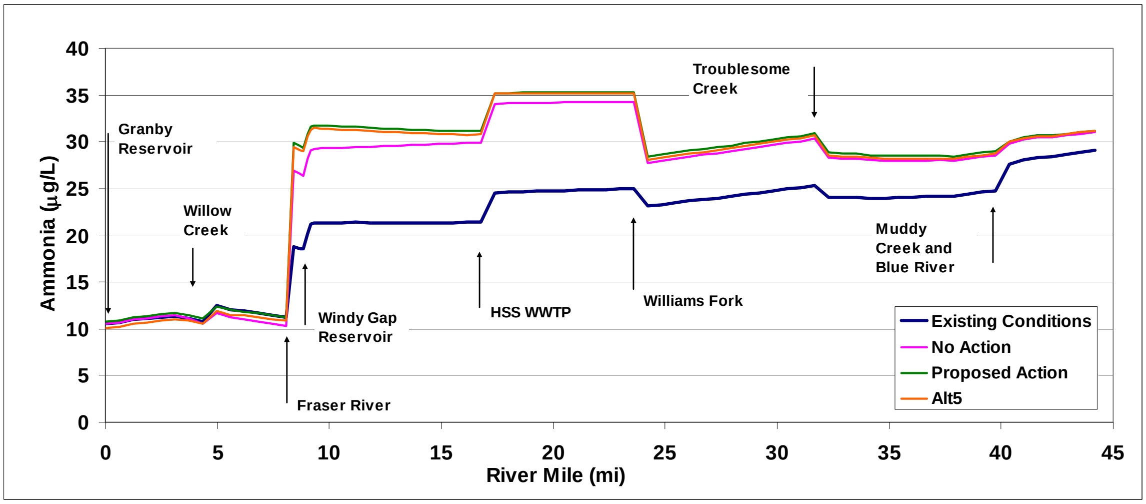
No exceedances of water quality standards are predicted in the Colorado River under cumulative effect conditions, with the exception of an increased exceedance of the MWAT and DM temperature standards between Windy Gap Reservoir and the Williams Fork in July and August of some years.

Specific Conductivity. Specific conductivity in the simulation of cumulative effects would increase slightly less than described for direct effects in Section 3.8.2.4. All alternatives would result in less than a 10 percent increase in conductivity under average July 25 flows below the Williams Fork. At minimum flow rates below Windy Gap Reservoir, the increase in conductivity for all alternatives would be up to a maximum of 44 percent greater between the Williams Fork and Troublesome Creek.

Dissolved Oxygen. DO concentrations would decrease by less than 0.1 mg/L from existing conditions under all alternatives under average July 25 flows. The decrease would not lower the concentration below the standard. DO concentrations would decrease by 0.5 mg/L under the No Action Alternative and 0.6 mg/L under the action alternatives at minimum instream flows below Windy Gap. A DO concentration as low as 6.9 mg/L for a short reach above the Williams Fork would be below the aquatic life spawning standard of 7.0 mg/L.

Ammonia. Ammonia concentrations are predicted to increase in the Colorado River below the Fraser River confluence because of projected future increase in ammonia concentrations in the Fraser River from additional WWTP discharges (Figure 3-85). A maximum increase above existing conditions of about 9.5 µg/L would occur under the No Action Alternative below the HSS WWTP.

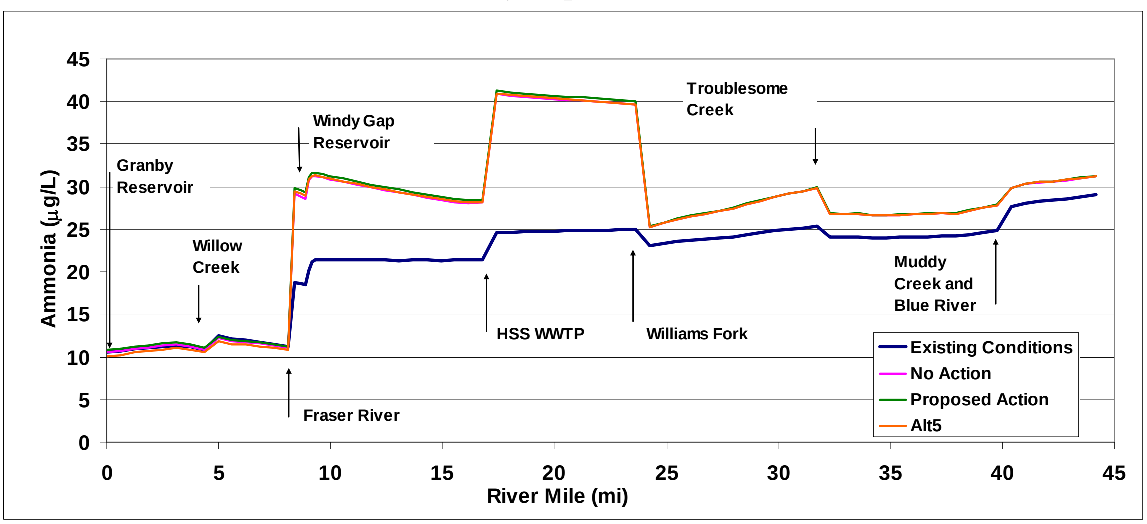
Figure 3-85. Colorado River ammonia concentrations for July 25—cumulative effects.



Ammonia would increase up to 11.1 µg/L under the Proposed Action and 10.7 µg/L under Alternative 5 below the Fraser River confluence above Windy Gap Reservoir. Biochemical processes and tributary inflow dilution would reduce these concentration increases to about 2.0 µg/L at the downstream end of the study reach below the Blue River. None of the alternatives would increase the ammonia concentration to above the aquatic life chronic ammonia standard. The maximum predicted ammonia concentration would occur under the Proposed Action (35.3 µg/L).

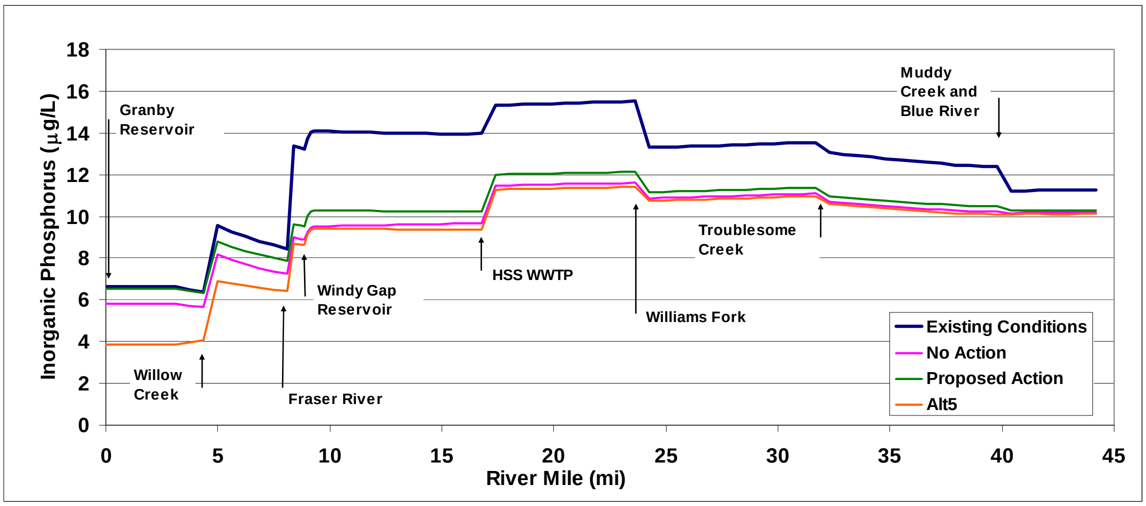
Diversions to the minimum streamflow below Windy Gap Reservoir would result in similar increases in ammonia concentrations below the HSS WWTP under all alternatives (Figure 3-86). A maximum increase of 16.7 µg/L of ammonia would occur under the Proposed Action, with a slightly smaller increase for the other alternatives. Ammonia concentrations of up to 41.1 µg/L would remain well below standards.

Figure 3-86. Colorado River ammonia concentrations for July 25 assuming diversion to the minimum streamflow below Windy Gap Reservoir—cumulative effects.



Inorganic Phosphorus. Phosphorus concentrations are predicted to be lower than existing conditions under all alternatives (Figure 3-87). Willow Creek phosphorus concentrations are assumed to remain the same, but lower Willow Creek flows would decrease the load of inorganic phosphorus to the Colorado River. Fraser River phosphorus concentrations are predicted to be lower as a result of advanced wastewater treatment practices that may be required in the future with additional discharges. The reduced phosphorus loading from the Fraser River would result in a decrease in inorganic phosphorus concentrations of about 4.6 µg/L under the No Action Alternative, decrease of 4.7 µg/L for Alternative 5, and a decrease of about 3.8 µg/L under the Proposed Action. Biological uptake and tributary inflows would reduce the decrease in phosphorus concentrations to about 1 µg/L near Kremmling. There are currently no water quality standards for phosphorus; however, the EPA-recommended concentration for streams is 100 µg/L (EPA 1986).

Figure 3-87. Colorado River inorganic phosphorus concentrations for July 25—cumulative effects.

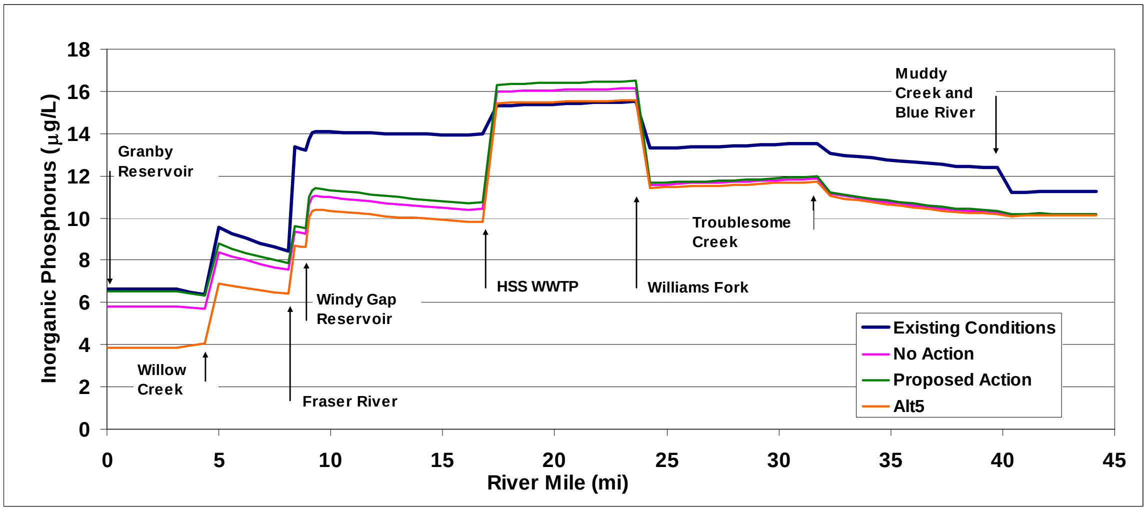


Windy Gap diversions resulting in a minimum streamflow in the Colorado River would reduce dilution of HSS WWTP discharges and increase inorganic phosphorus concentrations between the WWTP and the Williams Fork (Figure 3-88). Under No Action, inorganic phosphorus would increase 4.0 µg/L and would increase 3.7 µg/L under the Proposed Action and 4.7 µg/L under other alternatives. Elsewhere in the Colorado River study area, phosphorus concentrations would be lower than existing conditions for all alternatives primarily as a result of a decrease in projected loading from Fraser River WWTPs.

Selenium. Selenium concentrations in the Colorado River are predicted to increase by less than 0.02 µg/L under all alternatives for average July 25 flows. An increase of up to 0.1 µg/L would occur under all alternatives when flows below Windy Gap Reservoir are at the minimum flow. All of the increases in selenium occur below the confluence with Muddy Creek, which has a higher concentration than the Colorado River. Water quality standards for selenium would not be exceeded under any alternative.

Aquatic Plant Growth. For all alternatives, some increase in aquatic plant growth is possible as a result of the increase in nutrient (ammonia and phosphorus) concentrations. None of the projected changes in Colorado River quality would be expected to adversely contribute to the spread or development of didymo populations that are currently present in the river.

Figure 3-88. Colorado River inorganic phosphorus concentrations for July 25 assuming diversion to the minimum streamflow below Windy Gap Reservoir—cumulative effects.



Willow Creek

The Three Lakes WWTP was recently expanded. It is assumed that the expansion was designed with future foreseeable growth in the service area considered. Reduced streamflow in Willow Creek would increase concentrations for ammonia and copper under all alternatives (Table 3-99). A reduction in available flows for dilution of discharge from the Three Lakes WWTP would not result in an exceedance of water quality standards for the evaluated parameters under the alternative actions even at the maximum permitted WWTP discharge rate. Given the lack of algae and chlorophyll data for Willow Creek, it is not known whether the predicted increases in ammonia concentrations would result in algal growth problems in the creek. Willow Creek temperatures would decrease by less than 0.2°C under all alternatives from the greater contribution of cooler ground water inflows.

Jasper East Drainage and Rockwell/Mueller Creeks

The water quality for the Jasper East drainage and Rockwell/Mueller Creeks below potential new reservoirs would be similar to the quality of Jasper East Reservoir and Rockwell Reservoir as discussed below.

Table 3-99. Willow Creek average monthly ammonia, iron, and copper concentrations—cumulative effects.

Std/Alternative	Ammonia (mg/L)			Iron, dis (µg/L)			Copper, dis (µg/L)		
	June	July	Aug.	June	July	Aug.	June	July	Aug.
Standard[1]	2.87	2.87	2.45	300	300	300	10	10	10
WWTP[2]	1.4	2.7	1.7	43	75	70	11.4	14.5	16.2
Existing Conditions	0.03	0.03	0.03	92.5	92.5	92.5	3.4	3.4	3.4
Alt 1 – No Action	0.032	0.11	0.22	92.41	89.4	93.3	3.41	4	4.8
Alt 2 – Proposed Action	0.034	0.12	0.24	92.35	89.1	84.7	353	4.1	4.7
Alt 3 – 5	0.033	0.12	0.24	92.41	89.1	93.3	3.41	4.1	5

[1] Copper standard based on mean hardness of 112 mg/L (CDPHE 2011a).
[2] Effluent concentrations from the Three Lakes WWTP discharge to Church Creek, a tributary to Willow Creek (WQCD 2010).

Granby Reservoir

Nutrient concentrations in all of the Three Lakes would increase and dissolved oxygen concentrations would decrease under cumulative effects with the Proposed Action. Water clarity is not predicted to change in Granby Reservoir or Shadow Mountain Reservoir, but would decrease about 0.1 meter in Grand Lake.

Predicted average annual and the range in daily water quality for Granby Reservoir under existing conditions and the alternatives are summarized in Table 3-100. Table 3-101 shows the percent change in water quality for each alternative compared to existing conditions. Granby Reservoir would remain mesotrophic under all alternatives and there would be no change in Secchi-disk depth. Average chlorophyll *a* concentrations would not change for the No Action Alternative or the Proposed Action, and would decrease slightly for the other alternatives. Nitrogen concentrations would be higher than existing conditions for all alternatives. Phosphorus concentrations would be lower under the No Action Alternative and Alternative 5 and slightly higher under the Proposed Action. Phosphorus concentrations would be lower than in the direct effects analysis due to anticipated advanced wastewater treatment in the Fraser River basin in the future. Minimum DO concentrations would decrease about 4 percent under the Proposed Action. TSS would increase about 4 percent under the action alternatives. No change in epilimnetic temperature is predicted for any alternative.

Table 3-100. Average predicted water quality for Granby Reservoir—cumulative effects.

Parameter	Average Annual Value Over the 15-Year Model Period and the Range in Daily Values (min - max)			
	Existing Conditions	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	12.6 (4.5 – 25.0)	12.2 (4.5 – 22.1)	12.9 (4.5 – 22.4)	10.9 (4.8 – 17.7)
Total nitrogen (µg/L)	289 (228 – 375)	298 (229 – 396)	300 (229 – 395)	303 (230 - 360)
Chlorophyll *a* (µg/L)	4.2 (2.0 – 7.3)	4.2 (2.0 – 7.3)	4.2 (2.0 – 7.1)	4.1 (2.0 – 6.9)
Peak chlorophyll *a* (µg/L)	6.6	6.5	6.5	6.3
Secchi-disk depth (m)	3.6 (2.1 – 5.3)	3.6 (2.0 – 5.3)	3.6 (2.0 – 5.3)	3.6 (2.1 – 5.1)
Trophic state (Index)	Mesotrophic (46)	Mesotrophic (46)	Mesotrophic (46)	Mesotrophic (46)
Minimum DO (mg/L)	4.5	4.5	4.3	4.5
TSS (mg/L)	2.3 (1.1 – 5.9)	2.3 (1.1 – 6.1)	2.4 (1.1 – 6.2)	2.4 (1.1 – 5.1)

Note: All concentrations are for the epilimnion with the exception of minimum DO, which is for the hypolimnion.

Table 3-101. Granby Reservoir predicted water quality changes by alternative compared to existing conditions—cumulative effects.

Parameter	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	-3.2%	+2.4%	-13.5%
Total nitrogen (µg/L)	+3.1%	+3.8%	+4.8%
Chlorophyll *a* (µg/L)	No Change	No Change	-2.4%
Peak chlorophyll *a* (µg/L)	-1.5%	-1.5%	-4.5%
Secchi-disk depth (m)	No Change	No Change	No Change
Trophic state	No Change	No Change	No Change
Minimum DO (mg/L)	No Change	-4.4%	No Change
TSS (mg/L)	No Change	+4.3%	+4.3%

Granby Reservoir would continue to meet ammonia and nitrate standards. It is anticipated that manganese concentrations would increase over existing conditions for the Proposed Action due to lower DO concentrations in the hypolimnion. Therefore, the manganese water supply standard may continue to be exceeded for all alternatives. DO concentrations would continue to be below the spawning standard under all alternatives. Minimum DO would not change under the No Action Alternative or Alternative 5, and would decrease by 0.2 mg/L under the Proposed Action. Based on the temperature modeling, it is predicted that the temperature standard would not be exceeded under any of the alternatives. Predicted increased drawdowns in Granby Reservoir would expose greater areas of reservoir sediment that may increase suspended sediments in the reservoir during windy conditions or storm events.

Shadow Mountain Reservoir

Predicted average annual and the range in daily water quality for Shadow Mountain Reservoir under existing conditions and the alternatives are summarized in Table 3-102. Table 3-103 shows the percent change in water quality for each alternative compared to existing conditions. The reservoir would remain in a mesotrophic state for all alternatives. Only Alternative 5 indicates a 0.1-meter decrease in Secchi-disk depth. Average chlorophyll *a* concentrations would not change for the No Action Alternative or the Proposed Action, but would decrease about 5 percent for Alternative 5. Total phosphorus concentrations would increase for the Proposed Action and decrease for the other alternatives. Total nitrogen would increase less than 4 percent for all alternatives. Minimum DO concentrations would change little for all alternatives. It is expected that the temperature of Shadow Mountain Reservoir would not increase under any action alternative and may be cooler as discussed in Section 3.8.2.4.

Because the change in nutrient concentrations would be very low for all alternatives, no change in the amount and type of aquatic vegetation (macrophytes) in Shadow Mountain Reservoir is expected. Rooted aquatic plants generally meet their nutrient needs directly from the sediments (Barko et al. 1986). Thus, they can thrive even in oligotrophic systems (Cooke et al. 2005). Therefore, changes in nutrient concentrations cannot be expected to result in changes in macrophyte growth and biomass (Cooke et al. 2005) and although there are anticipated changes in nutrient concentrations associated with the alternatives, it is not anticipated that these changes would aggravate the macrophyte problem.

Shadow Mountain Reservoir would continue to meet DO, ammonia, and nitrate standards. It is anticipated that manganese concentrations would stay about the same for all alternatives based on the minimum DO concentrations in the hypolimnion. Therefore, the manganese water supply standard may continue to be exceeded for all alternatives.

Table 3-102. Average predicted water quality for Shadow Mountain—cumulative effects.

Parameter	Average Annual Value Over the 15-Year Model Period and the Range in Daily Values (min - max)			
	Existing Conditions	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	12.4 (4.9 – 20.3)	12.2 (4.9 – 20.3)	12.8 (4.9 – 20.3)	11.2 (4.9 – 20.3)
Total nitrogen (µg/L)	275 (190 – 330)	283 (198 – 338)	285 (196 – 344)	286 (256 – 341)
Chlorophyll *a* (µg/L)	5.7 (1.8 – 10.5)	5.7 (1.6 – 10.9)	5.7 (1.7 – 11.6)	5.4 (1.5 – 10.6)
Peak chlorophyll *a* (µg/L)	8.8	8.8	9.1	8.3
Secchi-disk depth (m)	2.0 (1.4 – 3.1)	2.0 (1.3 – 3.0)	2.0 (1.3 – 3.1)	2.1 (1.3 – 3.2)
Trophic state (Index)	Mesotrophic (48)	Mesotrophic (48)	Mesotrophic (48)	Mesotrophic (48)
Minimum DO (mg/L)	7.1	7.1	7.1	7.1
TSS (mg/L)	2.0 (1.1 – 5.3)	2.0 (1.1 – 5.5)	2.1 (1.1 – 5.4)	2.2 (1.1 – 5.4)

Table 3-103. Shadow Mountain predicted water quality changes by alternative compared to existing conditions—cumulative effects.

Parameter	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	-1.6%	+3.2%	-9.7%
Total nitrogen (µg/L)	+2.9%	+3.6%	+4.0%
Chlorophyll *a* (µg/L)	No Change	No Change	-5.3%
Peak chlorophyll *a* (µg/L)	No Change	+3.7%	-5.7%
Secchi-disk depth (m)	No Change	No Change	+5.0%
Trophic state	No Change	No Change	No Change
Minimum DO (mg/L)	No Change	-1.4%	No Change
TSS (mg/L)	No Change	+5.0%	+10.0%

Grand Lake

Predicted average annual and the range in daily water quality for Grand Lake under existing conditions and all of the alternatives are summarized in Table 3-104. Table 3-105 shows the percent change in water quality for each alternative compared to existing conditions. The reservoir would remain mesotrophic for all alternatives. Clarity would decrease slightly with a decrease of 0.1 meter in Secchi-disk depth under the Proposed Action, and would increase about 0.1 meter under Alternative 5. A small increase in chlorophyll *a* is predicted for the Proposed Action and a small decrease in chlorophyll *a* is predicted for Alternative 5. Nitrogen concentrations are slightly higher than existing conditions for all alternatives. Phosphorus concentrations are lower than existing conditions for the No Action Alternative and Alternative 5. The Proposed Action would increase phosphorus concentrations about 5 percent. DO concentrations would decrease for all alternatives.

Table 3-104. Average predicted water quality for Grand Lake—cumulative effects.

Parameter	Average Annual Value Over the 15-Year Model Period and the Range in Daily Values (min - max)			
	Existing Conditions	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	8.3 (4.3 – 13.7)	8.2 (4.1 – 16.0)	8.7 (4.2 – 18.6)	7.7 (4.2 – 13.9)
Total nitrogen (µg/L)	247 (174 – 330)	251 (158 – 386)	255 (157 – 336)	256 (165 – 339)
Chlorophyll *a* (µg/L)	4.9 (2.1 – 10.2)	4.9 (2.1 – 10.7)	5.0 (2.1 – 9.7)	4.6 (2.0 – 10.2)
Peak chlorophyll *a* (µg/L)	7.4	7.4	7.6	6.9
Secchi-disk depth (m)	2.6 (1.3 – 4.3)	2.6 (1.2 – 4.5)	2.5 (1.4 – 4.4)	2.7 (1.3 – 4.4)
Trophic state (Index)	Mesotrophic (47)	Mesotrophic (46)	Mesotrophic (47)	Mesotrophic (46)
Minimum DO (mg/L)	5.4	4.8	5.0	5.1
TSS (mg/L)	1.8 (1.0 – 4.1)	1.8 (1.1 – 3.8)	1.9 (1.1 – 4.2)	1.8 (1.1 – 4.1)

Note: All concentrations are for the epilimnion with the exception of minimum DO, which is for the hypolimnion.

Table 3-105. Grand Lake predicted water quality changes by alternative compared to existing conditions—cumulative effects.

Parameter	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	-1.2%	+4.8%	-7.2%
Total nitrogen (µg/L)	+1.6%	+3.2%	+3.6%
Chlorophyll *a* (µg/L)	No Change	+2.0%	-6.1%
Peak chlorophyll *a* (µg/L)	No Change	+2.7%	-6.8%
Secchi-disk depth (m)	No Change	-3.8%	+3.8%
Trophic state	No Change	No Change	No Change
Minimum DO (mg/L)	-11.1%	-7.4%	-5.6%
TSS (mg/L)	No Change	+5.6%	No Change

Grand Lake would continue to meet DO, ammonia, and nitrate standards. It is anticipated that manganese concentrations would increase over existing conditions due to lower DO concentrations in the hypolimnion. It is predicted that the No Action Alternative would result in the highest manganese concentrations and the Proposed Action alternative would result in the second highest manganese concentration. There is no indication that temperature standards would be exceeded because no increase in temperature is predicted. In addition, there is no evidence to suggest that pH would decrease more under any alternative; therefore, the pH standard would continue to be exceeded under all alternatives, similar to existing conditions.

Jasper East Reservoir

Water quality for Jasper East Reservoir was not modeled for the cumulative effects analysis, but is expected to be similar to Rockwell Reservoir.

Rockwell/Mueller Creek Reservoir

Predicted water quality for Rockwell Reservoir is summarized in Table 3-106. The reservoir is predicted to be mesotrophic. Rockwell Reservoir would retain some nitrogen and phosphorus, thereby reducing nutrient deliveries to Granby Reservoir. Rapid filling and drawdown could lead to an increase in reservoir erosion turbidity and suspended sediment delivery to Granby Reservoir.

Table 3-106. Average predicted water quality for Rockwell/Mueller Creek Reservoir—cumulative effects.

Parameter	Average Annual Values Over the 15-Year Model Period
Total phosphorus (µg/L)	15.1
Total nitrogen (µg/L)	286
Chlorophyll *a* (µg/L)	3.0
Secchi-disk depth (m)	3.1
Trophic state (Index)	Mesotrophic (41)

Fish and Wildlife Enhancement Plans, Denver Water Moffat Collection System Project Fish and Wildlife Mitigation Plan, and Colorado River Cooperative Agreement

As described in more detail in *Reasonably Foreseeable Actions* (Section 2.8.2), the Subdistrict and Denver Water have collaboratively developed separate FWEPs that include habitat restoration measures that may change stream morphology and flow characteristics from Windy Gap Reservoir downstream to about 2 miles below the Williams Fork. A change in stream morphology that results in a narrow and deeper channel has the potential to moderate stream temperatures and reduce the exceedances of the chronic and acute temperature standards in the Colorado River. Denver Water's FWMP and the *Colorado River Cooperative Agreement* include measures that would bypass water from the Fraser River Collection System and increase flows downstream in the Colorado River under certain conditions. Increased Colorado River flows as a result of these bypassed flows during the late summer would contribute toward maintaining lower stream temperatures in the Colorado River. Additional discussion of the effects of these measures is included in the sections on *Stream Morphology and Floodplains* (3.7.3), and *Aquatic Resources* (3.9.3.1).

Climate Change Effects

As described in Section 2.8.2.1, climatic models project a number of changes in temperature, precipitation, and streamflow that could affect water quality in the future. While the differences in model predictions indicate uncertainty in estimating future climatic and hydrologic conditions, the following are possible scenarios that could affect the water quality of the Colorado River, its tributaries, and lakes and reservoirs:

- More winter precipitation as rain
- Shorter seasons for snow accumulation and less snowpack
- Earlier snowmelt and earlier hydrograph peaks
- Higher average annual runoff, but lower flow rates during hot summer months
- Peak runoff in May rather than June, as currently happens
- Decreased baseflow from ground water to surface water
- Average year round air temperature increase of about 1.8°C
- Greater loss of water by evaporation and/or transpiration and decreased baseflow from ground water in late summer

Overall, it is difficult to predict the effects of climate change on water quality due to uncertainty associated with the range of predicted climate change effects on air temperatures, precipitation, and runoff response. As a result, climate change effects on water quality are discussed qualitatively. With or without the WGFP, a potential effect of climate change is increasing stream temperatures due to higher average air temperatures and lower flows in the summer. While the dynamic temperature model simulated cumulative effects using some of the warmest July and August temperatures on record (comparable to predicted climate change temperature increases), it did not simulate the hydrologic changes associated with climate change predictions, which could further exacerbate the temperature problems in the upper Colorado River. Climate change may also affect the timing and operation of the Windy Gap Project, as well as the water supply and demand by the Participants. If climate change reduces streamflows, Windy Gap would be able to divert water less frequently from the Colorado River. Another potential effect with or without the project is that greater lake evaporation would concentrate nutrient and other parameter concentrations in reservoirs and lakes, depending on resulting reservoir operations.

3.8.3.2 East Slope Cumulative Effects

Big Thompson River

Nitrogen and phosphorus concentrations in the Big Thompson River below Lake Estes are projected to increase by less than 0.02 mg/L under all alternatives in the months of May and July. Small projected increases in flow would have minimal effects on stream temperatures.

Big Thompson River flows also would increase as a result of additional discharges from the Loveland WWTP in the future. Predicted changes for ammonia and copper concentrations in the cumulative effects analysis would be similar to those described for direct effects, as shown in Table 3-79. Under all alternatives, ammonia concentrations in the Big Thompson River would decrease slightly from existing conditions because effluent ammonia levels are lower than in the river. A slight reduction in the potential for exceeding the ammonia standard is possible under all alternatives. Copper concentrations would increase under all alternatives, but would not exceed water quality standards.

North St. Vrain Creek

The changes in flow and water quality in North St. Vrain Creek under the No Action Alternative in the future would be essentially the same as discussed for direct effects (Section 3.8.2.5). The predicted flow changes would result in monthly increases and decreases in stream temperature, DO, and other parameters. No exceedance of water quality standards are predicted under cumulative effects.

St. Vrain Creek

The small changes in flow in St. Vrain Creek upstream of the St. Vrain Supply Canal under the No Action Alternative would have minimal effects on physical or chemical qualities of the stream, and would not result in exceedance of water quality standards.

St. Vrain Creek streamflow increases below Longmont's WWTP would result in an increase in the concentration of ammonia similar to that shown for direct effects in Table 3-80. Predicted increases in ammonia concentrations could result in occasional exceedances of the standard under all alternatives. The No Action Alternative would have the greatest potential to result in exceedances of the standard because of the higher maximum Windy Gap deliveries that could occur. None of the alternatives are predicted to result in exceedances of iron or manganese standards.

Assessment of St. Vrain Creek water quality below the St. Vrain Sanitation District WWTP for cumulative effects resulted in similar water quality changes as shown in Table 3-81. None of the alternatives would substantially increase the potential for exceedance of water quality standards in this reach of the creek.

Big Dry Creek

Increased flows from additional effluent discharges in Big Dry Creek below the Broomfield WWTP would increase the concentration of ammonia to about 2.4 mg/L under the No Action Alternative and about 2.6 mg/L under the action alternatives. The higher ammonia concentrations would increase the potential for exceeding the chronic ammonia standard. Iron concentrations, which currently exceed the standard, would decrease to below the standard under all alternatives. Manganese concentrations would decrease under all alternatives and remain below the standard.

Coal Creek

Higher streamflow in Coal Creek from additional WWTP discharges for Superior, Louisville, Lafayette, and Erie are expected to increase ammonia concentrations in Coal Creek based on the current quality of WWTP discharges. All alternatives could result in ammonia concentrations that would exceed the standard, particularly during low flows.

Cache la Poudre River

Additional WWTP discharges to the Cache la Poudre River below Greeley's WWTP would increase ammonia and copper concentrations similar to those shown in Table 3-83. All alternatives would have a similar increase in ammonia and copper concentrations. No exceedance of water quality standards for these parameters is predicted.

Chimney Hollow and Dry Creek

Water quality in the short reach of Chimney Hollow below the new reservoir and in Dry Creek would be similar to the water quality characteristics of the reservoirs as described later in this section. All water quality parameters are predicted to meet standards below both reservoirs.

Ralph Price Reservoir

A summary of estimated water quality changes for the enlargement of Ralph Price Reservoir under the No Action Alternative is shown in Table 3-107. Ralph Price Reservoir would remain in an oligotrophic state with no change in clarity. Water quality would improve slightly with a larger and deeper reservoir. Nutrient and chlorophyll *a* concentrations would decrease slightly from existing conditions. DO concentrations would likely increase. The larger reservoir would likely have slightly lower temperatures than existing conditions. Ralph Price Reservoir would continue to meet DO, ammonia, nitrate, dissolved manganese, and temperature standards.

Table 3-107. Average predicted water quality for Ralph Price Reservoir—cumulative effects.

Parameter	Average Annual Values Over the 15-Year Model Period	
	Existing Conditions	No Action
Total phosphorus (µg/L)	5.1	4.9
Total nitrogen (µg/L)	188	177
Chlorophyll *a* (µg/L)	0.6	0.4
Secchi-disk depth (m)	3.8	3.8
Trophic state (Index)	Oligotrophic (26)	Oligotrophic (22)

Water Delivery to East Slope Reservoirs

Water delivery to East Slope Reservoirs and nutrient loadings from the Adams Tunnel affects reservoir water quality. The average annual nutrient loads delivered through the Adams Tunnel, as predicted by the Three Lakes Model, are listed in Table 3-108. The highest loading occurs for the Proposed Action and the least for the No Action Alternative.

Table 3-108. Average nutrient load through the Adams Tunnel—cumulative effects.

Alternative	Average Phosphorus Load	Average Nitrogen Load
	(kg/yr)	
Existing Conditions	2,480	75,484
Alternative 1 – No Action	2,501	78,942
Alternative 2 – Proposed Action	2,774	82,947
Alternatives 3 – 5	2,369	82,516

Carter Lake

Cumulative impacts to Carter Lake and Horsetooth Reservoir water quality under the Proposed Action would be similar, but slightly less than direct effects because less water would be delivered to the East Slope.

Predicted water quality for Carter Lake under existing conditions and all alternatives is summarized in Table 3-109. Table 3-110 shows the percent change in water quality for each alternative compared to existing conditions. The trophic state would remain oligotrophic-mesotrophic and clarity would not change from existing conditions under all alternatives. Chlorophyll *a* would increase slightly under the action alternatives. Nutrient concentrations would increase the most under the Proposed Action. Model predictions indicate that all alternatives may slightly reduce DO concentrations in both the metalimnion and hypolimnion. The Proposed Action would likely result in the lowest DO concentrations.

Table 3-109. Average predicted water quality for Carter Lake—cumulative effects

Parameter	Average Annual Values Over the 15-Year Model Period			
	Existing Conditions	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	9.9	9.9	10.4	9.7
Total nitrogen (µg/L)	226	231	237	236
Chlorophyll *a* (µg/L)	1.8	1.8	2.0	1.9
Secchi-disk depth (m)	2.8	2.8	2.8	2.8
Trophic state (Index)	Oligotrophic - Mesotrophic (36)	Oligotrophic - Mesotrophic (37)	Oligotrophic - Mesotrophic (37)	Oligotrophic - Mesotrophic (37)

Table 3-110. Carter Lake predicted water quality changes by alternative compared to existing conditions—cumulative effects.

Parameter	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	No Change	+5.1%	-2.0%
Total nitrogen (µg/L)	+2.2%	+4.9%	+4.4%
Chlorophyll *a* (µg/L)	No Change	+11.1%	+5.6%
Secchi-disk depth (m)	No Change	No Change	No Change
Trophic state	No Change	No Change	No Change

Carter Lake would continue to meet DO, ammonia, and nitrate standards. Temperature standards are not predicted to exceed existing conditions. Dissolved manganese concentrations may increase due to decreased hypolimnetic DO concentrations, but it is unlikely that the standard would be exceeded for the alternatives.

Horsetooth Reservoir

Predicted water quality for Horsetooth Reservoir under existing conditions and all alternatives is summarized in Table 3-111. Table 3-112 shows the percent change in water quality for each alternative compared to existing conditions. The trophic state would remain unchanged for all alternatives. Clarity, as measured by Secchi-disk depth, would decrease by 0.1 meter for the Proposed Action. The Proposed Action also has the highest nutrient loading from the Adams Tunnel and would result in the highest reservoir nutrient and chlorophyll *a* concentrations. Dry Creek Reservoir under Alternative 5 would retain phosphorus, thereby reducing the phosphorus load to Horsetooth Reservoir. All alternatives may slightly reduce DO concentrations in both the metalimnion and hypolimnion.

Table 3-111. Average predicted water quality for Horsetooth Reservoir—cumulative effects.

Parameter	Average Annual Values Over the 15-Year Model Period			
	Existing Conditions	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	9.9	9.9	10.5	9.6
Total nitrogen (µg/L)	274	283	292	291
Chlorophyll *a* (µg/L)	3.5	3.6	3.8	3.6
Secchi-disk depth (m)	2.6	2.6	2.5	2.6
Trophic state (Index)	Mesotrophic (43)	Mesotrophic (43)	Mesotrophic (44)	Mesotrophic (43)

Table 3-112. Horsetooth Reservoir predicted water quality changes by alternative compared to existing conditions—cumulative effects.

Parameter	No Action	Proposed Action	Alternative 5
Total phosphorus (µg/L)	No Change	+6.1%	-3.0%
Total nitrogen (µg/L)	+3.3%	+6.6%	+6.2%
Chlorophyll *a* (µg/L)	+2.9%	+8.6%	+2.9%
Secchi-disk depth (m)	No Change	-3.8%	No Change
Trophic state	No Change	No Change	No Change

Horsetooth Reservoir would continue to meet ammonia and nitrate standards. Temperature standards are not predicted to exceed existing conditions. Dissolved manganese concentrations may increase slightly due to decreased hypolimnetic DO concentrations, which may result in continued exceedance in the DO and manganese water supply standards under all alternatives.

Chimney Hollow Reservoir

The predicted water quality for Chimney Hollow Reservoir for the Proposed Action is summarized in Table 3-113. Water quality for a 70,000 AF Chimney Hollow Reservoir under Alternatives 3 and 4 would be similar. The reservoir is predicted to be oligotrophic with low nutrient and chlorophyll *a* concentrations.

Table 3-113. Average predicted water quality for Chimney Hollow Reservoir—cumulative effects.

Parameter	Average Annual Values Over the 15-Year Model Period
Total phosphorus (µg/L)	8.5
Total nitrogen (µg/L)	185
Chlorophyll *a* (µg/L)	0.7
Secchi-disk depth (m)	3.7
Trophic state (Index)	Oligotrophic (25)

Dry Creek Reservoir

Predicted water quality for Dry Creek Reservoir under Alternative 5 is shown in Table 3-114. The reservoir is predicted to be oligotrophic. Water quality would be slightly lower than Chimney Hollow Reservoir.

Table 3-114. Average predicted water quality for Dry Creek Reservoir—cumulative effects.

Parameter	Average Annual Values Over the 15-Year Model Period
Total phosphorus (µg/L)	9.7
Total nitrogen (µg/L)	222
Chlorophyll *a* (µg/L)	1.3
Secchi-disk depth (m)	3.6
Trophic state (Index)	Oligotrophic (28)

3.8.4 Surface Water Quality Mitigation

Several mitigation measures were developed to address potential impacts to water quality from operation of the WGFP. The primary focus of mitigation efforts was to reduce nutrient loading into the Three Lakes system from additional WGFP pumping and to address the potential WGFP contribution to elevated Colorado River stream temperatures in the summer. These and other mitigation measures are described in the following discussion and are based on implementation of the Proposed Action.

3.8.4.1 Nutrient Reduction

> To offset nutrient loading to the Three Lakes, the Subdistrict would fund improvements to the Fraser Sanitation District WWTP, implement nonpoint source BMPs in the Colorado River basin, and other measures as needed to offset WGFP impacts. Such measures would avoid adverse impacts to water quality in the Three Lakes reservoirs and would have a year-round benefit to water quality in the Colorado River, as well as the Fraser River and Willow Creek.

The WGFP would result in additional pumping from the Colorado River at Windy Gap Reservoir with deliveries to Granby Reservoir and subsequent pumping and conveyance through Shadow Mountain Reservoir and Grand Lake prior to delivery through the Adams Tunnel to the East Slope. Distribution on the East Slope includes conveyance through other C-BT facilities including Carter Lake and Horsetooth Reservoir prior to delivery to WGFP Participants.

The WGFP does not introduce or directly contribute to the nutrients in the Colorado River that are pumped into the Three Lakes system. As described previously in Section 3.8.1.3, there are a number of sources that affect the nutrient concentrations in the Colorado and Fraser Rivers including, WWTP discharges, livestock, agricultural runoff, and other nonpoint sources such as roads and developed areas. Water quality modeling of the Proposed Action predicts that the WGFP would deliver an additional 6,128 kg/year of total nitrogen (Table 3-70) and 778 kg/year of total phosphorus (Table 3-69) compared to existing conditions into the Three Lakes on an average annual basis.

Nutrient concentrations are of concern in the Three Lakes system because of the role they play in increasing algae growth (measured as chlorophyll *a*), reducing clarity (Secchi disk depth), and increasing lake productivity (trophic level). Nutrients in the reservoir also affect dissolved oxygen concentrations and the concentrations of metals such as manganese. Water deliveries to the East Slope also convey nutrients to Carter Lake, Horsetooth Reservoir, and other streams and facilities.

To mitigate nutrient loading to the Three Lakes associated with WGFP pumping, the Subdistrict would be required to submit a nutrient reduction plan to Reclamation and the Corps for approval. The plan must be in place prior to the construction and operation of the WGFP. To offset the predicted nutrient loadings into the Three Lakes and reduce the associated water quality effects, the Subdistrict plans to implement both point source and nonpoint source nutrient reduction measures upstream from the Windy Gap Reservoir diversion point. The following sections provide an overview of the currently planned point and nonpoint source nutrient reduction measures the Subdistrict has identified.

Point Source Nutrient Reduction. Improvements to the three largest WWTP operations—Granby Sanitation District, Fraser Sanitation District, and Three Lakes Sanitation District, were evaluated to determine potential treatment process upgrades that would reduce nutrient discharges. Modeling of WWTP operations and upgrades determined that the most cost effective and efficient method for reducing WWTP nutrient discharges would be a series of improvements to the Fraser Sanitation District WWTP located just north of the Town of Fraser (Black and Veatch 2009).

Proposed Fraser Sanitation District WWTP improvements are estimated to reduce annual total nitrogen discharges to the Fraser River by 5,076 kg/year and total phosphorus loading by 6,566 kg/year. Because the WGFP only pumps a few months out of the year and does not pump all of the water in the river, the reduction in nutrient loading to the Three Lakes was based on projected WGFP pumping volumes from April to August. Thus, the actual reduction in nutrient loading to the Three Lakes is about 10 to 15 percent of total nutrient reductions from WWTP improvements, or 822 kg/year of total nitrogen and 774 kg/year of total phosphorus (Table 3-115). The Fraser River below the WWTP and the Colorado River downstream from the Fraser River confluence would benefit from the year-round reduction in nutrient discharges and the Three Lakes would benefit from reduced nutrient delivery when the Windy Gap Project is pumping. Point source nutrient reduction measures would offset about 13 percent of the projected WGFP nitrogen loadings into the Three Lakes and about 99 percent of the phosphorus loadings.

Table 3-115. Summary of nutrient reductions to Three Lakes with mitigation measures.

Nutrient Loading and Reduction Sources	Total Nitrogen	Total Phosphorus
	kg/year	
Projected nutrient loading to the Three Lakes from the WGFP compared to existing conditions	**6,128**	**778**
—Point source nutrient reduction – Fraser WWTP	822	774
—Nonpoint source nutrient reduction – E Diamond H Ranch	684	117
—Nonpoint source nutrient reduction – C-Lazy-U Ranch	1,836	237
Total identified nutrient reduction to Three Lakes	**3,343**	**1,128**
Additional nutrient reduction needed to offset loading to Three Lakes	**2,785**	**(350)**

To implement WWTP improvements, the Subdistrict and Fraser Sanitation District would enter into an agreement specifying the improvements and Subdistrict funding. Capital costs for improvements are estimated at about $3.3 million and annual operating costs would increase about $120,000 to $230,000. The improvements would be implemented prior to completion of Chimney Hollow Reservoir and operation of the WGFP.

Nonpoint Source Nutrient Reduction. The Subdistrict has identified several nonpoint source nutrient reduction measures to further reduce nutrient loadings from the WGFP. Nonpoint nutrient reduction measures focused on improved agricultural practices and reduced fertilizer application for several parcels of land in the Willow Creek watershed, which is tributary to the Colorado River above Windy Gap Reservoir as described below. Like point source nutrient reduction measures, the watersheds would see a greater reduction in nutrients than the actual nutrient reduction to the Three Lakes. Thus, there are beneficial effects to a broader geographic area than just the nutrient reduction to the Three Lakes.

E-Diamond H Ranch — This 265-acre ranch located on Church Creek, a tributary to Willow Creek, is currently irrigated from the Red Top Ditch and periodically fertilized for hay production. To reduce nutrient discharges from runoff, the land would no longer be irrigated and all fertilizer application would cease. These measures are predicted to reduce total nitrogen loading to the Three Lakes by 685 kg/year and total phosphorus by 117 kg/year (Table 3-115) (Black and Veatch Oct 9, 2009). The Subdistrict would enter into an agreement with the E-Diamond H Ranch to implement the changes in land management for this property prior to implementation of the WGFP.

C-Lazy-U Ranch — Several ranch management practices and BMPs would be implemented on the 300 acre C-Lazy-U Ranch located immediately upstream of Willow Creek Reservoir to reduce nutrient discharges. Primary improvements include a reduction in chemical fertilizer application, better manure management, use of vegetated buffer strips adjacent to Willow Creek to capture nutrients in surface water runoff, and streambank restoration to reduce erosion. A reduction in nutrient loadings from the C-Lazy-U Ranch would reduce direct nutrient loadings into Granby Reservoir via the Willow Creek Feeder Canal deliveries from Willow Creek Reservoir as well as releases from the reservoir that are pumped to Granby Reservoir from Windy Gap Reservoir. Implementation of these improvements would reduce total nitrogen loading to the Three Lakes by 1,836 kg/year and total phosphorus by 237 kg/year from the C-BT deliveries from Willow Creek Reservoir to Granby Reservoir (Table 3-115) (Black and Veatch Nov 6, 2009). The Subdistrict has entered into an agreement with the C-Lazy-U Ranch to implement the changes in land management for this property.

Total Nutrient Reductions. The incremental nutrient loadings from the Proposed Action compared to existing conditions would be an additional 6,128 kg/year of total nitrogen and 778 kg/year of total phosphorus (Table 3-115). Currently identified nutrient reduction measures would offset about 54 percent of the WGFP total nitrogen loadings to the Three Lakes or 3,343 kg/year. Thus, about 2,785 kg/yr of additional nitrogen reduction measures need to be identified. The Subdistrict will be responsible for developing other nonpoint source nutrient reduction measures or other actions elsewhere in the watersheds upstream of Windy Gap Reservoir to meet the total nitrogen reduction levels needed to provide at least a 1:1 reduction in TN and TP loadings to the Three Lakes. Implementation of point source and nonpoint source nutrient reduction measures would offset WGFP total phosphorus loadings to the Three Lakes by 350 kg/year more than projected WGFP loading (Table 3-115). While additional phosphorus reduction measures are not needed to offset WGFP loadings, any additional nutrient reduction measures to reduce nitrogen are also likely to further reduce phosphorus loading.

Monitoring. The Subdistrict will submit to Reclamation and the Corps for approval a monitoring program and annual results to ensure that proposed nutrient reduction measures and any additional unidentified point and nonpoint source mitigation measures are effective in offsetting all of the nitrogen and phosphorus loading to the Three Lakes attributable to the WGFP. Nutrient reduction measures would be implemented in an adaptive management approach with the results of monitoring used to demonstrate the effectiveness and need for additional or less mitigation.

The estimates of nutrient reduction from Fraser Sanitation District WWTP improvements are believed to be reasonably accurate because of the controlled environment associated with operation of a closed system. However, the effectiveness of WWTP improvements on nutrient reduction would be monitored at the discharge outlet. The monitoring program would include appropriate sampling parameters and frequency to calculate actual nutrient reduction.

Nonpoint source nutrient reductions are more difficult to predict because of the large geographic area, uncertainties in the interaction of biological, chemical, and physical processes in the watershed, and outside variables. To measure the effectiveness of nonpoint source mitigation measures, a monitoring program would be developed for the E-Diamond H Ranch and C-Lazy-U Ranch. The Subdistrict initiated water quality monitoring on Willow Creek near the C-Lazy-U Ranch and on Church Creek near the E-Diamond H Ranch in 2010 to begin establishing a baseline for water quality prior to implementing nonpoint source mitigation measures. Similar monitoring would be established for other locations where nonpoint source nutrient reduction measures are identified.

In addition, the reduced nutrient loading to the Three Lakes by upgrading the Fraser WWTP and nonpoint source BMPs would likewise reduce the nutrient load delivered to the East Slope in Carter Lake, Horsetooth Reservoir, and the C-BT system. Mitigation measures would offset the incremental total phosphorus loadings from the Proposed Action compared to existing conditions. Nutrient mitigation measures would reduce the potential for reductions in dissolved oxygen in Carter Lake and Horsetooth and the associated concerns with an increase in manganese availability and total organic carbon and geosmin in Horsetooth Reservoir.

3.8.4.2 Temperature Mitigation Measures

WGFP diversions would increase stream temperature in the Colorado River below Windy Gap Reservoir and at times, stream temperature could violate the state DM or MWAT. Additional stream temperature and climatic data became available following the initial analysis of temperature impacts for the Draft EIS. A dynamic temperature model was used to further evaluate the potential effects of the WGFP on temperature in the Colorado River downstream of the Windy Gap diversion. Results of this analysis indicated that most exceedances of the chronic MWAT and DM standards are likely to occur after July 15. As described in Section 3.8.2.4, dynamic modeling indicated that the MWAT and DM standards could be exceeded for several consecutive days or weeks depending on the hydrologic year, timing of WGFP diversions, streamflow volume, and climatic conditions.

> The Colorado Wildlife Commission and CWCB have adopted the FWMP prepared by the Subdistrict in compliance with CRS § 37-60-122.2. The Plan includes monitoring of stream temperature in the Colorado River and curtailing Windy Gap pumping under certain conditions to reduce the potential for exceedance of temperature standards.

In recognition of the state's responsibility for fish and wildlife resources found in and around state waters that are affected by water diversion, delivery, or storage facilities, the Colorado General Assembly enacted CRS § 37-60-122.2. This statute states that "fish and wildlife resources that are affected by the construction, operation or maintenance of water diversion, delivery, or storage facilities should be mitigated to the extent, and in a manner, that is economically reasonable and maintains a balance between the development of the state's water resources and the protection of the state's fish and wildlife resources." In compliance with CRS § 37-60-122.2, the Subdistrict prepared a *Fish and Wildlife Mitigation Plan* (FWMP) (Municipal Subdistrict 2011a) that includes mitigation measures for the identified impacts to Colorado River stream temperature from the WGFP. The FWMP was adopted by the Colorado Wildlife Commission on June 9, 2011 and by the CWCB on July 13, 2011. The FWMP is a component of the mitigation requirement to address the impacts identified in the EIS. Mitigation measures from the FWMP to reduce the potential for impacts to stream temperature from the WGFP are described below and are found in the FWMP in Appendix E.

Monitoring Stations. The Subdistrict will work with Denver Water to install, operate, and maintain two continuous real-time temperature monitoring stations on the Colorado River – one at the Windy Gap gage and one upstream of the confluence with the Williams Fork River.

Temperature Thresholds. For the purposes of the Plan, the threshold temperatures will be the following, as measured at the temperature monitoring stations identified above:

1. MWAT Chronic Threshold: 18.2°C (64.8°F), based on current MWAT Chronic Standard.
2. DM Acute Threshold: 23.8°C (74.8°F), based on current DM Acute Standard.

MWAT Chronic Threshold Exceedances – Reduction or Curtailment of WGFP Pumping. For the period after July 15 of each year:

1. At such times as the WAT exceeds the MWAT Chronic Threshold, the Subdistrict will reduce or curtail WGFP pumping at the Windy Gap diversion to the extent necessary to maintain temperatures within the MWAT Threshold. Reduced pumping may not be sufficient to maintain temperatures below the threshold.
2. Pumping for the original Windy Gap Project, now and after the WGFP is in operation, may occur at any time that the Windy Gap water rights are in priority and sufficient space is available in Granby Reservoir that such water pumped will not be reasonably expected to spill from the reservoir. Therefore, WGFP pumping will be defined as pumping that occurs at such times as Reclamation and the NCWCD jointly determines, based on the most probable forecasts of inflows to Granby Reservoir, that a spill of water from the C-BT system is reasonably foreseeable. All other pumping will be considered to be for the original Windy Gap Project.

DM Acute Threshold Exceedances – Reduction or Curtailment of Pumping for the WGFP and the Original Windy Gap Project.

1. At such times as the DM temperature is within 1°C of the DM Acute Threshold, the Subdistrict will reduce or curtail pumping for the original Windy Gap Project or the WGFP at the Windy Gap diversion to the extent necessary to maintain temperatures within the DM Threshold. Reduced pumping may not be sufficient to maintain temperatures below the threshold. In the future, the 1°C buffer may be altered, based on experience, to maintain compliance with the DM Threshold.

Limitations on Reduction or Curtailment of Windy Gap Pumping. The temperature mitigation measures identified above will be suspended in the event that, and at such times as, there is no material causal relationship between Windy Gap Project or WGFP operations and any exceedance of the MWAT Chronic threshold or DM Acute threshold at the monitoring stations identified above. For the purposes of this paragraph a "material causal relationship" is defined as either an actual measurable impact on temperature using readily available monitoring technology or a modeled impact on temperature that is not de minimus and is based on a computer model or studies accepted by the CDPW. The Subdistrict will cooperate with future studies to determine what factors, other than flow changes, have effects on water temperatures in the Colorado River below Windy Gap.

Use of the Windy Gap Bypass Valve and Auxiliary Outlet. The Subdistrict will use the Windy Gap Project Bypass Valve and Auxiliary Outlet to the maximum extent practicable, without causing adverse effects to the Windy Gap Project facilities or operations for the bypass of water that is otherwise bypassed from the Windy Gap Project. This measure is intended to make releases of water from these outlets deeper in the reservoir that may be colder than water bypassed over the spillway.

3.8.4.3 Other Mitigation Measures

Several other mitigation measures would be implemented to minimize construction related water quality impacts and to continue ongoing cooperative studies to improve water quality in Three Lakes and East Slope C-BT reservoirs.

- A construction stormwater management plan would be developed and implemented for new facility construction under all alternatives to reduce erosion and sediment delivery to nearby streams and water bodies as part of the NPDES Stormwater Permit.
- The Subdistrict would commit to continued participation and funding of the ongoing Nutrient Studies, with participation and collaboration by Reclamation, NCWCD, and Grand County, to better understand water quality issues in the Three Lakes system and provide guidance for future management decisions
- As described in Section 3.5.4.1, modified prepositioning would maintain higher water levels in Granby Reservoir, which can be a positive benefit to water quality.

3.8.5 Unavoidable Adverse Effects

Additional WGFP diversions may result in elevated Colorado River stream temperatures below Windy Gap Reservoir and the Williams Fork that at times could exceed chronic and/or acute water quality temperature standards. To minimize the potential for exceedance of the temperature standard, the Subdistrict would curtail diversion in accordance with the FWMP adopted by the Colorado Wildlife Commission and CWCB. A predicted increase in the concentration of nitrogen and phosphorus to the Three Lakes, Carter Lake, and Horsetooth Reservoir would be avoided with proposed point and nonpoint source nutrient reduction measures. An increase in WWTP return flows on the East Slope from additional use of Windy Gap water could increase the potential for exceedance of the ammonia standard in Big Dry Creek and Coal Creek.

3.9 Aquatic Resources

3.9.1 Affected Environment

3.9.1.1 Regulatory Framework

Fish are protected by a variety of federal and state laws and regulations. The Fish and Wildlife Coordination Act (16 U.S.C. §§ 661-667e) allows for coordination between the lead federal action agency and the FWS and CDPW. The goal of consultation under the Coordination Act is conservation of wildlife by preventing loss of, and damage to, wildlife resources and providing for the development and improvement of these resources in connection with water resource development. The FWS will issue a Fish and Wildlife Coordination Act report for the WGFP in compliance with the Coordination Act. EO 12962 relates to recreational fisheries. The intent of this EO is to conserve, restore, and enhance aquatic systems to provide for increased recreational fishing opportunities nationwide. Federally listed threatened and endangered fish species protected under the Endangered Species Act (ESA) are discussed in Section 3.13.

In recognition of the state's responsibility for fish and wildlife resources, the Colorado General Assembly enacted CRS § 37-60-122.2. This statute states that "fish and wildlife resources that are affected by the construction, operation or maintenance of water diversion, delivery, or storage facilities should be mitigated to the extent, and in a manner, that is economically reasonable and maintains a balance between the development of the state's water resources and the protection of the state's fish and wildlife resources." The Subdistrict prepared a FWMP in cooperation with the CDPW in compliance with CRS § 37-60-122.2 (Appendix E). The Colorado Wildlife Commission adopted the plan on June 9, 2011 and the CWCB adopted the FWMP on July 13, 2011. In addition, CDPW has the authority to manage and conserve hunted, fished, and nongame wildlife resources in the state. CDPW enforces various fishing regulations, including regulations concerning the illegal take or use of threatened or endangered species.

3.9.1.2 Area of Potential Effect

The area of potential effect for assessing impacts to aquatic resources encompasses the various West and East Slope streams and reservoirs that would experience hydrologic or water quality changes as a result of the alternative actions. On the West Slope this is the Colorado River from Granby Reservoir to below the confluence with the Blue River and Willow Creek below Willow Creek Reservoir. Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake also are in the study area, as well as potential new reservoir sites at Jasper East and Rockwell. Study area streams on the East Slope are North St. Vrain Creek below Ralph Price Reservoir, St. Vrain Creek, Big Thompson River, Big Dry Creek, and Coal Creek. East Slope reservoirs in the study area are Carter Lake, Horsetooth Reservoir, and Ralph Price Reservoir, as well as potential new reservoirs at Chimney Hollow and Dry Creek.

3.9.1.3 Data Sources

Information on fish and macroinvertebrates in the study area was collected from existing data sources and field studies. Fish population and fish community data were compiled from CDPW surveys and stocking records, and historical data collected from other sources. Fish habitat analysis on the Colorado River was based on the River2D instream flow model using hydrology modeling described in Section 3.5.2.2 and data gathered on channel topography, water surface elevation, water depth, and velocity profile, for two sites on the Colorado River, one upstream of and one downstream from the Williams Fork River confluence. Macroinvertebrate sampling was conducted on the Colorado River as part of the analysis for the EIS. Additional information on aquatic resources is found in the Aquatic Resources Technical Report (Miller Ecological Consultants 2010).

3.9.1.4 West Slope Rivers, Streams, and Reservoirs

Historical Perspective

The aquatic environment in the Colorado River below Granby Reservoir is the result of more than a century of human-induced changes to the stream ecosystem. These changes include introduction of nonnative species, management of fish for commercial harvest, sport fishing harvest and catch and release regulations, diversion of water for human use, and habitat fragmentation caused by dams and diversions. The aggregate of these multiple influences implemented over a long period have contributed to the current condition of the stream ecosystem.

Joseph et al. (1977) report that the native fish community in the upper Colorado River consisted of four species: Colorado River cutthroat trout (*Onchoryncus clarki pleuriticus*), speckled dace (*Rhinichthys osculus*), mottled sculpin (*Cottus bairdi*), and mountain whitefish (*Prosopium williamsoni*). This number of species is typical of many of the headwater trout streams in the central Rocky Mountains (Moyle and Herbold 1987). Behnke (1992) notes that the native Colorado River cutthroat trout were reported to achieve weights of up to 22 pounds. He does not state if these were lake-dwelling or riverine specimens. In other areas with both lake-dwelling and stream-dwelling forms, the lake forms attain larger sizes.

Nonnative species introductions began in the late 1800s as game management agencies stocked species for sport fishing opportunities for residents and tourists. The earliest documented stocking of game species in the upper Colorado River basin occurred in 1882 (Wiltzius 1985) when both brook trout and rainbow trout were stocked. Brown trout were first stocked in the upper Colorado River basin in 1888. The first introductions of nongame nonnative species occurred in the early 20th century. All of these nonnative species would have increased the competition with and possibly predation on the native species, including Colorado River cutthroat trout. Fathead minnow were stocked in the Colorado River near Hot Sulphur Springs in 1938. White sucker were stocked in a lake in the Colorado River headwaters in 1926 (Wiltzius 1985). In addition, both unintentional and intentional introductions of other game and nongame species have occurred over the past century. Over time, the native species, especially cutthroat trout, have declined and the nonnative trout have increased. The result is the current fish community in the upper Colorado River basin.

Commercial fisheries in the early 1900s in Colorado may have contributed to changes in the fish populations in the state. A report from the U.S. Fish Commission in 1903 stated that 290,390 pounds of "black-spotted" trout (the common name for the native cutthroat) and native suckers were caught in the state. In addition, a total of 1,069,776 pounds of nonnative fish were caught statewide (Wiltzius 1985). A total of 19,900 pounds of black-spotted trout were caught in 1900 in Grand County (Wiltzius 1985). Commercial fisheries likely contributed to the decline in native cutthroat populations in the upper Colorado River.

Sport fish management has had a major impact on the makeup of the fish community in the Colorado River near Windy Gap. Game fish limits have changed over the past 50 years from a "catch and keep" type of approach, which relies on fish stocking to supplement populations, to a "catch and release" type of approach, which relies more on natural reproduction. Most trout stocking in the last 50 years consisted of introducing the desired nonnative trout species, rainbow, brown, and cutthroat trout for sport catch rather than stocking native Colorado River cutthroat species. Those stocking efforts resulted in the reduction in the native cutthroat populations due to competition and predation from other species.

Other biotic factors also can impact the fish community. These factors include changes to the primary and secondary producers upon which the fish community depends and the introduction of parasites, in particular, whirling disease. Whirling disease was present in many Colorado rivers by the mid-1990s including the Colorado River near Windy Gap. Whirling disease resulted in a severe reduction in rainbow trout populations in many of the infected river systems. The Colorado River at Windy Gap, dominated by rainbow trout in the 1980s, is now dominated by brown trout. The decline of rainbow trout provided an opportunity for the increase in brown trout populations. Brown trout are managed for sport fishing by the CDPW. Brown trout are known predators and competitors of other trout species. Brown trout have been shown to reduce native cutthroat populations (Behnke 1992) and to reduce other salmonid populations through predation and competition (Taylor et al. 1984). Brown trout are nominated as one of the top 100 invasive species by the Global Invasive Species database (2010). The current number of brown trout in the Colorado River makes reestablishment of other salmonids, either rainbow trout or cutthroat trout, difficult. The reestablishment of other salmonids may require a reduction in the number of brown trout.

The first streamflow alterations on the Colorado River occurred with diversions for agricultural use and municipal and industrial water supplies. Those alterations have continued for more than 100 years and include transbasin diversions from the Colorado River basin to the South Platte River basin for use on the Colorado Front Range. The transbasin diversions began in the 1890s with the Grand River ditch and continued in the 1900s with Moffat in 1937, C-BT in 1947, and Windy Gap in 1985. Irrigation diversion began in Grand County in the 1890s. These incremental flow diversions have occurred for more than 100 years. As a result, the native flow volume has been reduced by approximately 70 percent by these diversions and off-stream uses. The flow pattern is still shaped by snowmelt runoff but at a reduced magnitude and duration. Approximately 33 percent of the current annual volume occurs in June compared to 36 percent of the native June annual volume. The large reservoirs and headwater transbasin diversions have the ability to reduce the peak river flows in most years. In years with high snowpack, such as the winter of 2010-2011, long duration, high flows still occur. The summer and fall low flows also are reduced from native flow conditions. July, August, and September flows have been reduced by approximately 65 percent from native conditions (Table 3-1) that occurred prior to any diversions. The lower summer flows may result in less area of suitable habitat and elevated stream temperatures than native conditions.

The combination of the above conditions provides the habitat for the existing fish and macroinvertebrate populations in the Colorado River near Windy Gap Reservoir. Trout populations continue to fluctuate from year to year, but the cause for the fluctuations is undetermined and likely a combination of multiple factors. Overall, the trout populations in the upper Colorado River are relatively high and comparable to other similar rivers in the state. While the macroinvertebrate community is diverse, one species, *Pteronarcys californica,* has declined in the Colorado River both upstream and downstream of Windy Gap Reservoir since the 1980s. The following discussion provides additional background on the current condition of aquatic life in the project area.

Colorado River

The Colorado River between Windy Gap Reservoir and Kremmling, Colorado is managed by CDPW as a sport fishery. The primary games species are brown trout and rainbow trout. Special regulations include a two-fish bag and possession limit from Granby Dam downstream to the lower boundary of Byers Canyon, and from the Troublesome Creek confluence downstream to Rifle, Colorado. The section between the lower boundary of Byers Canyon and the Troublesome Creek confluence is a catch and release Gold Medal-designated stream, allowing fishing with artificial flies and lures only. This designation is limited to “waters of the State accessible for fishing to the general angling public.” Only public waters are designated as Gold Medal; private waters are excluded by the above requirement.

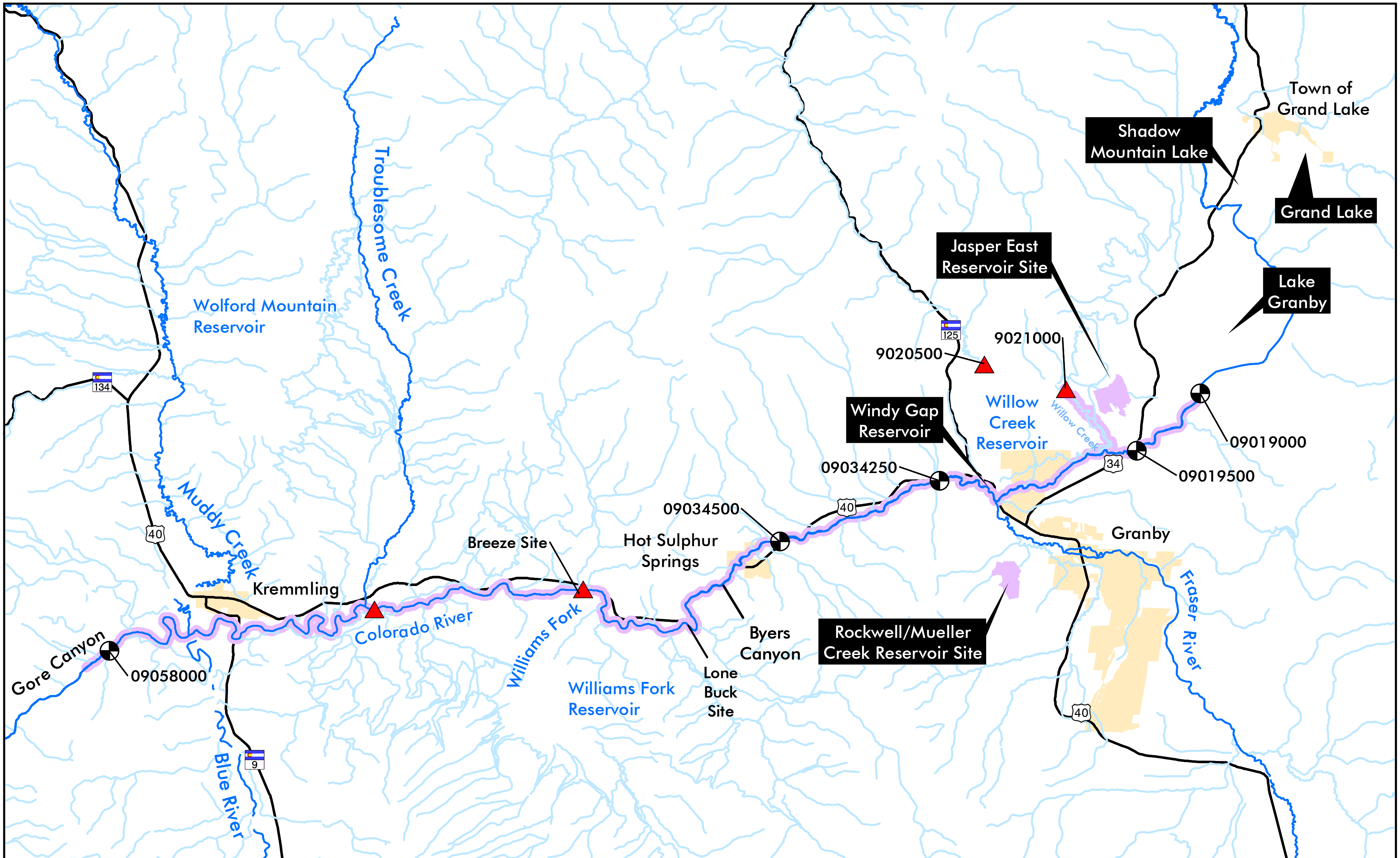
> The Colorado River supports a large population of brown trout, while the rainbow trout populations remain low as a result of whirling disease and competition with brown trout.

A 2002 CDPW fish survey in the Colorado River from Windy Gap Reservoir downstream to Kremmling indicated that brown trout and rainbow trout, both introduced species, were two of the dominant fish species at each sampling location (Ewert 2011). Recent surveys of fish populations in the Colorado River downstream of Windy Gap show that abundance of fish greater than 6 inches long has ranged from a high of 11,255 fish/mile in 2003 to a low of 3,441 fish/mile in 2010, with an average of 7,740 fish/mile over the 8-year period (Ewert 2011). Rainbow trout comprised approximately 2 percent of the total population in 2010. It is undetermined why the highest numbers were collected after one of the driest hydrologic years on record and the lower numbers were collected recently. The conditions for survival may have been better in 2001 and 2002 with lower peak flows. Nehring and Anderson (1993) found a strong correlation between year class strength and peak flows. While species composition and streamflow has changed substantially from presettlement conditions, the trout populations in the Colorado River are very high and comparable to the best fisheries in the state. Other rivers in Colorado have populations in the same range as the Colorado River downstream of Windy Gap. The Gunnison River near Almont has trout populations that range from approximately 3,500 fish/mile in 2004 to 5,500 fish/mile in 2008 (Brauch 2011). The majority of the fish population in the Gunnison River is brown trout. The Fryingpan River trout populations are approximately 9,000 fish/mile with brown trout approximately three times more numerous than rainbow trout (Bakich 2011). In the Colorado River between Parshall and Sunset from 2001 to 2007, two nonnative sucker species, the white sucker and longnose sucker, also were consistently reported throughout this reach. One nonnative minnow, the longnose dace, was found throughout the reach, while other small fish occasionally collected included the nonnative Johnny darter, nonnative creek chub, and native mottled sculpin. Prior to European settlement, Colorado River cutthroat trout was the only native trout species in the Colorado River. The existing habitat conditions are generally favorable for all the fish species collected.

Quantitative macroinvertebrate (aquatic insects) sampling was conducted at two sites (Lone Buck and Breeze) on the Colorado River (Figure 3-89) to characterize the composition and health of the benthic community. Ecological parameters such as diversity, evenness, biotic indices, taxa richness, biomass, and functional feeding groups were used to evaluate the existing condition of macroinvertebrate populations. Results of these evaluations indicated that aquatic conditions were excellent at both study areas, with the best metric values occurring at the Breeze site. More than 40 identifiable taxa were collected at each site with more than half of the taxa represented by species that are sensitive to disturbance (Plafkin et al. 1989). Sampling data indicated high biomass values at both sites, with the highest at the Lone Buck site. The Breeze site had the highest density values. Collector-gather functional feeding groups were most common at both sites, as is typical of most western streams; however, other groups also were well represented at each location.

Aquatic invertebrates in the Colorado River near Windy Gap have a high diversity with numerous species present (Miller Ecological Consultants 2010; Rees 2009). The Colorado Department of Public Health and Environment (CDPHE) evaluates macroinvertebrate communities for impairment based on the Multi Metric Index (MMI). This index assesses biological condition on a scale of 0 to 100. For high elevation cold water streams an MMI value of 50 or less indicates impairment (CDPHE 2010b). Rees (2009) calculated MMI values of 92 and 89 for the macroinvertebrates upstream and downstream of Windy Gap Reservoir, respectively. Miller Ecological Consultants data (2010) for the Lone Buck and Breeze sites had MMI values of 100. Both of these samples indicate a healthy macroinvertebrate community. However, although studies in 2004 (Miller Ecological Consultants 2010) found the *Pteronarcys* stonefly downstream of Windy Gap, surveys in 2009 (Rees) did not find *Pteronarcys* stoneflies upstream or downstream of Windy Gap. CDPW also reported a decrease in the abundance and distribution of both the stonefly *Pteronarcys* and mottled sculpin since Windy Gap Reservoir was constructed (Nehring et al. 2010).

The current water temperatures downstream of Windy Gap Reservoir have both seasonal and daily variations. Examples from July and August 2009 show the range of diurnal change and the seasonal variation without Windy Gap pumping (Figure 3-90). Thermal conditions are a result of several factors that include solar radiation, air temperature, relative humidity, wind speed, water volume, stream shading, channel geometry, and stream orientation (Theurer et al. 1984). The resulting water temperatures are the result of water passing through Windy Gap Reservoir and moving downstream combined with meteorological conditions. The August 2009 water temperature pattern followed air temperature more closely than it followed discharge. The mid-August time period illustrates this pattern (Figure 3-91).



ERO
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Figure 3-89
West Slope Aquatic Resource Study Area

Prepared for: Windy Gap Firming Project
File: 2390 WestSlopeAquatics.mxd (JP)

These daily and seasonal variations in stream temperature provide cues to stream biota for specific aspects of life history such as spawning. In addition, certain temperatures are required for energy assimilation and growth. This is especially important for young salmonids and other young fish that rely on summer growth to prepare for and survive harsher winter conditions. Adult fish rely on summer energy assimilation to prepare for winter and for preparation for reproduction. The best temperatures for growth vary by species.

Figure 3-90. Hourly water temperatures, air temperature (at Granby), and mean daily discharge for the Colorado River downstream of Windy Gap Reservoir – July 2009.

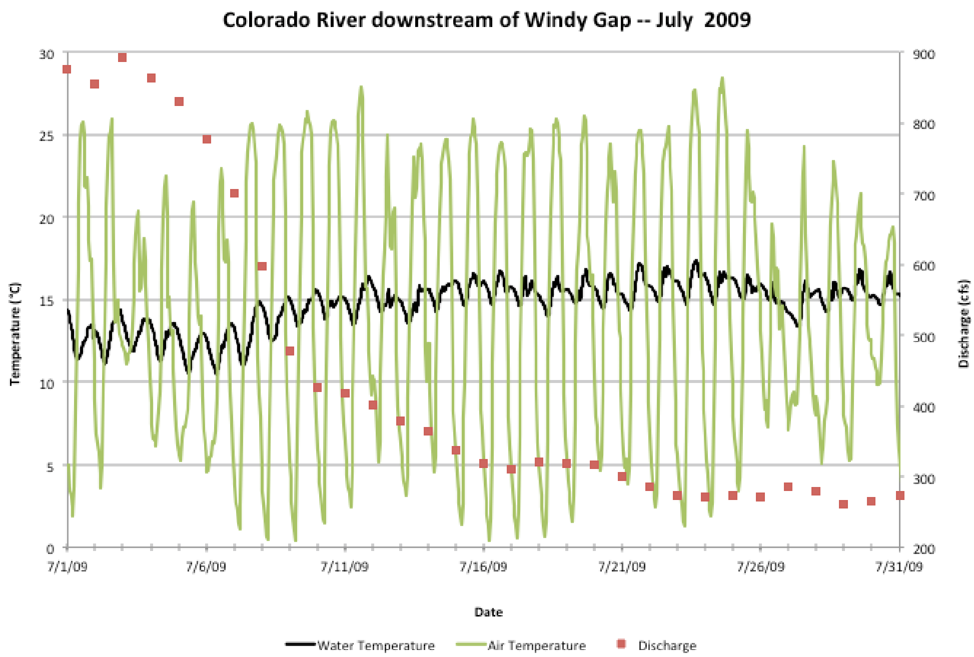
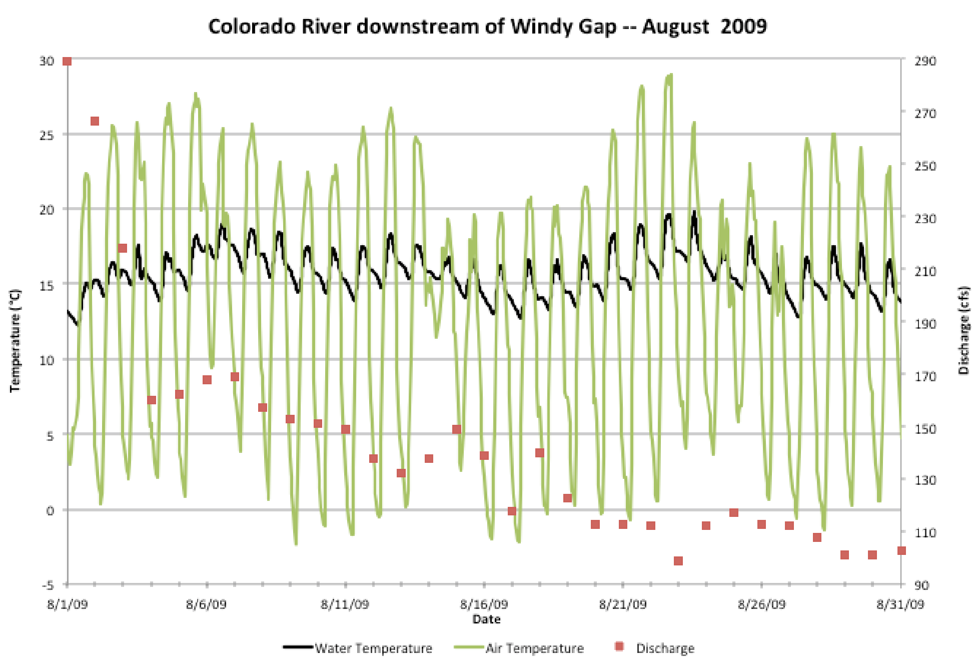


Figure 3-91. Hourly water temperatures, air temperature (at Granby), and mean daily discharge for the Colorado River downstream of Windy Gap Reservoir – August 2009.



Willow Creek

Fish population data were available for three locations on Willow Creek between Willow Creek Reservoir and the Colorado River (Miller Ecological Consultants 1997). Fish abundance was typical of small streams. Brown trout was the dominant species at all three locations with a relative abundance ranging from 63 to 97 percent. All life stages of brown trout were present and population estimates ranged from about 1,650 fish per acre to 2,670 fish per acre. The habitat conditions in Willow Creek support a reproducing brown trout population. Also present were longnose sucker, white sucker, Paiute sculpin, and rainbow trout.

Macroinvertebrate sampling on Willow Creek was conducted at the same sites and time as fish collection (Miller Ecological Consultants 1997). Index values used to assess aquatic health indicated some stress to the macroinvertebrate communities; however, the high number of individuals and taxa collected, and the presence of several pollution intolerant species suggests that pollution was not the cause of stress. It is likely that the effects of the Willow Creek Reservoir dam (i.e., less temperature fluctuation and rapid changes in discharge), or local land use created the disturbance necessary to have a slight negative effect on the index values. Typically, streams below dams support larger, but less diverse, macroinvertebrate communities.

Rockwell/Mueller Creeks and Unnamed Drainage at Jasper East Reservoir Site

CDPW does not have fish data for Rockwell and Mueller creeks or the unnamed drainage at the Jasper East Reservoir site. No fish were observed in the unnamed Jasper East drainage during a site visit. Short-lived invertebrates, typical of intermittent streams were observed, but intermittent flows are unlikely to support a fishery. Access to Rockwell and Mueller Creeks was not available to assess fish presence, but based on anecdotal information, conditions are likely similar to the drainage at Jasper East.

Grand Lake

Grand Lake provides recreational fishing for rainbow trout, brown trout, kokanee, and lake trout. Natural reproduction of lake trout is self-sustaining at a level to support a fishery. Lake trout were stocked on two occasions in the 1990s and additionally in 2004 and 2007 to investigate growth rates. No extensive stocking of lake trout is anticipated in the foreseeable future (Velarde, pers. comm. 2008). Populations of brown trout are at least partially maintained by natural reproduction in streams feeding into the lake. Other game fish populations are augmented through a stocking program conducted by CDPW. Rainbow trout and kokanee are stocked annually, while lake trout are stocked semiannually. In a July 2001 survey, rainbow trout and kokanee were not collected, but brown trout and lake trout were well represented (CDOW 2001 unpublished). The only other species present in collections was the longnose sucker.

Shadow Mountain Reservoir

Shadow Mountain Reservoir is managed by the CDPW as a recreational fishery that provides angling opportunities for rainbow trout, brown trout, cutthroat trout, kokanee, and lake trout. Natural reproduction for game fish is inadequate to support the existing level of angling recreation; therefore, populations are augmented through a stocking program. Rainbow trout, brown trout, and kokanee are stocked annually, and cutthroat trout are stocked in some years, but not always annually. Nonnative sucker species present are the longnose sucker and white sucker (CDOW 2001 unpublished). The white sucker was the dominant fish species collected in July 2001 (CDOW 2001 unpublished data).

Granby Reservoir

Granby Reservoir is a recreational fishery that provides angling opportunities for lake trout, kokanee, rainbow trout, and brown trout. Fish populations are maintained through natural reproduction and a strategic stocking program that provides angling opportunities while supporting a balanced fish community. Lake trout and brown trout are maintained through natural reproduction. Rainbow trout are capable of limited natural reproduction, but populations are augmented through annual stocking. Kokanee exhibit little or no natural reproduction; therefore, populations are dependent on stocking. However, Granby Reservoir is a critical source for kokanee eggs used in the hatchery program for kokanee stocking. An unpublished CDOW fish survey (2004) indicated that nonnative, nongame fish (longnose sucker and white sucker) were the most abundant, representing more than 85 percent of the total (CDOW 2004 unpublished data).

Balance between lake trout populations and kokanee is dependent on the water surface elevation of Granby Reservoir. During periods of low reservoir levels, the two species are thermally separated because the kokanee are more tolerant of warmer surface water than lake trout. Young lake trout survival is lower at low reservoir levels, which ultimately results in fewer lake trout, but a better balance between fish populations. During periods of high reservoir elevations, survival of young lake trout is greater than survival at low reservoir levels and less thermal separation occurs between lake trout and kokanee. The conditions that exist during high water elevations result in an overabundance of lake trout, with greater accessibility to and predation on kokanee. This, in turn, results in fewer kokanee, which eventually has negative effects on lake trout numbers because there is not a sufficient prey base to support the lake trout. Through stocking management, and specific angling regulations, CDPW strives to keep an appropriate balance between the predatory lake trout and the kokanee upon which lake trout prey.

Windy Gap Reservoir

Windy Gap Reservoir is a private reservoir operated by the Subdistrict that is not stocked or managed by CDPW; however, fish stocked in the Fraser or Colorado rivers upstream of Windy Gap are expected to be found in the reservoir. A 2004 CDOW fish survey at Windy Gap Reservoir indicated the presence of rainbow trout, brown trout, kokanee, longnose sucker, and white sucker. The white sucker was the dominant species comprising more than 85 percent of the captured fish (CDOW 2004 unpublished).

Whirling disease, which has been shown to decrease the survival of juvenile rainbow trout, is found in most West and East Slope streams, including Windy Gap Reservoir. Whirling disease is widespread across the state of Colorado and has resulted in the loss or reduction of rainbow trout populations in many of the state's rivers. The CDPW is actively researching ways to counteract whirling disease within the river systems including stocking of alternate species that are less susceptible to whirling disease. Whirling disease is caused by a parasite (*Myxobolus cerebralis*) with a complex life cycle that requires two aquatic host organisms (Nehring 2004). The earliest detection of *M. cerebralis* in the Upper Colorado River basin occurred in 1988. Since that time, recruitment of wild rainbow trout has severely declined (Nehring et al. 2000). The two host organisms required for completion of the *M. cerebralis* life cycle are aquatic tubificid worm (*Tubifex tubifex*) and a salmonid fish (trout). Spores released by one species of host organism infect the other host organism. The spore of *M. cerebralis* that is produced and released from *T. tubifex* worms is referred to as a triactinomyxon or TAM.

CDPW identified Windy Gap Reservoir as some of the most suitable habitat (low-velocity water and silt or mud substrate) for *T. tubifex*, especially those lineages that are most susceptible to infection by *M. cerebralis* (Beauchamp et al. 2002). Therefore, Windy Gap Reservoir has historically been considered a major source for TAM production in this drainage (Nehring and Thompson 2003). However, CDPW sampling in Windy Gap Reservoir in 2004 and 2005 indicated a dramatic decrease in the worm population structure in the lake in the last 5 to 6 years (Nehring, pers. comm. 2006). TAM production in Windy Gap Reservoir is now similar to that produced in the Fraser and Colorado rivers above the reservoir and is no longer producing TAMs at historical levels. The cause of the change is still being investigated but it may be the result of a shift in the species of tubifex less susceptible to infection (Thompson 2005). In a presentation made on the Colorado River fishery, Jon Ewert, CDPW biologist, stated that the nonhost tubifex species was becoming more prevalent in the reservoir and was part of the reason for the lower incidence of whirling disease pathogens (Ewert 2009). In addition, Thompson (2005) reported that the percent prevalence of myxospores in brown trout in the Williams Fork River, Fryingpan River, and Spring Creek in the Taylor River drainage were as high or higher than downstream from Windy Gap Reservoir, which demonstrates the widespread presence of whirling disease at high levels in streams and rivers in other parts of the state. The objective of the study was to determine the response of whirling disease presence to habitat modification. At the time of that research, Thompson concluded that habitat modifications did not result in significantly lower infection rates, as shown by the prevalence of whirling disease myxospores in young trout.

Grand County Stream Management Plan

Grand County prepared a three-phase SMP for approximately 80 miles of streams in Grand County (TetraTech et al. 2008, 2010). The SMP focuses on the Colorado River, Fraser River, and seven tributaries—Williams Fork, Blue River, Muddy Creek, and Willow Creek (tributaries to the Colorado River) and Vasquez, St. Louis, and Ranch Creek (tributaries to the Fraser River). The objective of the SMP is to develop flow recommendations to maximize available habitat for various life stages of rainbow and brown trout and other nonconsumptive water uses based on existing stream morphology.

The first phase of the SMP was an inventory of existing information in the upper Colorado River and Fraser River basins. The second phase of the SMP developed flow recommendations for aquatic life habitat and water users. Environmental flows were defined in the SMP as those necessary to best maintain the ecological needs of the stream in relation to its fisheries. The environmental flow analysis considered flow-habitat relationships for several life stages of rainbow and brown trout at multiple stream locations within the study area. Other environmental parameters included an assessment of the flow requirements to maintain stream morphology and aquatic habitat, stream temperature, and water quality. The preferred flow regimes recommended in the SMP are estimates of optimum flows to meet fisheries and water user needs in a given reach without consideration of whether water is available to meet the recommended flows.

The SMP also considered the flow regimes necessary to support water use requirements for irrigators, municipalities, industry, and recreation. Streamflow management for water users focused on the ability of water users to physically retrieve water from the stream and the water user's impact on flows in the stream relative to maintaining recommended flows. The SMP considered recreational flow requirements by identifying preferred flows for rafting, kayaking, and angling.

The SMP recognized that not all recommended flows for all uses on all reaches can be achieved at all times. Thus, the third phase of the SMP includes recommended target flows for the protection and enhancement of aquatic habitat, while at the same time protecting local water uses and retaining flexibility for future water operations. Phase 3 of the SMP also included an analysis of environmental flows, restoration opportunities (both physical and flow enhancements), and monitoring recommendations (TetraTech et al. 2010).

3.9.1.5 East Slope Rivers, Streams, and Reservoirs

Big Thompson River, North St. Vrain Creek, St. Vrain Creek, Big Dry Creek, and Coal Creek

East Slope streams in the study area contain both game and nongame species. Fish abundance varies by location, with cool water game species such as brown trout and rainbow trout found closer to the foothills. Warm water game and nongame species found farther east include smallmouth bass, walleye, black crappie, common carp, and a variety of minnow-type species.

Several of the warm water nongame species are state species of concern. These species are Iowa darter, plains topminnow, common shiner, brassy minnow, northern red-belly dace, stonecat, and Johnny darter. Although their presence varies by location, all of these species are present in the Big Thompson and St. Vrain drainages, Big Dry Creek, and Coal Creek.

Carter Lake and Horsetooth Reservoir

Carter Lake and Horsetooth Reservoir are managed by CDPW for recreational fishing. Fish species present include walleye, smallmouth bass, wiper, and trout species. Salmonid populations within both lakes are managed by stocking. Warmwater species, such as smallmouth bass populations are maintained by natural reproduction.

Ralph Price Reservoir

Ralph Price Reservoir is managed for fishing by CDPW and is stocked with brown and rainbow trout and with splake, a brook and lake trout hybrid. Access is limited to walk-in recreation use with no fishing from a boat allowed.

Chimney Hollow and Dry Creek

Chimney Hollow is an intermittent stream that is often dry and does not support a fishery. Dry Creek is an intermittent drainage that is dry in the upper reaches, but the lower reach supports fathead minnows and invertebrates common to intermittent streams.

3.9.2 Environmental Effects

3.9.2.1 Issues

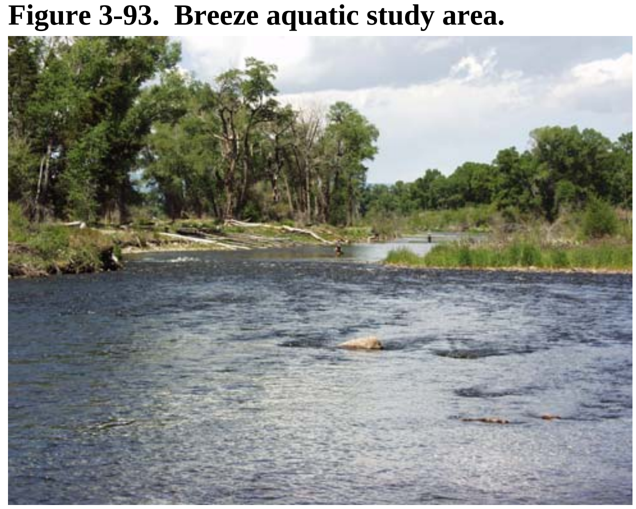
Key aquatic resource concerns identified during scoping were potential impacts to fish and other aquatic life from changes in streamflow, water quality, and temperature in the Colorado River and lakes and reservoirs. Also of concern was the potential for the spread or increase of whirling disease.

3.9.2.2 Method for Effects Analysis

Figure 3-92. Lone Buck aquatic study area.

The assessment of effects to fish habitat along the Colorado River was conducted using the River2D Model. Fish habitat in Willow Creek was assessed using Physical Habitat Simulation (PHABSIM). Data from a previous study (Miller Ecological Consultants 1997) was used to develop the habitat flow relationships. The approach used in the EIS follows the concepts of the Instream Flow Incremental Methodology (IFIM) (Bovee 1982; Bovee et al. 1998). IFIM is an analysis framework that combines stream hydraulics, habitat use criteria, and hydrology to predict fish habitat as a function of streamflow. Existing unpublished CDPW habitat suitability data were used for the target fish species. The analysis focused on juvenile and adult life stages of rainbow trout and brown trout. The species modeled at each site were determined in consultation with CDPW biologists at the initiation of the study during study site selection. The habitat suitability criteria for brown and rainbow trout were derived from CDPW data collected in the South Platte River in Cheesman Canyon, downstream of Spinney Mountain Reservoir and in the Cache la Poudre River. These data were collected by direct observation by life stage. The data for adult and juvenile trout were transformed to habitat suitability criteria using a bivariate analysis to develop a multivariate exponential equation. These normalized suitability functions were used to transform the hydraulic model output into habitat values for each study site using GIS. The two selected study sites are below the Windy Gap Reservoir diversion at Lone Buck, a State Wildlife Area upstream of the Williams Fork River (Figure 3-92), and at the Breeze State Wildlife Area downstream of the Williams Fork River (Figure 3-93). These areas are representative of the Colorado River from Windy Gap to the Blue River.

Figure 3-93. Breeze aquatic study area.



Hydrologic conditions at seven locations from Windy Gap downstream to the Kremmling Gage (downstream of the Blue River) were combined with the habitat data to determine quantitative changes in fish habitat for the alternative actions over time (Figure 3-89). Daily flows for average, wet, and dry year flow conditions were modeled under the various WGFP alternatives. This approach follows guidelines for alternatives analysis outlined in Bovee et al. (1998).

Daily habitat data, based on daily flows, were estimated for each alternative. A spreadsheet was used to calculate the change in habitat for each alternative compared to existing conditions, expressed as habitat area or percent change in habitat area. While values produced by the spreadsheet can be computed to several decimal places, there is error associated with these computed values. The sources of error include field measurements, hydraulic modeling, and habitat suitability indices. The interpretation of the results includes the application of a threshold at which the change is substantial enough to expect an observable change to the species being evaluated. For this analysis, a threshold of 15 percent change was used as the level above which impacts to aquatic habitat were considered to have effects. This threshold level has been used by other investigators in Oregon and Washington (Wald 2008). The rationale for selecting a threshold level is based on the error associated with field measurements and the error within the habitat models. As such, any change in habitat that was 15 percent or greater (+ or -) was considered a substantial change. Other factors that were considered in determining the significance of the change were the date and duration of occurrence as compared to the habitat over the entire year. The first step in this analysis was to calculate the daily percent change and summarize the daily values into two week periods over the entire year. The second step was to compare habitat at the date the change occurred with the remainder of the year. Longer periods of substantial change in habitat are expected to have more impact than short duration events. The daily percent change comparison expressed in 2-week time steps shows the seasonal change in habitat. The 2-week values were summarized for the entire year to provide a year round evaluation of habitat.

Because of the similarity in Colorado River diversions among the action alternatives, the effects to fish habitat are likewise similar and, therefore, the discussion of alternative effects is consolidated. Water diversions under the No Action Alternative would be less than the action alternatives; thus impacts to fish habitat under No Action typically would be less than for other alternatives as noted in the analysis. In addition to the habitat time series, hydrologic changes that could impact peak flows and sediment transport were used to determine the maintenance of fish and macroinvertebrate habitats.

Fish community and fish populations were assessed qualitatively based on changes in physical habitat, as well as projected changes to peak flows, sediment transport, water temperature, and other water quality parameters within those systems. The change was compared to the existing conditions in rivers and reservoirs to determine if there would be factors that affect fish populations at the acute or chronic level. Other factors such as fishing pressure, management, and stocking can affect fish populations and community structure more than physical habitat. Specific long-term field data for species occurrence by habitat type and population data by species and size are not available to develop cause and affect relationships between habitat change and population levels. There are basic assumptions in IFIM regarding population response to habitat. In general, more habitat is assumed to result in larger populations, but the relationship may not be linear and the response may not be immediate. Since detailed population data were not available (and are not available for most rivers), the qualitative approach was used for this analysis.

Water quality changes, as discussed in Section 3.8.2, also were used to evaluate effects to aquatic life. Dissolved oxygen (DO) and water temperature were the principal stream water quality parameters used to evaluate effects to fish habitat and populations. For reservoirs, the trophic state, DO, water temperature, and changes in reservoir depth and area were used to determine potential effects to fish.

Effects to fish habitat in East Slope reservoirs and streams were based on hydrologic and water quality changes and the likely potential for a change in habitat.

Macroinvertebrates were evaluated using the results of the baseline data collection and inferences made based on changes in peak flows, sediment transport, baseflows, and water quality. The time between low water and high water and flow changes during the summer were used as a qualitative indicator of effects to macroinvertebrate health.

3.9.2.3 West Slope Effects

Colorado River

Fish Habitat. The results of fish habitat modeling for the Colorado River provided information on the changes in fish habitat and the season when those changes would occur. The habitat versus discharge curves for the Lone Buck site show similar shape for juvenile rainbow and adult brown trout (Figure 3-94 and Figure 3-95). There is a much different response to flow between adult rainbow and brown trout. Habitat availability for adult rainbow trout is highest at flows between 250 and 400 cfs at Lone Buck. Brown trout adult habitat is highest at streamflows of about 500 cfs. Habitat for juvenile rainbow and brown trout is highest at flows from 400 to 500 cfs at both the Lone Buck and Breeze study sites (Miller Ecological Consultants 2010). Typically, a reduction in streamflow reduces available fish habitat; however, when flows exceed the flow at which the highest habitat occurs, as during periods of high runoff, a reduction in flow can increase available fish habitat. This occurs occasionally under all alternatives as a result of Windy Gap diversions during peak flows.

WGFP diversions would reduce available habitat for rainbow trout and to a lesser extent, brown trout habitat in the Colorado River below Windy Gap Reservoir in the early spring and late summer. A slight increase in fish habitat occurs from WGFP diversions during peak flows.

The habitats versus discharge functions are used in conjunction with daily hydrology to determine habitat over time. Daily hydrology data for all alternatives were used to evaluate impacts to aquatic habitat. Examples of these data show the differences in daily flow downstream of Windy Gap Reservoir (Figure 3-96) and upstream of the Blue River (Figure 3-97). The daily flow data, combined with the habitat function, result in the amount of daily habitat for each species and life stage. Examples of the daily habitat area for adult rainbow trout downstream of Windy Gap Reservoir (Figure 3-98) and upstream of the Blue River show how the amount of habitat changes in response to daily flows (Figure 3-99). At both locations, winter is when flow and habitat is least abundant and most likely to control the size of the fish population.

Figure 3-94. Rainbow trout habitat area versus discharge – Lone Buck site, Colorado River.

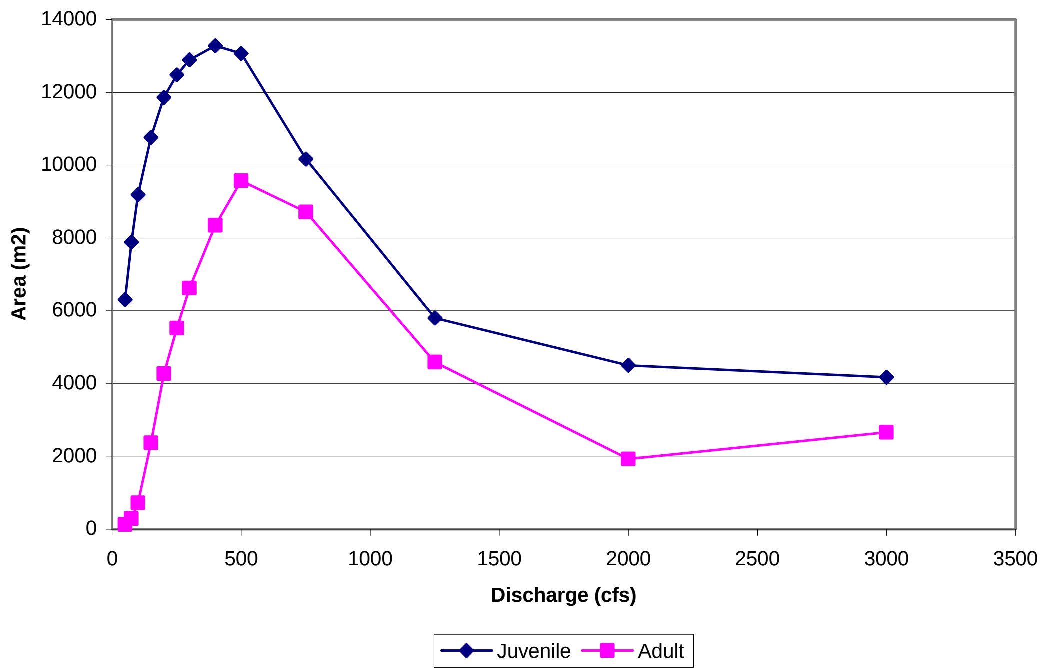


Figure 3-95. Brown trout habitat area versus discharge – Lone Buck site, Colorado River.

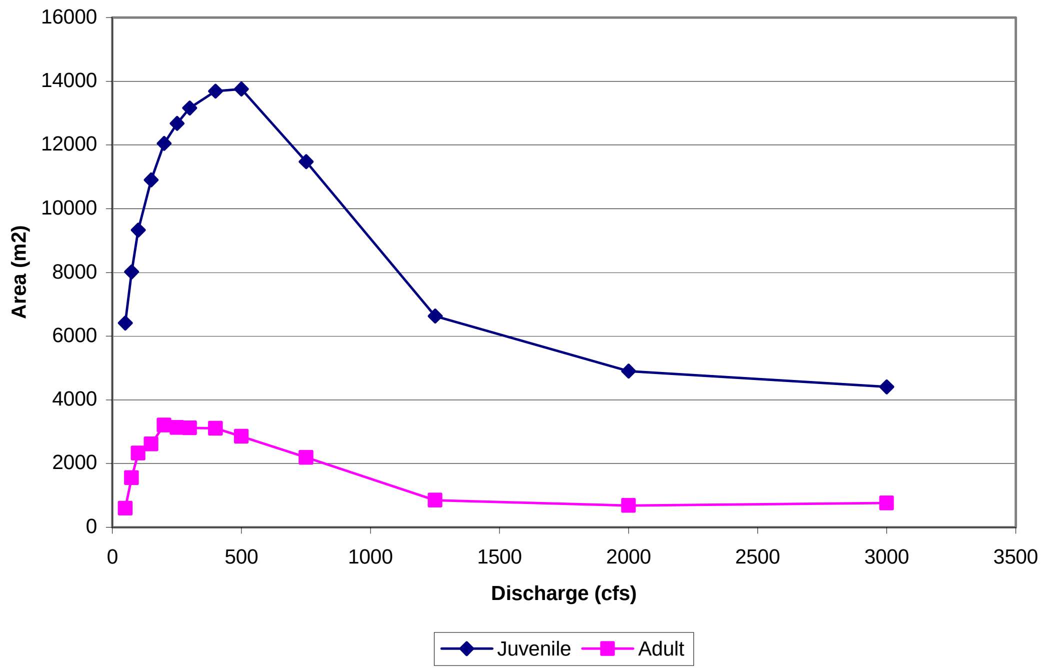


Figure 3-96. Average daily discharge for the Colorado River below Windy Gap Reservoir.

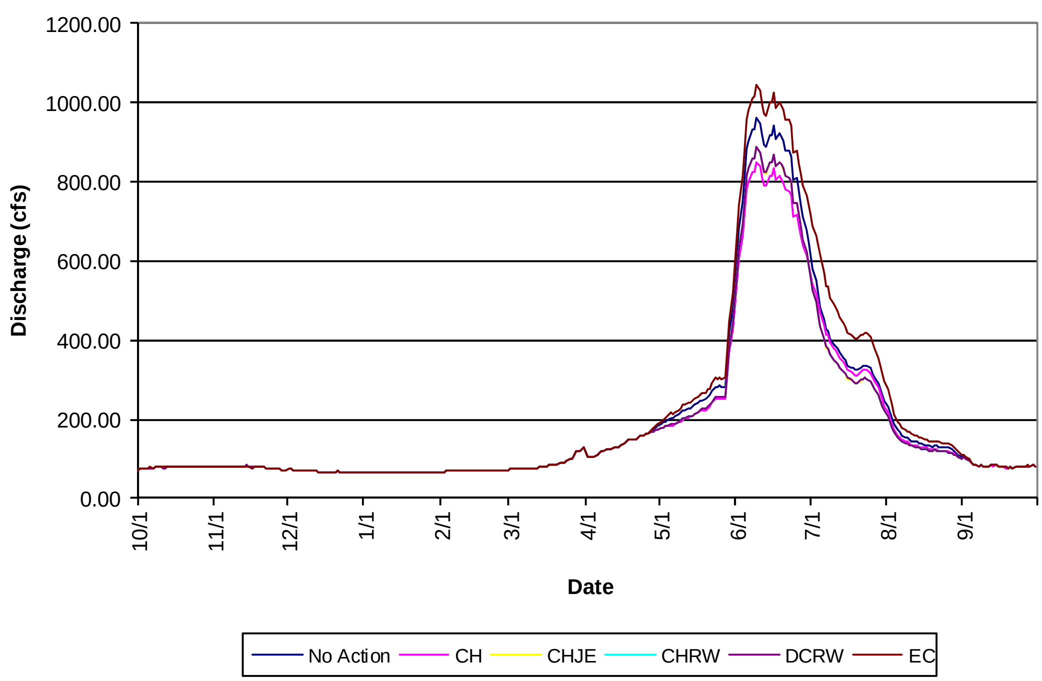


Figure 3-97. Average daily discharge for the Colorado River above the Blue River.

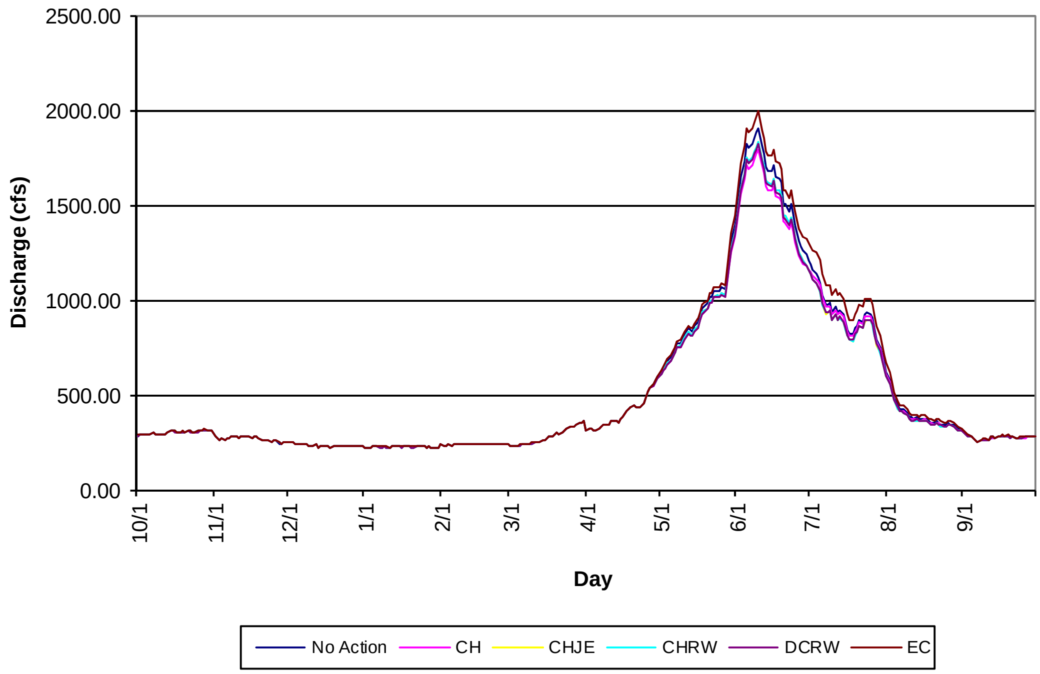


Figure 3-98. Rainbow trout (adult) average daily habitat area on the Colorado River below Windy Gap Reservoir.

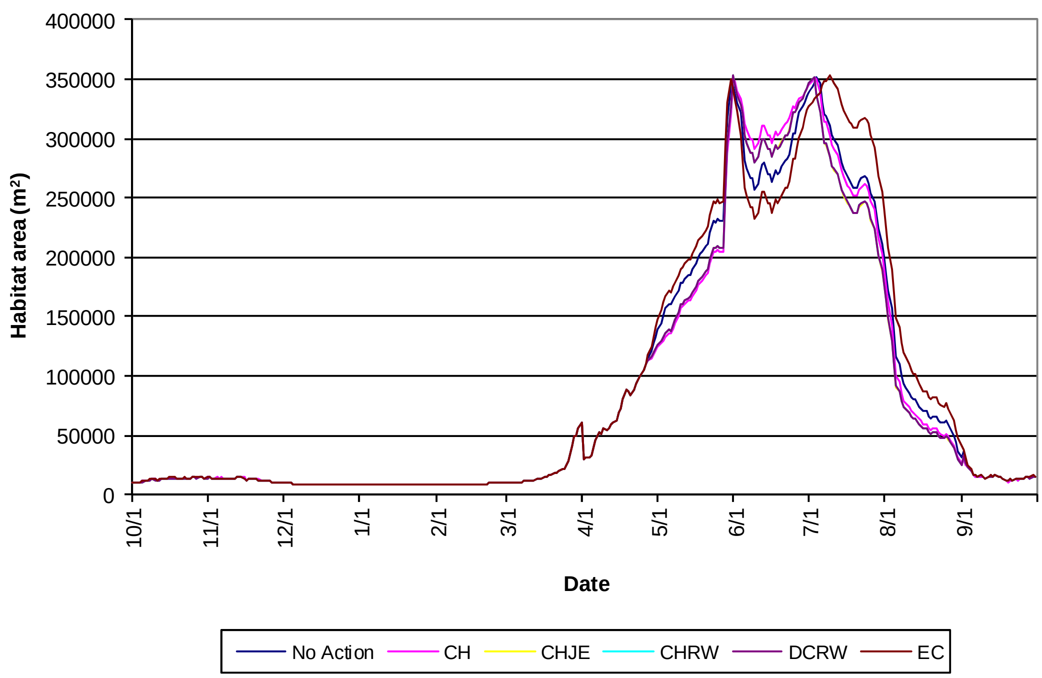
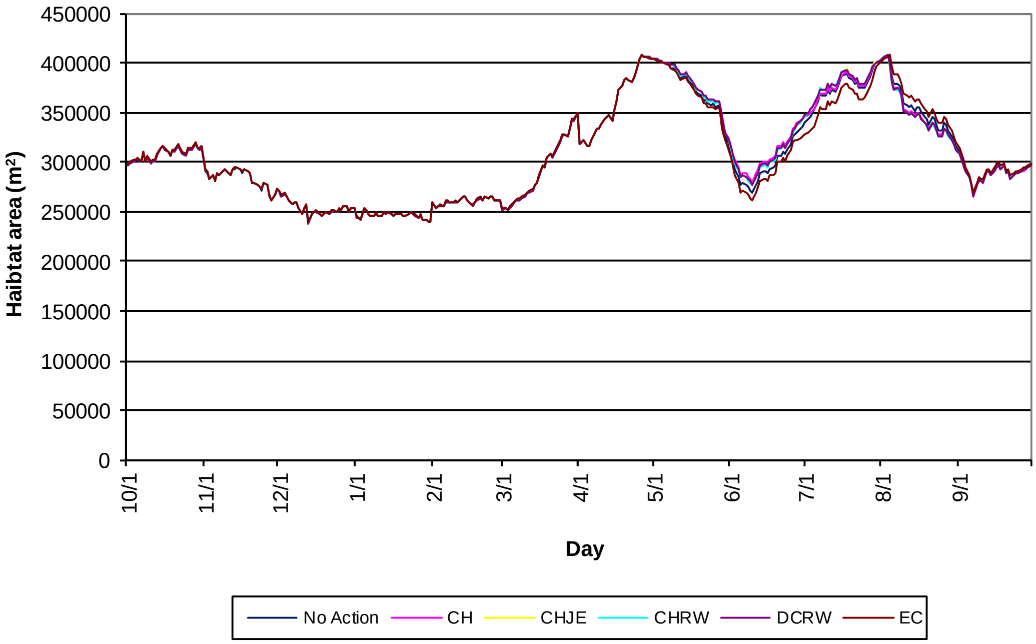


Figure 3-99. Rainbow trout (adult) average daily habitat area on the Colorado River above the Blue River.



Habitat time series model output generates information on the amount of habitat available over time. The largest decrease in adult rainbow trout habitat during average flow conditions on the Colorado River occurs in the reach immediately downstream from Windy Gap Reservoir (Figure 3-100). On this graph, the left axis indicates the percent change in habitat from existing conditions, where the 0 line is existing conditions. Values above the 0 line indicate an increase in habitat and values below the 0 line indicate a decrease in habitat. The bottom axis indicates the time during the year when habitat changes. Figure 3-101 illustrates the effect to adult brown trout habitat at the same location below Windy Gap Reservoir during average years. WGFP diversions during high runoff increase brown trout habitat. A similar example farther downstream for rainbow and brown trout on the Colorado River above the confluence with the Blue River is shown in Figure 3-102 and Figure 3-103. At this location, adult rainbow and brown trout habitat increases and decreases by less than 10 percent during the year, with small differences between the alternatives. Under the No Action Alternative for average conditions, adult rainbow trout habitat would decrease up to 21 percent in August of average years below Windy Gap (Figure 3-100). Both increases and decreases in adult brown trout habitat of about 10 percent occur under the No Action Alternative below Windy Gap (Figure 3-101), with small changes in rainbow or brown trout habitat above the Blue River (Figure 3-102 and Figure 3-103).

Figure 3-100. Percent change in adult rainbow trout habitat from existing conditions on the Colorado River below Windy Gap for an average water year.

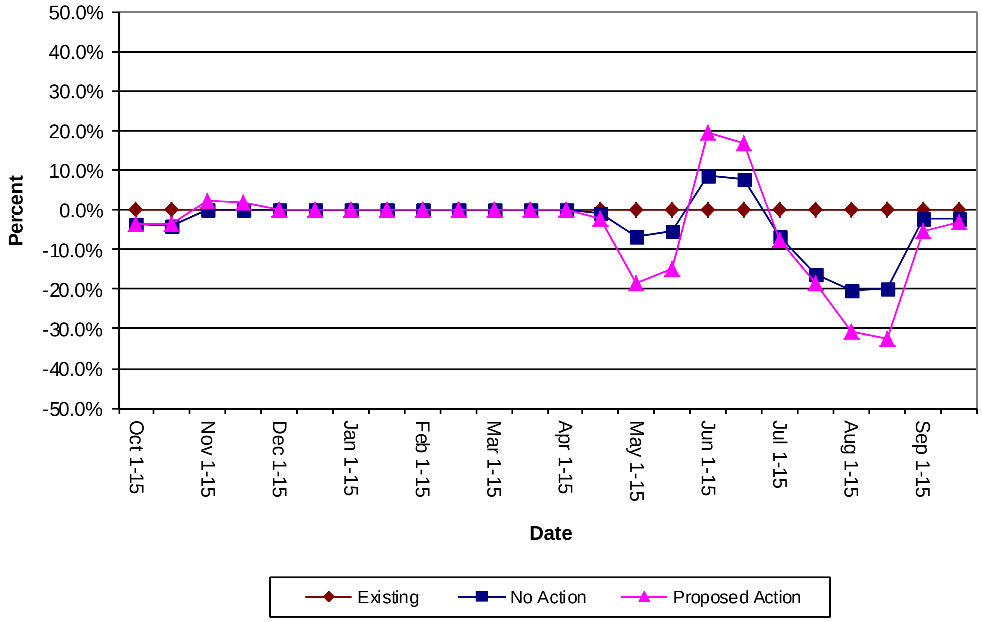


Figure 3-101. Percent change in adult brown trout habitat from existing conditions on the Colorado River below Windy Gap for an average water year.

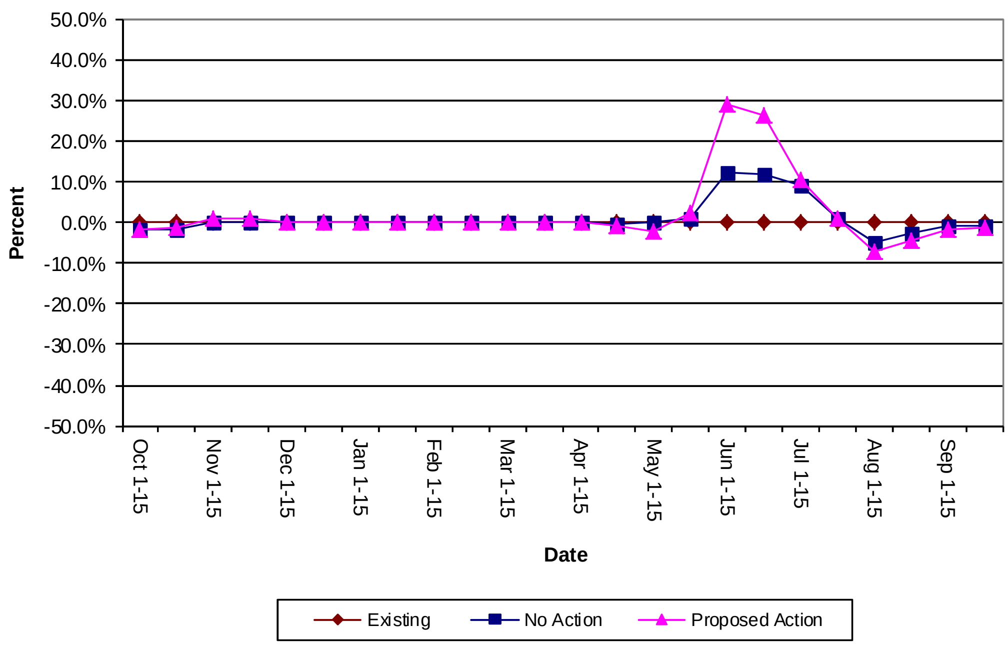


Figure 3-102. Percent change in adult rainbow trout habitat from existing conditions on the Colorado River above the Blue River for an average water year.

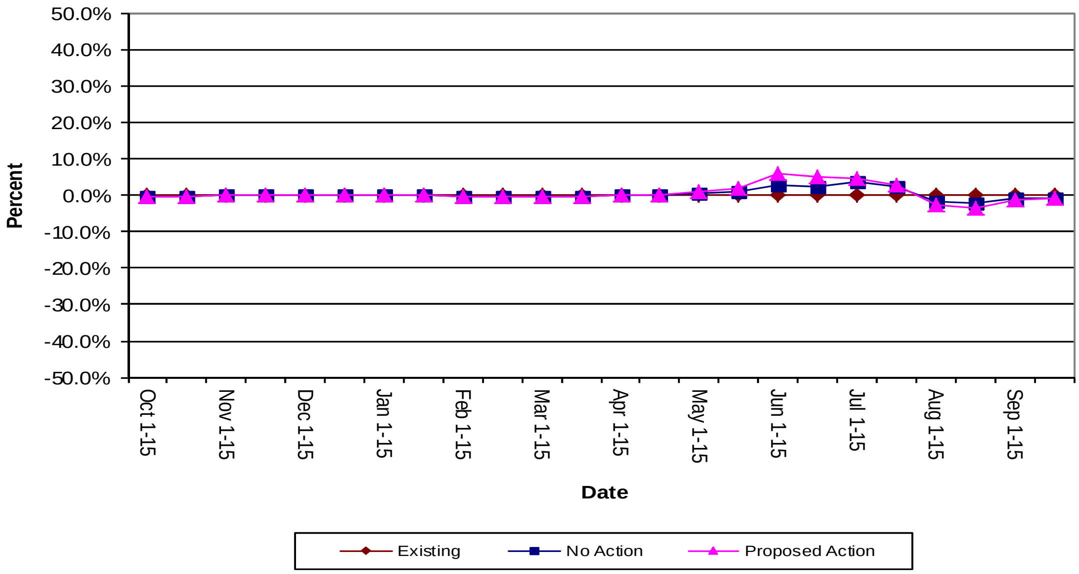
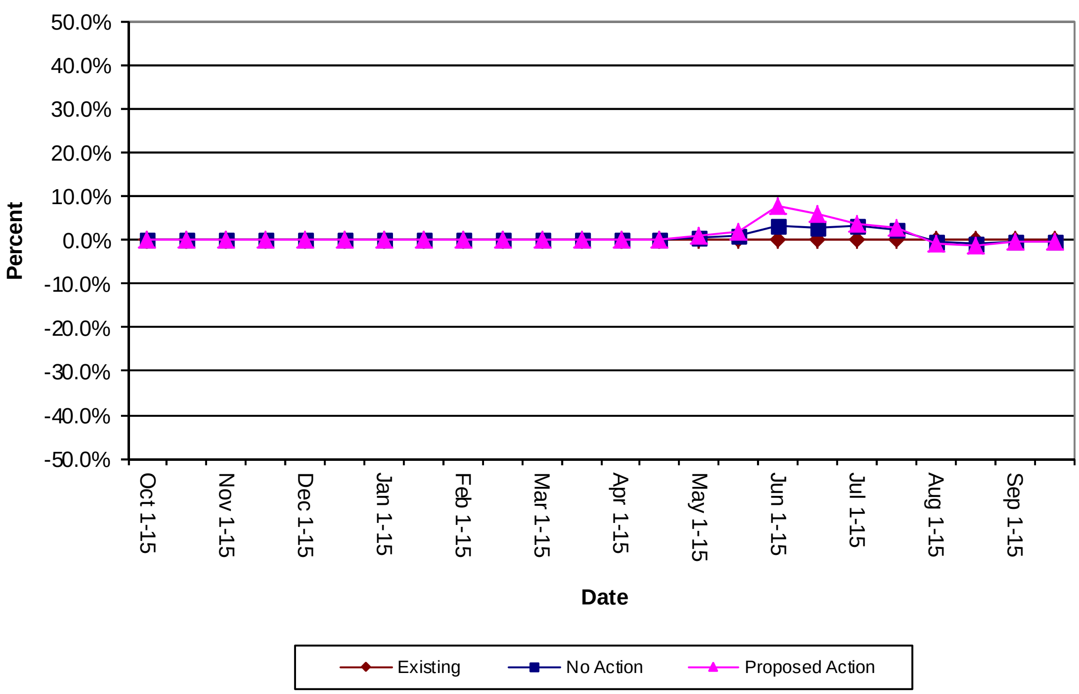


Figure 3-103. Percent change in adult brown trout habitat from existing conditions for the Colorado River above the Blue River for an average water year.



The results of the habitat modeling for rainbow and brown trout at locations on the Colorado River and Willow Creek for average years are summarized in Table 3-116 and Table 3-118. These data indicate the maximum change in habitat from WGFP diversions and the season when those changes would occur. The results are representative of all action alternatives because diversion volumes are similar and indicate the maximum change from existing conditions. The greatest decrease in habitat would occur from Windy Gap Reservoir downstream to the Williams Forks, where adult rainbow trout habitat would decrease up to 34 percent in August of average water years, while adult brown trout habitat would decrease less than 8 percent. Below the Williams Fork, maximum decreases in habitat would be less and would occur less frequently. The maximum decrease in rainbow or brown trout habitat for juveniles or adults would be less than 10 percent at all locations below the Williams Fork. WGFP diversions in June of average years would increase rainbow and brown trout habitat for juveniles and adults as much as 29 percent. Juvenile rainbow trout habitat would decrease up to about 6 percent below Windy Gap in average years (Table 3-116). Juvenile brown trout habitat would decrease about 6 percent in August and increase up to about 18 percent in June of average years below Windy Gap (Table 3-118). Adult brown trout habitat in Willow Creek would decrease up to 25 percent in July of average years and increase about 4 percent in June. Juvenile brown trout habitat in Willow Creek would decrease about 17 percent in July.

A summary of habitat modeling output under wet year hydrologic conditions is shown in Table 3-117 and Table 3-119. The Colorado River below Windy Gap and above the Williams Fork confluence showed the greatest maximum increase in fish habitat availability for adult rainbow trout during wet year flow conditions in July, but with decreases similar to average year conditions in August. Brown trout habitat for juveniles and adults would increase in July for all locations downstream of Windy Gap with a maximum decrease in habit of less than 9 percent. Trout habitat availability during dry year flow conditions would not change from existing conditions for any alternative because Windy Gap diversions would not change from existing conditions.

Table 3-116. Percent change in rainbow trout habitat from existing conditions under the Proposed Action for locations on the Colorado River and Willow Creek for average water years.

Location	Juvenile Rainbow Trout				Adult Rainbow Trout			
	Range of change from existing conditions				Range of change from existing conditions			
	↓ (%)	Date	↑ (%)	Date	↓ (%)	Date	↑ (%)	Date
Below Windy Gap	-6.1	Aug 1-15	+19.0	Jun 1-15	-32.5	Aug 16-30	+19.3	Jun 1-15
Hot Sulphur Springs	-5.5	Aug 16-31	+19.0	Jun 1-15	-28.7	Aug 16-31	+19.5	Jun 1-15
Above Williams Fork	-6.3	Aug 1-15	+18.8	Jun 1-15	-33.5	Aug 16-31	+19.1	Jun 1-15
Below Williams Fork	-3.1	May 1-15	+7.1	Jun 1-15	-9.1	May 1-15	+6.7	Jun 16-30
Above Troublesome Creek	-2.8	May 1-15	+7.1	Jun 1-15	-8.1	May 1-15	+6.6	Multiple
Above Blue River	-1.1	Aug 16-31	+4.7	Jul 1-15	-3.4	Aug 16-31	+6.1	Jun 1-15
Below Blue River	0.0	Multiple	+3.1	Jun 1-15	-0.1	Jan 16-31	+6.0	Jun 1-15
Willow Creek	-12.6	Jul 16-31	+1.1	Jun 1-15	-23.2	Jul 1-15	+1.3	Sep 16-30

Note: Percent change in habitat for Alternatives 3 to 5 are generally within 5% of the change shown for the Proposed Action.

Table 3-117. Percent change in rainbow trout habitat from existing conditions under the Proposed Action for locations on the Colorado River and Willow Creek for wet water years.

Location	Juvenile Rainbow Trout				Adult Rainbow Trout			
	Range of change from existing conditions				Range of change from existing conditions			
	↓ (%)	Date	↑ (%)	Date	↓ (%)	Date	↑ (%)	Date
Below Windy Gap	-5.0	Aug 16-31	+34.9	Jul 16-31	-29.4	Aug 16-31	+57.6	Jul 1-15
Hot Sulphur Springs	-4.4	Aug 16-31	+34.4	Jul 16-31	-17.7	Aug 16-31	+53.4	Jul 1-15
Above Williams Fork	-5.0	Aug 16-31	+35.2	Jul 16-31	-29.0	Aug 16-31	+59.4	Jul 1-15
Below Williams Fork	-0.3	Multiple	+12.0	Jul 1-15	-3.5	Aug 16-31	+21.1	Jul 1-15
Above Troublesome Creek	-0.3	Multiple	+12.1	Jul 1-15	-1.7	Aug 16-31	+21.3	Jul 1-15
Above Blue River	-3.8	Jun 1-15	+9.9	Jul 1-15	-3.8	Jun 1-15	+19.3	Jul 1-15
Below Blue River	-4.5	Multiple	+2.1	Aug 1-15	-4.5	Multiple	+3.3	Aug 1-15
Willow Creek	-12.9	Jun 1-30	+0.4	Jul 1-15	-12.9	Jun 1-30	0.0	Multiple

Note: Percent change in habitat for Alternatives 3 to 5 are generally within 5% of the change shown for the Proposed Action.

Table 3-118. Percent change in brown trout habitat from existing conditions under the Proposed Action for locations on the Colorado River and Willow Creek for average water years.

Location	Juvenile Brown Trout				Adult Brown Trout			
	Range of change from existing conditions				Range of change from existing conditions			
	↓ (%)	Date	↑ (%)	Date	↓ (%)	Date	↑ (%)	Date
Below Windy Gap	-6.2	Aug 1-15	+17.8	Jun 1-15	-7.4	Aug 1-15	+29.0	Jun 1-15
Hot Sulphur Springs	-5.6	Aug 1-15	+17.9	Jun 1-15	-7.4	Aug 1-15	+29.1	Jun 1-15
Above Williams Fork	-6.3	Aug 1-15	+17.7	Jun 1-15	-7.3	Aug 1-15	+28.5	Jun 1-15
Below Williams Fork	-3.0	May 1-15	+9.2	Jun 1-15	-2.4	May 16-31	+5.7	Multiple
Above Troublesome Creek	-2.7	May 1-15	+9.2	Jun 1-15	-2.4	May 1-15	+5.7	Multiple
Above Blue River	-0.9	Aug 16-31	+ 6.1	Jul 1-15	-1.4	Aug 16-31	+7.7	Jun 1-15
Below Blue River	0.0	Multiple	+3.0	Jun 1-15	0.0	Multiple	+8.3	Jun 1-15
Willow Creek	-16.5	Jul 16-31	+0.8	Sep 1-15	-24.8	Jul 1-15	+3.5	Jun 1-15

Note: Percent change in habitat for Alternatives 3 to 5 are generally within 5% of the change shown for the Proposed Action.

Table 3-119. Percent change in brown trout habitat from existing conditions under the Proposed Action for locations on the Colorado River and Willow Creek for wet water years.

Location	Juvenile Brown Trout				Adult Brown Trout			
	Range of change from existing conditions				Range of change from existing conditions			
	↓ (%)	Date	↑ (%)	Date	↓ (%)	Date	↑ (%)	Date
Below Windy Gap	-6.1	Aug 16-31	+35.2	Jul 16-31	-0.7	Jun 16-30	+63.5	Jul 16-31
Hot Sulphur Springs	-5.6	Aug 16-31	+34.7	Jul 16.31	-0.9	Sep 1-15	+62.2	Jul 16-31
Above Williams Fork	-6.1	Aug 16-31	+35.5	Jul 16-31	-1.2	Sep 1-15	+64.1	Jul 16-31
Below Williams Fork	-0.3	Apr 16-30	+11.7	Jul 1-15	-0.5	Multiple	+28.8	Jul 1-15
Above Troublesome Creek	-0.3	Apr 16-30	+11.7	Jul 1-15	-0.5	Sep 1-15	+29.2	Jul 1-15
Above Blue River	-3.8	Jun 1-15	+9.5	Jul 1-15	-9.0	Jun 16-30	+23.4	Jul 1-15
Below Blue River	-4.5	Multiple	+2.1	Aug 1-15	-4.5	Multiple	+4.1	Aug 1-15
Willow Creek	-12.9	Jun 1-30	0.0	Multiple	-12.9	Jun 1-30	0.0	Multiple

Note: Percent change in habitat for Alternatives 3 to 5 are generally within 5% of the change shown for the Proposed Action.

Overall, the modeled changes in fish habitat in the Colorado River for all alternatives indicate the most substantial changes in habitat would occur between Windy Gap Reservoir and the confluence with the Williams Fork River in both average and wet years. For the remainder of the Colorado River downstream of the Williams Fork, a reduction in habitat also would occur in average or wet years, but would not result in a substantial change (<15 percent) from existing conditions.

The largest reductions in fish habitat would occur during August of average and wet years when Windy Gap diversions occur. The hydrologic model indicates that WGFP diversions of more than 100 AF in August would increase from 6 times in the 47-year hydrologic modeling period to 15 times. Actual WGFP pumping in August is likely to be less because new reservoirs would typically be close to full in years when the WGFP diversions are in priority in August and the cost of pumping is high for the limited water that is available. Adult rainbow trout would have the largest reduction of all species and life stages. During the remainder of the year (September through April of average years), flow and available habitat are lower than during the time Windy Gap diversions occur. Habitat area available during the low-flow periods from fall to early spring is likely a more controlling factor that influences the size of the fish population than diversions that occur when more abundant habitat is present in late spring and summer. Therefore, even though the maximum percent reduction in habitat is large from Windy Gap diversions in the spring, diversions occur when habitat is greater than during the majority of the year. Because fish habitat can be less available at high flows, diversions that reduce high flow can result in increased available habitat during runoff. Habitat time series output indicates Windy Gap diversions from the Colorado River, in average and wet years, would result in increases in habitat in June and July. The more important factor during peak runoff is the flows that create and maintain the aquatic habitat as discussed below in the *Channel Morphology* section.

Trout in the study area have a maximum age of approximately 6 or 7 years; therefore, impacts to trout habitat that occur often during their life span (e.g., several times during a lifetime) may affect populations. Impacts to trout habitat that occur less frequently are less likely to affect populations. Trout populations would have multiple years of spawning and recruitment between the less frequent events of reduced flow, which is the reason these events would have less effect on the populations. The predicted maximum periodic decreases and short duration of the decrease in fish habitat are unlikely to substantially impact fish populations at most locations. The greater than 15 percent habitat reductions above the Williams Fork confluence could result in a slight decrease in adult rainbow trout population. The small changes in adult brown trout habitat and the frequency of those changes are unlikely to impact current populations. The short duration increase in habitat may be beneficial but the baseflow habitat is likely the controlling factor for populations. These changes are not expected to affect the Gold Medal Designation for the Colorado River downstream of Windy Gap Reservoir. To be eligible for gold medal fishery designation, the water must consistently produce a minimum standing stock of 60 pounds of trout per acre and a minimum of 12 quality trout (>14 inches long) per acre. The current population estimates are 131 pounds per acre and 51 fish greater than 14 inches. Based on CDPW data (Ewert 2011), populations of brown trout greater than 14 inches have varied from 100 fish per acre in 2000 to a low of 19 fish per acre in 2007 with an average of 51 quality brown trout per acre since 2000. This does not account for any rainbow trout that might be greater than 14 inches.

In general, CDPW research on Colorado rivers (Nehring and Anderson 1993) has demonstrated the greatest impact to trout populations occurs during high flows when small juvenile fish are present (especially during wet hydrologic years). This research demonstrated that the strongest year classes for juvenile fish were present when peak flows were lower than normal. This response to lower peak flows had a positive influence on the year classes in subsequent years. The WGFP would reduce Colorado River peak flows, which may be beneficial to fish, particularly in wet years, but is dependent on the time when the flows occur in relation to the presence of young trout.

Fall spawning brown trout would not be affected by Windy Gap diversions. Rainbow trout spawning occurs from mid-April through May, with hatching in June and July. Rainbow fry emerge from the gravel in July into the first of August (Nehring and Anderson 1993). With rainbow trout spawning occurring on the lower portion of the ascending limb of the hydrograph and an increase in flow after spawning, the redds would be covered by water through egg hatch and emergence. Since the eggs and fry would not be dewatered, an impact to these life stages is not likely for any of the alternatives.

Channel Morphology. In addition to hydrology and water quality, channel morphology is an important physical component of the riverine systems that affects the aquatic environment. The channel geometry and plan form of the channel and the biota within the channel are all affected by the volume and timing of annual discharges. Physical features of the stream channel change as a result of peak flows and the biota respond to those physical changes. During peak runoff, two factors that affect the physical conditions within the stream are the magnitude and duration of the peak runoff. Differing flow magnitudes and duration are required to move sediment, initiate channel migration, create and maintain habitat, and incorporate organic material in the form of woody debris and other plant material into the system. The amount of change in physical habitat from year to year is determined during the annual runoff cycle that shapes new habitats and maintains the current habitat.

Biological components of riverine systems include instream biota such as primary and secondary producers (e.g., algae, periphyton, and benthic invertebrates) and consumers (e.g., invertebrates and fish). Aquatic biota have evolved to survive within the range of flows that occur under natural conditions. Aquatic biota responses to peak flows are also apparent in the various biota that inhabit the stream. Benthic macroinvertebrates in snowmelt runoff systems have generally evolved to avoid the detrimental effects of high flows. These include being in locations or in life stages that avoid those high flow impacts. Many of the macroinvertebrates in western stream systems have evolved so that adults emerge and lay eggs prior to runoff. Therefore, the most dominant life stages that exist in peak flow are the egg or early instars. The small size of these life stages allows them to avoid many of the detrimental effects of peak flows. Similarly, the large woody debris and habitat features that are formed during previous years' peak runoff provide refuge habitat for the various life stages of fish species that inhabit streams. These types of habitat provide lower velocities during peak flow and shelters from the higher velocities normally associated with a peak runoff event.

Fish species also have evolved to minimize impacts from detrimental flows. Spawning, hatching, and emergence for native salmonids are timed to maximize success under natural flow regimes. The natural flow regimes create habitat that can be used by juvenile and adult fish to avoid detrimental effects of high flows and refuge habitat during low flows.

Overall stream productivity in natural systems is generally determined by the baseflow conditions that provide for primary and secondary productivity and feeding, as well as refuge habitat. Peak flows temper fish populations and can influence the year class strength of salmonids if very high discharges occur when the young fish are susceptible. In general, the peak flow time has the lowest amount of optimal habitat for fish species, but peak flow provides the work in the channel that shapes, creates, and maintains habitat for the majority of the year for those species.

As noted in the discussion of *Stream Morphology and Floodplains* (Section 3.7.2.3), the No Action and action alternatives would result in a reduced frequency and duration of channel maintenance flows on the Colorado River below Windy Gap. However, hydrology data for the alternatives indicate the magnitude and recurrence intervals for bankfull flows and other channel maintenance flows would continue to occur regularly. The frequency and duration of large peak flow events would not change substantially (e.g., flows of 2,000 cfs or greater would occur 1.6 percent of the time under the Proposed Action compared to 2 percent of the time under existing conditions). The maximum Windy Gap diversion of 600 cfs would reduce flows available for channel maintenance, but large flows would still occur. The predicted changes in channel maintenance and peak flow characteristics are not expected to result in substantial changes to the existing habitats that are created and maintained by the existing flow regime. The range in channel maintenance flows under all alternatives would continue to provide sufficient flows to maintain channel capacity, provide periodic scouring channel, maintain riparian habitat, and create habitat suitable for fish and macroinvertebrates. In addition, no substantial change in stream productivity is anticipated from flow changes. Therefore, the current channel type and habitat characteristics are expected to be maintained with all alternatives.

Sediment transport is another important component of channel maintenance flows that is necessary to maintain the conditions needed to create fish spawning habitat and macroinvertebrate habitat. Channel maintenance flows are critical to ensuring unimpaired flow and sediment conveyance. A range of channel maintenance flows provide the benefits of conveying water and eroded materials from tributaries without aggradation (raising of the streambed by deposition of sediment) or degradation (lowering of the streambed), preventing vegetation encroachment and narrowing of the channel, sustaining aquatic ecosystems, temporarily storing flood flows on the floodplain, and maintaining healthy streambank and floodplain vegetation (Schmidt and Potyondy 2004). As noted in *Stream Morphology and Floodplains* (Section 3.7.2.3), Colorado River flows under all of the alternatives would continue to have more than adequate capacity to transport the sediment supply without aggradation or degradation. Sediment transport calculations for the Colorado River show that fine sediments (sand and silt, 2 mm or finer) would be mobilized at flows of less than 50 cfs; fine gravel (8 mm) would require a flow of 200 cfs; medium gravel (16 mm) would require a flow of about 400 cfs; and coarse gravel (32 mm) would require a flow of about 850 cfs to be mobilized (ERC 2009). Channel maintenance flows under all alternatives would continue to provide flow sufficient to move medium to coarse gravel that is used as substrate by spawning trout. Flow magnitude and duration to flush fine material from spawning substrate would continue to occur under the Proposed Action and other alternatives. No impact to spawning habitat is expected due to changes in channel maintenance flows and peak flows.

> Estimated changes in Colorado River streamflow under the Proposed Action are not expected to adversely impact stream channel characteristics that create and maintain aquatic habitat. Streamflows would remain sufficient to transport sediment, prevent channel aggradation, and maintain spawning habitat.

Stream Temperature and Water Quality. Results of water quality modeling also were used to evaluate potential effects to aquatic life (Table 3-120). The current water temperature standards include both a numeric and narrative standard. The Colorado River near Windy Gap is classified as Cold Water Tier II. The water temperature standards are set to protect cold water species in the river from both sublethal and lethal effects of temperature changes. The MWAT is set as a chronic threshold. Water temperatures lower than the MWAT would not adversely impact the species. The DM is set to be protective against lethal conditions. The numeric standard (April though October) is a MWAT of 18.2°C and a DM of 23.8°C. The narrative standard is: "Temperature shall maintain a normal pattern of diel and seasonal fluctuations and spatial diversity with no abrupt changes and shall have no increase in temperature of a magnitude, rate, and duration deleterious to the resident aquatic life" (CDPHE Regulation 33, 33.5 (1)).

Table 3-120. Summary of stream water quality changes relevant to potential fish impacts.

Location	Greatest Change in Dissolved Oxygen (mg/L) from Existing Conditions for All Alternatives	Greatest Change in Water Temperature (°C) from Existing Conditions for All Alternatives
Colorado River in the study reach	-0.1 to -0.6	+2.7 MWAT, +6.0 DM
Willow Creek	No change	-0.2
St. Vrain Creek	No change	No change
North St. Vrain Creek	Decrease less than 0.5	No change
Big Thompson	No change	No change

Source: ERO and AMEC 2008a.

In some years, Colorado River stream temperatures between Windy Gap Reservoir and Williams Creek would exceed the MWAT standard and DM standard for aquatic life in July and August when WGFP diversions occur.

A dynamic temperature model was used in the Final EIS to better evaluate potential daily changes in stream temperature in the Colorado River for the Final EIS (Hydros 2011c). The analysis of potential changes in temperature was conducted for a range of water years as discussed in *Surface Water Quality* (Section 3.8.2.4). Water temperature simulations show that diurnal and seasonal water temperature patterns are similar to the existing conditions. Modeled water temperatures with the WGFP show a diurnal fluctuation change with warming during the day and cooling at night, which is similar to the pattern found under existing conditions (Figure 3-47). Currently, the highest observed seasonal temperatures in the Colorado River occur in July and August. The water temperature simulations show this same seasonal pattern. Thus, the narrative water quality standard for stream temperature would be met under all alternatives.

Dynamic temperature modeling of the Colorado River using 2007 meteorological data, which included the hottest August on record and the sixth hottest July on record, predict that primary increases in stream temperature would occur in the reach between Windy Gap Reservoir and the Williams Fork. In the 15 years of hydrology modeled, 4 years showed simulated temperature impacts under the Proposed Action that resulted in increased exceedances of WATs and/or DMs. Although exceedance of the MWAT and DM standard were predicted for several years under existing conditions, the No Action and action alternatives would increase the number of exceedances.

Temperature modeling results for the Colorado River showed a maximum 1-day increase in water temperature up to 6°C. This results in an estimated water temperature of about 24.8°C near Hot Sulphur Springs. The additional number of exceedances of the MWAT would likely increase the stress on the aquatic community. The additional exceedance of the DM would add stress above the level of the MWAT. The impacts from the exceedances would be greater if the exceedances were sequential rather than sporadic. Sequential exceedances would extend the time period when the fish are stressed and, therefore, have a higher probability of impact to the species, while sporadic exceedances may allow for recovery from the stressed condition. Higher stream temperatures over a long period of time may result in less fit individuals, and potential mortality. While both MWAT and DM are a concern, the increased number of DM exceedances may have the greatest impact. Downstream of the Williams Fork, no exceedance of temperature standards is expected as a result of the WGFP.

Modeling of water quality parameters for the Colorado River predicted a slight decrease of 0.1 to 0.6 mg/L in DO. Average DO concentrations for existing conditions are 8.3 mg/L or higher (Section 3.8.1.3). The DO concentration for all alternatives is within the range required by trout and other cold water species and does not drop below the nonspawning aquatic life water quality standard. However, the DO concentration may be slightly lower (6.9 mg/L predicted) than the spawning standard (7.0 mg/L) in late summer if flows drop to 90 cfs downstream of Windy Gap Reservoir, although this is not in the normal spawning period for trout and only occurs in a short reach of the river. DO levels in the Colorado River under all modeled conditions would be above the 5.0 mg/L required for lethal effects to trout and would not impact trout in this section of the river. DO levels would not violate the state standard, which is designed to protect all aquatic life, including non-trout species.

Modeling of other water quality parameters indicates a slight increase in ammonia and inorganic phosphorus concentrations in the Colorado River below Windy Gap. The total ammonia concentrations would be lower than the acute and chronic standards and no impacts are expected from the increased concentrations. The increase in phosphorus is also lower than the EPA-recommended value and no impact is expected from the increased phosphorus concentration.

Summary. The predicted flow regime in the Colorado River as a result of the No Action Alternative and action alternatives would still include the components for stream health, but at lower levels than existing conditions. Peak flows that exceed bankfull volumes on a regular basis and predicted future flow regimes would continue to provide the necessary conditions to create and maintain channel morphology and aquatic habitat. In addition, a range of channel maintenance flows would provide the conditions to maintain riparian habitat. Modeled baseflows under all alternatives would maintain benthic invertebrate populations. Sediment transport capacity of the Colorado River would still exceed the available sediment supply. Colorado River flows would continue to regularly move medium-sized gravels for trout spawning habitat. Winter flows, combined with the habitat created by periodic high flow events, would continue to provide refuge habitat during winter conditions. Projected increases in the exceedance of chronic and acute stream temperature standards under the alternatives would increase the stress on fish populations, although predicted exceedances as a result of the WGFP would occur only in about 4 out of 15 years, assuming very warm July and August air temperatures.

Recently, research has focused on comprehensive ecologically based management of riverine systems to provide function for both instream aquatic biota as well as near-stream riparian areas (Bunn and Arthington 2002; Chapin et al. 2002; Lytle and Merritt 2004; Lytle and Poff 2004; Poff and Zimmerman 2010; Richter et al. 2003). Natural flow regimes, with both floods and droughts, have occurred for many years prior to any river regulation and the biota in these ecosystems have adapted to that flow regime. That adaptation is the response to changes in the physical environment and the biological adaptation to withstand floods or prolonged droughts in those systems (Lytle and Poff 2004). The dynamic character of river systems has been stated as one of the important features in maintaining ecological integrity (Poff et al. 1997; Richter et al. 1997). Clipperton et al. (2003) incorporated four ecosystem components into an Instream Flow Needs Determination for the South Saskatchewan River Basin. The four components were: 1) fish habitat, 2) water quality, 3) riparian vegetation, and 4) channel maintenance. The objective of their determination was to provide a high level of protection for the riverine ecosystem that could be achieved by instream flows alone. Further, Clipperton et al. (2003) wanted to provide for protection of aquatic habitats in the short term while protecting processes that maintained aquatic habitat in the long term.

All four of these ecosystem components were evaluated as part of the analysis of the impacts to the aquatic environment for the WGFP. A reduction in Colorado River flows would reduce fishery habitat primarily for rainbow trout, but many of the impacts occur in the spring when flows are high or in August when WGFP diversions are infrequent. Minimal impacts to stream morphology, water quality (except water temperature), and riparian vegetation are predicted for all alternatives. Increased stream temperature, particularly the acute DM temperatures, has the greatest potential for affecting trout species in the Colorado River between Windy Gap Reservoir and the Williams Fork.

Willow Creek

The changes to Willow Creek habitat would be similar to those modeled for the Colorado River, with most decreases in habitat expected to be less than 15 percent, except for adult rainbow trout in July of average years and juvenile brown trout in July of average years (Table 3-116 and Table 3-117). The greatest change in habitat for adult brown trout during an average water year would be a 25 percent reduction during July of average years. Short-term changes of this magnitude are unlikely to be measurable at the population level for fish in Willow Creek. In addition to physical habitat, the estimated change in water quality shows that there would be a slight decrease in water temperature, which may benefit the fishery, although this water temperature impact would not be measurable at the population level. Overall, the fish community in Willow Creek is not expected to change with any alternative.

Macroinvertebrates

Habitat needs of the macroinvertebrates present in the Colorado River and Willow Creek are similar to those of the trout species. The species, abundance, and distribution of macroinvertebrates should remain similar to existing conditions under all alternatives based on the anticipated changes in flow and changes in water quality. Based on the field data, the wetted channel width reaches the banks at approximately 90 to 100 cfs, which provides the maximum wetted area for macroinvertebrates. The existing MMI for the Colorado downstream of Windy Gap ranges from 92 (Rees 2009) to 100 (Miller Ecological Consultants 2011). These MMI values indicate the existing macroinvertebrate community is unimpaired. The dissolved oxygen and temperature conditions are not expected to change to a point that would substantially impact macroinvertebrates. The sediment transport analysis shows the flow regime for the Proposed Action would provide the flows needed to flush fine sediments from the streambed and maintain macroinvertebrate habitat. Because none of the projected changes in wetted channel, channel morphology, and water quality under the alternatives are predicted to substantially impact aquatic habitat, no significant change to macroinvertebrate communities are expected.

Grand Lake, Shadow Mountain Reservoir, Granby Reservoir, and Willow Creek Reservoir

There would be no change in reservoir elevation in Grand Lake, Shadow Mountain Reservoir, or Willow Creek Reservoir under any alternative; thus there would be no effect to available fish habitat. Predicted decreases in Granby Reservoir water levels of up to 10 feet in wet years are not expected to change the dynamics of the fish population. Sequential dry years that result in substantially lower reservoir elevations would reduce available fish habitat and could affect the dynamic balance between lake trout and kokanee. The Proposed Action has the greatest potential for drawdown in consecutive dry years at Granby Reservoir.

Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir (Three Lakes) would remain mesotrophic under all alternatives; thus, lake productivity would not change. The minimum DO concentrations in the hypolimnion for Grand Lake would decrease up to 0.6 mg/L for the No Action Alternative and less under the action alternatives. Granby Reservoir and Shadow Mountain minimum DO levels would decrease less than 0.2 mg/L for all alternatives. None of the alternatives would affect Three Lakes' surface temperature. Because the trophic state is expected to remain the same, the DO levels would remain within the range observed under existing conditions, and temperature changes would be minor, no change in fish population dynamics are expected from changes in the physical environment at the Three Lakes for any alternative.

Windy Gap Reservoir

There are minimal or no changes expected to the trophic state, reservoir sediment conditions, or water temperature regimes in Windy Gap Reservoir and other C-BT system reservoirs; therefore, none of the alternatives are expected to enhance the conditions for the development and spread of whirling disease in Windy Gap Reservoir or elsewhere in the Colorado River, Three Lakes, or East Slope streams and reservoirs.

Jasper East Reservoir and Rockwell Reservoir

Jasper East and Rockwell reservoirs are predicted to be oligotrophic-mesotrophic (low to medium productivity). These reservoirs are likely to support a fishery with appropriate management, although the large fluctuations in reservoir storage may reduce productivity.

3.9.2.4 East Slope Effects

Big Thompson River, North St. Vrain Creek, St. Vrain Creek, Big Dry Creek, and Coal Creek

All alternatives would result in an increase (1 to 9 percent) in Big Thompson River flows below Lake Estes from April to October from additional Windy Gap deliveries. These slight flow changes could increase fish habitat, but are unlikely to measurably affect fish populations. Increased return flow below the Participant's WWTPs on the Big Thompson River, St. Vrain Creek, Big Dry Creek, and Coal Creek, which occurs year-round, could slightly enhance fish habitat in these streams under all alternatives.

The No Action Alternative would result in both increases and decreases in flows at North St. Vrain Creek below Ralph Price Reservoir and St. Vrain Creek to Lyons. A slight reduction in fish habitat would occur with lower May and July flows; however, increased flows in the fall and winter when flows are typically lowest would benefit fish habitat.

The small changes in streamflow and water quality parameters are not expected to impact the current fish or macroinvertebrate populations in East Slope streams under any of the alternatives.

Carter Lake and Horsetooth Reservoir

Estimated lower average water levels in Carter Lake and Horsetooth Reservoir, under the action alternatives, would slightly reduce available fish habitat; however, these changes would not measurably impact fish survival, reproduction, or fishing success. Under all alternatives, there would be no change in the trophic state or other water quality parameters that would adversely impact fish of Carter Lake or Horsetooth Reservoir. Therefore, the habitat in these reservoirs would continue to support fish under current management by CDPW.

Ralph Price Reservoir

The enlargement of the dam at Ralph Price Reservoir under the No Action Alternative may require a substantial drawdown of the reservoir, which could adversely impact existing fish populations during construction. Following construction, the fishery would be restored and maintained with conditions similar to the current reservoir. Water quality is predicted to be oligotrophic, which means productivity would be relatively low and growth for fish stocked in the lake may be slow, as is currently the case. Potential species for the reservoir after construction include rainbow trout, brown trout, and splake, as currently managed. The enlargement may allow the stocking of kokanee salmon as well.

Chimney Hollow and Dry Creek Reservoirs

There would be no adverse impact to aquatic habitat in Chimney Hollow because this intermittent stream is often dry and does not support a fishery. Dam construction and inundation of Dry Creek at Dry Creek Reservoir under Alternative 5 would impact intermittent aquatic habitat that supports minnows and aquatic invertebrates.

Chimney Hollow and Dry Creek reservoirs would require development of a fisheries management plan. The fishery would then be established based on reservoir characteristics and expected outcomes for anglers. It is likely these reservoirs would support a fishery similar to other Front Range reservoirs, with a combination of cool water and cold water species. Both reservoirs likely would be similar in species composition to Carter Lake or Horsetooth Reservoir; however, Chimney Hollow and Dry Creek reservoirs may be less productive because they are predicted to be oligotrophic, which is less productive than the trophic state of Carter Lake and Horsetooth Reservoir.

3.9.3 Cumulative Effects

The evaluation of aquatic resource cumulative effects was based on fish habitat model runs using the hydrologic conditions with reasonably foreseeable water-based projects in place. Hydrologic modeling did not include the future July/August to September releases from Granby Reservoir as part of the proposed 10825 Project. Thus, the analysis of fish habitat changes does not include the release of 5,412.5 AF from Granby Reservoir at rates ranging from 21 to 70 cfs depending on whether it is a dry or wet year. Most of these releases would come from as early as mid-July through September. As noted in the following discussion, these releases would increase available fish habitat and reduce stream temperatures during periods of low flow. Because some of the largest decreases in adult rainbow trout habitat occur in August, the 10825 Project releases would reduce habitat loss during these low periods regardless of Windy Gap pumping, which occurs infrequently in August.

3.9.3.1 West Slope Effects

Cumulative impacts to fish habitat on the West Slope, in particular to the Colorado River and Willow Creek, show a decrease in habitat for juvenile and adult rainbow and brown trout from Windy Gap Reservoir downstream to Troublesome Creek. This contrasts with the direct effects which only show a decrease for adult rainbow trout habitat in the reach between Windy Gap Reservoir and the Williams Fork Reservoir. The additional decrease in habitat is the result of future foreseeable changes to flow attributable to projects other than Windy Gap. The WGFP contribution to cumulative effects decreases slightly because less water would be available for diversion in the future with reasonably foreseeable actions in places.

Average year impacts for the Proposed Action would be similar to the direct effects (Table 3-121 and Table 3-122). The greatest decrease in adult rainbow trout habitat occurs in late August above the Williams Fork, with increases in habitat in June of average years. Habitat changes for brown trout show a similar pattern, but reasonably foreseeable actions other than the WGFP result in maximum habitat decreases in September. Figure 3-104 and Figure 3-105 illustrate the seasonal increases and decreases in adult rainbow trout and brown trout habitat during average flow years below Windy Gap Reservoir compared to existing conditions. Changes in fish habitat diminish downstream as shown in Figure 3-106 and Figure 3-107 for adult rainbow and brown trout habitat above the confluence with the Blue River.

Both increases and decreases in brown trout habitat occur in dry years as a result of reasonably foreseeable actions (Table 3-123). WGFP diversions in dry years would not change from existing conditions. There is a substantial increase in habitat for brown trout in wet years in July except for a decrease in habitat downstream of the Blue River (Table 3-124). Rainbow trout habitat changes show a similar pattern in dry and wet years (Miller Ecological Consultants 2010).

As noted in Figure 3-104 to Figure 3-107, cumulative impacts to rainbow and brown trout habitat with the No Action Alternative would parallel the impacts under the Proposed Action, but would not change as much, because Windy Gap diversions would be lower.

Table 3-121. Percent change in rainbow trout habitat from existing conditions under the Proposed Action for locations on the Colorado River and Willow Creek for average water years, cumulative effects.

Location	Juvenile Rainbow Trout				Adult Rainbow Trout			
	Range of change from existing conditions				Range of change from existing conditions			
	↓ (%)	Date	↑ (%)	Date	↓ (%)	Date	↑ (%)	Date
Below Windy Gap	-7.7	Aug 16-31	+28.9	Jun 1-15	-42.3	Aug 16-31	+26.6	Jun 1-15
Hot Sulphur Springs	-7.6	Aug 16-31	+29.3	Jun 1-15	-40.0	Aug 16-31	+27.1	Jun 1-15
Above Williams Fork	-8.5	Sep 16-30	+29.3	Jun 1-15	-45.7	Aug 16-31	+25.9	Jun 1-15
Below Williams Fork	-4.9	May 1-15	+9.0	Jun 1-15	-14.7	May 1-15	+8.4	Jun 16-30
Above Troublesome Creek	-5.9	May 1-15	+10.4	Jun 1-15	-17.2	May 1-15	+9.8	Jun 16-30
Above Blue River	-0.6	Apr 1-15	+8.5	Jul 1-15	-2.0	Apr 1-15	+9.2	Jun 1-15
Below Blue River	0.0	Multiple	+15.8	Jun 1-15	-0.4	Jan 16-31	+28.2	Jun 1-15
Willow Creek	-12.4	Jul 16-31	+1.1	Jun 1-15	-22.7	Jul 16-31	+1.2	Oct 1-15

Table 3-122. Percent change in brown trout habitat from existing conditions under the Proposed Action for locations on the Colorado River and Willow Creek for average water years, cumulative effects.

Location	Juvenile Brown Trout				Adult Brown Trout			
	Range of change from existing conditions				Range of change from existing conditions			
	↓ (%)	Date	↑ (%)	Date	↓ (%)	Date	↑ (%)	Date
Below Windy Gap	-7.7	Aug 1-15	+26.1	Jun 1-15	-20.3	Sep 16-30	+42.8	Jun 1-15
Hot Sulphur Springs	-7.5	Aug 16-31	+26.5	Jun 1-15	-19.0	Sep 16-30	+43.3	Jun 1-15
Above Williams Fork	-8.4	Sep 16-30	+26.1	Jun 1-15	-25.8	Sep 16-30	+42.5	Jun 1-15
Below Williams Fork	-4.8	May 1-15	+11.6	Jun 1-15	-1.3	Aug 1-15	+7.2	Jun 1-30
Above Troublesome Creek	-5.7	May 1-15	+13.4	Jun 1-15	-4.6	May 16-31	+8.4	Jun 16-30
Above Blue River	-0.5	Apr 1-15	+11.1	Jul 1-15	-0.8	Apr 1-15	+11.5	Jun 1-15
Below Blue River	-0.1	Jan 16-31	+15.4	Jun 1-15	-0.1	Jan 16-31	+38.9	Jun 1-15
Willow Creek	-16.2	Jul 16-31	+0.8	Oct 1-15	-24.3	Jul 16-31	+3.7	Jun 1-15

Table 3-123. Percent change in brown trout habitat from existing conditions under the Proposed Action for locations on the Colorado River and Willow Creek for dry water years, cumulative effects.

Location	Juvenile Rainbow Trout				Adult Rainbow Trout			
	Range of change from existing conditions				Range of change from existing conditions			
	↓ (%)	Date	↑ (%)	Date	↓ (%)	Date	↑ (%)	Date
Below Windy Gap	-6.7	Aug 16-31	+4.2	Jun 1-15	-20.1	Sep 16-30	+7.8	Jun 1-15
Hot Sulphur Springs	-6.8	Aug 16-31	+4.0	Jun 1-15	-21.4	Sep 16-30	+6.4	May 16-31
Above Williams Fork	-8.0	Aug 16-31	+5.1	Jun 1-15	-29.8	Sep 1-15	+5.7	May 16-31
Below Williams Fork	-5.9	Jul 16-31	+3.0	Jun 1-15	-5.6	Jul 1-15	+3.5	May 1-15
Above Troublesome Creek	-8.8	Jul 16-31	+2.3	Feb 1-15	-14.3	Jun 16-30	+2.0	Feb 1-15
Above Blue River	-1.8	Jun 16-30	+3.9	Sep 1-15	-2.5	May 1-15	+3.1	Sep 16-30
Below Blue River	-2.7	Jun 1-15	+7.8	Jul 1-15	-4.6	Jun 1-15	+5.3	Jul 1-15
Willow Creek	0.0	Multiple	0.0	Multiple	0.0	Multiple	0.0	Multiple

Table 3-124. Percent change in brown trout habitat from existing conditions under the Proposed Action for locations on the Colorado River and Willow Creek for wet water years, cumulative effects.

Location	Juvenile Rainbow Trout				Adult Rainbow Trout			
	Range of change from existing conditions				Range of change from existing conditions			
	↓ (%)	Date	↑ (%)	Date	↓ (%)	Date	↑ (%)	Date
Below Windy Gap	-6.1	Aug 16-31	+47.5	Jul 16-31	-10.9	Jan 1-15	+89.1	Jul 16-31
Hot Sulphur Springs	-5.7	Aug 16-31	+47.6	Jul 16-31	-9.0	Jan 16-31	+89.1	Jul 16-31
Above Williams Fork	-6.2	Aug 16-31	+48.3	Jul 16-31	-8.9	Jan 16-31	+90.8	Jul 16-31
Below Williams Fork	-2.2	Apr 16-30	+13.4	Jul 1-15	-1.9	Apr 16-30	+33.0	Jul 1-15
Above Troublesome Creek	-2.2	Apr 16-30	+14.4	Jul 1-15	-1.9	Apr 16-30	+35.7	Jul 1-15
Above Blue River	-6.4	Jun 1-15	+12.3	Jul 1-15	-12.0	Jun 16-30	+30.7	Jul 1-15
Below Blue River	-16.9	Jun 16-30	+6.7	May 16-30	-20.4	Jul 16-31	+15.1	May 16-31
Willow Creek	-12.2	Jun 1-15	0.0	Multiple	-16.5	Aug 16-31	0.0	Multiple

Figure 3-104. Percent change in rainbow trout (adult) habitat from existing conditions on the Colorado River below Windy Gap for average water year, cumulative effects.

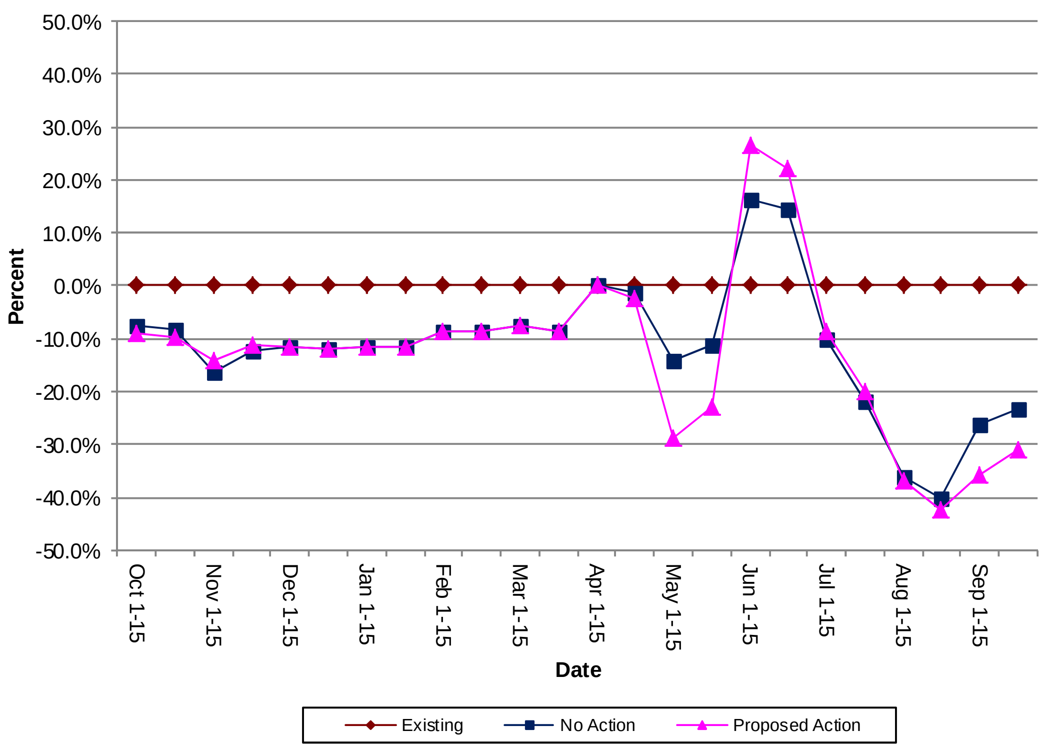


Figure 3-105. Percent change in brown trout (adult) habitat from existing conditions on the Colorado River below Windy Gap for average water year, cumulative effects.

Figure 3-106. Percent change in rainbow trout (adult) habitat from existing conditions on the Colorado River above the Blue River for average water year, cumulative effects.

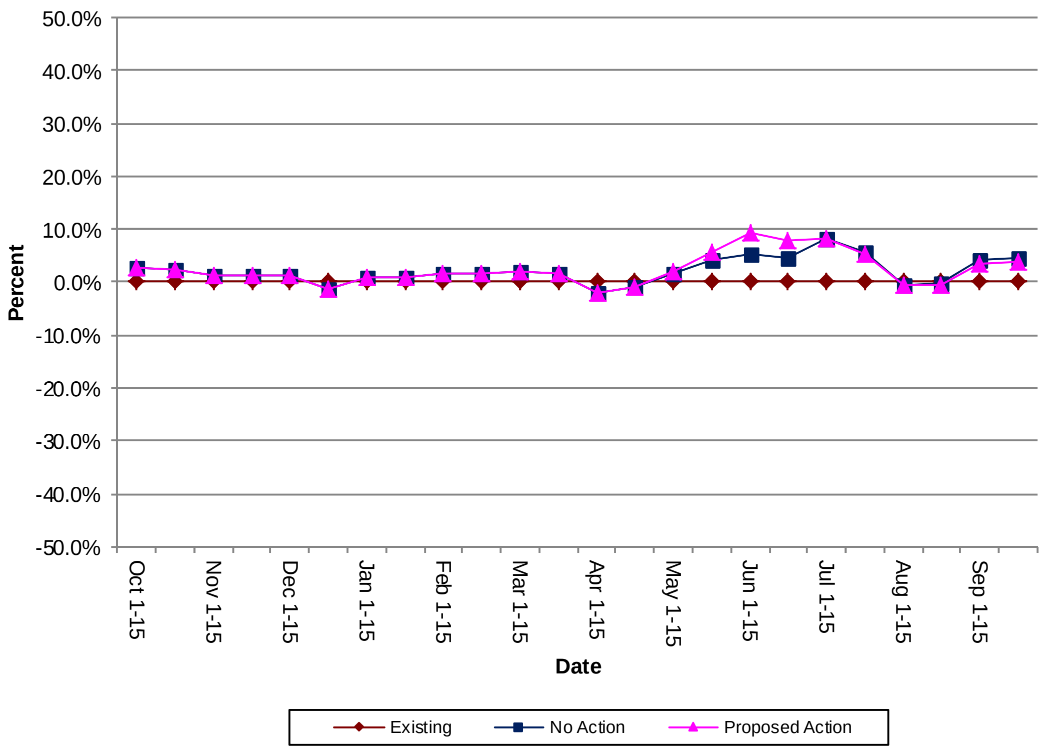
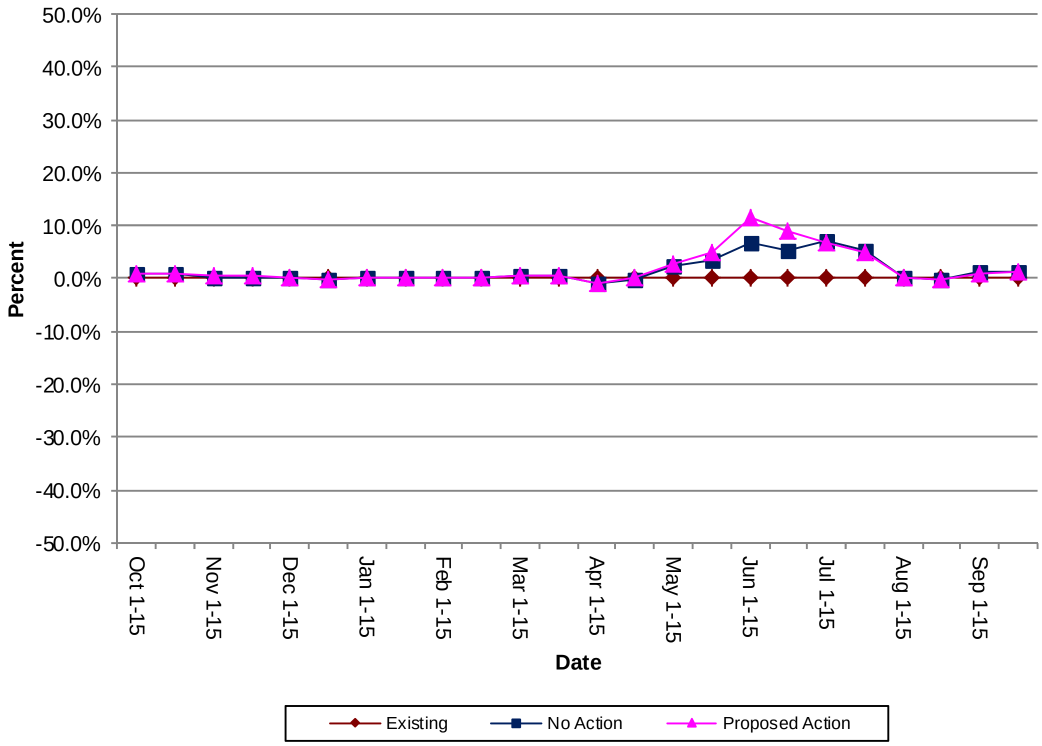


Figure 3-107. Percent change in brown trout (adult) habitat from existing conditions on the Colorado River above the Blue River for average water year, cumulative effects.



Dynamic temperature modeling of the Colorado River with the anticipated hydrologic conditions associated with reasonably foreseeable future actions in place was performed as described in *Surface Water Quality* (Section 3.8.3.1). Temperature modeling included Granby Reservoir releases for the 10825 Project (*Reasonably Foreseeable Actions*, Section 2.8.2.1) that could occur as early as July 15 and continue through the end of September. The rate of release depends on the type of water year, but would range from 50 cfs in August to 29 cfs in September based on an average runoff year. Three years out of the 15 years of hydrology modeled showed simulated exceedances of WATs and/or DMs for the Proposed Action in the reach between Windy Gap and the Williams Fork, although exceedance of the temperature standard also occurred under simulated existing conditions in some years. The 5,412.5 AF releases from Granby Reservoir have a noteworthy cooling effect on river flows, particularly when releases begin in mid-July. Elevated stream temperatures exceeding the MWAT standard, and in particular the DM standard, would increase the stress on fish populations, although predicted exceedances as a result of the WGFP are estimated to occur only in about 3 out of 15 years assuming July and August air temperatures similar to 2007, which as previously stated, included the hottest August on record and the sixth hottest July on record.

Projected Colorado River water quality changes for dissolved oxygen, ammonia, inorganic phosphorus, and other modeled parameters in the future are not expected to adversely affect aquatic life or the stream fishery. DO concentrations would decrease by up to 0.1 mg/L from existing conditions under all alternatives, but the decrease would not lower the concentration below the standard. However, a DO concentration as low as 6.9 mg/L for a short reach above the Williams Fork would be below the aquatic life spawning standard of 7.0 mg/L, but this would occur mid-summer, outside of the spawning season. Ammonia concentrations would increase, but none of the alternatives would increase the ammonia concentration above the aquatic life chronic standard and, therefore, no impact to aquatic life is expected. Inorganic phosphorus concentrations are predicted to increase in the future, but with minimal effect to aquatic life.

Cumulative impacts to the Three Lakes fishery would be about the same as those described in the direct effects evaluation. Small reductions in DO concentrations are expected, but no change in trophic state for any of the lakes or reservoirs is expected. Because no change in trophic state is predicted, no measurable change in fish populations is likely. There would be no temperature change in the Three Lakes system under any alternative.

Several future actions by the Subdistrict and Denver Water would benefit aquatic life. The Subdistrict and Denver Water cooperatively developed separate FWEPs to improve existing fish and wildlife resources beyond what currently exists (Municipal Subdistrict 2011a; Denver Water 2011a). The FWEPs for the WGFP and Moffat Project were adopted by the Colorado Wildlife Commission on June 9, 2011 and the CWCB on July 13, 2011. The components of the FWEPs are not intended to substitute for any mitigation required by the federal agencies for the projects. The goal of these plans is to coordinate the application of any required mitigation efforts with the voluntary and collaborative efforts of the stream enhancement projects to assure the maximum benefit for the stream environment. A key component of the FWEPs, as described in *Reasonably Foreseeable Actions* (Section 2.8.2.1), is the Upper Colorado River Habitat Project (habitat project). The goal of the habitat project is to design and implement a stream restoration program to improve the existing aquatic environment from the Windy Gap diversion to the lower terminus of the Kemp-Breeze State Wildlife Area about 2 miles downstream from the confluence with the Williams Fork. The Subdistrict and Denver Water will provide funding for this project and the CDPW will be responsible for developing the restoration plan in coordination with other local stakeholders. In addition, the Subdistrict has agreed to provide up to $250,000 to fund detailed studies of methods to bypass flows, sediment, and/or fish around Windy Gap Reservoir. Issues to be studied include sediment transport, water quality (effects on temperature and/or nutrients), and fish passage. CDPW would direct these studies to identify potential modifications that would provide tangible benefits to aquatic resources below Windy Gap Reservoir. Implementation of the measures in the FWEPs would improve existing aquatic habitat in the Colorado River.

As part of negotiations between West Slope parties and Denver Water, Grand County and Denver Water have reached a proposed agreement that addresses some of the issues related to Denver Water's existing operations in Grand County (Denver Water 2011c). In a *Proposed Colorado River Cooperative Agreement* (proposed agreement), Denver Water has committed to the Learning By Doing Cooperative Effort that provides environmental enhancements to benefit the aquatic environment in the Fraser, Williams Fork, and upper Colorado rivers as described in *Reasonably Foreseeable Actions* (Section 2.8.2.1). The proposed agreement includes funding by Denver Water to reduce nutrient loadings in Grand County, environmental enhancements, up to 1,000 AF of bypass water from the Fraser River Collection system, 1,000 AF of releases from Williams Fork Reservoir, plus 2,500 AF of storage for environmental releases. In addition, Denver Water would contribute up to $2 million to Grand County for the costs of pumping Windy Gap water for environmental purposes. This measure is contingent upon an agreement between Grand County and the Subdistrict to allow Windy Gap water to be pumped, under certain conditions, into Granby Reservoir for later release to the Colorado River to improve streamflow. All of the measures would benefit the existing aquatic habitat in the Colorado River below Windy Gap Reservoir, as well as other streams within Denver Water's collection system.

As part of the Moffat System Project, Denver Water has developed a FWMP that was adopted by the Colorado Wildlife Commission on June 9, 2011 and the CWCB on July 13, 2001 (*Reasonably Foreseeable Actions*, Section 2.8.2.1). The mitigation plan includes measures on the West Slope in the Fraser River, Williams Fork, Blue River, and Colorado River basins (Denver Water 2011b). Components of the mitigation plan with potential direct effects to the Colorado River below Windy Gap Reservoir include up to 250 AF of bypassed diversions from its Fraser River Collection System when stream temperature exceeds standards on either Ranch Creek near Fraser, Colorado; the Fraser River near Tabernash, Colorado; or on the Colorado River between Windy Gap Reservoir and the Williams Fork. These releases have the potential to improve flows and moderate high stream temperatures in the Colorado River and portions of the Fraser River.

3.9.3.2 East Slope Effects

No reasonably foreseeable water-based actions on the East Slope were identified that would add to the impacts of the Windy Gap Project. The changes in hydrology on the East Slope would be primarily related to less Windy

Gap deliveries to the East Slope with reasonably foreseeable West Slope water-based projects online. The pattern of flows is expected to be similar to the direct effects. Small increases in streamflow predicted for East Slope streams would generally be less than 10 percent and any change in aquatic life is likely not measurable.

Hydrologic changes in Horsetooth and Carter reservoirs with reasonably foreseeable actions are unlikely to measurably affect fish populations in those reservoirs. Hydrologic and water quality changes at Ralph Price Reservoir with reasonably foreseeable actions in place would result in effects similar to direct effects, with slightly improved habitat following reservoir enlargement.

3.9.4 Aquatic Resource Mitigation

Adverse impacts to aquatic life as the result of the WGFP diversions include a reduction in trout habitat in the Colorado River in the early spring and mid-summer. In addition, there would be an increase in the frequency of exceedances of the aquatic life MWAT standard and the DM during years when the WGFP diverts water in July and August. The majority of habitat impacts occur in the reach of the Colorado River between Windy Gap Reservoir and the confluence with the Williams Fork River. All of the potential exceedances of the temperature standard are predicted to occur between Windy Gap Reservoir and the Williams Fork.

> The Subdistrict, in cooperation with the CDPW, developed mitigation measures and monitoring protocols for addressing identified impacts to aquatic resources from the Proposed Action in accordance with CRS § 37-60-122.2.

In recognition of the state's responsibility for fish and wildlife resources found in and around state waters that are affected by water diversion, delivery, or storage facilities, the Colorado General Assembly enacted CRS § 37-60-122.2. This statute states that "fish and wildlife resources that are affected by the construction, operation or maintenance of water diversion, delivery, or storage facilities should be mitigated to the extent, and in a manner, that is economically reasonable and maintains a balance between the development of the state's water resources and the protection of the state's fish and wildlife resources." In compliance with CRS § 37-60-122.2, the Subdistrict prepared a FWMP (Municipal Subdistrict 2011a) that includes several mitigation measures for the identified impacts to aquatic life from the WGFP (Appendix E). The plan was adopted by the Colorado Wildlife Commission on June 9, 2011 and by the CWCB on July 13, 2011.

Mitigation measures from the FWMP to reduce the potential for impacts to stream temperature from the WGFP are described in detail in *Temperature Mitigation Measures* (Section 3.8.4.2) and Appendix E. Temperature mitigation includes real-time temperature monitoring below Windy Gap upstream of the Williams Fork Reservoir, with curtailment of WGFP pumping after July 15 when MWAT and DM temperature thresholds are exceeded. At such times as the WAT exceeds the MWAT chronic threshold, the Subdistrict would reduce or curtail WGFP pumping at the Windy Gap diversion to the extent necessary to maintain temperatures within the MWAT threshold. Pumping for the original Windy Gap Project, now and after the WGFP is in operation, could occur at any time that the Windy Gap water rights are in priority and sufficient space is available in Granby Reservoir that such water pumped will not be reasonably expected to spill from the reservoir. Therefore, WGFP pumping is defined as pumping that occurs at such times as Reclamation and the NCWCD jointly determines, based on the most probable forecasts of inflows to Granby Reservoir, that a spill of water from the C-BT system is reasonably foreseeable. All other pumping will be considered to be for the original Windy Gap Project. If temperatures get to within 1^{o}C of the DM standard, both WGFP and WGP pumping will be curtailed as necessary to prevent exceedance of the DM standard. In addition, the Subdistrict will use the Windy Gap Project Bypass Valve and Auxiliary Outlet to the maximum extent practicable to release cooler water from the bottom of Windy Gap Reservoir.

Mitigation measures to reduce nutrient loading to the Three Lakes, which also improve water quality in the Colorado River, Fraser River, and Willow Creek are described in *Nutrient Reduction* (Section 3.8.4.1). Nutrient mitigation includes implementing both point source and nonpoint source measures upstream from the Windy Gap Reservoir diversion to offset the predicted nutrient loadings into the Three Lakes and reduce the associated water quality impacts. This would provide a year-round improvement in water quality in Willow Creek, portions of the

Fraser River, and the Colorado River below Windy Gap and reduce the nutrient load delivered to the East Slope in Carter Lake, Horsetooth Reservoir, and the C-BT system.

Modified prepositioning as described in *Surface Water Hydrology* (Section 3.5.4.1), would maintain higher water levels in Granby Reservoir, as well as higher water levels in Carter Lake and Horsetooth Reservoir. The additional water in these reservoirs would provide a minor benefit to available aquatic habitat compared to the originally proposed prepositioning. However, modified prepositioning would result in lower water levels and greater fluctuations in Chimney Hollow Reservoir, which would slightly diminish the amount and quality of habitat for establishment of a fishery in the new reservoir. Although no direct impacts to aquatic life occur at Chimney Hollow, the establishment of a sport fishery in Chimney Hollow Reservoir is a potential action to enhance recreational opportunities.

3.9.5 Unavoidable Adverse Effects

The additional diversions under all alternatives would result in a decrease in available fish habitat in the Colorado River below Windy Gap Reservoir and Willow Creek below Willow Creek Reservoir. The greatest effect to fish habitat would occur in the reach between Windy Gap Reservoir and the Williams Fork River. Additional Windy Gap diversions from the Colorado River would increase the potential for exceedance of the chronic MWAT and acute DM temperature standards, although mitigation measures are anticipated to reduce the impact. Predicted changes in North St. Vrain Creek and St. Vrain Creek flows under the No Action Alternative could result in minor adverse effects to fish habitat in several months when flows decrease in the summer. Changes in Granby Reservoir, Carter Lake, and Horsetooth Reservoir storage could result in minor unquantifiable adverse effects to fish.

3.10 Vegetation

3.10.1 Affected Environment

3.10.1.1 Regulatory Framework

Vegetation resource management varies among federal and state agencies. Wetlands, which are regulated under the Clean Water Act, are discussed in Section 3.11. Federally listed plant species protected under the Endangered Species Act are discussed in Section 3.13. Plant species and communities of concern in the state are monitored by the Colorado Natural Heritage Program (CNHP). CNHP-monitored plants are discussed in this section, but there is no formal regulatory protection.

Noxious weeds are regulated under the Colorado Noxious Weed Act (CRS § 35-5.5), which states that all landowners must manage noxious weeds that may be damaging to adjacent landowners. Noxious weeds are classified as A, B, or C list species targeted for eradication or control. Within this classification system, local counties have priority lists for weed control, including species adapted to reservoirs (aquatic and semiaquatic).

3.10.1.2 Area of Potential Effect

The area of potential effect for vegetation resources is the potential reservoir sites and related pipelines, roads, and infrastructure that would be disturbed during construction or inundated by a new or larger reservoir. In addition, the area of potential effect includes riparian vegetation bordering the Colorado River, Willow Creek, Granby Reservoir, Horsetooth Reservoir, Carter Lake, and East Slope streams that would experience changes in hydrology.

3.10.1.3 Data Sources

Information on existing vegetation resources in the area of potential effect was collected from on-site field investigations and aerial photography at the Chimney Hollow, Dry Creek, and Jasper East reservoir sites and

Ralph Price Reservoir. Information for the Rockwell Reservoir site was taken primarily from aerial photography because of lack of access to private property. Reconnaissance field investigations and aerial photography also were used to characterize riparian vegetation adjacent to streams and existing reservoirs.

Dominant species in each vegetation community was grouped to produce a map of vegetation cover types for each of the reservoir sites. Noxious weeds were noted during field investigations. Site surveys at Chimney Hollow, Dry Creek, and Jasper East were used to determine the presence of CNHP-tracked plant communities or species in addition to a search of the CNHP database for nearby records of occurrence. Additional information on vegetation resources is included in the Vegetation Resources Technical Report (ERO 2007a).

3.10.1.4 Ralph Price Reservoir

Vegetation Cover Types

The Ralph Price Reservoir study area supports three vegetation cover types: upland native forest, upland native grassland, and upland shrubland.

Upland Native Forest. Upland native forest dominates most of the lands bordering the reservoir. Ponderosa pine forests are found primarily on south-facing slopes with an understory of junegrass, needle-and-threadgrass, and western wheatgrass. Cheatgrass—a C List noxious weed—is present in portions of the low density ponderosa pine stands. North-facing slopes consist of dense stands of Douglas-fir with scattered ponderosa pine and blue spruce.

Upland Native Grasslands. Upland native grasslands occur primarily near potential borrow areas for dam construction. Species in this vegetation type include western wheatgrass, blue grama, smooth brome, and various needle grasses.

Upland Shrubland. Small areas of upland shrubland are present on the eastern and northern side of the reservoir. Dominant plants in the upland shrubland cover type include mountain mahogany, bitterbrush, blue grama, western wheatgrass, and fringed sage.

CNHP Plant Communities and Species

The CNHP database indicates that suitable habitat for five imperiled or vulnerable plants species is present at Ralph Price Reservoir. Larimer aletes, rattlesnake fern, broad-leaved twayblade, Rocky Mountain cinquefoil, and prairie violet could potentially be present. Field surveys for these species would need to be completed if this alternative is selected.

3.10.1.5 Chimney Hollow and Dry Creek Reservoirs

Vegetation Cover Types

The Chimney Hollow and Dry Creek Reservoir sites are located in adjacent watersheds between a hogback ridge and the foothills (Figure 2-3). At an elevation of about 5,500 feet, both reservoir sites support similar vegetation cover types with slight differences in species composition. Primary vegetation cover types at these reservoir sites are described below.

Dry Creek Reservoir valley

Upland Native Forest. The upland native forest consists of ponderosa pine forests covering the foothills on the west side of the Chimney Hollow and Dry Creek drainages. The ponderosa pine forest vegetation cover type ranges from dense stands with little understory vegetation to open stands with mountain mahogany and grasslands of western wheatgrass, prairie dropseed, blue grama, and mountain muhly. Little bluestem and big bluestem are common in moist locations, particularly in the northwestern portion of Dry Creek and western portion of Chimney Hollow. The density and distribution of the noxious weed cheatgrass varies annually, but is a common component of the understory at Chimney Hollow and less so at Dry Creek.

Mesic Native Woodland. The mesic native woodlands vegetation cover type occurs in moist areas along the Chimney Hollow and Dry Creek drainages and in scattered locations along some of the west side drainages. Along Chimney Hollow, plains cottonwood and peachleaf willow are common with an understory of sandbar willow or smooth brome, western wheatgrass, redtop and snowberry. Small drainages in Chimney Hollow also support narrowleaf cottonwood and lanceleaf cottonwood with an understory of chokecherry and wild plum. Along Dry Creek, narrowleaf and plains cottonwood, along with box elder are common. The understory includes sandbar willow, chokecherry and grasses such as Canada wildrye, smooth brome, and Canada bluegrass.

Upland Native Shrubland. The upland native shrubland cover type is found along the low ridges and slopes west of Chimney Hollow and Dry Creek, as well as the west-facing hogback ridge. Mountain mahogany is the dominant species with skunkbush common on lower slopes. Ponderosa pine is scattered within the shrubland at some locations. The understory contains a variety of grasses and forbs including blue grama, needlegrasses, fringed sage, prickly pear cactus, and cheatgrass. On dry rocky ridges, the understory is sparse with grasses such as Indian rice grass and mixed forbs.

Mesic Native Shrubland. The mesic native shrubland vegetation cover type occurs primarily in the moist to wet drainages on the west side of reservoir valleys. Dense thickets of chokecherry and wild plum are found along ephemeral drainages in the study areas. Other shrubs include skunkbush, sandbar willow, snowberry, and currents.

Upland Native Grasslands. Upland native grasslands are present on the upper slopes of the Chimney Hollow and Dry Creek valleys and in pockets within the forest and shrublands of the foothills and hogback. Blue grama is dominant on dry slopes with sideoats grama and needle-and-thread grass common in other areas. On moist slopes, western wheatgrass and big bluestem is present. Mountain mahogany, yucca, fringed sage, and other small shrubs are also found in this grassland.

Mesic Mixed Grasslands. Native grasses such as western wheatgrass, various needlegrasses, and dropseed are found in the mesic mixed grassland vegetation cover type. Nonnative species include smooth brome and crested wheatgrass. Weeds include cheatgrass, musk thistle, mullein, and kochia. At both Chimney Hollow and Dry Creek, mesic mixed grasslands are found on valley sideslopes where previous livestock grazing occurred.

Upland Introduced Grasslands. Upland introduced grasslands are located along the valley floor of both reservoir sites where historical livestock grazing has been intense. Smooth brome, crested wheatgrass, and weedy species such as cheatgrass and kochia are common. Canada thistle and musk thistle also are present, especially on the Dry Creek Reservoir site.

CNHP Plant Communities and Species

The Chimney Hollow and Dry Creek Reservoir sites contain several vegetation communities classified as vulnerable or imperiled by the CNHP. These plant communities are present in the study area, but typically in scattered pockets or in combination with other more dominant species. CNHP plant communities and species found within the Chimney Hollow and Dry Creek study areas are discussed below.

Ponderosa Pine/Mountain Mahogany/Big Bluestem. The upland native forest vegetation cover type at both reservoir sites contains components of this vegetation community.

Mountain Mahogany/New Mexico Needlegrass. Patches of mountain mahogany/New Mexico needlegrass shrublands occur along the hogback on the east site of Chimney Hollow in the upland native shrublands vegetation cover type. This community was not observed in Dry Creek.

Skunkbush Riparian Community. Patches of this community were found in the dry narrow drainages on both the reservoir sites in the mesic native shrubland cover type.

Narrowleaf Cottonwood/Chokecherry Riparian Community. This community is found in scattered areas in northern drainages at Chimney Hollow in the mesic native woodland cover type.

Suitable habitat for 12 CNHP-tracked plant species is present in the Chimney Hollow and Dry Creek Reservoir sites. Although three species—Bell's twinpod, Larimer aletes, and strap-style gayfeather—have been recorded nearby, no occurrence is recorded for these species in the area of potential effect and field surveys of both reservoirs did not locate any of the 12 CNHP species (ERO 2007a).

3.10.1.6 Jasper East and Rockwell/ Mueller Creek Reservoirs

Vegetation Cover Types

Upland Native Forest. Lodgepole pine forests—an upland native forest vegetation type—are found at both potential reservoir sites. At Jasper East, lodgepole pine is found on scattered north-facing slopes and at Rockwell on the upper western slopes. Dominant understory species include grouse whortleberry, kinnikinnick, common juniper buffaloberry, heartleaf arnica, Nelson needlegrass, bluegrass, and elk sedge. Aspen upland native forest stands are present at Rockwell and less common at Jasper East. Understory species in aspen forests contain bitterbrush, shrubby cinquefoil, Woods' rose, bluebunch, wheatgrass and various forbs.

Upland Native Shrubland. Upland native shrubland with a sagebrush-dominant cover type is found on hillsides at both reservoir sites. Other shrubs present include snakeweed, bitterbrush, and snowberry. Common grasses and forbs include western wheatgrass, prairie junegrass, fringed sage, sulphur flower, Indian paintbrush, and yarrow.

Mesic Native Shrubland. The mesic native shrubland vegetation cover type includes riparian species such as planeleaf, strapleaf, and Geyer's willow. Understory species in dry areas include currant, shrubby cinquefoil, bluejoint reedgrass, bluebells, and Baltic rush. At Jasper East, this vegetation cover type is found near the Willow Creek pump station and drainages. At the Rockwell Reservoir site, mesic native shrublands are found along the drainages.

Upland Mixed Grassland. The upland mixed grassland vegetation cover type is dominated by mountain brome, smooth brome, slender wheatgrass, timothy, yarrow, clustered field sedge, Baltic rush, and slender wheatgrass. Canada thistle, a noxious weed, is found in some locations on the Jasper East Reservoir site.

Mesic Mixed Grassland. The Jasper Reservoir site contains irrigated hayfields of mesic mixed grasses that are mowed several times per year. Common species in this grassland include meadow foxtail, Kentucky bluegrass, smooth brome, timothy, and clover.

CNHP Plant Communities and Species

No CNHP-tracked vegetation communities were identified during field studies in the area of potential effect at Jasper East Reservoir. No surveys were conducted of the Rockwell Reservoir site because access was denied.

Suitable habitat for nine CNHP species is present at the Jasper East and Rockwell reservoir sites and historical records indicate Bodin milkvetch, Nagoon berry, and bitterroot have occurred nearby, but there are no known occurrences in the area of potential effect. The only CNHP species documented during field surveys of the Jasper East Reservoir site in 2004 (ERO 2007a) was Middle Park penstemon. This species is considered vulnerable to secure in Colorado and was found in low to moderate densities in upland native shrubland. The Rockwell Reservoir site would need to be surveyed to determine the presence of Middle Park Penstemon and other CNHP species.

3.10.1.7 Riparian Vegetation

Colorado River and Willow Creek

Riparian vegetation along the Colorado River is influenced by stream morphology, topography, ground water, streamflow, and agricultural irrigation. Topography along the Colorado River includes broad open valleys and narrow canyons. Where the floodplain is wide vegetation communities include stands of narrow-leaved cottonwoods, willows, sedges, and grasses. Irrigated meadows adjacent to portions of the river support meadow foxtail, smooth brome, and Kentucky bluegrass. Irrigation return flow is likely to help support riparian vegetation down gradient of the meadows. Within Byers Canyon and Gore Canyon, riparian vegetation, when present, is often limited to narrow bands adjacent to the channel.

An examination of historical aerial photographs of the Colorado River from the 1970s and 2005 indicate minimal changes in the overall distribution and composition of riparian vegetation (ERO 2007a). Shrub and tree size and density has increased in some locations and decreased in others, but changes appear within the natural variability expected over 30 years.

Riparian habitat along Willow Creek below Willow Creek Reservoir includes narrowleaf cottonwood, willows, and herbaceous vegetation. The upper portions of the area of potential effect include extensive irrigated hay meadows dominated by species such as meadow foxtail, smooth brome, timothy, and redtop. Downstream of irrigated meadows, the channel and riparian vegetation narrows before broadening out again near the confluence with the Colorado River.

East Slope Streams

Riparian habitat along East Slope streams within the area of potential effect is described below.

North St. Vrain and St. Vrain Creeks. North St. Vrain Creek below Ralph Price Reservoir flows through a narrow forested valley dominated by Douglas-fir and ponderosa pine. Riparian vegetation is limited to narrow scattered bands along the incised stream channel. Streambank vegetation includes willows, alder, cottonwood, chokecherry, and shrubby cinquefoil. Where the creek parallels Highway 36, riparian vegetation narrows as the stream is constricted by the road. Cottonwood trees dominate both North St. Vrain Creek and St. Vrain Creek once the streams reach the plains near the town of Lyons.

Big Thompson River. Riparian vegetation along the Big Thompson River below Lake Estes is characterized primarily by a narrow band of streambank vegetation through Big Thompson Canyon. Common species include blue spruce, cottonwood, willow, alder, hawthorn, sedges, and forbs in small wet areas. Cottonwoods become more common as the stream exits the mountains.

Coal Creek and Big Dry Creek. Riparian vegetation along these small perennial streams is dominated by willows, cottonwoods, mixed shrubs, and herbaceous vegetation.

3.10.2 Environmental Effects

3.10.2.1 Issues

Vegetation was identified as a resource of concern because of the potential effect to native vegetation communities or sensitive plant species. Potential effects to riparian vegetation associated with changes in streamflow or reservoir operation were also identified as an issue of concern.

3.10.2.2 Method for Effects Analysis

Direct effects to vegetation resources were assessed quantitatively by overlaying project features for each alternative on vegetation mapping from field surveys or aerial photos. Permanent effects to vegetation resources would occur in areas that would be inundated by a reservoir or located within the footprint of dams, roads, relocated transmission line, or other facilities. Temporary effects would occur in areas that would be revegetated following construction, such as pipeline routes and staging areas. Impacts to wetland vegetation were evaluated separately in Section 3.11.

Potential effects to CNHP-tracked vegetation communities are discussed, although the area of effect was not quantified because these communities are typically interspersed with other plant communities, making them difficult to delineate. Potential effects to CNHP-tracked plant species were evaluated based on the species' present in the area of potential effect.

The assessment of potential indirect effects to riparian vegetation, including wetlands, was based primarily on changing hydrologic conditions associated with each alternative. Key considerations were potential changes in stream morphology, changes in stream stage or reservoir elevation, and changes in ground water elevation. Water resource data discussed in Sections 3.5 to 3.7 and in more detail in the Water Resources Technical Report (ERO and Boyle 2007) provided information on changing hydrologic conditions for the assessment of riparian vegetation effects. Aerial photography also provided information on the distribution and the stability of riparian vegetation over time.

Vegetation effects common to all alternatives are discussed first, followed by direct effects to vegetation types, and CNHP plant communities and species for each alternative. Indirect effects to riparian vegetation from changing hydrologic conditions are discussed in Section 3.10.2.10.

3.10.2.3 Vegetation Effects Common to All Alternatives

Temporary Vegetation Disturbance

All alternatives would result in construction-related disturbances for staging areas, pipelines, and other facilities that would remove existing vegetation and require reclamation and revegetation following construction. As discussed in *Mitigation* (Section 3.10.4), a revegetation plan would be developed for temporarily disturbed areas. Revegetated areas are likely to take several years to recover and species composition may differ from current conditions, particularly where forested or upland shrub vegetation is removed. Temporary effects to vegetation are quantified in the discussion for each alternative.

Noxious Weeds

Construction activities at the reservoir sites would result in disturbed soils that are susceptible to the invasion and spread of noxious weeds. Most of the reservoir sites contain noxious weed populations that are likely to spread to newly disturbed areas and additional weeds could be introduced from construction equipment and other sources. In addition, aquatic and semiaquatic noxious weeds may have an opportunity to establish at new reservoirs. To control the establishment and spread of noxious weeds, a noxious weed control plan would be developed as discussed in *Mitigation* (Section 3.10.4).

3.10.2.4 Alternative 1—Ralph Price Reservoir (No Action)

Enlargement of Ralph Price Reservoir would result in a long-term loss of about 77 acres of vegetation from additional reservoir inundation and dam construction (Table 3-125). The majority of the effect would occur to upland native forests bordering the existing reservoir. Temporary vegetation impacts would depend on the location of staging areas and borrow areas.

Potential habitat for five CNHP plant species— Larimer aletes, rattlesnake fern, broad-leaved twayblade, Rocky Mountain cinquefoil, and prairie violet—would be affected. These species may be adversely affected if present.

Table 3-125. Alternative 1—Direct effects to vegetation cover types at Ralph Price Reservoir.

Vegetation Cover Type	Permanent Effects (acres)
Upland native shrublands	3
Upland native grasslands	1
Upland native forest	73
Total	**77**

3.10.2.5 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

Construction of Chimney Hollow Reservoir and related facilities would permanently affect about 788 acres of vegetation and temporarily disturb about 123 acres of vegetation (Table 3-126). The largest permanent effect would occur to upland native shrubs, mixed grasslands, and upland native forests.

Table 3-126. Alternative 2—Direct effects to vegetation cover types at Chimney Hollow Reservoir.

Vegetation Cover Type	Permanent Effects (acres)	Temporary Effects (acres)
Upland native shrublands	261	21
Upland native grasslands	119	39
Upland native forest	135	4
Upland introduced grasslands	32	10
Mesic mixed grasslands	193	24
Mesic native woodlands	40	6
Mesic native shrublands	8	19
Total	**788**	**123**

Relocation of the existing Western transmission line would result in small additional areas of vegetation loss associated with placement of the tower foundations as well as removal of the existing line. Removal of the existing poles and line would result in temporary vegetation disturbances, many of which would be located within the footprint of the reservoir that would be impacted by material excavation and eventually inundation in the new reservoir. Western would remove trees that could negatively impact the reliable operation of the relocated transmission line (e.g. trees that could grow tall enough to cause arcing between the tree and the conductors or could fall into the conductors or structures). Western would promote the growth of low-growing native plants on the ROW. There would be a long-term change in vegetation cover under the transmission line. Relocation of the transmission line also would result in vegetation disturbance during installation and from access and maintenance roads. The extent of these effects depends on the final transmission line alignment. Additional unquantified effects to vegetation would occur from construction of a parking area, picnic area, marina, and other recreation facilities anticipated on the west side of the reservoir near the dam. Upland native grasslands and native shrublands would be the primary vegetation types affected by these facilities. Trail construction for linkage with Larimer County Open Space on the west side of the reservoir also would result in a loss of vegetation. The specific placement of recreation facilities would not be determined until final design.

Four vulnerable to imperiled plant communities tracked by the CNHP are found in scattered locations and in varying conditions in the area of potential effect. These communities are ponderosa pine/mountain mahogany/big bluestem forest; mountain mahogany/New Mexico needlegrass shrublands; skunkbush riparian; and narrowleaf cottonwood/chokecherry riparian. These communities would be impacted by reservoir construction, but it is difficult to quantify the area of effect because these communities are often found in small pockets, they are mixed with other more dominant species, or they have been degraded by the presence of noxious weeds.

Potential habitat for several CNHP species is present in the area of potential effect, but none were found during field surveys; thus, there would be no effect.

3.10.2.6 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Construction of a 70,000 AF Chimney Hollow Reservoir would result in the permanent loss of about 669 acres of vegetation and a temporary disturbance to about 131 acres of vegetation (Table 3-127). The largest effect would occur to upland native shrubland and mesic mixed grasslands. Permanent impacts to vegetation at the Jasper East Reservoir site would be about 436 acres and temporary effects would be about 114 acres. The mesic mixed grasslands (irrigated meadows) would have the largest area of impact followed by upland native shrubland. The combined total permanent effect to vegetation from construction of both reservoirs would be 1,104 acres. About 245 acres of temporarily disturbed lands would need to be reclaimed following construction of both reservoirs.

Table 3-127. Alternative 3—Direct effects to vegetation cover types at Chimney Hollow Reservoir (70,000 AF) and Jasper East Reservoir.

Vegetation Cover Type	Chimney Hollow		Jasper East		Total	
	Permanent Effects (acres)	Temporary Effects (acres)	Permanent Effects (acres)	Temporary Effects (acres)	Permanent Effects (acres)	Temporary Effects (acres)
Upland native shrublands	204	30	107	58	311	88
Upland native grasslands	100	52	0	0	100	52
Upland native forest	117	12	13	1	130	13
Upland introduced /mixed grasslands	31	11	23	0	54	11
Mesic mixed grasslands	169	20	290	47	458	67
Mesic native shrublands	8	<1	3	8	11	8
Mesic native forest	40	6	0	0	40	6
Total	**669**	**131**	**436**	**114**	**1104**	**245**

The loss of CNHP plant communities at the Chimney Hollow Reservoir site would be similar to that described for Alternative 2. There would be no effect to individual CNHP plant species because none were found in the area of effect.

No CNHP plant communities would be affected at Jasper East Reservoir, but there would be a loss of a population of Middle Park penstemon. This CNHP-tracked species would be adversely affected by the permanent loss of about 107 acres of native shrublands and the temporary disturbance of about 58 acres. Given the abundance of sagebrush habitat and the apparent widespread distribution of Middle Park penstemon, it is unlikely this loss of habitat would affect the long-term viability of this species in the region.

3.10.2.7 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

The effect to vegetation and CNHP plant communities and species at Chimney Hollow Reservoir under Alternative 4 would be the same as described for Alternative 3.

Construction of a 20,000 AF Rockwell Reservoir would permanently affect about 304 acres of vegetation and temporarily disturb about 151 acres of vegetation (Table 3-128). The majority of the impact would occur to upland native shrub habitat. The combined permanent effect to vegetation for Chimney Hollow and Rockwell reservoirs would be about 973 acres. Temporary disturbances that require revegetation would total 281 acres.

Table 3-128. Alternative 4—Direct effects to vegetation cover types at Chimney Hollow Reservoir (70,000 AF) and Rockwell/Mueller Creek Reservoir.

Vegetation Cover Type	Rockwell/Mueller Creek		Total (Including Chimney Hollow)	
	Permanent Effects (acres)	Temporary Effects (acres)	Permanent Effects (acres)	Temporary Effects (acres)
Upland native shrublands	261	103	466	132
Upland native grassland	0	0	100	52
Upland native forest	5	14	122	26
Upland introduced/mixed grasslands	24	14	55	25
Mesic mixed grasslands	<1	15	169	35
Mesic native shrubland	14	5	21	5
Mesic native forest	0	0	40	6
Total	**304**	**151**	**973**	**281**

No field surveys were done at the Rockwell Reservoir site so the presence of CNHP species is not known. The area of potential effect includes about 364 acres of upland native shrubland that would be permanently and temporarily affected. Middle Park penstemon, which was found at the Jasper East Reservoir site, could be present at Rockwell Reservoir.

3.10.2.8 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Construction of Dry Creek Reservoir would permanently disturb about 647 acres of vegetation and temporarily disturb about 149 acres of vegetation (Table 3-129). The largest effect would occur to upland native forest, mesic mixed grassland, and upland native shrubland. The construction of a 30,000 AF Rockwell Reservoir would permanently disturb about 378 acres of vegetation and temporarily disturb 156 acres of vegetation (Table 3-129). Most of the impact would occur to upland native shrubland vegetation. The combined effect to vegetation under Alternative 5 would be a permanent loss of about 1,025 acres and temporary disturbance to 305 acres.

Table 3-129. Alternative 5–Direct effects to vegetation cover types at Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir (30,000 AF).

Vegetation Cover Type	Dry Creek Reservoir		Rockwell/Mueller Creek Reservoir (30,000 AF)		Permanent Effects (acres)	Temporary Effects (acres)
	Permanent Effects (acres)	Temporary Effects (acres)	Permanent Effects (acres)	Temporary Effects (acres)		
Upland native shrublands	149	31	323	108	475	139
Upland native grasslands	90	25	0	0	90	25
Upland native forest	201	36	9	14	209	50
Upland introduced/mixed grasslands	11	5	30	14	40	19
Mesic mixed grasslands	160	42	<1	15	160	57
Mesic native shrublands	12	2	16	5	27	7
Mesic native woodlands	24	8	0	0	24	8
Total	**647**	**149**	**378**	**156**	**1025**	**305**

Two CNHP plant communities would be adversely affected by construction of Dry Creek Reservoir. Ponderosa pine/mountain mahogany/big bluestem forest found in scattered patches on the northwest side of the reservoir would be adversely affected. The skunkbush riparian plant community found in narrow tributaries to Dry Creek also would be adversely affected. There would be no effect to CNHP-tracked plant species at the Dry Creek Reservoir site because none were found during field surveys. The Rockwell Reservoir site would need to be surveyed to determine species of concern.

3.10.2.9 Comparison of Vegetation Effects by Alternative

The estimated permanent and temporary effects to vegetation for each alternative are summarized in Table 3-130. The No Action Alternative would have the least effect on vegetation resource because it only includes enlarging Ralph Price Reservoir. The Proposed Action would have the least effect to vegetation of the action alternatives because only one reservoir would be constructed.

Table 3-130. Summary of direct effects to vegetation by alternative.

Alternative	Permanent Effects (acres)	Temporary Effects (acres)	Total (acres)
Alt 1 – No Action	77	NA	77
Alt 2 – Proposed Action	788	123	911
Alt 3	1,104	245	1,349
Alt 4	973	281	1,254
Alt 5	1,025	305	1,330

3.10.2.10 Effects to Riparian Vegetation

Existing Reservoirs

Each alternative would result in changes in reservoir storage at several existing C-BT reservoirs—Granby Reservoir, Carter Lake, and Horsetooth Reservoir. In general, all alternatives, including No Action, would result in lower water surface levels in Granby Reservoir throughout the year and during the growing season. On average, Granby Reservoir would be about 2.1 feet lower than existing conditions from May to September under the No Action Alternative, and about 5.4 feet lower under the Proposed Action (Section 3.5.2). For the other alternatives, the change in water levels would fall in between these values.

Horsetooth Reservoir water levels would be up to 6 feet lower on average in the summer under the Proposed Action and 1 to 2 feet lower under other alternatives. Changes in reservoir level in Carter Lake would be less than 2 feet for all alternatives under wet, dry, and average conditions. Decreases in water levels in all three reservoirs would be slightly more in dry years and less in wet years for all alternatives and would fluctuate within the levels maintained as part of existing reservoir operations.

Historically, Horsetooth Reservoir has fluctuated up to 45 feet and Granby Reservoir water levels have fluctuated by nearly 90 feet. The vegetation types bordering Granby Reservoir, Carter Lake, and Horsetooth Reservoir primarily include upland species not dependent on lake levels, with limited riparian shoreline development. Lower water levels in Granby Reservoir, Carter Lake, and Horsetooth Reservoir are unlikely to substantially affect existing vegetation communities for any alternative because reservoir fluctuations would fall within the historical operations of the reservoir.

None of the alternatives would affect reservoir water levels in Shadow Mountain Reservoir, Grand Lake, Willow Creek Reservoir, or other smaller C-BT reservoirs. Thus, there would be no effect on riparian vegetation at these reservoirs.

New Reservoirs

Development of riparian vegetation bordering any of the potential new reservoirs is possible. The steep topography bordering Ralph Price Reservoir is unlikely to result in substantial riparian development except perhaps at tributary inlets. Chimney Hollow Reservoir and Dry Creek Reservoir would be maintained near full most of the time; therefore, riparian development is possible in flat shoreline areas and tributary inlets. The projected wide range in reservoir elevations at Jasper East and Rockwell is unlikely to provide conditions suitable for substantial riparian development.

Streams

Potential effects to streamside riparian vegetation were assessed based on an analysis of predicted changes in stream morphology, ground water, and stream stage. All alternatives would have somewhat similar effects because each alternative would increase diversions from the Colorado River.

Channel maintenance flows are composed of a range of flows that maintain the physical characteristics of the stream channel. Potential changes in channel maintenance flows and the affect on riparian vegetation were evaluated. The magnitude, duration, timing, and frequency of streamflow can affect riparian vegetation and channel conditions (Schmidt and Potyondy 2004). A reduction in channel maintenance flows can allow riparian vegetation to encroach into the channel. An increase in flows can increase streambank erosion and reduce riparian vegetation in areas where streamflow velocities are high.

Colorado River. Potential effects to riparian vegetation along the Colorado River below Granby Reservoir from changes in streamflow were examined. At the Hot Sulphur Springs gage on the Colorado below the Windy Gap diversion, there would be a 2- to 4-day reduction in the average number of days per year that streamflow equals or exceeds the low range of channel maintenance flows (80 percent of 1.5-year peak flow to the 2-year peak flow) for all alternatives. The potential for reaching this flow range in a given year would decrease by 9 to 11 percent and for reaching the upper range of channel maintenance flows (25-year peak flow) in a given year would be reduced by less than 10 percent under all alternatives. The effect to channel maintenance flows would diminish downstream with tributary inflows.

The changes in Colorado River streamflow under the Proposed Action are not expected to alter channel morphology and the conditions for maintenance of existing riparian vegetation. Stream stage would decrease from WGFP diversions, but the duration and amount of flow reductions are not anticipated to measurably impact riparian vegetation.

Projected changes in bankfull discharge streamflow volumes also were reviewed to evaluate potential changes in channel morphology that may affect riparian vegetation. Many of the morphologic characteristics of a stream are formed when a stream flows at its bankfull discharge (1.5- to 2-year peak flow) (Rosgen 1996). Under existing conditions, bankfull discharge at Hot Sulphur Springs would be exceeded between about 4 to 7 percent of the time. Under all alternatives, the frequency of bankfull discharge at Hot Sulphur Springs would decrease to about 3 to 5 percent of the time. At the Kremmling gage on the Colorado River, the existing bankfull discharge frequency of 3 percent would decrease only slightly (1 percent or less) under all of the alternatives.

The magnitude, timing and frequency of channel maintenance flows in the Colorado River below Granby Reservoir also would change as a result of changes in spills. When spills are not occurring, the flow of the river below Granby Reservoir is controlled by instream flows. Changes in the magnitude, frequency, timing and duration of spills under the alternatives would be minor and are not expected to alter channel morphology.

The projected changes in channel maintenance flows and the slight reduction in the percentage of time that flows exceed bankfull discharge for all alternatives compared to existing conditions are not expected to alter channel morphology or sediment movement on the Colorado River. No aggradation or degradation of the stream channel is predicted. As a result, the conditions for growth, establishment, maintenance, and periodic scouring of riparian vegetation below Granby Reservoir or the Windy Gap diversion are not expected to change substantially as a result of the No Action Alternative or any of the WGFP action alternatives. Additional discussion on impacts to stream morphology is found in Section 3.7.2.

Stream stage changes and potential effects on alluvial ground water for the Colorado River were examined to determine if the timing and amount of change in the surface elevation of the river might affect hydrologic conditions for riparian vegetation. Monthly stream stage under existing conditions was compared to each alternative at the Hot Sulphur Springs (Figure 3-108) and near Kremmling gages (Figure 3-109) on the Colorado River. At the Hot Sulphur Springs gage, average monthly stream stage under the No Action Alternative would range from 0.03 feet to 0.16 feet lower than existing conditions from May to August. Alternatives 2 to 5 would range from 0.06 to 0.23 feet lower than existing conditions. Under all alternatives, the greatest percent change in stream stage would occur in July. The No Action Alternative would reduce average stream stage in July by about 12 percent compared to 14 percent by the Proposed Action and about 17 percent for the other alternatives. In wet years, stream stage under No Action would range from 0.02 feet to 0.35 lower than existing conditions. Under Alternatives 2 to 5, wet year average monthly stream stage would be about 0.01 feet to 0.41 feet lower than existing conditions. There would be no change from existing conditions in dry years for any alternative.

Figure 3-108. Colorado River stream stage at Hot Sulphur Springs.

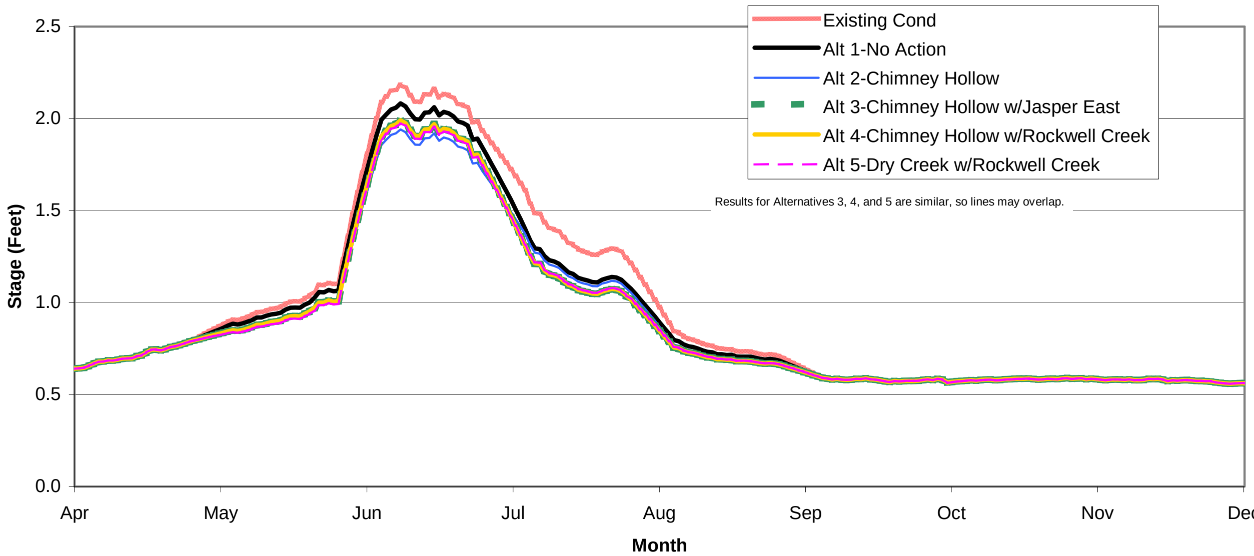
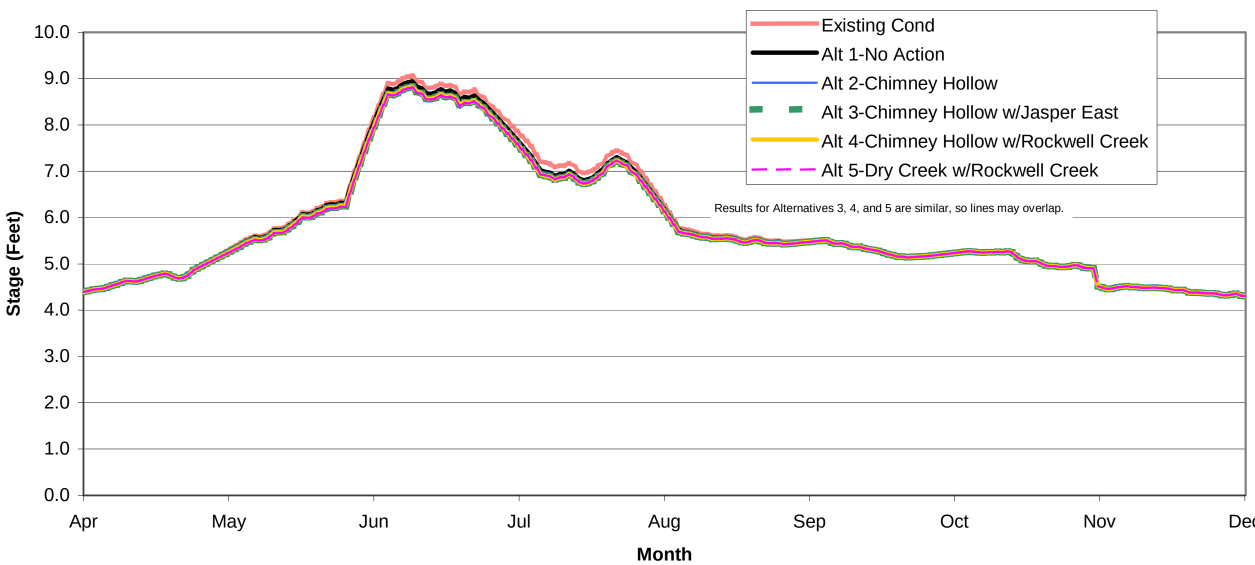


Figure 3-109. Colorado River stream stage near Kremmling.



Average monthly stream stage on the Colorado River near Kremmling under the No Action Alternative would range from 0.02 feet to 0.17 feet lower than existing conditions from May to August. Alternatives 2 to 5 would range from 0.02 to 0.28 feet lower than existing conditions. The No Action Alternative would reduce average stream stage in July by about 2 percent compared to about 3 percent by the Proposed Action and other alternatives. In wet years, stream stage under No Action would range from 0.03 feet to 0.39 lower than existing conditions. Under Alternatives 2 through 5, wet year average monthly stream stage would be about 0.11 feet to 0.45 feet lower than existing conditions.

The projected changes in stream stage would be minor with respect to potential effects to adjacent alluvial ground water levels. There would be no change in average monthly stream stage for any alternative during dry years when riparian and wetland vegetation is more susceptible to drought. In wet years, the stage of the Colorado River would be nearly twice as high as average years for all alternatives during the growing season. Thus, supporting hydrology for riparian wetland vegetation would not be a limiting factor in wet years.

The projected magnitude of changes in stream stage is unlikely to adversely affect riparian and wetland vegetation along the Colorado River for any alternative. In the study area, most of the Colorado River is a gaining stream; thus, contributions from adjacent lands likely play an important role in supporting riparian vegetation. Riparian vegetation adjacent to the river would continue to be supported by streamflow, ground water discharge, and irrigation return flows under each alternative. Existing instream flow requirements below Granby Reservoir and below the Windy Gap diversion that contribute to supporting riparian vegetation would not change under any alternative.

Willow Creek. Examination of bankfull discharge indicates that the 2-year peak discharge would decrease by less than 1 percent between existing conditions and all alternatives. It is unlikely that there would be a significant effect to stream morphology or change in sediment transport or deposition for any alternative that would affect maintenance of riparian vegetation. Stream stage data are not available for Willow Creek, but average monthly streamflow during the growing season would decrease from 0 to 19 percent under No Action compared to existing conditions and from about 0 to 36 percent for the Proposed Action and other alternatives. These changes are not expected to substantially affect alluvial ground water levels for any alternative. It is unlikely that riparian vegetation along Willow Creek would be adversely affected by the projected changes in streamflow given the natural contribution from ground water discharge, irrigation return flows, and continued Willow Creek Reservoir minimum releases of at least 7 cfs.

North St. Vrain and St. Vrain Creeks. Under the No Action Alternative, there would be a change in streamflow on North St. Vrain Creek below Ralph Price Reservoir and on St. Vrain Creek to the St. Vrain Supply Canal near Lyons. The greatest decrease in flow in North St. Vrain Creek would be a 25 percent decrease in average July flows below Longmont Reservoir and a 13 percent decrease in St. Vrain Creek at Lyons (Table 3-15). Other months would have smaller decreases or increases in flow. The projected magnitude of the changes in streamflow is unlikely to adversely affect the shrub and tree riparian vegetation along these creeks, which would continue to be supported by ground water discharge and streamflow, including existing bypass flows on North St. Vrain Creek below Ralph Price Reservoir.

Big Thompson River. Stream stage on the Big Thompson River below Lake Estes would increase less than 0.04 feet under No Action compared to existing conditions. Under the Proposed Action and other alternatives, stream stage would increase less than 0.02 feet compared to existing conditions. These projected minor increases in streamflow are unlikely to adversely affect channel morphology or hydrologic conditions supporting riparian vegetation.

Big Dry Creek and Coal Creek. Projected increases in streamflow in these drainages from additional Windy Gap return flows under all alternatives are unlikely to substantially alter channel morphology or hydrologic conditions for riparian vegetation. The increases in flows as discussed in Section 3.5.2 would be a small additional increment to the range of flows currently occurring in these drainages.

3.10.3 Cumulative Effects

Land-based reasonably foreseeable actions potentially occurring in the basins where alternative reservoir facilities would be located were used to estimate cumulative direct effects to vegetation. The development of Larimer County Open Space adjacent to the Chimney Hollow Reservoir site and a residential development near Jasper East were the only reasonably foreseeable land-based actions identified with potential cumulative effects. Reasonably foreseeable water-based actions that may affect hydrologic resources were evaluated for potential indirect cumulative effects to riparian and wetland vegetation as per the methods discussed in Section 3.10.2.2.

3.10.3.1 Alternative 1—Ralph Price Reservoir (No Action)

Ponderosa pine, Douglas-fir forests, and riparian areas along North St. Vrain Creek have been affected by the original construction of Ralph Price Reservoir. Reservoir operations and recreation activities have had a limited effect on existing vegetation resources. No reasonably foreseeable land development activities near the reservoir have been identified; thus, there would be no cumulative effects to vegetation from enlarging Ralph Price Reservoir.

3.10.3.2 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

Vegetation resources at the Chimney Hollow Reservoir site and surrounding lands have been influenced by historical livestock operations. The future planned management of the Chimney Hollow Reservoir site as part of Larimer County's adjacent Chimney Hollow Open Space includes trail development and public access. There would be a cumulative loss of vegetation from construction of about 10 miles of trail in addition to the vegetation disturbance and loss from construction of Chimney Hollow Reservoir and related facilities. Potential cumulative impact to CNHP-tracked plant communities or species from trail construction is possible; however, trails can typically be located to avoid sensitive areas. Open space designation and management by Larimer County would protect the area from future development, which would be beneficial to vegetation communities.

3.10.3.3 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Chimney Hollow

Cumulative effects to vegetation for a 70,000 AF Chimney Hollow Reservoir would be similar to Alternative 2.

Jasper East

Existing vegetation at the Jasper East Reservoir site has been influenced by irrigation, hay production, grazing, and construction of the Willow Creek Canal, pump station, forebay, and roads. Reasonably foreseeable future development in the Jasper East basin includes about 980 acres of planned residential development at the C-Lazy-U Preserve located north of the reservoir site. A total cumulative effect to vegetation of up to 1,465 acres from the 485-acre Jasper East Reservoir and the C-Lazy-U development is possible. However, future land developments at C-Lazy-U would impact a relatively small portion of the site based on planned low-density housing and designation of common open space. Much of C-Lazy-U land is currently used for hay production and pasture. The loss of sagebrush habitat at C-Lazy-U could result in a cumulative impact to habitat for Middle Park penstemon, a CNHP species considered vulnerable.

3.10.3.4 Alternative 4—Chimney Hollow Reservoir and Rockwell Reservoir

Chimney Hollow

The cumulative effect to vegetation and plant species of concern at Chimney Hollow Reservoir under this alternative would be the same as Alternative 3.

Rockwell/Mueller Creek

Vegetation at the Rockwell Reservoir site has been affected by low density residential housing roads, and livestock grazing. No reasonably foreseeable land development activities in the reservoir basin have been identified; thus, there would be no incremental cumulative effects to vegetation.

3.10.3.5 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Dry Creek

The Dry Creek Reservoir site is mostly undeveloped land with a few scattered homes. Planned trail construction on adjacent Larimer County Open Space could result in a minor incremental cumulative effect to vegetation resources.

Rockwell/Mueller Creek

No cumulative effects to vegetation from construction of a 30,000 AF Rockwell Reservoir were identified.

3.10.3.6 Riparian Areas

Hydrology model output, which included reasonably foreseeable water-based actions, was used to evaluate potential indirect cumulative effects to riparian and wetland areas along streams and bordering reservoirs. Hydrologic output for Alternative 5 was used in the cumulative effects assessment as representative of Alternative 3, 4, and 5 because of the similarity in the effects of these alternatives.

Granby Reservoir, Carter Lake, and Horsetooth Reservoir

Projected changes in water levels at these reservoirs, as discussed in Section 3.5, would result in lower average water levels during the growing season for all alternatives. No measurable effect to riparian vegetation is expected for any alternative because reservoir fluctuations would fall within the historical operations of the reservoir and the vegetation bordering the reservoirs is not dependent on lake levels.

Colorado River

Projected future actions along with WGFP diversions would change the timing and amount of flow in the Colorado River. For all alternatives, the frequency of flows exceeding the 2-year peak discharge would decrease from about 4 percent to 3 percent at Hot Sulphur Springs with a smaller change at Kremmling bankfull discharges in a given year would decrease by about 15 percent at Hot Sulphur Springs and about 17 percent near Kremmling. In a given year 10- to 25-year flows would decrease by about 9 percent at Hot Sulphur Springs and 3 percent near Kremmling. The duration of bankfull discharges would decrease by 2 to 5 days at Hot Sulphur Springs, but the duration of 10- to 25-year flows would double to about 8 days. Near Kremmling, the duration of bankfull discharges would decrease by 4 to 5 days, but would remain the same or increase for 10- to 25-year flows. Table 3-35 and Table 3-36 from the *Stream Morphology and Floodplain* section show that peak flows ranging from bankfull flows to 25-year flows would continue to occur under the alternatives. Modeled Colorado River flows below Granby Reservoir and at Hot Sulphur Springs for all alternatives indicate changes in the magnitude, timing, and frequency of channel maintenance flows from existing conditions (ERO and Boyle 2007), but none of the changes are of a magnitude sufficient to measurably alter channel morphology or sediment movement. Therefore, riparian and wetland resources are unlikely to be adversely affected because there would be no substantial change in channel capacity, scouring flows, and other channel-forming processes that maintain a suitable substrate for vegetation.

Changes in stream stage and alluvial ground water levels also were examined along the Colorado River. Reductions in peak flows below the Windy Gap diversion would result in short periods (up to 30 days, but typically less than 2 weeks) when stage reductions averaging 4 inches (and as much as 2.2 feet for a few days in 2 percent of all years) could occur in the alluvium within a few feet of the river. At Hot Sulphur Springs below the Windy Gap diversion, the average monthly stream stage would decrease by less than 0.35 feet for all alternatives. There would be negligible changes in dry years and up to a 0.5-foot decrease in stage during wet years. The average monthly stream stage on the Colorado River below the Blue River confluence would decrease up to about 1 foot for the Proposed Action and Alternative 5 and about 0.85 foot under No Action. The larger changes in stream stage (a decrease of up to 1 foot in average years in June and July) near the top of Gore Canyon would occur where the channel deepens and riparian vegetation begins to narrow; thus, potential effects to riparian and wetland vegetation are unlikely. Floodplain areas also are recharged by the water movement, both on the surface and as ground water, from higher areas to the river. Given the predicted stage reductions and the short periods of time when they would occur, it is unlikely there would be significant effects to riparian communities. These communities already experience similar changes in surface flows and ground water levels as a result of natural climatic variability, as well as surface water use and shallow alluvial ground water pumping. Projected changes in stream stage would not substantially alter alluvial ground water levels (ERO and Boyle 2007) and are unlikely to measurably affect the distribution and composition of riparian and wetland vegetation along the Colorado

River. Riparian vegetation would continue to be supported by various hydrologic sources, including streamflow, ground water, and irrigation return flows.

The habitat project described as part of the FWEPs developed by the Subdistrict (2011a) and Denver Water (2011a) includes measures for restoration of aquatic habitat from Windy Gap Reservoir downstream to about 2 miles below the confluence with the Williams Fork. While details of habitat restoration have not been developed, actions may narrow the stream channel, which could increase or modify the adjacent riparian habitat.

Willow Creek

Projected changes in Willow Creek streamflow indicate a slight decrease in the frequency of 2-year peak discharges for all alternatives, which currently occur about 5 percent of the time (ERO and Boyle 2007). This small change in peak discharge is unlikely to affect stream morphology and conditions for riparian and wetland growth and establishment. Stream stage for Willow Creek is not available, but projected changes in streamflow would not measurably affect ground water levels adjacent to the creek. Therefore, it is unlikely that riparian and wetland vegetation on Willow Creek, which is supported by irrigation return flows, ground water, and streamflow, would be affected by changes in flow.

East Slope Streams

The change in East Slope streamflow, including increased flows in the Big Thompson River between Lake Estes and the Charles Hansen Feeder Canal, and below WWTP discharge points for WGFP Participants on the Big Thompson River, St. Vrain Creek, Coal Creek, and Big Dry Creek, would be less than or equal to the amounts discussed for direct effects for all alternatives. With reasonably foreseeable actions in place, Windy Gap deliveries to the East Slope would be less than under direct effects. The same is true for the No Action Alternative, which would result in less water exchanged to Ralph Price Reservoir and less or equal changes in North St. Vrain Creek and St. Vrain Creek streamflow than the direct effects assessment. As discussed in Section 3.7, these changes in streamflow are unlikely to measurably affect stream morphology, ground water levels adjacent to streams, or hydrologic support for riparian and wetland vegetation.

3.10.4 Vegetation Mitigation

Mitigation measures and BMPs would be used to minimize impacts to vegetation, control noxious weeds, and reduce erosion during reservoir and facility construction for all alternatives. As noted in the FWMP (Appendix E), this includes revegetation and weed control on all disturbed areas in accordance with the Stormwater Management Plan required for erosion prevention and control under Colorado NPDES permitting requirements for construction sites. Key components of the revegetation plan would include:

- Establishing well-defined construction limits to minimize vegetation disturbance.
- Minimizing the length of time that soils are exposed.
- Salvaging topsoil from weed free disturbed areas to aid in revegetation.
- Applying soil amendments, mulches, organic matter, and other measures as needed to facilitate revegetation.
- Using native seed and planting shrubs and trees according to site-specific conditions and vegetation communities. Species selection would be coordinated with local agencies such as Larimer County Open Space and the CDPW.
- Monitoring revegetation until native vegetation cover is at least 70 percent of the original vegetation cover in accordance with Colorado NPDES stormwater permitting requirements. Corrective actions would be implemented as needed to ensure that adequate vegetation cover of native species is established.

A weed management plan would be prepared in accordance with the Colorado Noxious Weed Control Act and in cooperation with Larimer, Boulder, and Grand County weed programs. Key components of the plan would include:

- Requiring that equipment be washed and inspected prior to entering the project area to prevent importing weeds on vehicle tires and mud.
- Limiting the use of fertilizers that may favor weeds over native species.
- Using periodic inspections and spot controls to prevent weed establishment. If terrestrial, semiaquatic, or aquatic weeds invade an area, an integrated weed management process to selectively combine management techniques (biological, chemical, mechanical, and cultural) to control the particular weed species would be used.

Habitat mitigation for wildlife at Chimney Hollow Reservoir is described in *Wildlife Mitigation* (Section 3.12.4) and the FWMP (Appendix E).

3.10.5 Unavoidable Adverse Effects

There would be an unavoidable permanent loss of existing vegetation resources associated with construction of any of the alternative reservoirs under the action alternatives and enlargement of Ralph Price Reservoir under the No Action Alternative. CNHP plant communities at the Chimney Hollow Reservoir site would be adversely affected under the Proposed Action and Alternatives 3 and 4. CNHP plant communities at the Dry Creek Reservoir site would be adversely affected under Alternative 5. There would be an adverse effect to existing populations of Middle Park penstemon, a CNHP-tracked plant species at Jasper East under Alternative 3, and possibly Alternative 5. Temporary disturbances to vegetation communities during construction would be unavoidable. Although reclamation of these areas would restore native vegetation, there would be long-term changes in the composition of shrub or forested vegetation communities. Exposure of soil during construction would increase the potential for noxious weed establishment; however, mitigation measures would prevent long-term establishment and spread.

3.11 Wetlands and Other Waters

3.11.1 Affected Environment

3.11.1.1 Regulatory Framework

The Corps regulates the placement of dredged or fill material into waters of the U.S. under Section 404 of the Clean Water Act. Federal agencies also have responsibilities to avoid, minimize, and mitigate unavoidable impacts on wetlands under EO 11990. The Corps defines wetlands (33 CFR 323.2[c]) as:

> "…those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."

Other waters of the U.S. include streams (perennial, intermittent, and ephemeral), ponds, and lakes (33 CFR 328.3[a]). Waters tributary to navigable and interstate waters are considered waters of the U.S. and are subject to the Corps' jurisdiction. Wetlands subject to the Corps' jurisdiction (jurisdictional wetlands) meet the Corps' definition of wetlands and are adjacent, neighboring, or have a surface tributary connection to interstate or navigable waters of the U.S. For purposes of this EIS, all wetlands found in the study area are included; although the determination of the jurisdictional status of these wetlands has not been made by the Corps. Effects to jurisdictional wetlands and waters will be determined as part of the Section 404 permit application process.

As described in the Alternative Selection Process in Section 2.1, Section 404(b)(1) Guidelines (40 CFR, Part 230), were used in the screening of alternatives to identify the least damaging practicable alternatives to the aquatic environment. The 404(b)(1) Analysis is found in Appendix C. The discussion in the EIS includes a comparison of the potential effect to wetlands and waters for each alternative.

3.11.1.2 Area of Potential Effect

The area of potential effect for wetland resources and other waters includes the reservoir sites and related pipelines, roads, and infrastructure that would result in the placement of dredge or fill material into waters of the U.S. Wetlands and waters that would be affected by inundation from construction or enlargement of a reservoir are included in the area of potential effect. Wetlands that could be indirectly affected by changing hydrologic conditions along streams and surrounding reservoirs are discussed in *Effects to Riparian Vegetation* (Section 3.10.2.10).

3.11.1.3 Data Sources

Wetlands at the Chimney Hollow, Dry Creek, and Jasper East Reservoir sites were identified and mapped in the field using methods outlined in the 1987 Corps of Engineers Wetland Delineation Manual (Corps 1987). Wetlands were determined based on the presence of three wetland indicators: hydrophytic vegetation, hydric soils, and wetland hydrology. Results of the wetland delineation were documented in wetland delineation reports for each of these three study areas (ERO 2003b, 2004a, 2004b). Small portions of the Dry Creek Reservoir study area were not delineated because landowner access was not secured. In this portion of Dry Creek Reservoir, wetlands were mapped using aerial photographs.

Wetlands were not delineated at the Rockwell Reservoir study area because access was denied. Wetlands at this site were mapped using aerial photographs, National Wetland Inventory (NWI) maps from the FWS, and a review of the site conducted from nearby public roads.

Wetlands at Ralph Price Reservoir were mapped using aerial photography, NWI maps, and field observations of wetlands around the existing reservoir shoreline and below the dam.

Wetlands at Chimney Hollow, Dry Creek, and Jasper East were rated for functions and values using a modified Montana Method (Burgland 1999). This method provides a rating of low, moderate, high, or not applicable based on observations of wetland characteristics for representative wetland types. Other waters were identified by field observations, USGS quadrangle maps, and aerial photography.

3.11.1.4 Ralph Price Reservoir

Wetlands

No wetlands in the area of potential reservoir enlargement or the potential borrow areas are indicated on NWI maps; however, field observations indicate small areas of shoreline wetlands and wetland vegetation bordering the North St. Vrain Creek inlet. Dominant species in the wetland areas include Nebraska sedge, Baltic rush, soft-stem bulrush, and redtop.

Other Waters

Ralph Price Reservoir is an existing water body with a surface area of about 227 acres when full. Other waters potentially affected by enlargement of Ralph Price Reservoir are upstream and downstream portions of North St. Vrain Creek and possibly ephemeral tributaries to the reservoir including Rattlesnake Gulch, Long Gulch, and other unnamed drainages.

3.11.1.5 Chimney Hollow Reservoir

Wetlands

Wetlands are present primarily in narrow bands along the Chimney Hollow drainages. Vegetation along Chimney Hollow includes plains cottonwood, crack willow, wild plum, sandbar willow, redtop, and sedges. Small ephemeral tributary drainages to Chimney Hollow support wetlands in scattered isolated pockets. These wetlands include sandbar willow-dominated patches with occasional narrowleaf cottonwoods, and herbaceous wetlands dominated by redtop, Nebraska sedge, or cattails.


Wetlands along Chimney Hollow

Wetland functions for the Chimney Hollow drainage were rated high for:

- Habitat for rare or imperiled CNHP tracked wildlife species
- Ground water discharge/recharge

Wetlands functions were rated as moderate for general wildlife habitat, and low to moderate for sediment/shoreline stabilization, and production export/food chain support. Wetlands functions and values were rated low for fish and aquatic habitat, flood attenuation and storage, sediment/nutrient/ toxicant retention and removal, uniqueness, and recreation/education potential.

Other Waters

Generally, other waters are defined as those drainages characterized by either flowing water or unvegetated drainages with evidence of flowing water. These waters include reaches of the Chimney Hollow drainage, which flow into Flatiron Reservoir. Below Flatiron Reservoir the drainage becomes Dry Creek, a tributary to the Big Thompson River. Several small unnamed ephemeral drainages are found on the west side of the Chimney Hollow valley.

3.11.1.6 Dry Creek Reservoir

Wetlands

Wetlands are primarily found in 1- to 20-foot-wide bands bordering Dry Creek and small ponds in the channel. The wetlands along Dry Creek support cottonwoods, especially around the ponds. Patches of sandbar willow wetlands are interspersed with herbaceous wetlands dominated by redtop, cattails, mixed grasses and sedges. Wetlands are also found on ephemeral tributary drainages and seeps particularly near rock outcrops. Along the tributaries, wetlands generally consist of patches of herbaceous species interspersed with sandbar willow. The small seeps on the western hillsides tend to be dominated by herbaceous species such as Nebraska sedge and cattails.


Wetlands at Dry Creek

Wetland functions for Dry Creek were rated high for:

- Habitat for rare or imperiled CNHP-tracked wildlife species
- General wildlife habitat (moderate to high)

- Ground water discharge/recharge
- Sediment/shoreline stabilization
- Production export/food chain support (low to high)

Wetlands functions were rated as moderate for flood attenuation and storage, and sediment/nutrient/ toxicant retention/removal. Wetlands were rated low for recreation/education potential, fish and aquatic habitat, and uniqueness.

Other Waters

Waters include reaches of Dry Creek and its ephemeral tributaries. Dry Creek is a tributary to the Little Thompson River. Waters of the U.S. in the study area are characterized by either flowing water or unvegetated areas with evidence of flowing water. Several small ponds also are present along Dry Creek.

3.11.1.7 Jasper East Reservoir

Wetlands

Wetlands occur along several ephemeral drainages and within irrigated meadows. Most of the wetland areas support herbaceous plant species dominated by beaked sedge, small-winged sedge, water sedge, short-beaked sedge, and tufted hairgrass. Other common species include Baltic rush and Jacob's ladder. Planeleaf willow and Geyer's willow occur in some wetlands.

Wetlands found in irrigated meadows contain meadow foxtail, Kentucky bluegrass, smooth brome, timothy, and clover. It is likely that many of the wetlands found within irrigated meadows are supported entirely by irrigation waters and are not naturally occurring. Additional studies would be necessary to determine the extent of wetlands supported by irrigation.

For two representative wetlands, wetland functions were rated high for:

- Ground water discharge/recharge
- Sediment/shoreline stabilization

Wetlands functions were rated moderate to high for production export/food chain support and dynamic surface water storage. General wildlife habitat and uniqueness were rated as moderate. Other wetland functions including flood attenuation and storage, sediment/nutrient/toxicant retention and removal, uniqueness, and recreation/education potential were rated low to moderate.

Other Waters

Waters at Jasper East include an unnamed tributary to Church Creek, which is tributary to Willow Creek. The Willow Creek Canal and pump station forebay are located in the area of potential effect. Irrigation ditches that distribute water to the irrigated hay meadows also are present.

3.11.1.8 Rockwell/Mueller Creek Reservoir

Wetlands

Wetlands at Rockwell Reservoir based on secondary sources and reconnaissance observations from public roads are expected to occur within the mesic native shrubland vegetation type present along Rockwell and Mueller creeks. The species composition is likely to include planeleaf, strapleaf, and Geyer's willow, with understory species of shrubby cinquefoil, bluejoint reedgrass, bluebells, and Baltic rush. Additional wetlands are found along the pipeline route to Windy Gap Reservoir including those along the Colorado River.

Other Waters

Waters on the reservoir site include Rockwell and Mueller Creek, which are tributary to the Fraser River. A small stock pond also is within the reservoir area. In addition, the pipeline to Windy Gap Reservoir would cross the Colorado River.

3.11.2 Environmental Effects

3.11.2.1 Issues

Wetlands were identified as a resource of concern because of the potential loss or impact to wetland communities and the associated functions and values. Effects to waters also were of concern because of the value associated with streams, ponds, and other open water. As discussed previously in the *Regulatory Framework* section, effects to wetlands are of concern because of the requirements under the Clean Water Act and EO 11990 to avoid and minimize wetland impacts.

3.11.2.2 Method for Effects Analysis

Direct effects to wetlands were evaluated by overlaying maps of project facilities with wetland mapping from field delineations or other data sources. Potential effects were quantified as either a permanent effect from inundation, dam construction, and other infrastructure, or a temporary effect associated with a pipeline crossing and other short-term disturbances. Due to lack of access at the Rockwell Reservoir study area, effects to wetlands were based on secondary data sources. Estimates of wetland effects at Ralph Price Reservoir were based on field observations. Indirect effects to riparian from hydrologic changes were evaluated in *Effects to Riparian Vegetation* (Section 3.10.3.6).

Potential effects to waters of the U.S. were determined from field investigations of waters and the expected loss or disturbance from reservoir and facility construction. The potential area of effect was calculated from GIS mapping of the drainage and estimates of average widths of the drainages at Chimney Hollow, Jasper East, and Dry Creek. For the Rockwell Reservoir site and Ralph Price Reservoir, waters of the U.S. were estimated from USGS 1:24,000 topographic quadrangles and aerial photographs.

3.11.2.3 Alternative 1—Ralph Price Reservoir (No Action)

The enlargement of Ralph Price Reservoir is estimated to inundate about 0.3 acre of wetlands around the existing shoreline and at stream inlets (Table 3-131). New shoreline wetlands would likely develop along stream inlets and shoreline areas of the expanded reservoir, similar to those currently present depending on the topography. Likewise, lost wetland functions would likely be replaced with redevelopment of similar communities around the expanded reservoir. No temporary effects to wetlands have been identified, but disturbances are possible depending on project disturbance limits.

Additional permanent or temporary wetland effects are possible in borrow areas once the specific location is known; however, any wetlands present could probably be avoided.

Enlargement of the reservoir would inundate about 500 feet, or 0.1 acre, of the North St. Vrain Creek at the upstream end of the reservoir (Table 3-132). It is uncertain if raising the existing dam by 50 feet would require additional fill in North St. Vrain below the dam. Small tributaries to Ralph Price Reservoir, such as Rattlesnake Gulch, Long Gulch, and other unnamed drainages, also may have waters that would be inundated. The enlarged reservoir would create about 77 acres of additional open water.

Table 3-131. Summary of wetland effects by alternative.

Alternative	Permanent Effects	Temporary Effects	Total
	acres		
Alternative 1 No Action[1]	0.3	–	0.3
Alternative 2 Proposed Action	1.6	0.1	1.7
Alternative 3 Chimney Hollow Jasper East **TOTAL**	1.5 21.2 **22.7**	0.1 4.8 **4.9**	1.6 26.0 **27.6**
Alternative 4 Chimney Hollow Rockwell **TOTAL**	1.5 3.0-13.6 **4.5- 15.1**	0.1 2.0-5.0 **2.1-5.1**	1.6 5.0-18.6 **6.6-20.2**
Alternative 5 Dry Creek Rockwell **TOTAL**	6.2 3.0-15.6 **9.2-21.8**	0.3 2.0-5.0 **2.3-5.3**	6.5 5.0-20.6 **11.5-27.1**

[1] Additional permanent or temporary wetland effects are possible below the dam or in borrow areas.

Table 3-132. Summary of effects to other waters by alternative.

Alternative	Permanent Effects	Temporary Effects	Total
	acres		
Alternative 1 No Action[1]	0.1	–	0.1
Alternative 2 Proposed Action	1.3	0.1	1.4
Alternative 3 Chimney Hollow Jasper East[2] **TOTAL**	1.3 6.3 **7.6**	0.1 0.2 **0.3**	1.4 6.5 **7.9**
Alternative 4 Chimney Hollow Rockwell **TOTAL**	1.3 3.6 **4.9**	0.1 1.7 **1.8**	1.4 5.3 **6.7**
Alternative 5 Dry Creek Rockwell **TOTAL**	2.8 3.7 **6.5**	0.3 1.7 **2.0**	3.1 5.4 **8.5**

[1] Additional temporary effects to waters below the dam are possible and at borrow areas.
[2] In addition, the existing 6-acre Willow Creek Pump Canal forebay would be relocated.

3.11.2.4 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

The Proposed Action would result in a permanent impact to 1.6 acres of wetlands from construction of Chimney Hollow Reservoir. Purchase of wetland credits in a wetland bank, as preferred by the Corps, would mitigate impacts.

About 1.6 acres of wetlands would be permanently impacted and about 0.1 acre of wetlands would be temporarily disturbed from construction of a 90,000 AF Chimney Hollow Reservoir and facilities (Table 3-131). Wetlands along Chimney Hollow have been disturbed somewhat by grazing, although the wetlands in the tributaries are relatively undisturbed. Impacted wetlands are rated with a high function for rare or imperiled CNHP-tracked wildlife species habitat and ground water discharge. Wetland and riparian vegetation communities could develop around portions of the lake margin because the reservoir would remain near capacity throughout the growing season and the rest of year. Stable water levels would help support shoreline wetlands and riparian species, although steep banks would prevent substantial riparian development around much of the reservoir. Seepage below the dam also could increase the potential for wetland or riparian vegetation establishment.

Construction of Chimney Hollow Reservoir would permanently affect 1.3 acres of waters along Chimney Hollow and several small ephemeral drainages (Table 3-132). Temporary effects to waters would be about 0.1 acre. The new reservoir would create about 742 acres of open water when full.

3.11.2.5 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Chimney Hollow Reservoir (70,000 AF)

Permanent effects to wetlands from construction of a 70,000 AF Chimney Hollow Reservoir would be slightly less than the 90,000 AF Chimney Hollow Reservoir in the Proposed Action. About 1.5 acres of wetlands would be permanently affected and about 0.1 acre of wetlands would be temporarily affected (Table 3-131). Effects to wetland functions would be the same as the Proposed Action.

On average, Chimney Hollow Reservoir levels would remain fairly stable throughout the year, but generally below capacity. The establishment of wetland and riparian vegetation tolerant of periodic inundation on the reservoir perimeter where the shoreline is less steep is possible.

The effect to waters would be the same as the Proposed Action (Table 3-132). A 70,000 AF Chimney Hollow Reservoir would create about 674 acres of open water.

Jasper East Reservoir

About 21.2 acres of wetlands would be permanently impacted in the footprint of the dam, pump station, access road, and reservoir (Table 3-131). About 4.8 acres of wetlands would be temporarily disturbed during construction of pipelines and other facilities. Some of the wetlands (an estimated 8 acres, or 38 percent of the permanently impacted wetlands) are likely created as a result of flood irrigation and have been affected by grazing and hay harvesting. The development of shoreline wetlands and riparian vegetation communities around the reservoir margin is unlikely because of projected large annual fluctuations in reservoir elevations. Seepage below the dam could increase the potential for wetland or riparian vegetation establishment.

About 0.3 acre of waters in the unnamed ephemeral drainage located within the reservoir and dam footprint would be permanently impacted (Table 3-132). Temporary effects to waters in the same drainage would affect about 0.2 acre. The existing, approximate 6-acre forebay and the Willow Creek Pump Canal would be relocated to the north. The new reservoir would create about 434 acres of open water.

Total Effects to Wetland and Waters

The combined permanent effect to wetlands for both reservoirs is 22.7 acres and the total temporary effect would be 4.9 acres (Table 3-131). The total permanent impact to other waters would be about 7.9 acre with a temporary effect of less than 0.3 acre (Table 3-132). About 1,108 acres of waters would be created with construction of both reservoirs when they are full.

3.11.2.6 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Chimney Hollow Reservoir (70,000 AF)

Effects to wetlands and waters would be the same as described for Alternative 3.

Rockwell/Mueller Creek Reservoir (20,000 AF)

The permanent effect to wetlands from construction of Rockwell Reservoir is estimated to range from 3.0 acres to 13.6 acres (Table 3-131). The 3.0-acre value is based on NWI mapping and the 13.6-acre value is based on the assumption that wetlands are located with the mesic native shrubland community mapped from aerial photography. Using the same data sources, temporary wetland effects are estimated to range from 2 to 5 acres.

Permanent wetland effects would occur primarily from dam construction and inundation from the reservoir. Temporary wetland effects would result from installation of the pipeline connection to Windy Gap Reservoir, which would involve crossing the Colorado River floodplain. Wetland functions and values were not investigated in the Rockwell Reservoir study area, but are likely similar to those in the Jasper East study area.

The development of shoreline wetlands and riparian vegetation communities around the Rockwell Reservoir margin is unlikely because of projected large annual fluctuations in reservoir elevations that would limit wetland development. Seepage below the dam could increase the potential for wetland or riparian vegetation establishment.

Although not field verified, it is assumed that Rockwell and Mueller creeks possess the characteristics of a water of the U.S. Construction of the 30,000 AF Rockwell Reservoir dam is estimated to inundate or permanently fill about 0.6 acre of stream channel (Table 3-132) and an approximately 3-acre stock pond. In addition, about 1.7 acres of waters would be temporarily impacted during placement of the raw water pipeline across the Colorado River. A 20,000 AF Rockwell Reservoir would create about 294 acres of open water.

Total Effects to Wetland and Waters

The combined permanent effect to wetlands for both reservoirs would range from about 4.5 to 15.1 acres and the total temporary effect would range from about 2.1 to 5.1 acres (Table 3-131). The total permanent impact to other waters would be about 4.9 acres with a temporary effect of 1.8 acres (Table 3-132). About 968 acres of waters would be created with construction of both reservoirs when they are full.

3.11.2.7 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Dry Creek Reservoir

About 6.2 acres of wetlands would be permanently impacted and about 0.3 acre of wetlands would be temporarily impacted from construction of Dry Creek Reservoir and facilities (Table 3-131). Along Dry Creek, wetlands that would be permanently impacted have been somewhat disturbed by grazing; however, wetlands in the tributaries are relatively undisturbed. This alternative would affect wetlands rated with a high function for rare or imperiled CNHP-listed wildlife species habitat, general wildlife habitat, ground water discharge/recharge, sediment/shoreline stabilization, and production export/food chain support.

Construction of the reservoir may result in the development of new vegetation communities around the lake margin because the reservoir would remain near capacity throughout the growing season and the rest of year. Stable water levels would help support shoreline wetlands and riparian species, although steep banks would prevent substantial riparian development. Seepage below the dam also could increase the potential for wetland or riparian vegetation establishment along Dry Creek.

Construction of Dry Creek Reservoir would permanently affect about 2.8 acres of waters (Table 3-132) including Dry Creek and several tributaries, either from inundation, fill from dam construction, or spillway. Temporary effects to waters would be about 0.3 acre. The new reservoir would create about 589 acres of open water.

Rockwell/Mueller Creek Reservoir (30,000 AF)

Construction of a 30,000 AF Rockwell Reservoir would permanently affect about 3 to 15.6 acres of wetlands based on NWI mapping and aerial photography (Table 3-131). Temporary wetland effects would range from about 2 to 5 acres. Wetland functions and values were not investigated, but are likely similar to those at Jasper East Reservoir.

The development of shoreline wetlands and riparian vegetation communities around the Rockwell Reservoir margin is unlikely because of projected large annual fluctuations in reservoir elevations, but seepage below the dam could support downstream wetlands.

Rockwell Reservoir is estimated to inundate or permanently fill from dam construction about 0.7 acre of stream channel and a 3 acres stock pond (Table 3-132). In addition, about 1.7 acres of waters would be temporarily impacted during placement of the raw water pipeline across the Colorado River. A 30,000 AF Rockwell Reservoir would create about 348 acres of open water.

Total Effects to Wetland and Waters

The combined permanent effect to wetlands for both reservoirs would range from 9.2 to 21.8 acres and the total temporary effect would range from 2.3 to 5.3 acres (Table 3-131). The total permanent impact to other waters would be 6.5 acres with a temporary effect of 2.0 acres (Table 3-132). About 937 acres of waters would be created with construction of both reservoirs when they are full.

3.11.3 Cumulative Effects

Potential direct cumulative effects to wetlands from land-based reasonably foreseeable actions, in addition to the wetland impacts identified at the reservoir sites, are possible. Reasonably foreseeable land-based developments potentially occurring in the basins where alternative reservoir facilities are located include Larimer County Open Space adjacent to Chimney Reservoir site and a residential development near Jasper East. Potential indirect effects to riparian areas and wetlands along streams and bordering reservoirs are discussed in Section 3.10.3.6.

No reasonably foreseeable future actions that would result in a direct cumulative effect to wetlands were identified in the Ralph Price Reservoir or Rockwell Reservoir basins. Planned future recreation development of Larimer County open space adjacent to Chimney Hollow and part of Dry Creek could potentially impact wetlands from trail construction. Specific trail locations have not been determined, but typically trails can be located to avoid wetlands. Development of the C-Lazy-U Preserve residential development north of the Jasper East Reservoir site could result in a cumulative impact to wetlands in the basin. Impacts to wetlands from development of C-Lazy-U Preserve are not known at this time. Any future losses to wetlands associated with future development may require permitting and mitigation.

The habitat project described as part of the FWEPs developed by the Subdistrict (2011a) and Denver Water (2011a) includes measures for restoration of aquatic habitat from Windy Gap Reservoir downstream to about 2 miles below the confluence with the Williams Fork. While details of habitat restoration have not been developed, actions may narrow the stream channel, which could affect existing streamside wetlands or create additional wetlands.

3.11.4 Wetland and Other Waters Mitigation

Avoidance and minimization of potential impacts to wetlands and waters began with the alternative selection process by using wetlands and perennial streams as key screening criteria. All of the potential action alternatives are located on small intermittent and ephemeral drainages with limited natural wetlands present. Because complete avoidance of wetlands and waters is difficult with water storage projects, all alternatives would require mitigation for wetland impacts. Regardless of the alternative, to the greatest degree possible, impacts on wetlands would be avoided or minimized during final design.

A wetland mitigation plan has been prepared to address permanent and temporary impacts to wetlands and has been submitted to the Corps as part of the 404 Permit application for the Proposed Action. Proposed mitigation for permanent effects to jurisdictional wetlands includes purchase of wetland credits in an approved wetland bank as preferred by the Corps.

Temporary wetland impacts from actions such as pipeline construction would be addressed by the use of BMPs. BMPs would include limiting the area of disturbance, establishing erosion control, salvaging existing wetland plants, restoring natural hydrology, controlling weeds, and monitoring revegetation success.

Mitigation for lost waters would occur from the creation of additional open water aquatic habitat from reservoir construction.

3.11.5 Unavoidable Adverse Effects

All alternatives would result in unavoidable temporary and permanent effects to existing wetlands and waters. Complete avoidance of wetlands is not feasible, but additional modifications during final design could slightly reduce wetland effects associated with project facilities. Unavoidable permanent wetland impacts for the action alternatives range from 1.6 acres for the Proposed Action to 22.7 acres for Alternative 3 with other alternatives falling within this range. The No Action Alternative would permanently impact about 0.3 acre of wetlands. Unavoidable permanent effects to existing waters would range from 1.3 acres for the Proposed Action to 7.6 acres for Alternative 3 compared to 0.1 acre for the No Action Alternative.

Following proposed mitigation, all of the temporary disturbed wetlands would be restored to near existing conditions, although complete restoration of wetland functions could take several years. All permanently affected wetlands and associated functions would be replaced by creation or restoration of new wetlands. Lost waters are proposed to be replaced by reservoir creation.

3.12 Wildlife

3.12.1 Affected Environment

3.12.1.1 Regulatory Framework

As directed by Colorado State Statute 33 (CRS Ann. §§ 33-1-101-124) for wildlife species not federally listed as threatened or endangered, the Colorado Wildlife Commission issues regulations and develops management programs, which are implemented by CDPW. This includes maintaining a list of state threatened and endangered species. CDPW also maintains a list of species of concern, but these are not protected under Statute 33. Take of game species, such as deer, elk, pheasant, quail, and some species of waterfowl, is permitted through a hunting license. Take of nongame species, such as small mammals, birds, and reptiles, is permitted for specific activities such as scientific collecting.

In recognition of the state's responsibility for fish and wildlife resources found in and around state waters that are affected by water diversion, delivery, or storage facilities, the Colorado General Assembly enacted CRS § 37-60-122.2. This statute states that "fish and wildlife resources that are affected by the construction, operation or maintenance of water diversion, delivery, or storage facilities should be mitigated to the extent, and in a manner, that is economically reasonable and maintains a balance between the development of the state's water resources and the protection of the state's fish and wildlife resources." The Subdistrict prepared a FWMP in cooperation with the CDPW, which was adopted by the Wildlife Commission and the Colorado River Water Conservation Board (Appendix E).

The Fish and Wildlife Coordination Act requires the federal action agency to consult with the FWS and the CDPW on issues related to conservation of wildlife resources for federal projects resulting in modifications to waters or channels of a body of water (16 U.S.C. §§ 661-667c). The FWMP will be a component of the Fish and Wildlife Coordination Act Report.

Migratory birds, including raptors and active nests, are protected under the Migratory Bird Treaty Act (MBTA). The MBTA prohibits activities that may harm or harass migratory birds during the nesting and breeding season. Removal of active nests that results in the loss of eggs or young is also prohibited under the MBTA. In Colorado, most birds except for European starling, house sparrow, and rock dove (pigeon) are protected under the MBTA (§§ 703-712). Additionally, EO 13186 directs federal agencies to take certain actions to implement the MBTA (86 FR 3853). The Bald Eagle Protection Act includes several prohibitions not found in the MBTA, such as molestation or disturbance; in 1962, the Act was amended to include the golden eagle.

The Colorado Natural Heritage Program (CNHP) maintains a list and ranking of rare and imperiled wildlife and plant species in Colorado. CNHP-tracked species generally include federal and state listed endangered species, as well as other species of concern. CNHP-listed species have no formal regulatory status or protection.

Federally listed threatened and endangered species protected under the Endangered Species Act are discussed in Section 3.13.

3.12.1.2 Area of Potential Effect

The study area for evaluating potential effect to wildlife includes the reservoir sites and related pipelines, roads, and infrastructure that would be directly affected by the alternative actions. Because many wildlife species use a variety of habitats and have a wide range of movement, the study area includes a 3-mile buffer around reservoir sites and project facilities.

3.12.1.3 Data Sources

Wildlife resource data were collected from field observations at all of the reservoir sites except Rockwell Reservoir, where access to the privately owned property was denied. Other data sources for species occurrence and potentially suitable habitat included aerial photography, published reports, database searches of the Colorado Natural Diversity Information Source (CNDIS) and CNHP. Consultation with the FWS and CDPW also provided information. The Wildlife Resources Technical Report provides additional information on wildlife resources (ERO 2007b).

The affected environment describes wildlife in four categories: 1) state endangered, threatened, and species of concern; 2) CNHP-listed species; 3) migratory birds and raptors; and 4) large game and other wildlife.

3.12.1.4 State Endangered, Threatened, and Species of Concern

State endangered, threatened, and species of concern with potentially suitable habitat in the study area are listed in Table 3-133 and described below.

Boreal Toad

The boreal toad inhabits wetland areas such as beaver ponds, wet meadows, and slow moving streams at elevations above 7,800 feet (Hammerson 1999). The species was removed as a candidate for federal listing (FWS 2005).

West Slope Study Area. The boreal toad is known to occur along Willow Creek in Grand County (USFS 2005). Wetland and aquatic habitat at the Jasper East Reservoir site does not contain preferred foraging and breeding habitat suitable for the boreal toad and none were discovered during field surveys. There are no records of boreal toad presence near the Rockwell Reservoir study area. The small pond and two drainages provide limited suitable habitat for boreal toad.

East Slope Study Areas. The Chimney Hollow, Dry Creek, and Ralph Price Reservoir study areas are below the boreal toad's known elevation range and therefore do not contain any habitat for this species.

Table 3-133. State endangered, threatened, and species of concern potentially occurring in the study areas.

Common Name	State Status	Ralph Price	Chimney Hollow	Dry Creek	Jasper East	Rockwell/ Mueller
Amphibians						
Boreal toad	SE	0	0	0	1	1
Northern leopard frog	SOC	1	3	3	1	1
Wood frog	SOC	0	0	0	1	1
Reptiles						
Common gartersnake	SOC	0	3	3	0	0
Birds						
Ferruginous hawk	SOC	0	1	1	1	1
Greater sandhill crane	SOC	0	0	0	1	0
Peregrine falcon	SOC	1	3	3	1	0
Greater sage grouse	SOC	0	0	0	1	3
Mammals						
Townsend's big-eared bat	SOC	1	1	1	0	0
River otter	ST	1	0	0	0	0

0– No habitat
1 – Limited habitat present, species unlikely to occur
2 – Potential foraging habitat
3 – Potential breeding and foraging habitat
SE = State Endangered ST = State Threatened SOC = State Species of Concern
Source: CDOW 2006.

Northern Leopard Frog

The northern leopard frog occupies much of Colorado with the exception of the southeastern part of the state. Typical habitat includes irrigation ditches, streams, wet meadows, marshes, ponds, and lakes (Hammerson 1999). The CDPW lists the northern leopard frog as uncommon in Boulder and Larimer counties and rare in Grand County (CNDIS 2006).

West Slope Study Areas. Historically the northern leopard frog was recorded along all of the major drainages in Grand County. Potentially suitable habitat exists within wetland areas in the Jasper East study area; however, none were discovered during field surveys. Potentially suitable habitat exists in and near wetland areas associated with the pond and stream in the Rockwell Reservoir study area. The nearest capture site is along the Colorado River approximately 3 miles northwest of the Rockwell Reservoir site (CDOW 2005).

East Slope Study Areas. Suitable habitat for northern leopard frog exists in wetland areas within the Chimney Hollow and Dry Creek drainages. One adult leopard frog was observed in July 2005 along Dry Creek. It is likely that small breeding populations exist along wetter areas of Dry Creek. No leopard frogs were observed during field surveys at Chimney Hollow, but they could be present. Dry Creek contains more riparian wetlands and several small ponds that provide more suitable leopard frog habitat than Chimney Hollow.

The steep rocky areas along the Ralph Price Reservoir shoreline do not provide quality habitat for northern leopard frog; however, this species may be present upstream and downstream of the reservoir along shallow areas of North St. Vrain Creek.

Wood Frog

This species typically inhabits high mountain marshes, bogs, beaver ponds, willow thickets and stream borders (Hammerson 1999). In Colorado this species is only known in Larimer, Jackson, and Grand counties. The CDPW lists the wood frog as common in Grand County (CNDIS 2006).

West Slope Study Areas. The nearest known population of the wood frog occurs along the Colorado River near Grand Lake (CDOW 2005b). Potentially suitable habitat for the wood frog exists within wetland areas of the Jasper East study area; however, none were found during field surveys. The pond and wetlands present at Rockwell Reservoir do not provide the type of habitat favored by the wood frog.

East Slope Study Areas. No potential habitat exists for the wood frog in the Chimney Hollow, Dry Creek, or Ralph Price study areas. All three sites are located below the elevation range for this species in Colorado.

Common Gartersnake

The common gartersnake is distributed in northeastern Colorado and is associated with the South Platte River and its tributaries at elevations below 6,000 feet (Hammerson 1999). It is found in aquatic and riparian habitats within floodplains and inhabits marshes, ponds, and stream edges. The CDPW lists the common gartersnake as sparsely common in Boulder County and uncommon in Larimer County (CNDIS 2006).

West Slope Study Areas. Both the Jasper East and Rockwell study areas are located outside the known range of the common gartersnake in Colorado.

East Slope Study Areas. The Chimney Hollow and Dry Creek study areas contain suitable habitat for the common gartersnake and it was observed at Chimney Hollow during field studies. It is likely that this species inhabits the wetland and riparian areas at both East Slope reservoir sites.

Ralph Price Reservoir is above the upper elevation limit for this species and, therefore, the common gartersnake is unlikely to be present. It may occur downstream of the reservoir along North St. Vrain Creek.

Ferruginous Hawk

The ferruginous hawk inhabits open prairie and desert habitats and is strongly associated with primary prey species such as ground squirrels and jackrabbits. Ferruginous hawks are relatively common winter residents in eastern Colorado, particularly in association with the black-tailed prairie dog (Kingery 1998). The CDPW lists the ferruginous hawk as an uncommon to rare breeder in Boulder, Larimer, and Grand counties (CNDIS 2006).

West Slope Study Areas. Breeding bird surveys did not document any nesting of this species in the county (Kingery 1998); however, the Colorado River basin within Grand County is considered winter and migration habitat (Andrews and Righter 1992). Ferruginous hawks were observed in low numbers near Jasper East and Rockwell during field studies. Wintering ferruginous hawks could possibly roost within or near West Slope study areas.

East Slope Study Areas. No records of ferruginous hawks nesting in central or western Larimer or Boulder counties are known (Kingery 1998). This species is a common migrant along the Front Range. Although it may occasionally occur at the Chimney Hollow, Dry Creek, and Ralph Price study areas, it is unlikely to nest at any of these study areas because more suitable habitat is available to the east.

Greater Sandhill Crane

In Colorado, the greater sandhill crane nests west of the Continental Divide, typically near flooded wetlands, beaver ponds, and wet meadows. The CDPW lists the northern sandhill crane as an unknown breeder in Boulder and Larimer counties and uncommon in Grand County (CNDIS 2006).

West Slope Study Areas. The greater sandhill crane has been recorded nesting in the northwestern portion of Grand County, but no breeding populations have been noted within or near the Jasper East or Rockwell (Kingery 1998; Sumerlin, pers. comm. 2005). The Jasper East study area contains irrigated wet meadows that could be used for foraging, but is unlikely to provide nesting habitat because the area is mowed regularly. The Rockwell

Reservoir site contains narrow riparian wetlands and a small pond that does not provide suitable for foraging or nesting habitat.

East Slope Study Areas. No suitable nesting or foraging habitat for this species exists within the Chimney Hollow, Dry Creek, or Ralph Price study areas.

Peregrine Falcon

The peregrine falcon has been removed from both the CDPW and federal endangered species lists, but it remains a state species of concern. Peregrines nest on high steep cliffs generally along stream courses. The peregrine falcon migrates through eastern Colorado and nests in canyons and cliffs along the Front Range (Craig and Enderson 2004).

West Slope Study Areas. Peregrine nesting has never been documented in Grand County, but breeding populations have been noted in nearby Jackson County (Kingery 1998). The Jasper East study area does not contain suitable nesting habitat for the peregrine falcon. Rocky outcrops to the northeast provide potential habitat for the peregrine, but the U.S. Forest Service has no records of occurrence in the area (Sumerlin, pers. comm. 2005). No rocky cliffs or canyon habitat that peregrines typically favor occur at or near the Rockwell Reservoir study area.

East Slope Study Areas. Although no nests or individuals have been recorded in the East Slope study areas, rocky outcrops and cliffs on the hogback east of Chimney Hollow and Dry Creek and rocky outcrops near Ralph Price have potentially suitable habitat. The hogbacks near Chimney Hollow and Dry Creek are relatively small and provide habitat more suitable for prairie falcons. No peregrine falcon was observed at Chimney Hollow or Dry Creek during field surveys and there are no records of occurrence at Ralph Price (CNHP 2006).

Greater Sage Grouse

Greater sage grouse populations in North and Middle Parks of central Colorado typically occur in sagebrush habitat between 7,000 and 9,500 feet (Kingery 1998). Habitat requirements shift from sage-dominated habitat in winter to more variable mountain-shrub habitat in summer (GSGCP 2001). In the spring, male grouse congregate in courtship displays in flat open areas dominated by sagebrush. Nesting usually occurs near production areas (leks) and 80 percent of sage grouse forage within 4 miles of a lek. Sage grouse is not present in Boulder or Larimer counties, but is present in portions of Grand County (CNDIS 2006). This species was found “warranted but precluded” from protection under the ESA by the FWS in March 2010 and thus remains a candidate for future listing.

West Slope Study Areas. Vegetation mapping and site reconnaissance indicate that habitat preferred by sage grouse is present in the Jasper East study area. Sage grouse are common in west Grand County and uncommon in east Grand County, with only two leks remaining (CNDIS 2006). CDPW recorded breeding activity in drier habitat west of the Jasper East Reservoir site in 2004 (CDOW 2005a). The Horn lek, above the intersection of Highways 34 and 40 and south of Jasper East, was active with five males on the lek in 2005 and 2006, and only one male in 2007 (Cowardin 2006, 2007).

The eastern side of the Rockwell study area includes a designated sage grouse lek (CDOW 2001b; CNDIS 2006). A sage grouse brooding area also has been identified north and east of Rockwell. Sagebrush at Rockwell provides nesting and year-round grouse habitat. Sage grouse have experienced population declines in eastern Grand County and residential development in the Granby area has reduced available habitat. The highest number of males counted on the Linke lek, east of Rockwell, was 26 in 1990. The decline has been significant over the last few years from 20 males in 2004 to five in 2005, three in 2006, one in 2007, and then nine in 2008 (Cowardin 2006, 2008).

East Slope Study Areas. The Chimney Hollow, Dry Creek, and Ralph Price study areas do not contain suitable sage-dominated habitat for sage grouse.

Townsend's Big-eared Bat

The Townsend's big-eared bat is a year-round resident in the western ⅔ of Colorado (Fitzgerald et al. 1994). This species inhabits woodland areas with rocky outcrops, vacant buildings, caves and old mine shafts (Fitzgerald et al. 1994). The CDPW lists the Townsend's big-eared bat as uncommon in Boulder and Larimer counties and has no records of occurrence for Grand County (CNDIS 2006).

West Slope Study Areas. Due to the lack of large rocky outcrops and vacant mines or buildings on both West Slope study areas, it is unlikely that the species occurs at Jasper East or Rockwell. However, it may intermittently forage in these study areas.

East Slope Study Areas. The Chimney Hollow, Dry Creek, and Ralph Price study areas contain potentially suitable habitat for the Townsend's big-eared bat. The species could potentially roost or hibernate in rocky areas along the hogbacks and foothill areas, as well as in old buildings or small caves.

River Otter

The river otter inhabits riparian habitats across a variety of ecosystems ranging from semi-desert shrublands to montane and subalpine forests. River otter requires clear, permanent water with an abundant food base of fish and crustaceans. Other habitat requirements include ice-free water in winter, water depth, stream width, and suitable access to shoreline (Fitzgerald et al. 1994).

West Slope Study Area. River otter occur in all the larger streams of eastern Grand County, including the Colorado and Fraser rivers and Willow Creek, both above and below Willow Creek Reservoir. Otter may occasionally visit the Jasper East or Rockwell area, but the sites lack suitable habitat, including permanent water of relatively high quality and an abundant food base.

East Slope Study Area. No known populations of otter occur near any of the three East Slope study areas. Although tracks and other sign of otter have been found in the Poudre and Laramie drainages in Larimer County the nearest location to Chimney Hollow and Dry Creek is more than 15 miles east, near Windsor (CNDIS 2007). The Chimney Hollow and Dry Creek study areas also lack suitable habitat for river otter including permanent water of relatively high quality and an abundant food base.

3.12.1.5 CNHP Species

Colorado Natural Heritage Program species considered imperiled, rare, or vulnerable in the state with potentially suitable habitat in the study area are listed in Table 3-134 and described below.

Sage Sparrow

The sage sparrow is a local and irregular summer resident in western Colorado (CNDIS 2006). This sparrow has a narrow habitat requirement for nesting, but tends to be associated with sagebrush. Most of the confirmed nests for sage sparrow in Colorado are in Moffat County (Kingery 1998). The CDPW lists the sage sparrow as unknown in Boulder, Larimer, and Grand counties (CNDIS 2006).

West Slope Study Areas. Jasper East and Rockwell study areas contain potentially suitable nesting habitat for the sage sparrow. However, based on museum records and statewide breeding bird surveys, no documented nesting has been recorded in Grand County (Andrews and Righter 1992; Kingery 1998). This species may occasionally visit these sites during migration.

East Slope Study Areas. The Chimney Hollow and Dry Creek study areas do not contain sage habitat that this species typically favors. Sage sparrow has not been documented nesting in Boulder or Larimer counties (Kingery 1998).

Table 3-134. CNHP-tracked species potentially occurring in the West and East Slope study areas.

Common Name	CNHP Ranking	Ralph Price	Chimney Hollow	Dry Creek	Jasper East	Rockwell/ Mueller
Birds						
Sage sparrow	G5, S3	0	0	0	3	3
Butterflies						
Arogos skipper	G3/G4, S2	0	3	3	0	0
Ottoe skipper	G3/G4, S2	0	3	3	0	0
Dusted skipper	G4/G5, S2	0	3	3	0	0
Cross-line Skipper	G5, S3	0	3	3	0	0
Mottled duskywing	G3/G4, S2/S3	0	3	3	0	0
Moss' elfin	G3/G4/T3, S2/S3	3	3	3	0	0
Rhesus skipper	G4, S2/S3	0	3	3	0	0
Simius roadside skipper	G4, S3	0	3	3	0	0

0– No habitat
1 – Limited habitat present, species unlikely to occur
2 – Potential foraging habitat
3 – Potential breeding and foraging habitat
Source: CNHP 2005.
CNHP Ranks:
G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction. (Critically endangered throughout its range.)
G2 = Imperiled globally because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extinction throughout its range. (Endangered throughout its range.)
G3 = Vulnerable throughout its range or found locally in a restricted range (21 to 100 occurrences). (Threatened throughout its range.)
G4 = Apparently secure globally, though it might be quite rare in parts of its range, especially at the periphery.
G5 = Secure – Common; widespread and abundant.
GU = Unable to assign rank due to lack of available information.
S1 = Critically imperiled in state because of extreme rarity (5 or fewer occurrences, or very few remaining individuals, or because of some factor of its biology making it especially vulnerable to extirpation from the state. (Critically endangered in state.)
S2 = Imperiled in state because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extirpation from the state. (Endangered or threatened in state.)
S3 = Vulnerable in state (21 to 100 occurrences).
S4 = Apparently secure in the state, though it might be quite rare in parts of its range, especially at the periphery.
B = Breeding season imperilment, not permanent residents
T(1-5) = Trinomial Rank – Used for subspecies. These species are ranked on the same criteria as G1 to G5.

Butterflies—Argos Skipper, Ottoe Skipper, Dusted Skipper, Cross-line Skipper, Mottled Duskywing, Moss' Elfin, Rhesus Skipper, and Simius Roadside Skipper

Habitat for several species of butterfly is present along the East Slope of the Front Range within the study areas for Chimney Hollow and Dry Creek. There is no suitable habitat for these butterfly species in the West Slope study areas.

Argos skipper and ottoe skipper prefer habitat dominated by big bluestem grasslands. Big bluestem is not abundant at Chimney Hollow or Dry Creek, but Argos skipper has been found in the grasslands and foothills near the reservoir sites (CNHP 2005).

Dusted skipper occurs in abandoned agricultural fields, open woodlands, and mid- to tallgrass prairies; cross-line skipper favors prairie grasslands. Both skippers inhabit areas with little bluestem and dusted skipper also prefers big bluestem. Chimney Hollow and Dry Creek provide patches of potential habitat for these species.

Mottled duskywing occurs in hilly open woodlands preferring buckbrush shrubs. It has been found in central Larimer County (CNHP 2005). Mountain mahogany shrublands with scattered buckbrush at Chimney Hollow and Dry Creek provide potential habitat.

Moss' elfin is found in moist north-facing slopes and steep canyons. The caterpillar stage of this species feeds on yellow stonecrop. Areas of potential habitat could be present at Chimney Hollow, Dry Creek, and Ralph Price if stonecrop is present.

Rhesus skipper and simius roadside skipper prefer shortgrass prairie habitat dominated by blue grama grass. A population of simius roadside skipper was recorded in the foothills near Chimney Hollow and Dry Creek (CNHP 2005). Potential habitat for both species is present at Chimney Hollow and Dry Creek.

3.12.1.6 Migratory Birds

Nearly all bird species potentially present in the East and West Slope study areas are protected under the MBTA. Bald eagles, which were downlisted from a federally threatened species in August 2007, are still protected under the MBTA and Bald and Golden Eagle Protection Act. Known and potential species for each reservoir site are discussed below.

Ralph Price Study Area

The mixed ponderosa pine and Douglas-fir forest and open water at Ralph Price Reservoir provides habitat for migratory upland birds and waterfowl. Species observed by reservoir management staff and during an August 2005 site visit included osprey, great blue heron, cormorant, and gadwall. Northern goshawks also have been observed in the area (Jones 2006). No bald eagle active nest sites, winter range, winter roost site, or winter concentration area or associated buffers are known at Ralph Price Reservoir (CNDIS 2006), although bald eagle have been observed (Jones 2006). The St. Vrain River east of Lyons about 6 miles from Ralph Price Reservoir supports known bald eagle nesting, winter roosting, and summer foraging areas. Habitat for waterfowl, including various ducks, and white pelican is available at Ralph Price Reservoir. Forests bordering the reservoir likely support pygmy nuthatch, Steller's jay, mountain blue-bird, hairy woodpecker, dark-eyed junco, and other woodland species.

Chimney Hollow and Dry Creek Study Areas

Several migratory bird species were observed foraging within the Chimney Hollow and Dry Creek study area during field surveys. Ground-nesting species observed within the study areas included spotted towhee, savannah sparrow, western meadowlark, and mourning dove. Species observed in riparian and wetland habitat included Bullock's oriole, American goldfinch, and yellow warbler. Additional species observed were barn swallow, eastern kingbird, American robin, American kestrel, and chipping sparrow. Riparian and ridge areas, combined with ponderosa pine forests in the higher elevations of the site, contained potentially suitable nesting habitat for several bird species such as dark-eyed junco, pygmy nuthatch, western tanager, American crow, and red-tailed hawk.

Bald eagle winter range is present east of the Chimney Hollow Reservoir site, which incorporates Carter Lake and the east side of the Dry Creek Reservoir site (CNDIS 2006). Bald eagle winter concentration areas are present along the Little Thompson River south of the Dry Creek Reservoir dam site. Bald eagle use of the Chimney Hollow or Dry Creek Reservoir sites for winter roosting or nesting is unlikely because no perennial streams or large bodies of water are present; however, they may occasionally forage in the area.

Several small nests were observed in riparian areas along Chimney Hollow, Dry Creek, and adjacent tributaries. Many of the nests were identified as oriole and magpie nests. Three large nests were present on rocky outcrops and cliffs on the ridgeline east of Chimney Hollow. Two of these large nests appeared to be inactive during the July 2003 site visit. Adult and fledgling golden eagles were observed in a third nest. All large nests on the ridgeline are likely used as alternative nests for golden eagles in the area.

A red-tailed hawk nest was observed in a stand of cottonwood trees in the southern portion of Dry Creek. A large golden eagle nest also was seen along the eastern ridgeline on the northern end of the Dry Creek study area. Both nests showed evidence of activity in 2005.

Jasper East Study Area

Raptors and migratory birds likely forage throughout the Jasper East study area. Ground-nesting birds observed, such as green-tailed towhee, savannah sparrow, and killdeer, are likely to inhabit pasture or meadow habitat. Species such as golden eagle and cliff swallow, common raven, American kestrel, and red-tailed hawk are likely to nest along the rocky ridges of the hogbacks northeast of the reservoir site. Wetland and riparian species such as red-winged blackbird, yellow-headed blackbird, and song sparrow are likely to nest in cattail stands or along the edge of wet areas. Several generalist species such as American robin, violet-green swallow, and American crow may nest in forested or wetland areas. Waterfowl, herons, and an occasional migrant sandhill crane have been observed in wetlands and open water habitats in the Jasper East study area (Sumerlin 2005). Nearby Willow Creek Reservoir and Granby Reservoir support breeding Canada geese, mallards, and common mergansers (Kingery 1998).

Bald eagle winter concentration and winter foraging areas are present along the Colorado River and Willow Creek west and south of the Jasper East Reservoir study area and north of the Rockwell Reservoir site (CNDIS 2006). Two active nests are near Granby Reservoir. There is no habitat suitable for winter roosting, nesting, important foraging areas, or essential eagle habitat at the Jasper East or Rockwell Reservoir sites, but bald eagles could occasionally forage in the area.

No potentially suitable raptor nests were identified directly within the Jasper East study area during the 2004 and 2005 site visits. A series of three alternate golden eagle nests are located on Table Mountain, northeast of the reservoir site. One of these nests was active in 2007 (Sumerlin, pers. comm. 2007). An osprey nest is located on a platform approximately 1,000 feet east of the potential reservoir. Foraging osprey were observed during the 2004 site visit along the Willow Creek Pump Canal within the potential reservoir footprint.

Rockwell Study Area

The Rockwell study area contains habitat similar to Jasper East, although somewhat drier without irrigated meadows. Bald eagle habitat in the region is described previously under Jasper East Reservoir. The pipeline connection to Windy Gap Reservoir for Rockwell Reservoir would cross bald eagle winter range along the Colorado River. The stock pond and Rockwell and Muller Creeks provide habitat for wetland bird species. Various waterfowl such as gadwall, American wigeon, and mallard may use the stock pond. Dry meadow and sagebrush habitat may support shrubland and ground-nesting species such as killdeer, Brewer's sparrow, and vesper sparrow.

3.12.1.7 Large Game and Other Wildlife

Large game wildlife such as deer, elk, pronghorn, bighorn sheep, mountain lion, and black bear are economically important species in Colorado. The Colorado Wildlife Commission through the CDPW is responsible for regulations and policies regarding game management and hunting.

No major large game migration routes exist within the East and West Slope study areas (CNDIS 2006; SREP 2005), although ridgelines and drainages often serve as smaller movement corridors for game species as well as other wildlife species. The CDPW has identified and mapped the overall range of large game throughout Colorado. The CDPW has further identified seasonally important areas, including winter range, winter concentration areas, and severe winter range for several large game species within the study areas (CNDIS 2006). Winter range is defined as an area of land necessary for winter survival of large game species. Severe winter range is defined as, "winter range where 90 percent of the individuals are located when the annual snow pack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten." Winter concentration area is defined as "that part of the winter range where densities are at least 200 percent greater than the surrounding winter range density" (CNDIS 2006). Big game and other wildlife habitat in the study areas are described below.

Elk

Elk are an important big game species in Colorado. This species primarily inhabits the western two-thirds of the state, but is occasionally found east of the Front Range foothills (Fitzgerald et al. 1994). Elk are generally associated with forested areas adjacent to meadows, open parks, and tundra in the warmer months.

West Slope Study Areas. The Jasper East and Rockwell study areas contain the scattered meadow/forest habitat that provides elk overall range. Elk winter range and concentration areas occur on the south side of Jasper East. Nearby lands bordering the reservoir site also provide winter range and winter concentration areas for elk. No elk migration routes are present at the Jasper East site, but elk move across a broad area in the Willow Creek drainage, with seasonal movement and numerous road kills along U.S. Highway 34 to the east (Oldham, pers. comm. 2007). The Rockwell study area provides summer elk range and winter range on the west and northwest side of the reservoir site.

East Slope Study Areas. The Chimney Hollow and Dry Creek study areas contain overall range and winter range for elk. Elk winter concentration areas are located northeast of the Chimney Hollow Reservoir site. According to the CDPW, development north and west of the Chimney Hollow and Dry Creek study areas, and the impacts of drought has increased the importance of these valleys as wintering areas for both deer and elk. Elk in this region use a variety of habitat in the foothills, plains, and agricultural and residential areas. No summer concentration ranges occur near either study area.

The Ralph Price study area is within elk overall winter and severe winter range. The north side of the reservoir provides winter concentration area. No important summer concentration or summer range is present.

Mule Deer

Mule deer are an important big game species in Colorado that occupies all ecosystems in Colorado from grasslands to alpine tundra (Fitzgerald et al. 1994). This species reaches it greatest densities in shrublands that provide abundant forage and cover.

West Slope Study Areas. The Jasper East and Rockwell study areas are located in mule deer summer range, although, mule deer likely visit these areas during all seasons. Mule deer winter range occurs southeast of the Jasper East Reservoir site and a small area of severe winter range overlaps the southern portion of the reservoir. Winter mule deer range is located east and west of the Rockwell study area.

East Slope Study Area. The Chimney Hollow and Dry Creek study areas are located in mule deer overall and summer range. Additionally, both study areas are located within winter concentration areas and overall winter range for mule deer. The Ralph Rice study area provides overall summer and winter range for mule deer.

White-tailed Deer

White-tailed deer are less widespread and more secretive than mule deer. The white-tailed deer occupies shrublands that provide plentiful forage and cover. White-tailed deer are often seen in riparian areas bordering larger streams and rivers. This species does not migrate in large numbers, but does move seasonally up and down river corridors in small numbers.

West Slope Study Areas. No white-tailed deer concentration areas occur within the Jasper East or Rockwell study areas. White-tailed deer are found along the Colorado River approximately 1 mile south of the Jasper East and along the Fraser River approximately ½ mile north of Rockwell. White-tailed deer occasionally may forage on both sites.

East Slope Study Areas. The Chimney Hollow and Dry Creek study areas fall within the overall range for the white-tailed deer. No white-tailed deer concentration areas, winter, or summer ranges occur at either site. The Ralph Price Reservoir study area does not fall within the overall range for white-tailed deer.

Pronghorn

The pronghorn is a big game species in Colorado that inhabits grasslands and semi-desert shrublands on rolling topography that provides good visibility (Fitzgerald et al. 1994). Pronghorn tend to favor vast expanses of open areas and are typically sensitive to human presence.

West Slope Study Areas. The Jasper East and Rockwell study areas fall within the overall range for pronghorn. However, no identified seasonal ranges, migration corridors or seasonal concentration areas occur in either study area.

East Slope Study Areas. Both the Chimney Hollow and Dry Creek study areas fall within the overall range for pronghorn. No seasonal ranges, migration corridors or seasonal concentration areas have been identified in either study area. No large open meadow areas or seasonal ranges for pronghorn occur at Ralph Price Reservoir.

Bighorn Sheep

Bighorn sheep inhabit steep, rocky areas in the mountains of Colorado (Fitzgerald et al. 1994). Once thought to have ranged throughout the Colorado foothills and mountains, the sheep currently have sporadic distribution in locations throughout the higher mountains.

West Slope Study Areas. The nearest sheep population is north of the proposed Jasper East and Rockwell Reservoir sites near the Grand County boundary with Jackson and Larimer counties. It is unlikely that bighorn sheep migrate onto either study area because of a lack of suitable habitat.

East Slope Study Areas. The nearest sheep population is located south and west of the Chimney Hollow and Dry Creek within Big Thompson Canyon and the western Larimer County boundary with Jackson County. It is unlikely that bighorn sheep migrate onto either study area because of the distance to the nearest population and a lack of suitable habitat.

Bighorn sheep have been observed approximately 5 miles west of the Ralph Price Reservoir (CNDIS 2006). Winter range is located west and southeast of the reservoir.

Black Bear

The black bear is Colorado's largest carnivore and inhabits montane shrublands and forests. It also is found in subalpine forests at moderate elevations, and even ranges from the edge of the alpine tundra to canyon country and lower foothills (Fitzgerald et al. 1994).

West Slope Study Areas. The Jasper East and Rockwell study areas are within the overall range for black bear. A portion of the Jasper East reservoir footprint overlaps a black bear summer concentration area.

East Slope Study Area. The Chimney Hollow and Dry Creek study areas are within the overall range for black bear. Both study areas also are located within a black bear fall concentration area. Black bear may occasionally forage on both of the sites at all times of the year. Because of the number of human residences and recreation areas, the CDPW has identified Carter Lake, to the east and northeast of both study areas, as a black bear/human conflict area.

The Ralph Price Reservoir study area provides overall range for black bear. No human conflict areas or seasonal concentration areas occur immediately adjacent to the reservoir.

Mountain Lion

This species typically inhabits rocky outcroppings and ridges near the foothill and mountain areas of the state. Mountain lions prey mainly on deer, as well as elk and other ungulates in North America and their distribution and movements correspond to their ungulate prey (Fitzgerald et al. 1994).

West Slope Study Areas. The Jasper East and Rockwell study areas are within the overall range for mountain lion; however, this species typically favors rocky outcroppings, not the open meadow and sage habitat located in the study areas.

East Slope Study Areas. The Chimney Hollow and Dry Creek study areas are within the overall range for the mountain lion and tracks of a female lion with two cubs were observed during field studies at Chimney Hollow. Mountain lion typically favor rocky outcroppings, such as the hogbacks west and east of the reservoir sites. Because of the intense use the Chimney Hollow and Dry Creek study areas by deer and elk, these valleys provide high quality habitat for mountain lion. Carter Lake and Flatiron Reservoir north and east of the Chimney Hollow study area and south of the Dry Creek study area are human conflict areas because of the high quality habitat combined with the density of human residences and recreation areas.

Ralph Price Reservoir is within the mountain lion overall range. No concentration areas or human conflict areas are nearby.

Moose

Moose were introduced to the state in 1978. This species inhabits high elevation meadows and boreal forest edges in northern and central Colorado (Fitzgerald et al. 1994).

West Slope Study Areas. Moose overall range includes the Jasper East and Rockwell study areas. Moose winter range and winter concentration areas are north of the Jasper East Reservoir site.

No seasonal ranges or concentration areas are within 5 miles of Rockwell. Winter range and winter concentration areas are about 8 miles southwest of the Rockwell site.

East Slope Study Areas. The Chimney Hollow, Dry Creek, and Ralph Price study areas are outside of the overall range for moose in Colorado.

Other Wildlife

West Slope Study Areas. Both the Jasper East and Rockwell study areas provide habitat for a variety of other mammals. Larger mammals likely to use habitat in either study area include coyote, red fox, badger, raccoon, porcupine, and bobcat. Smaller mammals such as deer mouse, mountain cottontail, montane vole, and northern pocket gopher are likely to be present in the study areas.

East Slope Study Areas. The Chimney Hollow, Dry Creek, and Ralph Price study areas provide habitat for species similar to those mentioned for the West Slope study area. Coyote, red fox, raccoon, bobcat and porcupine all likely occur on these sites. Smaller mammals, such as cottontail rabbit, deer mouse, northern pocket gopher and amphibians and reptiles, including Woodhouse toad, and bullsnake potentially use habitat within these study areas. Wildlife endemic to ponderosa pine or Front Range canyon habitats include long-eared myotis, rock squirrel, northern rock mouse, and Mexican woodrat.

3.12.2 Environmental Effects

3.12.2.1 Issues

Wildlife issues of concern included the potential loss and fragmentation of habitat and potential effects to big game species, raptors and other birds, and sensitive species.

3.12.2.2 Method for Effects Analysis

The potential effect on wildlife resources was evaluated for each alternative. Effects were assessed using information on known populations or suitable habitat. Colorado NDIS habitat ranges and distribution were overlain on maps showing project features to determine the potential loss of habitat. Permanent impacts to wildlife habitat could occur in areas that are inundated or permanently filled by project features such as the dam, access roads, and pump stations. Temporary impacts to habitat could occur in areas that would be reclaimed following construction, such as pipeline routes and staging areas. Effects to waterbirds and aquatic and riverine mammals from changes in hydrology were based on potential effects to riparian vegetation as discussed in Section 3.10.2.10. The following effects discussion focuses on wildlife species or habitat most likely to be affected by potential alternatives.

3.12.2.3 Potential Wildlife Effects Common to All Alternatives

Changes in Stream and Reservoir Hydrology

Each alternative would result in changes in C-BT and Windy Gap storage and release from the primary C-BT reservoirs—Granby Reservoir, Carter Lake, and Horsetooth Reservoir. In addition, the action alternatives would create one to two new reservoirs and the No Action Alternative would enlarge an existing reservoir. All alternatives would result in changes in streamflow in the Colorado River below Granby Reservoir and small changes in streamflow to East Slope streams. Potential effects to wildlife for West Slope and East Slope streams and for existing and new reservoirs are discussed below. *Aquatic Resources* (Section 3.9) discusses effects to aquatic species.

West Slope Streams. Each alternative would result in increased stream diversions from the Colorado River and changes in releases from Granby Reservoir. Changes in streamflow would have no direct effect on terrestrial wildlife habitat. Potential indirect effects are possible if changes in streamflow result in a change in vegetation composition or characteristics in the riparian areas bordering the Colorado River or Willow Creek that are used by wildlife. Based on the analysis of changes in streamflow and stream geomorphology, measurable changes in vegetation composition are unlikely for any alternative. As a result, a change in streamflow in the Colorado River and Willow Creek under any alternative is unlikely to affect terrestrial wildlife resources because there would be no adverse effect to habitat.

East Slope Streams. Minor increases in streamflow would occur in several East Slope streams as Participants use Windy Gap water and increase their WWTP discharges. Changes in streamflow for the Big Thompson River, St. Vrain Creek, Coal Creek, and Big Dry Creek would fall well within the range of historical flows under all alternatives and are unlikely to substantially change stream channel characteristics, or vegetation composition; hence, changes in streamflow are unlikely to affect wildlife habitat.

Existing Colorado-Big Thompson Reservoirs. The availability of additional storage for Windy Gap water under all alternatives would reduce the use of storage by Windy Gap and C-BT (under the Proposed Action) in Granby Reservoir, Carter Lake, and Horsetooth Reservoir by varying amounts. The largest change in storage would occur under the Proposed Action, because prepositioning would allow storage of C-BT water in Chimney Hollow Reservoir. The smallest change would occur under the No Action Alternative, which has the smallest increase in Windy Gap firming storage with the enlargement of Ralph Price Reservoir. Existing reservoirs would continue to operate within the historical range of seasonal and annual variability depending on precipitation, evaporation, and water demand. Terrestrial wildlife are not dependent on reservoir levels and would not be directly affected by fluctuations in reservoir elevations. Lower reservoir levels would reduce available habitat for waterfowl, but it is unlikely that lower reservoir levels would adversely affect breeding or foraging habitat.

New Reservoirs. Enlargement of Ralph Price Reservoir or the construction of Chimney Hollow Reservoir, Dry Creek Reservoir, Jasper East Reservoir, or Rockwell Reservoir would increase open water habitat for waterfowl, bald eagles, and osprey. Chimney Hollow and Dry Creek reservoirs would have the most stable lake levels, which would most benefit these species. West Slope reservoirs would fluctuate more on a seasonal and annual basis, but would still provide habitat beneficial to waterfowl and raptors that forage on fish or waterfowl. Improved waterfowl habitat could increase the production of nuisance species, such as Canada geese. Conversely, waterfowl populations could indirectly provide improved waterfowl hunting opportunities at locations other than the reservoir sites. The lack of hunting waterfowl at a new reservoir would create a refugia that could further increase conflicts with nuisance geese.

Construction Disturbance

All alternatives involve earthmoving, heavy equipment, noise, and other disturbances during construction of dams and other facilities, which would displace wildlife. These disturbances would have a direct impact to burrows, dens, and possible mortality of small less mobile mammals, reptiles, and amphibians. More mobile mammals and birds would be displaced from disturbed habitat. Construction activity would indirectly affect wildlife behavior in the vicinity. Tolerance to disturbance varies by species and individuals, but behavioral responses range from habituation to activity, to complete avoidance of undisturbed habitat near the construction site, or increased movement and expenditure of energy reserves. The indirect displacement of wildlife during construction would be a temporary effect, but would last about 3 years depending on the alternative.

3.12.2.4 Alternative 1—Ralph Price Reservoir (No Action)

State Threatened, Endangered and Species of Concern

Reservoir enlargement would inundate about 0.1 acre of riparian vegetation on North St. Vrain Creek that could provide habitat for northern leopard frog and common gartersnake. Projected minor changes in streamflow below the reservoir would not measurably affect riparian vegetation or habitat for leopard frog or gartersnake. No peregrine falcon habitat would be affected. Potential Townsend's big-eared bat habitat could be impacted if rocky areas bordering the reservoir are inundated.

CNHP Species

Yellow stonecrop, the host plant for the butterfly Moss' elfin, could potentially occur within the area of inundation, although habitat for the stonecrop is marginal.

Migratory Birds and Raptors

Reservoir expansion would inundate potential foraging and nesting habitat for some migratory birds, primarily tree-nesting birds. No known raptor nests would be affected, but suitable habitat is present for northern goshawk, Cooper's hawk, flammulated owl, and red-tailed hawk. There would be no impact to any existing bald eagle nesting or roosting sites. Reservoir drawdown during construction would temporarily reduce bald eagle foraging opportunities. Bald eagle, osprey and waterfowl would benefit slightly from a larger reservoir.

Large Game and Other Wildlife

Ralph Price Reservoir expansion would result in a permanent loss of about 77 acres of elk winter range, including 4 acres of elk winter concentration area. The same amount of mule deer summer and winter range and overall range for white-tailed deer, black bear, and mountain lion would also be lost. No areas of severe winter range, which is the most critical to large game would be affected. Winter range for elk and mule deer is widespread throughout Boulder County; thus, populations of these big game species are unlikely to be adversely affected by the habitat loss. No seasonal ranges for black bear or mountain lion would be affected. Additional temporary effects to big game habitat are possible if borrow areas outside the reservoir footprint are needed. The expansion of the existing reservoir would not substantially affect wildlife movement or fragment habitat.

Other wildlife species potentially displaced with reservoir expansion include coyote, red fox, cottontail rabbit and species common in ponderosa pine and Douglas-fir habitat such as long-eared myotis, porcupine, rock squirrel, northern rock mouse, southern red-backed vole, and Mexican woodrat.

3.12.2.5 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

State Threatened, Endangered and Species of Concern

The loss of about 2.5 acres of wetland and creek habitat from reservoir construction would affect potential northern leopard frog habitat. A leopard frog was observed along Dry Creek and similar, but lower quality habitat is present at Chimney Hollow. Common gartersnake, which also uses wetland habitat as well as mesic woodlands and shrublands, also could be affected by the loss of about 50 acres of suitable habitat. Replacement of lost wetland habitat and natural riparian development around the new reservoir would offset some of the lost habitat for leopard frog and gartersnake.

> Construction of Chimney Hollow Reservoir would impact potential habitat for two state species of concern — the northern leopard frog and the common gartersnake. Habitat for several CNHP butterfly species also would be impacted.

The loss of grassland and shrubland habitat would reduce habitat for potential prey species of ferruginous hawk and peregrine falcon that may occasionally forage or migrate over this area. This alternative is unlikely to adversely affect these species because of the lack of documented breeding activity in the area and the availability of alternative prey nearby. Potential nest habitat for peregrines on the hogback east of Chimney Hollow would not be affected. The Chimney Hollow site contains limited potential habitat at the periphery of the Townsend's big-eared bat's range and there are no records of occurrence.

CNHP Species

Suitable habitat for several butterfly species would be affected by construction of Chimney Hollow Reservoir and facilities. There would be a loss of about 390 acres of native grassland and shrubland habitat that contains areas of blue grama grass used by simius road skipper and rhesus skipper. Argos skipper, dusted skipper, ottoe skipper, and cross-line skipper use big bluestem and little bluestem grassland habitat. There would be a loss of ponderosa pine and native grassland habitat where scattered patches of these grasses are present. The loss of about 270 acres of shrublands would affect potential habitat used by mottled duskywing.

Migratory Birds and Raptors

Construction of Chimney Hollow Reservoir would affect nesting and foraging habitat for several migratory birds and raptors. There would be a permanent loss of about 400 acres of upland forest and shrub habitat, in which raptors such as Swainson's hawk and red-tailed hawk and other species such as black-billed magpie and American crow could nest. The loss of 40 acres of mesic native woodland habitat and riparian areas along Chimney Hollow would reduce potential foraging and breeding habitat for migratory bird species such as American robin, red-winged and yellow-headed blackbirds, and Bullock's oriole. Inundation or disturbance of about 340 acres of upland and mesic grassland habitat would reduce habitat for ground-nesting species such as killdeer, mourning dove, and western meadowlark. The loss of habitat would displace species that have historically nested in these habitats.

The disturbance of about 150 acres of various habitats from pipeline construction, staging areas, and other temporary activities would have a short-term effect on potential bird habitat until sites are revegetated. Clearing of about 43 acres of forest under the transmission line would reduce available habitat for tree- and cavity-nesting birds. Western would design the transmission line in conformance with *Suggested Practices for Protection of Raptors on Power Lines* (APLIC 1994) and *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006* (APLIC 2006).

Approximately 7 acres of bald eagle winter range would be disturbed from construction of a southern access road. This road would be located within an existing transmission line maintenance road and may be partially reclaimed following construction. The new reservoir would result in a beneficial long-term effect to bald eagles by creating open water foraging habitat once a fish population is established. The loss of bald eagle winter range would have a minor effect, while the construction of new open water habitat would have a long-term beneficial effect by providing eagle foraging habitat.

There would be no direct effect on golden eagle nest sites located on the hogback ridge to the east, although foraging habitat would be reduced with the loss of terrestrial habitat that supports small mammal prey species. Noise and visual disturbance during construction could affect normal behavior of golden eagles during the breeding season; however, all construction would be outside CDPW's recommended ¼-mile buffer. No known raptor nests would be affected, but the loss of riparian woodlands along the Chimney Hollow drainage would eliminate potential nest and roost sites for raptors and other birds.

Osprey, and waterfowl, such as mallard, double-crested cormorant, and gadwall, would benefit from additional open water habitat.

Large Game and Other Wildlife

> Construction of Chimney Hollow Reservoir would result in a loss of about 810 acres of elk and mule deer winter range, and a loss of a black bear fall concentration area. Habitat for foraging and nesting migratory birds and raptors also would be affected. The new reservoir would provide suitable habitat for waterfowl, bald eagles, and osprey.

There would be a permanent loss of about 810 acres of elk winter range, mule deer winter range and concentration areas and mule deer summer range from reservoir construction. Loss of winter range would reduce the availability of forage and increase competition for limited forage resources during winter. The loss of elk and mule deer winter range represents about a 0.2 percent loss of available winter range within CDPW Game Management Unit 20, which encompasses Larimer County and northern Boulder County. The Chimney Hollow study area occurs within the overall range of white-tailed deer, but there would be no effect to winter or summer ranges.

There would be a loss of about 810 acres of black bear fall concentration area, which would reduce foraging opportunities. The loss of foraging would be offset partially by increased opportunities to forage on fish and waterfowl attracted to reservoirs. There would be no effect to mountain lion seasonal ranges. Expansion of existing mountain lion/human conflict areas north of the reservoir site and black bear/human conflict areas near Carter Lake is possible with planned recreation activity in the area.

A new reservoir in the Chimney Hollow valley would fragment existing habitat for some mammals. Elk winter range and black bear fall concentration areas on the east side of Chimney Hollow may be more difficult to access due to the new reservoir and topographic constraints. Although no designated migration corridors for big game would be disrupted, Chimney Hollow Reservoir would alter local movement patterns by deer, elk, and other wildlife. Other common mammals that would be displaced include coyote, red fox, cottontail rabbit, long-eared myotis, rock squirrel, northern rock mouse, Mexican woodrat, and other small mammals.

3.12.2.6 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Construction of a 70,000 AF Chimney Hollow Reservoir would have effects to wildlife similar to those described for Alternative 2; however, the permanent loss of terrestrial habitat would decrease to about 670 acres and the temporary effect would be about 145 acres. Specific differences include a slight reduction in the loss of wetland and water habitat potentially used by northern leopard frog and common gartersnake. There would be a loss of about 675 acres of elk winter range, mule deer summer, winter, winter concentration areas, and black bear fall concentration areas. Impacts to bald eagles and golden eagles during construction would be the same as Alternative 2.

The following discussion pertains to the effect from construction of Jasper East Reservoir.

State Threatened, Endangered and Species of Concern

The Jasper East Reservoir site does not contain quality habitat for boreal toad, wood frog, and northern leopard frog and none were found in field surveys, but there would be a loss of about 22 acres of potential habitat in wetlands and waters. There would be no effect to potential breeding habitat for ferruginous hawks, which may migrate through the area in the winter, or to peregrine falcons that are not known to nest in Grand County. The loss of hayfields and wetlands is unlikely to adversely affect sandhill crane, which prefers grain fields with better forage and nesting habitat that is not mowed. There would be a loss of about 125 acres of native sagebrush shrublands and a temporary impact on 35 acres that could provide habitat for greater sage grouse. There would be no effect to any known sage grouse populations, but the loss of potentially suitable habitat could affect eastward expansion of a sage grouse population located west of Jasper East.

CNHP Species

The loss of sagebrush habitat would reduce suitable foraging habitat for the sage sparrow, which may migrate through the area.

Migratory Birds and Raptors

The loss of about 190 acres of grasslands and 129 acres of shrublands would reduce available foraging and nesting habitat for birds such as spotted towhee, savannah sparrow, and other ground-nesting birds. The loss of about 14 acres of upland forest would reduce habitat for tree- and cavity-nesting species. The disturbance to about 128 acres from pipelines and construction staging would temporarily displace birds from potential foraging and nesting sites.

Road construction would affect about 3 acres of bald eagle winter range, and pipeline construction would temporarily affect about 5 acres of bald eagle winter range. The temporary disturbance of winter range would have a short-term minor effect on bald eagles. Construction of new open water habitat would have a long-term beneficial effect by increasing bald eagle foraging habitat.

There would be no effect to the golden eagle nest site located on a bluff to the east of the Jasper East reservoir site. This alternate nest site was active in 2007, but is more than 1 mile from the reservoir site. No other known raptor nest would be affected. Jasper East Reservoir would provide additional foraging habitat for osprey and waterfowl.

Large Game and Other Wildlife

There would be a loss of about 480 acres of moose and mule deer summer range from construction of Jasper Reservoir. Summer range is not a limiting factor for either of these species, and the loss of a very small portion of summer range would not have any measurable effect on mule deer or moose populations. Relocation of the Willow Creek pump station and canal would affect about 16 acres of moose winter range and winter concentration area. The reservoir would impact about 24 acres of elk winter range. The small loss of these winter ranges would not have any measurable effect on populations; however, there would be a shift in the seasonal movement of some elk that could increase collisions with vehicles along Highway 34. Additional temporary impacts include disturbance of 85 acres of moose and mule deer summer range and 17 acres of elk winter range and concentration area. Overall range for white-tailed deer would be lost.

There would be a loss of about 93 acres and a temporary impact to 19 acres of black bear summer concentration area. No mountain lion seasonal range or concentration areas would be affected. Construction of Jasper East Reservoir would displace some widely dispersed and common wildlife species.

3.12.2.7 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Effects to wildlife for Chimney Hollow Reservoir under Alternative 4 would be the same as Alternative 3. The effects below pertain to Rockwell Reservoir.

State Threatened, Endangered and Species of Concern

Construction of Rockwell Reservoir would result in the loss of about 17 acres of wetland and riparian habitat that potentially could provide habitat for boreal toad, wood frog, and northern leopard frog. The site is geographically separated from other boreal toad populations; therefore, effects are unlikely. Wood frogs are unlikely to be affected because they typically prefer higher elevation marshes that provide better quality habitat than available at Rockwell Reservoir. There would be no effect to potential breeding habitat for ferruginous hawk, which may migrate through the area in the winter, or peregrine falcon, which is not known to nest in Grand County. Sandhill cranes are unlikely to be affected because of a lack of suitable habitat. The loss of about 290 acres of sagebrush habitat within a sage grouse production and brood rearing area would adversely affect a declining sage grouse population.

CNHP Species

The loss of sagebrush habitat would reduce suitable foraging habitat for sage sparrow that may migrate through the area.

Migratory Birds and Raptors

The loss of about 297 acres of shrubland habitat would reduce foraging and nesting habitat for species such as Brewer's sparrow and vesper sparrow. Removal of about 14 acres of lodgepole pine forest would reduce habitat for cavity-nesting species. The loss of about 17 acres of riparian habitat along Rockwell and Mueller Creek would reduce habitat for species such as, pine siskin, white-crowned sparrow, and western wood pewee. Pipeline construction and staging areas would temporarily disturb about 105 acres of potential habitat used by various bird species that use grass and shrubland habitat.

The Rockwell Reservoir pipeline connection to Windy Gap Reservoir in Alternatives 4 and 5 would cross bald eagle winter range and winter concentration areas along the Colorado River. Construction of new open water habitat at Rockwell Reservoir would have a long-term beneficial effect by increasing bald eagle foraging habitat. No known raptor nests would be affected, but suitable foraging habitat is present and forested areas provide roost and perch sites. A new reservoir would provide breeding and foraging habitat for waterfowl and other waterbirds.

Large Game and Other Wildlife

There would be a permanent loss of about 312 acres of summer range for moose and mule deer. Summer range is not a limiting factor for either of these species, and the loss of a very small portion of summer range would not have any measurable effect on mule deer or moose populations. The reservoir would permanently impact about 73 acres of elk winter range and 82 acres of summer range. The loss of elk winter range represents a loss of less than 0.1 percent of available winter range within CDPW Game management Unit 18 in Grand County. Loss of this habitat could locally displace elk onto adjoining private property, increasing game damage conflicts. Temporary disturbance to 56 acres of elk summer range and 9 acres of elk winter range would occur at borrow areas and along the pipeline route. Overall range for white-tailed deer would be lost. There would be no impact to black bear or mountain lion seasonal ranges, although these species may use habitat in the area. Reservoir construction would displace widely dispersed wildlife species such as coyote, gray fox, and black-tailed jack rabbit, and striped skunk.

3.12.2.8 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

The effect to wildlife resources from construction of a 30,000 AF Rockwell Reservoir would be similar, but slightly greater than those described for the smaller reservoir in Alternative 4. There would be a permanent loss of about 390 acres wildlife habitat and a temporary loss of about 69 acres of wildlife habitat. Key differences include a permanent impact to 334 acres of sage grouse breeding and brood rearing habitat, which would affect the existing population. The loss of moose and mule deer summer range would increase to about 393 acres and about 97 acres of elk winter range would be lost. The loss of elk winter range represents about 0.15 percent of the available winter range in CDPW Game Management Unit 18 in Grand County.

The remainder of this section discusses effects to wildlife from construction of Dry Creek Reservoir.

State Threatened, Endangered and Species of Concern

The loss of about 8.5 acres or wetland and water habitat from Dry Creek Reservoir construction would affect known northern leopard frog habitat. Common gartersnake, which also uses wetland habitat as well as mesic woodlands and shrublands, also could be affected by the loss of about 30 acres of suitable habitat. Replacement of lost wetland habitat and riparian development around the new reservoir could potentially offset some of the lost habitat for leopard frog and gartersnake.

The loss of grassland and shrubland habitat would reduce potential foraging habitat for ferruginous hawk and peregrine falcon. Potential nesting, migration, and roosting habitat for peregrines on the hogback east of Dry Creek would not be affected. The loss of potential foraging habitat is unlikely to adversely affect these species because of the lack of documented activity in the area. The Dry Creek site contains limited potential habitat at the periphery of the Townsend's big-eared bat's range, but there are no records of this species' occurrence in the study area.

CNHP Species

Suitable habitat for several butterfly species would be affected by construction of Dry Creek Reservoir and facilities. There would be loss of about 239 acres of native grassland and shrubland habitat that contains areas of blue grama grass used by simius road skipper and rhesus skipper. Argos skipper, dusted skipper, ottoe skipper, and cross-line skipper habitat would be affected by the loss of ponderosa pine and native grasslands that contain areas of big bluestem and little bluestem grasses. The loss of about 162 acres of shrublands would affect potential habitat used by mottled duskywing.

Migratory Birds and Raptors

Construction of Dry Creek Reservoir would affect nesting and foraging habitat for several migratory birds and raptors. A permanent loss of about 200 acres of ponderosa pine forest would reduce available habitat for American crow, pygmy nuthatch, Steller's jay, and other forest-nesting species. The loss of about 400 acres of shrubland and grassland would affect habitat used by western meadowlark, morning dove, savannah sparrow, and other ground-nesting birds. The loss of about 30 acres of woodlands and wetlands along Dry Creek would affect potential habitat for raptors, magpies, robins, goldfinch, and a variety of small birds. A red-tailed hawk nest located along Dry Creek would be lost. There would be no effect to a golden eagle nest located more than 3 miles away on the hogback to the east, although there would be loss of foraging habitat.

There would be a permanent impact to about 165 acres of bald eagle winter range and temporary disturbance of 40 acres of winter range. Construction of the spillway would affect less than 1 acre of bald eagle winter concentration area. The loss of winter range would reduce terrestrial habitat for bald eagle foraging while the construction of a new reservoir would have a long-term beneficial effect by creating open water foraging habitat.

The disturbance of about 158 acres of various habitats from pipeline construction, staging areas, and other temporary activities would have a short-term effect on potential bird habitat until sites are revegetated.

Osprey and waterfowl such as mallard, double-crested cormorant, and gadwall would benefit from additional open water habitat.

Large Game and Other Wildlife

About 650 acres of elk winter range, mule deer summer range, and mule deer winter range and winter concentration areas would be lost permanently. The loss of this small portion of the overall available winter range would not have any measurable effect on elk or mule deer populations. The loss of elk and mule deer winter range represents a loss of less than 0.2 percent of available winter range within CDPW Game Management Unit 20, which encompasses southern Larimer County and portions of northern Boulder County. Pipeline construction and construction staging would temporarily impact approximately 158 acres of elk winter range, mule deer summer range, and mule deer winter range and winter concentration areas. White-tailed deer overall range would be impacted, but no seasonal ranges would be affected.

There would be a permanent impact to 619 acres of black bear fall concentration area and overall mountain lion range. The loss of this small portion of the overall available range would not have a measurable effect on bear populations. Temporary impacts would occur to about 69 acres of black bear fall concentration area. Human conflict areas for black bear and mountain lions are possible if recreation use is developed at Dry Creek Reservoir.

Other common mammals that would be displaced include coyote, red fox and cottontail rabbit, as well as species endemic to ponderosa pine habitats, such as long-eared myotis, rock squirrel, northern rock mouse, Mexican woodrat, and other small mammals.

3.12.3 Cumulative Effects

Cumulative effects to wildlife focused on the loss or change in habitat associated with reasonably foreseeable land-based developments within 5 miles of each of the alternative reservoir locations (Figures 2-15 and 2-16). A 5-mile analysis area was used because many species of wildlife use a range of habitats over a wide area. Use of a broad study area provides an indication of the cumulative regional impact to wildlife within about an 80 square mile area surrounding each alternative reservoir site. Indirect effects to terrestrial wildlife from water-based reasonably foreseeable actions are not expected to measurably affect riparian vegetation that provides habitat for some wildlife species as discussed in Section 3.12.2.3. Potential cumulative effects to wildlife are discussed for each alternative.

Alternative 1—Ralph Price Reservoir (No Action)

Wildlife habitat near Ralph Price Reservoir has been affected by the original reservoir construction, which inundated about 1.5 miles of North St. Vrain Creek and adjacent upland habitat and created about 220 acres of open water habitat. No reasonably foreseeable actions were identified within 5 miles of the reservoir that would result in a cumulative effect to wildlife.

Alternative 2—Chimney Hollow Reservoir (Proposed Action)

Wildlife resources and habitat near the Chimney Hollow Reservoir have been affected by historical livestock operations and nearby land development such as construction of Carter Lake, Flatiron Reservoir, and other C-BT facilities, Bureau of Reclamation offices, rural residential development, and roads. Reasonably foreseeable future development includes about 1,440 acres of primarily residential development and other surface disturbances within about 5 miles of the Chimney Hollow Reservoir site (Figure 2-16). In addition to construction of Chimney Hollow Reservoir, these developments would result in a cumulative effect to about 2,240 acres of terrestrial wildlife habitat. Reasonably foreseeable future land developments are unlikely to completely eliminate existing wildlife habitat, but a reduction in wildlife value for some species is likely.

A cumulative loss of potentially suitable habitat for state species of concern—northern leopard frog and common gartersnake—is possible if riparian habitat is affected at future developments. The loss of grasslands at future developments could reduce potential foraging habitat for ferruginous hawk. A cumulative effect to other state species is unlikely because no suitable habitat to support these species is present in the region or there would be no effect on these specific species from construction of Chimney Hollow Reservoir.

Reasonably foreseeable land developments near Chimney Hollow Reservoir would affect about 66 acres of elk winter range. The loss of about 800 acres of elk winter range with construction of Chimney Hollow Reservoir would result in a cumulative regional loss of about 866 acres of winter foraging habitat for elk. The loss of elk winter range represents about a 0.2 percent impact on available winter range within CDPW Game Management Unit 20. Cumulative effects to mule deer winter range and winter concentration areas would include a loss of 800 acres from construction of Chimney Hollow Reservoir and an impact of about 1,290 acres from reasonably foreseeable land developments for total cumulative effect of about 2,090 acres. This represents a cumulative effect to about 0.6 percent of available mule deer winter range within CDPW Game Management Unit 20.

Reasonably foreseeable future developments within about 5 miles of Chimney Hollow Reservoir could affect about 1,375 acres of bald eagle winter range. This, in addition to the loss of 7 acres of winter range from construction of Chimney Hollow Reservoir and facilities under the Proposed Action, would result in a cumulative impact to about 1,382 acres of bald eagle winter range.

The cumulative loss of undeveloped upland areas would reduce available habitat for migratory birds, particularly ground- nesting species. There would be a cumulative loss of terrestrial nongame wildlife habitat for small and medium sized mammals. The cumulative loss and change in wildlife habitat would fragment wildlife habitat, which could disrupt animal travel corridors, reduce available foraging and breeding habitat, and displace some wildlife species.

Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Chimney Hollow. Construction of a 70,000 AF Chimney Hollow Reservoir would result in a cumulative loss of terrestrial wildlife habitat of about 2,115 acres. This includes the loss of about 675 acres from construction of the reservoir, dam, and spillway and 1,440 acres of reasonably foreseeable land development within 5 miles of the reservoir site. The potential effects to wildlife would be similar to Alternative 2. The cumulative loss of elk winter range would be about 741 acres of elk winter range including the loss of 675 acres with construction of Chimney Hollow Reservoir and 66 acres from reasonably foreseeable developments. Cumulative effects to mule deer winter range and winter concentration areas would include a loss of 675 acres from construction of Chimney Hollow Reservoir and an impact of about 1,290 acres from reasonably foreseeable land developments in the region for a total cumulative effect of about 1,965 acres.

A 70,000 AF Chimney Hollow Reservoir would result in a loss of bald eagle winter range similar to Alternative 2 and a cumulative increase in open water foraging habitat of about 625 acres.

Jasper East. Wildlife habitat at the Jasper East Reservoir site has been influenced by irrigation and mowing of pasture lands, construction of the Willow Creek Canal, pump station, and forebay, and the presence of County Road 40, which bisects the property. Reasonably foreseeable future development within about 5 miles of the Jasper East Reservoir site includes about 1,590 acres of land development southwest of the Town of Granby and 980 acres of planned residential development at the C-Lazy-U Preserves located just north of the reservoir site. The cumulative effect to terrestrial wildlife habitat from construction of an approximately 485-acre Jasper East Reservoir and future land development would total about 3,005 acres. However, some developments such as the C-Lazy-U Preserve include areas of undisturbed open space that would continue to provide habitat value for wildlife.

A cumulative loss of potentially suitable habitat for sage grouse is possible from the loss of about 125 acres of sagebrush habitat at Jasper East in addition to an unknown loss of sagebrush from future development at C-Lazy-U Preserve.

Cumulative impacts to elk winter range include the loss of about 24 acres from reservoir construction and 1,230 acres from future land development. This represents a cumulative impact to about 1.5 percent of available elk winter range in Game Management Unit 18. The cumulative effect to moose winter range would be about 327 acres—16 acres from construction of Jasper East Reservoir and 311 acres from nearby future land developments. The cumulative effect to moose winter range would be about 1.2 percent of available range in Game Management Unit 18.

Reasonably foreseeable future land development south of Jasper East Reservoir could affect about 222 acres of bald eagle winter range including 55 acres of winter concentration area. Construction of Jasper East Reservoir would add about 3 acres to the cumulative effect on bald eagle winter range.

There would be a cumulative loss of terrestrial nongame wildlife habitat including potential fragmentation of wildlife habitat, which could disrupt animal travel corridors, reduce available foraging and breeding habitat, and displace some wildlife species

Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Chimney Hollow. The cumulative effect to wildlife resources at Chimney Hollow Reservoir under this alternative would be the same as described for Alternative 3.

Rockwell. Wildlife habitat in the 20,000 AF Rockwell Reservoir site has been affected in the past by low density residential housing, roads, and livestock grazing. Reasonably foreseeable future development within about 5 miles of the Rockwell Reservoir site includes residential, commercial, and mixed development at Grand Elk and Granby Ranch. Future development encompasses areas of existing development, but further infill of these lands is expected. The total cumulative regional effect on terrestrial wildlife habitat including reasonably foreseeable land development and construction of Rockwell Reservoir would be about 5,105 acres. This includes the loss of about 335 acres from construction of the reservoir, dam, and spillway and 4,770 acres of reasonably foreseeable land development.

There would be a cumulative impact to about 740 acres of sage grouse production area consisting of the loss of about 290 acres from construction of Rockwell Reservoir and 450 acres from other reasonably foreseeable actions. The cumulative loss of sage grouse habitat could result in the complete loss of this declining population. A cumulative effect to other state species is unlikely because no suitable habitat is present in the region or there would be no effect from construction of Rockwell Reservoir.

A cumulative loss in elk winter range of about 3,173 acres would occur from the loss of about 73 acres from construction of Rockwell Reservoir and 3,100 acres from development on nearby lands. The cumulative impact to elk winter range would affect about 4.1 percent of the available winter range in Game Management Unit 18.

The Rockwell Reservoir pipeline to Windy Gap Reservoir would temporarily affect a bald eagle winter concentration area, but would not add to any permanent cumulative effects from other land developments in the region. Much of the land within areas of reasonably foreseeable future development has already been disturbed, although additional development would further reduce these lands' suitability for wildlife use. Construction of Rockwell Reservoir site would contribute to the loss of upland terrestrial habitat, but would provide open water habitat for waterfowl and foraging habitat for bald eagles and osprey.

Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Dry Creek. The Dry Creek Reservoir site is mostly undeveloped land and currently supports a few scattered homes, unpaved roads, and a small llama ranch. Historically, livestock grazing also influenced the condition of the area. Reasonably foreseeable actions within about 5 miles of Dry Creek Reservoir would be about 1,460 acres of land that is under county development review for subdivision, dispersed residential development, commercial development, and/or special review for a proposed change in land use.

The total cumulative impact to terrestrial wildlife habitat would be about 2,091 acres. This consists of the loss of about 630 acres from construction of the Dry Creek Reservoir, dam, and spillway and 1,460 acres of reasonably foreseeable land development. Dry Creek Reservoir would provide about 590 acres of open water habitat for waterfowl, shore birds, bald eagles, and aquatic species. Future land developments are unlikely to completely eliminate existing wildlife habitat, but a reduction in wildlife value for some species is likely.

A cumulative loss of habitat for two state species of concern—northern leopard frog and common gartersnake—is possible if riparian habitat is affected at future developments. The loss of grasslands at future developments could reduce potential foraging habitat for ferruginous hawk. A cumulative effect to other state species is unlikely because no suitable habitat is present in the region or there would be no effect from construction of Dry Creek Reservoir.

The cumulative loss of undeveloped upland areas would reduce available habitat for migratory birds and in particular ground-nesting species because most of the reasonably foreseeable land development would be in open grasslands.

Cumulative effects to elk winter range would be 630 acres from construction of Dry Creek Reservoir and 52 acres from reasonably foreseeable land development for a total impact of about 682 acres. The loss of elk winter range represents less than a 0.2 percent impact on available winter range within CDPW Game Management Unit 20. The cumulative effect on mule deer winter range and concentration areas would be about 1,934 acres consisting of impacts of 630 acres from reservoir construction and 1,304 acres from future development. This represents a cumulative effect to about 0.5 percent of available mule deer winter range within CDPW Game Management Unit 20.

Reasonably foreseeable land developments near Dry Creek Reservoir could affect about 1,409 acres of bald eagle winter range. Construction of Dry Creek Reservoir would add 165 acres of impact to bald eagle winter range for a cumulative effect of 1,574 acres.

The cumulative loss of terrestrial habitat for wildlife in the region would reduce available foraging and breeding habitat for upland species, as well as fragmenting existing areas of available wildlife habitat.

Rockwell. Construction of a 30,000 AF Rockwell Reservoir would result in a cumulative impact to about 5,196 acres of terrestrial wildlife habitat from about 4,770 acres of reasonably foreseeable land development and the 425-acre Rockwell Reservoir.

There would be a cumulative impact to about 784 acres of sage grouse production area from the 334 acres lost from reservoir construction and 450 acres potentially disturbed by other reasonably foreseeable actions. This accounts for more than 12 percent of the greater sage grouse habitat surrounding the Linke Lek. The cumulative loss of sage grouse habitat could result in the complete loss of this declining population.

A cumulative loss in elk winter range of about 3,197 acres would occur from the loss of about 97 acres at Rockwell Reservoir and from development of 3,100 acres on nearby lands. The cumulative loss in elk winter range would affect about 4.5 percent of the available winter range in Game Management Unit 18.

The Rockwell Reservoir pipeline to Windy Gap Reservoir would temporarily affect a bald eagle winter concentration area, but would not add to any permanent cumulative effects from other land developments in the region.

3.12.4 Wildlife Mitigation

In accordance with the requirements of CRS § 37-60-122.2, the Subdistrict prepared a FWMP (Appendix E) in cooperation with the CDPW to develop specific mitigation measures for the identified impacts of the Proposed Action. The following measures from the FWMP address wildlife habitat mitigation at the Chimney Hollow Reservoir site and have been adopted by the Colorado Wildlife Commission and the CWCB. The Subdistrict would develop a plan to replace the values provided by habitat lost or altered by construction of Chimney Hollow Reservoir. Mitigation of impacts to wildlife resources will involve a combination of mitigation strategies and tools, as described below.

3.12.4.1 Restoration of Temporary Disturbances

The temporary loss of 123 acres of wildlife habitat will be mitigated through reclamation and revegetation of all habitats disturbed during construction and relocation of the transmission line and towers. The temporary loss of vegetation communities due to construction of dams, pipelines, staging, and access roads will be restored with plantings and seed mixes that replicate the vegetation cover types. Vegetation restoration of the transmission line corridor will involve working closely with Western to incorporate strategies for maintenance of stable low-growing vegetative communities that include mechanical cutting, removal of timber, on-site treatment of slash, and planting sustainable, low-growing shrubs and grasses. Plantings and seed mixes will focus on restoring diverse vegetation communities that provide wildlife forage, particularly during fall and winter. A reclamation plan will be developed as part of the construction program and the SMP.

3.12.4.2 Habitat Enhancement

The Subdistrict will work with Larimer County to develop a land management plan that will include habitat enhancement of vegetation communities surrounding Chimney Hollow Reservoir, which involves planting native species beneficial to wildlife where appropriate. The Subdistrict will provide $50,000 to Larimer County to use in their ongoing habitat management plan. A weed control plan would be developed in cooperation with Larimer County prior to implementing habitat enhancement to improve the quality of lands not specifically within the areas of vegetation enhancement. Weed management would focus on monitoring restored habitats and implementing an integrated weed management approach of mechanical, chemical, and biological control strategies. Integrated weed management strategies also will be used to control existing areas of noxious and invasive species, particularly large patches of thistle and cheatgrass. The weed management plan will be developed prior to construction disturbances and will be updated periodically through implementation of wildlife enhancement.

3.12.4.3 Hunting Opportunities

Larimer County will develop a management plan for the Chimney Hollow area. As part of this process, the Subdistrict and Larimer County will work with CDPW and Larimer County to explore opportunities to provide seasonal hunting on portions of the Chimney Hollow Reservoir site and open space to assist with game management and provide additional recreation.

3.12.4.4 Minimization of Human-Wildlife Conflicts

The displacement of elk and bear into surrounding residential areas as they search for lost food resources will be offset by the habitat enhancement activities and hunting opportunities described above. Additionally, the Subdistrict will work with Larimer County and CDPW to reduce/eliminate wildlife attractants from recreation facilities and establish education/outreach programs and information kiosks/signs informing the public on the dangers of close interactions with wildlife, and methods to avoid and minimize potentially dangerous encounters.

3.12.4.5 Implementing Migratory Bird Avoidance Plan

The active nesting season for most migratory bird species in Colorado is between April 1 and August 15. Over the past few years, FWS and CDPW have suggested that the best way to avoid a violation of the MBTA is to remove vegetation outside of the active breeding season. The Subdistrict will develop BMPs in accordance with CDPW guidance to avoid disturbing active bird nests at the Chimney Hollow Reservoir site. Note: Implementing these BMPs demonstrates a good faith effort to avoid incidental violation of the MBTA, but does not guarantee that migratory birds will not still nest in some areas despite these efforts.

3.12.4.6 Seasonal Restrictions and Buffer Zones for Raptors

Avoidance and mitigation options for nesting raptors at the Chimney Hollow Reservoir site consists of: 1) conducting nest surveys prior to construction, 2) establishing reasonable site-specific buffers and seasonal restrictions, 3) implementing seasonal restrictions to avoid and minimize disturbance, and 4) removing inactive nests from the transmission line corridor, construction footprints, reservoir pool area, or other areas of permanent impacts. Currently, there are no expected permanent impacts to existing raptor nests; however, there is the possibility that a new active raptor nest could be established in areas slated for disturbance or inundation. The intent of any mitigation is to encourage individual raptor pairs to nest at selected and more secure locations. BMPs will be developed in accordance with CDPW guidance to avoid, minimize, and mitigate potential impacts.

3.12.5 Unavoidable Adverse Effects

All alternatives would result in the unavoidable loss of terrestrial wildlife habitat from dam construction, inundation, and other surface facilities. There would be a loss in habitat for state threatened, endangered, and species of concern, CNHP species, migratory birds, raptors, big game, and other wildlife. Temporary disturbances would reduce the quality of vegetation and wildlife habitat until restoration is complete. Construction-related activity would temporarily displace some wildlife from adjacent lands. Creation of new or additional open water habitat would benefit waterfowl, some raptors, amphibians, and would create opportunities for enhancement and protection of habitat.

3.13 Threatened and Endangered Species

3.13.1 Affected Environment

3.13.1.1 Regulatory Framework

Federally threatened and endangered species are protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). A potential effect to a federally listed species or its designated critical habitat resulting from a project with a federal action requires consultation with the FWS under Section 7 of the ESA. Consultations are not required for effects to candidate species; however, if a species were to become listed during project planning or construction, consultation with the FWS would be required for the newly listed species.

3.13.1.2 Area of Potential Effect

The study area for evaluating potential direct effects to threatened and endangered plants and wildlife includes the reservoir sites and related pipelines, roads, and infrastructure. In addition, because some wildlife species use a variety of habitats and have a wide range of movement, the study areas include lands surrounding reservoir sites and project facilities, or downstream areas that could be directly or indirectly affected by changes in hydrology or water quality.

3.13.1.3 Data Sources

Information on threatened or endangered species potentially occurring in the study areas was taken from the Boulder, Larimer, and Grand counties lists of endangered species maintained by the FWS (2010). Other data sources for evaluating the occurrence of species and potentially suitable habitat included published reports, database searches of the Colorado Natural Diversity Information Source and CNHP. Information was also obtained through consultations with the FWS and CDPW. Field investigations were conducted to evaluate habitat suitability, and for some species field surveys were conducted to determine if a species was present. No field investigation was conducted at Rockwell Reservoir because access to the privately owned property was denied. Additional information on threatened and endangered species is found in the Wildlife Resources Technical Report (ERO 2007b), the Aquatic Resources Technical Report (Miller Ecological Consultants 2010), and the Vegetation Resources Technical Report (ERO 2007a).

3.13.1.4 Federally Threatened and Endangered Species

Federally listed threatened and endangered species identified by the FWS as potentially occurring in Boulder, Larimer, and Grand counties are shown in Table 3-135. Habitat suitability, survey, and other sources of data were used to determine whether any of these species are within the area of potential effect for each alternative. Potential Canada lynx habitat is found near the Rockwell Reservoir site and potential habitat for the Colorado butterfly plant is found at Chimney Hollow and Dry Creek reservoirs. Osterhout milkvetch and Penland beardtongue are endangered plant species with potential habitat on the West Slope. Threatened and endangered fish species in the Colorado River are located downstream near Rifle. The following sections provide a brief description for each of the species and potential presence in the study areas.

Interior Least Tern, Piping Plover, Whooping Crane, Pallid Sturgeon, Western Prairie Fringed Orchid

The interior least tern, piping plover, and whooping crane seasonally use habitat along the Platte River in Nebraska. Western prairie fringed orchid is found in wet meadow habitat including the Platte River floodplain in Nebraska. Pallid sturgeon also is found in the Missouri River downstream from the East Slope study area. These species are potentially affected by water depletions in the South Platte River basin. All of the WGFP alternatives import water from the West Slope to the East Slope; therefore, there would be no depletion to streamflows in the Platte River that would affect piping plover, least tern, whooping crane, western prairie fringed orchid, or pallid sturgeon. A negligible increase in flows in the Platte River are possible from return flows after WGFP water is used; however, Windy Gap water is reusable to extinction and most WGFP Participants have plans to reuse the water in some capacity and, therefore, any appreciable increase in Platte River flows is unlikely.

Table 3-135. Federally listed threatened and endangered species in Boulder, Larimer, and Grand counties potentially occurring in the study areas or downstream.

Common Name	Federal Status	Suitable Habitat in the Area of Potential Effect				
		Ralph Price	Chimney Hollow	Dry Creek	Jasper East	Rockwell
BIRDS						
Interior least tern[1]	Endangered	N	N	N	N	N
Piping plover[1]	Threatened	N	N	N	N	N
Whooping crane[1]	Endangered	N	N	N	N	N
Mexican spotted owl	Threatened	N	N	N	N	N
MAMMALS						
Black-footed ferret	Endangered	N	N	N	N	N
Canada lynx	Threatened	N	N	N	N	Y
Preble's meadow jumping mouse	Threatened	N	N	N	N	N
FISH						
Bonytail chub[2]	Endangered	N	N	N	N	N
Colorado pikeminnow[2]	Endangered	N	N	N	N	N
Humpback chub[2]	Endangered	N	N	N	N	N
Razorback sucker[2]	Endangered	N	N	N	N	N
Greenback cutthroat	Threatened	N	N	N	N	N
Pallid sturgeon[1]	Endangered	N	N	N	N	N
PLANTS						
Ute ladies'- tresses orchid	Threatened	N	N	N	N	N
Colorado butterfly plant	Threatened	Y	Y	Y	Y	Y
Osterhout milkvetch	Endangered	N	N	N	N	N
Penland beardtongue	Endangered	N	N	N	N	N
Western prairie fringed orchid[1]	Threatened	N	N	N	N	N

[1] Water depletions in the South Platte River may affect the species and/or critical habitat in downstream reaches in other states.
[2] Water depletions in the Upper Colorado River and may affect the species and/or critical habitat in downstream reaches.

Mexican Spotted Owl

Mexican spotted owl typically inhabits areas with steep, exposed cliffs and canyons that are characterized by piñon-juniper and old-growth forests interspersed with Douglas-fir, ponderosa pine, and white fir (Andrews and Righter 1992). No critical habitat has been designated in Boulder, Larimer, or Grand County (66 FR 8530).

No suitable habitat or documented observations of Mexican spotted owl are reported for Ralph Price, Chimney Hollow, or Dry Creek Reservoir study area. Chimney Hollow and Dry Creek reservoir sites do not contain old growth coniferous forests typically favored by this species. Although mixed Douglas-fir and ponderosa pine forests surround Ralph Price Reservoir, the only recorded occurrence of a Mexican spotted owl was 8 miles south of Ralph Price Reservoir (BCAS 2005).

The Jasper East and Rockwell Reservoir study areas do not contain suitable old growth Douglas-fir and ponderosa pine forests or rocky cliffs that this species typically inhabits. Mexican spotted owl has never been recorded in this portion of the state (Andrews and Righter 1992).

Black-footed Ferret

The black-footed ferret is associated with prairie dog colonies because it depends on prairie dogs for food and shelter. No prairie dog colonies are present within the study areas for any alternative.

Canada Lynx

Canada lynx (lynx) in Colorado typically forage in spruce/fir forests surrounded by lodgepole pine, with uneven-aged stands, open canopies, and mature understories at higher elevations. The lynx's foraging and denning habitat closely follows that of the snowshoe hare—the primary food source in Colorado, although alternative prey including grouse, voles, and squirrels will be taken (Fitzgerald et al. 1994; Ruggiero et al. 2000; NatureServe 2006). Lynx rarely venture into open nonforested areas wider than 300 feet (Ruggiero et al. 2000).

The Chimney Hollow, Dry Creek, and Ralph Price Reservoir study areas are located below the known lower elevation limits for lynx.

The western side of the Rockwell Reservoir study area and adjacent lands to the west have been identified by the CNDIS (2006) as potential lynx habitat. Lynx could occasionally visit the site, but the area contains limited coniferous forest habitat that lynx typically favors. The study area does not contain habitat for the snowshoe hare, the lynx's primary prey. No designated lynx habitat is present at Jasper East Reservoir, but nearby lands to the north and west provide potential habitat. Lynx could occasionally travel through the Jasper East Reservoir study area; however, suitable foraging and denning habitat is not present, the area lacks suitable habitat for snowshoe hare, and contains large open meadows that lynx typically avoid.

Preble's Meadow Jumping Mouse

Preble's meadow jumping mouse (Preble's) is typically found in riparian corridors with trees or tall shrubs and low undergrowth, or in wet meadows. Along Colorado's Front Range, Preble's is generally found between 5,000 and 7,600 feet in elevation, generally in lowlands with medium to high moisture along permanent or intermittent streams and irrigation canals (FWS 1999a; Meaney et al. 1997). There is no designated critical habitat within or downstream of any of the study areas (68 FR 37276).

Ralph Price Reservoir does not contain the shrub and riparian habitat that Preble's typically inhabits and, therefore, is not likely to occur in the area. Preble's have been captured approximately 5 miles downstream of the reservoir near Lyons (FWS 1999a).

Field trapping surveys for Preble's conducted in 1997 (CNHP) and 2000 (ERO) at the Chimney Hollow Reservoir study area did not locate Preble's. Following the 2000 survey, the FWS concluded that a population of Preble's was not likely to be present within the Chimney Hollow Reservoir study area and that development or other actions on the site would not directly affect Preble's. A subsequent habitat evaluation on an additional portion of the Chimney Hollow site determined that no suitable habitat was present in previously surveyed areas or the expanded area (ERO 2003c). The FWS (2003) concurred with the habitat assessment, but requested an additional habitat assessment prior to construction. Reclamation discovered Preble's mouse on Dry Creek (different Dry Creek than the one in Alternative 5) downstream of Flatiron Reservoir, as discussed further in the section below in the section on *Colorado-Big Thompson Project Consultation*.

Trapping surveys at Dry Creek Reservoir did not locate Preble's (ERO 2004c). The FWS (2004) concurred with the negative findings, but requested that the area be surveyed again prior to construction of the reservoir.

The Jasper East Reservoir and Rockwell Reservoir study areas are located out of the known geographic range for Preble's.

Fish

No threatened or endangered fish species are present near potential reservoir sites on the West Slope. However, four endangered fish species—bonytail chub, Colorado pikeminnow, humpback chub, and razorback sucker and associated critical habitat are present downstream from the Windy Gap diversion on the Colorado River below Rifle.

On the East Slope, one threatened species is present in Larimer County and Boulder County, the greenback cutthroat trout. Greenbacks do not occur within the study area, but are generally present in small headwater areas with isolation from other cutthroat species.

Ute Ladies'-Tresses Orchid

Habitat for Ute ladies'-tresses orchid (orchid) typically includes subirrigated alluvial soils along streams, and in open meadows and floodplains (Spackman et al. 1997) at elevations from 4,500 to 6,800 feet.

Although the Chimney Hollow and Dry Creek Reservoir study areas do not meet the FWS orchid survey protocol for Larimer County (areas with suitable habitat along perennial streams (FWS 1992), field surveys were conducted along these two drainages. The orchid was not found at either reservoir site (ERO 2006b).

Ralph Price Reservoir and the Jasper East and Rockwell Reservoir study areas are outside the elevation range for the orchid.

Colorado Butterfly Plant

The Colorado butterfly plant (CBP) is a short-lived perennial herb found in moist areas of floodplains occurring on sub-irrigated, alluvial soils on level or slightly sloping floodplains and drainage bottoms at elevations 5,000 to 6,000 feet (Spackman et al. 1997).

Ralph Price Reservoir is above the elevation range for the CBP.

The riparian areas along Chimney Hollow and Dry Creek provide marginal habitat for the CBP because of grazing, weed infestation, and lack of an active floodplain. No CBP were found during field surveys at the Chimney Hollow or Dry Creek Reservoir (ERO 2007a).

Jasper East and Rockwell reservoirs are outside the elevation range for the CBP.

Osterhout Milkvetch

Osterhout milkvetch occurs in highly seleniferous, grayish brown clay soils derived from shales of the Niobrara, Pierre, and Troublesome formations, often in sagebrush shrublands (Spackman et al. 1997). Osterhout milkvetch was recorded near Jasper East Reservoir in 1961 (CNHP 2004), but field surveys in 2004 did not locate this species. No field surveys were conducted at Rockwell Reservoir because the landowner denied access.

There is no suitable habitat for this species at Ralph Price, Chimney Hollow, or Dry Creek Reservoir.

Penland Beardtongue

Penland beardtongue occurs in strongly seleniferous clay-shales of the Troublesome Formation, in areas with sparse plant cover, often in sagebrush (Spackman et al. 1997). Field surveys at Jasper East Reservoir did not locate this species. No field surveys were conducted at Rockwell Reservoir because the landowner denied access.

There is no suitable habitat for this species at Ralph Price, Chimney Hollow, or Dry Creek Reservoir.

Colorado-Big Thompson Project Consultation

The Eastern Colorado Area Office (ECAO) of Reclamation is currently undergoing separate consultation with the Service on the potential impacts of Reclamation's C-BT Project, which includes the continued operation of the East Slope features of the C-BT Project, on the listed species and habitats not addressed in the Platte River Recovery Program. In 2006, the ECAO contracted to survey all C-BT Project lands below elevations of 7,000 feet msl; this was approximately the elevation of the Pole Hill Power Plant west of Loveland. All fee-owned lands were evaluated for whether they provided potential habitat for the Preble's meadow jumping mouse, Colorado butterfly plant, and Ute ladies'-tresses orchid. All lands associated with the following C-BT features were evaluated: Pole Hill Reservoir and adjacent lands; Pinewood Reservoir and adjacent fee-owned lands; Flatiron Reservoir and adjacent fee-owned lands; Carter Lake and adjacent fee-owned lands; Horsetooth Reservoir and adjacent fee-owned lands; Charles Hansen Feeder Canal – all fee-owned lands adjacent to the canal between Flatiron Reservoir and Horsetooth Reservoir; and St. Vrain and Boulder Creek Supply Canals – all fee-owned lands adjacent to the canals from Carter Lake to Boulder Reservoir. The survey identified nine areas with potential habitat for one or more of the above-listed species. Seven areas were identified as potential habitat for Preble's, two areas for orchid, and one site for CBP. Subsequent discussions with the FWS eliminated several of these parcels as potential habitat because of their size and adjacent disturbances. In 2007 and 2008, two parcels at Pinewood Reservoir and one parcel along the Boulder Feeder Canal were surveyed for orchid and the CBP with negative results. In 2008, one parcel of land near Flatiron Reservoir was surveyed for Preble's with positive results. To verify the results, additional sampling was conducted in 2009 and a population of Preble’s was confirmed. ECAO is in the process of preparing a biological assessment addressing the effects of C-BT Project East Slope facilities on listed species not covered by the Platte River Recovery Program. When completed, the biological assessment will be submitted to the FWS with appropriate recommendations.

3.13.2 Environmental Effects

3.13.2.1 Issues

Public scoping identified concerns about the potential impact to Preble’s meadow jumping mouse, Colorado River endangered fish species from flow changes, and other threatened and endangered species.

3.13.2.2 Methods for Effects Analysis

Potential direct and indirect effects to threatened or endangered species were evaluated for each alternative. Impacts were based on potential effects to known populations or from a loss of suitable habitat. Permanent impacts could occur in areas that are inundated or permanently disturbed by project features such as the dam, access roads, and pump stations. Temporary impacts to habitat could occur in areas that would be reclaimed following construction, such as pipeline routes and staging areas. The following effects discussion focuses on threatened and endangered species with suitable habitat or known presence in the study area for each alternative. Because none of the alternatives would result in a water depletion to the Platte River basin, there would be no effect to downstream threatened and endangered species, such as interior least tern, piping plover, whooping crane, pallid sturgeon, and western prairie fringed orchid. A determination of effect for all species is given in Table 3-136, but only species potentially affected are discussed in greater detail below.

Table 3-136. Summary of effects determination for federally listed threatened and endangered species by alternative.

Species	Alternative 1 No Action	Alternative 2 Proposed Action	Alternative 3	Alternative 4	Alternative 5
	Determination of Potential Effects[1]				
BIRDS					
Interior least tern	No effect	No effect	No effect	No effect	No effect
Mexican spotted owl	No effect	No effect	No effect	No effect	No effect
Piping plover	No effect	No effect	No effect	No effect	No effect
Whooping crane	No effect	No effect	No effect	No effect	No effect
MAMMALS					
Black-footed ferret	No effect	No effect	No effect	No effect	No effect
Canada lynx	No effect	No effect	No effect	May affect	May affect

Species	Alternative 1 No Action	Alternative 2 Proposed Action	Alternative 3	Alternative 4	Alternative 5
	Determination of Potential Effects[1]				
Preble's meadow jumping mouse[2]	No effect	No effect	No effect	No effect	No effect
FISH					
Bonytail chub	Adverse effect	Adverse effect	Adverse effect	Adverse effect	Adverse effect
Colorado pikeminnow	Adverse effect	Adverse effect	Adverse effect	Adverse effect	Adverse effect
Greenback cutthroat trout	No effect	No effect	No effect	No effect	No effect
Humpback chub	Adverse effect	Adverse effect	Adverse effect	Adverse effect	Adverse effect
Razorback sucker	Adverse effect	Adverse effect	Adverse effect	Adverse effect	Adverse effect
Pallid sturgeon	No effect	No effect	No effect	No effect	No effect
PLANTS					
Colorado butterfly plant	No effect	No effect	No effect	No effect	No effect
Ute ladies'- tresses orchid	No effect	No effect	No effect	No effect	No effect
Osterhout milkvetch	No effect	No effect	No effect	May affect[3]	May affect[3]
Penland beardtongue	No effect	No effect	No effect	May affect[3]	May affect[3]
Western prairie fringed orchid	No effect	No effect	No effect	No effect	No effect

[1] A **no effect** determination indicates there would be no impact on the species. A **may affect** determination is not likely to adversely affect the species. The effect could be discountable, insignificant, or completely beneficial. An **adverse effect** determination indicates the species is likely to be adversely affected. Adverse effects to Colorado River fish species are addressed under the Colorado River Programmatic Biological Opinion.

[2] The FWS has requested another habitat evaluation for Chimney Hollow Reservoir and a second survey for Dry Creek Reservoir prior to construction.

[3] Field survey of the Rockwell Reservoir site is needed to determine species presence.

3.13.2.3 Direct and Indirect Effects to Threatened and Endangered Species

Canada Lynx

The Proposed Action would have no effect on federally listed terrestrial wildlife species or plants. WGFP Colorado River stream depletions would adversely impact four endangered Colorado River fish species. The Subdistrict would make a monetary contribution for the 21,317 AF of Colorado River depletions to support the recovery efforts for these species in accordance with the Recovery Implementation Program Recovery Action Plan.

There would be no effect to lynx from the enlargement of Ralph Price Reservoir under the No Action Alternative because no suitable habitat is present. The same is true for construction of Chimney Hollow Reservoir in the Proposed Action and Alternatives 3 and 4, and for Dry Creek Reservoir in Alternative 5.

Construction of Jasper East Reservoir in Alternative 3 would not affect potentially suitable lynx habitat. There would be a loss of about 13 acres of native coniferous forest. The areas of impacted forest consist of small, isolated stands that do not provide foraging or denning habitat for lynx; therefore, Jasper East Reservoir would have no effect on the Canada lynx.

Construction of the 20,000 AF Rockwell Reservoir in Alternative 4 and associated facilities would permanently impact about 5 acres of native forest and temporarily disturb about 14 acres of native forest within potential lynx habitat. Construction of a 30,000 AF Rockwell Reservoir in Alternative 5 would have similar temporary impacts and about 9 acres of permanent impacts to potential lynx habitat. Much of the forested area adjacent to the Rockwell Reservoir study area has been previously fragmented by road construction and residential development.

The loss of forest may affect, but is not likely to adversely affect lynx because this forest habitat is on the edge of potential lynx habitat, is discontinuous and fragmented, and most of the reservoir site is nonforested.

Preble's Meadow Jumping Mouse

Enlargement of Ralph Price Reservoir under the No Action Alternative would not impact populations of Preble's because no suitable habitat is present. As discussed in *Vegetation Resources* (Section 3.10.2.10), projected changes in streamflow below the reservoir on North St. Vrain Creek and St. Vrain Creek would not adversely affect riparian vegetation and, therefore, would not indirectly affect potential Preble's habitat downstream. There would be no change in flow in St. Vrain Creek from Windy Gap exchanges to Ralph Price Reservoir below the St. Vrain Supply Canal or at the closest recorded population of Preble's near Lyons.

Construction of Chimney Hollow Reservoir under the Proposed Action and Alternatives 3 and 4 would have no affect on Preble's populations based on trapping surveys. The FWS concurred that a population of Preble's does not likely occur within the Chimney Hollow study area. There would be no changes in streamflow below Chimney Hollow Reservoir that would affect potential downstream Preble's habitat or the Preble's population discovered on Dry Creek below Flatiron Reservoir. Based on negative survey findings, lack of potentially suitable habitat, and past FWS concurrence, construction of Chimney Hollow Reservoir would have no effect on Preble's. The FWS recommends a habitat evaluation prior to construction in case conditions change (FWS 2003).

Based on the negative trapping results at Dry Creek Reservoir in Alternative 5, there would be no direct impact to Preble's populations from construction of the reservoir and facilities. There would be no change in streamflow below the reservoir site that would affect potential Preble's habitat downstream. The FWS (2004) has requested an additional survey prior to construction to confirm the absence of Preble's. Thus, the interim determination of effects for the Preble's is no effect unless additional surveys locate Preble's.

There is no suitable habitat for Preble's at Jasper East or Rockwell Reservoir. Thus, there would be no effect to Preble's from construction of these facilities.

Fish

Impacts to the endangered species in the Colorado River were originally addressed in the 1981 FWS Biological Opinion for the original Windy Gap Reservoir based on an estimated average annual diversion of 57,300 AF. A Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin was initiated on January 22, 1988. The Recovery Program was intended to be the reasonable and prudent alternative for individual projects to avoid the likelihood of jeopardy to the endangered fishes from depletions from the Upper Colorado River Basin. A Section 7 agreement was implemented on October 15, 1993 by Recovery Program participants. Incorporated in this agreement is a Recovery Implementation Program Recovery Action Plan (RIPRAP) which identifies actions currently believed to be required to recover the endangered fish. On December 20, 1999, the Service issued a final programmatic biological opinion (PBO) for Reclamation's Operation and Depletions, Other Depletions, and Funding and Implementation of Recovery Program Actions in the Upper Colorado River above the Confluence with the Gunnison River. The Service determined that projects that fit under the umbrella of the Colorado River PBO would avoid the likelihood of jeopardy and/or adverse modification of critical habitat for depletion impacts. The Colorado River PBO states that in order for actions to fall within the umbrella of the PBO and rely on the RIPRAP to offset its depletions, the following criteria must be met:

- A Recovery Agreement must be offered and signed prior to conclusion of Section 7.
- A fee to fund recovery actions will be submitted as described in the Proposed Action for new depletion projects greater than 100 AF/year. The 2010 fee is $18.99 per AF and is adjusted each year for inflation.
- Reinitiation stipulations will be included in all individual consultations under the umbrella of this PBO.
- The Service and project proponents will request that discretionary Federal control be retained for all consultations under this PBO.

Reclamation reinitiated consultation with the Service because the stream depletions associated with the Preferred WGFP Alternative would adversely impact bonytail chub, Colorado pikeminnow humpback chub, and razorback sucker. The Service issued a biological opinion on February 12, 2010 for the Preferred Alternative (Appendix D). The biological opinion determined that the original Windy Gap Project meets the criteria for coverage under the PBO because a Recovery Agreement was signed by the Subdistrict in March of 2000 and the depletions existed when the Recovery Program was initiated. Because it was not a new depletion, no additional fees were submitted for compliance with the PBO. Hydrologic modeling for the PBO determined that the existing average annual depletions caused by the Windy Gap Project between 1981 and 1999 was 18,779 AF. The proposed WGFP would cause an additional average annual depletion of 21,317 AF/year. The average annual water depletion from the Colorado River as a result of the Windy Gap Project, including the additional depletions of the proposed WGFP, would be 40,096 AF/year.

In order for the WGFP to rely on the Recovery Program to offset the new average annual depletions of 21,317 AF, the Subdistrict would need to make a monetary contribution for water depletions greater than 100 AF to help fund their share of the costs of recovery actions. The Subdistrict would pay a one-time depletion fee prior to construction of the project at the appropriate rate per acre-feet in the year of payment. At 2010 rates of $18.99/AF, the cost for increased depletion of 21,317 AF for the Proposed Action would be $404,809.83.

There would be no effect to greenback cutthroat trout on the East Slope because they are not present in streams or reservoirs affected by alternative actions.

Ute Ladies'-Tresses Orchid and Colorado Butterfly Plant

Negative survey results for the orchid and CBP and a lack of suitable orchid habitat at Chimney Hollow and Dry Creek reservoirs indicate no effect to either species. Thus the Proposed Action and Alternatives 3, 4, and 5 would have no effect on the orchid or CBP. There would be no effect to these species from Jasper East or Rockwell Reservoir because no suitable habitat is present.

Osterhout Milkvetch and Penland Beardtongue

There would be no effect to Osterhout milkvetch or Penland beardtongue from construction of Jasper East Reservoir under Alternative 3 based on negative survey results. Rockwell Reservoir, a component of Alternatives 4 and 5, has potential habitat for Osterhout milkvetch and Penland beardtongue, but no field surveys were conducted because the landowners denied access. Thus, construction of Rockwell Reservoir and related facilities may affect, but are not likely to adversely affect, these plant species pending field surveys. There would be no effect to these species from Chimney Hollow or Dry Creek Reservoir because no suitable habitat is present.

3.13.3 Cumulative Effects

Cumulative effects to threatened and endangered species considered the potential incremental impact from reasonably foreseeable land-based developments within 5 miles of each of the alternative reservoir locations for terrestrial wildlife and plant species. Hydrologic data under cumulative effect conditions was used to quantify impacts to aquatic species. Potential cumulative effects to threatened and endangered species are discussed for each of the species where possible direct effects were identified.

Canada Lynx

Reasonably foreseeable land developments within 5 miles of Rockwell Reservoir could affect about 1,432 acres of potential lynx habitat. Construction of Rockwell Reservoir in Alternatives 4 and 5 would affect less than 20 acres of forest within potential lynx habitat. The incremental affect to potential lynx habitat under Alternatives 4 and 5, in addition to possible effects from future nearby land development, would be small, but may contribute to the loss or disturbance of potential lynx habitat. Because much of the land in the area is of marginal value for lynx and areas of future development include areas with existing disturbance, the cumulative impact to lynx habitat may affect, but is unlikely to adversely affect, the lynx.

Preble's Meadow Jumping Mouse

There would be no cumulative effect to Preble's from construction of Chimney Hollow or Dry Creek Reservoir because no Preble's is present at either location.

Fish

Colorado River depletions from the WGFP would be lower under cumulative effects for all alternatives because less water would available for diversions due to the actions of others. Depletions by other reasonably foreseeable actions that reduce flows in the Colorado River could result in adverse impacts to Colorado River endangered fish and would be need to be addressed under the compliance requirements for other projects. The 10825 Project is intended to provide improved flows in the 15-Mile Reach of the Colorado River to aid in the recovery of endangered fish species. Flow releases of 5,412.5 AF from Ruedi Reservoir and Granby Reservoir during the late summer/fall would have a beneficial effect on endangered fish species. There would be no cumulative impact to greenback cutthroat trout because the WGFP would not impact this species.

Ute Ladies'-Tresses Orchid and Colorado Butterfly Plant

There would be no cumulative effect to the orchid or CBP from construction of Chimney Hollow or Dry Creek reservoirs because these plants are not present at either location.

Osterhout Milkvetch and Penland Beardtongue

There would be no cumulative effect to Osterhout milkvetch or Penland beardtongue from construction of Jasper East Reservoir because neither species is present. Construction of Rockwell Reservoir could potentially impact these species. A cumulative effect to these endangered plants is possible if these species are present and if other future land disturbance impacts suitable habitat.

3.13.4 Threatened and Endangered Species Mitigation

The FWS issued a Biological Opinion on February 12, 2010 (Appendix D) for the Preferred Alternative indicating WGFP coverage under the PBO with participation in the Upper Colorado River Recovery Program and payment of a depletion fee for additional depletions of 21,317 AF attributable to the WGFP. The Section 7 consultation process would be completed, assuming an action alternative is selected, when the Subdistrict pays the appropriate depletion fee. Documentation of Section 7 consultation will be submitted to the Corps to meet requirements for the Fish and Wildlife Coordination Act.

Surveys for Osterhout milkvetch and Penland beardtongue would be conducted if the Rockwell Reservoir site is selected to determine their presence and if mitigation is needed. Mitigation for the loss of a small amount of potential lynx habitat at Rockwell Reservoir would be determined in consultation with the FWS. An additional Preble's jumping mouse survey would be conducted if Dry Creek Reservoir is developed to confirm their absence; if present, a mitigation plan would be developed. A Preble's jumping mouse habitat evaluation would be conducted at Chimney Hollow Reservoir prior to construction.

3.13.5 Unavoidable Adverse Effects

WGFP diversions from the Colorado River would result in an adverse effect to Colorado River endangered fish species, which would be mitigated per the conditions of the Biological Opinion. Construction of Rockwell Reservoir under Alternatives 4 and 5 would result in a small unavoidable adverse effect to potential lynx habitat and possibly suitable habitat for Osterhout milkvetch and Penland beardtongue. Construction of Dry Creek Reservoir could result in the loss of Preble's mouse habitat, although none were found during field surveys.

3.14 Geology and Paleontology

3.14.1 Affected Environment

3.14.1.1 Area of Potential Effect

The area of potential effect for geologic and paleontological resources includes the reservoir sites, projected areas of disturbance for dam construction, borrow areas, and other facilities.

3.14.1.2 Data Sources

Information on geologic resources was gathered from geologic maps, reports, and limited field investigation (Boyle Engineering 2005b). Information on potential paleontological resources was based on literature review and geology.

3.14.1.3 Ralph Price Reservoir

The Ralph Price Reservoir site is located in the Front Range foothills. The geology of the area is composed of Precambrian-aged granitic rocks that typically weather to sand and gravel, with some silts and clays (Braddock 1988). No geologic hazards or faults were identified in previous geologic studies for raising Button Rock Dam (Woodward-Clyde 1987). Suitable rock and earthfill material sources for use in enlarging the dam have been identified in the reservoir footprint and surrounding lands. The Ralph Price area is not currently recognized as a source of mineral or energy resources, although the granite could be used as coarse aggregate (Cappa et al. 2000). Paleontological resources are unlikely in the area because the geology is composed primarily of igneous rock.

3.14.1.4 Chimney Hollow Reservoir

The Chimney Hollow area is in the foothills of the Colorado Front Range. The western side of Chimney Hollow is characterized by a complex series of sedimentary and volcanic rocks intruded by igneous dikes and sills (Braddock et al. 1988). The hogback to the east of Chimney Hollow is part of a series of north to south trending ridges. The ridges consist of tilted sandstone and limestone. The lower slopes and valleys consist of siltstone and shale covered with alluvium and loose rock. Several faults are located about ½ to 3 miles west and northwest of Chimney Hollow. A pair of northwest-southwest trending faults is located within a few hundred feet of the proposed right dam abutment. Faults in the area are not considered active or potentially active (Widmann et al. 2002). No landslides or other geologic hazards have been documented in past or recent field investigations (Braddock et al. 1988; Crosby 1978; Boyle 2005b). Slickensides were observed along bedding planes in the finer grain portion of the bedrock in drill core samples and test pits and during construction of the nearby Flatiron Powerplant. Slickensides may indicate potentially weakened slip surfaces that can result in slides or wall failures into open excavation for which a contractor would need adequate temporary slope stabilization (Boyle 2005b).

Borrow areas for dam construction would be located within the Chimney Hollow Reservoir footprint. Granite along the north-central portion of the reservoir would provide rockfill for the dam and fine-grained deposits in the valley and lower slopes would be used to construct the core of the dam if a central core rockfill dam is selected. The Chimney Hollow area is not recognized for potential oil and gas deposits, metallic mineral resources, coal-bearing rocks, or sand and gravel deposits (Streufert and Cappa 1994; Cappa et al. 2001). Several sandstone quarries are located on the hogback to the east (Keller et al. 2002).

The eastern side of Chimney Hollow includes sandstone rocks of the Fountain and Lykins Formations. Trace fossils of plants and invertebrates have been found in these formations at locations near Denver and Castle Rock, but none have been identified near Chimney Hollow.

3.14.1.5 Dry Creek Reservoir

The regional and local geology of the Dry Creek Reservoir site is similar to Chimney Hollow. The west side of the Dry Creek valley includes volcanic and sedimentary rock and the east side of the Dry Creek valley includes sedimentary rock. The Blue Mountain Fault parallels the Little Thompson drainage to the south and several faults are located about 5 miles to the northwest. All of these faults are considered nonactive (Widmann et al. 2002). No landslides, debris flows, or other geologic hazards are believed to be present in the Dry Creek area (Braddock et al. 1988).

Published geologic mapping (Braddock et al. 1998) indicates granite bedrock in the Dry Creek area could provide a possible aggregate source for dam construction. Field exploration would be needed to confirm the presence and quantity of local material sources. The Dry Creek area is not recognized for potential oil and gas deposits, metallic mineral resources, coal-bearing rocks, or sand and gravel deposits (Streufert and Cappa 1994; Cappa et al. 2001). Several sandstone quarries located on the hogback to the east extract decorative building material (Keller et al. 2002).

Sandstone rocks from the Fountain Formation and Lyons Formation on the east side of Dry Creek are not known to contain paleontological resources.

3.14.1.6 Jasper Reservoir

The landform at the Jasper East Reservoir site is the result of faulting, uplift, glaciation, and erosion. Predominant surface rock from the Troublesome Formation consists of mudstone and sandstone interlayered with basalt flows and granite and volcanic material. Alluvial deposits of sand and gravel are also present. A series of northwest trending inferred faults are located near the proposed east dam embankment trending along the toe of Table Mountain (Izett 1974; Kirkham and Rogers 1981). A northwest trending fault is located north of the existing Willow Creek Pump Canal forebay dam. Two other faults parallel Willow Creek to the west of the Jasper Reservoir site. None of these faults are considered active or potentially active (Widmann et al. 2002). A landslide area is present on the south end of Table Mountain northeast of the reservoir site (Izett 1974). No evidence of other landslides or instability was observed or mapped in the study area.

Material from overburden deposits and weathered fine grain bedrock within the reservoir footprint may provide suitable material for dam construction (Boyle 2005e). Basalt bedrock located near the reservoir site contains potential riprap and bedding material. An existing sand and gravel quarry near the left dam abutment also may provide suitable material for dam construction. Field exploration would be needed to confirm the presence and quantity of local material sources. The Jasper East study area is not known for potential oil, gas, metallic minerals, or coal (Streufert and Cappa 1994; Cappa et al. 2001). An existing sand and gravel quarry is located on the west side of the reservoir site.

Portions of Jasper East dam and reservoir are in the Tertiary-age Troublesome Formation, which is known to contain fossil mammals (Lewis 1969).

3.14.1.7 Rockwell/Mueller Creek Reservoir

The Rockwell site is underlain by the Troublesome Formation, except for the alluvial deposits in the narrow Rockwell Creek drainage. Rocks in the Troublesome Formation include interbedded siltstone, mudstone or shale with less abundant amounts of sandstone, conglomerate, limestone, ash, tuff and granitic cobbles (Shroeder 1995). A north-south trending fault is located about ½ mile west of the proposed reservoir. Another fault is located about 800 feet east of the proposed north dam abutment. These faults are not considered active or potentially active (Widmann et al. 2002), nor is seismic activity considered to be a hazard based on studies for existing dams in the area (Unruh et al. 1996). Landslide material is present downstream of the reservoir site. No other geologic hazards were identified in the proposed reservoir area.

Fine grained material for dam construction may be available onsite from overburden deposits and weathered bedrock. If this material is not suitable, a potential borrow area about 1 mile south may provide material. Riprap and filter/drain material does not appear to be present at the reservoir site, so import from off-site sources may be necessary. Field exploration would be needed to confirm the presence and quantity of local material sources. The Rockwell area is not recognized for potential oil and gas deposits, metallic minerals, coal-bearing rocks, or sand and gravel deposits (Streufert and Cappa 1994; Cappa et al. 2001). The proposed pipeline across the Colorado River could transect sand and gravel deposits.

Rockwell is in the Tertiary-age Troublesome Formation, which is known to contain fossil mammals (Lewis 1969).

3.14.2 Environmental Effects

3.14.2.1 Issues

Geologic issues of concern were the presence of geologic hazards that may affect dam and facility construction, and safety. Possible effects to paleontological resources from earthwork also were a concern.

3.14.2.2 Method for Effects Analysis

Potential effects to geologic resources included an evaluation of the presence of geologic hazards that might affect the stability of the dam or other structures, such as faults, slope failures, or landslides. The potential loss of known mineral resources, such as oil, natural gas, metallic and nonmetallic minerals, also was evaluated. The potential for fossil-bearing formations was evaluated based on the types of rock present and available published data.

3.14.2.3 Effects Common to All Alternatives

All of the new reservoirs and enlargement of Ralph Price Reservoir would result in wetting of the reservoir slopes as the reservoirs fill. Wave action and wetting and draining of soils on reservoir slopes resulting from raising and lowering water levels could result in creep movement or sloughing of near surface materials into the reservoir. Such occurrences are considered normal and acceptable in the operation of reservoirs and in the terrain and environments such as these reservoirs. There are no indications of potential slides, slope failures, or debris flows that would adversely affect the integrity or safety of any of the potential dam sites based on available information. The perimeter soil erosion and sloughing of shallow, near surface materials would contribute sediment to the reservoir.

3.14.2.4 Alternative 1—Ralph Price Reservoir (No Action)

Enlarging Ralph Price Reservoir would require excavation of geologic material from borrow areas to raise the existing dam approximately 50 feet in elevation. Potential borrow areas include areas within the footprint of the existing reservoir as well as several nearby sites. No known geologic hazards are located within the study area; however, the faults within the project limits and study area would need further investigation to determine their characteristics and impact on facility design. There are no known oil and/or natural gas production areas, metallic mineral resources, coal-bearing formations, or other industrial mineral deposits in the area that would be affected. The Silver Plume granite present in the area may have some use as a coarse aggregate. No known geologic formations containing potential paleontological resources would be affected by enlarging Ralph Price Reservoir.

3.14.2.5 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

> No geologic hazards or important mineral, energy, or paleontological resources are known to occur at the Chimney Hollow Reservoir site.

None of the faults present near Chimney Hollow are active or potentially active; thus, there is little to no hazard from seismic activity from known fault zones. However, the faults would need additional investigation during final design to determine their characteristics and effect on the facility construction.

There are no known oil and/or natural gas production areas, metallic mineral resources, coal-bearing formations, or sand, gravel or other industrial mineral deposits in the area that would be affected by construction. The construction road access corridor through the hogback on the southeast side of the reservoir would cross a sandstone quarry, which could affect quarry operation. No currently known geologic formations containing potential paleontological resources would be affected by construction of Chimney Hollow Reservoir and facilities; however, plant and invertebrate fossils could be present in some sandstone formations.

3.14.2.6 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

The effect to geologic resources for a 70,000 AF Chimney Hollow Reservoir would be similar to those described for Alternative 2.

A landslide area on the south end of Table Mountain is unlikely to affect Jasper East Reservoir construction because of its distance from the reservoir. There would be little to no potential hazard to the dam or facilities from faulting. However, the faults within the project limits and study area would need investigation to determine their characteristics and potential impact to structures and facilities during final design. There would be no effect to known oil and/or natural gas production areas, metallic mineral resources, or coal-bearing formations in the area. The existing aggregate source near Jasper East Reservoir would be used for reservoir construction. Excavations in the Troublesome Formation could expose mammal fossils, which would require monitoring for possible salvage during construction.

3.14.2.7 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Potential effects to geologic resources at Chimney Hollow Reservoir would be the same as described for Alternative 2.

If the sideslope landslide downstream of the Rockwell Reservoir site is active in the future, it could impact drainage on Rockwell Creek. Future studies would be required to evaluate this potential hazard. There is no indication of potential slides, slope failures, or debris flows that would adversely affect the integrity or safety of the dam based on available information. There is little to no hazard from faulting; however, the faults in the area would need further investigation to determine their characteristics and impact on facility design. There would be no effect to known oil and/or natural gas production areas, metallic mineral resources, coal-bearing formations, or other industrial mineral deposits in the area. The pipeline across the Colorado River would include excavation in potential sand and gravel deposits that are often found in alluvial floodplain. Excavations in the Troublesome Formation could expose mammal fossils, which would require monitoring and salvaging during construction.

3.14.2.8 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Potential effects to geologic resources for a 30,000 AF Rockwell Reservoir would be similar to Alternative 4.

There would be minimal hazard to Dry Creek Reservoir from faulting and seismic activity. However, the faults within the project limits and study area would need further investigation to determine their characteristics and impact on facilities or structures. There would be no effect to known oil and/or natural gas production areas, metallic mineral resources, coal-bearing formations, sand, gravel or other industrial mineral deposits in the area. The pipeline to Carter Lake would cross a sandstone quarry, which could affect quarry operations. No known geologic formations containing potential paleontological resources would be affected by reservoir and facility construction.

3.14.3 Cumulative Effects

No reasonably foreseeable actions that would incrementally add to the disturbance to geologic resources were identified at the potential reservoir sites. No cumulative effects are expected from water-based reasonably foreseeable actions.

3.14.4 Geology and Paleontology Mitigation

Further evaluation is needed at all of the reservoir sites to determine if potential geologic hazards need to be addressed during final design. Construction of either Jasper East or Rockwell reservoirs could expose fossil mammals from the Troublesome Formation. Excavation in the sandstone formations at Chimney Hollow could uncover plant and invertebrate fossils.

Prior to construction of the Preferred Alternative, the Subdistrict would contract with a professional paleontologist to review the site for potential fossils. If the likelihood for finding important fossils is high, a paleontologist would then provide orientation to Subdistrict staff and construction inspectors on where fossils might be found and in recognizing them. Prior to construction, Denver Museum of Nature and Science and University of Colorado Museum paleontologists would be notified that excavation work could potentially discover paleontological resources and they would be contacted to participate in an assessment of the significance of a find. In the event that construction activities uncover concentrations of fossil remains or unusually large specimens, work in the area of the discovery would be suspended until the significance of the find is evaluated. The contractor would immediately contact a professional paleontologist, as well as Denver Museum of Nature and Science and University of Colorado Museum paleontologists to evaluate the find and make recommendations. Work would resume once significant fossils are examined and/or recovered and removed from the site. All efforts would be made to quickly evaluate fossils to minimize delays in construction activities.

3.14.5 Unavoidable Adverse Effects

Reservoir and dam construction would result in an unavoidable disturbance to geologic resources from excavation and earthmoving activities. There would be a potential loss of fossil mammals from excavations at Jasper East and Rockwell reservoirs and possibly plant and invertebrate fossils at Chimney Hollow Reservoir.

3.15 Soils

3.15.1 Affected Environment

3.15.1.1 Area of Potential Effect

The area of potential effect for evaluating soil resources includes the alternative reservoir sites and related pipelines, roads, and infrastructure that would permanently or temporarily affect soils.

3.15.1.2 Data Sources

Information on soils was collected from published data sources including Natural Resources Conservation Service (NRCS) soil survey reports for Larimer, Boulder, and Grand counties, and the NRCS Web Soil Survey (2006).

Potential water quality effects associated with erosion and sedimentation at reservoir sites are addressed in *Surface Water Quality* (Section 3.8). Fugitive dust is discussed in *Air Quality* (Section 3.16). Revegetation of disturbed soils is discussed in *Vegetation* (Section 3.10). Additional information on soils is included in the Geology and Soils Technical Report (ERO and Boyle 2006).

3.15.1.3 Ralph Price Reservoir

The NRCS has not surveyed soils at Ralph Price Reservoir. Information from the Boulder County Soil Survey (NRCS 1975) for lands with similar parent material and geographic position was used to estimate likely soil types at the reservoir. Based on this information, it is likely the Juget-Rock outcrop soil complex is present on the mountain slopes surrounding Ralph Price Reservoir. The Juget soil series consists of shallow, somewhat excessively drained soils derived from weathered granite on slopes of 9 to 55 percent. Surface and subsurface soils are very gravely sandy loams over granite bedrock. Runoff is rapid and the erosion hazard is high for this soil.

3.15.1.4 Chimney Hollow and Dry Creek Reservoirs

The soil types (NRCS 1980) present in the Chimney Hollow and Dry Creek study areas are similar. The characteristics for common soils present at these reservoir sites are listed below.

Kirtley-Purner complex, 5 to 20 percent slopes. This complex occurs on upland and valley sides on the west side of the reservoirs. The Kirtley series is a moderately deep, well-drained soil formed from weathered sandstone and shale. The surface is loam textured and the subsurface is a heavy loam. The Purner series is a shallow, well drained soil formed from weathered sandstone. The surface horizon and subsoil is composed of a fine sand loam. Runoff is rapid and the erosion hazard is severe.

Purner-Rock outcrop complex, 10 to 50 percent slopes. This soil complex is found at the toe of the hogback ridge along the east shoreline of the reservoirs. The rock outcrop in this unit is primarily in the steep ridges of the hogback above the reservoirs. Runoff is rapid and the erosion hazard is severe.

Ratake-Rock outcrop complex, 25 to 55 percent slopes. This complex consists of steep soils on the northwest portion of Chimney Hollow, the pipeline route to the Bald Mountain surge tank and near the Dry Creek Reservoir dam. The Ratake series consists of shallow, well drained to somewhat excessively drained soils that formed from weathered granite, schist, or phyllite. The surface soil is a channery loam with increasing rock content with depth. Runoff is rapid and the erosion hazard is severe.

Wetmore-Boyle-Moen complex, 5 to 40 percent slopes. This soil complex is found in the area of the western shoreline sideslopes of both the reservoirs. The Wetmore series consists of shallow, well drained soils derived from weathered granite. The surface horizon is a sandy loam and subsurface horizons have a gravelly loamy sand texture. The Boyle series is a shallow, well drained soil formed from weathered sandstone. The surface soil is a stony sandy loam with increasing rock content with depth. The Moen series is a moderately deep, well drained soil formed from weathered granite and schist with a loam surface texture and clay loam subsurface texture. Runoff is rapid and the erosion hazard is severe.

Connerton-Barnum complex, 3 to 9 percent slopes. This soil complex is located along the Chimney Hollow drainage in a few scattered locations at Dry Creek. The Connerton series consists of deep, well drained soils that formed in mixed alluvial material with a fine sandy loam surface and loam subsurface. The Barnum series consists of deep, well drained soils formed in alluvium valleys. These soils have a loam textured surface and subsurface. Runoff is medium and the erosion hazard is moderate to severe.

The Dry Creek Reservoir site has several additional soil types not common or present at Chimney Hollow. These include:

Haplustolls-Rock outcrop, complex steep. This complex consists of soils on slopes ranging in steepness from 5 to 50 percent and rock outcrop located on the southeast shoreline of the reservoir. Haplustolls are present along the east side of the hogback ridge where the pipeline connection to Carter Lake would be located. Haplustolls are shallow to deep and have surface and subsurface layers of loam or clay loam with varying amounts of cobbles and rock. Runoff is rapid and the erosion hazard is moderate to severe.

Nunn clay loam, 3 to 5 percent. This gently sloping soil is located along a portion of the pipeline route to Carter Lake. These soils are deep, well drained, and have a light clay loam surface and clay loam subsurface. Runoff is medium and the water erosion hazard is moderate.

Satanta loam, 3 to 5 percent. This soil is located on upland side slopes along the pipeline route to Carter Lake. The Satanta soil is deep, and well drained with a loam surface and heavy loam to clay loam subsurface. Runoff is medium and the erosion hazard is moderate.

Both reservoir sites contain several other less common soil map units. These map units consist of different complexes with the same soil series previously described and other soil types with similar parent material, soil textures, depths, and slopes as described for the dominant soil types.

3.15.1.5 Jasper Reservoir

The Jasper Reservoir site, access roads, pipeline route, and relocated Willow Creek Canal overlay 20 different soil map units (NRCS 1983). Principle soil types in the study area include:

Cimarron loam, 2 to 35 percent. This deep, well drained soil is found within the reservoir footprint and along portions of the Willow Creek Pump Canal. These soils formed from shale and alluvium. The surface layer is loam and the subsurface is clay. Surface runoff is slow and the erosion hazard is slight on slopes less than 6 percent. Runoff is rapid and the erosion hazard is severe on slopes steeper than 15 percent.

Youga loam, 2 to 45 percent. This deep well drained soil is found in the reservoir footprint, on the northern and western dam abutment, and in the filter borrow area and a portion of the access road. This soil has a surface horizon of loam with a subsoil of loam and clay loam. Surface runoff is medium and the erosion hazard is moderate.

Leavitt loam, 6 to 50 percent slopes. This deep well drained soil is found within the reservoir footprint, in the rock borrow area, and portions of the Willow Creek Pump Canal. This soil is formed in local alluvium from sedimentary rock. The surface layer is loam and the subsurface is clay loam. Surface runoff is slow on slopes less than 15 percent and the erosion hazard is moderate. On steeper slopes the surface runoff is medium and the erosion hazard is high.

Mayoworth clay loam, 6 to 50 percent slopes. This is a moderately deep, well drained soil found within the reservoir footprint and along the Willow Creek Pump Canal route. The surface is a clay loam and the subsurface is clay above shale bedrock. Surface runoff is rapid and the erosion hazard ranges from moderate to high depending on slope.

Waybe clay loam, 10 to 55 percent slopes (Map Unit 90). This shallow, well drained soil is found within the reservoir and dam footprint and access roads. The surface layer is a clay loam and the subsoil is clay over weathered shale. Surface runoff is rapid and the erosion hazard is high.

Remaining soil types are found in lesser amounts in the study area and mostly have loam and clay loam surface horizons with slopes below 30 percent. Several small areas of rock outcrop are found in scattered locations. Cumulic Cryaquolls are dark wet soils along the drainage that supports wetlands.

3.15.1.6 Rockwell/Mueller Creek Reservoir

The Rockwell Reservoir, dam, pipeline to Windy Gap Reservoir, and relocated county road would cross 18 different soil map units (NRCS 1983). Several of the same soil map units previously described for the Jasper East study area are also present in the Rockwell Reservoir study area. Cimarron loam, is the dominant soil type in the reservoir and dam footprint. Mayoworth clay loam is present within the reservoir footprint, the rock borrow area, and along the pipeline. Waybe clay loam is found in the reservoir, dam, and construction staging area. Additional dominant soil map units in the Rockwell Reservoir study area not previously described include:

Aaberg clay loam, 15 to 30 percent slopes. This moderately deep, well drained soil is found on mountainsides within the reservoir footprint. The surface soil is a clay loam and the subsoil is clay over soft shale. Surface runoff is rapid and the erosion hazard is high.

Gateway loam, 15 to 50 percent slopes. This soil is moderately deep, well drained, and is found on the west side of the reservoir and in the borrow area south of the reservoir. The surface texture is loam and the subsoil is clay over mudstone. Surface runoff is rapid and the erosion hazard is high.

Quander stony loam, 15 to 55 percent slopes. This deep, well drained soil is the dominant soil in the borrow area. It has a surface layer of stony loam over very stony sandy clay loam. Surface runoff is rapid and the erosion hazard is high.

The pipeline from Rockwell Reservoir to Windy Gap Reservoir crosses several soil map units in addition to those previously described. The pipeline route through the Colorado River floodplain crosses Cumulic Cryaquolls soils, which are formed in alluvium. Tine gravelly sandy loam, 0 to 3 percent is present in the gently sloping terrace along the pipeline route. This is a deep, well drained soil with a loam surface horizon and very cobbly loam subsoil. Surface runoff is slow and the erosion hazard slight on these gentle slopes.

Other soils in the study area occur in smaller amounts and are primarily loams and sandy loams of widely varying slope ranges.

3.15.2 Environmental Effects

3.15.2.1 Issues

Soil resources of concern were the potential effect on revegetation of disturbed areas and the potential for increased erosion and impacts to water quality.

3.15.2.2 Method for Effects Analysis

Potential effects to soil resource were evaluated for the loss of soil resources or reduced productivity, potential for erosion during construction, shoreline erosion or sedimentation at new reservoirs, and soil suitability for revegetation of disturbed areas. Project features were overlain on soil maps to determine the acreage and soil types affected by permanent and temporary disturbances.

Susceptibility to wind and water erosion is primarily a function of soil texture, vegetation cover, and slope. The evaluation of susceptibility to wind erosion was based on the wind erodibility group for the soil map unit as designated by the NRCS soil survey. The potential for water erosion was based on the erosion hazard classification for each map unit and the individual soil physical properties that determine the soil erosion factor. Successful revegetation depends in part on the quality of the soils salvaged and replaced. The NRCS established ratings for topsoil suitability for each map unit were used to evaluate revegetation potential for temporarily disturbed soils.

3.15.2.3 Effects Common to All Alternatives

For all temporary soil disturbances associated with construction activities at any of the potential reservoir sites, a revegetation and erosion control plan would be developed. The revegetation plan would include site-specific details on the removal, handling, storage, and replacement of soil for revegetation, but there would be a loss in productivity from soils that are stripped, stored, and reapplied. Revegetation of areas with poor topsoil quality may require additional soil amendments and would take longer to establish vegetation.

3.15.2.4 Alternative 1—Ralph Price Reservoir (No Action)

Soil Loss and Disturbance

The enlargement of Ralph Price Reservoir would result in a permanent loss of about 77 acres of soil resources from inundation and possible other losses from enlarging the dam and spillway construction. If borrow areas are located within the reservoir footprint, there would be no additional loss of soil from extraction of material for dam construction. It is assumed that the majority of the soil loss would occur in the Juget-Rock outcrop complex.

Additional temporary soil disturbance is likely from construction staging and if a borrow site outside of the reservoir footprint is used. The area of temporary disturbance is not known, but is assumed that the Juget-Rock outcrop complex would be a component of the disturbed soils.

Shoreline Erosion

Existing shoreline erosion around Ralph Price Reservoir is minimal because the shoreline is fairly stable and has weathered to bedrock. Enlarging the reservoir would inundate soils and increase the potential for shoreline erosion until a new equilibrium is reached. Seasonal fluctuations in water levels of about 14 feet on average and up to 33 feet in wet years also would contribute to shoreline erosion. Based on the condition of the existing shoreline, the granitic bedrock underlying the shallow soils would create a stable nonerosive shoreline over the long term if the reservoir is enlarged.

Sedimentation

Sedimentation in Ralph Price Reservoir from local sources in the North St. Vrain Creek basin is possible, but would likely be minimal because the majority of the upstream watershed is within National Forest and National Park Service ownership. However, the reservoir would continue to accumulate sediment from stream inflows. Shoreline erosion and areas of soil disturbance from construction also would contribute sediment to the reservoir.

Temporary Erosion

Temporary wind and water erosion of soils is possible during dam and spillway construction and if a borrow area outside the reservoir footprint is used. The Juget-Rock outcrop soil complex has a very low susceptibility to wind erosion when vegetation is removed; thus, wind erosion is expected to be minor. The water erosion hazard is severe because of the steep slopes, although the Juget soil has a low erosion factor based on soil texture and the high amount of rock.

Revegetation Potential

The amount of area that would require revegetation is unknown, but would likely include construction staging areas near the dam and spillway and possible borrow areas. The Juget-Rock outcrop complex has poor topsoil suitability because of the depth to bedrock, rock fragments, and steep slopes. Revegetation of disturbed lands may be difficult because of these limitations.

3.15.2.5 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

Soil Loss and Disturbance

> Construction of Chimney Hollow Reservoir would result in a long-term loss of soil resources with the potential for shoreline erosion and a short-term increase in erosion until disturbed areas are revegetated or stabilized.

Construction of Chimney Hollow Reservoir and facilities would result in a permanent loss of about 794 acres of soil resources. Affected soils would either be inundated by the new reservoir or buried or removed for dam, spillway and road construction. Proposed borrow areas are located within the reservoir footprint so there would be no additional loss of soil from extraction of material for dam construction. There also would be a small loss of soil resources associated with construction of the foundation for new transmission line towers. The majority of the lost soil resources would be to the Kirtley-Purner soil complex (48 percent) and the Purner-Rock outcrop complex (19 percent).

Construction of the pipeline connection to the Bald Mountain surge tank, as well as inlet/outlet pipelines below the dam, and construction staging areas would temporarily affect soil resources on about 130 acres.

Shoreline Erosion

Shoreline erosion on Chimney Hollow Reservoir is possible from wave action. Chimney Hollow Reservoir would remain close to full throughout the year under most conditions with fluctuations in reservoir elevation of less than 2 feet. Erosion of shoreline soils, particularly during the first several years following reservoir construction, is likely until the shoreline stabilizes. The Purner-Rock outcrop soil complex dominates the east side of the reservoir site. The Purner soil has a moderate erosion potential, but steep slopes increase the potential for erosion on the shoreline and prevailing winds would generate wave action on the east side of the reservoir. Soil map units on the west side of the reservoir have a lower erosion factor, but areas with steeper slopes have increased susceptibility to erosion. The fine textured soils of the Kirtley-Purner complex at the north end of the reservoir have a moderate erosion factor, and gentle slopes. This portion of the reservoir may develop beach areas with areas of sand or mudflats, as well as wetland or riparian vegetation.

Sedimentation

Sedimentation in Chimney Hollow Reservoir from local sources within the basin is expected to be minimal. The relatively undisturbed Chimney Hollow watershed is about 3,000 acres. All of the Chimney Hollow drainage would be inundated by the new reservoir; therefore, the only local source of inflow would be from ephemeral tributary drainages to the east and west. Shoreline erosion and areas of soil disturbance from construction also would contribute sediment to the reservoir. Development of recreation facilities by Larimer County Parks and Open Lands Department would generate minor sources of sedimentation from a parking area and trails.

Temporary Erosion

Temporary wind and water erosion of soils is possible during excavation of material for dam construction, installation of pipelines, road construction, relocation of the transmission line, and other facilities until disturbed areas can be revegetated. The Kirtley, Purner, and Ratake soils have moderate susceptibility to wind erosion when vegetation is removed. These same soils are subject to severe water erosion hazard, particularly where the slopes are steep due to rapid runoff and the texture of the surface soil. An increase in soil erosion is likely during construction, but implementation of an erosion control plan and revegetation would reduce soil loss.

Revegetation Potential

Reclamation of about 130 acres of temporarily disturbed soils to facilitate vegetation establishment would be needed. NRCS topsoil suitability ratings for temporarily disturbed soils in the study area indicate that about 67 acres of soils have fair suitability for use as topsoil and 62 acres have poor suitability. Less than 1 acre of soils has good suitability for topsoil. The Kirtley-Purney complex, which makes up most of the disturbed soils, has fair topsoil suitability and is limited because the soil material is less than 20 inches thick over bedrock. The poorly rated soils are composed primarily of the Ratake-Rock outcrop complex and are limited because of steep slope, shallow soils, and the amount of rock in the soil.

3.15.2.6 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Chimney Hollow Reservoir

Soil Loss and Disturbance. Construction of a 70,000 AF Chimney Hollow Reservoir and facilities would result in a permanent loss of about 671 acres of soil resources. The majority of the lost soil resources would be to the Kirtley-Purner soil complex (54 percent) and the Purner-Rock outcrop complex (15 percent).

Construction of the pipeline connection to the Bald Mountain surge tank, as well as inlet/outlet pipelines below the dam, construction staging areas, and 23 acres of borrow area outside of the reservoir footprint, would temporally affect soil resources on about 149 acres.

Shoreline Erosion. Shoreline erosion at Chimney Hollow Reservoir from wave action and fluctuating water levels would be similar to the 90,000-AF reservoir in the Proposed Action. However, a wider range in reservoir water surface fluctuations of about 15 feet on average and up to 28 feet in wet years could increase the potential for shoreline erosion.

Sedimentation. The potential for sedimentation in Chimney Hollow Reservoir from local sources within the basin would be similar to the Proposed Action, although there would be a slightly larger area of temporary soil disturbance from a borrow area outside the reservoir footprint that could contribute additional sediment until revegetated.

Temporary Erosion. The potential for temporary wind and water erosion of soils would be the same as discussed for the Proposed Action because similar soil types would be disturbed.

Revegetation Potential. Approximately 149 acres of soils would be temporarily disturbed during construction. NRCS topsoil suitability ratings for temporarily disturbed soils in the study area indicate about 76 acres with fair suitability for topsoil and 73 acres with poor suitability. The soils rated with fair topsoil suitability are limited because the soil material is less than 20 inches thick over bedrock and the poorly rated soils are limited because of steep slope, shallow soils, and the amount of rock in the soil.

Jasper East Reservoir

Soil Loss and Disturbance. Construction of Jasper East Reservoir and facilities would result in a permanent loss of about 491 acres of soil resources. Affected soils include those inundated by the new reservoir or buried or removed for dam, spillway and road construction and soils affected by relocation of the Willow Creek Canal, pump station, and forebay. Soil loss would be spread over 20 different map units. The larger map units affected include Cimarron loam (34 percent), Leavitt loam (13 percent), Youga loam (10 percent), and Mayoworth clay loam (9 percent).

Temporary disturbance from construction staging areas, borrow sites, and the relocation the Willow Creek pipeline would affect soil resources on about 125 acres.

Shoreline Erosion. Wave action and wide fluctuations in Jasper Reservoir water levels would result in shoreline erosion. Water levels in Jasper East Reservoir would fluctuate about 59 feet on average and as much as 72 feet during wet years. Shoreline soils are primarily clay loam and clays that would contribute fine textured suspended sediment. Weathered shale parent material below the soil also would be subject to shoreline erosion.

Sedimentation. Potential local sources of sedimentation to Jasper East Reservoir in addition to shoreline erosion are limited within the 957-acre watershed within which the reservoir would be located. Surrounding lands are undeveloped rangeland with near natural levels of erosion. Relocation of County Road 40 below the reservoir dams would eliminate road-generated erosion and sediment. Minor sources of sedimentation could be generated if recreation facilities are developed.

Temporary Erosion. Disturbance of soils during construction would result in a temporary increase in wind and water erosion. Dominant soil types representing about 55 percent of the area expected to be disturbed, include Cimarron loam, Youga loam, and Mayoworth clay loam, which have a low potential for wind erosion. Remaining soils have a moderate potential for wind erosion when exposed. The potential for water erosion is high for most of the areas of expected disturbance, although areas with gentle slopes including Youga loam and Mayoworth loam have moderate ratings for water erosion.

Revegetation Potential. Reclamation of about 125 acres of temporarily disturbed soils would be needed for construction staging areas, along the Willow Creek pipeline and pipeline connection to the existing Windy Gap pipeline, and roadside disturbance associated with relocation of County Road 40. NRCS topsoil suitability ratings for temporarily disturbed soils in the study area indicate that the majority of soils (93 acres) have a poor suitability for topsoil and 32 acres have fair topsoil suitability. None of the temporarily disturbed areas have good topsoil suitability. Temporarily disturbed soils including Cimarron, Mayoworth, and Waybe soil series have poor topsoil properties because of a high clay content. Steep slopes for some soils and the amount of rock fragments also reduce topsoil suitability. The Youga loam soil series has fair topsoil suitability, with limitations because of the amount of rock fragments or the steepness of the slope.

3.15.2.7 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Chimney Hollow Reservoir

Potential effects to soil resources at Chimney Hollow Reservoir would be the same as described for Alternative 3.

Rockwell/Mueller Creek Reservoir

Soil Loss and Disturbance. Construction of Rockwell Reservoir and facilities would result in a permanent loss of about 315 acres of soil resources. Primary soil types affected include Cimarron loam (54 percent), Mayoworth clay loam (18 percent) and Aaberg clay loam (16 percent).

Temporary disturbance from construction staging areas, an offsite borrow area, and the pipeline to Windy Gap Reservoir would affect soil resources on about 155 acres.

Shoreline Erosion. Wave action and fluctuations in reservoir levels would result in erosion of the shoreline. Water levels in Rockwell Reservoir could fluctuate 80 feet on average and as much as 102 feet during wet years. Shoreline soils are primarily clay loam and clays that would contribute fine textured suspended sediment. Weathered shale parent material below the soil also would be subject to shoreline erosion.

Sedimentation. Potential local sources of sedimentation to Rockwell Reservoir in addition to shoreline erosion in the 1,358-acre watershed include undeveloped forest, scattered homes, and gravel roads. Erosion from upstream land development is likely to be minor because of the buffer areas of native forest vegetation. Minor sources of sedimentation could be generated if recreation facilities are developed.

Temporary Erosion. Wind erosion susceptibility varies from low to high for the various soils that would be exposed during construction. Low to moderate wind erodibility would occur from exposure of Gateway loam, Quander cobbly loam, and Cimarron loam. Exposures of Rogert gravelly sandy loam, Tine gravelly sandy loam, and Waybe clay loam have a higher potential for wind erosion. The potential for water erosion is high for most of the areas of expected disturbance because of steep slopes. The water erosion hazard is slight on gentle slopes where the pipeline to Windy Gap crosses the Tine and the Cumulic Cryaquolls soil map units near the Colorado River. The Youga loam soil type along the pipeline route has a moderate water erosion hazard.

Revegetation Potential. Reclamation of about 155 acres of temporarily disturbed soils would be needed for construction staging areas, along the pipeline to Windy Gap Reservoir, and for the offsite borrow area. NRCS topsoil suitability ratings for temporarily disturbed soils in the study area indicate that 142 acres of soil have poor suitability for topsoil. Poor topsoil suitability is due to the amount of clay in the Cimarron, Mayoworth, and Gateway loam soil series, and a combination of shallow depth and/or rock fragment limitations in most of the other soils. About 13 acres of the Clayburn loam and Youga loam along the pipeline route have fair topsoil suitability, but with limitations because of the amount of rock fragments.

3.15.2.8 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Dry Creek Reservoir

Soil Loss and Disturbance. Construction of Dry Creek Reservoir and facilities would result in a permanent loss of about 633 acres of soil resources. Affected soils include those inundated by the new reservoir or buried or removed for dam, spillway and access roads along the pipeline from the north and from the east over the hogback. The majority of the lost soil resources would be to the Kirtley-Purner soil complex (31 percent), the Wetmore-Boyle-Moen complex (20 percent), and the Ratake-Rock outcrop complex (19 percent).

Temporary disturbance from construction staging areas, along access roads, and the pipeline connection to the Bald Mountain surge tank, and from the dam to Carter Lake would affect soil resources on about 158 acres.

Shoreline Erosion. Dry Creek Reservoir would fluctuate about 9 feet on average, but as much as 17 feet in wet years. Shoreline soils subject to erosion from wave action and fluctuating reservoir levels include principally the Purner-Rock outcrop complex on the west side of the reservoir and the Wetmore-Boyle-Moen complex on the west side of the reservoir. Both these soils have severe erosion hazard because of slope, but both have low erosion factors, which indicates low susceptibility to sheet and rill erosion on gentle slopes. The shallow Purner soils overlay sandstone, which would result in a fairly stable shoreline. The granitic bedrock underlying the Wetmore-Boyle-Moen complex would result in a weather resistant shoreline following erosion of surface soil. The finer textured soils of the Kirtley-Purner complex at the north end of the reservoir have a moderate erosion factor, and gentle slopes. This portion of the reservoir may develop beach areas with areas of sand or mudflats.

Sedimentation. Sedimentation in Dry Creek Reservoir from local sources within the basin other than shoreline erosion is expected to be minimal. The relatively undisturbed Dry Creek watershed is about 2,500 acres. All of the Dry Creek drainage above the dam would be inundated by the new reservoir; therefore, the only local source of inflow would be from ephemeral tributary drainages to the east and west. Sediment input from these tributaries would be at natural erosion rates. Minor sources of sedimentation could be generated if recreation facilities are developed.

Temporary Erosion. The majority of soils subject to wind erosion from temporary disturbances have a moderate susceptibility for erosion along the pipeline to Carter Lake, the pipeline to the Bald Mountain surge tank, and construction staging areas. The Paoli fine sandy loam, Pinata-Rock outcrop, and Connerton-Barnum complex found along pipeline routes and staging areas are more susceptible to wind erosion when disturbed. The potential for water erosion is generally severe because of the steep slopes, although erosion hazard is moderate on gentle slopes in the Connerton-Barnum and Nunn clay loam soils found along pipeline routes.

Revegetation Potential. Reclamation of about 158 acres of temporarily disturbed soils to facilitate vegetation establishment would be needed for construction staging areas, along pipelines, and other areas of construction disturbance. NRCS topsoil suitability ratings for temporarily disturbed soils in the study area indicate that 74 acres of soils have poor suitability for use as topsoil, 71 acres have fair suitability, and 13 acres have good suitability. The Connerton-Barnum soils along the pipeline route to the north have good topsoil characteristics for revegetation. The Kirtley-Purney complex, which makes up a majority of the soils rated as fair topsoil suitability, is limited because the soil material is less than 20 inches thick over bedrock. The Ratake-Rock outcrop complex is poorly rated for topsoil use because of steep slopes, shallow soils, and the amount of rock in the soil. The Nunn clay loam and Pinata-Rock Outcrop are too clayey for topsoil use.

Rockwell/Mueller Creek Reservoir

Soil Loss and Disturbance. Construction of a 30,000 AF Rockwell Reservoir and facilities would result in a permanent loss of about 393 acres of soil resources from inundation and dam, spillway, and road construction. The same soil types would be affected as the 20,000-AF reservoir in Alternative 4. Temporary soil disturbances would affect 161 acres.

Shoreline Erosion. The potential for shoreline erosion from wave action and fluctuating water levels would be similar to Alternative 4. The reservoir would fluctuate about 70 feet on average and up to 100 feet in wet years. Large fluctuations in water levels expose more of the reservoir to wind action and increase the potential for erosion.

Sedimentation. The potential for sedimentation in Rockwell Reservoir from local sources within the basin would be similar to Alternative 4.

Temporary Erosion. The potential for temporary wind and water erosion of soils would be the same as discussed for Alternative 4 because similar soil types would be disturbed.

Revegetation Potential. Reclamation of about 161 acres of temporarily disturbed soils to facilitate vegetation establishment would be needed. NRCS topsoil suitability ratings for temporarily disturbed soils in the study area indicate about 148 acres have poor suitability for topsoil, 13 acres are rated fair, and none are rated good. The soils rated as fair topsoil suitability are limited because of the amount of rock fragments and the poorly rated soils are limited because of clay content, shallow soils, and the amount of rock.

3.15.3 Cumulative Effects

No reasonably foreseeable actions that would incrementally add to the disturbance to soil resources and increase the potential for localized erosion were identified at the potential reservoir sites. No cumulative effects are expected from water-based reasonably foreseeable actions.

3.15.4 Soils Mitigation

A number of mitigation measures would be implemented prior to and during construction for any alternative to minimize effects to soil resources. Measures include:

- Clearly defining construction limits to minimize soil disturbance.
- Developing an erosion control plan as part of the required Stormwater NPDES permit to reduce the potential for erosion from disturbed areas or capture sediments on-site.
- Integrating the erosion control plan with the revegetation plan.
- Salvaging of suitable topsoil from areas of temporary disturbance, where possible, to aid in revegetation following construction.
- Using soil amendments or additional site preparation techniques to revegetate disturbed areas with poor topsoil suitability.

3.15.5 Unavoidable Adverse Effects

There would be an unavoidable long-term loss of soils in areas affected by dam construction, inundation by the reservoir, and other permanent facilities. Temporarily disturbed soils would be subject to wind and water erosion that could lead to reduced soil productivity and effects to water quality. Implementation of erosion control measures including revegetation would reduce erosion from temporary disturbances to natural erosion rates over the long-term. Shoreline erosion from wave action would result in sediment contributions to new reservoirs.

3.16 Air Quality

3.16.1 Affected Environment

3.16.1.1 Regulatory Framework

The Clean Air Act (CAA) of 1970, 42 U.S.C. 7401 et seq., was enacted to protect and enhance air quality and to assist state and local governments with air pollution prevention programs. The CAA requires the EPA to identify and publish a list of common air pollutants that could endanger public health or welfare. The EPA has delegated enforcement of the CAA to the Air Pollution Control Division (APCD) of the Colorado Department of Public Health and Environment (CDPHE). All state programs regarding the provisions and enforcement of the CAA are subject to oversight and approval by the EPA.

The EPA has established National Ambient Air Quality Standards (NAAQS) for six criteria air pollutants—carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, particulate matter fewer than 10 microns in diameter (PM_{10}), and lead—to protect the public from health hazards associated with air pollution. These pollutants are called “criteria air pollutants” because the EPA has regulated them by first developing health-based criteria as the basis for setting permissible levels. One set of limits (primary standard) protects health; another set of limits (secondary standard) is intended to prevent environmental and property damage. A geographic area that has air quality equal to or better than a primary standard is called an attainment area; an area that does not meet a primary standard is a nonattainment area.

Emission sources of pollutants are categorized as either stationary or mobile. Stationary sources of pollutants include activities such as combustion of fossil fuels for power, emissions from industrial or commercial processes, and burning from natural fires. Mobile sources of pollutants include on-road (cars and trucks) and off-road vehicles (farm and construction equipment), and fugitive dust from unpaved roads and construction activities. Fugitive dust can be generated by either earth disturbing activities or by wind.

Colorado’s air quality laws contain requirements for controlling fugitive dust emissions during construction activities. These requirements vary depending on the amount of land disturbed and the duration of the disturbance.

3.16.1.2 Area of Potential Effect

The area of potential effect for air quality includes the area of projected disturbance for each alternative where sources of emissions would be generated, as well as surrounding lands where emissions would disperse.

3.16.1.3 Data Sources

Regional air quality is described based on available information from the EPA and CDPHE. Additional information is included in the Air Quality and Noise Technical Report (ERO 2006).

3.16.1.4 Existing Air Quality

The existing air quality for all of the study areas on both the East and West Slope is good. The reservoir sites and associated facilities are primarily located in rural areas with emissions occurring mostly from on-road and off-road vehicles and from fugitive dust. Nearby urban areas such as Loveland and Lyons on the East Slope and Granby on the West Slope may have slightly lower air quality from vehicle emissions and stationary pollution sources. Particulate concentrations are higher near unpaved roads, disturbed lands, and fallow agricultural fields compared to vegetated rangeland.

The existing air quality in the East and West Slope study areas does not exceed NAAQS, with the exception of ozone. The Denver-Metro area and north Front Range (all of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson counties and portions of Larimer and Weld counties) are in a nonattainment area for the 8-hour ozone standard (CDPHE 2008b).

3.16.2 Environmental Effects

3.16.2.1 Issues

Potential effects to air quality identified during scoping were air pollution from vehicle emissions and dust during and after construction.

3.16.2.2 Methods for Effects Analysis

Potential effects to air quality were evaluated based on source of air quality emissions and the duration of the effects. Adverse impacts to air quality are possible if NAAQS are exceeded.

3.16.2.3 Effects Common to all Alternatives

For the No Action and action alternatives, air quality impacts during construction would primarily include exhaust emissions from construction equipment, employee and delivery vehicles, and from fugitive dust. With the exception of lead, all of the criteria pollutants would be emitted or created due to construction activities. Fugitive dust would be generated from activities associated with soil disturbance and from equipment and vehicular traffic moving over the disturbed site. These emissions would be greatest during the initial site preparation activities and would vary from day-to-day depending on the construction phase, level of activity, and prevailing weather conditions. The amount of emissions of both fugitive dust and vehicle exhaust would depend on the number of vehicles used at specific sites and the disturbed area.

Because the project area for all alternatives exceeds 25 contiguous acres, one or more land development permits would be required from the APCD. As part of the land development permit application, a Fugitive Particulate Emission Control Plan that outlines the specific steps that would be taken to minimize fugitive dust generation would be prepared.

3.16.2.4 Alternative 1—Ralph Price Reservoir (No Action)

Enlarging Button Rock Dam and spillway at Ralph Price Reservoir is estimated to require about 30 months. Vehicle emissions and fugitive dust generated during construction would result in minor localized and temporary effects to air quality. It is unlikely that the increased pollutants during construction would exceed NAAQS for any criteria pollutants because of the relatively small disturbance area in comparison to regional emission sources throughout the Boulder-Longmont area. Increased emissions would cease after construction; therefore, there would be no long-term effect to air quality.

3.16.2.5 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

Construction of Chimney Hollow Reservoir would impact local air quality from vehicle and equipment emissions and dust generated from earthwork during the 3- to 5-year construction period.

Construction of Chimney Hollow dam and the associated pipeline, roads, and facilities would take about 3 to 5 years. Construction equipment, traffic from a workforce ranging from 200 to 500 workers and truck deliveries of about 5 to 10 vehicles per day would result in a temporary increase in vehicle exhaust emissions. Dust from surface disturbances at rock borrow areas, the dam site, along pipeline routes, and construction access roads would increase during construction. Removal and relocation of Western's transmission line would result in short term, minor air quality impacts from emissions from diesel-fueled equipment and dust related to construction activities.

The Proposed Action would result in negligible to minor impacts on existing air quality during construction at the reservoir site. Regional impacts to northeast Colorado air quality from construction are unlikely to exceed NAAQS for any criteria pollutants because of the relatively localized nature of construction and emission sources in comparison to regional emissions present in Larimer County. Emissions would decrease following completion of construction.

Following construction, Chimney Hollow Reservoir and adjacent Larimer County Open Space would be opened for recreational use. Recreation traffic to the reservoir would result in a negligible long-term increase in vehicle emissions that would not adversely affect local air quality or exceed applicable standards.

3.16.2.6 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Construction of a 70,000 AF Chimney Hollow Reservoir would be similar to that described for Alternative 2. The smaller dam would not substantially change the size of the workforce, construction traffic or vehicle and dust emissions. Impacts to air quality would be similar to that described for Alternative 2.

Construction of Jasper East Reservoir is estimated to take 2.5 to 5 years and would include relocation of the Willow Creek Pumping Station, relocation of County Road 40, followed by development of borrow areas, dam construction, spillways, and pipeline and booster pump installation. Construction equipment, traffic from a workforce of up to 160 workers, and truck deliveries of about 5 to 10 vehicles per day would result in a temporary increase in vehicle exhaust emissions. Dust would be generated from surface disturbance at the reservoir site and construction traffic along the existing and relocated County Road 40. Regional impacts to Grand County air quality from construction are unlikely to exceed NAAQS for any criteria pollutants because of the relatively small localized sources of emission during construction. Increased emissions would cease after construction, although if recreation facilities were developed at the reservoir, there would be negligible long-term increase in vehicle exhaust and dust along County Road 40 from visitor traffic.

3.16.2.7 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Air quality effects associated with construction a 70,000 AF Chimney Hollow Reservoir would be similar to that described for Alternative 2.

Construction of Rockwell Reservoir is estimated to take 2.5 to 4.5 years and would include the development of borrow and staging areas, dam construction, spillways, and pipeline and booster pump installation. The average truck traffic to the site would be about 18 vehicles per day, peaking at as many as 45 vehicles per day during dam construction. About 26 trucks per day would access the project area during pipeline construction. Construction activities and associated traffic would increase emissions from vehicle exhaust and fugitive dust along County Roads 56 and 57. Regional impacts to Grand County air quality from construction are unlikely to exceed NAAQS for any criteria pollutants because of the relatively small localized sources of emission during construction. Increased emissions would cease after construction, although if recreation facilities were developed at the reservoir, there would be negligible long-term increase in vehicle exhaust and dust along county access roads from visitor traffic.

3.16.2.8 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Potential air quality effects from construction of a 30,000 AF Rockwell Reservoir would be similar to that described for Alternative 4.

Construction of the Dry Creek Reservoir dam and appurtenances is estimated to take 2.5 to 4.5 years and includes the establishment of staging areas, development of borrow areas, and construction of the dam, spillways, and pipelines including the outlet boring to Carter Lake. The average truck traffic during dam construction is estimated at about five vehicles per day with peak deliveries of 10 vehicles per day. Construction equipment, truck deliveries, and traffic from a workforce of up to 460 workers would increase vehicle emissions. Traffic along dirt access roads and from surface disturbances would increase dust. Regional impacts to northeast Colorado air quality from construction are unlikely to exceed NAAQS for any criteria pollutants because of the relatively small localized emission sources in comparison to regional emissions present in Larimer County. Increased emissions due to construction activities would cease after completion. If recreation facilities were developed, there could be negligible increase in vehicle emissions from visitor traffic and possibly dust depending on the location and surface of an access road.

3.16.3 Cumulative Effects

No reasonably foreseeable actions were identified in the vicinity of the reservoir sites for the No Action or action alternatives that would result in a cumulative long-term effect to air quality.

3.16.4 Air Quality Mitigation

Several mitigation measures would be used to reduce air emissions:

- Preparing a Fugitive Particulate Emission Control Plan according to applicable local and state management practices to minimize particulate and dust emissions. Inclusion of dust palliative application and/or dust abatement as bid items if they are considered among the management practices.
- Ensuring construction equipment (especially diesel equipment) meets opacity standards for operating emissions.
- Revegetating or stabilizing disturbed areas as soon as possible to reduce dust sources.

3.16.5 Unavoidable Adverse Effects

There would be an unavoidable temporary increase in air pollutants primarily near the reservoir sites for each alternative during construction. There would be no long-term adverse impact to air quality after reservoir and facility construction.

3.17 Noise

3.17.1 Affected Environment

3.17.1.1 Regulatory Framework

CRS § 30-15-401(m)(I) authorizes counties to enact ordinances that regulate noise on public and private property. Maximum permissible noise levels in Colorado are stated in CRS § 25-12-103 and have been adopted into Larimer and Boulder counties' ordinances (Table 3-137). Grand County does not have a noise ordinance (Campbell 2006).

Table 3-137. Maximum noise levels by sound source for Boulder and Larimer counties.

Sound Source	Maximum Noise (dB(A)) 7 AM to 7 PM	Maximum Noise (dB(A)) 7 PM to 7 AM
Residential Zones	55	50
Construction/ Demolition	80	75

Source: Boulder County 2006; Larimer County 2006.

3.17.1.2 Area of Potential Effect

The area of potential effect for evaluating noise is the reservoir and facility construction areas and potential receptors bordering the construction sites that may experience increased noise.

3.17.1.3 Data Sources

Ambient noise levels were based on comparative information for conditions similar to the reservoir sites. Information on construction-related noise was obtained from published sources. Additional information is included in the Air Quality and Noise Technical Report (ERO 2006).

3.17.1.4 Existing Noise Levels

Noise, usually defined as unwanted or unacceptable sound, is measured in terms of decibels (dB) scaled to approximate the hearing capability of the human ear dB(A). A decibel is a unit of measurement that quantifies the sound pressure differences in the air that are perceived as sound (or noise) on a scale ranging from zero decibels on up. Zero decibels is the threshold of human hearing, 40 to 50 dB(A) is normal for a peaceful neighborhood, 70 to 80 dB(A) is the level adjacent to a busy urban street or 50 feet from a major freeway, and 120 to 140 dB(A) is a typical level at which sound is painful.

The study areas for alternative reservoir sites, pipelines, and other facilities currently have negligible vibration and low ambient noise levels (35 to 45 dB(A)) typical of rural locations. Existing noise levels at Ralph Price Reservoir are very low because no private vehicles are allowed at the reservoir and no motorized boating is allowed. Sources of noise at Chimney Hollow are limited primarily to activities at nearby Bureau of Reclamation facilities. Rural public and private roads and a few residents are the primary sources of noise near the Dry Creek Reservoir site. Noise sources at Jasper East include traffic along the existing County Road 40 that bisects the reservoir site, excavation at a nearby aggregate quarry, and tractors and equipment from ranching activities. Noise sources near the Rockwell Reservoir site include traffic on county roads and nearby residential and commercial development.

3.17.2 Environmental Effects

3.17.2.1 Issues

Potential short- and long-term increases in noise levels near reservoir sites were identified as an issue during scoping.

3.17.2.2 Methods for Effects Analysis

Potential impacts from increased noise were evaluated based on anticipated noise levels, the duration of the effects, and the location of nearby receptors. Noise-evaluation criteria are based on land use compatibility and on the direction and magnitude of noise level changes. Annoyance effects are typically the primary consideration. Often, the magnitude of a noise level change is as important as the resulting overall noise level. A noticeable increase in noise levels often is considered a substantive effect by local residents, even if the overall noise level remains within land use compatibility guidelines or complies with local ordinances. Conversely, sometimes noise levels that are somewhat above land use compatibility guidelines or ordinance-specified levels are not noticeable to people.

Noise levels are loudest near the point of generation and decrease with increased distance from the source. Sound intensity decreases in proportion with the square of the distance from the source. Generally, sound levels for a point source will decrease by 6 dB(A) for each doubling of distance (Table 3-138).

Table 3-138. Distance attenuation for construction noise.

Receptor Distance (feet)	Noise Level at Receptor (decibels)
50	95
100	89
200	83
400	77
800	71
1,600	65
3,200	59

Note: Reference noise level is 95 dB(A) for construction equipment. Basic sound level decrease is 6 dB(A) for each doubling of distance. Sound level decrease does not include atmospheric absorption or terrain and vegetative barriers.
Source: FHWA 1995.

3.17.2.3 Effects Common to All Alternatives

Construction activities would be similar for all alternatives. Direct and indirect effects would include noise from construction equipment, increased traffic noise from project-vicinity roadways, and noise from operation of pump stations. Construction activities would generate noise from diesel-powered earth moving equipment such as dump trucks and bulldozers, back-up alarms on certain equipment, compressors, and pile drivers, if necessary. Construction noise at off-site receptor locations is usually dependent on the loudest one or two pieces of equipment operating at the moment. Noise levels from diesel-powered equipment range from 80 to 95 dB(A) at a distance of 50 feet. Impact equipment such as rock drills and pile drivers can generate louder noise levels (FTA 1995).

It is difficult to predict reliable levels of construction noise at a particular receptor or group of receptors. Heavy machinery, the major source of noise in construction, is constantly moving in unpredictable patterns. Construction normally occurs during daylight hours when occasional loud noises are more tolerable. No one receptor is expected to be exposed to construction noise of long duration; therefore, extended disruption of normal activities is not anticipated. However, provisions would-be included in the plans and specifications requiring the contractor to comply with local and state noise ordinances for construction noise.

Blasting would be necessary at all of the reservoir sites for all the action alternatives and possibly for the No Action Alternative. Blasting is needed to: 1) obtain a suitable foundation for the dam prior to placement of the embankment materials; 2) produce suitable rock for the upstream and downstream slopes of the dam from the borrow areas; and 3) construct water conveyance facilities, temporary or permanent access roads, and other project features. Blasting activities could take place throughout the construction period depending on the contractor's plans for producing and stockpiling rock for use in the dam. Blasting would be below the ground and occur for short periods of time during daylight hours. The vibration and sound from blasting can produce a startle effect, although below ground blasts are somewhat muffled and dissipate with distance depending on the geology and meteorological conditions.

Construction of project components would be phased depending on need; however, once all components are constructed, construction noise would cease. Noise levels during operations would be negligible.

3.17.2.4 Alternative 1—Ralph Price Reservoir (No Action)

Raising Button Rock Dam would result in a temporary increase in noise and vibration during construction. Noise from construction would be heard at residences that are about 200 feet from the reservoir. These noise levels could be as much as much as 83 dB(A), which would exceed Larimer County's maximum permissible noise levels (Larimer County 2006).

3.17.2.5 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

Noise and vibration would result from construction of Chimney Hollow dam and the associated pipeline, roads, and related facilities. Nearby residents located on the hogback about 1,000 feet east of the proposed reservoir would experience temporary increased noise levels during construction. These noise levels could reach about 71 dB(A). This temporary noise level would conform to the maximum noise level for construction activity permitted by Larimer County (Table 3-137) (Larimer County 2006). Removal and relocation of Western's transmission line would result in short term, noise impacts from construction activity.

> A local temporary increase in ambient noise levels would occur during the construction of Chimney Hollow Reservoir. The area also would experience a long-term increase in noise associated with development of the area as open space for day use recreational activities.

Power supply to the reservoir and conveyance facilities would come from the existing facilities associated with the Flatiron Power Plant. A substation may be needed to step down voltage; however, the noise generated would not exceed 50 dB(A) at the property boundary, which is the nighttime noise allowance for residential areas in Larimer County (Larimer County 2006).

After project completion, recreational access would be allowed at Chimney Hollow Reservoir and adjacent Larimer County Open Space. Visitors to the site would increase noise from existing levels, but because recreation would be limited to day use and nonmotorized boating, residents on the hogback ridge east of the Chimney Hollow Reservoir site would be unlikely to experience substantial changes in sound levels.

3.17.2.6 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Noise-related impacts for Chimney Hollow Reservoir would be similar to that described for Alternative 2.

Residents located on private lands north and south of County Road 40 and along Highway 34 near the Jasper East Reservoir site may experience temporary increased noise levels during construction. The closest residences are about 1,600 feet from the reservoir site and would experience noise levels of up to about 65 dB(A). Visitors to Willow Creek Reservoir may experience occasional increased noise levels during construction; however, the intensity of the impact would vary according to the activity in progress, and would likely be minor. If recreation facilities were developed, there could be minor levels of noise from visitor traffic and recreation activity.

The booster pump station would contribute to long-term intermittent exterior noise levels; however, the noise generated would not exceed 50 dB(A) at the property boundary.

3.17.2.7 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Noise-related impacts for Chimney Hollow Reservoir would be similar to that described for Alternative 2.

Residents near Rockwell Reservoir would experience temporary increased noise levels during construction. Residences are at least 800 feet from the proposed reservoir and at that distance would experience noise levels of up to 71 dB(A). The booster pump station, which would assist in the delivery to Granby Reservoir, would contribute to exterior noise levels; however, the noise generated would not exceed 50 dB(A) at the property boundary. If recreation facilities were developed, there could be minor levels of noise from visitor traffic and recreation activity.

3.17.2.8 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Noise-related impacts for Rockwell Reservoir would be similar to that described for Alternative 4.

Residents near Dry Creek Reservoir would experience temporary increased noise levels during construction. Residences are at least 800 feet from the proposed reservoir and at that distance would experience construction noise levels of up to 71 dB(A). Residences located about 200 feet from the outlet boring to Carter Lake may experience temporary noise levels of up to about 83 dB(A), which would exceed Larimer County's maximum permissible noise levels (Larimer County 2006). If recreation facilities were developed, there could be minor levels of noise from visitor traffic and recreation activity.

3.17.3 Cumulative Effects

In the vicinity of the alternative reservoir sites, no reasonably foreseeable actions were identified that would result in a cumulative long-term change in noise levels. However, as discussed for Alternative 2, future recreation activities on Larimer County Open Space adjacent to the Chimney Hollow Reservoir site would result in a minor long-term increase in noise.

3.17.4 Noise Mitigation

Potential effects from noise and vibration would be mitigated by:

- Ensuring construction equipment functions as designed and conforms to applicable noise emission standards.
- Requiring the contractor to adhere to project work hour restrictions.
- Restricting access to construction areas so that the public could not be in close proximity to loud equipment or blasting.
- Developing a blasting schedule and notification process for nearby residents when blasting is anticipated to occur. Proceeding blasting with a warning alarm. Blasting plans would include the implementation of seismographs for vibration measurements and air blast recordings for noise.
- Locating operating equipment (e.g., pump stations) in structures designed to minimize radiated noise outside the structure, and designing structures to meet local noise ordinance requirements.
- Developing a noise monitoring and noise mitigation plan if activities are expected to exceed maximum permissible noise levels.

3.17.5 Unavoidable Adverse Effects

All alternatives would result in an unavoidable temporary increase in noise levels during construction. Recreation development at Chimney Hollow Reservoir in Alternatives 2, 3, and 4 would result in a minor long-term increase in noise levels.

3.18 Land Use

3.18.1 Affected Environment

3.18.1.1 Regulatory Framework

County land use regulations for water resource developments vary for each of the counties where project facilities would be located. The enlargement of Ralph Price Reservoir in Boulder County would be subject to special use review, location and extent review, and 1041 Review of Areas and Activities of State Interest (Boulder 2011). The Larimer County Comprehensive Plan and Larimer County Zoning Code regulate land use activities in the county. Construction of Chimney Hollow or Dry Creek reservoirs would be subject to the Location and Extent Review Process prior to county approval (Larimer County 2011). Larimer County 1041 regulations also include review and permitting for power lines, such as relocation of Western's line at Chimney Hollow. Water projects, such as construction of Jasper East or Rockwell reservoirs in Grand County are subject to a Special Use Review (Grand County 2009). In addition, Grand County 1041 Regulations include permit requirements for municipal and industrial water projects.

3.18.1.2 Area of Potential Effect

The area of potential effect for evaluating land use includes the alternative reservoir sites and related pipelines, roads, and infrastructure that would be permanently or temporarily affected. In addition, lands surrounding the reservoir sites that could be indirectly affected are included in the study area. Project facilities for the alternatives are located in three counties. Chimney Hollow and Dry Creek reservoirs would be located in Larimer County, Jasper East and Rockwell Reservoir would be located in Grand County, and Ralph Price Reservoir is located in Boulder County.

3.18.1.3 Data Sources

Information on existing land ownership and use was collected from local, state, federal sources, as well as on-site verification of land use. Colorado Department of Transportation (CDOT) and county data were used to estimate existing traffic volumes near potential reservoir sites. Additional information is included in the Land Use Technical Report (ERO 2008a).

3.18.1.4 Regional Overview

State and federal lands comprise 72 percent of the land in Grand County, 52 percent of the land in Larimer County, and 36 percent of Boulder County (CDOA 2005). Predominant land uses in Grand, Larimer, and Boulder counties near potential project facilities include agriculture, recreation, small town urban areas, and low-density residential homes.

Agricultural activities occur on about 18.5 percent of the land in Grand County, 20 percent in Larimer County, and 22 percent of Boulder County (USDA 2002). Recreation is an important component of land use in all three of the counties. National Forest lands in Grand County, including the Arapaho National Recreation Area that encompasses Granby Reservoir, Shadow Mountain Lake, Grand Lake, and Willow Creek reservoirs, provide popular recreation opportunities. Rocky Mountain National Park is in Grand and Larimer counties. National Forest land and county open space support a variety of recreation activities in Larimer County. Municipal and county open space, along with National Forest lands provide public recreation opportunities in Boulder County.

Urban and residential areas in Grand County are located along the Colorado River and Fraser River. The Town of Granby is south of the Jasper East Reservoir site and north of the Rockwell Reservoir site. Much of the residential development in Grand County is dispersed as low-density rural areas, but many new developments include low to moderate densities of homes. Residential land use near Chimney Hollow and Dry Creek reservoirs in Larimer County is primarily low-density rural homes. Loveland and Berthoud are the closest communities to these reservoir sites. Lyons is the closest community to Ralph Price Reservoir and residences near the reservoir are few and scattered.

3.18.1.5 Ralph Price Reservoir

Land Ownership

Ralph Price Reservoir, including the area of potential enlargement, is on land owned by the City of Longmont (Figure 3-110). Potential borrow sites are located on city, National Forest, and private lands.

Land Use

Ralph Price Reservoir is an existing reservoir in unincorporated Boulder County. The reservoir and surrounding lands are designated in the Boulder County Comprehensive Plan as a *Municipal Watershed* and zoned as *Forestry* (Boulder County 2004). Recreation and water storage are permitted uses. The City of Longmont manages the reservoir and surrounding land for resource preservation and water storage as part of the Button Rock Preserve. Two private residences are located on the north side of the reservoir. City of Longmont property includes a ranger residence. Angling opportunities are available at Ralph Price Reservoir and the surrounding lands offer opportunities for hiking and wildlife viewing.

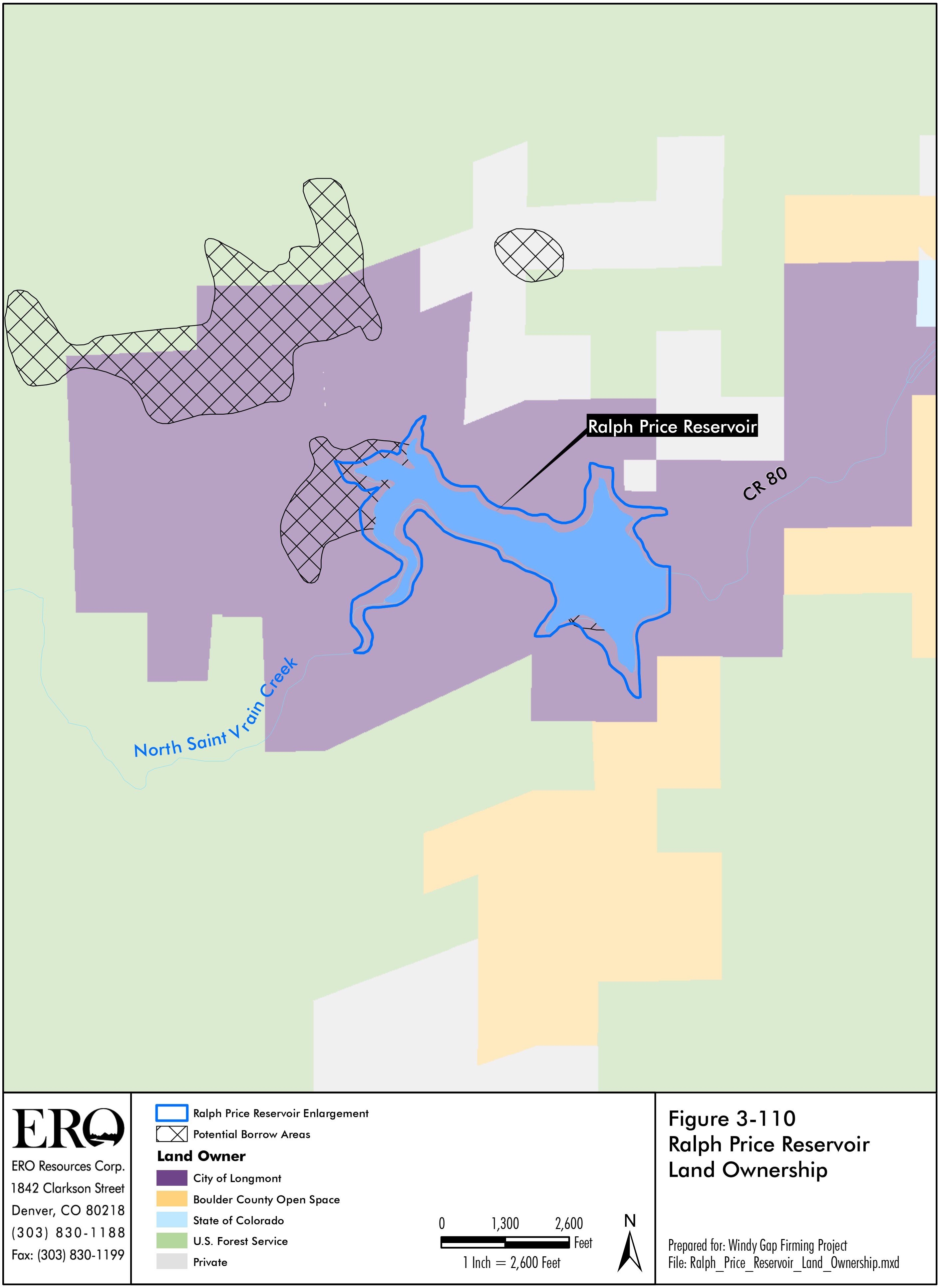


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Figure 3-110
Ralph Price Reservoir
Land Ownership

Prepared for: Windy Gap Firming Project
File: Ralph_Price_Reservoir_Land_Ownership.mxd

Transportation

Access to the Ralph Price Reservoir is provided via Boulder County Road 80 off U.S. 36, although visitor parking is located about 2 miles from the reservoir. Existing average daily traffic on County Road 80 is 320 vehicles (Boulder County 2005).

3.18.1.6 Chimney Hollow Reservoir

Land Ownership

Chimney Hollow Reservoir would be located primarily on land owned by the Subdistrict (Figure 3-111). A portion of the reservoir and project facilities would be located on private lands, Larimer County Open Space, and Reclamation property.

Land Use

The Chimney Hollow Reservoir site is currently undeveloped land zoned as *Open Lands (low density rural residential 1/10 acres) and Estate-1* lands (Larimer County 2004). Historically the land was used for livestock grazing and as a private recreation area. The proposed reservoir footprint includes 63 acres of two soil types classified as farmland of local importance and farmland of statewide importance (NRCS 2005a). Areas having this soil complex with slopes less than 6 percent would qualify as prime farmland if irrigated with an adequate supply of water (SCS 1982). None of the affected lands are currently farmed or irrigated.

No occupied homes are present at the site. Several homes are located on the hogback ridge east of the reservoir site. A 115-kV electric transmission line operated by the Western Area Power Administration runs the length of the site. Flatiron Reservoir, a hydropower generation facility, Reclamation offices, and other C-BT facilities are located just north of the Chimney Hollow Reservoir site.

No active land use or management activities are presently occurring in the Chimney Hollow area. The 1998 Larimer County Open Lands Plan identified lands at Chimney Hollow as part of the Blue Mountain Project and a potential high priority open space. The goals of the Blue Mountain Project are to protect natural resources and open space (including ridgelines) and provide ecosystem connectivity between Blue Mountain Ranch and Carter Lake (Larimer County 1998). Lands at the Blue Mountain Ranch were recently protected from further development through a Larimer County conservation easement. Larimer County has purchased over 1,700 acres of land adjacent to Subdistrict lands; these lands would become part of the planned Chimney Hollow Open Space area. Larimer County and the Subdistrict entered into an intergovernmental agreement that includes a recreational lease by the county of about 1,600 acres of the Subdistrict property at no fee (Larimer County-Municipal Subdistrict 2004). The recreational lease is contingent on construction of Chimney Hollow Reservoir.

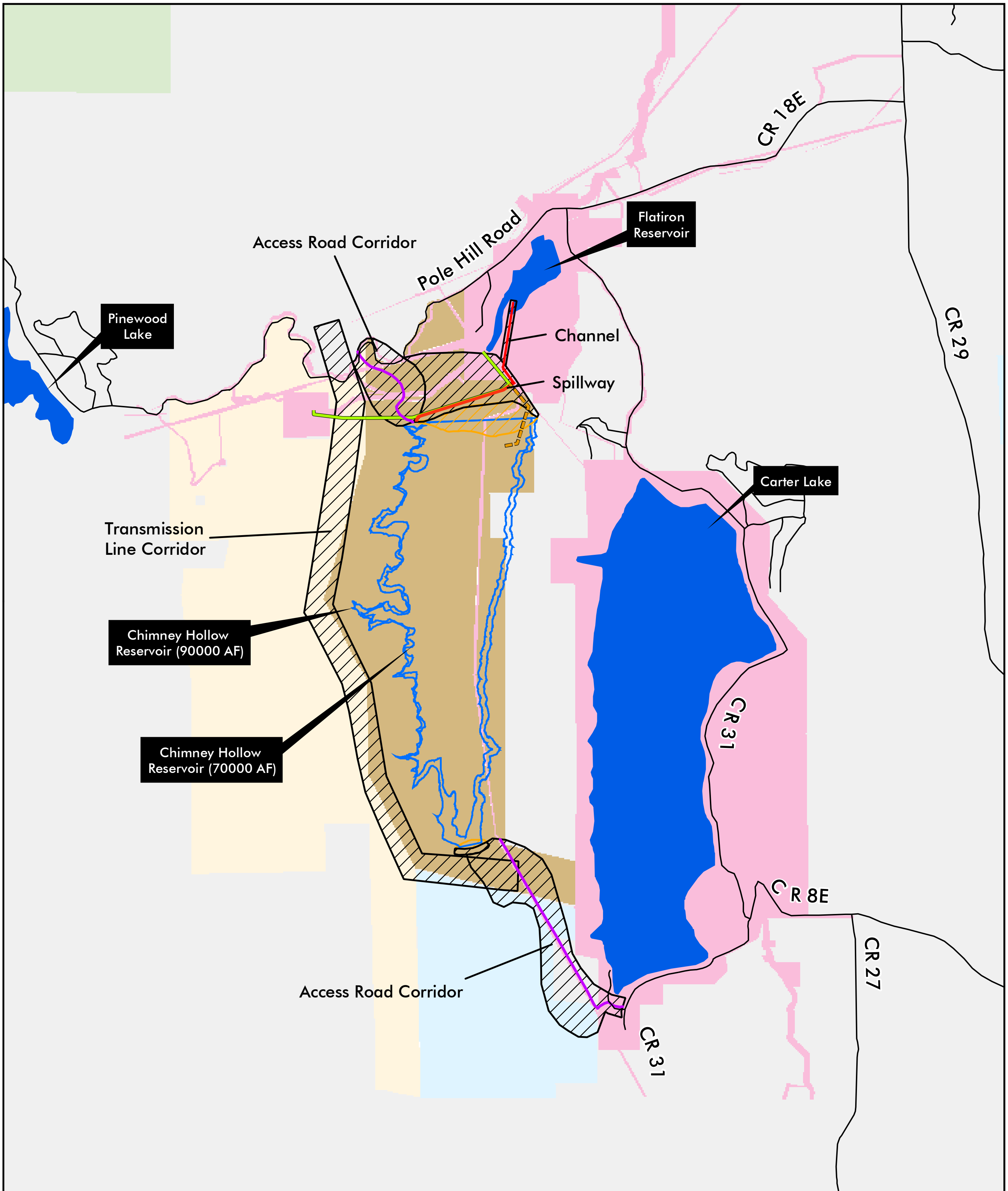
Transportation

An existing private dirt road and several spur roads extending from County Road 18E and County Road 31 provide access to the reservoir site. Other nearby county roads that provide linkage to the reservoir site are shown in Figure 3-111 and the existing traffic volumes are shown in Table 3-139.

Table 3-139. Average daily traffic and vehicle capacity near Chimney Hollow and Dry Creek reservoirs.

Access Road	Average Daily Traffic	Vehicle Per Day Capacity
CR 18E	1,300	3,200
CR 31	800	5,400
CR 8E	1,200	5,400
CR 29	1,800	5,800

Source: Larimer County 2000.



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Land Owner

- State of Colorado
- U.S. Forest Service
- Reclamation Lands
- Subdistrict
- Larimer County Open Space
- Private

- New or Improved Road Access
- Inlet - Outlet
- Spillway/Channel
- Pipeline
- Potential Disturbance Area

0 2,000 4,000 Feet

1 Inch = 4,000 Feet

N

Figure 3-111
Chimney Hollow Land Ownership

Prepared for: Windy Gap Firming Project
File: Chimney_Hollow_Land_Ownership_All.mxd

3.18.1.7 Dry Creek Reservoir

Land Ownership

Dry Creek Reservoir is primarily on private property and Colorado State Land Board property (Figure 3-112). A small portion of the reservoir footprint is located on Larimer County Open Space. Pipeline connections would cross Subdistrict, private, and Reclamation property.

Land Use

The Dry Creek area is mostly undeveloped and provides habitat for a variety of wildlife species. The reservoir site is located on lands zoned primarily as *Open Lands (low density rural residential 1/10 acres) and Estate-1* lands (Larimer County 2004). Like Chimney Hollow, Larimer County has identified the Dry Creek site as part of the Blue Mountain Project and as high priority open space (Larimer County 1998). Included on the site are three private residences, one of which is a llama operation. This small business specializes in breeding, showing, and packing llamas, and in 2005 had about 13 animals. The State Land Board currently has a mining lease with a party who is selling moss rock from the site (Routen, pers. comm. 2006a). State Land Board property at Dry Creek has historically been leased for grazing and is currently closed to public use.

Dry Creek Reservoir includes 10 acres of soils classified as farmland of local importance (NRCS 2005b). Areas having this soil complex with slopes less than 6 percent would qualify as prime farmland if irrigated with an adequate supply of water (SCS 1982). None of this land is currently farmed or irrigated.

Transportation

Access to the site is via U.S. 36, unpaved County Road 71, and other private roads northwest of Lyons. An unimproved road extends through the center of the site in addition to several private dirt roads that provide access to homes.

3.18.1.8 Jasper East

Land Ownership

The Jasper East Reservoir site is on NCWCD and Reclamation property (Figure 3-113).

Land Use

Agriculture is the primary land use at the Jasper East Reservoir site. Lands are zoned by Grand County as *Forestry/Open* lands (Grand County 2009, 2011). Approximately 313 acres are flood irrigated for cultivation of hay and cattle grazing; however, no prime farmland is present (SCS 1982). The Willow Creek Pump Station, forebay, and portions of the Willow Creek pump canal, which are features of the C-BT Project used to carry water from Willow Creek Reservoir to Granby Reservoir, are located at the site. The remainder of the site is undeveloped and provides wildlife habitat. No homes are present at Jasper East.

Transportation

County Road 40 provides access from Highway 34 to the reservoir site as well as to Willow Creek Reservoir, private land, and residences. Average daily traffic on Highway 34 is 4,400 vehicles (CDOT 2004).

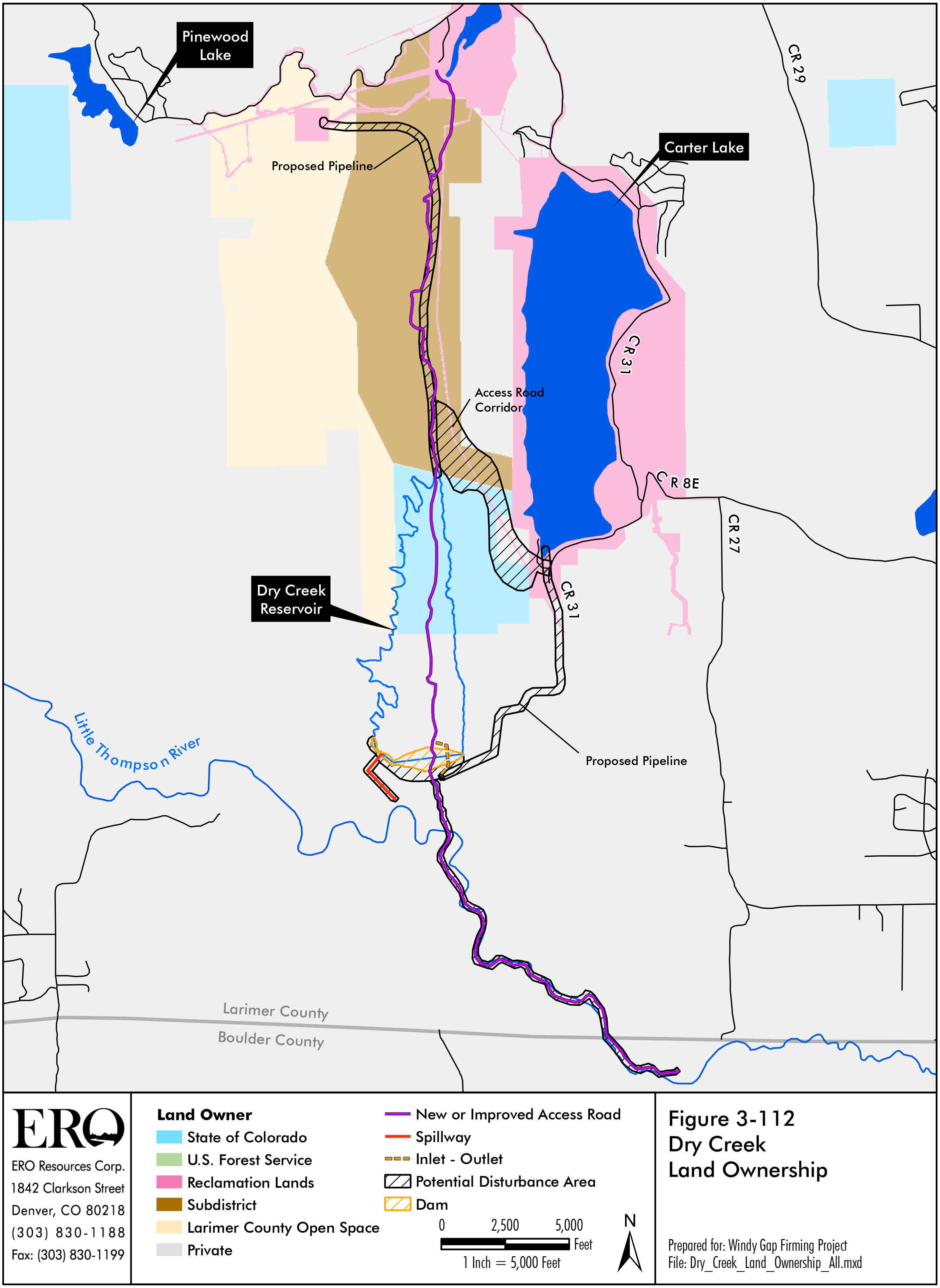

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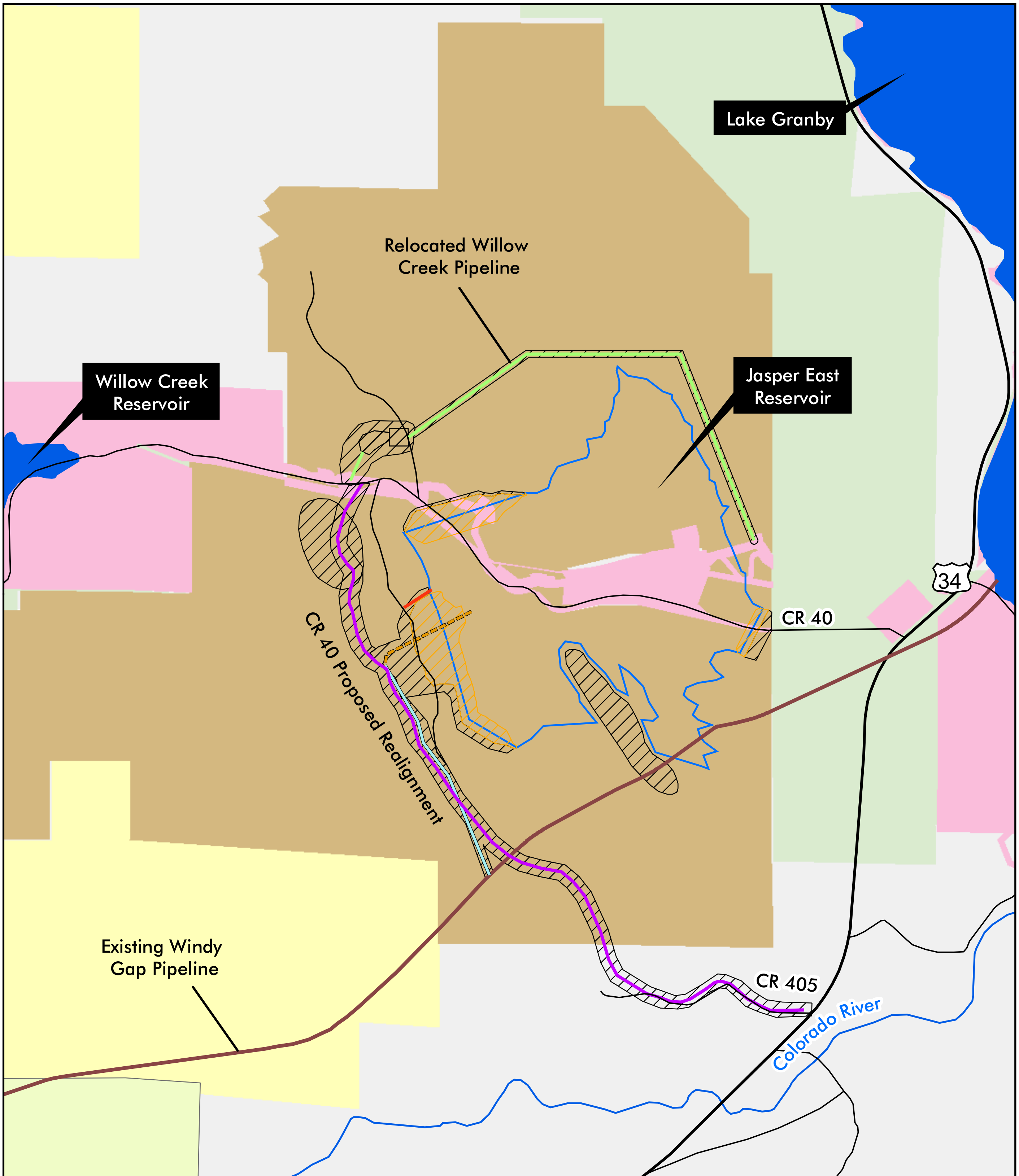
Figure 3-112
Dry Creek
Land Ownership

Prepared for: Windy Gap Firming Project
File: Dry_Creek_Land_Ownership_All.mxd



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Land Owner
- Bureau of Land Management
- U.S. Forest Service
- Reclamation Lands
- Subdistrict
- Private
- New or Improved Access Road
- New Pipeline
- Inlet - Outlet
- Spillway
- Dam
- Potential Disturbance Area

0 1,100 2,200 Feet
1 Inch = 2,200 Feet
N

Figure 3-113
Jasper East
Land Ownership

Prepared for: Windy Gap Firming Project
File: Jasper_East_Land_Ownership_All.mxd

3.18.1.9 Rockwell Reservoir

Land Ownership

The Rockwell Reservoir site is on private and BLM property (Figure 3-114).

Land Use

The Rockwell Reservoir site supports irrigated and nonirrigated meadows used as pastureland, a small stock pond, and four private residences. No prime farmland is present at the site (SCS 1982). The undeveloped portions of this site provide wildlife habitat. Lands are zoned by Grand County as *Forestry/Open* lands (Grand County 2009, 2011).

Transportation

Access to the site is via unpaved county roads. County Road 57 off U.S. 40 provides access from the north and County Road 56 off U.S. 40 provides access from the east. Average daily traffic on U.S. 40 near County Road 56 is 9,100 vehicles per day and existing average daily traffic near County Road 57 is 6,400 vehicles per day (CDOT 2004).

3.18.2 Environmental Effects

3.18.2.1 Issues

Potential effects to private and public land ownership and existing land uses were identified as issues of concern during scoping. Also of concern were effects to local transportation near new reservoir sites during construction and with any new recreation development.

3.18.2.2 Methods for Effects Analysis

Potential effects to existing land ownership were evaluated by overlaying proposed project facilities for each alternative on land ownership maps. Similarly, effects to existing land uses were evaluated based on anticipated changes at reservoir sites. Potential conflicts with local land use regulations were also evaluated for each of the alternative reservoir sites. Predicted construction traffic volumes and visitor estimates were used to evaluate short and long-term effects to local traffic.

3.18.2.3 Land Use Effects Common to All Alternatives

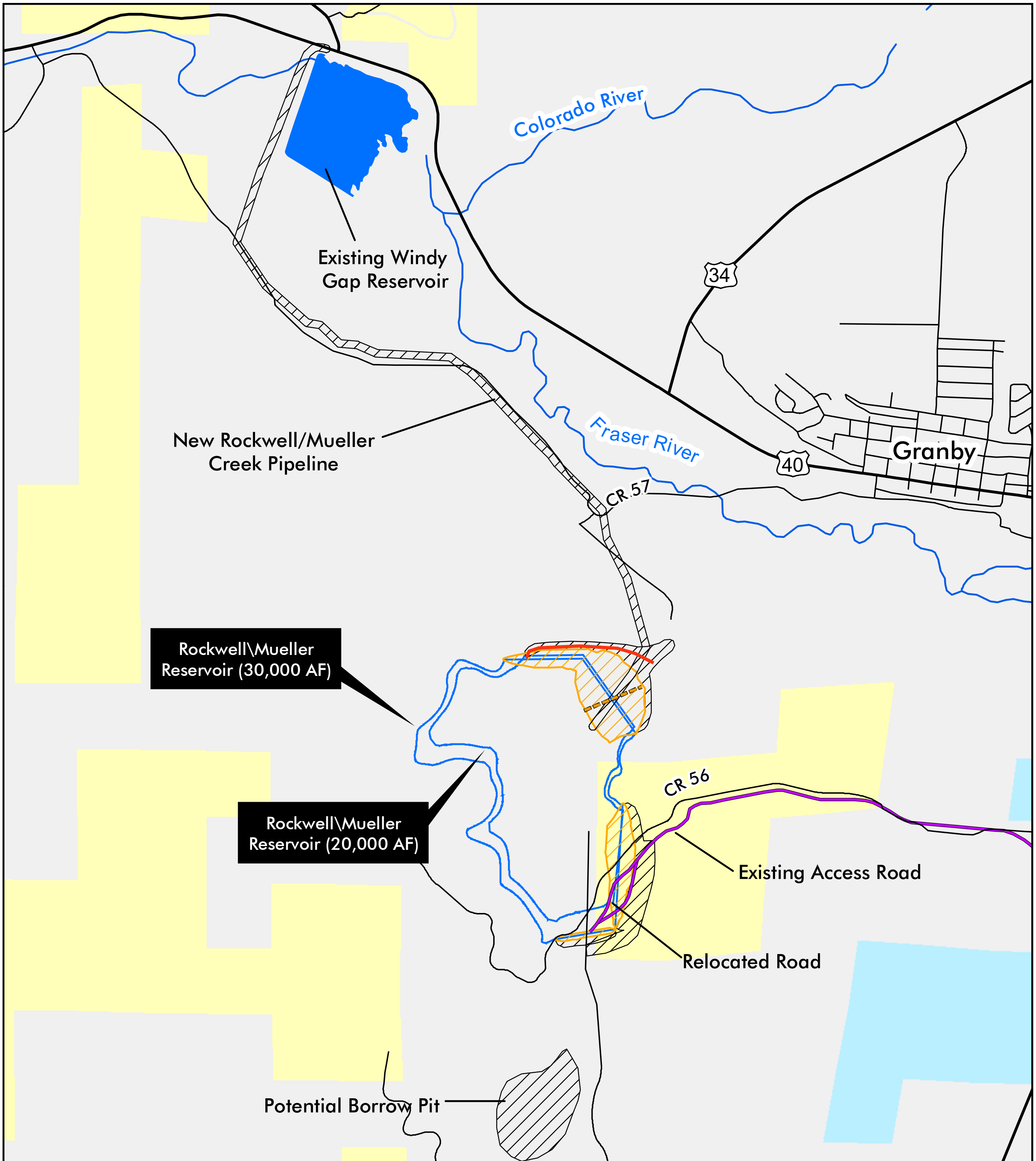
All alternatives include the diversion of water from the Colorado River at the existing Windy Gap Reservoir west of the Town of Granby. The Subdistrict would continue to operate the Windy Gap diversion and reservoir on property it owns. No new facilities would be constructed along the Colorado River that would affect existing land ownership and land uses. Water rights for existing agriculture, municipal, and other uses would be protected under Colorado water law. Municipal and agricultural diversions downstream from Windy Gap Reservoir, per Colorado water law (CRS § 37-92-102(2)(b)), would remain responsible for developing a reasonable means of diversion for their water.

None of the alternatives would directly affect land use at locations outside of those needed to support project facilities. Future land development in Boulder, Grand, and Larimer counties is determined by local land use plans and zoning.

3.18.2.4 Alternative 1—Ralph Price Reservoir (No Action)

Land Ownership

The enlargement of Ralph Price Reservoir would occur on about 77 acres of City of Longmont property (Table 3-140). Borrow areas likely would be located on city land, but could potentially be located on private or National Forest lands. No land acquisition is required to enlarge Ralph Price Reservoir.



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New or Improved Access Road
Inlet - Outlet
Spillway
Dam
Potential Disturbance Area
Reservoir

0 1,400 2,800 Feet
1 Inch = 2,800 Feet
N

Figure 3-114
Rockwell Land Ownership

Prepared for: Windy Gap Firming Project
File: Rockwell_Land_Ownership_All.mxd

Table 3-140. Current land ownership at potential reservoir sites.

Alternative	Private	Subdistrict	Reclamation	BLM	State Land Board	County/ Municipal
	acres					
Alternative 1						
Ralph Price	-	-	-	-	-	77
Alternative 2						
Chimney Hollow	36	858	70	-	2	54
Alternative 3						
Chimney Hollow	26	750	66	-	2	54
Jasper East	10	536[1]	70	-	-	-
Total	**36**	**1,286**	**136**		**2**	**54**
Alternative 4						
Chimney Hollow	26	750	66	-	2	54
Rockwell	443	-	-	29	-	-
Total	**469**	**750**	**66**	29	**2**	**54**
Alternative 5						
Dry Creek	459	74	18	-	233	7
Rockwell	504	-	-	51	-	-
Total	**963**	**74**	**18**	51	**233**	**7**

[1] The Subdistrict would need to acquire these lands from the NCWCD.

Land Use

Existing recreation activities and public access at Ralph Price Reservoir and Button Rock Preserve would be temporarily suspended during construction; however, access and amenities would be restored following reservoir enlargement. There would be no direct effect to private residences near the reservoir, but Longmont's ranger residence could be affected. No elements of the expansion of Ralph Price Reservoir were identified that would directly conflict with the Boulder County Comprehensive Plan or other regulations. The county review process would further evaluate the effects of the action and any conditions for approval.

Transportation

During the estimated 30-month construction period, traffic on U.S. 36 and County Road 80 would increase. In addition to supply and equipment deliveries, the construction workforce of up to 100 workers would increase current average daily traffic levels on County Road 80 by about 63 percent. Following construction, traffic levels would be expected to return to existing levels.

3.18.2.5 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

Land Ownership

The Subdistrict currently owns about 84 percent of the land needed to construct and operate the proposed Chimney Hollow Reservoir (Table 3-140). Portions of several small, private parcels near the northeast corner of the proposed reservoir would need to be acquired in addition to several easements. No private homes would need to be acquired. Western would need to acquire easements on Larimer County, Subdistrict, Reclamation, and possibly State Land Board property depending on the final design and alignment for relocation of 3.8 miles of transmission line. The pipeline connection to the Bald Mountain Tunnel Surge Tank and the Flatiron Penstock Valve house would require a 1,640-foot construction and permanent easement from Larimer County and a 1,035-foot easement from Reclamation. The 1.3-mile construction access road at the south dam would require acquisition of an

> Chimney Hollow Reservoir would be constructed primarily on land owned by the Subdistrict, but several private parcels of land and easements for Reclamation and Larimer County property would need to be acquired. No private residences would be directly affected.

approximately 0.3-mile easement across State Land Board property, as well as 0.4 mile of easement on private land, and 0.2 mile of easement on Reclamation land (Boyle Engineering 2005b).

Land Use

None of the property is used for agriculture, but there would be a loss of 63 acres of land classified as farmland of local and state-wide importance including land that would be considered prime farmland if irrigated (NRCS 2005a). Because none of the property potentially affected by construction of Chimney Hollow Reservoir is irrigated, there would be no loss of prime farmland associated with construction of Chimney Hollow Reservoir.

Subdistrict land, including the reservoir, would be managed for recreation use by Larimer County in an agreement with the Subdistrict as part of the larger Chimney Hollow Open Space area (Larimer County–Municipal Subdistrict 2004). Subdistrict and county lands would be protected from future development and would be open to a variety of nonmotorized recreational opportunities including hiking, biking, and horseback riding. Water-based recreation opportunities would be angling and nonmotorized boating. Anticipated recreation features that would be developed in a recreation management plan would include a parking area, trails, boat dock and ramp, picnic facilities, and vault toilets. It is estimated that 10 miles of trail would be constructed on both county and Subdistrict land (Larimer County-Municipal Subdistrict 2004). Larimer County Parks and Open Land would prepare a recreation master plan prior to completion of the reservoir.

There would be no impact to existing or planned residential or commercial property. No elements associated with the construction of Chimney Hollow Reservoir and facilities were identified that would directly conflict with Larimer County land use plans or other regulations. The county review process would further evaluate the effects of the action and any conditions for approval.

Transportation

With an estimated peak workforce of up to 500 workers and 5 to 10 truck deliveries per day, construction traffic, would increase traffic volume on County Road 18E (Figure 3-111) about 79 percent during the estimated 38-month construction period. Although the traffic increase would remain below the capacity of 3,200 vehicles per day, traffic delays and congestion at intersections during the morning and afternoon commuting periods would be likely. A portion of the traffic would access the south end of the reservoir off County Road 31 for construction of the saddle dam; however, traffic volumes would be well below the capacity of 5,400 vehicles per day. The Subdistrict and contractors would comply with applicable Larimer County Road and Bridge Department regulations and work with the county to minimize impacts to roads and maintain traffic safety during construction.

No existing public recreation use of the property would be affected. No impact to recreation use at Flatiron Reservoir is anticipated, but there would be additional traffic and construction related noise nearby. Following construction, vehicle access to the reservoir and Chimney Hollow Open Space would be limited to a new road extending off County Road 18E to the west side of the reservoir above the dam. A long-term increase in traffic on County Road 18E would occur from projected recreation of 50,000 visitors annually. Recreation traffic likely would be greatest on weekends during the summer.

3.18.2.6 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Chimney Hollow Reservoir

Land Ownership. Construction of a 70,000 AF Chimney Hollow Reservoir would affect land ownership on 10 fewer acres of private land, 4 acres less of Reclamation land, and 108 acres less of Subdistrict land than the Proposed Action (Table 3-140). Other easement requirements would be similar to the Proposed Action.

Land Use and Transportation. Land use and transportation effects would be the same as described for the Proposed Action.

Jasper East Reservoir

Land Ownership. The majority of Jasper East Reservoir, dam, and facilities would be located on land owned by the NCWCD and that would need to be purchased by the Subdistrict (Table 3-140). About 70 acres would be located on Reclamation property. Reclamation and the Subdistrict would need to develop an appropriate agreement to permit construction of the reservoir. This could involve either a land exchange or a contract between Reclamation and the Subdistrict. The relocation of about 1.6 miles of County Road 40 would require purchase of about 4.4 acres of private land and 6.9 acres of NCWCD property. Road relocation could affect existing private lands uses, which currently support livestock grazing. The relocated road would need to be constructed to Grand County road and drainage standards, although maintenance would remain with Grand County. Relocation of 1.7 miles of the Willow Creek Pump Canal and the 1.1-mile Jasper East-Windy Gap pipeline connection would require acquisition of NCWCD property by the Subdistrict.

Land Use. Construction of Jasper East Reservoir and associated facilities would permanently remove about 313 acres of irrigated hay meadows from use for grazing and hay production. This would be less than a 1 percent reduction in Grand County total farmland. There would be a loss in lease and agricultural production revenue associated with the change in land use. No prime farmland would be affected (SCS 1982).

There would be no impact to existing or planned residential or commercial property. Construction of large reservoirs, dams, and other water management structures are permitted under Grand County regulations by Special Use Review. County zoning regulations contain specific regulations for special use permits to "construct or operate facilities for a trans-basin diversion" (Grand County 2009). Jasper East Reservoir would be located outside of the Three Lakes Design Review Area. No elements associated with the construction of Jasper East Reservoir and facilities were identified that would directly conflict with Grand County land use plans or other regulations. However, the county review process would further evaluate the effects of the action and any conditions for approval through its Special Use Review and 1041 Regulations to ensure that the project complies with county planning and zoning policies and regulations.

No existing public recreation use of the property would be affected. Recreation development at the new reservoir is possible if a managing entity is identified. Forest Service management of the property would likely require a transfer of land (Mathew, pers. comm. 2005). If an entity is found to manage recreation facilities, a management plan would be prepared to determine what types of activities to allow and how the facility would operate. Development of recreation facilities would contribute to changes in land use from the additional public access and associated traffic. Construction of Jasper East Reservoir would not affect conceptual trail corridors being evaluated in the county (Headwaters Trails Alliance 2008, Elicker, pers. comm. 2008).

Transportation. County Road 40 would be relocated to maintain access to Willow Creek Reservoir and private residences and property. Construction traffic, composed of an estimated peak workforce of up to 160 workers and 5 to 10 truck deliveries per day, would increase traffic volume on U.S. 34 and County Road 40 (Figure 3-113) during the estimated 38-month construction period. The construction workforce would likely commute from Grand Lake, Granby, Hot Sulphur Springs, and other nearby communities. The estimated increase in traffic volume of 340 vehicles per day would be an 8 percent increase from existing traffic volumes on U.S. 34. No existing traffic count data are available for County Road 40, but relocation of County Road 40 would assist in separating construction traffic from local traffic.

Traffic to the reservoir following construction for operation and maintenance would be minimal. If recreation facilities are developed, an increase in traffic, particularly during the summer season, would occur.

3.18.2.7 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Chimney Hollow Reservoir

Land use effects for Chimney Hollow Reservoir under Alternative 4 would be the same as Alternative 3.

Rockwell/Mueller Creek Reservoir

Land Ownership. Rockwell Reservoir and associated facilities would require Subdistrict acquisition of about 443 acres of private land owned by several landowners and about 29 acres of BLM land (Table 3-140). The Subdistrict would need to obtain a BLM special use permit prior to using 56 acres of BLM property for a potential borrow pit (Cassel, pers. comm. 2005a). Realignment of 2,200 feet of County Road 56 would require acquisition of an easement along undeveloped BLM property. Construction of the 3.2-mile pipeline to Windy Gap Reservoir and placement of a booster station would require acquisition of a 100-foot-wide construction easement, as well as a 50-foot-wide permanent easement directly adjacent to County Road 57 from private landowners (Boyle Engineering 2005b).

Four private homes would need to be purchased and residents would be displaced with reservoir construction. There would be no effect to commercial or urban property.

Land Use. Reservoir construction would eliminate about 53 acres of pastureland and displace existing livestock grazing, and landowners. Construction of large reservoirs, dams, and other water management structures are regulated under Grand County Special Use Review. The zoning regulations contain specific regulations for special use permits to "construct or operate facilities for a trans-basin diversion" (Grand County 2009). Rockwell Reservoir would be located outside of the Three Lakes Design Review Area. No elements associated with the construction of Rockwell Reservoir and facilities were identified that would directly conflict with Grand County land use plans or other regulations. The county review process would further evaluate the effects of the action and any conditions for approval through its Special Use Review and 1041 Regulations to ensure that the project complies with county planning and zoning policies and regulations.

No existing public recreation use of the property would be affected. Recreation development at the new reservoir is possible if a managing entity is identified. If an entity is found to manage recreation facilities, a management plan would be prepared to determine what types of activities to allow and how the facility would be operated. Development of recreation facilities would contribute to changes in land use from the additional public access and associated traffic.

Transportation. Access to Rockwell Reservoir would occur via County Road 57 from the north and County Road 56 to the east. Both of these roads may need to be improved to handle construction traffic. County Road 56 would need to be realigned south of the dam prior to construction to maintain private property access. The realignment of county roads would need to be constructed to Grand County road and drainage standards. Maintenance would remain with Grand County if road construction were approved.

Construction traffic, including a peak workforce of up to 152 workers and 5 to 10 truck deliveries per day would increase traffic volume on U.S. 40 and County Roads 56 and 57 (Figure 3-114) during the estimated 38-month construction period. Assuming that construction traffic is evenly split between County Road 56 and County Road 57, the additional 324 vehicles per day would result in a 4 percent increase in average daily traffic on U.S. 40 near the intersection of County Road 56, and a 5 percent increase in average daily traffic on U.S. 40 near the intersection of County Road 57. The additional traffic may result in periodic travel delays and congestion at intersections.

Following construction, traffic to the reservoir for operation and maintenance would be minimal. If recreation facilities are developed, an increase in traffic, particularly during the summer season would occur.

3.18.2.8 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Dry Creek Reservoir

Land Ownership. The Subdistrict would need to acquire about 459 acres of private land and about 230 acres of State Land Board property to construct Dry Creek Reservoir (Table 3-140). About 18 acres of Reclamation lands would be disturbed by new or improved access roads and pipeline connections. A potential construction access route from the south via Meadow Hollow would require acquisition of an easement from private landowners for access and road improvements. The pipeline connection to C-BT facilities would extend across about 317 feet of

Reclamation property and 3 miles of Subdistrict land. Construction of a 2-mile long pipeline between Dry Creek and Carter Lake would require acquisition of a 100-foot-wide construction and 50-foot-wide permanent easement from private landowners and Reclamation (Boyle Engineering 2005b).

Construction of Dry Creek Reservoir would require acquisition of three private homes, which would permanently displace the residents.

Land Use. Reservoir construction would permanently displace the existing llama operation. None of the property is used for agriculture, but there would be a loss of about 10 acres of land classified as farmland of local and state-wide importance including land that would be considered prime farmland if irrigated (NRCS 2005a). However, there would be no loss of prime farmland associated with construction of Dry Creek Reservoir because none of the land is irrigated.

No existing public recreation use of the property would be affected. Recreation development at the new reservoir is possible if a managing entity is identified. If an entity is found to manage recreation facilities, a management plan would be prepared to determine what types of activities to allow and how the facility would be operated. Development of recreation facilities would contribute to changes in land use from the additional public access and associated traffic.

No elements associated with the construction of Dry Creek Reservoir and facilities were identified that would directly conflict with Larimer County land use plans or other regulations. The county review process would further evaluate the effects of the action and any conditions for approval.

Transportation. It is assumed that construction access would be primarily via County Road 18E and an improved access road built from the north through Chimney Hollow (Figure 3-112). Construction traffic, with an estimated peak workforce of up to 460 workers and 5 to 10 truck deliveries per day, would increase average daily traffic volume on County Road 18E about 72 percent during the estimated 38-month construction period. The additional traffic is likely to reduce vehicle speeds and increase congestion at intersections. The traffic increase would remain within Larimer County's capacity of 3,200 vehicles per day. Access from the south or east off of County Road 31 is also possible, which would disperse traffic over a greater area.

Following construction, traffic to the reservoir for operation and maintenance would be minimal. If recreation facilities are developed, an increase in traffic, particularly during the summer season, would occur.

Rockwell/Mueller Creek Reservoir

Land Ownership. Effects to land ownership and land use associated with construction of a 30,000 AF Rockwell Reservoir would be similar to those described for Alternative 4. The Subdistrict would need to acquire about 530 acres of private land and about 52 acres of BLM property (Table 3-140). Similar easements would be required including an additional 0.1 mile for relocation of County Road 56.

Land Use and Transportation. Land use and transportation effects would be the same as described for Alternative 4.

3.18.3 Cumulative Effects

No reasonably foreseeable future land developments were identified near Ralph Price Reservoir that would contribute to a cumulative effect on local land use.

Reasonably foreseeable future residential development on 1,440 acres of land within 5 miles of Chimney Hollow Reservoir would contribute to a cumulative loss in undeveloped land in the area under the Proposed Action and Alternatives 4 and 5. Larimer County Open Space development on lands adjacent to Chimney Hollow Reservoir would add to a cumulative increase in recreation opportunities.

Future residential and commercial land developments within 5 miles of the Jasper East Reservoir site in Alternative 3 would contribute about 1,590 acres of additional land use change to the local area, including a potential loss in additional agricultural land and undeveloped land.

Planned future residential, commercial, and mixed land use developments near Rockwell Reservoir in Alternatives 4 and 5 would contribute about 4,770 acres of additional land use change to the area. This could include a cumulative loss of land used for agriculture and undeveloped land.

Reasonably foreseeable future residential land developments near Dry Creek Reservoir in Alternative 5 would add about 1,460 acres of land use change to the area. This would contribute to the cumulative loss of undeveloped land near the reservoir site.

Reasonably foreseeable water-based actions on the West Slope would affect streamflow in the Colorado River, but would not have any direct incremental effect on land ownership or use that overlaps the effects of the WGFP. The expiration of Denver Water's contract with Big Lake Ditch in 2013 would reduce the amount of irrigated agriculture in the Reeder Creek drainage and add to the cumulative loss of agricultural production in Grand County with construction of Jasper East Reservoir under Alternative 3. No other cumulative effects were identified for water-based reasonably foreseeable actions.

3.18.4 Land Use Mitigation

No specific mitigation was identified other than what may be needed for land acquisitions or county land use requirements, including special use review, location and extent review, and 1041 permitting. The Subdistrict would compensate landowners for acquisition of property or homes impacted by project facilities.

If Chimney Hollow Reservoir is constructed, the Subdistrict and construction contractors would comply with applicable Larimer County Road and Bridge Department regulations and work with the county to minimize impacts to roads and maintain traffic safety. If a potential impact to recreation access at Flatiron Reservoir is identified during construction planning, appropriate mitigation measures to minimize impacts on recreation use of Flatiron Reservoir would be developed.

3.18.5 Unavoidable Adverse Effects

There would be a long-term change in land use and for some reservoir sites, in land ownership, associated with construction and operation of the alternative reservoirs and facilities.

3.19 Recreation

3.19.1 Affected Environment

3.19.1.1 Area of Potential Effect

The study area for assessing potential effects to recreation resources includes portions of Grand, Larimer, and Boulder counties where project facilities would be located and existing streams, lakes, and reservoirs that would be affected by changes in flow or storage. C-BT reservoirs that would experience a change in operations—Granby Reservoir on the West Slope and Carter Lake and Horsetooth Reservoir on the East Slope are also in the study area. Water levels in Grand Lake and Shadow Mountain Reservoir would not change, but potential changes in water quality that could affect recreation are discussed. Willow Creek Reservoir is not in the study area because there would be no change in water surface elevation or water quality under any alternative, and consequently no impact to recreation. Streams with potential recreation-related effects are the Colorado River from Granby Reservoir to State Bridge and Willow Creek below Willow Creek Reservoir on the West Slope. East Slope streams in the recreation study area are North St. Vrain Creek, St. Vrain Creek, Big Thompson River, Big Dry Creek, and Coal Creek.

3.19.1.2 Data Sources

Information on recreation activities and facilities in the study area was gathered from the BLM, Forest Service, CDPW, and Larimer County Parks and Open Lands. Information was also obtained from reports, communication with river guides, and field visits. Emphasis was given to water-based recreation because the greatest potential for recreation impacts would occur to activities such as boating and fishing. Additional information on recreation is found in the Recreation Resources Technical Report (ERO 2008b).

3.19.1.3 West Slope Reservoir Recreation

Grand Lake, Shadow Mountain, and Granby Reservoir

Recreation at Three Lakes—Grand Lake, Shadow Mountain, and Grand Lake—primarily consists of boating, fishing, and sightseeing during the summer season. The Three Lakes are part of the Arapaho National Recreation Area managed by the U.S. Forest Service. Winter recreation includes cross-country skiing, snowmobiling, and ice fishing. Power and sail boating are popular, along with canoeing and kayaking. Boating facilities include boat ramps and marinas at all Three Lakes (Table 3-141). Many homes and businesses also have private boat docks. An estimated 500 to 3,000 anglers visit the Three Lakes on busy summer weekends (Oldham, pers. comm. 2005). Camping and hiking are also popular near the Three Lakes.

Table 3-141. Three Lakes boating facilities.

Lake	Surface Acres	Boat Ramps	Marinas
Grand Lake	507	1 (public)	2
Shadow Mountain Reservoir	1,852	2	1
Granby Reservoir	7,250	3	4

Windy Gap Reservoir

Windy Gap Reservoir, located on the Colorado River west of the Town of Granby, provides wildlife viewing and picnicking.

Rockwell Reservoir

Rockwell Reservoir is located mostly on private lands not available for public use. About 50 acres of the site is on BLM land and receives occasional dispersed recreation use (Cassel, pers. comm. 2005b).

Jasper East Reservoir

The Jasper East Reservoir site is located on NCWCD and Reclamation land not open for public use, although Reclamation leases land for a model airplane park. County Road (CR) 40 crosses the reservoir site and provides access to Willow Creek Reservoir, which provides camping, boating, and fishing opportunities as part of the Arapaho National Recreation Area.

3.19.1.4 West Slope River Recreation

Fishing and boating are popular recreation activities at several locations along the Colorado River and campsites are found at some state wildlife areas (SWAs) and on BLM land. Recreation activities vary by reach between Granby Reservoir and State Bridge (Figure 3-115). Recreation resources along the Colorado River are described for five river reaches.

Colorado River: Granby Reservoir to Windy Gap Reservoir

The 7-mile reach of the Colorado River between Granby Reservoir and Windy Gap Reservoir is mostly private land with no designated recreation sites. Fishing opportunities are present primarily on private land. The Orvis Shorefox property west of the Town of Granby is currently in foreclosure and future use of this property is unknown. This reach of the river is not known for boating use.

ERO
ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: (303) 830-1199

- Bureau of Land Management
- Colorado State Lands
- National Park Service
- Private
- U.S. Forest Service
- Boating Destination
- Potential New or Enlarged Reservoir
- Lake or Reservoir
- Study Area Reservoir
- Study Area Rivers
- Rivers
- Fishing
- Boating
- Campground

0 2.5 5 Miles
1 Inch = 5 Miles
N

Figure 3-115
Colorado River Recreation

Prepared for: Windy Gap Firming Project
File: 2390 Rec_Fig4_colorado_River Recreation.mxd(JP)

Colorado River: Windy Gap Reservoir to Williams Fork

Recreation in this 14-mile reach supports boating, fishing, and camping. Byers Canyon downstream of Hot Sulphur Springs is a 2.6-mile reach that provides Class IV to V whitewater boating. Class IV- rapids are present at flows between 400 and 1,000 cfs, Class IV+ between 1,000 and 2,000 cfs, an Class V rapids over 2,000 cfs (Banks and Eckhardt 1999). Byers Canyon is not used for commercial boating (Farr, pers. comm. 2006), but receives occasional use, estimated at 15 boaters per year by private kayakers (Crosby, pers. comm. 2008). This reach of the Colorado River is designated as a Gold Medal stream for outstanding fishing opportunities. Public access is available at Beaver Creek, Lone Buck, and Paul Gilbert Fishing Area Units of the Hot Sulphur Springs SWA for about 2 miles.

Colorado River: Williams Fork to Kremmling

This 16-mile reach of the Colorado River has no developed recreation facilities and is not known as a popular boating destination. Gold Medal waters for fishing are present upstream of Troublesome Creek. Public fishing access is available within the Kemp-Breeze SWA and BLM's Sunset Bridge, Powers, and Highway 9 sites. Private lands adjacent to the river, such as Elktrout Lodge property, also provide opportunities for fishing access and guided fishing.

Colorado River: Kremmling to Pumphouse

The Colorado River from the confluence with the Blue River to the Pumphouse Recreation Area is known as Big Gore Canyon. This reach of the river supports 9.2 miles of difficult Class V to VI rapids. This area attracts advanced boaters and is used by commercial and private rafters and kayakers. The preferred flow range for both commercial and private boating (rafting and kayaking) is about 850 to 1,250 cfs (Sommerhoff, pers. comm. 2006; Hydrosphere 2003a; Banks and Eckhardt 1999; TetraTech et al. 2008). Flows within this range typically occur in early May and in August and September. Commercial trips are usually only run in the later season when temperatures are warmer. Private boaters run the river at flows above 1,250 cfs, but safety becomes a concern at higher flows. High flows and lack of public shoreline access preclude most fishing in this reach. The Gore Race, a popular whitewater rafting race, is held annually on this reach of the river. August is the primary month for boating in Big Gore Canyon and the Gore Race is typically held the third week of the month. No formal data are available for boating use in Gore Canyon; however, total annual boating use is estimated at 1,200 users, of which about 500 are commercial user days, 500 are private, and about 200 are participants in the Gore Race (Windsor, pers. comm. 2008).

> The preferred flow range for rafting and kayaking the Colorado River in Gore Canyon is about 850 to 1,250 cfs. In the Pumphouse reach, flows of 1,100 to 2,200 cfs are preferred for boating.

Colorado River: Pumphouse to State Bridge

The Colorado River in this reach provides most of the river-based recreation in the study area. This 11.6-mile reach of the Colorado River includes Class II and III water for intermediate level commercial and private boaters. Preferred flows for rafting and kayaking in this reach are generally between 1,100 and 2,200 cfs (Hydrosphere 2003a; Banks and Eckhardt 1999; TetraTech et al. 2008; Windsor, pers. comm. 2009).

The Pumphouse run is one of the state's most heavily used day use sites (Arkins, pers. comm. 2004). The boating season is during the summer months of June to August. Although detailed information is not available, the distribution of boating use by month is estimated to be 18 percent in June, 42 percent in July, and 32 percent in August (Windsor, pers. comm. 2008). The remaining 8 percent of use occurs in May, September, and October. The BLM Kremmling Field Office reports total visitation for 2004 and 2005 of 44,566 and 42,247, respectively. These totals reflect the use of the Pumphouse and Radium Recreation Areas for boating, fishing, camping, and day uses. A breakdown of total commercial boating and fishing use numbers along multiple reaches of the Colorado River from 1999 to 2005 is provided in Table 3-142. Commercial numbers only reflect boating and fishing user days at Pumphouse and Radium on the Colorado River. Commercial boating user days in the Upper Colorado River were estimated to be about 31,000 in 2006 and 32,000 in 2007 (CROA 2008).

Table 3-142. Total annual commercial boating and fishing visitor days (1999-2005) along the Colorado River.

Boating and Fishing Use	1999	2000	2001	2002	2003	2004	2005
Commercial Boating	38,803	42,933	34,381	37,801	32,188	29,681	27,211
Commercial Fishing	1,560	1,671	1,537	1,992	1,745	3,552	2,225
Total Annual Commercial Visitors	40,363	44,604	35,918	39,793	33,933	33,233	29,436
Annual Percent Change		+9%	-19%	+10%	-14%	-2%	-11%

Source: BLM 2007b.

River shore and floatfishing are popular activities in the designated Wild Trout water found in this reach. In 2005, 15 companies offered guided fishing trips (Sterin, pers. comm. 2006). The BLM estimates that there were about 3,000 to 4,000 annual user days for fisherman in 2004 (Arkins, pers. comm. 2004). Camping, hiking, mountain biking, and off-highway vehicle use are available on nearby lands.

Wild and Scenic Rivers Study

The BLM completed the eligibility phase of a wild and scenic river evaluation for various reaches of the Colorado River within the study area to identify river segments for possible designation under the National Wild and Scenic Rivers Act (BLM 2007a). This inventory and eligibility review was conducted as part of the BLM's Resource Management Plan (RMP) revision process. Eligibility criteria included free-flowing streams with outstanding remarkable values for scenic, recreational, geologic, fish, wildlife, historic, cultural, and other similar values. Five segments of the Colorado River were identified as eligible in the BLM study. These segments and the outstanding remarkable values for each segment are:

- Windy Gap to Hot Sulphur Springs — recreational (fish), wildlife, and historic
- Byers Canyon — recreational (fishing and floatfishing, scenic driving, and other recreation), scenic, wildlife, geological, and historic
- Below Byers Canyon to the mouth of Gore Canyon — recreational (fishing, scenic driving, and other recreation), wildlife, and historic
- Gore Canyon — recreation (fishing, floatfishing, scenic driving, and other recreation), scenic, geological, wildlife, historic, and cultural
- Pumphouse to State Bridge — recreation (fishing, floatfishing, scenic driving, and other recreation), scenic, geological, paleontological, wildlife, historic, and cultural

There are three classes for river designation under the Wild and Scenic Rivers Act—Wild, Scenic, and Recreational. All of these river reaches were preliminarily classified by BLM as Recreational.

The next phase of evaluation is to determine whether eligible river segments are suitable for inclusion in the Wild and Scenic Rivers System. BLM will complete the suitability evaluation as part of its RMP revision process with recommendations given in a Draft EIS that was released on September 16, 2011. BLM's policy is to manage and protect eligible river segments so as not to adversely constrain the suitability assessment or any subsequent recommendations to Congress. River or stream segments must be found eligible and suitable to be considered for designation in the National Wild and Scenic Rivers System and only Congress or the Secretary of the Interior can designate segments.

Willow Creek

Willow Creek below Willow Creek Reservoir is located mostly on private land with limited opportunities for public recreation access. Fishing may occur on private land, but no boating occurs.

3.19.1.5 East Slope Reservoir Recreation

Carter Lake, Horsetooth Reservoir, and Ralph Price Reservoir provide a variety of recreation opportunities along the Front Range. Constructed as part of the C-BT Project, Carter Lake and Horsetooth Reservoir are Reclamation reservoirs that are leased and managed by Larimer County Parks and Open Lands Department for public recreation.

Carter Lake

Carter Lake has a marina, three boat ramps, two campgrounds, trails, and other recreation facilities. Fishing is allowed year-round from shore or boat. Primary recreation use occurs from May to September, with peak weekend boating use of 140 to 190 boats depending on reservoir levels (Fleming, pers. comm. 2003).

Horsetooth Reservoir

Recreation facilities include four campgrounds, five boat ramps, a marina, and swim beach. Use of the reservoir varies during the year, with the greatest activity on weekends and holidays from May to September. While formal visitation records are not maintained, it is estimated that there were about 700,000 visitor days in 2004 (Coffman, pers. comm. 2005). The reservoir can reach the carrying capacity for boats during busy summer days, which ranges from 90 to 380 boats, depending upon the reservoir level (Coffman, pers. comm. 2005.).

Ralph Price Reservoir

This reservoir is located along North St. Vrain Creek about 7 miles west of Lyons. The reservoir is within the Button Rock Preserve, which provides fishing, hiking, and wildlife viewing. No boating is allowed and fishing requires a permit from the City of Longmont. Visitor days in 2004 were estimated to be about 17,000 (Huson, pers. comm. 2005).

Chimney Hollow Reservoir

This reservoir site is owned by the Subdistrict and is currently closed to public use. Larimer County Parks and Open Lands own about 1,800 acres of adjacent land to the west. Recreation use on Larimer County lands is currently limited, but trail development, nonmotorized boating, and fishing are planned for the future. If Chimney Hollow Reservoir is built, Larimer County would manage recreation use at the reservoir and adjacent county lands.

Dry Creek Reservoir

There is no public recreation use on the private or state lands at the Dry Creek Reservoir site.

3.19.1.6 East Slope River Recreation

Big Thompson River

The Big Thompson River Canyon downstream of Drake offers about 6.2 miles of Class IV rapids when the river is above 400 cfs (Banks and Eckhardt 1999). This is not a popular kayak destination and is not used by commercial or private rafters. Opportunities for fishing occur on public and private land.

North St. Vrain Creek and St. Vrain Creek

Three reaches of North St. Vrain Creek below Longmont Reservoir are used by kayakers at flows between 150 and 500 cfs. A 2-mile reach of the creek between Longmont Reservoir and CR 80 provides Class V rapids. From CR 80 to Apple valley there are 2.4 miles of Class III rapids, and below this reach to Lyons there are 4.2 miles of Class III water. Under average flow conditions, June and July are historically the only months North St. Vrain Creek is boatable. A whitewater park for kayakers on St. Vrain Creek in Lyons is typically used in late May through early July at flows from 60 to 200+ cfs (Boulder Outdoor Center 2006). No commercial boating occurs on these stream segments. Fishing occurs on private and public land along both streams.

Other East Slope Streams

Other streams in the study area are lower portions of the Big Thompson River, St. Vrain Creek to the South Platte River, Coal Creek from Superior to Boulder Creek, and Dry Creek from Boulder to the South Platte River. These streams have limited recreation use. Most of these reaches occur in or near urban areas and experience occasional uses such as fishing, wildlife viewing, and tubing.

3.19.2 Environmental Effects

3.19.2.1 Issues

Recreation issues of concern identified during scoping were the potential effect to recreation use at existing reservoirs from changes in water levels and the types of recreation that might be available at new reservoirs. Also of concern was the potential effect to streamflow supporting rafting and kayaking on the Colorado River.

3.19.2.2 Methods for Effects Analysis

Potential recreation effects were based primarily on changes in hydrologic conditions at reservoirs and streams in the study area. A 47-year hydrologic period of record (1950 to 1996) was used to describe existing conditions and evaluate changes to reservoir and stream conditions under each alternative. The 47-year study period contains a mixture of average, wet, and dry years reflective of the range of historical hydrologic conditions. The methods and findings of this hydrologic model are described in detail in *Surface Water Hydrology* (Section 3.5).

Effects to reservoir recreation were evaluated by comparing changes in surface area and water levels under the alternatives to existing conditions. Because of the similarity in effects between Alternatives 3, 4, and 5, values for Alternative 5 are representative of all three alternatives and are shown in figures and tables comparing alternatives. In general, a decrease in water surface area would be considered a negative effect, although it is difficult to quantify any change in visitor use. The analysis also considered how changes in reservoir water level may affect access to boat ramps.

Changes in streamflow were used to evaluate effects to river-based recreation. The effects analysis focused on the primary recreation season—May to September—which also coincides with most of the hydrologic changes. For the Colorado River, potential effects to rafting and kayaking were determined by evaluating changes daily flow. Flow changes were evaluated at the three segments of the Colorado River where boating occurs: Byers Canyon near the Hot Sulphur Springs gage, and in the Big Gore Canyon and Pumphouse reaches of the river represented by the Kremmling gage. Preferred river flows for boating were simplified following comments on the Draft EIS and information from the Grand County SMP to better illustrate potential effects. The simplified preferred flow ranges resulted in changes to the effects downstream for the following discussion of Colorado River recreation and the socioeconomic effects in Section 3.22.

Average monthly flow data provide a general graphical representation of the changes in streamflow in relation to boating preferences. Daily hydrologic data were used to estimate the change in the number of days when preferred rafting and kayaking flows would occur. This involved an analysis of the number of days during the boating season when flows would be within preferred ranges for rafting or kayaking. Daily data from the 47-year hydrologic period of record indicated the number of days when flow fell within a preferred boating range and the range of change in the number of days per year that preferred flows for boating would occur compared to existing conditions. The analysis of daily data also indicated the frequency of flow changes based on the number of years in the period of record that there would be a change in the number of days with preferred boating flows for each of the alternatives. The potential effects to angling were based on the results of the aquatic resource evaluation discussed in Section 3.9.

To facilitate the comparison of recreation impacts among the alternatives, this section is organized by reservoir and stream locations on the West and East Slopes. In general, the action alternatives result in similar hydrologic and recreation effects on streams because similar amounts of water are diverted.

Potential effects to recreation for Colorado River reaches eligible for designation under the Wild and Scenic Rivers Act are discussed, but no determination is made on whether the alternatives would affect the suitability of these reaches for designation. The BLM is currently evaluating suitability as part of the RMP revisions.

3.19.2.3 Effects Common to All Alternatives

Effects to water-based recreation from the action alternatives would have limited direct impacts on land-based recreation activities such as camping, picnicking, and hiking. Effects to recreational boating under any alternative, as described below, are generally not expected to measurably impact recreation use of campgrounds and other facilities near lakes and streams affected by the action alternatives. The recreational experience for activities such as camping, hiking, mountain biking, hunting, scenic driving, and OHV riding is unlikely to be affected, although some visitors may discern a reduction in aesthetic value of the Colorado River from periodic lower flows or lower reservoir levels in Granby Reservoir or Horsetooth Reservoir.

Potential effects to aquatic resources from changes in streamflow and reservoir storage on the West Slope and East Slope are discussed in detail in *Aquatic Resources* (Section 3.9). Results of habitat and temperature modeling indicate reduced Colorado River flows from additional WGFP diversions under all of the alternatives would reduce habitat for rainbow and brown trout and would increase stream temperature in some years. The greatest change in habitat would occur in the reach of the Colorado River below Windy Gap Reservoir and the confluence with the Williams Fork River. Effects of the WGFP diminish downstream from the Williams Fork, with input from tributary flows. The greatest percent decrease in habitat occurs for adult rainbow trout in late August with smaller changes for brown trout. For both species, there would be an increase in habitat below Windy Gap Reservoir under the alternatives when diversions reduce high flows. Predicted changes in fish habitat are unlikely to measurably impact fish populations or adversely impact sport fishing under any alternative. Stream habitat improvements and curtailment of WGFP diversions for temperature were identified as two potential mitigation measures that would be implemented as mitigation to reduce potential impacts to fish. These mitigation measures are discussed in *Water Quality* (Section 3.8.4.2) and *Aquatic Resources* (Section 3.9.4). Because alternative actions would not affect fishing opportunities or success for individual anglers or private fishing lodges, impacts to fishing are not discussed further in this section.

3.19.2.4 West Slope Reservoir Recreation

Grand Lake and Shadow Mountain Reservoir

There would be no change in surface water elevation at Grand Lake or Shadow Mountain Lake for any alternative because the C-BT Project limits reservoir fluctuations to no more than 1 foot from the top of the conservation pool. Thus, none of the alternatives would result in hydrologic changes that would affect recreation activities or opportunities. As indicated in *Surface Water Quality* (Section 3.8), predicted changes in water quality would not impact water quality standards for recreation use. Reduced water clarity and algal growth has been a concern in Grand Lake and Shadow Mountain Reservoir that may contribute to a diminished recreation experience (Stahl and Crabtree 2005). Predicted small reductions in water clarity would continue or slightly increase the potential for a diminished recreation experience under all of the alternatives. The assessment of aquatic resources in Section 3.9 determined that the predicted water quality changes in Grand Lake and Shadow Mountain Lake would not adversely impact fish and, therefore, there would be no effect to fishing opportunities in these lakes.

Granby Reservoir

Water levels in Granby Reservoir would be lower during the summer months under all alternatives. The No Action Alternative would reduce water surface area by less than 140 acres or about 2 percent compared to existing conditions during the summer in average years (Table 3-143). The Proposed Action would reduce summer water surface area by between 225 and 351 acres (about 3 to 6 percent on average), with smaller changes under Alternatives 3 to 5. Wet year surface area changes would be slightly greater for all alternatives in early summer and less in late summer. Dry year reductions in lake surface area would be similar to average years.

Under the Proposed Action, the Arapaho Bay boat ramp at Granby Reservoir would not be accessible in May of average water years. In dry years, the Arapaho Bay boat ramp would not be accessible in August. Other boat ramps could be inaccessible if a sequence of back-to-back dry years occurs.

Table 3-143. Average monthly changes in Granby Reservoir surface area.

Alternative	May	June	July	August	September
	Surface Area (acres)				
Existing Conditions	**5,970**	**6,440**	**6,722**	**6,750**	**6,691**
	Changes in Lake Surface Area from Existing Conditions (acres)				
Alt 1 – No Action	-140	-113	-90	-88	-96
Alt 2 – Proposed Action	-351	-281	-225	-226	-251
Alt 3 – 5	-167	-174	-147	-143	-150

The maximum decreases in lake levels during the summer recreation season would be 23 feet (1,142 acres) under the Proposed Action, with smaller changes for other action alternatives. As a basis of comparison, the recent 2002 drought year was similar to the dry years which occurred in 1955–1957 and 1965 (within the hydrological model period of record). These maximum decreases would be minimized as a result of proposed mitigation measures described in Section 3.19.4.

In average years, all boat ramps, except for Arapaho Bay in May, would remain accessible in the summer under the action alternatives (Figure 3-116). In dry years, all alternatives would lower Granby Reservoir below the Arapaho Bay boat ramp in August. Under maximum drawdown conditions (consecutive dry years), the Proposed Action also would result in lake levels below the Arapaho Bay boat ramp in May, and possibly below the Stillwater and Sunset boat ramps.

The relatively small percent reduction in boatable area on this large reservoir in most years is unlikely to noticeably affect recreation use or the quality of the recreation experience under any alternative. Additional exposed shoreline at lower water levels could reduce the aesthetic value. Lower water levels under all alternatives would not substantially affect accessibility for shoreline fishing, but with maximum drawdowns in periods of consecutive dry years, the lower water levels would affect boat ramp, private boat dock, and marina access, which would limit boating opportunities and reduce the quality of the overall recreation experience. Camping, hiking, and shoreline activities could decrease during periods of low water levels. Visitor user days have historically declined during dry or drought years, although this may be due to factors other than water levels, including campfire restrictions or weather (Orr, pers. comm. 2008).

Windy Gap Reservoir

There would be no substantial changes in the operation of Windy Gap Reservoir under any alternative that impact existing recreation use.

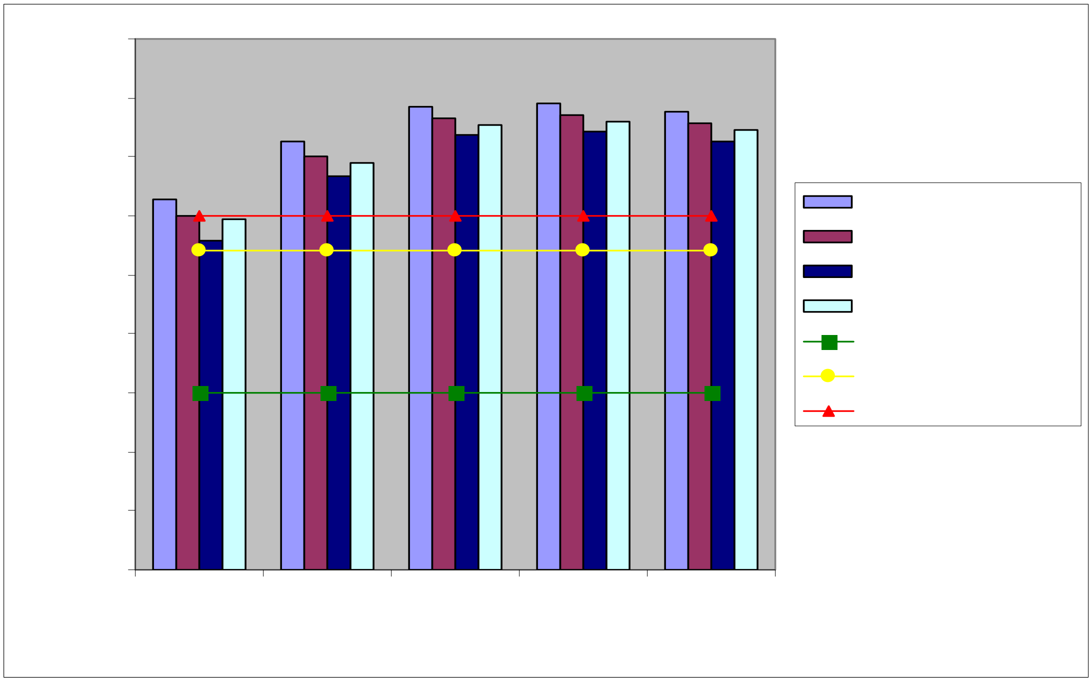
Jasper East Reservoir

Construction of Jasper East Reservoir in Alternative 3 would displace a model airplane facility on Reclamation property. Reservoir construction would require rerouting CR 40, which provides access to Willow Creek Reservoir, as well as local residences. Recreation access to Willow Creek Reservoir would be maintained during and following construction. No other public accessible recreation would be affected. Jasper East Reservoir could provide a recreation opportunity if a managing entity is found. However, wide fluctuations in reservoir water levels would reduce suitability for recreation and maintaining a fishery.

Rockwell Reservoir

No existing recreation resource facilities would be affected with construction of either size of Rockwell Reservoir in Alternative 4 or 5. Recreation facilities could be developed if a managing entity is found. Seasonal water level fluctuations and low water levels during the winter months could affect the establishment of a viable fishery and recreation activities.

Figure 3-116. Average monthly water levels at Granby Reservoir boat ramps.



3.19.2.5 West Slope River Recreation

Potential effects to recreation activities were evaluated for the Colorado River and Willow Creek. No other West Slope streams would be affected by the alternatives. Colorado River streamflow was evaluated for five reaches between Granby Reservoir and State Bridge. Daily data for all years in the 47-year study period were used to evaluate the effect on preferred boating flows. There would be no change from existing conditions for any alternative in dry years during the recreation season. Changes in wet year flows are generally not a concern because streamflow is about two to three times greater than average, so sufficient water is typically available to meet recreation needs.

Colorado River: Granby Reservoir to Windy Gap Reservoir

Changes in flow below Granby Reservoir are primarily a function of changes in spills. In average conditions, the No Action Alternative would reduce average monthly Colorado River streamflow above Windy Gap 0 to 6 percent from existing conditions from May to September (Appendix Table A-9). The Proposed Action and Alternatives 3, 4, and 5 would result in an average monthly flow reduction of 0 to 11 percent in Colorado River between May and September. Because this reach of the river is not a popular boating destination, there would be negligible impact to boating activities.

Colorado River: Windy Gap Reservoir to Williams Fork

Average flows in Byers Canyon typically exceed the 400 cfs needed for kayaking in June and July under existing conditions. Under all of the alternatives, average monthly streamflow would remain above 400 cfs in June, but would drop below 400 cfs in July (Figure 3-117). Estimated daily flow data indicate that in 29 years of the 47-year period of record there would be no change in the number of days that flow exceeds 400 cfs for any of the alternatives (Table 3-144). In the remaining 18 years, there would be an estimated average decrease of 8 days per year with flows less than the preferred kayaking minimum of 400 cfs under No Action and an estimated average of 12 fewer days per year for the action alternatives. In those years when there is a change in the number of days with flows greater than 400 cfs, the estimated change varies from 1 more day to up to 49 fewer days. Although Byers Canyon does not support commercial boating and is infrequently used for kayaking, these changes would affect boating opportunities in this reach of the river primarily in July.

Figure 3-117. Average monthly streamflow on the Colorado River in the Byers Canyon kayak reach below Hot Sulphur Springs.

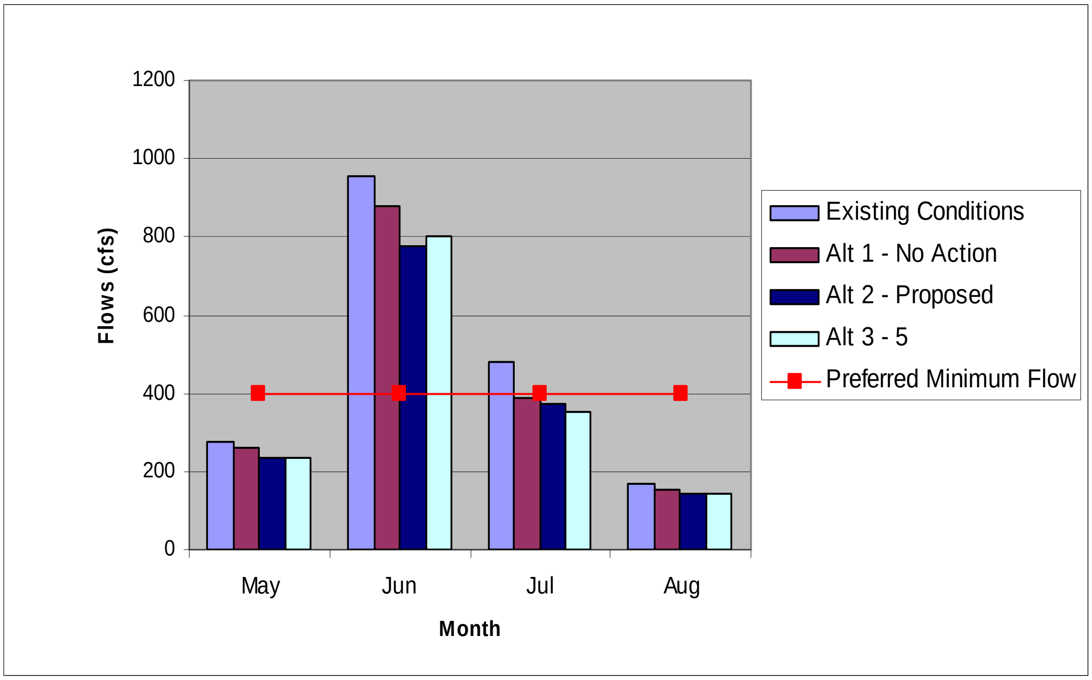


Table 3-144. Comparison of preferred kayaking flow days (flows above 400 cfs) in Byers Canyon (June 1 through July 26) between existing conditions and the alternatives.

Alternative	Total days in 47-year period flows are >400 cfs	Average change in preferred flow days per year from EC during the 18 years when flow changes occur[1]	Greatest change in the number of preferred flow days in a single year compared to EC during the 18 years when flow changes occur
Existing Conditions (EC)	1,012		
Alt 1 – No Action	870	8.0	-34 to 0
Alt 2 – Proposed Action	792	12.0	-49 to +1
Alt 3	793	11.0	-49 to +1
Alt 4	778	12.3	-49 to +1
Alt 5	789	12.4	-49 to 0

[1] There would be no change in the number of days when flows exceed 400 cfs between EC and any of the alternatives in 29 of the 47 years.

Colorado River: Williams Fork to Kremmling

Average monthly streamflow would decrease up to 13 percent under the No Action Alternative in July compared to a decrease of 15 percent under the Proposed Action in June, and a decrease of up to 18 percent in July for the other action alternatives. Because of the limited existing boating in this reach of the Colorado River, none of the alternatives would substantially affect recreational boating.

WGFP Colorado River diversions would reduce the number of days that preferred boating flows would occur in Gore Canyon. There would be no change in providing 850 to 1,250 cfs in 37 years out of the 47-year period of record, and a decrease of less than 3 days per year on average in the 10 years when flows would not meet the preferred flow range.

Colorado River: Kremmling to Pumphouse

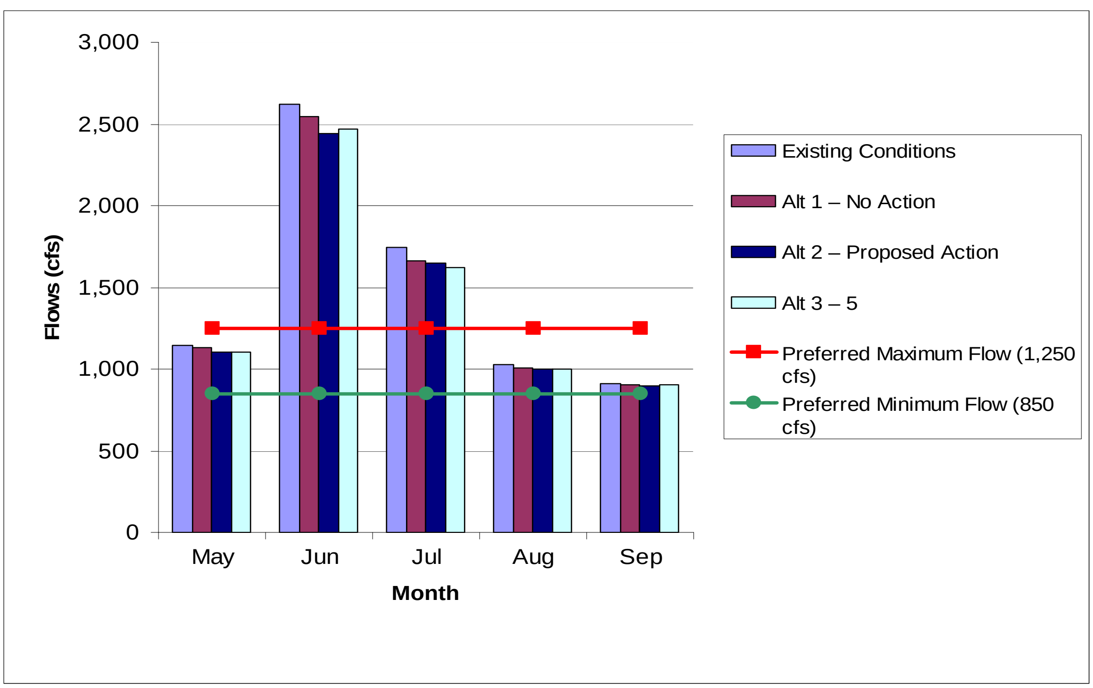
The Big Gore Canyon of the Colorado River from the Blue River confluence near Kremmling to Pumphouse provides advanced whitewater boating. Average monthly May to September flow reductions in this reach of the Colorado River range from 1 to 5 percent under the No Action Alternative (Table 3-145). Under the Proposed Action and other action alternatives, average monthly streamflow would decrease up to 7 percent. None of the alternatives would reduce May to September flow below 850 cfs, which is generally the preferred low flow for rafting and kayaking (Figure 3-118).

Table 3-145. Average monthly changes to Colorado River flows in Gore Canyon to State Bridge.

Alternative	May		June		July		August		September	
	cfs	%[1]	cfs	%[1]	cfs	%[1]	cfs	%[1]	cfs	%[1]
Existing Conditions	**1,145**	—	**2,619**	—	**1,745**	—	**1,026**	—	**909**	—
Alt 1 – No Action	1,129	-1%	2,542	-3%	1,660	-5%	1,010	-2%	901	-1%
Alt 2 – Proposed Action	1,104	-4%	2,442	-7%	1,647	-6%	1,002	-2%	899	-1%
Alt 3 – 5	1,101	-4%	2,466	-6%	1,624	-7%	999	-3%	901	-1%

[1] Percent change in streamflow from existing conditions.

Figure 3-118. Average monthly streamflow on the Colorado River through Big Gore Canyon for rafting and kayaking.



Estimated daily flow data indicate that in 37 years of the 47-year period of record, there would be no change from existing conditions in the number of days preferred rafting and kayaking flows of 850 to 1,250 cfs occur in Big Gore Canyon for any of the alternatives (Table 3-146). Preferred rafting and kayaking flows in Gore Canyon would occur about 24 days less under the No Action Alternative compared to existing conditions over the 47-year study period. Under the Proposed Action, preferred rafting flows would occur about 23 days less than existing conditions over the 47 years. On average, this would be about 2.3 days per year with fewer preferred flows during the 10 years when flows fall outside of the preferred range. The greatest decrease in preferred flows in a single year would be 11 days under all of the alternatives (year 1961), with an increase of 1 day in some years for the action alternatives. Projected flows for all of the alternatives would allow commercial outfitters to continue to run trips through Big Gore Canyon in August most of the time. Reduced flow in about 10 out of 47 years would decrease opportunities for commercial rafting by several days.

Table 3-146. Comparison of preferred boating flow days (850 to 1,250 cfs) in Big Gore Canyon between existing conditions and the alternatives in August.

Alternative	Total days in 47-year period flows were between 850 and 1,250 cfs	Average change in preferred flow days per year from EC during the 10 years when flow changes occur[1]	Greatest change in the number of preferred flow days in a single year compared to EC during the 10 years when flow changes occur
Existing Conditions (EC)	848		
Alt 1 – No Action	824	-2.4	-11 to 0
Alt 2 – Proposed Action	825	-2.3	-11 to +1
Alt 3	825	-2.3	-11 to +1
Alt 4	829	-1.9	-11 to +1
Alt 5	821	-2.7	-11 to +1

[1] There would be no change in the number of days when flows are between 850 and 1,250 cfs in 37 of 47 years.

Higher flows preferred by expert kayakers through Big Gore Canyon generally range between 1,100 and 2,200 cfs (Table 3-147). Effects on flows to this range (which is similar to preferred flows for the Pumphouse reach) are shown in Figure 3-118 and below in the *Pumphouse* section.

Table 3-147. Comparison of preferred boating flow days (1,100 to 2,200 cfs) in Big Gore Canyon and Pumphouse to State Bridge between existing conditions and the alternatives from June to August.

Alternative	Total days in 47-year period flows were between 1,100 and 2,200 cfs	Average change in preferred flow days per year from EC during the 15 years when flow changes occur[1]	Greatest change in the number of preferred flow days in a single year compared to EC during the 15 years when flow changes occur
Existing Conditions (EC)	1,034		
Alt 1 – No Action	1,035	+<1	-15 to +7
Alt 2 – Proposed Action	1,030	-<1	-15 to +6
Alt 3	1,030	-<1	-15 to +6
Alt 4	1,037	+<1	-15 to +10
Alt 5	1,033	-<1	-15 to +10

[1] There would be no change in the number of days when preferred flows for boating are between 1,100 and 2,200 cfs in 32 of the 47 years.

Results of the analysis indicate the potential for impacts to the annual Gore Race, usually held the third week in August, is unlikely in most years and the Subdistrict would curtail diversions during the race if flows fall below

1,250 cfs at Kremmling as a mitigation measure (Section 3.19.4); therefore, the WGFP would have no effect on the Gore Race.

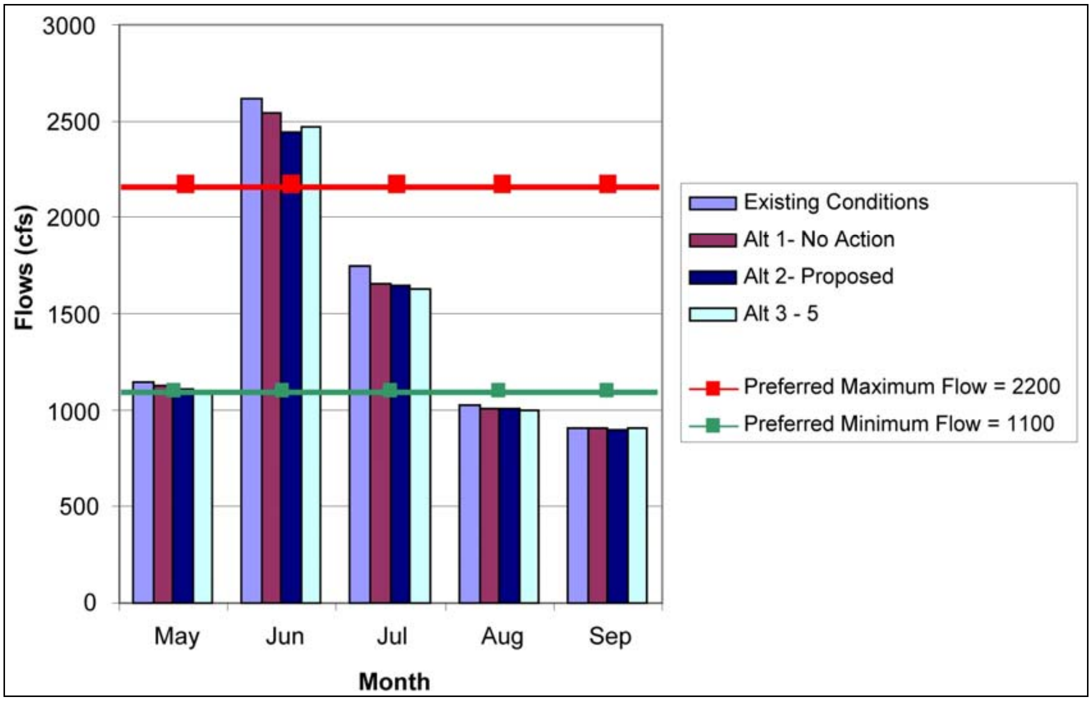
Colorado River: Pumphouse to State Bridge

WGFP Colorado River diversions would slightly reduce the number of days that preferred boating flows would occur in the Pumphouse reach. There would be no change in flows of 1,100 to 2,200 cfs in 32 years out of the 47-year period of record, and a decrease of about 1 day per year on average in the 15 years when flows would not meet the preferred flow range.

The reach of the Colorado River between Pumphouse and State Bridge is generally flat water with some Class II and III rapids. The flows for this reach are measured by the same gage as for Big Gore Canyon (Table 3-145). Preferred flows for the Pumphouse reach generally range between 1,100 and 2,200 cfs for both rafting and kayaking (Figure 3-119). This range also represents higher flows preferred by some expert kayakers through Big Gore Canyon (Figure 3-118).

Estimated daily flow data indicate that in 32 years of the 47-year study period, there would be no change in the number of days in the flow range (1,100 to 2,200 cfs) for any of the alternatives. Results also indicate that over the 47-year study period, there would be about 1 more day of preferred flows under the No Action Alternative compared to existing conditions. Under the Proposed Action, there would be about 4 fewer days of preferred flows, which would average 1 day less per year of preferred flows during the 15 years when flow changes occur. The greatest change in preferred flows in a single year would be 15 days fewer under all of the alternatives, with an increase of up to 7 days with preferred flows under the No Action Alternative and 6 days under the Proposed Action. It is possible that camping and other recreation uses in the Pumphouse and Radium areas could also change as a result of changes in streamflow, following a pattern that is similar to changes in boating flows.

Figure 3-119. Average monthly streamflow on the Colorado River from Pumphouse to State Bridge for rafting and kayaking.



Willow Creek

Willow Creek is not used for recreational boating and, therefore, there would be no effect under any alternative.

3.19.2.6 East Slope Reservoir Recreation

Ralph Price Reservoir

Enlargement of Button Rock Dam at Ralph Price Reservoir would require temporary suspension of recreation access during the estimated 2-year construction period. During this time, no fishing, hiking, wildlife viewing, or other activities would be allowed. Upon completion of the dam, recreation access and activities would resume, similar to current conditions. Fishing opportunities may be diminished for several years following construction until the reservoir refills, but a larger reservoir would improve habitat for fish. Portions of the existing trail around the reservoir also would need to be reconstructed. Recreation use would likely be similar to existing conditions once the reservoir refills.

Carter Lake

Carter Lake water levels would decrease less than 1-foot on average under all of the alternatives, although larger decreases are possible with sequential dry years.

Carter Lake surface area would decrease less than 1 percent and the surface elevation would decrease less than 1 foot from existing conditions during the peak recreation season under all alternatives in average conditions. In wet years, average monthly reservoir levels would be less than 2 feet lower than existing conditions for all alternatives in the peak recreation season, and dry year water levels would typically not change from existing conditions. Boat ramps would remain accessible in average, wet, and dry years for all alternatives. The projected minor decrease in surface area under all alternatives is unlikely to adversely affect visitor numbers or recreation activities. In periods of consecutive dry years, Carter Lake could experience reductions in lake levels up to 7 feet under No Action, and as much as 27 feet under the Proposed Action. Other alternatives would have declines of up to 2 feet. A large decline in surface area after several consecutive dry years, primarily under the Proposed Action, could diminish the overall quality of the user experience by increasing the distance between land-based facilities and the water surface, and potentially reducing the overall aesthetics of the experience.

Horsetooth Reservoir

Horsetooth Reservoir average monthly water levels would decrease up to 6 feet during the summer recreation season under the Proposed Action. Access to the South Bay-South boat ramp could be affected in September. Dry years would impact access to other boat ramps.

Monthly water levels would not change from existing conditions under the No Action Alternative in the primary recreation season from May to September in average, wet, and dry years. The Proposed Action would reduce average monthly reservoir water surface area up to about 5 percent or 80 acres in May (a 6-foot decrease in water level from existing conditions). Other alternatives would reduce reservoir surface area less than 30 acres. Wet year changes would be similar to average years, and in dry years the Proposed Action would reduce Horsetooth Reservoir surface water area up to 9 percent (109 acres) during the recreation season. Other alternatives would experience less than a 66 acre decrease in water surface area in dry years. A series of consecutive dry years could result in a decline in lake levels of 35 feet during the recreation season under the Proposed Action.

Boat ramp access at Horsetooth Reservoir would not be affected by any alternative in average years during the primary recreation season except for the possible use of the South Bay-South boat ramp in September under the Proposed Action. In dry years, all alternatives would lower lake levels to an elevation below one boat ramp in August and two of the five boat ramps in September. Boating opportunities are unlikely to be adversely affected in average years for any alternative. A slight reduction in the carrying capacity for boats is possible in dry years under the Proposed Action, particularly consecutive dry years. This could diminish the overall quality of the user experience. Recreational experiences may change to the extent that changes in lake levels affect the aesthetic quality of the experience. These effects of the Proposed Action would be reduced or eliminated due to modified prepositioning efforts, which are described below under *Proposed Mitigation* (Section 3.19.4).

Chimney Hollow Reservoir

The Chimney Hollow Reservoir site does not currently support recreation use. If either size of reservoir is constructed in Alternatives 2, 3, and 4, Larimer County Parks and Open Lands would manage recreation use of the reservoir in concert with adjacent Larimer County Open Space land to the west. Recreation at Chimney Hollow would be limited to day use activities such as hiking, picnicking, fishing, and nonmotorized boating. Because reservoir water levels would remain relatively high with moderate fluctuations, it should provide good fishing opportunities. It is estimated that Chimney Hollow Reservoir would receive about 50,000 annual visitors under the Proposed Action and Alternatives 3 and 4 compared to about 300,000 annual visitors at Carter Lake (Flenniken, pers. comm. 2006; Rieves, pers. comm. 2005).

Dry Creek Reservoir

No existing recreation resource facilities would be affected with construction of Dry Creek Reservoir. Recreation activities and development similar to those anticipated at Chimney Hollow are possible if a managing entity is found. Public access to the reservoir site would need to be developed.

3.19.2.7 East Slope River Recreation

Big Thompson River

All alternatives would maintain or increase Big Thompson River flow below Lake Estes during the May to September recreation season in average years. There would be less than a 1 percent increase in flows under No Action and up to a 7 percent increase in average flows in May and July under the Proposed Action. Average monthly flows would increase between 0 and 4 percent for other alternatives. In wet years, the No Action Alternative would reduce Big Thompson River flows less than 1 percent and the Proposed Action would increase flows less than 3 percent, with no change in flow for other alternatives. In dry years, there would be no change in flow for any alternative.

The lower portion of Big Thompson Canyon provides Class IV kayaking at flows above 400 cfs. None of the alternatives would reduce the frequency of flows greater than 400 cfs during average, wet, or dry years and thus, kayaking would not be adversely affected.

North St. Vrain Creek and St. Vrain Creek

Only the No Action Alternative would affect streamflow in North St. Vrain Creek below Longmont Reservoir and St. Vrain Creek above the St. Vrain Supply Canal near Lyons. Average monthly streamflow in North St. Vrain Creek would decrease about 11 percent in May, decrease 27 percent in July, and increase 19 percent in September. Flow changes in June and August would be minimal. The kayak runs between Longmont Reservoir and Lyons are generally boatable in June and part of July under existing conditions at flows from 150 to 500 cfs. The No Action Alternative would not affect boating during June, but average flows in July would drop below preferred low flows for kayaking. This would likely reduce kayaking opportunities during the later part of July, although under existing conditions average flows are just below the minimum preferred level in July. Less than a 13 percent decrease in average monthly streamflow on St. Vrain Creek near Lyons would not reduce preferred flows for kayaking (>200 cfs) from May to July.

Other East Slope Streams

The Big Thompson River, St. Vrain Creek, Coal Creek, and Big Dry Creek would receive increased return flow below Participant WWTP facilities under all alternatives. East Slope streamflow would increase from about 0.5 to 11 cfs. Project flow increases and water quality changes are not expected to adversely affect fish or fishing opportunities. Other limited recreation use of these drainages also would unlikely be affected by minor increases in flow.

3.19.3 Cumulative Effects

Cumulative effects to recreation considered the reasonably foreseeable future water-based actions described in Chapter 2 and the future development of Chimney Hollow Open Space by Larimer County. The evaluation of cumulative recreation effects used the same methods as direct effects. Cumulative effects hydrology is based on implementation of reasonably foreseeable future actions, past actions, and the incremental changes in hydrology for each of the WGFP alternatives. Because of the similarity in effects for Alternatives 3, 4, and 5, the cumulative effects analysis used the results of Alternative 5 as representative of these three alternatives.

Cumulative effects hydrology does not include the 10825 Project and the release of 5,412.5 AF from Granby Reservoir from as early as July through September. Releases from this project of 21 to 70 cfs would improve flows available for late summer boating. Cumulative effects hydrology also does not include potential bypass flows by Denver Water as part of their FWEP and the *Colorado River Cooperative Agreement*. Flow releases associated with these actions could also increase the volume of water available for boating on the Colorado River.

3.19.3.1 Effects Common to All Alternatives

Cumulative effects to land-based recreation activities such as camping, picnicking, and hiking are expected to be similar to direct effects plus additional flow reductions in the Colorado River from reasonably foreseeable future actions. Potential effects to aquatic resources from changes in streamflow and reservoir storage on the West Slope and East Slope are discussed in Section 3.9.

Reductions in Colorado River streamflow from reasonably foreseeable actions plus the WGFP would result in additional reductions in trout habitat below Windy Gap Reservoir. The greatest effect would occur between Windy Gap Reservoir and the Williams Fork. Reasonably foreseeable actions also would result in reduced flows during the fall and winter months. Minor cumulative impacts to fish populations and sport fishing are possible. Cumulative impacts to fishing in Willow Creek, Three Lakes, Carter Lake, and Horsetooth Reservoir would be minimal as described for direct effects. The remainder of the discussion is for boating impacts.

3.19.3.2 West Slope Reservoir Recreation

Grand Lake, Shadow Mountain Reservoir, and Willow Creek Reservoir

There would be no change in surface water elevation at these lakes for any alternative. Projected changes in water quality in Grand Lake and Shadow Mountain Reservoir would not impact designated water quality standards for recreation uses. Predicted small reductions in water clarity may affect aesthetics and would continue or slightly increase the potential for a diminished recreation experience under all of the alternatives.

Granby Reservoir

> Granby Reservoir water levels would be below the Arapaho Bay and Stillwater boat ramps in May of average years, and most of the summer months in dry years under cumulative effects hydrology.

Water levels in Granby Reservoir would be slightly lower under cumulative effects than direct effects because less Windy Gap water would be available for diversion. In average hydrologic conditions during the recreation season, Granby Reservoir surface area would decrease up to about 190 acres or 3 percent under the No Action Alternative compared to existing conditions. The Proposed Action would result in a decrease in lake surface area of up to 431 acres, or about 7 percent, while Alternatives 3 to 5 would result in less than a 4 percent decrease in surface area. In a wet year, decreases in water surface area represent less than a 5 percent change from existing conditions for the No Action Alternative and Alternatives 3, 4, and 5, and less than 8 percent for the Proposed Action. In a dry year, water surface area would decrease up to 9 percent under the Proposed Action, up to 7 percent for the No Action Alternative, and up to 4 percent under Alternatives 3, 4, and 5.

All alternatives would result in lake levels below the Arapaho Bay boat ramp in May of average years and most of the summer months in dry years. The Proposed Action would also result in lake levels below the Stillwater boat ramp in May. Boatable surface area at Granby Reservoir would decrease less than 3 percent under No Action, less than 7 percent under the Proposed Action, and less than 4 percent for other alternatives in average years.

Because of the often wide fluctuations in Granby Reservoir water levels, the projected changes in surface area and boat ramp access in the early season are unlikely to adversely affect recreation activity in average years for any alternative. Lower water levels and reduced surface area in dry years could reduce the quality of the recreation experience or displace some visitor use from Granby Reservoir to Grand Lake, Shadow Mountain Lake, or other locations.

Jasper East and Rockwell Reservoirs

No reasonably foreseeable actions were identified that would result in cumulative recreation effects at these reservoirs.

3.19.3.3 West Slope River Recreation

Predicted changes in daily flows and average monthly flows were used to evaluate the cumulative effects for recreational boating in the Colorado River. Dry year effects on recreation would be primarily related to changes in flow from reasonably foreseeable actions because WGFP diversions would be the same as existing conditions in dry years. Changes in wet year flows are generally not a concern because streamflow is substantially greater than average, so sufficient water is typically available to meet recreation needs.

Colorado River: Granby Reservoir to Windy Gap Reservoir

Average monthly May to September streamflow in the Colorado River above Windy Gap Reservoir would decrease from 6 to 15 percent under the No Action Alternative (Appendix Table A-32). Under the Proposed Action, the decrease would range from 7 to 21 percent, with up to an 18 percent decrease for Alternatives 3, 4, and 5. Because this reach of the river is not a popular boating destination, there would be negligible impacts to boating activities.

Colorado River: Windy Gap Reservoir to Williams Fork

Streamflow in Byers Canyon under all alternatives would remain above suitable kayaking flows of 400 cfs in June, but would drop below 400 cfs in July, reducing kayaking opportunities. Estimated daily flow data indicates that in 22 years of the 47-year period of record, there would be no change in the number of days that flow exceeds 400 cfs for any of the alternatives. In the remaining 25 years, there would be an estimated average decrease of 11 days with flows less than the preferred kayaking minimum of 400 cfs under the No Action Alternative and an estimated 12 to 13 fewer days for the action alternatives (Table 3-148). In those years when there is a change in the number of days with flows greater than 400 cfs, the estimated change varies from 1 more day to up to 56 fewer days.

Table 3-148. Comparison of preferred kayaking flow days (flows above 400 cfs) in Byers Canyon (June 1 through July 26) between existing conditions and the alternatives—cumulative effects.

Alternative	Total days in 47-year period flows are >400 cfs	Average change in preferred flow days per year from EC during the 25 years when flow changes occur[1]	Greatest change in the number of preferred flow days in a single year compared to EC during the 25 years when flow changes occur
Existing Conditions (EC)	1,012		
Alt 1 – No Action	768	-11.0	-56 to 0
Alt 2 – Proposed Action	725	-11.6	-56 to +1
Alt 3 – 5	703	-12.7	-56 to +1

[1] There would be no change in the number of days when kayaking flows exceed 400 cfs between EC and any of the alternatives in 22 of the 47 years.

Although Byers Canyon does not support commercial boating and is infrequently used for kayaking, these changes would reduce the availability of whitewater flows in Byers Canyon primarily during July. If Byers Canyon is not boatable due to low water, kayakers would likely be displaced to lower stretches of the Upper Colorado River, such as Gore Canyon, for the Class IV to V experience.

Colorado River: Williams Fork to Kremmling

Average monthly streamflow would decrease up to 19 percent under the No Action Alternative in July compared to a maximum decrease of 20 percent under the Proposed Action in May, and a maximum decrease of 21 percent in May and July for other alternatives (Appendix Table A-36). Because of the limited existing boating in this reach of the Colorado River, none of the alternatives would substantially affect recreational boating.

Colorado River flows under cumulative effects hydrology would reduce the number of days that preferred boating flows would occur in Gore Canyon. There would be no change in providing 850 to 1,250 cfs in 13 years out of the 47-year period of record, and a decrease of less than 2 days per year on average in the 34 years when flows would not meet the preferred flow range.

Colorado River: Kremmling to Pumphouse

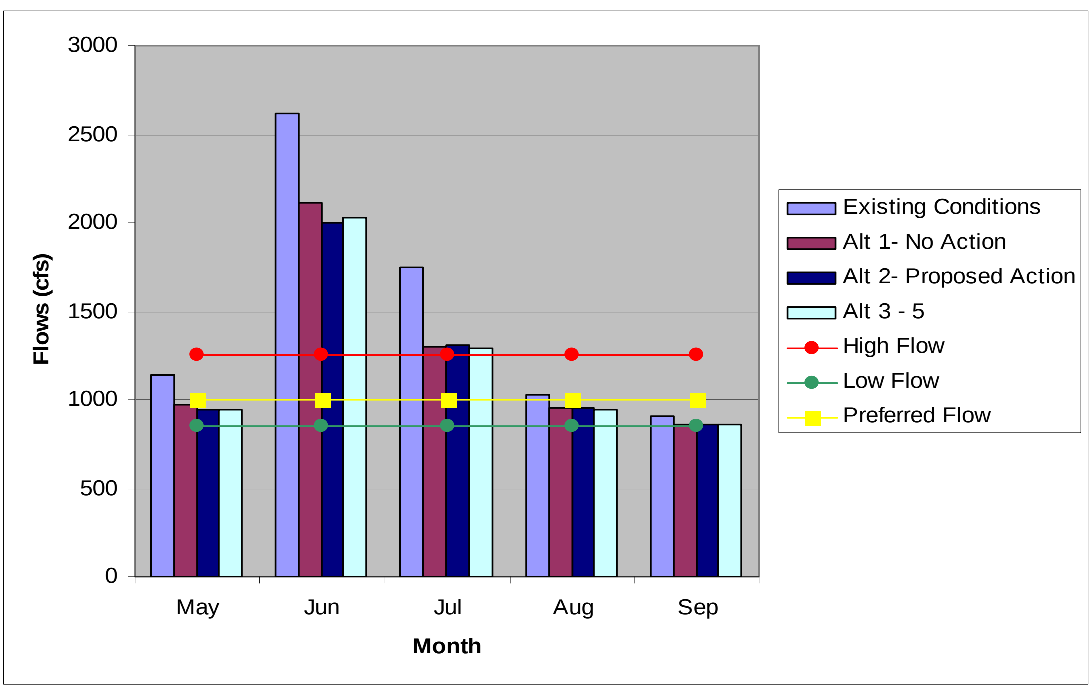
Average monthly May to September flow in this reach of the Colorado River would decrease up to 25 percent under the No Action and Proposed Action alternatives (Table 3-149). Alternatives 3, 4, and 5 would reduce flow up to 26 percent in July. Dry year flow decreases of about 3 to 25 percent would be similar for all alternatives, including No Action. Streamflow through Big Gore Canyon, with reasonably foreseeable future water developments in place, indicates fewer days with preferred rafting and kayaking flows between 850 cfs and 1,250 cfs in average conditions (Figure 3-120).

Table 3-149. Average monthly changes to Colorado River flow for Big Gore Canyon—cumulative effects.

Alternative	May		June		July		August		September	
	cfs	%[1]	cfs	%[1]	cfs	%[1]	cfs	%[1]	cfs	%[1]
Existing Conditions	**1,145**	—	**2,619**	—	**1,745**	—	**1,026**	—	**909**	—
Alt 1 – No Action	975	-15%	2,114	-19%	1,303	-25%	953	-7%	864	-5%
Alt 2 – Proposed Action	948	-17%	2,002	-24%	1,313	-25%	953	-7%	859	-5%
Alt 3 – 5	945	-17%	2,030	-22%	1,286	-26%	948	-8%	862	-5%

[1] Percent change in streamflow from existing conditions.

Figure 3-120. Colorado River average year flows for boating in Gore Canyon and Pumphouse – cumulative effects.



Estimated daily flow data indicate that in 13 years of the 47-year period of record, there would be no change in the number of days that preferred rafting and kayaking flows of 850 to 1,250 cfs occurs for any of the alternatives. Preferred flows in Gore Canyon would occur about 40 days less (over the 47-year study period) under the No Action Alternative compared to existing conditions (Table 3-150). Under the Proposed Action, preferred rafting flows would occur about 56 days less than existing conditions over the 47 years. On average, this would be about 1 to 2 days fewer with preferred rafting flows during the 34 years when flows fall outside of the preferred range. The greatest decrease in the number of days with preferred flows in a single year would be 23 days under the No Action Alternative and up to 31 days for the Proposed Action and other alternatives. There would also be years when the number of boating days increases. The No Action Alternative would increase the number of days with preferred flows by up 17 days in a single year and the action alternatives up to 22 days. Projected flows for all of the alternatives would allow commercial outfitters to continue to run trips through Big Gore Canyon in August most of the time. In some years, there would be more days with preferred flows than currently occur and in other years there could be fewer days.

Table 3-150. Comparison of preferred boating flow days (850 to 1,250 cfs) in Big Gore Canyon between existing conditions and the alternatives in August—cumulative effects.

Alternative	Total days in 47-year period were between 850 and 1,250 cfs	Average change in preferred flow days per year from EC during the 34 years when flow changes occur[1]	Greatest change in the number of preferred flow days in a single year compared to EC during the 34 years when flow changes occur
Existing Conditions (EC)	848		
Alt 1 – No Action	808	-1.2	-23 to +17
Alt 2 – Proposed Action	792	-1.7	-31 to +22
Alt 3 – 5	786	-1.8	-31 to +22

[1] There would be no change in the number of days when preferred flows for boating are between 850 and 1,250 cfs in 13 of 47 years.

The cumulative effects on expert flows through Big Gore Canyon (about 1,100 to 2,200 cfs) are the same as those described below for the Pumphouse reach.

The WGFP under all of the alternatives would curtail diversions during the Gore Race if flows are below 1,250 cfs, thus there would be no impact from the Proposed Action. Reduced flows from other reasonably foreseeable alternatives, including future reductions in Blue River flows to the Colorado River, would have the greatest impact on Colorado River flows in August.

Colorado River: Pumphouse to State Bridge

A change in the number of days of preferred flows between 1,100 and 2,200 cfs in the Pumphouse reach also was evaluated. This flow range also represents expert kayaking flows through Big Gore Canyon (Table 3-151). There would be no change in the number of days in this flow range in 7 years out of the 47-year study period. Results also indicate that over the 47-year study period, there would be about 190 fewer days of preferred flows under the No Action Alternative compared to existing conditions, and about 207 fewer days under the Proposed Action. On average, this would be about 5 less days per year of preferred flows during the 40 years where flow changes occur. In those years with a change in the number of days with flows between 1,100 and 2,200 cfs, the estimated change varies from 31 more days to 56 fewer days. It is possible that camping and other recreation uses in the Pumphouse and Radium areas could also change as a result of changes in streamflow, following a pattern that is similar to changes in boating flows.

Colorado River flows under cumulative effects hydrology would reduce the number of days that preferred boating flows would occur in the Pumphouse reach. There would be no change in flows of 1,100 to 2,200 cfs in 7 years out of the 47-year period of record, and a decrease of about 5 days per year on average in the 40 years when flows would not meet the preferred flow range.

Table 3-151. Comparison of preferred boating flow days (1,100 to 2,200 cfs) from Pumphouse to State Bridge between existing conditions and the alternatives from June to August—cumulative effects.

Alternative	Total days in 47-year period flows were between 1,100 and 2,200 cfs	Average change in preferred flow days per year from EC during the 40 years when flow changes occur[1]	Greatest change in the number of preferred flow days in a single year compared to EC during the 40 years when flow changes occur
Existing Conditions (EC)	1,034		
Alt 1 – No Action	844	-4.8	-56 to +31
Alt 2 – Proposed Action	827	-5.2	-56 to +31
Alt 3 – 5	834	-2.0	-56 to +29

[1] There would be no change in the number of boating days when flows are between 1,100 and 2,200 cfs in 7 of the 47 years.

Dry year cumulative effects streamflow in the Pumphouse reach would be substantially lower under all alternatives (Table 3-22). Colorado River flows during dry years through this reach would be below the preferred flow range throughout the summer recreation season for both existing conditions and all of the alternatives. Reasonably foreseeable future actions would be responsible for the changes in flow in dry years because dry year flows would not change from existing conditions under the WGFP.

Cumulative effect hydrologic changes on the Colorado River for Big Gore Canyon and Pumphouse and the resulting impacts to boating are somewhat overstated. Denver Water's future water demands in the Blue River watershed would be about 30,000 AF less than used in the analysis for the WGFP (Corps 2010). Thus, changes to preferred flow ranges for boating would likely be less than estimated.

Willow Creek

Willow Creek is not used for recreational boating and there would be no effects to recreation.

3.19.3.4 East Slope Reservoir Recreation

Ralph Price Reservoir

No reasonably foreseeable actions were identified that would result in cumulative recreation effects if Ralph Price Reservoir is enlarged.

Carter Lake

Water levels at Carter Lake would be minimally affected based on cumulative effects hydrology under any of the alternatives. During average conditions or a dry year, average monthly surface area would decrease less than 5 acres under any alternative. In wet years under all alternatives, the average monthly lake surface area would decrease less than 11 acres (Appendix Table A-42). In dry years, fluctuations would be within 1 foot of existing conditions for all alternatives. These changes would not impact access to boat ramps or noticeably change boating opportunities.

> Carter Lake water levels would decrease about 1-foot on average during the summer recreation season under cumulative effects hydrology with the Proposed Action.

Horsetooth Reservoir

Cumulative effects hydrologic conditions with the No Action Alternative would not affect water levels in Horsetooth Reservoir during the peak recreation season from May to September in average, wet, or dry years. Reasonably foreseeable action and the Proposed Action would reduce average monthly water surface area less than 72 acres during the recreation season compared to about a 25 acre decrease for the other action alternatives (Appendix Table A-44).

> Horsetooth Reservoir average monthly water levels would decrease up to 6 feet during the summer recreation season under cumulative effects hydrology with the Proposed Action. Access to the South Bay-South boat ramp could be affected in September.

Boat ramps would remain accessible throughout the primary recreation season for all alternatives in average years, although use of the South Bay-South boat ramp may not be accessible under the Proposed Action in September. The South Bay-South boat ramp would be inaccessible in August and September of dry years under all alternatives. The Satanka Cove boat ramp could also be unusable in September under existing conditions and unusable in dry years under all alternatives.

The loss of use of one or two of the five boat ramps at Horsetooth Reservoir could increase crowding at usable boat ramps. Loss of boat ramp access would occur primarily during the late season and would most likely occur under the Proposed Action. Projected changes in lake levels may reduce the carrying capacity for boating when water levels are low. Recreational experiences may change to the extent that changes in lake levels affect the aesthetic quality of the experience.

Chimney Hollow Reservoir

Recreational development at Chimney Hollow Reservoir, along with those planned by Larimer County Parks and Open Lands on adjacent property would enhance regional recreation opportunities.

Dry Creek Reservoir

Recreation activities and development similar to those anticipated at Chimney Hollow are possible if a managing entity is found. Public access to the reservoir site would need to be developed.

3.19.3.5 East Slope River Recreation

Big Thompson River

Average year flows on the Big Thompson River during the May to September recreation season below Lake Estes would increase under all alternatives with cumulative effect hydrologic conditions. Streamflow increases of up to 7 percent under the Proposed Action in July and similar flow increases in other months, and for the other alternatives, would not substantially change kayaking opportunities on the Big Thompson River during average, wet, or dry years (Appendix Table A-30).

North St. Vrain Creek and St. Vrain Creek

Changes in streamflow in these streams would only occur under the No Action Alternative. There would be no change in average monthly June flows when most kayaking occurs, but a 25 percent decrease in July flows would reduce flows below 150 cfs, the lower limit of acceptable flows for kayaking. Less than a 13 percent decrease in average monthly streamflow on St. Vrain Creek near Lyons would not reduce preferred flows for kayaking (>200 cfs) from May to July.

Other East Slope Streams

Increased flows from greater WWTP discharges below Participant outfalls on the Big Thompson River, St. Vrain Creek, Big Dry Creek, and Coal Creek would occur under all alternatives with cumulative effects hydrology. Flow increases between 0 and 7.6 cfs and water quality changes may slightly improve fish habitat and are not expected to affect infrequent water-based recreation.

3.19.4 Recreation Mitigation

3.19.4.1 Colorado River Flows

The Subdistrict would curtail WGFP diversions from the Colorado River during the annual Big Gore Race typically held the third week in August if flows at the Kremmling gage are below 1,250 cfs. Periodic curtailment of WGFP diversions in response to elevated stream temperatures in the Colorado River after July 15, as described in *Temperature Mitigation Measures* (Section 3.8.4.2), would add to the available flows for boating in some years.

3.19.4.2 Granby Reservoir

> Implementation of modified prepositioning for the Proposed Action would reduce Granby Reservoir drawdowns and preserve access to boat ramps in most years. It also would limit drawdowns in Carter Lake and Horsetooth Reservoir to less than 2 feet on average from existing conditions.

As discussed in *Surface Water Hydrology* (Section 3.5.4.1), the Subdistrict would modify prepositioning operations (moving C-BT water into Chimney Hollow Reservoir) to moderate Granby Reservoir water level fluctuations. Prepositioning would be curtailed when Granby Reservoir storage reaches about 340,000 AF (8,250 feet in elevation). Average summer monthly water levels in Granby Reservoir would decrease less than 5 feet from existing conditions under the Proposed Action (Table 3-30). The surface area of the reservoir would decrease up to about 245 acres under the Proposed Action with modified prepositioning compared to a decrease of up to 351 acres under original prepositioning.

Maximum decreases in Granby Reservoir water levels also would decrease under modified prepositioning. Without modified prepositioning, decreases in water surface elevation during the summer recreation season would be up to 23 feet (1,142 acre decrease in reservoir surface area) under the Proposed Action, with smaller changes for other action alternatives. With modified prepositioning, water levels in Granby Reservoir would decrease no more than 15 feet (777 acre decrease in reservoir surface area) under the Proposed Action compared to existing conditions (May-September recreation season).

Modified prepositioning would maintain access to Granby Reservoir boat ramps during average, wet, and dry years. The Sunset boat ramp would likely remain accessible in successive dry years. However, hydrologic conditions or C-BT deliveries could result in a decrease in water levels independent of the effect of the WGFP or modified prepositioning. Mitigation measures to maintain higher water levels in Granby Reservoir would reduce potential effects to boating, shoreline fishing, marinas, aesthetics, and recreation use of the reservoir.

3.19.4.3 Carter Lake

There would be minimal change to Carter Lake water levels under original prepositioning and modified prepositioning would further reduce changes in water levels. Thus, there would be no noticeable effect to recreation use at Carter Lake.

3.19.4.4 Horsetooth Reservoir

Modified prepositioning efforts would mitigate impacts to Horsetooth Reservoir boating and recreation. Average monthly water at Horsetooth reservoir would decrease 2 feet compared to existing conditions under modified prepositioning (83 acre decrease in reservoir surface area) compared to a 6-foot decline under the originally proposed prepositioning. No boat ramps would be affected during the summer recreation season. In dry years under the Proposed Action with modified prepositioning, the South Bay – South boat ramp would remain inaccessible in September, which also would occur under existing conditions in dry years. No other boat ramps would be affected in average, wet, or dry years with modified prepositioning. The minor changes in reservoir water levels and surface area with implementation of mitigation measures would have minimal impact on recreation activities at Horsetooth Reservoir.

3.19.4.5 Chimney Hollow Reservoir

Modified prepositioning would result in lower water levels in Chimney Hollow Reservoir because less C-BT water would be available for storage. Greater fluctuations and lower average water levels in Chimney Hollow Reservoir would slightly diminish the quality of boating and fishing activities at the new reservoir.

3.19.5 Unavoidable Adverse Effects

Lower Colorado River flows under all alternatives in the popular boating reaches below Kremmling to State Bridge would result in a reduction in preferred boating flows in some years. Colorado River flows in Byers

Canyon would be lower in July under all alternatives, resulting in reduced kayaking opportunities in this low use reach of the river.

Water storage, primarily in Granby Reservoir, and to a lesser extent in Carter Lake and Horsetooth Reservoir would be lower on average under all alternatives. Modified prepositioning would reduce recreation potential recreation impacts at Granby Reservoir and eliminate recreation impacts at Carter Lake and Horsetooth Reservoir. The greatest impact at Granby Reservoir would occur during infrequent periods of consecutive dry years when reservoir storage drops and access to some boat ramps could be impacted. Under the No Action Alternative, recreation activities at Ralph Price Reservoir would be suspended for about 2 years until the dam enlargement is complete. Also under No Action, lower July flows in the North St. Vrain River would reduce kayaking opportunities.

3.20 Cultural Resources

3.20.1 Affected Environment

3.20.1.1 Regulatory Framework

Section 106 of the National Historic Preservation Act (NHPA) of 1966 as amended (16 U.S.C. 470, et seq.) and its implementing regulations under 36 CFR 800 require all federal agencies to consider effects of federal actions on cultural resources eligible for or listed in the National Register of Historic Places (NRHP). Both listed and eligible properties must be considered during Section 106 review.

Traditional Cultural Properties (TCPs) are protected under Section 106 of the NHPA; the American Indian Religious Freedom Act of 1978 (AIRFA); and, the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA). A TCP may be eligible for listing in the NRHP because of its association with cultural practices or beliefs of a living community that (a) are rooted in the history of the community or tribe, and, (b) are important in maintaining the continuing cultural identity of the community or tribe.

3.20.1.2 Area of Potential Effect

The NHPA and 36 CFR Part 800 requires Reclamation to consider effects to historic properties within the area of potential effect (APE). The APE is defined as “the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist (36 CFR Part 800.16).” The WGFP APE has been defined by Reclamation to include the five reservoir study areas (i.e., the project footprint) and an approximate 2-mile buffer surrounding each. The Colorado State Historic Preservation Officer (SHPO) has concurred with this definition (Contiguglia, pers. comm. 2007). The APE for Chimney Hollow has a 1-mile buffer because intensive Class III pedestrian surveys were conducted for the reservoir footprint (WCRM 2004a, 2004b) and its associated facilities (WCRM 2010). The APE includes areas of possible direct, indirect, and cumulative effects. The study area for each of the alternative reservoir sites includes areas that could be directly affected by reservoir construction, including the footprint of the reservoir pool, dam, spillway, pipelines, access roads, rerouted transmission lines, staging areas, borrow areas, and other facilities. Areas that would be indirectly affected include planned open space recreation associated with Chimney Hollow Reservoir and possibly recreation at other reservoir sites. Reasonably foreseeable future land development in the APE could also contribute to cumulative effects.

3.20.1.3 Data Sources

Area of Potential Effect (APE) is the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if such properties exist. The APE is influenced by the scale and nature of the undertaking, and may be different for different kinds of effects caused by the undertaking. It includes a buffer around the areas proposed for direct disturbance.

Study Area is the area directly affected by reservoir construction including the footprint of the reservoir pool, dam, spillway, pipelines, access roads, rerouted transmission lines, staging areas, borrow areas, and other facilities.

Class I file searches and literature reviews of the APE including the study areas where project facilities for the five potential reservoir sites are located were conducted by Western Cultural Resource Management, Inc. (WCRM) at the Colorado Office of Archaeology and Historic Preservation (OAHP) to determine the presence of previously recorded and/or documented cultural resources (WCRM 2004a, 2004b, 2006, 2007, and 2010). In addition to this file search data, Reclamation provided information on three studies not officially on file with the OAHP. The first study included a prehistoric lithic scatter (5LR57) recorded by Joe Ben Wheat in 1953. The second study was conducted by Jonathan Kent of Metropolitan State College and covered four years of field school in the Carter Lake and Chimney Hollow locales. A report on the fieldwork conducted in 1993 (Kent 1994) details findings to the east at the Carter Lake Reservoir; these resources are within the Chimney Hollow APE but outside of the reservoir footprint. Kent's final report (*Carter Lake Archaeological Project Final Report*), currently in progress, will include work in the Carter Lake and Chimney Hollow areas conducted during 1994, 1995, and 1996 field seasons. Kent located 22 sites and 43 isolates within the Chimney Hollow APE. Cultural Resource Analysts, Inc. completed a third study in 2007 (Kester-Tallman and Brant 2008) when Carter Lake and Flatiron Reservoirs were drained. Eight sites and six isolates were recorded within the Chimney Hollow APE, while two sites were reevaluated.

Reclamation contacted Native American tribes to request information on whether TCPs are located within the APE; the tribes contacted included: Apache Tribe of Oklahoma, Cheyenne and Arapaho Tribes of Oklahoma, Cheyenne River Sioux Tribe, Comanche Nation of Oklahoma, Crow Creek Sioux Tribe, Fort Sill Apache Tribe, Jicarilla Apache Tribe, Kiowa Tribe of Oklahoma, Mescalero Apache Tribe, Northern Arapaho Tribe, Northern Cheyenne Tribe, Northern Ute Tribe, Oglala Sioux Tribe, Pawnee Nation of Oklahoma, Rosebud Sioux Tribe, Eastern Shoshone Tribe, Southern Ute Indian Tribe, Standing Rock Sioux Tribe, Ute Mountain Ute Tribe, Comanche Nation of Oklahoma, and the Crow Creek Sioux Tribe.

Five tribes responded to the invitation to consult with Reclamation. The Southern Ute Tribe had no interest in the area. The Pawnee of Oklahoma indicated no historic properties would be affected. The Cheyenne River Sioux, Southern Arapahoe, and the Eastern Shoshone requested continued consultation as the project progresses.

Potential historic properties may include districts, sites, buildings, structures, and objects that possess historical integrity and are more than 50 years old. Cultural resource types found within the APE for all reservoir study areas include prehistoric and historic archaeological sites, historic buildings, structures, and features, and isolated finds. Examples of prehistoric archaeological sites include camps where short-term occupation took place by hunter-gatherers, lithic scatters that represent the remains of temporary work areas, and hunting sites and blinds, among others. Historic period cultural resources include the archaeological remains of various site types as well as ranches, water diversion features, roads and trails, and features related to the Colorado-Big Thompson (C-BT) Project Historic District, among others.

The current NRHP status of known resources determined to be within the APE of the proposed federal undertaking was documented. The Chimney Hollow Reservoir footprint and all but 17.2 acres within the associated facilities (i.e., study area), were surveyed at a Class III level, and resources were fully documented and evaluated for NRHP significance (WCRM 2004a, 2004b, 2010). Access to 17.2 acres located on two private parcels was denied within the Chimney Hollow Reservoir facilities, and it is known that at least one resource, a segment of the Estes to Lyons Tap Transmission Line (5LR9454), crosses one of these parcels and would need to be recorded, evaluated, and possibly treated in the future. Evaluation of cultural resources is codified under 36 CFR 60.4, and summarized below (NRHP, National Register Bulletin, revised 1998):

The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

a) that are associated with events that have made a significant contribution to the broad patterns of our history; or
b) that are associated with the lives of persons significant in the past; or
c) that embody the distinctive characteristics of a type, period, or method of construction, or that represents the work of a master, or that possess high artistic value, or that represent a significant or distinguishable entity whose components may lack individual distinction; or
d) that have yielded, or are likely to yield, information important in prehistory or history.

Properties listed in or eligible for listing in the NRHP must be important in American history, architecture, archaeology, engineering, or culture. In addition, to be significant, a property also must have physical integrity to be listed in or be eligible for listing in the NRHP. In some cases, additional information must be gathered to evaluate a cultural resource with regard to the NRHP criteria. This information may be gathered by means of limited excavation and/or testing to determine the presence and extent of significant buried cultural material or, in the case of historic sites, archival research to better evaluate these sites under criteria a-c, as summarized above. Cultural resource sites recommended not eligible for the NRHP either do not meet any of the criteria outlined under 36 CFR 60.4 or lack physical integrity (i.e., have been significantly altered or destroyed by previous human activity or natural processes). Sites with field evaluations (i.e., field eligible, field not eligible, field needs data), those that have not been assessed with regard to NRHP eligibility, or that cannot be relocated by means of file search data alone are considered potentially eligible for inclusion in the NRHP.

3.20.1.4 Cultural History Overview

Summarizing the cultural history of the APE requires an evaluation of human history on both sides of the Continental Divide. Much of the story is the same—humans have inhabited Colorado for at least 12,000 years. A succinct summary of this history is provided below, subdivided into chronologically sequential stages defined primarily by changes in subsistence strategies and material culture. These stages are Paleoindian, Archaic, Late Prehistoric, and Historic. The cultural overview provided below is taken entirely from the synthetic overviews published by the Colorado Council of Professional Archaeologists (CCPA) (Gilmore et al. 1999; Reed and Metcalf 1999). Although the project APE includes two distinct geographical areas, the close proximity of the western portion is considered in this document to be most similar to the Front Range/Plains ecotone and, as such, the chronological sequence adopted for the South Platte basin is used here (Gilmore et al. 1999).

The Paleoindian stage is further subdivided into three periods: Clovis, Folsom, and Plano. Each of these periods is characterized by highly stylized projectile points—a reflection on the emphasis these people placed on hunting now-extinct mammoth and bison and later modern but smaller species of bison. Sites common to the periods include camps and kill sites. Archaeological sites of this general period are relatively rare, but some of the better known sites are found in Middle Park, including Grand County and the Denver basin along the Front Range.

The Archaic stage is subdivided into Early, Middle, and Late period designations, based partially on changes in projectile point form and changes in settlement and subsistence strategies. Changes in climate led to adaptive human subsistence strategies geared more toward generalized hunting and gathering where each was an equally important food source. It is during this stage that hunter-gatherers likely began to form into bands reminiscent of those tribes encountered during the 19th century. Common sites include camps, hunting sites, and limited-activity lithic scatters.

The Late Prehistoric stage again comprises three periods: Early Ceramic, Middle Ceramic, and Protohistoric. The Early Ceramic period witnessed the adoption of ceramic technology and the bow and arrow. Horticulture was practiced in the Denver basin during the Early Ceramic period, but not in Middle Park. A change in climate initiated the transition to the Middle Ceramic period, when much of the Front Range may have been abandoned, due to drought, which forced an emigration into the mountains. The Protohistoric sub-period begins in A.D. 1540 with the arrival of the Spanish in the Southwest; however, it took nearly 200 years for Euroamerican goods, including horses, to affect a change in Native American culture.

The advent of the horse radically changed the disposition of Native American tribes, turning semi-nomadic hunter-gatherers into highly nomadic, horse-mounted cultures. A succession of tribes occupied the Denver basin and Front Range, including the Apache, Comanche, Kiowa, Cheyenne, and Arapaho. The Ute arrived in the Southern Rocky Mountains by at least A.D. 1400, but made only excursions into the Plains. The arrival of Euroamericans in the Denver basin beginning around 1860 permanently impacted Native American culture. By the 1880s, Native Americans had been forcibly removed to reservations in Wyoming and Oklahoma (Clark 1999).

The discovery of gold at the confluence of Cherry Creek and the South Platte River began the Historic period in earnest. Thousands of prospectors and commercial opportunists swarmed to the Denver basin lured by the incentive of easy wealth. Once the furor of gold abated, many who failed at prospecting tried their luck at ranching and farming. Inexpensive land and ranching opportunities were incentives for Euroamericans to settle in the mountains. Ranching and farming were and continue to be the primary commercial enterprises within the project APE. Common historic archaeological sites include: active and/or abandoned farms and ranches and associated facilities; early commercial endeavors such as water reclamation projects; and, early transportation features such as the railroad and roads.

3.20.1.5 Ralph Price Reservoir

A total of 21 sites and 33 isolated finds were identified within the Ralph Price APE (WCRM 2006, 2007). Twenty sites (Table 3-152) are either eligible or potentially eligible for inclusion in the NRHP. There are no known sites within the reservoir study area, but three cultural resources (5BL1, 5BL16, and 5BL24) identified during the file search have not been assessed and their location is unclear.

Table 3-152. Eligible or potentially eligible cultural sites within the Ralph Price Reservoir APE.

Site Number	Site Type	NRHP Status
5BL1	Open Camp	No Assessment – exact location unknown
5BL16	Open Camp	No Assessment – exact location unknown
5BL24	Open Camp	No Assessment – exact location unknown
5BL26	Open Camp	Field Not Eligible
5BL27	Open Camp	Field Needs Data
5BL483	Longmont Power Plant and Hydroelectric Plant	Officially Listed
5BL518	Stage Stop	No Assessment
5BL4838	Open Camp	Officially Eligible
5BL5661	Prehistoric Hunting Blinds	Field Eligible
5BL5662	Rock Shelter and Hunting Blind	Field Eligible
5BL6449	Homestead	Field Not Eligible
5BL6450	Homestead	Field Eligible
5BL6453	Nelson Ranch/Clarke Homestead	Field Not Eligible
5BL6454	Open Lithic	Field Not Eligible
5BL6460	Historic Trash Scatter	Field Not Eligible
5BL6461	Homestead	Field Not Eligible
5BL6466	Multicomponent	Field Not Eligible
5BL6467	Open Camp	Field Needs Data
5BL6469	Open Camp	Field Not Eligible
5BL6471	Open Lithic	Field Not Eligible

3.20.1.6 Chimney Hollow Reservoir

As a result of Class I and Class III investigations conducted by WCRM, a total of 54 sites and 74 isolated finds were identified within the Chimney Hollow APE (WCRM 2004a, 2004b, 2006, 2007, 2010). The prehistoric component of site 5LR57 was also recorded as part of multicomponent site 5LR10386 and has been combined under that number. Forty sites (Table 3-153) are either eligible or potentially eligible for inclusion in the NRHP; 16 are within the reservoir study area.

Table 3-153. Eligible or potentially eligible cultural sites within the Chimney Hollow Reservoir APE.

Site Number	Site Type	NRHP Status
5LR42[2]	Open Camp/Burial	Officially Eligible
5LR55	Open Architectural	Not Assessed
5LR57[1] (see 5LR10386)	Open Lithic	Combined under 5LR10386 as Officially Eligible
5LR343	Open Camp	Not Assessed
5LR390	Open Architectural	Not Assessed
5LR1316	Open Lithic	Field Not Eligible
5LR1363[1]	Carter Lake Historic Area	Contributing to Historic District
5LR1734	Historic Water Control	Field Eligible
5LR1735	Historic Water Control	Field Not Eligible
5LR1749	Open Lithic	Field Needs Data
5LR1750	Fire Altered Rock Mound	Field Needs Data
5LR1751	Open Camp	Field Eligible
5LR1752	Open Camp	Field Needs Data
5LR1753	Open Lithic	Field Not Eligible
5LR1754	Sandstone Enclosure/Structure (prehistoric?)	Field Needs Data
5LR1888[1, 5]	Unnamed Rock Wall	Officially Needs Data
5LR3984[1]	Flatiron Dam and Reservoir	Contributing to Historic District
5LR3986[1]	Flatiron Power & Pump Plant	Contributing to Historic District
5LR4002[1]	Carter Lake Pressure Conduit and Tunnel	Contributing to Historic District
5LR9454[1, 3]	Estes to Lyons Tap Transmission Line Segment	No Assessment Available
5LR10380[1, 4]	Eagle Trap	No Assessment Available
5LR10386[1, 5]	Multicomponent	Officially Eligible
5LR10394	Historic Range Management Complex	Field Eligible
5LR10395	Open Lithic	Field Not Eligible
5LR10396	Homestead	No Assessment Available
5LR10397[1] (see 5LR10735)	Multicomponent	Combined under 5LR10735 as Officially Needs Data
5LR10416[1, 5] (see 5LR10740)	Two Stone Walls	Combined under 5LR10740 as Officially Needs Data
5LR10419[1, 5]	Rock Wall	Officially Needs Data
5LR10420[1, 5]	Multicomponent	Officially Needs Data
5LR11930.1	Historic Rock Wall	Field Not Eligible

Site Number	Site Type	NRHP Status
5LR10735[1]	Multicomponent	Officially Needs Data
5LR10740[1, 5]	Historic Rock Wall Alignment	Officially Needs Data
5LR11931	Historic Structure/Artifacts	Field Not Eligible
5LR11932	Open Camp	Field Not Eligible
5LR11935	Open Lithic	Field Not Eligible
5LR11936	Open Lithic	Field Not Eligible
5LR11937	Open Camp	Field Eligible
5LR11938	Historic Quarry	Field Not Eligible
5LR11950	Historic Structure	Field Not Eligible
5LR12074[1]	Carter Lake South Shore	Contributing to Historic District
5LR12545[1, 5]	Isolated Historic Rock Wall Alignment	Officially Needs Data
5LR12546[1, 5]	Isolated Historic Rock Cairn	Officially Needs Data
5LR12547[1, 5]	Isolated Historic Rock Cairn	Officially Needs Data

[1] Resources within reservoir study area (i.e., footprint).
[2] The buffers for Chimney Hollow and Dry Creek reservoirs overlap, so 5LR42 falls within the APE for both.
[3] Segment not yet recorded or assessed. Permission to enter denied by landowner (WCRM 2010).
[4] Information on the exact location of this site not available at this time, therefore, it is included in area of direct effects.
[5] The NRHP eligibility of these sites is currently under review; their official determinations may change.

Previous studies have been conducted within the reservoir study area. A prehistoric site, 5LR57, was recorded by Joe Ben Wheat of the University of Colorado Museum in 1953. The Carter Lake Historic Area (5LR1363) and the Carter Lake South Shore (5LR12074) incorporate the C-BT facilities surrounding Carter Lake and have been recommended as contributing elements to the C-BT Historic District. The boundaries of the district extend into a small portion of the proposed Chimney Hollow Reservoir study area. The Flatiron Dam and Reservoir (5LR3984), Flatiron Power and Pump Plant (5LR3986), and Carter Lake Pressure Conduit and Tunnel (5LR4002) are also part of the C-BT Historic District and have been determined to be contributing elements. Segments of three historic transmission lines are located within the APE: the Flatiron-Pole Hill Transmission Line (5LR9388), the Flatiron valley to Greeley Transmission Line (5LR9389), and the Estes to Lyons Tap Transmission Line (5LR9454). Twenty-two sites (5LR1749-1754, 5LR10380, 5LR10386, 5LR10394-10398, 5LR10401, 5LR10406-10407, 5LR10409-10410, 5LR10415-10416, 5LR10419-10420) were recorded within the APE by Jonathan Kent of Metropolitan State College; 13 are within the reservoir footprint (10 prehistoric and 3 multicomponent). The documentation for sites 5LR1749-1754 located outside of the Chimney Hollow Reservoir footprint near Carter Lake has been submitted to Reclamation (Kent 1994), but the review process has not been completed with the SHPO. Official documentation for all other sites recorded by Kent has not been completed or submitted to Reclamation; however, in 2010, WCRM attempted to revisit and reevaluate sites documented by Kent within the reservoir study area. It was found that one site documented by Kent, 5LR10386, included the prehistoric component of site 5LR57; they have been combined under the number 5LR10386. Another site documented by Kent, a lithic scatter (5LR10410) located within the pool of the reservoir study area, was recently tested (WCRM 2010) and officially determined not eligible for inclusion in the NRHP on March 22, 2011. Two sites documented by Kent under the numbers 5LR10397 and 5LR10416 had been officially recorded by WCRM during subsequent fieldwork as 5LR10735 and 5LR10740; the Colorado OAHP determined the sites should retain the numbers under which they were officially recorded (i.e., 5LR10735 and 5LR10740). WCRM's findings with regard to sites previously documented by Kent within the project footprint were submitted to Reclamation for eligibility determinations in consultation with the SHPO. Cultural Resource Analysts, Inc. (Kester-Tallman and Brant 2008) recorded eight sites (5LR11930.1, 5LR11931-11932, 5LR11935-11938, and 5LR11950) and reevaluated two sites (5LR1316 and 5LR1751) within the Chimney Hollow APE in 2007; they have been submitted to Reclamation for review but official consultation with the SHPO has not yet occurred.

3.20.1.7 Dry Creek Reservoir

A total of 10 sites and 10 isolated finds were identified within the Dry Creek Reservoir APE (WCRM 2006, 2007). Six sites (Table 3-154) are either eligible or potentially eligible for inclusion in the NRHP; two are within the reservoir study area.

Table 3-154. Eligible or potentially eligible cultural sites within the Dry Creek Reservoir APE.

Site Number	Site Type	NRHP Status
5LR42[2]	Open Camp/Burial	Officially Eligible
5LR59	Open Lithic	No Assessment
5LR435	Historic Dugout/Rock Art	Field Needs Data
5LR653[1]	Historic Quarry	Field Eligible
5LR1363[1]	Carter Lake Historic Area	Contributing to Historic District
5LR2114	Multicomponent	Field Eligible

[1] Resources within reservoir study area (i.e., footprint).
[2] The buffers for Chimney Hollow and Dry Creek reservoirs overlap, so 5LR42 falls within the APE for both.

Site 5LR653 is a historic quarry listed as field eligible. The Carter Lake Historic Area (5LR1363), previously discussed under the Chimney Hollow Reservoir, overlaps a portion of proposed disturbance area associated with the Dry Creek Reservoir site.

3.20.1.8 Jasper East Reservoir

A total of 64 sites and 20 isolated finds were identified within the Jasper East APE (WCRM 2006, 2007). Forty-four sites located within the APE (Table 3-155) are either eligible or potentially eligible for inclusion in the NRHP; seven are located within the reservoir study area.

Table 3-155. Eligible or potentially eligible cultural sites within the Jasper East Reservoir APE.

Site Number	Site Type	NRHP Status
5GA118	Open Camp	Field Needs Data
5GA119[1]	Prehistoric Quarry	Field Needs Data
5GA128	Open Architectural	Officially Eligible
5GA149	Open Lithic	Field Needs Data
5GA150[1]	Open Lithic	Field Not Eligible
5GA151[1]	Prehistoric Quarry	Officially Eligible
5GA152	Open Lithic	Field Not Eligible
5GA163	Open Lithic	Field Not Eligible
5GA164	Open Lithic	Field Not Eligible
5GA165	Multicomponent	Officially Eligible
5GA240	Open Lithic	Field Not Eligible
5GA245	Open Lithic	Field Not Eligible
5GA247	Open Lithic	Field Not Eligible
5GA248	Open Lithic	Field Eligible
5GA666	Open Lithic	Field Needs Data
5GA668	Open Lithic	Field Not Eligible

Site Number	Site Type	NRHP Status
5GA671	Open Lithic	No Assessment
5GA1685	Historic Mine	Field Not Eligible
5GA1697	Homestead	Field Not Eligible
5GA1700	Historic Mine	Field Not Eligible
5GA2266	Open Camp	Officially Needs Data
5GA2277	Willow Creek Dam	Within Potential District – Unknown Status
5GA2278[1]	Willow Creek Feeder Canal	Within Potential District – Unknown Status
5GA2312	Open Camp	Officially Needs Data
5GA2397[1]	Willow Creek Switchyard-Pumping Plant	Within Potential District – Unknown Status
5GA2400[1]	Willow Creek to Willow Creek Dam Transmission Line	Field Not Eligible
5GA2401[1]	Transmission Line	Field Eligible
5GA2773.2	Ditch Segment	Officially Needs Data
5GA2946	Open Lithic	Officially Eligible
5GA3006	Open Lithic	Field Not Eligible
5GA3070	Open Camp	Officially Eligible
5GA3071	Open Lithic	Officially Needs Data
5GA3072	Open Lithic	Officially Needs Data
5GA3073	Open Lithic	Officially Needs Data
5GA3074	Open Lithic	Officially Needs Data
5GA3075	Open Lithic	Officially Needs Data
5GA3076	Open Lithic	Officially Needs Data
5GA3077	Open Lithic	Officially Needs Data
5GA3078	Open Lithic	Officially Needs Data
5GA3079	Multicomponent	Officially Needs Data
5GA3080	Open Lithic	Officially Needs Data
5GA3081	Open Lithic	Officially Needs Data
5GA3082	Open Lithic	Officially Needs Data
5GA3083	Homestead/Ranch	Officially Eligible

[1] Resources within reservoir study area (i.e., footprint).

Two prehistoric quarries (5GA119 and 5GA151) and one prehistoric lithic scatter (5GA150) are located in the reservoir study area. Site 5GA119 is recommended field needs data, while 5GA150 is recommended field not eligible. Site 5GA151 was officially determined eligible on September 9, 1981. Sites 5GA2278, 5GA2397, and 5LR2400 are associated with the Willow Creek Canal, which transports water from Willow Creek Reservoir to Granby Reservoir. The Willow Creek Feeder Canal (5GA2278) and the Willow Creek Switchyard-Pumping Plant (5GA2397) are recommended potentially eligible for inclusion in the NRHP as part of the C-BT Historic District. The Willow Creek to Willow Creek Dam Transmission Line (5GA2400) is recommended field not eligible, while an unnamed transmission line (5GA2401) is recommended field eligible.

3.20.1.9 Rockwell/Mueller Creek Reservoir

A total of 46 sites and 54 isolated finds were identified within the Rockwell Reservoir APE (WCRM 2006, 2007). Eighteen sites (Table 3-156) are either eligible or potentially eligible for inclusion in the NRHP; one is located within the reservoir study area.

Table 3-156. Eligible or potentially eligible cultural sites within the Rockwell/Mueller Creek Reservoir Area of Potential Effect.

Site Number	Site Type	NRHP Status
5GA122	Multicomponent	Officially Eligible
5GA123	Open Lithic	Officially Needs Data
5GA157	Open Camp	Field Needs Data
5GA159	Open Lithic	Field Needs Data
5GA160	Open Camp	Field Needs Data
5GA238	Stone Quarry; Open Lithic	Field Not Eligible
5GA241	Open Lithic	Field Not Eligible
5GA606	Open Lithic	Officially Eligible
5GA669	Open Lithic	Officially Eligible
5GA670	Open Architectural	Officially Eligible
5GA680	Stone Quarry	Officially Eligible
5GA686	Historic Road and Trash Dump	No Assessment
5GA686.1	Historic Road Segment	Officially Eligible
5GA687	Open Lithic	Officially Eligible
5GA869	Open Camp	Officially Eligible
5GA1684	Open Lithic	No Assessment
5GA2281[1]	Granby Warehouse	Field Not Eligible
5GA2811	Open Lithic	Officially Needs Data

[1]Resources within reservoir study area (i.e., footprint).

The Granby Warehouse (5GA2281) has been recommended field not eligible; a reevaluation and official NRHP determination is required. The pipeline connection to Windy Gap Reservoir would cross the existing Denver and Rio Grande Railroad (D&RG) and a possible water diversion ditch. Elsewhere in Colorado, the D&RG (5GA3564) is considered an officially eligible historic resource; the segment within the reservoir study area has not been formally recorded. It is presently unknown whether the diversion ditch is historic; if so, it would require formal documentation.

3.20.2 Environmental Effects

3.20.2.1 Issues

Potential impacts to important cultural resources from reservoir construction were identified as an issue of concern during scoping.

3.20.2.2 Methods for Effects Analysis

The NRHP eligibility of each cultural resource previously documented and/or recorded within the APE was reviewed. Prehistoric, historic, and traditional cultural properties are considered significant under 36 CFR 60.4 if they are eligible for listing in the NRHP.

For purposes of the Section 106 process, consultation regarding resources located within the APE must occur between Reclamation, the Colorado SHPO, and other consulting parties. NRHP evaluation of the resources and determinations of effect would be carried out by Reclamation in consultation with the SHPO. In general, the SHPO recommends that sites be rerecorded when the previous recording occurred five or more years in the past. A site should be reevaluated whenever its eligibility is being considered or integrity challenged. The SHPO can be consulted to determine when a site needs to be rerecorded or reevaluated. Reclamation would consult with the SHPO regarding any historic properties that may be affected by the WGFP and assess any adverse effects. After consultation, the SHPO provides a determination of eligibility (DOE) for each cultural resource within the APE. Some cultural resources recorded within the proposed reservoir study areas already have an official DOE.

If SHPO or other consulting parties do not concur with the recommendations provided by Reclamation, continued consultation can occur or the Advisory Council on Historic Preservation (ACHP) can be asked to review the findings. Cultural resources that remain eligible for listing in the NRHP and cannot be avoided during project implementation would be adversely affected. To address these adverse effects, Reclamation would consult with the SHPO and other consulting parties to resolve the adverse effects and develop a Memorandum of Agreement (MOA) or Programmatic Agreement (PA). The MOA/PA would specify the mitigation or alternatives agreed to by the consulting parties, identify who is responsible for carrying out the specified measures, and serve as evidence that Reclamation has complied with Section 106.

3.20.2.3 Effects Common to All Alternatives

Construction of new reservoirs or the enlargement of an existing reservoir may adversely affect cultural resources. Direct effects include construction of access roads, borrow pits, transmission lines, pipelines, and dam facilities. Consultation between Reclamation and the SHPO on January 24, 2007 determined that there would be minimal indirect and cumulative effects from the WGFP. Indirect effects at all proposed reservoir sites could occur because of possible recreation development and inundation of resources. No recreation development is currently planned at the Jasper East, Rockwell/Mueller Creek, or Dry Creek reservoir sites. Ralph Price Reservoir would continue to be managed for open space recreation by the City of Loveland, while the Chimney Hollow Reservoir site would be managed for recreation by Larimer County Parks and Open Lands. Recreation development could result in indirect adverse effects to cultural resource sites because of increased visitation by the public. Increased access and exposure of sites can contribute to the illicit collection of artifacts, unauthorized excavation of archaeological material, and potential erosion from trails and recreation development. The inundation of cultural resources is an indirect effect that can be either adverse or beneficial. Adverse effects can occur to sites located in the area of oscillating shoreline during the cyclical period of drawdown and filling. In addition, reservoir dredging could adversely affect inundated sites. Beneficial effects of inundation occur to sites that are not subject to shoreline erosion, dredging, and are preserved from the silting of the reservoir bottom. Once the preferred alternative is selected, a MOA/PA would be developed by Reclamation to address possible direct and indirect effects.

Reclamation, in consultation with the SHPO, would determine the level of survey needed for those areas not previously surveyed that would be affected by project construction; it is likely that some previously recorded sites would need to be reevaluated. In addition, within the area of potential effects, all areas not previously surveyed to a Class III level would be inventoried, resources would be evaluated with regard to the NRHP, and adverse impacts would be mitigated.

3.20.2.4 Alternative 1—Ralph Price Reservoir (No Action)

It is uncertain as to whether the enlargement of Ralph Price Reservoir would have a direct or indirect effect on known cultural resources. Twenty-one previously recorded sites were identified within the reservoir APE. There are no known cultural resources that would be directly impacted by the project. The exact location of three sites (5BL1, 5BL16, and 5BL24) is unknown; they may be within the reservoir study area. Intensive (Class III) cultural resource investigations would need to be conducted in areas of direct, indirect and cumulative effects to identify known and unknown potentially eligible sites if the No Action Alternative is implemented. All previously recorded sites would need to either be rerecorded or reevaluated.

3.20.2.5 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

> Several cultural resources were identified within the area of potential effect at Chimney Hollow Reservoir. Appropriate mitigation measures would be developed for impacts to resources eligible for the National Register of Historic Places.

Forty cultural resource sites eligible or potentially eligible for listing in the NRHP were identified within the Chimney Hollow Reservoir APE, while 16 are located within the reservoir study area and could be directly affected. These cultural resources include the Carter Lake Historic Area (5LR1363); four rock walls (5LR1888, 5LR10419, 5LR10740, and 5LR12545); two rock cairns (5LR12546 and 5LR12547); the Flatiron Dam and Reservoir (5LR3984); the Flatiron Power and Pump Plant (5LR3986); the Carter Lake Pressure Conduit and Tunnel (5LR4002); one inaccessible segment of the Estes to Lyons Tap Transmission Line (5LR9454); a possible eagle trap (5LR10380); three multicomponent sites (5LR10386, 5LR10420, and 5LR10735); and the Carter Lake South Shore site (5LR12074).

Six sites have been officially determined eligible. The historic component of 5LR10386 will be directly affected by the Chimney Hollow Reservoir; consultation between Reclamation and the SHPO will result in a treatment plan to mitigate adverse effects. Five sites (5LR1363, 5LR3984, 5LR3986, 5LR4002, and 5LR12074) have been determined to be contributing elements to the C-BT Historic District. Current project design indicates that a portion of the southern construction access road would overlap part of Carter Lake Historic Area (5LR1363) and the Carter Lake South Shore (5LR12074). Recent Class III investigations within the expanded Chimney Hollow Reservoir facilities areas (WCRM 2010) recorded these resources to SHPO standards. Consultation between Reclamation and the SHPO would determine whether reservoir construction would affect the District's historical integrity. Appropriate mitigation measures with regard to all five resources would be determined in consultation with the SHPO.

NRHP assessments could not be obtained for a segment of the Estes to Lyons Tap Transmission Line (5LR9454); a possible eagle trap (5LR10380); two multicomponent sites (5LR10420 and 5LR10735); four rock walls (5LR1888, 5LR10419, 5LR10740, and 5LR12545); and two rock cairns (5LR12546 and 5LR12547). Additional data will need to be gathered in order to make official NRHP eligibility determinations for these sites and, if required, mitigation measures may need to be developed and implemented.

Access was denied to two private parcels within the Chimney Hollow Reservoir facilities; therefore, Class III survey of 17.2 acres could not be conducted. These parcels would be surveyed to a Class III level prior to construction. Resources that are located would be evaluated with regard to the NRHP, and any adverse effects would be mitigated. It is known that an unrecorded segment of 5LR9454 crosses one of the parcels.

Indirect effects to unknown cultural resources from public visitation could result in the collection of artifacts and potential unauthorized excavation or disturbance of cultural deposits.

3.20.2.6 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Chimney Hollow Reservoir

There are two unevaluated cultural resources (5LR10397 and 5LR10420) between the 70,000-AF Chimney Hollow Reservoir boundary of Alternative 3 and the 90,000-AF Chimney Hollow Reservoir boundary of the

Proposed Action (Alternative 2). Therefore, the effects associated with construction of a 70,000-AF Chimney Hollow Reservoir would affect 14 eligible or unevaluated sites rather than 16 as described for the Proposed Action.

Jasper East Reservoir

Forty-four cultural resources eligible or potentially eligible for inclusion in the NRHP were identified within the Jasper East Reservoir APE. Seven sites are located within the proposed Jasper East Reservoir study area and could be directly affected. The resources include: two prehistoric quarries (5GA119 and 5GA151), one prehistoric lithic scatter (5GA150), three sites associated with the Willow Creek Reservoir (5GA2278, 5GA2397, and 5GA2400), and one unnamed transmission line (5GA2401).

Site 5GA151 is a prehistoric quarry that has been officially determined to be eligible for inclusion in the NRHP. After review and possible reevaluation or recording of the site, Reclamation, in consultation with the SHPO, would develop a data recovery plan to mitigate any adverse effects.

NRHP assessments for 5GA119, 5GA150, 5GA2278, 5GA2397, 5GA2400, and 5GA2401 remain to be officially determined by Reclamation in consultation with the SHPO. Further data would need to be collected from the sites through various measures including reevaluation, rerecording, or data collection before assessments can be made. If Reclamation and the SHPO concur with the field recommendations, no further work would be necessary. Conversely, appropriate mitigation measures would need to be developed for sites that are determined eligible and would be adversely affected by the project.

Indirect effects to unknown cultural resources from public visitation could result in the collection of artifacts and potential unauthorized excavation or disturbance of cultural deposits if recreation development occurs.

3.20.2.7 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Chimney Hollow Reservoir

Two unevaluated cultural resources (5LR10397 and 5LR10420) are located between the 70,000 AF Chimney Hollow Reservoir boundary of Alternative 4 and the 90,000 AF Chimney Hollow Reservoir boundary of the Proposed Action (Alternative 2). Therefore, the effects associated with construction of a 70,000 AF Chimney Hollow Reservoir would affect 14 eligible or unevaluated sites rather than 16 as described for the Proposed Action.

Rockwell/Mueller Creek Reservoir

Eighteen previously recorded cultural resources eligible or potentially eligible for inclusion in the NRHP were identified within the Rockwell Reservoir APE. One site, the Granby Warehouse (5GA2281), is located within the proposed Rockwell/Muller Reservoir study area. This site, recommended field not eligible, would need to be reevaluated and an official determination assessed. As mentioned previously, the pipeline connection to Windy Gap Reservoir would cross the existing D&RG (5GA3564) and a possible water diversion ditch. Both resources should be formally recorded and evaluated for their eligibility with regard to the NRHP.

Indirect effects to unknown cultural resources from public visitation could result in the collection of artifacts and potential unauthorized excavation or disturbance of cultural deposits if recreation development occurs.

3.20.2.8 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Dry Creek Reservoir

Six known cultural resources eligible or potentially eligible for inclusion in the NRHP were identified within the Dry Creek Reservoir APE. Two sites are located within the proposed Dry Creek Reservoir study area and could be directly affected. These resources are a historic quarry (5LR653) and the Carter Lake Historic Area (5LR1363). This historic area is mentioned previously in the discussion under the proposed Chimney Hollow Reservoir.

Site 5LR653, a historic quarry, has been recommended field eligible for inclusion in the NRHP. If after review and possible reevaluation, Reclamation in consultation with the SHPO, agrees with the field determination, appropriate mitigation measures would be developed.

With regard to the Carter Lake Historic Area (5LR1363), as previously mentioned under the proposed Chimney Hollow Reservoir, after appropriate survey measures and reevaluation of this site have occurred, consultation between Reclamation and the SHPO would determine whether reservoir construction would affect the historical integrity of the C-BT Historic District; if the district would be adversely affected, appropriate mitigation measures would be determined. Effects to the Carter Lake Historic Area would be similar to Alternative 2 with disturbance related to a construction access road and the pipeline to Carter Lake. At this time, it is not known precisely what features would be impacted, but comparison with the District documentation (WCRM 1990) indicates that Area 17 (sandstone quarries) and Area 18 (South Shore recreational facilities) could be affected by construction.

Indirect effects to unknown cultural resources from public visitation could result in the collection of artifacts and potential unauthorized excavation or disturbance of cultural deposits if recreation development occurs.

Rockwell/Mueller Creek Reservoir

There are no known eligible or unevaluated cultural resources located between the 20,000 AF Rockwell Reservoir boundary of Alternative 4 and the 30,000 AF Rockwell Reservoir boundary of Alternative 5. Therefore, the effects associated with construction of a 20,000 AF Rockwell Reservoir would be the same as described for the 30,000 AF Rockwell Reservoir with regard to known eligible or unevaluated cultural resources

3.20.2.9 Traditional Cultural Properties

To date, TCPs have not been identified within the APE of the proposed alternatives.

3.20.3 Cumulative Effects

Both water-based and land-based actions could result in cumulative effects; a description of reasonably foreseeable actions considered in this Final EIS is presented in Section 2.8.2. Reasonably foreseeable land-based actions have not been identified within the APE for expansion of Ralph Price Reservoir under the No Action Alternative; however, a variety of new land developments near the Jasper East, Rockwell, Chimney Hollow, and Dry Creek reservoir sites could result in cumulative effects to eligible or potentially eligible cultural resources within the reservoir APEs. In addition, Larimer County Parks and Open Lands have acquired acreage adjacent to the Chimney Hollow and Dry Creek reservoir APEs for future recreation use. Any future impacts anticipated from trail development, facility construction, or other ground-disturbing activities related to the WGFP would be addressed by Reclamation in a MOA/PA.

3.20.4 Cultural Resource Mitigation

3.20.4.1 Mitigation Common to All Alternatives

Specific mitigation measures for the direct, indirect, and cumulative impacts of the Preferred Alternative would be developed by means of a MOA or PA in compliance with Section 106 of the NHPA. The MOA/PA would be developed between Reclamation, the ACHP, the Colorado SHPO, and, if necessary, Grand and Larimer counties to specify:

- the measures to be taken with regard to identification and evaluation of historic properties;
- the components of a treatment plan and subsequent treatment report to resolve adverse effects;
- any modifications to the project design;
- preconstruction meeting(s) between Reclamation and the construction contractor with a cultural resource contractor present;
- the measures to be taken in the event there are unanticipated discoveries of historic properties;
- the measures to be taken in the event there are unanticipated discoveries of human remains;

- a curation facility; and
- any other terms and conditions.

Special attention would be paid to the project's potential impacts on sites within the C-BT Project Historic District (5BL7953, 5GA2409, and 5LR9611) and any properties considered to be contributing thereto.

All alternatives would require ongoing consultation with Native American Tribes and the public. Mitigation measures for known historic properties within the APE are discussed below by alternative.

Reclamation would coordinate with the SHPO throughout the course of the project to protect and mitigate cultural resources affected by the Proposed Action. Should any archeological resources be uncovered during construction, work would be halted in the area and a Reclamation archeologist, SHPO, and appropriate Native American tribes would be contacted for further consultation. In the unlikely event that human remains are discovered during construction, provisions outlined in the Native American Graves Protection and Repatriation Act (1990) would be followed. The Subdistrict would ensure that all contractors and subcontractors are informed of the penalties for illegally collecting artifacts or intentionally damaging archeological sites or historic properties. Contractors and subcontractors also would be instructed on procedures to follow if previously unknown archeological resources are uncovered during construction.

3.20.4.2 Ralph Price Reservoir

No mitigation efforts are currently identified for the No Action Alternative other than continued Native American and public consultation. Three resources (5BL1, 5BL16, and 5BL24) may be present within the proposed reservoir study area. Reclamation in consultation with the SHPO would determine the level of survey needed for those areas that would be affected by project construction. If these sites are relocated during a Class III cultural resource survey, they would be reevaluated and/or rerecorded and evaluated.

3.20.4.3 Chimney Hollow Reservoir

With regard to sites that have officially been determined eligible for inclusion in the NRHP, appropriate mitigation measures will need to be developed by Reclamation in consultation with the SHPO as part of a MOA/PA and would include at least six sites (5LR1363, 5LR3984, 5LR3986, 5LR4002, 5LR10386, and 5LR12074) project. Sites that lack an official NRHP determination (a segment of 5LR1888, 5LR9454, 5LR10380, 5LR10419, 5LR10420, 5LR10735, 5LR10740, 5LR12545, 5LR12546, and 5LR12547) will require further data gathering and documentation. It will also be necessary to complete a Class III survey of 17.2 acres on two parcels where access was previously denied. Resources found on these parcels should be recorded, assessed, and, if necessary, treated; it is known that an unrecorded segment of 5LR9454 is located across one of the parcels.

3.20.4.4 Dry Creek

Site 5LR653 is recommended field eligible and, pending an official determination of eligibility, may require the development of a mitigation plan. Mitigation for 5LR1363 would be the same as described under the Chimney Hollow alternative and would involve consultation between Reclamation and the SHPO. Reclamation in consultation with the SHPO would determine the level of survey needed for those areas that would be affected (directly, indirectly, or cumulatively) by project construction; it is likely that previously recorded sites would need to be reevaluated.

3.20.4.5 Jasper East

Reclamation, in consultation with the SHPO, would determine the level of survey needed for areas that would be affected (directly, indirectly, or cumulatively) by project construction; it is likely that six previously recorded sites within the reservoir study area would need to be reevaluated, and in some cases, rerecorded before NRHP assessments could be determined. A seventh site (5GA151), a prehistoric quarry, was officially determined eligible on November 8, 1981. After NRHP determinations for the six sites lacking official evaluations have been made by Reclamation in consultation with the SHPO and, if necessary, the ACHP, appropriate mitigation measures would be developed for 5GA151 and any other eligible sites. Sites officially determined not eligible would require no further work.

3.20.4.6 Rockwell/Mueller Creek Reservoir

A reevaluation and official determination of eligibility would need to be obtained for the Granby Warehouse (5GA2281). If determined eligible, mitigation measures would need to be developed through consultation. Reclamation, in consultation with the SHPO, would determine the level of survey needed for those areas that would be affected (directly, indirectly, or cumulatively) by project construction; it is likely that previously recorded sites would need to be reevaluated.

3.20.5 Unavoidable Adverse Effects

Unavoidable adverse effects include inundation of cultural resources within the reservoir pool and destruction of cultural resources located in areas of ground disturbance for the different alternative sites. Cultural resources determined officially eligible, and that would be adversely affected by project development, would be mitigated in consultation between Reclamation and the SHPO. Mitigation serves to recover all reasonably available data through further documentation and/or excavation.

3.21 Visual Quality

3.21.1 Affected Environment

3.21.1.1 Area of Potential Effect

The study areas for the visual quality assessment includes the alternative reservoir sites and surrounding areas up to 2.5 miles away with potential views of the reservoir and dam as determined by digital viewshed analysis. Potential effects to visual quality from changes in hydrology also are considered at existing reservoirs and streams.

3.21.1.2 Data Sources

The visual quality in the area of potential effect was based on field observations, aerial photography, maps, and digital elevation topography data. Additional information is included in the Visual Assessment Technical Report (ERO 2008b).

3.21.1.3 Existing Visual Quality

The existing visual quality of all of the alternative reservoir sites is generally high because the sites are in areas with limited development.

Ralph Price Reservoir

The Ralph Price Reservoir site is located in a scenic valley along the North Fork of St. Vrain Creek. The existing reservoir is surrounded by dense coniferous forest on low mountains. The reservoir is visible to recreation visitors who hike to the lake and a few nearby private homes. The reservoir is not visible from any public roads.

Chimney Hollow Reservoir

The Chimney Hollow Reservoir site is located in a valley bordered by the steep ridge and cliffs of a hogback formation to the east and moderately sloped and forested foothill mountains to the west. The majority of the valley is open grass and shrublands with scattered ponderosa pine forest on the western foothills and cottonwoods along the valley bottom. The existing visual character of the Chimney Hollow valley includes several artificial linear forms including a transmission line that extends throughout the length of the valley, several small power lines, and a large aboveground pipeline. The Chimney Hollow valley is currently visible from several homes on the eastern hogback ridge and small portions of County Road 18E, but is otherwise secluded.

Dry Creek Reservoir

The Dry Creek Reservoir site is in a hogback-framed valley similar to Chimney Hollow. Shrubland and sandstone rock outcrops are found along the steep hogback east of Dry Creek Reservoir and rolling foothill mountains are present on forested slopes to the west. Dry Creek Reservoir supports mixed woodlands and small ponds. A few single-family residences, rural roads, and wire fences are the only artificial forms in the area. The Dry Creek Reservoir site is visible only from private residences and public roads to the residences.

Jasper East Reservoir

The Jasper East Reservoir site is characterized by a large open valley with rolling hills and mountain ranges in the distance. The area supports a mix of irrigated meadows, sagebrush hills, and isolated stands of lodgepole pine. CR 40 is a gravel road that bisects the property, along with smaller private roads. Other artificial landforms include the Willow Creek Pump Canal, forebay, and pump station, and an asphalt runway for model airplanes. The Jasper East Reservoir site is primarily visible from the county road and from some private residences to the west.

Rockwell/Mueller Creek Reservoir

The Rockwell Reservoir site is located in an open hillside drainage above the Fraser River valley. Sagebrush and grasslands encompass most of the site with shrubby riparian vegetation along two small drainages, and coniferous and aspen forest along the western perimeter. Existing visual quality is influenced by scattered low-density housing on and near the site, adjacent county roads, and private roads. Although portions of the site are visible from the Town of Granby, Highway 40 and other man-made obstructions are common in the foreground. Residential and commercial areas in the Fraser River valley also have some visibility of the reservoir site.

3.21.2 Environmental Effects

3.21.2.1 Issues

Issues of concern identified during scoping were the potential effect to existing visual quality near the reservoir sites, the visual impact of relocating the transmission line at Chimney Hollow, and the impact to scenic resources from hydrological changes.

3.21.2.2 Methods for Effects Analysis

Potential effects to visual quality considered changes in the visual quality due to reservoir and facility construction, both temporary and permanent, and the impact to the scenery from nearby observation points where the reservoir and dam would be visible. The visual quality assessment for the reservoir sites consisted of two separate assessments:

- A line-of-sight/viewshed analysis, called a visibility study, identified areas with views of the alternative dams and reservoirs. Using digital terrain modeling, a polygon of points was set at the top of the dam elevation in the shape of the reservoir. If any point could see the surrounding terrain within a 2.5-mile radius of the reservoir’s edge, a shaded area was created. The shaded areas away from the reservoir, therefore, identified locations from which the reservoir would be visible. At distances beyond 2.5 miles, visibility would diminish, as would impacts to scenic quality.
- A scenic quality assessment evaluated the existing scenic quality in the study areas. This portion of the assessment is a field measurement of the physical characteristics, or elements, of scenic quality. These elements include landform types, rock form types and sizes, water form types, artificial form types and quantity, the size of the field of view (referred to as containment), and the color and texture variations.

Potential visual quality effects at reservoirs and streams were evaluated based on changes in reservoir water surface area and streamflow.

3.21.2.3 Effects Common to All Alternatives

Scenic quality at all of the reservoir sites would be temporarily impacted during dam and facility construction. This would include removal of vegetation and exposure of soil and geologic material from material source sites, preparation of the dam foundation, and pipeline installation. Exposed soil material would contrast with adjacent vegetated areas and would generate dust. Construction equipment, vehicles, temporary buildings, and supplies would affect the visual quality of the area for the 4- to 5-year construction period for Alternatives 2, 3, 4, and 5 and about 30 months for the No Action Alternative. Temporarily disturbed areas would be revegetated following construction, but new vegetation would contrast with undisturbed vegetations for several years.

Once reservoir construction is completed and the reservoirs are filled, the scenic character at the new reservoir sites would shift from a mostly natural landform to a flat water feature. The presence of water would provide a visual complement or contrast to the surrounding landscape. Reduced scenic quality is expected where the dam face or other aboveground artificial features would be visible.

3.21.2.4 Visual Quality Effects at Alternative Reservoir Sites

This section includes a discussion of the effects to visual quality for each of the new reservoir sites.

Ralph Price Reservoir

The visual quality at Ralph Price Reservoir would not change substantially if the existing reservoir is enlarged by about 77 surface acres. Visual quality would temporarily diminish if the reservoir is drained during construction; however, public access to the reservoir would be restricted during construction. The scenic quality from the two private residences and for visitors when the reservoir is completed and filled would remain about the same because the larger dam and greater area of inundation would not increase the visibility from surrounding areas.

Ralph Price Reservoir water elevations would fluctuate slightly more than existing conditions from the exchange of Windy Gap water to the reservoir. During the summer months, the reservoir would operate at about 72 to 80 percent of capacity; therefore, portions of the shoreline would be visible. Although the reservoir would be larger than existing conditions at capacity, the visual quality of the reservoir would be similar to existing condition.

Chimney Hollow Reservoir

> Construction of Chimney Hollow Reservoir would result in a permanent change to the landscape. The dam would be visible from vantage points to the north. Relocation of Western's transmission line to the west of the new reservoir would be more visible than the existing location.

Changes in the scenic quality of Chimney Hollow Reservoir would be similar for both the 90,000-AF reservoir in the Proposed Action and the 70,000-AF reservoir in Alternatives 3 and 4. The dam for the larger reservoir size would be about 30 feet higher and a larger reservoir pool would make the reservoir and dam more visible. Chimney Hollow Reservoir would be visible primarily from homes along the hogback to the east and from lands to the west where the reservoir is not screened by trees. There are no key observation points west of the reservoir, although trail development on Larimer County Open Space is likely to provide views of the reservoir as would recreation facilities at the reservoir. The Chimney Hollow dam face would be visible from observation points to the north up to about 2.5 miles away. The dam also would be visible from Reclamation offices, Flatiron Reservoir, scattered residences, and County Road 18E.

A portion of Western's existing transmission line within the footprint of the new reservoir would be relocated to the west. A visibility simulation was conducted with input from Larimer County Parks and Open Space, Western, Reclamation, and the NCWCD to determine the best location for the relocated line. A number of alternative routes on the west side of the reservoir were evaluated. Factors used in consideration of a location included: 1) visibility of the line from observation points to the east, 2) maintaining adequate distance between the line conductors and the maximum water level, where the line crosses open water, and 3) accessibility of the line for installation and maintenance. Results of the analysis identified a 750-foot-wide corridor for line placement (Figure 2-5) that would meet relocation objectives and minimize resource and visual impacts. The final transmission route within the identified corridor would be determined during final design. The transmission line would be visible from several locations including the reservoir surface and shoreline and possibly from new trails on Larimer County Open Space. The transmission line would be most prominent where linear forest clearings about 100 feet wide are required. Western would promote low growing native vegetation under the transmission line. To minimize the visibility of the line, nonspecular, nonreflective wire would be used and possibly nonreflective steel poles. Additional details on transmission line construction are included in Section 2.4.1.4.

A 90,000 AF Chimney Hollow Reservoir would be operated to remain at about 95 percent of capacity throughout the year. Because water levels would remain fairly stable, shoreline exposure would be limited, which would reduce the visual contrast between water and vegetated areas. Effects to visual quality, due to water level fluctuations would be unnoticeable to most viewers. A 70,000 AF Chimney Hollow Reservoir under Alternatives 3 and 4 would have a relatively stable water surface elevation on average, remaining at about 70 to 80 percent of capacity throughout the year. A portion of the reservoir shoreline would remain exposed throughout the year except during very wet years when storage is higher. As described in *Mitigation* (Section 3.21.4), modified prepositioning under the Proposed Action would maintain higher water levels in Granby Reservoir, but water levels would be lower in Chimney Hollow Reservoir.

Dry Creek Reservoir

Construction of Dry Creek Reservoir under Alternative 5 would change the visual character of the existing valley by introducing a large body of water and dam enclosing the southern portion of the valley. The new reservoir would be visible from scattered locations to the west and east of the reservoir and from higher elevations up to 2 miles south. There are few observation points for the reservoir because most of the area is undeveloped and has limited access. The dam face would be visible from portions of a gravel road along Little Thompson Creek. Scattered rural residences also may have views of the dam and reservoir.

Dry Creek Reservoir content would fluctuate seasonally but would operate between about 75 and 80 percent of capacity on average. Lower water levels would expose a contrasting shoreline that would remain visible much of the year.

Jasper East Reservoir

Construction of Jasper East Reservoir under Alternative 3 would introduce another water feature to the region between the Willow Creek Reservoir and Granby Reservoir. Jasper Reservoir would be visible from surrounding lands at higher elevations, although observation points are limited. Because the reservoir includes three dams, the dam faces would be visible from lands to the north, west, and south. The majority of the lands that would have a view of the dams are unoccupied, but residences to the west, and portions of the Arapaho National Recreation Area could have views of a dam. The Jasper East Reservoir would require relocation of County Road 40 to the south, which would have views of two of the dams.

Water storage in Jasper East Reservoir would vary seasonally from 20 to 80 percent of capacity. The fluctuations in water levels would expose large areas of unvegetated shoreline when the reservoir is low, which would reduce the scenic quality of the reservoir. However, the lowest water levels would occur during the winter and early spring when visitor use would be low and snow cover is possible. Higher water levels would be present during the summer months when more visitors could be present.

Rockwell Reservoir

The surface of Rockwell Reservoir would be visible primarily from higher topographic positions to the west and south. Because most of this area is forested, views of the reservoir would be limited. Rockwell Reservoir's north dam face would be visible over a large area including the Town of Granby. However, views of the dam would be over 1 mile away and would be screened by urban development and trees along Highway 40. The east-facing dam would be visible from portions of the Grand Elk development, Granby Ranch, and Highway 40. Homes closest to the dam site would have the greatest change in scenic quality.

Rockwell Reservoir would operate similar to Jasper East Reservoir with wide fluctuations in reservoir content and reduced scenic quality from exposure of the shoreline during winter and spring.

3.21.2.5 Visual Quality at Existing Reservoirs and Streams

Windy Gap Reservoir

Windy Gap Reservoir would continue to function as a regulating reservoir for pumping water into Granby Reservoir under all of the alternatives. Additional pumping would not necessarily cause lower reservoir levels. Water level in Windy Gap Reservoir would fluctuate by 1 to 2 feet during pumping, but typically would not cause noticeable changes in exposed lake shoreline. Algae are visible in the reservoir under existing conditions and this would continue in the future under all of the alternatives. Increased nutrient loadings from upstream sources could cause an increase in algal growth and therefore reduce the visual quality of the reservoir.

Grand Lake and Shadow Mountain Reservoir

None of the WGFP alternatives would result in changes in the water levels of Grand Lake or Shadow Mountain Reservoir; therefore there would be no change in the amount of exposed shoreline. Predicted small reductions in water clarity and increased algal growth in Grand Lake may contribute to diminished visual quality at times of the year under all of the alternatives. The decrease in water clarity of about 0.1 meters would be the same for Alternatives 1 through 4 and there would be no change for Alternative 5.

There would be no change in clarity in Shadow Mountain Reservoir for any of the alternatives. Predicted minor water quality changes in Shadow Mountain Reservoir are unlikely to noticeably affect the visual quality. Aquatic vegetation would continue to be visible, but none of the alternatives would substantially contribute to the growth of rooted plants. As described in *Mitigation* (Section 3.21.4), proposed nutrient mitigation measures would reduce the potential for increased algae and diminished water clarity in the Three Lakes.

Granby Reservoir

A change in water storage at Granby Reservoir under all alternatives would affect visual quality by reducing water levels, thereby increasing the amount of visible shoreline, and diminishing the amount of visible surface water. Under existing summer conditions (May to August) in average years, about 290 acres of exposed shoreline are visible. Under the No Action Alternative, lower summer water levels in Granby Reservoir would increase the amount of visible shoreline about 108 acres. The Proposed Action would increase the amount of exposed shoreline by about 270 acres more than existing conditions during the summer. Alternatives 3, 4, and 5 would increase visible shoreline by about 155 acres. As described in *Mitigation* (Section 3.21.4), modified prepositioning under the Proposed Action would maintain higher water levels in Granby Reservoir.

> Modified prepositioning would maintain higher water levels in Granby Reservoir, Carter Lake, and Horsetooth Reservoir with less exposed shoreline than under original prepositioning. Water quality mitigation measures would help maintain water clarity in the Three Lakes by reducing nutrient loading.

During successive drought years, Granby Reservoir water levels would drop up to 23 feet under the Proposed Action and up to 15 feet under Alternatives 3, 4, and 5, which would increase the amount of shoreline visible. Granby Reservoir water levels currently fluctuate as much as 90 feet, but the lower water levels in average and drought years would reduce the visual quality of the reservoir for some viewers compared to existing conditions. As described in *Mitigation* (Section 3.21.4), modified prepositioning under the Proposed Action would maintain higher water levels in Granby Reservoir.

Carter Lake

A decrease in water levels of about 1 foot on average in Carter Lake would result in a negligible change to shoreline visibility that is unlikely to be noticeable under any of the alternatives. Dry year changes in Carter Lake water levels would also be less than 1 foot under all of the alternatives with a negligible effect on the visual quality of the reservoir. During wet years, water levels would be as much as 2 feet lower than existing conditions in the summer months, but water levels would remain above average and would have little, or no noticeable affect on visual quality.

For all alternatives, the decrease in reservoir surface area would be less than 6 percent during the summer in average, wet, and dry years. This relatively small change in a 6,500 acre reservoir would have a minor effect on visual quality from the increased exposure of shoreline.

Horsetooth Reservoir

At Horsetooth Reservoir, under existing conditions in the summer (May to August) of average years, about 82 acres of exposed shoreline are visible. Under the No Action Alternative exposed shoreline would increase less than 6 acres in the summer, which would not noticeably increase shoreline visibility. Under the Proposed Action, the exposed shoreline would increase about 73 acres on average in the summer. For Alternatives 3, 4, and 5 the additional shoreline exposure would average less than 24 acres. In dry years, the additional visible shoreline under the No Action Alternative in the summer would be less than 6 acres compared to a maximum of 109 acres for the Proposed Action. Alternatives 3, 4, and 5 would increase the visible shoreline from 6 to 66 acres during the summer months of dry years. The effect to visual quality, due to water level fluctuations would be unnoticeable to most viewers because of current water level fluctuations and relatively small changes in surface area in a reservoir that is typically about 1,800 acres in size during the summer.

West Slope Streams

All of the alternatives would result in a change in streamflow on the West Slope from increased diversions on the Colorado River and operational changes that reduce flows on Willow Creek. The majority of these streamflow reductions occur in May and June, but they could occur from April to October. Average monthly stream stage below Windy Gap Reservoir would decrease up to 0.1 feet under the No Action Alternative, 0.22 foot under the Proposed Action, and about 0.19 foot for other alternatives compared to existing conditions. There would be no change in Colorado River flows from existing conditions in dry years and the change in wet years would be greater, but streamflows would be substantially higher than average years. Reductions in Colorado River average monthly stream stage downstream of Kremmling compared to existing conditions would range from about 0.12 foot for the No Action Alternative to 0.28 foot under the Proposed Action, and about 0.24 foot for other alternatives. Lower streamflows could potentially reduce the visual quality of the Colorado River, but for most viewers these changes would not be discernible because the majority of diversions would occur at higher flows. Diversions in the summer months when flows are lower would be more noticeable. Overall, the scenic character of these streams would remain similar to existing conditions.

Streamflow in Willow Creek below Willow Creek Reservoir would decrease mostly in wet years and primarily from June to August. Under the No Action Alternative, average monthly streamflow would decrease about 11 to 29 percent compared to about 16 to 36 percent for the action alternatives, compared to existing conditions. There would be no change in Willow Creek streamflow in dry years. The projected lower flows would reduce the visual quality of the stream, although public access to this section of the stream is limited.

East Slope Streams

The additional import of water to the East Slope through the Adams Tunnel would result in slightly increased flows to several streams. The Big Thompson River below Estes Park to the canyon mouth would experience an increase in average monthly flow of up to 1 percent under No Action, 9 percent under the Proposed Action, and less than 5 percent for other alternatives compared to existing conditions. Streams below Participant WWTPs also would have an increase in flow following use of Windy Gap water. Streams that would experience an increased inflow below WWTPs include St. Vrain Creek, Big Thompson Creek, Big Dry Creek, and Coal Creek. The relatively small increases in flow would most likely be unnoticeable to most viewers. Under the No Action Alternative, there would be both increases and decreases in streamflow below Ralph Price Reservoir in the North Fork of the St. Vrain and the St. Vrain River above Lyons from exchanges and releases to storage. Visual quality would potentially decrease in May and July, and increase in other months.

3.21.3 Cumulative Effects

Cumulative effects to visual quality were assessed by looking at reasonably foreseeable land developments likely to occur in the future near the alternative reservoir sites. The study area for cumulative visual effects includes the

2.5-mile buffer surrounding the reservoir sites used in the visibility analysis. Identified reasonably foreseeable changes to visual quality in the study area were primarily planned future residential and commercial land developments. Thus, the cumulative effect to local visual quality would include the changes to the landscape from alternative reservoirs and facilities plus other new land developments. These cumulative effects are discussed for each of the reservoir sites in the alternatives. Reasonably foreseeable water-based actions on the West Slope would affect streamflows in the Colorado River, but would not result in any new direct disturbance that would affect visual quality. The hydrologic changes to streams and reservoirs associated with implementation of future water-based actions and the WGFP were evaluated for potential affects to visual quality.

3.21.3.1 Water-Based Reasonably Foreseeable Actions

New or Enlarged Reservoirs

Construction of Chimney Hollow Reservoir, Dry Creek Reservoir, Jasper East Reservoir, Rockwell/Mueller Creek Reservoir, or the enlargement of Ralph Price Reservoir would all operate in a manner similar to that without reasonably foreseeable actions in place, thus the visual quality of these reservoirs would be similar to that described previously for direct effects. However, reasonably foreseeable future actions would reduce the amount of water available for diversion by the WGFP, thus Colorado River streamflows would be slightly higher under cumulative effects hydrology and less water would be delivered through the Three Lakes to the East Slope.

Grand Lake and Shadow Mountain Reservoir

Water levels in these reservoirs would not change from existing conditions; therefore, there would be no change in visible shoreline. Predicted water quality changes potentially affecting the visual quality of Grand Lake include a decrease in clarity of about 0.1 meters for the Proposed Action, no change for the No Action Alternative, and an improvement in clarity of about 0.1 meters for the other alternatives. The predicted small reductions in water clarity and increased algal growth in Grand Lake may contribute to diminished visual quality at times of the year.

Water clarity in Shadow Mountain Reservoir would not change under No Action or the Proposed Action. Under Alternatives 3, 4, and 5, clarity would improve about 0.1 meters. Thus, there would be no change in the visual quality of Shadow Mountain Reservoir under the No Action and Proposed Action alternatives and a slight improvement under other alternatives.

Granby Reservoir

Under existing conditions in average years during the summer (May to August), about 290 acres of exposed shoreline are visible. Under the No Action Alternative, exposed shoreline would increase about 160 acres during the summer and the Proposed Action would increase the average summer shoreline exposure about 348 acres. Alternatives 3 to 5 would increase the amount of exposed shoreline about 166 acres. Changes in shoreline exposure would decrease the visual quality of the reservoir under all alternatives for some viewers.

> Lower water levels in Granby Reservoir under the Proposed Action would expose more shoreline than existing conditions.

In wet years, under the No Action Alternative, exposed shoreline would increase about 171 acres in the summer and under the Proposed Action, the exposed shoreline would increase about 288 acres. Under Alternatives 3 to 5, the exposed shoreline would increase about 232 acres. In the summer of dry years under existing conditions, the reservoir water surface area is about 6,020 acres with an exposed shoreline of about 735 acres. Under the No Action Alternative, exposed shoreline would increase about 172 acres and under the Proposed Action, the exposed shoreline would increase about 288 acres. Under Alternatives 3, 4, and 5, the exposed shoreline would increase about 152 acres. The increases in exposed shoreline would diminish visual quality for some viewers, during dry year conditions.

Windy Gap Reservoir

Effects to visual quality in Windy Gap Reservoir would be similar to those described for direct effects.

Carter Lake

Water level changes at Carter Lake would not be noticeably affected under any of the alternatives. During average or dry years, average monthly surface area would decrease less than 5 acres and lake levels would not decrease more than 1 foot under any of the alternatives. In wet years, under all alternatives, the average monthly lake surface area would decrease less than 11 acres and lake levels would decrease less than 2 feet for all alternatives. In dry years, fluctuations would be within 1 foot of existing conditions for all alternatives. Therefore changes to exposed shoreline areas and the visual quality of the reservoir would be negligible or unnoticeable.

Horsetooth Reservoir

At Horsetooth Reservoir, under existing conditions in the summer (May to August) of average years, about 82 acres of exposed shoreline are visible. The No Action Alternative would not affect water levels in Horsetooth Reservoir during summer, the peak recreation season, under average conditions, wet years, or dry years. The Proposed Action would increase exposed shoreline area less than 72 acres during the same period under average conditions. Alternative 5 would increase exposed shoreline area less than 25 acres during summer average conditions. There would be less than a 2 acre change in exposed shoreline in wet years under the No Action Alternative. During wet years, the Proposed Action would increase exposed shoreline area less than 70 acres and Alternatives 3, 4, and 5 would increase exposed shoreline area less than 15 acres. The Proposed Action would increase exposed shoreline area up to 89 acres during dry years, compared to 53 acres for Alternatives 3, 4, and 5 and less than 3 acres for the No Action Alternative. Therefore changes to exposed shoreline areas and the visual quality of the reservoir would be negligible or unnoticeable.

West Slope Streams

Cumulative effects to Colorado River streamflow would occur with reasonably foreseeable future water-based actions implemented along with one of the WGFP alternatives. The average monthly change in stream stage below Windy Gap Reservoir would decrease up to 0.19 feet under the No Action Alternative, 0.33 feet under the Proposed Action, and about 0.29 feet for other alternatives, compared to existing conditions. Dry year changes in river stage of less than 0.3 feet would occur as the result of reasonably foreseeable actions. The change in river stage in wet years would be greater, but streamflows would be substantially higher than average years. Reductions in Colorado River average monthly stream stage downstream of Kremmling would range from about 0.85 feet for the No Action Alternative to 1.04 feet under the Proposed Action, and about 1.00 foot for other alternatives, compared to existing conditions. The stream channel at this gage near the mouth of Gore Canyon is much narrower and deeper than upstream portions of the Colorado River. Lower streamflows could potentially reduce the scenic quality of the Colorado River, but for many viewers these changes may not be discernible.

Average annual streamflow in Willow Creek below Willow Creek Reservoir would decrease about 9 percent under No Action compared to about 15 percent for the Proposed Action and 13 percent for other alternatives, compared to existing conditions. The projected lower flows would occur from May to November and may reduce the visual quality of the stream.

East Slope Streams

Less water would be available for import the East Slope through the Adams Tunnel under cumulative effects, but imports would still result in a slight increase flows to several streams similar to described that described for direct effects. The relatively small increases in flow are unlikely to be discernable, and therefore no change to the visual quality of these streams from the existing condition is expected.

3.21.3.2 Land-Based Reasonably Foreseeable Actions

Ralph Price Reservoir

No reasonably foreseeable actions were identified near Ralph Price Reservoir that would add to the cumulative visual effects for the area.

Chimney Hollow Reservoir

The only reasonably foreseeable land developments within 2.5 miles of Chimney Hollow Reservoir are residential developments northeast and east of Carter Lake and planned future trail development on Larimer County Open Space on the west side of Chimney Hollow. The planned residential development near Carter Lake would add an artificial form to the landscape. Trails on Larimer County Open Space would add linear features to the landscape, but many of the trails would be screened by forest vegetation.

Dry Creek Reservoir

No reasonably foreseeable developments would occur within 2.5 miles of the Dry Creek Reservoir site that would add to cumulative visual impacts.

Jasper East Reservoir

The planned C-Lazy-U Preserve is about 1 mile northwest of the reservoir site. The low-density housing planned for C-Lazy-U Preserve and residential development on other properties in the study area would contribute to a cumulative change in the visual quality of the area.

Western is planning on rebuilding the transmission line between the Granby Pumping Plant on the north side of Granby Reservoir and the Windy Gap Substation near Windy Gap Reservoir. The use of new poles in the existing alignment or a possible new alignment would result in an additional change to the landscape east of the Jasper Reservoir site.

Rockwell Reservoir

Planned future residential and commercial developments within 2.5 miles of the Rockwell Reservoir site in addition to the reservoir would result in a cumulative change to the visual quality of the landscape.

3.21.4 Visual Quality Mitigation

Mitigation measures for all alternatives include measures to minimize the amount of ground clearing, reclamation, and restoration of areas disturbed during construction. As described in *Vegetation* (Section 3.10.4), all temporarily disturbed lands, such as staging areas, pipelines, and other surfaces disturbances, would be revegetated with species similar to existing conditions. Aboveground structures would be constructed with materials that complement the adjacent existing landscape. As discussed in *Air Quality* (Section 3.16.4), dust-control measures would be used during construction to reduce visual emissions.

The proposed relocation of the transmission line at Chimney Hollow Reservoir for the Proposed Action and Alternatives 3 and 4 included a visual simulation to minimize the visual effect. Western, which is responsible for relocating the transmission line, would work with Larimer County Open Space and the Subdistrict on the final alignment within the proposed corridor to further reduce visual impacts. The relocated transmission line would be constructed using nonspecular wire, nonreflective insulators, and monopoles finished to complement the sky background or forest background. The finish and color of the monopoles is yet to be determined. Maintenance roads would be located and aligned to minimize earthwork for the road construction, and avoid or minimize the removal of trees.

Modified prepositioning for the Proposed Action, as described in *Surface Water Hydrology* (Section 3.5.4), would maintain higher water levels in Granby Reservoir and lower water levels in Chimney Hollow Reservoir. Prepositioning would be curtailed when Granby Reservoir storage reaches about 340,000 AF (8,250 feet in elevation). Average summer monthly water levels in Granby Reservoir would decrease less than 5 feet from existing conditions under the Proposed Action (Table 3-30). The surface area of the reservoir would decrease up to about 245 acres under the Proposed Action with modified prepositioning compared to a decrease of up to 351 acres under original prepositioning. Thus, less exposed shoreline would be visible and impacts to the visual quality of the reservoir would be less noticeable. In addition, the maximum decreases in reservoir water levels would decrease under modified prepositioning. Without modified prepositioning, decreases in water surface elevation during the summer recreation season would be up to 23 feet (1,142-acre decrease in reservoir surface area) under the Proposed Action, with smaller changes for other action alternatives. With modified prepositioning, water levels in Granby Reservoir would decrease no more than 15 feet (777-acre decrease in reservoir surface area) under the Proposed Action compared to existing conditions (May-September recreation season).

Modified prepositioning also would reduce drawdowns in Carter Lake and Horsetooth Reservoir. Average monthly water levels in Carter Lake would decrease less than 1 foot under the Proposed Action. Average monthly water at Horsetooth Reservoir would decrease about 2 feet under modified prepositioning (83 acre decrease in reservoir surface area) compared to a 6-foot decline under the originally proposed prepositioning. With less drawdown, exposure of the shoreline around these reservoirs would be less and visual quality impacts reduced.

Modified prepositioning would result in lower water levels on average in Chimney Hollow Reservoir, thus, this reservoir would experience greater exposure of the shoreline.

3.21.5 Unavoidable Adverse Effects

All of the action alternatives would result in an unavoidable change in the character of the visual landscape from the introduction of a new large water body and dam structure. The visual quality of the landscape would change less under the No Action Alternative because only the existing Ralph Price Reservoir would be enlarged. The visual quality of affected streams and reservoirs would also change with increased water diversions on the West Slope, increased deliveries and return flows on the East Slope, and a change in water levels for several reservoirs.

3.22 Socioeconomics

3.22.1 Affected Environment

3.22.1.1 Area of Potential Effect

The study area includes areas that could experience socioeconomic effects from implementation of the alternatives. The primary study area includes the counties and nearby communities where potential reservoirs and associated facilities would be located (Grand, Larimer, and Boulder counties). Also discussed are the service areas of the WGFP Participants, which encompass portions of Boulder, Larimer, Weld, and Broomfield counties on the East Slope and the MPWCD, which serves Grand and Summit counties on the West Slope.

3.22.1.2 Data Sources

Information from federal, state, and local sources was used to characterize the overall baseline and future economic and demographic conditions in the study area. Data was collected for population, employment, earnings by sector, labor force, unemployment rate, household income, wage rates, and other economic and demographic variables. Socioeconomic information was obtained through personal interviews with key individuals in the study area, such as city and county planners, local business leaders, recreation specialists, and utility planners. Data for specific economic sectors and activities that might be particularly affected, such as recreation, was taken from the Recreation Resources Technical Report (ERO 2008b). Information on Participant population growth, water supply and projected demands, water rates, and rate structures are taken from the WGFP Purpose and Need Report (ERO and Harvey Economics 2005). Additional information is included in the Socioeconomic Resources Technical Report (ERO 2008c).

The following sections provide an overview of the population, employment, income, community services, and land use values for the study area.

3.22.1.3 Population

The populations of Grand, Larimer, and Boulder counties have all grown sharply over the last decade and are expected to continue to increase in the future (Table 3-157). The population in the service areas for WGFP Participants is also expected to continue to grow.

Table 3-157. Population trends by county.

	Grand County				Larimer County				Boulder County			
	1990	2000	2003	2030	1990	2000	2003	2030	1990	2000	2003[1]	2030
Total Population	7,966	12,442	13,732	28,800	186,136	251,494	266,610	440,675	225,339	291,288	277,467	383,634
Change	-	4,476	1,290	15,068	-	65,358	15,116	174,065	-	65,949	-13,821	106,167
Percent Change	-	56.2%	10.4%	109%	-	35.1%	6.0%	65%	-	29.3%	-4.7%	38%

[1] Boulder County population decrease between 2000 and 2003 is attributed to the City and County of Broomfield seceding from Boulder County.

Source: DOLA 2004a.

Grand County's 2003 permanent population of 13,732 is expected to reach almost 29,000 by 2030 (DOLA 2004d). During the winter, seasonal residents increase the population up to 18,000 and summer residents increase the population about 5,000 (Grand County 1998). In addition, Grand County receives more than 1 million ski visitors per year and many of the almost 3 million tourists that visit Rocky Mountain National Park each year. Key trends influencing the seasonal population are tourists and second home residents that visit during the off-season. About 55 percent of the population in Grand County resides in unincorporated areas. Granby and Kremmling are the most populated towns in the county along the Colorado River corridor with populations of about 1,700 each in 2003. Hot Sulphur Springs had a population of about 570, and the town of Grand Lake had about 480 in 2003 (DOLA 2004b). According to census data, the population of Grand County is about 95.2 percent white, and Hispanics account for about 4.4 percent of the population (Census 2000a).

The Larimer County population has increased over 40 percent between 1990 and 2003 to 266,610 residents and is expected to reach over 440,000 by 2030 (DOLA 2004b). Much of this growth is expected to occur within existing urban growth areas near the cities of Fort Collins, Loveland, and Berthoud. Fort Collins is the largest community in Larimer County with a 2003 population of about 125,500 (DOLA 2004b). Loveland is the next largest municipality with a population of about 56,000 in 2003 (DOLA 2004b). Race statistics (Census 2000a) indicate about 91.4 percent of Larimer County is white, and Hispanics are the largest minority group at 8.3 percent.

Boulder County's population increased about 29 percent between 1990 and 2000 and was about 277,467 residents by 2003 (DOLA 2004d). The Boulder County population is projected to reach almost 384,000 by 2030 (DOLA 2004d). Most residents in the county reside in the town of Boulder with a 2003 population of about 98,000. Hispanics are the largest minority group in the county at 10.5 percent and the white population is about 89.5 percent (Census 2000a).

Much like county trends, the population of each WGFP Participant's jurisdiction or service area has increased substantially in recent years (ERO and Harvey Economics 2005). Participants are planning for and expecting future population growth from 25 to 334 percent in the next 20 to 25 years. While many of these Participants are expected to reach build-out by 2020 to 2030, several (such as Evans, Fort Lupton, and Greeley) would continue to experience population increases beyond these dates. Chapter 2 provides additional detail on population growth for each of the Participants.

3.22.1.4 Employment

Total employment in Grand County was about 6,462 in 2002 with an unemployment rate of about 4 percent (DOLA 2004c). Almost half of Grand County's labor force resides in Granby, Kremmling, Grand Lake, or Hot Sulphur Springs. Wage and salary employment accounted for 69 percent of the jobs and the remainder was from self employment. Top industries that provide about 42 percent of the employment in Grand County include the categories of arts, entertainment, recreation, accommodation, food services, construction, and retail trade (BEA 2002a). Many of these jobs support skiing, rafting, outfitters, and other outdoor recreation activities. Jobs directly related to visitors accounted for about 39 percent of Grand County jobs in 2003 (Coley Forrest 2007). State and local government is also a large employer in Grand County and provides about 10 percent of the employment.

Larimer County employment in 2002 was about 148,500 with an unemployment rate of about 5 percent (DOLA 2004c). The City of Loveland accounted for about 19 percent of the county employment. Wage and salary employment accounted for 77 percent of the jobs and the remainder was from self employment. Top employers in Larimer County include the categories of state and local government, retail trade, and manufacturing, which provide about 35 percent of the jobs (BEA 2002a).

Boulder County employment was about 156,000 in 2002 with an unemployment rate of 5 percent (DOLA 2004c). Wage and salary employment accounted for 78 percent of the jobs and the remainder was from self employment. A wide variety of employers are present in Boulder County, but retail trade, manufacturing, and educational services provide about 23 percent of the employment (BEA 2002a).

3.22.1.5 Income

Per capita income in Grand, Larimer, and Boulder counties ranged from 88 to 119 percent of the state average in 2002 (BEA 2002b). Grand County per capita income of $29,560 ranked 19th in the state. In Larimer County, per capita income was $31,400 in 2002 and ranked 14th in the state. Boulder County's per capita personal income of $34,228 ranked 5th in the state in 2002. Individual poverty levels in 2000 were 5.4 percent in Grand County, 9.2 percent in Larimer County, and 9.5 percent in Boulder County. The statewide individual poverty level was 9.3 percent (Census 2000a).

3.22.1.6 Community Services

Each of the counties where reservoir storage sites would be located and construction activities would occur have developed school, medical, fire, and police services supporting local communities. Schools and community services in the portion of the counties near project facilities are briefly outlined below.

Grand County has three elementary schools, one middle school, one high school, and one private school with a combined enrollment of about 1,370 students. Emergency services nearest the potential West Slope reservoir sites include the St. Anthony Granby Medical Center and the Kremmling Memorial Hospital. Fire services near these sites base out of Granby, Hot Sulphur Springs, and Grand Lake. The Colorado State Patrol has a base office in Granby.

Larimer County's Thompson School District encompasses schools in Berthoud and Loveland. The District includes 18 elementary schools, five middle schools, and five high schools. District-wide enrollment in 2003-2004 was over 14,600 students. Emergency medical services are available at Poudre Valley Hospital, Longmont United Hospital, and Boulder Community Hospital. Fire and police services nearest the potential reservoir sites are located in Loveland and Berthoud.

Boulder County's St. Vrain School District encompasses schools in Lyons, Longmont, and Erie. District-wide enrollment in 2003-2004 was 22,180 students. Emergency medical services are available at Longmont United Hospital and Boulder Community Hospital. Fire and police services are located in Lyons, Longmont, and Erie.

3.22.1.7 Land Use Values

Land uses at potential reservoir sites with socioeconomic values primarily include agriculture, recreation, and residences. Existing reservoirs and streams with projected hydrologic effects primarily have land use values associated with recreation. The following section discusses land use values in the study area. More information on land use is included in Section 3.18.

Ralph Price Reservoir

Ralph Price Reservoir is located in unincorporated Boulder County on land owned and managed by the City of Longmont for water supply storage and recreation. Recreation access for hiking and sightseeing is free to the public, but a permit is required for fishing. Two private residences are located on the northern side of the reservoir. The City of Longmont's caretaker for the site has a home near the reservoir. There is no agricultural use of the land.

Chimney Hollow Reservoir Site

The land on which the Chimney Hollow Reservoir would be located is primarily owned by the Subdistrict and currently does not support agricultural or recreational activities or private residences.

Dry Creek Reservoir Site

The Dry Creek Reservoir site supports a small llama breeding operation in addition to three private residences. The state owns a portion of the site that currently has a mining lease for selling moss rock (Routen, pers. comm. 2006b) and that in the past has included livestock grazing. No public recreation activities occur at the site.

Jasper East Reservoir Site

Livestock production is the primary land use at the Jasper East Reservoir site. Approximately 313 acres are flood irrigated for cultivation of hay and cattle grazing. Income generated from agricultural production is primarily associated with an annual sale of calves. Cattle grazed on the Jasper East Reservoir site produce about 45 calves annually, contributing to about $27,000 in annual income (Alexander, pers. comm. 2005).

The Willow Creek Pump Station, forebay, and portions of the Willow Creek pump canal, which is used to carry water from Willow Creek Reservoir to Granby Reservoir, are located at the site. No homes are present and the only recreation is a model airplane facility.

Rockwell/Mueller Creek Reservoir Site

The Rockwell Reservoir site includes meadows used as pastureland for horses and four private residences. No public recreation is available.

Three Lakes and Colorado River

Tourism is an important component of the Grand County economy. In 2003, about 12.5 percent of Grand County's jobs were attributed to recreation, arts, and entertainment, which include recreation activities such as rafting, skiing, and other activities related to tourism (BEA 2002a). Winter visitation associated with downhill skiing is the largest contributor to the Grand County recreation and tourism industry, contributing about 27 percent ($162.3 million) of countywide sales in 2002 (Lloyd Levy Consulting 2004). The direct impact of spending by visitors in Grand County in 2003 was estimated at about $170 million (Coley/Forrest 2007). Expenditures included travel, lodging, food and beverages, recreation, and other visitor-related commodities, but did not include the secondary economic benefits. Boating and fishing are popular summer attractions at Shadow Mountain Reservoir, Grand Lake, Granby Reservoir, and along the Colorado River. The CDPW has rated the Colorado River between Windy Gap Reservoir and Troublesome Creek as a Gold Medal fishery because of the outstanding fishing opportunities. No complete statistics are available on the amount of angling use on the Colorado River; however, BLM records permits for commercial fishing use in the Pumphouse reach of the Colorado River. These records indicate an average of 2,040 user days per year between 1999 and 2004 (BLM 2007b). The average annual economic value of this angling activity is estimated to be about $108,000 based on outdoor recreation use values for fishing in the Intermountain region of $53.04 per user day (indexed to 2007 dollars) (Loomis 2005). Using 2008 estimates prepared for CDPW, the average annual economic value of 2,040 angler visitor days would range from $136,680 in direct expenditures to $424,320 of total value including secondary impacts, depending on the mix of Colorado and non-Colorado residents (BBC 2008). These estimates of angling economic value reflect total statewide expenditures, which are greater than the amount spent solely in Grand County. Additional angling activity occurs on publicly accessible lands at State Wildlife Areas, BLM land, as well as fishing from privately held property and resorts along the Colorado River.

Boating is most popular on the Colorado River below Kremmling. In 2007, commercial boating on the Upper Colorado River generated the sixth highest level of direct economic impact (about $3.4 million) and total economic impact (about $8.7 million) when compared to all other Colorado rivers (CROA 2008). There were about 32,000 commercial user boating days in 2007 (CROA 2008).

Carter Lake and Horsetooth Reservoir

Carter Lake and Horsetooth Reservoir in Larimer County provide year-round water- and land-based recreation opportunities including boating, angling, camping, and other land-based recreation. Recreation, arts, and entertainment accounted for about 2.4 percent of Larimer County's employment in 2003 (BEA 2003).

3.22.2 Environmental Effects

3.22.2.1 Issues

Identified socioeconomic issues of concern were the loss of private property or homes and the potential for vandalism or trespass if recreation activities are allowed at reservoir sites. Potential impacts to tourism and recreation, particularly related to effects on Colorado River boating, was a concern on the West Slope. The economic impact to West Slope communities and real estate values were also mentioned as a concern during scoping.

3.22.2.2 Method for Effects Analysis

Regional Input-output Modeling System (RIMS II) multipliers were used to estimate secondary effects to regional earnings and employment as a result of construction, operation, and maintenance of the alternatives. RIMS II multipliers are commonly used to estimate the total regional effects on industrial output, earnings, and employment for any county or group of contiguous counties resulting from any industry activity.[4] Expected employment needs and direct employment costs were based on preliminary project design and cost estimates (Boyle 2005b).

Calculations of regional economic effects including output, earnings, and employment assume that certain percentages of construction, operation, and maintenance spending would occur within the region where each reservoir site is located. The three RIMS II data regions relevant to the study area include the "Scenic and Resort Region" (Jasper East Reservoir and Rockwell Reservoir sites in Grand County), "Larimer and Weld Region" (Chimney Hollow and Dry Creek reservoir sites), and the "Denver Metro Region" (Ralph Price Reservoir). For Jasper East Reservoir and Rockwell Reservoir, it is assumed that 25 percent of the total project cost would be spent locally in the Scenic and Resort Region. This is consistent with the anticipated percentage of the workforce that is expected to be hired locally (Bandy pers. comm. 2005) and the fact that the regional economy is not highly diversified and is unlikely to include all of the necessary construction inputs necessary to construct a reservoir. For Chimney Hollow Reservoir and Dry Creek Reservoir, it is assumed that 50 percent of the total project cost would be spent in the local region. It is expected that a substantial portion of the construction inputs would need

[4] Industrial output is a measure of the economic activity created by spending associated with a project. Earnings (sometimes referred to as wages and salaries) are a subset of total economic output. More specifically, earnings refer to a measure, expressed in millions of dollars, of the change in the value of earnings that are received by households from the production of regional goods and services. Employment is expressed as full-time person years of employment.

to be brought in from the Denver Metro Region or other surrounding regions. For expansion of Ralph Price Reservoir, it was assumed that 100 percent of the project spending would occur within the Denver Metro Region. Economic output from construction-related spending outside of the local study areas also would generate economic benefits to those locations. Construction costs are in 2003 dollars.

Potential economic effects to recreation associated with changes in rafting and kayaking opportunities as a result of different hydrologic conditions on the Colorado River were based on the estimated changes in the number of days preferred flows would occur, as described in *Recreation* (Section 3.19). Available data on commercial boating use and user permits from the BLM provided estimates of annual boating and recreation use in the Big Gore Canyon and Pumphouse reaches of the Colorado River downstream from Kremmling. No detailed records on visitor use are available, but the BLM provided estimates on the location and season of use.

The analysis of effects to boating was based on changes in the number of days that streamflow fell within preferred flow ranges for rafting and kayaking in the Colorado River. The following flow ranges for the three river segments evaluated were:

- Byers Canyon: >400 cfs
- Big Gore Canyon: 850 to 1,250 cfs for kayaking and rafting
- Pumphouse: 1,100 to 2,200 cfs for kayaking and rafting

These flow ranges represent preferred flows; however, boaters currently use the river at flows as low as 400 cfs, with the exception of commercial rafting in Big Gore Canyon, which only occurs at flows between 850 and 1,250 cfs. The economic analysis provides a worst-case scenario because all changes in the number of days outside of the preferred range were considered a loss in visitor days and the associated recreation value. Boating would likely continue, as it currently does, outside of the preferred flow ranges as long as minimum boating flows are available, but there could be a decrease in the quality of the experience for some boaters. Boating use could also occur above the preferred flow range, but only more experienced boaters use the river at higher flows.

Daily hydrology data for the 47-year hydrologic period of record (1950 to 1996) were used for the evaluation of changes in the number of days with preferred boating and kayaking flows during the summer boating season from June to August. Daily data indicated the number of days when flows fell within a preferred boating range, the frequency of changes in preferred boating flows, and the maximum range of change in the number of days in a year that preferred flows for boating would occur compared to existing conditions.

Recreation economic impacts were based on the unit-day approximation of willingness to pay. This valuation is common for this type of analysis and can be applied to the limited existing data. Under this approach, the value of the recreation impact is the unit-day value, expressed in terms of dollars per visitor day, multiplied by the estimated gain or loss in visitors. Baseline unit-day values used in the analysis were derived from Loomis (2005). The Loomis unit-day value for nonmotorized boating was escalated to 2007 dollars using the Consumer Price Index and rounded up to $73. The dollars per visitor day are assumed to apply equally to all boating locations and for both private and commercial boating. The unit-day value of $37 for camping from the Loomis study was escalated to 2007 dollars and used to estimate impacts from potential changes in camping. All of the direct recreational value would not accrue to Grand County because not all of the expenditures would occur there.

There may be other indirect costs or benefits associated with recreation that accrue to Grand County or other locations. Indirect economic impacts associated with commercial rafting have been estimated by the Colorado River Outfitters Association to be about 1.56 times direct expenditures for all commercial boating in the state (CROA 2008). The secondary impacts associated with changes in recreation expenditures were not explicitly quantified for this analysis because accurate estimates of the percentage of those expenditures in the study area were not available. For simplicity, this analysis assumes that using the full direct economic impact as accruing to the study area encompasses both the direct and indirect impacts that might occur within the study area. Also, because the analysis conservatively assumes a total loss of boating user days when preferred flows are not met, no additional estimates of indirect economic impacts were made.

Because most economic data are available on a countywide or regional basis, economic impacts are reported for the affected county or region. However, those impacts may be concentrated in particular portions of communities within the county or region. Environmental justice was based on the potential for disproportionate impacts to minority or low-income populations from implementation of any alternative.

The water delivered from Grand Lake through Reclamation hydropower facilities from increased Windy Gap diversions would generate additional power under all of the alternatives. Estimates of the net change in power generation were based on hydrologic data and estimates of what similar amounts of energy would cost.

3.22.2.3 Socioeconomic Effects Common to All Alternatives

Community Services

Construction of reservoirs and associated facilities for any alternative would result in a slight increase in the demand for community services during the construction period. Communities near the reservoir sites are unlikely to experience a substantial increase in the need for police, fire, medical, education, or other community services. Existing community services in Loveland, Berthoud, and Larimer County should be sufficient to serve the temporary increase in workforce associated with construction of Chimney Hollow Reservoir or Dry Creek Reservoir. Granby and other surrounding Grand County communities should also have the capacity to meet community service needs during construction of Jasper East or Rockwell reservoirs.

Property Values

Property values around Granby Reservoir are not likely to be substantially affected by the change in water levels, clarity, or water quality under any of the alternatives because the incremental change in these parameters is small relative to the current wide fluctuations.

Construction of new reservoirs is unlikely to adversely affect adjacent property values over the long term and may increase values if recreation is developed. A temporary reduction in property values is possible where residents near the reservoir sites are affected by noise, traffic, and disturbances during construction.

Colorado River Water Use and Quality

The WGFP would be subject to downstream senior water rights that have the ability to place a call on the river if flows are not sufficient; therefore, there would be no economic effect to senior water right holders. The WGFP would not reduce Colorado River streamflow downstream of Windy Gap Reservoir below the 90 cfs minimum instream flow and would have no effect on flows when natural conditions or actions by others reduce flows below 90 cfs. Streamflows below Windy Gap Reservoir, at or below the minimum flow, have occurred historically without Windy Gap diversions; however, the WGFP would slightly increase the frequency of flows at 90 cfs. The Municipal Subdistrict paid $500,000 to upgrade diversion structures for ranches on the Colorado River below Windy Gap Reservoir as part of the original construction of Windy Gap Reservoir. Municipal and agricultural diversions downstream from Windy Gap Reservoir, per Colorado water law (CRS § 37-92-102(2)(b)), would remain responsible for developing a reasonable means of diversion for their water.

None of the WGFP alternatives are projected to result in the exceedance of water quality standards that would affect municipal water diversions or discharges. The Municipal Subdistrict paid the Town of Hot Sulphur Springs $150,000 for assistance in improving its water treatment facility and $270,000 for improving its WWTP as mitigation for the original Windy Gap Project, which was intended to divert more water than the proposed WGFP. As described in Section 3.8.4.1, water quality mitigation would provide a year-round improvement in water quality for portions of the Fraser and Colorado rivers.

Environmental Justice

EO 12898 established a goal of environmental justice to ensure that minority and low-income populations are not disproportionately affected by adverse human health or environmental impacts of a federal action. Environmental justice embraces two principles: (1) fair treatment of all people regardless of race, color, nation of origin, or income and (2) meaningful involvement of people in communities potentially affected by program actions.

None of the alternatives would disproportionately affect minority or low-income populations. Reservoir sites are located primarily in rural areas with low population density and although small numbers of minority or low-income populations are present within broader Census Tract and Block Groups in the respective counties (Census 2000b), reservoir construction would not disproportionately affect local minority or low-income residents. Temporary construction jobs may provide employment opportunities for minority and low-income populations within the local regions. These employment opportunities would provide wages that are higher than many local service jobs.

Hydropower Energy Production

The additional water delivered from Grand Lake through Reclamation C-BT hydropower facilities would generate additional power under all alternatives as discussed in Section 3.5.1.6. Table 3-158 indicates the net increase in energy that would be generated considering the additional power generated at Marys Lake, Estes, Pole Hill, Flatiron, and the Big Thompson Power Plants less the additional energy costs for pumping water at the Willow Creek Pump Canal, Granby Pump Canal, and Flatiron No. 3. The estimated value of the additional energy generation was based on the power production costs for an equivalent amount of energy generated from a coal power plant in 2015 adjusted to 2005 dollars, which would be about $56 per megawatt hour or $56,000 per gigawatt hour (GWH) (Energy Information Administration 2007). The retail value of generated energy would be higher.

Table 3-158. Net increase in energy generation and production value over existing conditions.

Alternative	Energy Generation (GWH)	Production Value
Alt 1 – No Action	18.95	$1,062,500
Alt 2 – Proposed Action	26.03	$1,459,500
Alt 3 – Chimney Hollow/Jasper	25.79	$1,446,000
Alt 4 – Chimney Hollow/Rockwell	25.83	$1,448,300
Alt 5 – Dry Creek/Rockwell	29.57	$1,658,000

Western anticipated greater hydropower generation following construction of the Windy Gap Project based on the original diversion projections. As a result, Western entered into agreements to provide energy based on those original projections; however, because diversions were less than anticipated and hydropower generation was less than projected, Western has had to purchase replacement power to meet commitments. The replacement power that Western purchased is generally from coal fired power plants. If Windy Gap diversions increase as a result of the WGFP, Western would be able to reduce its purchase of replacement power from coal fired power plants.

The Municipal Subdistrict would be responsible for the power costs associated with pumping additional water from Windy Gap Reservoir to Granby Reservoir. These costs vary with the amount of pumping and other factors, but average about $25 per AF. Based on average year diversions of 43,573 AF under the No Action Alternative, energy costs for pumping to Granby Reservoir would be about $1.09 million. Energy costs for the action alternatives would range from about $1.15 million for the Proposed Action to $1.21 million for Alternative 5. The Municipal Subdistrict is also responsible for paying Reclamation for the pumping costs associated with the delivery of Windy Gap water from Granby Reservoir to Shadow Mountain Reservoir/Grand Lake and from Flatiron Reservoir to Carter Lake. The repayment is only for water delivered through the Adams Tunnel and is based on the pump energy charges for the Farr Pumping Plant and Flatiron Pumping Plant.

Project Financing and Water Rates

Municipal and water district water rates and water rate structures are established to recover expenses such as annual operating and maintenance expenditures associated with water delivery and treatment, projected debt service, and capital improvements. Most WGFP Participants use inclining block rate pricing, where water rates increase as consumption increases. Other Participants have found that a uniform water rate adequately covers the expenses of providing water to their customers and use other measures and programs to encourage water conservation.

Each Participant has planned for the purchase of WGFP storage. Some Participants, such as Longmont, Greeley, Lafayette, and Louisville, have already set aside funding for the purchase of WGFP storage. Other Participants, such as Broomfield, have set aside at least a portion of the necessary funding for the project and plan to acquire any additional needed funds through development fees or bonding measures. Still others, such as Erie, Fort Lupton, and Evans, are financing the purchase of the Windy Gap water rights and/or storage through a combination of development fees including tap fees and bonding measures. A breakdown of the anticipated funding mechanisms and cost allocation for each Participant in the WGFP is shown in Table 3-159 based on the cost of the Proposed Action. The percent allocation would be the same for any of the action alternatives. Longmont would solely fund the enlargement of Ralph Price Reservoir under the No Action Alternative. All Participants would continue to monitor and adjust water rates as necessary to meet the ongoing costs associated with the development, treatment, and delivery of water to their respective service areas.

Table 3-159. Participant funding and financial contribution to the WGFP.

Participant	Expected Contribution to WGFP[1]	Percent of Total Cost	Cash Financing	Cash and Debt Financing	All Debt Financing
Broomfield	$61,000,000	28%		X	
Erie	$15,000,000	7%			X
Evans	$4,000,000	2%			X
Fort Lupton	$2,000,000	1%			X
Greeley	$18,000,000	8%	X		
Lafayette	$4,000,000	2%	X		
Longmont	$32,000,000	15%	X		
Louisville	$7,000,000	3%	X		
Loveland	$15,000,000	7%	X		
Superior	$11,000,000	5%		X	
LTWD	$11,000,000	5%			X
CWCWD	$1,000,000	<1%	X		
Platte River	$32,000,000	14%	X		
MPWCD[1]	$7,000,000	3%	n/a	n/a	n/a

[1] Cost allocation based on percent of total requested storage volume for Proposed Action (Chimney Hollow Reservoir) rounded to the nearest million.

3.22.2.4 Economic Effects to Recreation that are Similar for all Alternatives

All of the alternatives would result in similar types of effects to recreation on the Colorado River and at Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir from changes in hydrologic conditions. Potential effects to the recreation economy include changes in recreational boating, fishing opportunities, and other related land-based activities such as camping and sightseeing.

Colorado River Boating

The potential effects to rafting and kayaking on the Colorado River for three sections of the Colorado River — Byers Canyon downstream of Hot Sulphur Springs, Big Gore Canyon, and the Pumphouse downstream of Big

Gore Canyon discussed in *Recreation* (Section 3.19), were evaluated to determine potential effects to the recreation economy.

Byers Canyon. Byers Canyon provides Class IV to V whitewater kayaking at streamflows above 400 cfs. This reach of the river is not a popular boating destination and is used infrequently by private boaters. No commercial boating occurs in this reach. No statistics are available on boater use, but currently about 15 boaters per year are estimated to use this reach of the river (Crosby, pers. comm. 2008). Flows sufficient for kayaking under existing conditions are available primarily in June and July.

Daily flow data indicate that in June and July there would be no change in the number of days that flow exceeds 400 cfs in 29 years of the 47-year period of record. In years when there is a change in flow, there would be an average decrease of 8 kayaking days per year under the No Action Alternative and about 12 fewer kayaking days per year for the action alternatives. The greatest decrease in boating days in a single year would be 34 days under the No Action Alternative and 49 days under the Proposed Action and other alternatives. Assuming the maximum loss of 49 boating days would eliminate all kayaking activity in the year with the lowest available flow, this would represent a loss of about 15 user days with a per unit day value of about $73 or about $1,095.

WGFP diversions that reduce flows in the Colorado River below the preferred boating volume in Big Gore Canyon and Pumphouse would have an annualized impact of about $3,000, assuming no boating would occur outside of the preferred flow range. Economic impacts of up to about $500,000 could occur in years with the greatest decrease in preferred flows.

Big Gore Canyon. Big Gore Canyon provides Class V whitewater used by commercial rafting companies as well as private rafters and kayakers. Preferred boating flows are from 850 to 1,250 cfs. August is the primary month for boating in Big Gore Canyon and the Gore Race is typically held the third week of the month.

The net economic effect under the No Action Alternative from the estimated loss of about 2.4 boating days on average per year during 10 years out of the 47-year study period would be a loss of about 94 visitor days with an annual value of about $6,833 (2.4 days x 39 visitors per day x $73). For the Proposed Action and other alternatives, there would be a loss of about 2.3 boating days per year on average during 10 years out of the 47-year study period, or a loss of about 90 visitor days with a value of $6,548. A maximum loss of 11 boating days in a single year under each alternative could result in a loss of 429 visitor days with a value of $31,317. A beneficial effect from 1 additional day in some years would provide 39 additional visitor days with a value of $2,847 per year under the action alternatives. There would be no economic effect to the annual Gore Race in August because the WGFP would curtail diversions during the race if flows at the Kremmling gage fall below 1,250 cfs.

Pumphouse. The reach of the Colorado River between the Pumphouse and State Bridge provides generally flat water with Class II and III rapids. Preferred flows for boating in this reach of the river are from 1,100 to 2,200 cfs.

As discussed in the Recreation analysis, there would be no change in the number of days with the preferred flows in 32 years of the 47-year study period. There would be 1 more day of preferred boating flows under the No Action Alternative and 4 fewer days under the Proposed Action for the entire study period. On average during the 15 years with impacts, there would be about 1 day less boating during the preferred flow range. The maximum decrease in preferred boating flows in a single year would be 15 days under all alternatives; while there would be a maximum increase in preferred flows in a single year of 7 days under the No Action Alternative, 6 days under the Proposed Action, and 10 days for the other alternatives.

The net economic effect from the loss of 1 day per year of preferred boating flows during 15 years out the 47-year study period when flow changes affect boating under all of the alternatives would be a loss of about 450 visitor days with an annual value of about $32,850. A maximum loss of 15 boating days in a single year under all of the alternatives could result in a loss of 6,705 visitor days with a value of $492,750. Beneficial effects from 6 to 10 additional days in some years for the alternatives would provide 2,700 to 4,500 additional visitor days with a value of $197,100 to $328,500. The net increase of 1 boating day over the 47-year study period under the No

Action Alternative, and a net decrease of 4 boating days over 47 years for the Proposed Action would result in a minor long-term economic effect. Similar small changes in the total number of preferred boating days would occur for Alternatives 3, 4, and 5.

Comparison of Effects to Boating. To provide a common basis for comparing the economic effects to boating on the Colorado River, the change in the number of boating days over the 47-year study period was used to annualize gains or losses in boating recreational values (Table 3-160). Minor beneficial effects are not included in the effects calculation. The average cost per year for reduced boating opportunities in Byers Canyon would be minor (about $50/year for the No Action Alternative and up to $90/year for the action alternatives). A reduction in the number of rafting and kayaking days in Big Gore Canyon could result in an average annual loss in recreation value ranging from $1,151 for Alternative 4 to $1,636 for Alternative 5 (e.g., for the Proposed Action, there would be 23 fewer preferred boating days over the 47-year period; 23 days x 39 boaters/day x $73/day ÷ 47 years = $1,393/year). In the Pumphouse reach, the No Action Alternative could result in a slight increase in average annual recreation value for kayaking and rafting, while other alternatives could result in an average annual loss in value of about $2,100 for Alternative 5 to about $10,500 for Alternative 4. As previously stated, this analysis assumes a complete loss of boating days when flows fall outside of preferred ranges; however, the range of flows acceptable for boating would not change substantially from existing conditions, and actual economic effects are likely to be less.

Table 3-160. Annualized cost or benefit to recreational boating on the Colorado River by alternative.

Alternative	Byers Canyon (Kayaking)	Big Gore Canyon (Rafting and Kayaking)	Pumphouse (Rafting and Kayaking)
No Action	Minor	-$1,454	+$699
Proposed Action	Minor	-$1,393	-$2,796
Alt 3	Minor	-$1,393	-$2,796
Alt 4	Minor	-$1,151	+$2,097
Alt 5	Minor	-$1,636	-$699

Colorado River Camping

It is possible that camping, sightseeing, and other recreation use in the Pumphouse and Radium areas would also change as a result of changes in streamflow. Assuming that nonboating recreation changes in a pattern similar to that of rafting, then an average decrease of 1 day of rafting could result in the loss of about 10 nonboating visitor days with an economic value of about $370. This loss would occur in 28 years of the 47-year study period. A maximum annual loss of nonboating recreation from 17 fewer rafting days under the Proposed Action and Alternatives 3 and 4 would translate to a loss of 170 nonboating user days with a value of $6,290. The estimated increase in nonboating recreation would range from 30 to 110 visitor days with a value of $1,100 to $4,070 when streamflow changes increase rafting opportunities.

Colorado River Angling

> The Proposed Action would reduce available fish habitat and increase stream temperature in the Colorado River for some months. Impacts are not of a magnitude that are predicted to adversely impact angling, particularly with planned mitigation measures.

Angling opportunities along the Colorado River are an important component of the local economy. Fishing occurs on BLM lands, State Wildlife Areas, and on private lands and resorts. Projected changes in streamflow on the Colorado River below Granby Reservoir under all of the alternatives would result in a loss of fish habitat, but that loss of habitat would not result in impacts to fish populations or angling opportunities (Miller Ecological Consultants 2010). An increase in water temperature also would occur below the Windy Gap Reservoir diversion under some conditions. The anticipated reduced flows, which are greatest during the high runoff period, are not expected to adversely impact fish populations or fishing opportunities. High stream flushing flows sufficient for channel and fish habitat maintenance and sediment transport would still occur (ERO and Boyle 2007). No Windy Gap diversions would occur when flows reach the minimum streamflow requirement under all of the alternatives. Projected effects to fish habitat are not predicted to translate to a loss in angling opportunities or fishing success (see *Aquatic Resources* Section 3.9). No flow preferences for angling are available for the Colorado River, but fly fisherman typically like lower to moderate flows for wading (Smith and Hill 2000). Windy Gap diversions during high flow periods could increase the suitability for wading. Lower flows in some months could diminish the aesthetic value of the river for some visitors and possibly affect the quality of the recreation experience. The WGFP would not increase the potential for production or distribution of whirling disease, which affects rainbow trout populations throughout the Colorado River and numerous locations throughout the State (Miller Ecological Consultants 2010). No measurable effect to angler user days on the Colorado River or associated economic effects were identified for any of the alternatives.

Three Lakes Recreation

No changes in surface water elevation at Grand Lake and Shadow Mountain Reservoir would occur under any of the alternatives because, as part of the C-BT Project, Reclamation limits reservoir fluctuations to no more than 1 foot from the top of the conservation pool. No change in water quality parameters that exceed water quality standards for recreation use would occur. Reduced water clarity and algal growth has been an issue of concern in Grand Lake and Shadow Mountain Reservoir, which may contribute to a diminished recreation experience. Predicted small reductions in water clarity would continue or slightly increase the potential for a diminished recreation experience under all of the alternatives. It is unknown whether these water clarity issues would translate to a loss in visitors and associated economic effects. Proposed nutrient mitigation would reduce the potential for any economic effects (see Section 3.8.4.1). Aquatic weeds in Shadow Mountain Reservoir are also an issue that Reclamation, the NCWCD, and numerous entities from Grand County are cooperating in an attempt to address that issue. None of the alternatives are anticipated to result in changes to the conditions that contribute to the aquatic weed problem and, therefore, the WGFP is unlikely to exacerbate the problem (AMEC 2008a).

There also have been concerns related to algal toxins in Grand Lake including an advisory issued in the summer of 2007 related to use of the lake for drinking water. Microtoxin levels did not exceed concern levels, but ongoing monitoring and accurate analysis would help determine if production of toxins is a problem. Chronic toxin levels could have an economic effect, but there is currently not enough information to determine that this would occur.

Projected relatively small reductions in boatable area for Granby Reservoir in most years are unlikely to noticeably affect recreation use of the reservoir or the quality of the recreation experience under any of the alternatives. Additional exposed shoreline at lower water levels could reduce the aesthetic value and affect the quality of the visitor experience. During a sequence of dry years, there would be reduced access to boat ramps under all of the alternatives, which may reduce the number of visitors and quality of the recreation experience at Granby Reservoir. Camping, hiking, and shoreline activities could decrease during periods of low water levels, when boat ramp access declines, or from a perceived decrease in aesthetic values. Visitor user days have historically declined during dry or drought years, although this may be due to factors other than water levels, including campfire restrictions or weather (Orr 2008). Sufficient information is unavailable to quantify the incremental effect of lower Granby Reservoir water levels. Proposed modified prepositioning would reduce Granby Reservoir drawdowns, particularly in dry years as described in *Surface Water Hydrology* mitigation (Section 3.5.4.1).

Predicted minor changes in the physical and water quality conditions for aquatic life in Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir is unlikely to affect the fish communities in Grand Lake and Shadow Mountain Reservoir (AMEC 2008a; Miller Ecological Consultants 2010). Thus, there would be no effect to recreational fishing opportunities at the Three Lakes for any of the alternatives.

Grand County Land-Based Recreation

As discussed under *Recreation Resources*, no measurable impacts are expected to land-based recreational activities such as camping, hiking, mountain biking, scenic driving, and sightseeing based on the relatively small incremental changes in river and reservoir water levels and water quality.

Carter Lake and Horsetooth Reservoir Recreation

The small projected changes in Carter Lake water surface area under all of the alternatives would unlikely adversely affect visitor numbers or recreation activities. Larger reductions in surface area after several consecutive dry years, particularly under the Proposed Action, could diminish the overall quality of the user experience by potentially reducing the overall aesthetics of the experience. No measurable economic impact to local economies is likely from predicted changes in reservoir storage.

Projected changes in Horsetooth Reservoir water elevations are unlikely to substantially affect recreation activities under any of the alternatives. A reduction in lake surface area, particularly under the Proposed Action, could diminish the overall quality of the user experience by potentially reducing the overall aesthetics of the experience. A larger decline in lake levels after several consecutive dry years, primarily under the Proposed Action, would impact access to boat ramps, reduce boating capacity, and diminish the quality of the recreation experience. A decrease in recreation value is possible during periods when Horsetooth Reservoir water levels are substantially lower, such as sequential dry years.

Proposed prepositioning would substantially mitigate fluctuations in Carter Lake and Horsetooth Reservoir as described in *Surface Water Quality* (Section 3.5.4.1).

3.22.2.5 Alternative 1—Ralph Price Reservoir (No Action)

Construction Employment and Spending

The average workforce anticipated during the estimated 2 years of construction would be 50 employees with a peak employment of 100 (Boyle 2005d). A temporary localized population increase may occur during construction in nearby towns such as Lyons. Of the estimated $31 million in construction cost, about $8 million would be for direct labor (Table 3-161). Indirect labor would contribute an additional $8.7 million to regional earnings and create 69 temporary jobs. If all of the construction-related costs are expended in the Denver Metro Region, then the project would generate about $73 million in total economic output including local government (e.g., sales tax revenue) and secondary effects from spending in the region (Colorado Division of Local Government 2005). To the extent that construction spending takes place outside of the region, such as materials purchased elsewhere, these direct and secondary benefits would accrue to other regions. All population-, employment-, and income-related effects would be temporary for the construction period. Reservoir operation and maintenance costs would be similar to existing conditions.

Table 3-161. Project, direct labor, and operation and maintenance cost by alternative.

Alternative	Total Project Cost	Direct Labor	Annual O&M Cost[1]
	(millions of dollars)		
Alt 1 – No Action	$31	$8	No change
Alt 2 – Proposed Action	$223	$47	$0.79
Alt 3	$240	$49	$1.37
Alt 4	$252	$52	$1.73
Alt 5	$288	$60	$2.24

[1] A detailed cost breakdown by Alternative is found in Chapter 2, Table 2-4.

Land Use Values

There would be no direct impact to private residences or acquisition of private property needed to expand Ralph Price Reservoir. Recreation activities would be suspended during construction and there would be a loss in revenue to the City of Longmont from the sale of fishing permits for several years. Following completion of the reservoir enlargement, recreation activities would be restored.

3.22.2.6 Alternative 2—Chimney Hollow Reservoir (Proposed Action)

Construction Employment and Spending

> Construction of Chimney Hollow Reservoir would cost about $223 million, which includes about $47 million for direct labor. The project would require a workforce of about 500 during construction.

Construction of Chimney Hollow Reservoir would require an average workforce of about 235 during the 3- to 5-year construction period. The workforce could reach about 500 at peak construction. It is estimated that about 50 percent of the workers would commute from existing residences near Loveland, Berthoud, and other northern Front Range communities (Bandy, pers. comm. 2005). The remaining 50 percent would likely come from the Denver Metro Region. Some workers could relocate to communities near the reservoir site, but the temporary population increase would be relatively small compared with the overall population, and local housing would likely be sufficient.

Total construction costs would be about $223 million of which about $47 million would be for direct labor (Table 3-161). A portion of construction dollars would create secondary income and jobs in the region. If 50 percent of the project costs were spent in the local Larimer and Weld Region, the project would generate an estimated $292 million in total economic output and secondary economic effects from spending and about 127 additional jobs. Indirect labor would contribute an additional $20 million to local earnings in the Larimer and Weld Region. Similar direct and secondary economic output would occur in the Denver Metro Region or other locations from employment and spending.

Annual operation and maintenance of the reservoir and conveyance facilities would cost about $795,000 annually and would require four employees. Ongoing operations would produce a small positive economic effect over the life of the project.

Land Use Values

The Subdistrict owns the majority of the Chimney Hollow Reservoir site, but would need to purchase small areas of private land and/or acquire easements or leases. There would be no loss in agricultural production or impact to private residences from construction of Chimney Hollow Reservoir.

Larimer County anticipates expenditures of about $1 million for the development of recreation facilities at the Chimney Hollow Reservoir and adjacent county open space. Annual management costs for staff, facility and trail maintenance, weed control, patrol, vehicles, and administration are estimated to be about $265,000 (Flenniken pers. comm. 2006). Projected annual visitation of 50,000 could result in an increase in revenues to local businesses associated with recreational visitor expenditures.

There would be no impact on Larimer County property tax revenues due to the purchase of land for construction of Chimney Hollow Reservoir because the property is tax exempt.

3.22.2.7 Alternative 3—Chimney Hollow Reservoir and Jasper East Reservoir

Construction Employment and Spending

Construction of two reservoirs under Alternative 3 would require an average workforce of about 190 at Chimney Hollow Reservoir and about 65 for Jasper East Reservoir during the 2.5- to 5-year construction period. The combined peak labor needs for both reservoirs could reach about 570. Construction activities would have a temporary beneficial effect to local employment and income in nearby towns including Loveland and Berthoud for Chimney Hollow Reservoir and Granby, Hot Sulphur Springs, Kremmling, Fraser, and Grand Lake for Jasper East Reservoir. Similar to Alternative 2, about half the workers for Chimney Hollow Reservoir would come from local communities and the rest from other locations including the Denver Metro Region. At the Jasper East Reservoir, it is estimated that about 25 percent of the workers would be drawn from local Grand County communities and another 25 percent from the Denver Metro Region. The remainder of workers would likely come from other locations in the state. Housing needs on the West Slope for construction workers could likely be met with the existing supply, particularly during the nonwinter season when rental and hotel occupancy is lower.

Sufficient local housing and community services should be available to meet the need during construction of Chimney Hollow Reservoir.

Construction of Chimney Hollow Reservoir is estimated to cost about $180 million and Jasper East Reservoir about $60 million for a combined cost of $240 million (Table 3-161). Direct labor costs for both reservoirs would be about $49 million. Indirect labor would create about 102 additional jobs and contribute about $16 million in addition to direct earnings to the Larimer and Weld Region and would create about 30 additional jobs and generate about $2 million to the Grand County area. Total economic output, earnings, and expenditures from construction of Chimney Hollow Reservoir would generate $236 million locally in the Larimer and Weld Region with a similar amount possible in the Denver Metro Region or other locations. Construction of Jasper East Reservoir would generate a total economic output of about $35 million in the Grand County area.

Annual operation and maintenance costs for Chimney Hollow Reservoir would be about $795,000 annually and require four employees. Jasper East Reservoir would cost $417,000 annually to maintain and operate plus $162,000 in energy costs to pump water to Granby Reservoir. Two employees would be needed to operate and maintain Jasper East Reservoir.

Land Use Values

Effects to land use values for a 70,000 AF Chimney Hollow Reservoir would be the same as described for Alternative 2.

Construction of Jasper East Reservoir would result in a loss of grazing land and a decrease in agricultural output. The value of lost income for livestock production would be about $27,000 in gross profit per year. NCWCD would forego lease revenue associated with the site and state and local governments would experience a small loss in tax revenue associated with reduced agricultural activity. A beneficial effect to nearby private property is possible if recreation is developed at Jasper East Reservoir.

There would be no impact on Larimer County or Grand County property tax revenues due to the purchase of land for construction of Chimney Hollow or Jasper East reservoir because the properties are tax exempt.

3.22.2.8 Alternative 4—Chimney Hollow Reservoir and Rockwell/Mueller Creek Reservoir

Construction Employment and Spending

Construction employment, income, and spending for Chimney Hollow Reservoir would be the same as described for Alternative 3.

Construction of Rockwell Reservoir would require an average workforce of about 76 and a peak workforce of about 150. Similar to the discussion on Jasper East Reservoir, about 25 percent of the employment is expected to come from the Grand County area, 25 percent from the Denver Metro Region, and the remainder from other regional locations. A slight increase in local population in Grand County is likely during construction, but would be relatively small and within the capacity of local lodging.

Construction related spending for Rockwell Reservoir would generate about $41 million in total direct and indirect local economic output for Grand County. Direct labor costs of $4 million in Grand County would generate an additional $3 million in indirect earnings and create about 30 new jobs. Total economic output, earnings, and expenditures from construction of Rockwell Reservoir would generate $41 million locally in Grand County. Construction-related employment and spending would last from 2.5 to 5 years.

Annual Rockwell Reservoir operation and maintenance costs would be about $728,000 and require two employees. An additional power generation cost of $207,000 annually would be needed for pumping water to Granby Reservoir.

Land Use Values

Effects to land use values for a 70,000 AF Chimney Hollow Reservoir would be the same as described for Alternative 2.

Construction of Rockwell Reservoir would require the purchase of four private residences and the land for the reservoir. Additional easements would be needed for the pipeline to Windy Gap Reservoir. The Subdistrict would have to pay just compensation for these properties. Property owners near the new reservoir could benefit if recreational amenities are developed. Local communities and businesses could also benefit from recreation-related expenditures at a new reservoir.

Grand County property tax revenues would be reduced by approximately $7,800 per year due to the purchase of land for construction of the Rockwell Reservoir. There would be no impact on Larimer County property tax revenues due to the purchase of land for construction of Chimney Hollow Reservoir because the property is tax exempt.

3.22.2.9 Alternative 5—Dry Creek Reservoir and Rockwell/Mueller Creek Reservoir

Construction Employment and Spending

The construction of Dry Creek and Rockwell reservoirs would require an average workforce of about 210 at Dry Creek Reservoir and 92 at Rockwell Reservoir over the 2.5- to 4.5-year construction period. During peak construction, the combined workforce could reach 657. It is estimated that about 50 percent of the construction workforce for Dry Creek Reservoir would come from nearby local communities near Loveland and Berthoud and that the remaining 50 percent would come from other areas, including the Denver Metro Region. The workforce for Rockwell Reservoir is expected to come from local communities in Grand County (25 percent), the Denver Metro Region (25 percent), and the rest from other locations. Some workers could move into the communities for the duration of construction.

Construction costs for Dry Creek Reservoir are estimated at $180 million including $42 million in direct labor cost. Indirect labor would generate about $17 million in earnings to the Larimer and Weld Region and 112 secondary jobs. Total economic output for the Larimer and Weld Region would be about $236 million, with a similar amount generated for locations outside of the local region.

Construction of a 30,000 AF Rockwell Reservoir would cost $88 million (2003 dollars). This would generate about $18 million in direct labor costs with about $5 million in the Grand County area. Indirect labor would contribute another $3 million to the Grand County area and 42 jobs. Total economic output related to the construction of Rockwell Reservoir would be in the order of $51 million in the Grand County area.

Land Use Values

Effects to land use values for a 30,000 AF Rockwell Reservoir would be the same as described for Alternative 4.

Construction of Dry Creek Reservoir would displace the Rancho Lobo y Mariposa Llama Ranch and the associated economic value of this business. The loss of this relatively small operation would not have a substantial effect on the overall agricultural activity in Larimer County, but would adversely impact a small business. In addition, reservoir construction would require acquisition of three private residences and purchase of private land and a section of state land. The revenues associated with lease of the state land for a moss rock collection and the economic value for a landscape rock business would be lost. The Subdistrict would have to negotiate just compensation for acquisition of these properties.

The impact on Larimer County property tax revenues would be about $4,000 per year at Dry Creek due to the purchase of land for reservoir construction. Grand County property tax receipts would be reduced by approximately $9,200 per year due to the purchase of land for construction of the Rockwell Reservoir.

3.22.3 Cumulative Effects

Cumulative socioeconomic effects were evaluated for both water-based and land-based reasonably foreseeable actions. Water-based reasonably foreseeable actions are located on the West Slope and land-based reasonably foreseeable actions occur near potential reservoir sites on both the East Slope and West Slope. Potential cumulative socioeconomic effects include the overlapping effects that might occur to population, employment, income, land use values, and community services from the combination of the WGFP alternative actions with reasonably foreseeable future actions. The additional net hydropower production and value, and Colorado River recreation impacts were calculated the same as direct effects using cumulative effects hydrology.

3.22.3.1 Hydropower Energy Production

The additional net energy production and estimated value compared to existing conditions for each alternative is shown in Table 3-162. Energy production would be lower than under direct effects because less water Windy Gap water would be delivered to the East Slope.

Table 3-162. Net increase in energy generation and production value over existing conditions—cumulative effects.

Alternative	Energy Generation (GWH)	Production Value
Alt 1 – No Action	15.16	$850,000
Alt 2 – Proposed Action	21.42	$1,201,000
Alt 3 – Chimney Hollow/Jasper	20.94	$1,174,100
Alt 4 – Chimney Hollow/Rockwell	20.99	$1,176,900
Alt 5 – Dry Creek/Rockwell	24.69	$1,384,400

Western's plan to rebuild the transmission line from the Granby Pumping Plant to the Windy Gap Substation would improve the reliability and quality of electric service to the region. The existing transmission line and associated infrastructure currently serving the Windy Gap pumping plant is adequate to meet current and future needs if the WGFP is implemented. The rebuilt transmission line could improve reliability for Windy Gap pumping, but is not necessary for continued operation of the existing pumps. The Municipal Subdistrict would pay a portion of the costs associated with the line upgrade per existing agreements with Western and Reclamation. Implementation of the WGFP would not result in additional costs to Grand County for transmission line improvements.

3.22.3.2 Water-Based Reasonably Foreseeable Actions

The Moffat Collection System Project, future population growth and increased water use in Grand and Summit counties, and other expected changes in water use would result in additional water diversions out of the Fraser River and Colorado River or changes in flow. None of the reasonably foreseeable future changes in water use on the West Slope involve new infrastructure that would add to the potential employment or expenditures if a West Slope reservoir is built under Alternative 3, 4, or 5. Construction of the Moffat Project water storage facilities on the East Slope would contribute additional short-term employment and income effects and add to the total economic output from implementation of any of the WGFP alternatives. Both projects would have a positive short-term employment and income effects that would occur in the Denver Metro Region.

The exercise of water rights by Denver Water for the Moffat Project, Grand and Summit counties water providers, and those for the WGFP are subject to the state's priority system for allocation of water rights. Additional water diversions are subject to any senior agricultural water rights in the Colorado River basin and thus the exercise of these rights would have no cumulative effect to existing agricultural production or farm income in Grand County. The expiration of the Big Lake Ditch contract in 2013 would reduce irrigated agriculture in the Reeder Creek drainage. The loss of irrigated lands with construction of Jasper East Reservoir in Alternative 3 would result in a small adverse cumulative impact to the agriculture economy in Grand County.

Reasonably foreseeable water-based actions in addition to diversions for the WGFP would reduce or change flows in the Colorado River. As discussed in *Aquatic Resources* (Section 3.9) and *Recreation* (Section 3.19), no adverse impact to fishing in the Colorado River that would impact the tourism-related expenditures is likely for any alternative. Reasonably foreseeable water-based actions would not directly impact water storage or recreation at Granby Reservoir, Grand Lake, Shadow Mountain Reservoir, and Willow Creek Reservoir.

3.22.3.3 Land-Based Reasonably Foreseeable Actions

Potential future land-based developments near alternative reservoir sites primarily include new residential and commercial developments. Larimer County is planning for future management of open space lands adjacent to Chimney Hollow Reservoir. In addition, a general trend in population growth and development in the northern Front Range counties where WGFP Participants are located is expected.

New residential developments near alternative reservoir sites would result in an increased population, along with temporary increases in employment and income during home construction. New commercial developments would result in a long-term increase in employment and income. The relatively short-term economic effects associated with construction of any of the alternative reservoirs in addition to the effects associated with new land developments would have minimal cumulative effects to population, employment, and income in the counties where alternatives are located. Property values near new reservoirs may be enhanced if recreation is developed.

The planned future development of open space facilities by Larimer County adjacent to Chimney Hollow Reservoir would provide employment during construction of recreation facilities and long-term employment for Larimer County Parks and Open Lands staff. There would also be a cumulative increase in recreation opportunities in Larimer County under Alternatives 2, 3, and 4. Open space lands would not directly generate revenue because there would no entrance fee; however, local business could benefit from recreation user expenditures.

Construction of Jasper East Reservoir would result in loss of hay production, and some grazing land would be lost at the Rockwell Reservoir site. Planned future development of the C-Lazy-U Preserve near Jasper East Reservoir and other residential or commercial developments would result in an incremental cumulative loss in agricultural production and farm income in Grand County under Alternatives 3, 4, and 5. Proposed retirement of 845 acres of irrigated agricultural land in the Willow Creek watershed as part of the 10825 Project would add to the cumulative loss of irrigated agriculture in Grand County. About 313 acres of this land includes irrigated land within the Jasper East Reservoir site. The cumulative loss would be a relatively minor component of county-wide farm income.

Like many other Front Range counties where WGFP Participants are located, Boulder, Broomfield, Larimer, and Weld counties have experienced significant population growth during the last decade. The populations of these counties are expected to continue to grow through 2030 with or without construction of any one of the alternatives. Implementation of any of the WGFP alternatives would allow Participants to meet anticipated water needs that support local economies.

3.22.3.4 Economic Effects to Recreation that are Similar for all Alternatives

All of the alternatives would result in similar cumulative effects to recreation on the Colorado River and at Grand Lake, Shadow Mountain Reservoir, Granby Reservoir, Carter Lake, and Horsetooth Reservoir from changes in hydrologic conditions and water quality. Potential economic effects to changes in recreation from implementation of water-based reasonably foreseeable actions along with the WGFP are described below.

Colorado River Boating

The potential cumulative effects of changes in boating days on the Colorado River discussed in *Recreation* (Section 3.19) were evaluated to determine potential effects to the recreation economy. The cumulative effects of the alternatives are relative to existing conditions.

Byers Canyon. An estimated maximum loss of 56 boating days would eliminate all kayaking activity in the year with the lowest flow, which would represent a loss of about 15 user days (based on the existing level of use) with a value of about $1,095. The loss would be similar for all alternatives.

Gore Canyon. The economic effect from the loss of about 1.2 to 1.8 boating days on average per year during 34 years of the 47-year study period, under each of the alternatives, would be about 47 to 70 visitor days with an annual value of about $3.416 to $5,125. A maximum loss of 23 boating days in a single year under the No Action

Alternative would result in a loss of 897 visitor days with a value of $65,481. Under the Proposed Action and other alternatives, a maximum loss of 31 days would result the loss of all 1,200 boating visitors with an impact of $87,600. If flow levels are insufficient to support the Big Gore Race in late August, there would be additional direct and secondary economic effects associated with impacts to this event. The WGFP under all of the alternatives would rarely divert water in August except in wet years and would curtail diversions during the Big Gore Race if flows at the Kremmling gage are less than 1,250 cfs, thus, there would be no effect on the Gore Race. Beneficial effects from the additional days within the preferred flow range in some years would range from 663 additional visitor days with a value of $48,399 for the No Action Alternative to 858 additional visitor days under the other alternatives with a value of $62,634.

Pumphouse. The net cumulative economic effect from an average reduction in 4.4 days per year with preferred flows for boating, which occurs in 40 years out of the 47-year study period, would be a loss of about 1,908 visitor days with an annual value of about $144,540. A maximum decrease of 56 days with preferred boating flows in a single year under all of the alternatives would result in a loss of 25,200 visitor days with a value of $1,839,600. Beneficial effects from up to 31 additional days with preferred flows in some years for the No Action and Proposed Action alternatives would provide 13,950 additional visitor days with a value of $1,018,350.

Comparison of Effects to Boating. To provide a common basis for comparing the cumulative economic effects to boating on the Colorado River, the change in the number of boating days over the 47-year study period was used to annualize gains or losses in boating recreational values. The average cost per year for reduced boating opportunities in Byers Canyon would be minor (about $100 per year) for each of the alternatives (Table 3-163). A reduction in the number of rafting and kayaking days in Big Gore Canyon would result in an average annual loss in recreation value ranging from $2,423 for the No Action Alternative to $3,756 for Alternatives 3, 4, and 5 (e.g., for the Proposed Action, there would be 56 fewer preferred boating days over the 47-year period; 56 days x 39 boaters/day x $73/day ÷ 47 years = $3,392/year). In the Pumphouse reach, all of the alternatives would result in a decrease in average annual recreation value for kayaking and rafting of about $70,000. As previously stated, this analysis assumes a complete loss of boating days when flows fall outside of preferred ranges; however, the range of acceptable boating flows would be similar to existing conditions; therefore, the actual economic effects would likely be less.

Table 3-163. Annualized cost or benefit to recreational boating on the Colorado River by alternative — cumulative effects relative to existing conditions.

Alternative	Byers Canyon (Kayaking)	Big Gore Canyon (Rafting and Kayaking)	Pumphouse (Rafting and Kayaking)
No Action	Minor	-$2,423	-$132,798
Proposed Action	Minor	-$3,392	-$144,680
Alt 3 – 5	Minor	-$3,756	-$139,787

Camping and Sightseeing

It is possible that camping, sightseeing, and other recreation use in the Pumphouse and Radium areas would also change as a result of changes in streamflow. Assuming that nonboating recreation changes in a pattern similar to that of rafting, then an average decrease of 9 days of rafting would result in the loss of about 90 nonboating visitor days with an economic value of about $3,330. This loss would occur in about 21 years out of the 47-year study period. A maximum annual loss of nonboating recreation from 15 fewer rafting days under the No Action Alternative would be $5,550. The camping value of the loss of 14 days for other alternatives would be $5,180. The estimated increase in nonboating recreation would range from an additional 270 visitor days under Alternatives 3, 4, and 5 to 310 visitor days under the No Action and the Proposed Action alternatives. The recreational value of these additional camping days would range from $9,990 to $11,470.

Colorado River Angling

When reasonably foreseeable water-based actions are in place, WGFP diversions would decrease, although Colorado River flows would be lower than with just the WGFP operating. Projected changes in streamflow on the Colorado River below Granby Reservoir in the future under all of the alternatives would result in a loss of fish habitat (Miller Ecological Consultants 2010). An increase in water temperature also would occur under some conditions below Windy Gap Reservoir. The anticipated reduced flows, which are greatest during the high runoff period, are not expected to adversely impact fish populations or fishing opportunities. High stream flushing flows sufficient for channel and fish habitat maintenance and sediment transport would still occur (ERO and Boyle 2007). No Windy Gap diversions would occur when flows reach minimum streamflow requirements under all of the alternatives. Projected effects to fish habitat are not predicted to translate to a loss in angling opportunities or fishing success. Lower flows in some months could diminish the aesthetic value of the river for some visitors and possibly affect the quality of the recreation experience. No measurable effect to angler user days on the Colorado River or associated economic effects were identified for any of the alternatives.

Three Lakes Recreation

The surface water elevation at Grand Lake and Shadow Mountain Reservoir would not change from existing conditions under any of the alternatives. No change in water quality parameters that exceed water quality standards for recreation use would occur. Predicted small reductions in water clarity would continue or slightly increase the potential for a diminished recreation experience under all of the alternatives. It is unknown whether the water clarity issues would translate to a loss in visitors and associated economic effects. Predicted minor changes in water quality and aquatic habitat in the Three Lakes would not adversely impact recreational fishing opportunities for any of the alternatives (Miller Ecological Consultants 2010). Proposed nutrient mitigation would reduce the potential for any economic effects from the WGFP (see Section 3.8.4.1).

Cumulative average monthly Granby Reservoir water surface area would be lower under all of the alternatives during the summer months. The decrease in boatable surface area is unlikely to measurably affect recreation activity in a reservoir of this size under any of the alternatives. Additional exposed shoreline at lower water levels could reduce the aesthetic value and affect the quality of the visitor experience. During a sequence of dry years, access to boat ramps would be reduced under all of the alternatives, which may reduce the number of visitors and quality of the recreational experience at Granby Reservoir. Camping, hiking, and shoreline activities could decrease during periods of low water levels, when boat ramp access declines, or from a decrease in aesthetic value. Visitor user days have historically declined during dry or drought years, although this may be due to factors other than water levels, including campfire restrictions or weather (Orr 2008). There is insufficient information to determine if lower Granby Reservoir water levels would directly affect visitor use. Proposed modified prepositioning would reduce Granby Reservoir drawdowns from the WGFP, particularly in dry years as described in *Surface Water Hydrology* mitigation (Section 3.5.4.1).

Carter Lake and Horsetooth Reservoir Recreation

The small projected changes in Carter Lake water surface area under all of the alternatives are unlikely to adversely affect visitor numbers or recreation activities. Larger reductions in surface area after several consecutive dry years, particularly under the Proposed Action, could diminish the overall quality of the user experience by potentially reducing the overall aesthetics of the experience. No measurable economic impact to local economies is likely from the small predicted changes in reservoir storage.

Projected changes in Horsetooth Reservoir water elevations are unlikely to substantially affect recreation activities under any of the alternatives. A reduction in lake surface area, particularly under the Proposed Action, could diminish the overall quality of the user experience by potentially reducing the overall aesthetics of the recreation experience. A large decline in lake levels after several consecutive dry years under the Proposed Action would impact access to boat ramps, reduce boating capacity, and diminish the quality of the recreation experience. An unquantified decrease in recreation value is possible during periods when Horsetooth Reservoir water levels are low.

Proposed prepositioning would substantially mitigate fluctuations in Carter Lake and Horsetooth Reservoir from the WGFP (*Surface Water Quality* Section 3.5.4.1).

3.22.4 Socioeconomic Mitigation

The Subdistrict would negotiate just compensation for acquisition of any property or homes that would be impacted by implementation of any alternative.

The Subdistrict would curtail Colorado River diversions during the annual Big Gore Race typically held the third week in August if flows at the Kremmling gage are below 1,250 cfs to avoid any economic effects to this event.

The FWMP developed between the Subdistrict and CDPW will address potential impacts to aquatic life and possible recreation related economic effects to fishing. Nutrient mitigation measures would reduce the potential for aesthetic, recreation, or water quality impacts in the Three Lakes, as well as Carter Lake and Horsetooth Reservoir. Modified prepositioning would reduce potential recreation related socioeconomic effects associated with lower water levels in Granby Reservoir, Carter Lake, and Horsetooth Reservoir.

3.22.5 Unavoidable Adverse Effects

Construction of Jasper East Reservoir under Alternative 3 would result in the loss of agricultural revenues from the current livestock operation. Construction of Rockwell Reservoir would result in the loss of four homes under Alternatives 4 and 5. If Dry Creek Reservoir is built in Alternative 5, there would be an unavoidable loss of three homes and the revenues from the llama ranch.

Reduced Colorado River streamflow could result in a loss or diminished recreation value for boating in some years under all of the alternatives. Impacts to recreation use or activities are possible from lower water levels at Granby Reservoir.

3.23 Relationship between Short-Term Uses of the Environment and Long-Term Productivity

Potential effects to the environment can be either short-term or long-term. Effects can be either beneficial or negative and often there is a trade-off between short-term uses and long term productivity. As described earlier in this chapter short-term effects for this project are defined as those that occur from the beginning of construction through completion of reclamation or about 5 years. Long-term effects would occur for the life of the project. The following discussion summarizes the relationship between short-term uses and long-term productivity for the proposed project.

All alternatives would result in similar types of impacts, although the location of disturbance and amount of impact would vary. All alternatives, including No Action would result in the long-term diversion of water from the Colorado River and reduced flow in Willow Creek. This would result in long-term effects to stream hydrology, morphology, water quality, aquatic habitat, and recreation as described previously for each of the resources. Additional water deliveries to the East Slope would result in a long-term increase in streamflow and water quality changes for the Big Thompson River, St. Vrain Creek, Coal Creek, and Big Dry Creek. The No Action Alternative would also result in a long-term change in flows in North St. Vrain Creek. Changes in water deliveries, storage, and water quality would have long-term consequences to the Three Lakes, Carter Lake, and Horsetooth Reservoir.

Construction of one or more new reservoirs would result in both short and long-term effects. Short-term effects during construction would be soil disturbance, vegetation clearing, wildlife habitat disturbance, as well as the noise, dust, and traffic generated by construction activities. Construction spending, employment, and socioeconomic effects would primarily be short-term effects for communities near the new reservoirs. There would be a long-term change in land use at new reservoir sites for the action alternatives. Construction of Rockwell and/or Dry Creek Reservoir would result in the long-term displacement of several residents. New land use at the Chimney Hollow Reservoir site would include recreation activities and establishment of a fishery.

Other reservoir sites could have similar recreation opportunities. Enlargement of Ralph Price Reservoir under the No Action Alternative would not substantially change land use, but would trade natural vegetation and wildlife habitat for additional open water. All alternatives would result in disturbance of plant and wildlife habitats that could result in the long-term reduction in biological productivity. Construction activities would result in a short-term impact to visual resources, as well as long-term effects to visual quality from vantage points near the reservoir sites. Additional water to WGFP Participant's under the Proposed Action, and to a lesser degree under the other alternatives, would provide a long-term reliable water supply to support regional communities and businesses.

3.24 Irreversible or Irretrievable Commitment of Resources

This section describes irreversible and irretrievable commitments of resources associated with implementation of the alternatives. An irreversible commitment of resources means that nonrenewable resources are consumed or destroyed; these resources are permanently lost due to project implementation. For example, fossil fuel resources used during construction would represent an irreversible commitment of resources because their use is lost for future generations.

In contrast, an irretrievable commitment of resources is the loss of resources or resource production, or use of renewable resources during project construction and during the period of time that the project is in place. Irretrievable commitments are not permanent; but are lost for a period of time. An irretrievable commitment of resources would apply to the loss of production or use of natural resources, such as plant communities disturbed during construction and not restored until construction activities are complete.

The construction or operation of the action alternatives would involve irreversible and irretrievable commitments of various resources that are either consumed, committed, or lost during the life of the project. The irreversible and irretrievable commitment of resources includes:

- Water Resources: Water diverted and evaporated or consumed under the proposed project would be irretrievably lost.
- Geology: Material excavated for use in construction of the reservoir dam would be irretrievably lost.
- Soils: Soils within the area of reservoir inundation would be irreversibly lost, while those temporarily disturbed during construction would be irretrievably committed for period of time, but productivity would be restored following construction.
- Construction materials: Use of aggregate, steel, concrete, and fossil fuels for facilities construction would be irreversibly lost.
- Cultural Resources: Construction may cause the incidental impact to cultural resources and nonrenewable resources could be lost.
- Vegetation, Wildlife Habitat, and Wetlands: Biotic resources would be irretrievably lost from construction of dams, inundation within the reservoir. Construction of the pipelines and other temporary disturbances would be a temporary irretrievable loss of vegetation, wildlife habitat, and wetlands that would be restored following construction.
- Visual: The substantial earthwork associated with reservoir construction would result in irreversible change to the scenic character of the landscape, while shorter term disturbances that are revegetated would be an irretrievable commitment of scenic resources for the period of disturbance.

3.25 Mitigation and Environmental Commitments Summary

The screening criteria described in the alternatives selection process in Chapter 2 were used to initially avoid and minimize the environmental impacts of the proposed project. Comments received on the Draft EIS from the public; federal, state, and local agencies; and cooperating agencies provided additional feedback on mitigation measures that would help reduce identified resource impacts (Volume 2–Appendix F). Since release of the Draft EIS, Reclamation and the Subdistrict have identified additional mitigation measures that would be implemented to minimize impacts of the Proposed Action. Table 3-164 provides a summary of resource impacts and associated mitigation commitments. Additional details on mitigation are included in the *Mitigation* section for each of the resources in Chapter 3. The FWMP prepared by the Subdistrict in cooperation with the CDPW and adopted by the Colorado Wildlife Commission (CWC) on June 9, 2011 and by the CWCB on July 13, 2011 in accordance with CRS § 37-60-122.2 is found in Appendix E. On October 6, 2011, Reclamation was notified by the State of Colorado (Hickenlooper, pers. comm. 2011) that the FWMP incorporated into and made a part of this EIS as Appendix E, comprehensively addresses impacts to Colorado's fish and wildlife resource and is the official position of the State with regard to mitigation of impacts from this project. The FWMP identified the minimum commitments to mitigate fish and wildlife impacts of the WGFP.

Reclamation will incorporate final mitigation measures into the Record of Decision. Reclamation will be responsible for enforcing the monitoring and mitigation measures that are finalized in the ROD. In the event that identified mitigation measures are unsuccessful in reducing or avoiding resource impacts as anticipated, Reclamation would coordinate with the Subdistrict and other appropriate entities to determine what steps should be taken to correct any deficiencies in planned mitigation or develop alternative methods to achieve mitigation objectives. If Reclamation receives credible information that the Subdistrict's operation of the WGFP is causing a violation of regulations established by the WQCC in accordance with CRS 25-8-101 et seq., Reclamation will immediately initiate discussions among the appropriate parties, including the WQCC and the entity or entities that submitted the information to Reclamation to develop a solution.

The Corps may require additional mitigation measures as part of their evaluation for compliance with Section 404 Clean Water Act requirements. The Corps will be responsible for enforcing mitigation measures that are included in the Section 404 permit for the WGFP.

It is probable that Reclamation's ROD and the Corps 404 permit will contain some of the same mitigation measures. In that case, Reclamation and the Corps will cooperate through their respective authorities to assure that the objective of the mitigation measure is accomplished.

Table 3-164. Mitigation and environmental commitments for the Proposed Action.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
1	**Surface Water Hydrology**		
1a	Reduced spills from Granby Reservoir to the Colorado River as a result of fewer Windy Gap spills.	None. *See Corps note below.	Existing Reclamation minimum flow releases below Granby Reservoir would be maintained. The hydrologic model overestimated the frequency of Granby Reservoir spills under existing conditions because the model does not have forecasting capabilities. Thus, actual change in spill frequency between existing conditions and the Proposed Action are anticipated to be less than the hydrologic model indicates.
1b	Reduced flows in Colorado River below Windy Gap diversion.	None. To assure that water diverted from the Colorado River is used as efficiently as possible; all Participants in the WGFP would be required to have water conservation plans in accordance with the requirements of CRS § 37-60-126 prior to the initial delivery of any water after construction of the WGFP. Reduced flows, as they affect temperatures in the Colorado River downstream of Windy Gap, are addressed in the FWMP developed with the CDPW and adopted by the CWC in accordance with the requirements of CRS § 37-60-122.2. See also Sections 3a and 4a-d below. *See Corps note below.	Current minimum bypass flows below Windy Gap Reservoir would continue per existing agreements except as modified by the FWMP.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
1c	Lower water levels in Granby Reservoir as a result of prepositioning.	In any year when Granby Reservoir is projected to fall below an elevation of 8,250 feet, modified prepositioning, which reduces the delivery of C-BT water from Granby Reservoir to Chimney Hollow Reservoir, would be implemented to maintain higher water levels in Granby Reservoir. Details of this measure would be developed by the Subdistrict and incorporated into a proposed agreement between Reclamation and the Subdistrict with evaluation by the Corps. The objective is to minimize the adverse effects of prepositioning on water levels in Granby Reservoir.	This measure would minimize any potential negative effects on aquatic resources and recreation in Granby Reservoir that may be caused by reduced water levels from prepositioning.
1d	Lower water levels in Carter Lake (~1 foot).	None. *See Corps note below.	Modified prepositioning as discussed in 1c above would result in less change in Carter Lake water levels (<1 foot lower) and thus only minor impacts.
1e	Lower water levels in Horsetooth Reservoir (6 feet lower on average).	None. *See Corps note below.	Modified prepositioning as discussed in 1c above would result in less change in Horsetooth Reservoir water levels (<2 feet lower) and thus only minor impacts.
2	**Ground Water**		
2a	Small changes in Colorado River, Willow Creek, and East Slope stream stage that would not significantly impact alluvial ground water levels.	None. *See Corps note below.	Minor impact.
2b	Small changes in surface water quality in West and East Slope streams and reservoirs would have minor effects on alluvial ground water quality.	None. *See Corps note below.	Negligible impact.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
3	**Stream Morphology and Floodplains**		
3a	A decrease in the frequency of 2-year peak discharge and in-channel maintenance flows in the Colorado River.	None. Any effect on fisheries from reduced flows are addressed in the FWMP developed by the Subdistrict and the CDPW and adopted by the CWC in accordance with the requirements of CRS § 37-60-122.2. *See Corps note below.	Flushing flows from the original Windy Gap Project (1980 MOU) would be modified to increase from 450 cfs to 600 cfs. In any year when flows below Windy Gap have not exceeded 600 cfs for at least 50 consecutive hours in the previous two years, and total Subdistrict water supplies in Chimney Hollow and Granby Reservoirs exceed 60,000 AF on April 1, the Subdistrict would cease all Windy Gap pumping for at least 50 consecutive hours to enhance peak flows below Windy Gap. The frequency of higher volume flows would remain sufficient for maintaining channel morphology. The capacity of the Colorado River would exceed that needed to convey the sediment load.
3b	Small decrease frequency of 2-year peak discharge and in-channel maintenance flows in Willow Creek.	None. *See Corps note below.	Minor impact.
3c	Potential for flooding along the Colorado River and Willow Creek would decrease.	None. *See Corps note below.	Potential for flooding would decrease.
3d	Increased flows on East Slope streams below Participant WWTPs could have slight effects on stream morphology.	None. *See Corps note below.	Potential effects negligible.
3e	Flows in East Slope streams would increase slightly.	None. *See Corps note below.	Potential effects negligible.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
4	**Surface Water Quality**		
4a	Colorado River temperature between Windy Gap Reservoir and Williams Fork may exceed the 18.2°C chronic MWAT or the 23.8°C DM state standard as a result of WGFP diversions that lower flows in the Colorado River. Impacts are most likely in the occasional years when WGFP diversions occur after July 15.	Effects of the WGFP on temperature in the Colorado River are addressed in the FWMP developed with the CDPW in accordance with CRS § 37-60-122.2. Temperature mitigation measures include, among other things, installation of real-time temperature monitoring stations at two locations on the Colorado River below Windy Gap and curtailment of diversions in accordance with the requirements of Section 5.3.3 of the FWMP. In addition, the Subdistrict would use the Windy Gap Project Bypass Valve and Auxiliary Outlet to the maximum extent practicable to release colder water without causing adverse effects to the Windy Gap Project facilities or operations for the bypass of water that is otherwise bypassed from the Windy Gap Project. Other temperature mitigation measures are detailed in Section 5.3.3 of the FWMP. These requirements would be documented in the contract negotiations or in a separate operating or working agreement between Reclamation and the Subdistrict. *See Corps note below.	Details of temperature mitigation are found in the FWMP in Appendix E.
4b	Additional WGFP pumping would increase nutrient (nitrogen and phosphorus) loading in Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake, resulting in increased chlorophyll *a* and manganese (Mn) concentrations and a decrease in dissolved (DO).	The Subdistrict would develop a proposed nutrient reduction mitigation plan for Reclamation and Corps evaluation. Currently, the Subdistrict's plan includes point source nutrient reductions from WWTP discharges in the Fraser River basin and nonpoint source nutrient reductions from agricultural land in the Willow Creek watershed. Other nutrient reduction measures would be implemented by the Subdistrict as necessary to meet the requirement to provide a documented nutrient reduction credit factor of 1:1 to satisfy Reclamation and Corps mitigation requirements.	Nutrient loading to the Three Lakes system from additional Windy Gap pumping would be offset by nutrient reductions that could occur in the Willow Creek, Fraser River, and Colorado River watersheds above Windy Gap. Nutrient reductions would result in a year-round improvement to water quality in streams where nutrient reduction measures are implemented.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
4c	Decrease in Colorado River DO below Windy Gap Reservoir. DO concentrations are predicted to remain above the 6.0 mg/L standard. DO could fall below the fish spawning standard of 7.0 mg/L between Windy Gap Reservoir and Williams Fork at low flows; however, reduced DO below the spawning occurring as a result of the WGFP is most likely to occur during the summer months outside of the spring and fall spawning seasons.	Mitigation for temperature (4a) and aquatic resource effects should improve and maintain DO levels above the state standard. Any plan to monitor and mitigate DO changes would be evaluated by the Corps. If DO concentrations fall below the standards and result in water quality standards violations that are attributable to Windy Gap Project pumping, Reclamation, the Corps, and the Subdistrict will discuss the violations and, if necessary, identify and implement additional mitigation measures to address the DO violations. *See Corps note below.	
4d	Higher concentration of nutrients in the Colorado River below Windy Gap Reservoir as a result of WGFP pumping that reduces dilution flows.	None. *See Corps note below.	Nutrient mitigation described in 4b in the watershed upstream of the Windy Gap diversion would improve Fraser River and Colorado River water quality year-round.
4e	Slight increase in nutrient and metal concentrations in Willow Creek.	None. *See Corps note below.	Nutrient mitigation described in 4b in the Willow Creek watershed would reduce nutrient loading to the creek. The nutrient mitigation plan required by 4b must be reviewed and evaluated by Reclamation and the Corps.
4f	Increased ammonia concentrations in St. Vrain Creek, Big Dry Creek, and Coal Creek as a result of increased discharges from Participant WWTPs.	None. *See Corps note below.	WGFP Participants would take appropriate actions, if needed, to meet ammonia discharge limitations in accordance with Colorado water quality standards and as part of their NPDES Permit for WWTP discharges.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
4g	Nutrient increases (TP, TN) resulting in higher chlorophyll *a* concentrations and a decrease in DO in Carter Lake and Horsetooth Reservoir.	None. In accordance with 4b above, plans to monitor and mitigate nutrient increases in the Three Lakes system should address this issue. The plan must be evaluated by Reclamation and the Corps. *See Corps note below.	Measures described in 4b would reduce nutrient loading to waters that would be moved from the West Slope to the East Slope. Any DO issues in Carter Lake or Horsetooth Reservoir would not be exacerbated as a result of the WGFP.
5	**Aquatic Resources**		
5a	Decrease in the amount and frequency of available fish habitat in the Colorado River and an increase in stream temperature.	The Subdistrict would provide mitigation in accordance with the FWMP developed with CDPW in accordance with CRS § 37-60-122.2. Measures identified in 4a above would address the effects of temperature increases on aquatic resources. *See Corps note below.	Bypass flows required at Granby Reservoir and Windy Gap Reservoir by existing agreements would continue. In addition, the Subdistrict would increase flushing flows as described above in 3a. The Subdistrict's FWEP endorsed by the Wildlife Commission does include a component for stream restoration of the Colorado River below Windy Gap. While these measures are outside of proposed mitigation for the WGFP, they would improve existing aquatic habitat.
5b	Decrease in the amount and frequency of available fish habitat in Willow Creek.	None. *See Corps note below.	Projected changes in aquatic habitat and slightly cooler water temperatures are not predicted to impact existing aquatic populations.
5c	Lower water levels in Granby Reservoir would slightly reduce available fish habitat.	Modified prepositioning (1c), per the FWMP developed in accordance with CRS § 37-60-122.2, would reduce drawdowns and the loss of habitat in Granby Reservoir. *See Corps note below.	
5d	Lower water levels in Carter Lake and Horsetooth Reservoir would slightly reduce available fish habitat.	Only a small decrease in Carter Lake and Horsetooth Reservoir water levels and fish habitat would occur with modified prepositioning as discussed for 1c. *See Corps note below.	

	Resource Impacts	Mitigation/Environmental Commitments	Notes
6	**Vegetation**		
6a	Temporary impact to 123 acres of vegetation during construction of Chimney Hollow Reservoir.	The Subdistrict would provide mitigation in accordance with the FWMP developed in accordance with CRS § 37-60-122.2. Such measures include restoration of temporary disturbances, weed control, and habitat enhancement measures. *See Corps note below.	Revegetation and weed control on all disturbed areas would be conducted in accordance with an erosion control plan to be developed by the Subdistrict and evaluated by Reclamation and the Corps.
6b	Permanent loss of 788 acres of vegetation from inundation and dam at Chimney Hollow.	The Subdistrict would provide mitigation in accordance with the FWMP developed in accordance with CRS § 37-60-122.2. Habitat enhancement measures on lands bordering the reservoir would be used to improve the quality of remaining habitat. The Subdistrict would provide $50,000 to Larimer County to use in their ongoing habitat management plan. *See Corps note below.	The Subdistrict would work with Larimer County and CDPW in developing a management plan for lands adjacent to Chimney Hollow Reservoir.
6c	Effects to riparian vegetation along the Colorado River from reduced streamflow.	None. *See Corps note below.	Expected effects to Colorado River riparian vegetation are predicted to be minor and not measurable because of small changes in stream stage and continued flows sufficient for channel maintenance. Additional flushing flows, as noted for 3a would help maintain riparian vegetation. While not a component of the mitigation plan the Subdistrict's FWEP includes funding for habitat restoration below Windy Gap Reservoir that may benefit riparian vegetation.
7	**Wetlands and Adjacent Riparian Habitats**		
7a	Temporary disturbance of about 0.2 acre of wetlands during Chimney Hollow Reservoir construction.	Avoid, minimize, and mitigate wetland impacts as specified in 33 CFR Part 332 (Mitigation Rule, 10-Apr-08) and as evaluated by Reclamation and the Corps. *See Corps note below.	Temporarily disturbed wetlands would be restored following construction.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
7b	Permanent impact to about 2 acres of wetlands at Chimney Hollow Reservoir.	Avoid, minimize, and mitigate wetland impacts as specified in 33 CFR Part 332 (Mitigation Rule, 10-Apr-08) and as evaluated by the Corps. *See Corps note below. Wetlands would be mitigated by contribution to an approved wetland mitigation bank. Habitat enhancement at Chimney Hollow Reservoir as identified in the FWMP may include wetland and riparian habitat creation on the lake shoreline. Any wetland creation work would need to be evaluated by Reclamation and the Corps.	Under modified prepositioning, as described for 1c, there would be greater water level fluctuations and lower water levels in Chimney Hollow Reservoir; thus establishment of shoreline wetlands may be difficult.
7c	Permanent impact to about 0.5 acre of waters of the U.S. along Chimney Hollow.	Avoid, minimize, and mitigate water impacts as specified in 33 CFR Part 332 (Mitigation Rule, 10-Apr-08) and as evaluated by the Corps. *See Corps note below.	Creation of large open water reservoir.
7d	Effects on wetlands adjacent to the Colorado River and downstream of the Windy Gap diversion.	None. The Corps will evaluate potential indirect impacts to adjacent wetlands as part of compliance with Clean Water Act 404 requirements.	Expected effects to Colorado River wetlands are predicted to be minor and not measurable because of small changes in stream stage and continued flows sufficient for channel maintenance. Additional flushing flows, as noted for 3a would help maintain wetland vegetation. While not a component of the mitigation plan the Subdistrict’s FWEP includes funding for habitat restoration below Windy Gap Reservoir that may benefit wetland vegetation.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
8	**Wildlife**		
8a	Loss of 810 acres of elk winter range, mule deer winter range and concentration area, and black bear foraging area at Chimney Hollow.	The FWMP developed and adopted in accordance with CRS § 37-60-122.2 includes habitat improvements and management measures that compensate for the loss of habitat. The mitigation plan developed in accordance with CRS § 37-60-122.2 will be submitted to the Fish and Wildlife Service to meet the requirements of the Fish and Wildlife Coordination Act. *See Corps note below.	A FWMP was prepared by the Subdistrict in cooperation with the CDPW and adopted by Colorado in accordance with CRS § 37-60-122.2 Larimer County, Subdistrict, and CDPW would coordinate details of wildlife management in concert with the Chimney Hollow recreation plan.
8b	General loss of habitat for other terrestrial species, birds, amphibians, reptiles, and butterflies at Chimney Hollow.	The FWMP developed in accordance with CRS § 37-60-122.2 includes habitat enhancement and other management actions to protect and improve wildlife habitat at Chimney Hollow Reservoir. Vegetation clearing would be conducted outside of the nesting season of protected bird species or the area would be surveyed prior to disturbance. A buffer would be maintained around active golden eagle nests during the breeding season. The mitigation plan developed in accordance with CRS § 37-60-122.2 will be submitted to the Fish and Wildlife Service to meet requirements for the Fish and Wildlife Coordination Act. *See Corps note below.	
8c	Loss of 7 acres of bald eagle winter range at Chimney Hollow.	None. *See Corps note below.	This effect is minor as there is sufficient bald eagle wintering habitat in the area. A new reservoir would provide open water foraging habitat for bald eagles.
9	**Threatened and Endangered Species**		
9a	No impact at Chimney Hollow.	None. *See Corps note below.	

	Resource Impacts	Mitigation/Environmental Commitments	Notes
9b	Depletion to Colorado River impacts T&E fish.	Section 7 consultation and compliance consistent with the requirements of the Programmatic Biological Opinion (PBO). The Service issued a Biological Opinion on February 12, 2010 for the Preferred Alternative indicating WGFP coverage under the PBO with participation in the Upper Colorado River Recovery Program and payment of depletion fee for additional depletions attributable to the WGFP. Documentation of Section 7 consultation will be submitted to the Corps in order to meet requirements for the Fish and Wildlife Coordination Act. *See Corps note below.	
10	**Geology**		
10a	Potential for uncovering fossils during Chimney Hollow Reservoir construction.	A paleontological survey would be conducted prior to construction and the Denver Museum would be contacted if important fossils are discovered. Paleontological resources would be dealt with in accordance with the MOA or PA between Reclamation, the State Historic Preservation Officer, the Subdistrict, and possibly the Advisory Council.	
11	**Soils**		
11a	Temporary and permanent loss of soil during Chimney Hollow Reservoir construction.	Erosion control and revegetation.	
11b	Shoreline erosion at Chimney Hollow Reservoir.	None.	
12	**Air Quality**		
12a	Dust and vehicle emissions during Chimney Hollow Reservoir construction.	A fugitive particulate emissions control plan and BMPs would be developed in order to meet requirements for Colorado Air Quality Control Standards. *See Corps note below.	
12b	Increased ambient noise from construction of Chimney Hollow Reservoir.	BMPs to minimize noise.	

	Resource Impacts	Mitigation/Environmental Commitments	Notes
13	**Land Use**		
13a	A portion of Chimney Hollow would be on private property or Larimer County property.	Private land acquisition or the necessary access rights and easements.	
13b	A portion of Chimney Hollow Reservoir facilities would be on Reclamation property.	Easements or appropriate permits from Reclamation would be acquired.	
13c	Sandstone quarry operations could be affected by the southern access road to Chimney Hollow Reservoir.	Quarry access would be maintained.	
13d	Increased construction traffic on CR 18E and CR 31 and impacts to roads during reservoir construction and from recreation access to Chimney Hollow Open Space managed by Larimer County.	The Subdistrict would comply with all County road and permitting requirements.	
14	**Recreation**		
14a	Reduction in preferred kayaking flow days in Byers Canyon.	None.	In 29 of 47 years in the period of record, there would be no change in preferred kayaking flows. In other years, there would be a slight decrease in the average number of days per year with preferred kayaking flows.
14b	Preferred rafting and kayaking flows in Big Gore and Pumphouse of the Colorado River would decrease.	None, except WGFP diversions would be suspended during the Gore Race in August if flows drop below the preferred range (1,250 cfs).	The WGFP would both decrease and increase by less than 3 days per year, on average, the number of days within the preferred boating flow range. Curtailment of WGFP for temperature mitigation per 4a above may periodically increase summer flows.

	Resource Impacts	Mitigation/Environmental Commitments	Notes
14c	Access to Granby Reservoir boat ramps at Arapaho Bay, Stillwater, and Sunset could diminish in some months.	None. Modified prepositioning discussed in 1c would maintain higher water levels in Granby Reservoir during years when the reservoir is anticipated to fall below an elevation of 8,250 feet, thereby improving boat ramp access.	All boat ramps are expected to remain accessible throughout the recreation season with mitigation.
14d	Access to the South Bay-South boat ramp in Horsetooth could be impacted.	Modified prepositioning would maintain higher water levels in Horsetooth Reservoir. Boat ramp access would not change with mitigation.	
14e	Effects on recreational fishing in the Colorado River downstream of the Windy Gap diversion from habitat loss and temperature impacts between Windy Gap and the Blue River.	Stream temperature mitigation measures in the FWMP developed in accordance with CRS § 37-60-122.2 would reduce impacts to fish. Mitigation proposed under aquatic resources and the mitigation plan developed in accordance with CRS § 37-60-122.2 should improve Colorado River downstream of Windy Gap for fishing. *See Corps note below.	The Subdistrict's FWEP includes funding for habitat restoration below Windy Gap Reservoir that would benefit aquatic habitat between Windy Gap and the Kemp Breeze State Wildlife Area.
15	**Cultural Resources**		
15a	Twenty-four eligible or potentially eligible cultural resources could be impacted by construction of Chimney Hollow Reservoir.	Compliance with Section 106 of the National Historic Preservation Act including additional evaluation and mitigation will be conducted in coordination with Reclamation, the Corps, and SHPO. Cultural resources would be dealt with in accordance with a Programmatic Agreement or MOA to be developed and signed by Reclamation, the SHPO, and the Subdistrict.	
16	**Visual Quality**		
16a	Temporary impacts from construction of Chimney Hollow Reservoir.	Revegetation and BMPs.	
16b	Permanent changes in landscape.	Revegetation, weed control, and maintenance.	
16c	Relocation of transmission line	A visual sensitivity analysis was conducted in siting relocated transmission line. Nonspecular, nonreflective wire would be used and possibly nonreflective steel poles. All site disturbances would be revegetated following construction.	

	Resource Impacts	Mitigation/Environmental Commitments	Notes
17	**Socioeconomics**		
17a	Property acquisition.	Any properties required to be purchased for the project would be purchased for just compensation following an appraisal in accordance with the Water Conservancy Act (CRS § 27-45-101 to 153) and other applicable state laws.	
17b	Lost recreational boating value in the Colorado River in some years due to lower flows.	None. The Subdistrict would curtail diversion during the Gore Race as needed per 14b to avoid socioeconomic effects associated with this event.	Although preferred boating flows are not always met, rafting and kayaking opportunities would remain (i.e., flows would rarely drop below the minimum flows needed for boating). Curtailed WGFP diversions for temperature mitigation as noted in 4a would increase Colorado River flows in some years.
17c	Reduction in aesthetic value in Grand Lake if algae concentrations increase.	Nutrient mitigation measures discussed in 4b would offset nutrient loading from increased WGFP pumping that could contribute to algae growth.	

* Any submittals required by this mitigation plan will be evaluated by the Corps for compliance with Section 404 Clean Water Act requirements. With some resource issues, the Corps may require additional mitigation measures.

Mitigation Submittals

In addition to specific measures identified in the above table, the following submittals must be developed by the Subdistrict and presented to Reclamation and the Corps for approval. Approval of the submittals will constitute approval of the mitigation for the particular resource addressed in the submittal. After the mitigation is implemented, both Reclamation and the Corps must approve the work. After all of the individual measures identified in the above table are implemented, submittals have been approved, implemented, and the implementation approved by Reclamation and the Corps, mitigation for the proposed WGFP will be considered complete.

Mitigation requirements for the WGFP will be documented in the Record of Decision, contract negotiations, and in a separate operating or working agreement between Reclamation and the Subdistrict.

1. Reduced flows on Colorado River (1b): To assure that additional water made available by the WGFP is used as efficiently as possible on the East slope, the Subdistrict will submit documentation to Reclamation and the Corps that each Participant in the WGFP has a Water Conservation Plan in accordance with the requirements of CRS § 37-60-126 prior to the initial delivery of any water after construction of the WGFP.
2. Granby Reservoir elevations (1c, 14c): Specific proposed operating procedures to be implemented when Granby Reservoir is projected to fall below an elevation of 8,250 feet of any year.
3. Effects on wetlands and adjacent riparian habitats (6c, 7d): If the Corps determines that additional mitigation is necessary for effects to wetlands and riparian habitats downstream of the Windy Gap diversion for compliance with the 404(b)(1) guidelines and other 404 regulations, the Subdistrict will develop a plan to mitigate these effects and submit it to Reclamation and the Corps for evaluation.
4. Nutrient reduction plan (4b): The Subdistrict will develop and submit to Reclamation and the Corps for approval a plan that would result in a documented nutrient reduction credit factor of 1:1 (e.g., 1 unit of predicted nitrogen and phosphorus reductions due to facility enhancements and operational changes afford the project 1 unit of credit for nutrient mitigation). The plan will be submitted to Reclamation and the Corps for approval and will be implemented, with the documented nutrient reductions, prior to the completion of construction. The plan must reduce nutrients sufficiently to meet Reclamation and Corps requirements. The plan can include any combination of permanent land use changes and/or physical improvements to existing WWTPs to decrease nutrient loading to the Three Lakes System. If a 1:1 reduction cannot be documented, additional measures would be evaluated and implemented as agreed to by Reclamation, the Corps, and the Subdistrict.
5. Vegetation (6a): A revegetation plan for areas affected by construction activities to be evaluated by Reclamation, the Corps, and the CDPW.
6. *Fish and Wildlife Mitigation Plan* in accordance with CRS § 37-60-122.2: A (1b, 3a, 4a, 5a, 5b, 5c, 5d, 6b, 6c, 7b, 7d, 8a, 8b, and 14e), a copy of the mitigation plan adopted by the Colorado Wildlife Commission and CWCB will be used in further coordination with the Fish and Wildlife Service and compliance with the requirements of the Fish and Wildlife Coordination Act (FWCA). If the Fish and Wildlife Service makes additional mitigation recommendations in the FWCA Report, Reclamation and the Corps will fully consider the recommendations and incorporate appropriate measures into the Record of Decision.