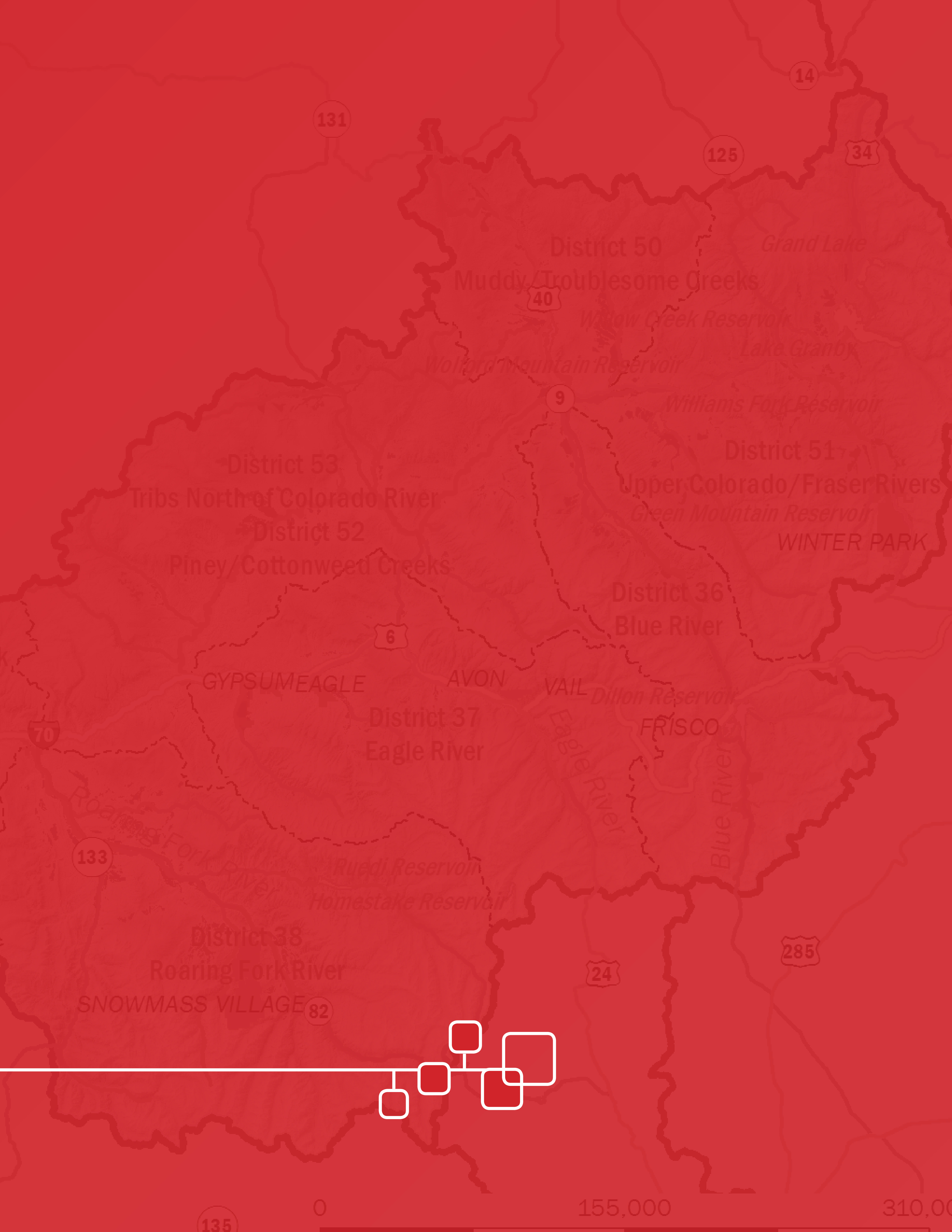
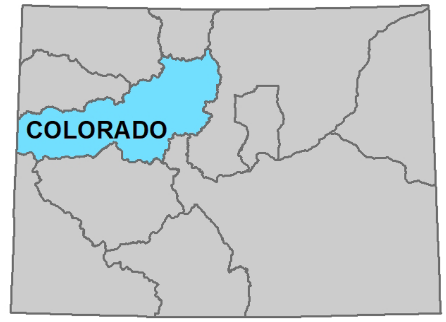
The mainstem Colorado Basin in Colorado encompasses approximately 9,830 square miles and extends from Rocky Mountain National Park to the Colorado-Utah state line. Elevations range from more than 14,000 feet to about 4,300 feet. Snowpack in the high country is an important water source to both sides of the Continental Divide, as the state's largest transbasin diversions are here. Ranching and livestock production typify agriculture in the upper reaches, while the Grand Valley has a long history of fruit and vegetable production. With major ski areas as well as boating and fishing opportunities, water drives a robust recreation and tourism economy throughout the basin.

COLORADO


District 50
Muddy/Troublesome Creeks
District 51
Upper Colorado/Fraser Rivers
District 53
Tribs North of Colorado River
District 52
Piney/Cottonwood Creeks
District 36
Blue River
District 37
Eagle River
District 38
Roaring Fork River
Grand Lake
Willow Creek Reservoir
Lake Granby
Wolford Mountain Reservoir
Williams Fork Reservoir
Green Mountain Reservoir
WINTER PARK
GYPSUM
EAGLE
AVON
VAIL
Dillon Reservoir
FRISCO
Eagle River
Blue River
Roaring Fork River
Ruedi Reservoir
Homestake Reservoir
SNOWMASS VILLAGE
131
14
125
34
40
9
6
70
133
82
24
285
135
0
155,000
310,00

4.4 COLORADO BASIN RESULTS

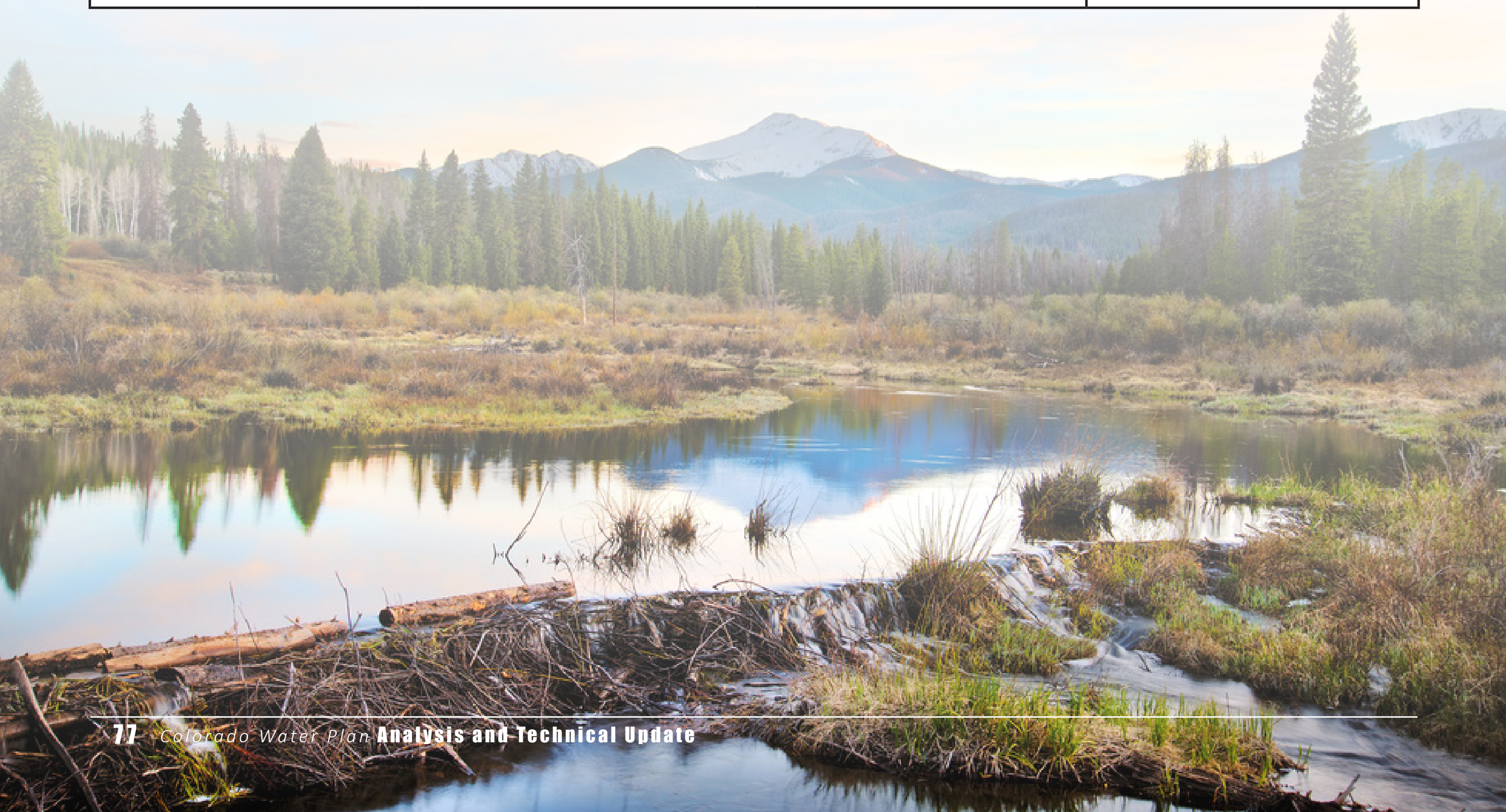


4.4.1 BASIN CHALLENGES

Key future water management issues in this basin include competing resources for agriculture, tourism and recreation, protection of endangered species, and the threat of a Colorado River Compact call. These challenges are described in Colorado's Water Plan and summarized below in Table 4.4.1.

Table 4.4.1 Key Future Water Management Issues in the Colorado Basin

Agriculture	Environment and Recreation	Municipal and Industrial	Compacts and Administration
• Despite the importance of agriculture, continued urbanization of agricultural lands could reduce irrigated acres in the basin.	• Success of the Upper Colorado River Endangered Fish Recovery Program is vital to the river's future. The program is designed to address the needs of endangered fish while protecting existing and future use of Colorado River water. • Recreational use and environmental conservation are major drivers in the basin and are important for economic health and quality of life.	• Development of conditional transbasin water rights is a concern, and Colorado must consider the effect on in-basin supplies.	• There is concern over a potential compact shortage during severe and sustained drought and the potential effects to in-basin supplies. Demand management to conserve water per the recently signed Drought Contingency Plan is a pressing issue.
• Selenium and salinity are of concern in parts of the basin.			



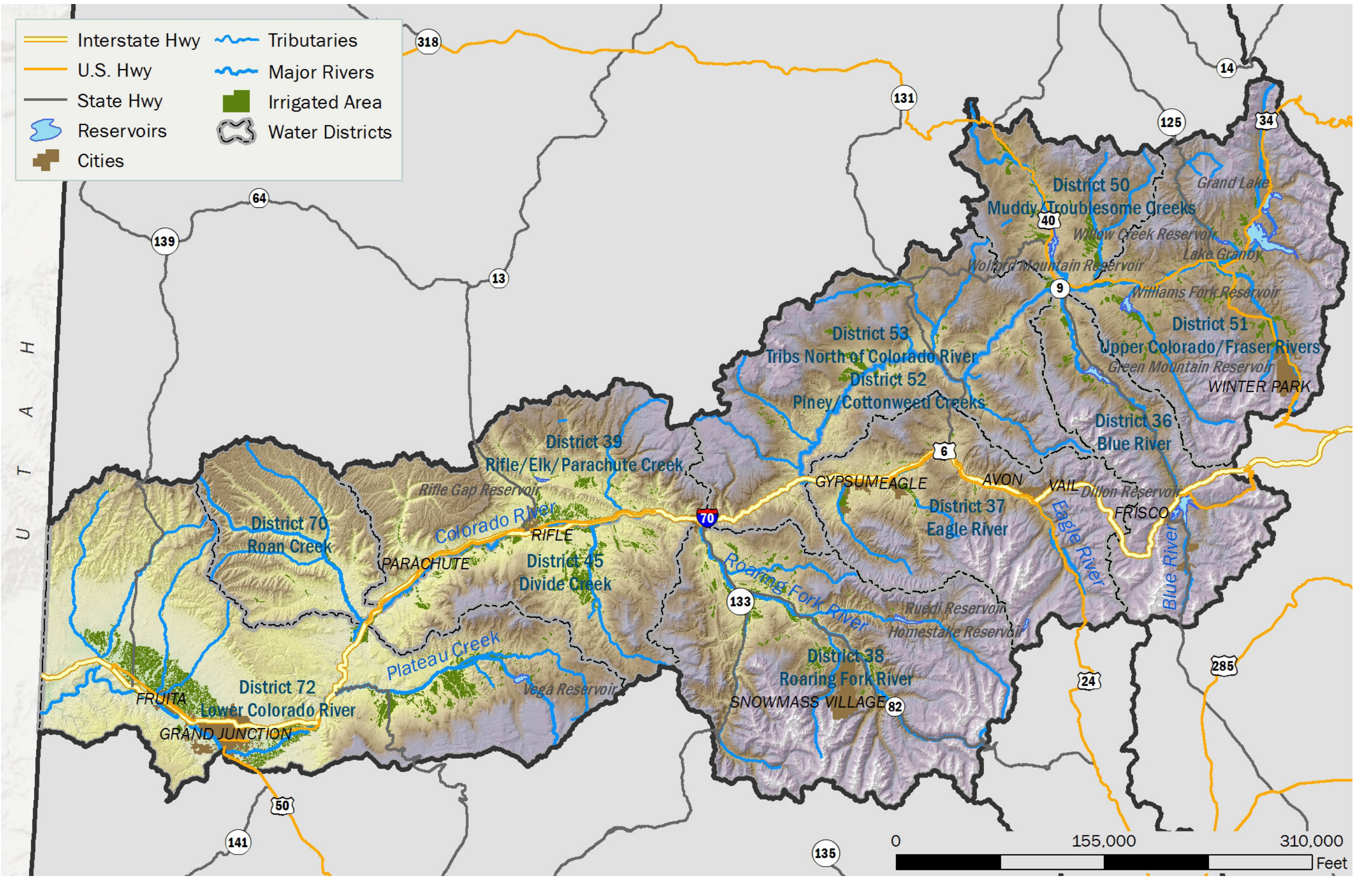


Figure 4.4.1 Map of the Colorado Basin

4.4.2 SUMMARY OF TECHNICAL UPDATE RESULTS

Key results and findings of the Technical Update pertaining to agricultural and M&I demands and gaps, as well as findings related to environmental and recreational attributes and future conditions, are summarized below in Table 4.4.2.

Table 4.4.2 Summary of Key Results in the Colorado Basin

Agriculture	Environment and Recreation	Municipal and Industrial
• Although irrigated area is estimated to decrease by 13,600 acres as cities expand onto irrigated land, IWR may increase in a warmer future climate. • Emerging technology, including adoption of higher system efficiencies, may mitigate climate impacts and reduce demand below baseline. • The future incremental gap ranges from 0 to 4 percent of baseline demand • Scenarios that assume current climate conditions (Business as Usual and Weak Economy) have agricultural gaps around 3 percent of demand. Gaps (as a percentage of demand) increase in scenarios that assume a warmer and drier future climate.	• In climate-impacted scenarios, peak flow generally moves earlier in the year. • Aquatic and riparian attributes may be affected differently based on location and potential changes in stream flow magnitude and timing.	• Per capita municipal usage is projected to decrease in the future. • Municipal demand is projected to increase for all scenarios due to increased population; however, except for Hot Growth, the systemwide demand projections for all future scenarios are similar, showing that pairing of drivers and population can offset each other and even out the results. • Increases in SSI demands in Business as Usual and Hot Growth represent anticipated energy development.

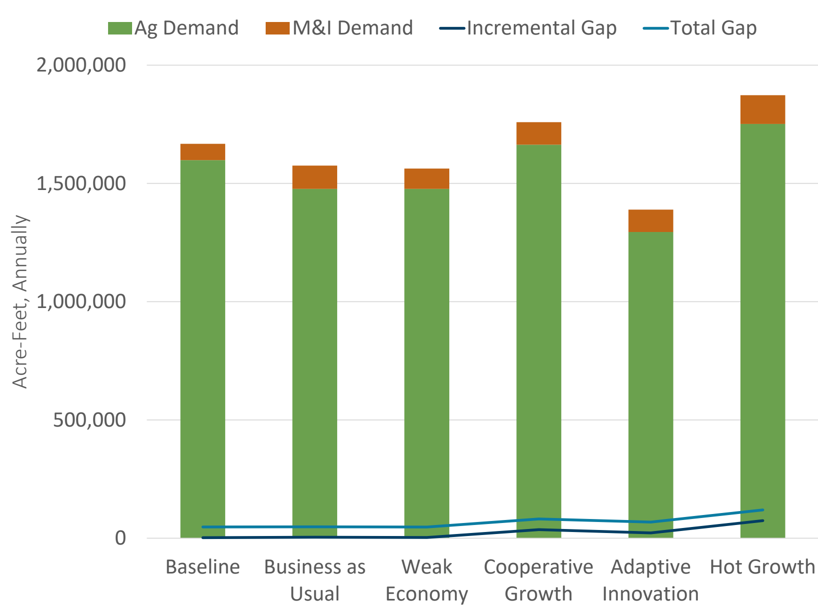
Results describing current and potential future M&I and agricultural demands and gaps are summarized in Table 4.4.3 and in Figure 4.4.2.

Table 4.4.3 Summary of Diversion Demand and Gap Results in the Colorado Basin

	Current (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average Annual Demand						
Agricultural (AFY)	1,598,900	1,476,800	1,476,800	1,663,800	1,294,900	1,751,600
M&I (AFY)	68,500	98,400	85,800	95,400	94,500	121,400
Gaps						
Ag (avg %)	3%	3%	3%	5%	5%	6%
Ag (incremental-AFY)	-	-	-	30,900	16,200	58,500
Ag (incremental gap as % of current demand)	-	0%	0%	2%	1%	4%
M&I (max %)	0%	4%	4%	6%	7%	13%
M&I (max-AF)	0*	4,200	3,300	5,300	6,600	15,800

**CDSS water allocation model in this basin calculates small baseline M&I gaps, but they are either due to calibration issues or they are reflective of infrequent, dry-year shortages that are typically managed with temporary demand reductions, such as watering restrictions.*

Figure 4.4.2 Summary of Diversion Demand and Gap Results in the Colorado Basin



Summary of Environmental and Recreational Findings

- In climate-impacted scenarios, peak flow is projected to move earlier in the year, with March, April and May flows increasing substantially and June flows decreasing; possible mis-matches between peak flow timing and species' needs may occur. Flow magnitude could decrease some, but peak-flow risk for plants and fish is projected to remain moderate.
- In some areas (e.g., Crystal River above Avalanche Creek near Redstone), peak flow magnitude is projected to increase substantially, potentially over-widening the creek channel and causing habitat issues during low-flow periods.
- Under *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*, mid- and late-summer flows may be reduced by 60 to 70 percent and create high risk for fish from loss of habitat and, in trout regions, high water temperatures.
- Downstream from major reservoirs (e.g., Frying Pan, Green Mountain), diminished peak flows could create high to very high risk for riparian/wetland vegetation and fish habitat if sediment is not flushed, while consistent mid- and late-summer flows could keep risk to fish low to moderate.

- Several recreational in-channel diversions and Instream Flow water rights may be unmet more often with diminished June to August flows.
- In critical habitat for endangered species, highly reduced flows in mid- and late-summer will make it more difficult to meet flow recommendations.

4.4.3 NOTABLE BASIN CONSIDERATIONS

Section 4.1 described several analysis assumptions and limitations that apply to all basins and should be considered when reviewing and interpreting analysis results. Additional considerations specific to the Colorado Basin are listed below:

- The Colorado River Model includes operations that allow Ruedi Reservoir, Wolford Mountain Reservoir, and Green Mountain Reservoir to make releases from their contract accounts to meet M&I demands aggregated by location throughout the basin. In most years, these contract supplies are sufficient to meet the projected M&I demands in the planning scenarios.
- Historical transbasin diversions from the Colorado Basin are included in the model as an export demand. In certain planning scenarios, the export demand cannot be fully met as a result of changed hydrology or increased agricultural demands of senior water users. When this occurs, the export demand is shorted in the Colorado Basin model, and that shortage is reflected on the East Slope as reduction in transbasin imports.
- Water demands for energy development were based primarily on SWSI 2010 data and were varied based on the language in each scenario. The demand data were not updated per Technical Advisory Group input because estimates of water needs have varied substantially, and defendable updated datasets are not currently available.

4.4.4 AGRICULTURAL DIVERSION DEMANDS

The irrigated agriculture industry across the Colorado Basin is highly diverse. Large ranching operations dominate agriculture in the basin's higher elevations, particularly around the towns of Kremmling, Collbran, and Rifle. Farming regions focused on the cultivation of fruits, vegetables, and alfalfa are more prevalent in the lower basin due to a longer growing season and warmer summer temperatures. The largest of these farming operations, the Grand Valley Project, irrigates about a quarter of the 206,700 acres irrigated in the entire basin. Mixed between these agricultural operations are many growing municipalities, such as Grand Junction.

Planning Scenario Adjustments

Section 2 described ways in which inputs to agricultural diversion demand estimates were adjusted to reflect the future conditions described in the planning scenarios. Adjustments in the Colorado Basin focused on urbanization, potential future climate conditions, and implementation of emerging technologies.

2050 population projections reflect significant increases for counties across the Colorado Basin. The impact of urbanization, however, is tied to the proximity of existing municipalities to agricultural operations. The impact of urbanization to resort communities, such as the towns of Winter Park, Breckenridge, Glenwood Springs, Snowmass Village, Vail and Avon, is limited due to lack of adjacent irrigated acreage to urbanize. The impact of urbanization is expected to be much larger in agricultural-based communities, such as Fruita, Grand Junction, Palisade, Eagle, and Rifle. In total, nearly 14,000 acres of irrigated land are expected to be urbanized, with one-third of that expected to occur in municipalities located within the Grand Valley Project and Grand Valley Irrigation Company service areas.

IWR could increase in this basin due to climate change by 20 percent and 31 percent on average in the "In-Between" and "Hot and Dry" climate projections, respectively.

In *Adaptive Innovation*, in addition to assuming reduced IWR, the average irrigation efficiency was assumed to increase by 10 percent. Irrigation systems efficiencies vary across the Colorado Basin depending upon irrigation infrastructure and practices, averaging just under 30 percent basinwide. System efficiencies were increased by 10 percent for ditches that provide water solely for irrigation purposes in *Adaptive Innovation*. Structures that carry water both for irrigation and for other purposes (e.g., power operations) were not adjusted.

Table 4.4.4 summarizes the planning scenario adjustments described above and other adjustments that impact agricultural diversion demands in the various scenarios.

Table 4.4.4 Planning Scenario Adjustments for Agricultural Demands in the Colorado Basin

Adjustment Factor	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Change in Irrigated Land due to Urbanization	13,600 Acre Reduction	13,600 Acre Reduction	13,600 Acre Reduction	13,600 Acre Reduction	13,600 Acre Reduction
IWR Climate Factor	-	-	20%	31%	31%
Emerging Technologies	-	-	-	10% IWR Reduction 10% System Efficiency Increase	-

See section 2.2.3 for descriptions of adjustment methodologies and assumptions.

Agricultural Diversion Demand Results

Table 4.4.5 and Figure 4.4.3 summarize the acreage, IWR, and the agricultural diversion demand for surface water supplies in the Colorado Basin for current conditions and the five planning scenarios. Demand is lower than current conditions in *Business as Usual* and *Weak Economy*, because irrigated acreage is projected to be urbanized. Although *Cooperative Growth* and *Hot Growth* feature the same reduction in irrigated acres, higher IWR could drive demand above current levels. In *Adaptive Innovation*, the reduction in IWR, increase in system efficiency, and reduction in acreage results in the lowest demand among all scenarios even with the potential effects of a hotter and drier climate.

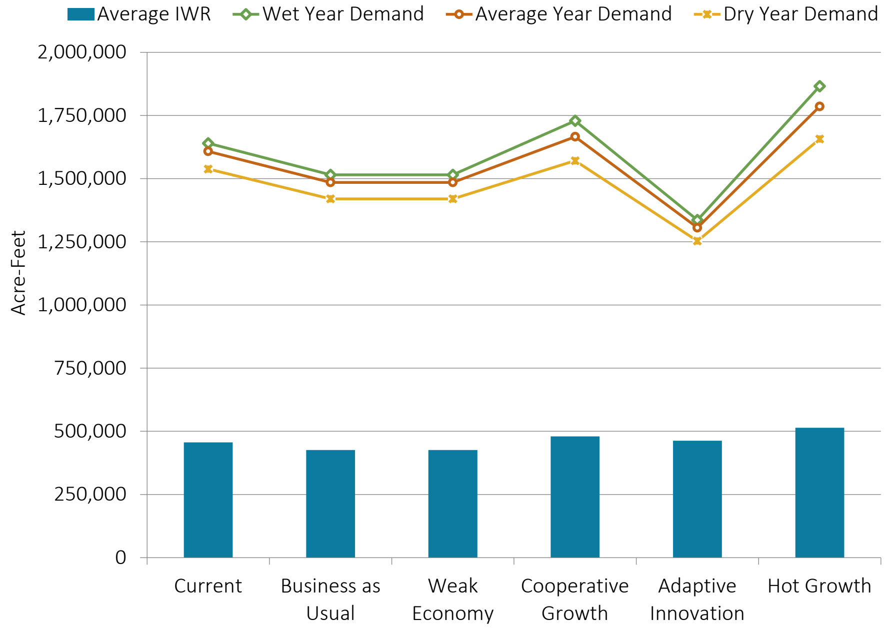
SYSTEM EFFICIENCY

In some cases, diversion demands can be higher in wet years because system efficiency decreases due to the relative abundance of supply.

Table 4.4.5 Summary of Agricultural Diversion Demand Results in the Colorado Basin

	Current (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Irrigated Acreage (acres)	206,700	193,100	193,100	193,100	193,100	193,100
Average IWR (AFY)	456,500	426,000	426,000	480,000	463,000	514,000
Diversion Demand						
Average Year (AFY)	1,608,000	1,485,000	1,485,000	1,666,000	1,306,000	1,786,000
Wet Yr. Change	2%	2%	2%	4%	2%	4%
Dry Yr. Change	-4%	-4%	-4%	-6%	-4%	-7%

Figure 4.4.3 Agricultural Diversion Demands and IWR Results in the Colorado Basin



4.4.5 Municipal and Self-Supplied Industrial Diversion Demands

Population Projections

The Colorado Basin includes about 6 percent of the statewide population. Between the years 2015 and 2050, it is projected to grow from approximately 310,000 to between 460,000 and 580,000 people in the low and high growth projections, respectively. Using the specific numbers, this is an increase in population of 48 percent to 88 percent. Table 4.4.6 shows how population growth is projected to vary across the planning scenarios for the Colorado Basin.

Table 4.4.6 Colorado Basin 2015 and Projected Populations

Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
307,600	515,500	456,300	549,200	572,900	577,800

Current Municipal Demands

The Colorado Basin baseline water demands were largely based on water-provider-reported data, with approximately 43 percent of the baseline population demands represented by WEPs, 25 percent from 1051 data, and 9 percent from BIPs. The remaining baseline water demand had to be estimated. Figure 4.4.4 shows the proportions of each data source among all sources.

Figure 4.4.4 Sources of Water Demand Data in the Colorado Basin

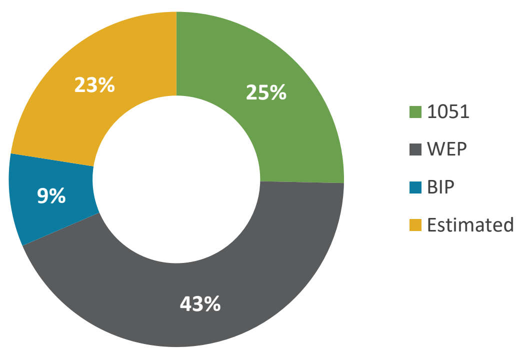


Figure 4.4.5 shows the proportion of each category of municipal baseline water usage in the Colorado Basin. On a basin scale, the residential indoor demand as a percentage of the systemwide demands are relatively high, at 44 percent of the systemwide demands.

Figure 4.4.5 Categories of Municipal Water Usage in the Colorado Basin

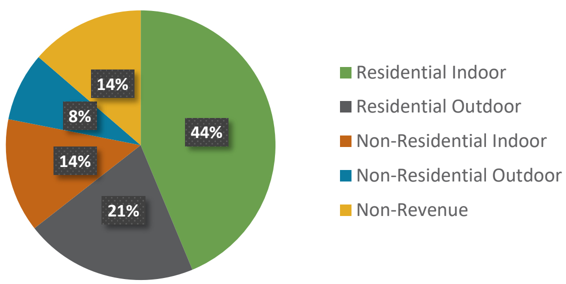
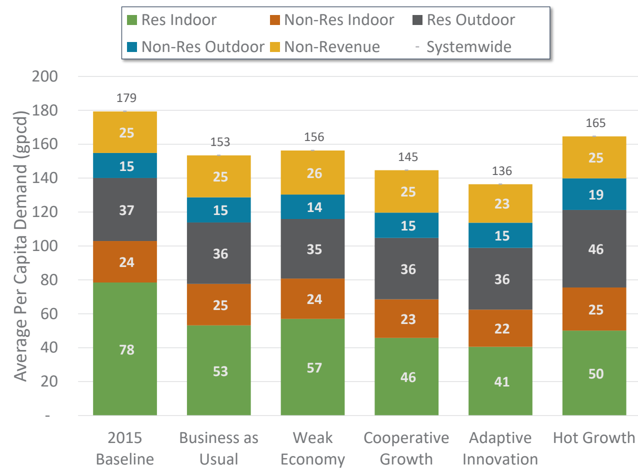


Figure 4.4.6 Colorado Basin Municipal Baseline and Projected per Capita Demands by Water Demand Category



Projected Municipal Demands

Figure 4.4.6 provides a summary of per capita baseline and projected water demands for the Colorado Basin.

Systemwide, all of the projected total per capita demands are projected to decrease relative to the baseline. Consistently across all scenarios, residential indoor demand is the greatest individual demand category while non-residential outdoor is the lowest. Aside from *Hot Growth*, there is minimal variation in outdoor demands across scenarios. This is due to the scenario pairing of water demand reductions and climate drivers, particularly for *Adaptive Innovation,* which has high outdoor reductions coupled with the "Hot and Dry" climate. Outdoor demands increased significantly for the *Hot Growth* scenario, due to an increase in outdoor demands coupled with the "Hot and Dry" climate.

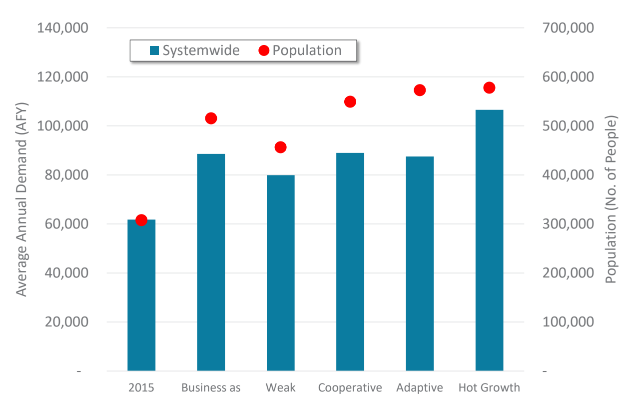
The Colorado Basin municipal baseline and projected diversion demands provided in Table 4.4.7 show the combined effect of population and per capita demands. Municipal demands are projected to grow from approximately 62,000 AFY in 2015 to between 80,000 and 107,000 AFY in 2050. Mesa County accounts for about 28 percent of the baseline demand, followed by Garfield County at about 23 percent of the basin demand.

Table 4.4.7 Colorado Basin Municipal Baseline and Projected Demands (AFY)

Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
61,800	88,600	79,900	89,000	87,500	106,600

Figure 4.4.7 shows baseline and projected diversion demand by scenario, as well as population for each scenario. All projection scenarios result in an increase relative to the baseline. Except for *Hot Growth*, the systemwide demand projections for all the Colorado Basin scenarios are similar, which demonstrates how the pairing of drivers and population can offset each other and even out the results.

Figure 4.4.7 Colorado Basin Baseline and Projected Population and Municipal Demands



Self-Supplied Industrial Demands

The Colorado Basin currently includes about 4 percent of the statewide SSI demand. SSI demands in this basin are associated with the large industry, snowmaking, and energy development sub-sectors, with no demands projected for the thermoelectric sub-sector. Basin-scale SSI demands are shown on Figure 4.4.8 and summarized in Table 4.4.8.

Large-industry demands are related to a mining facility in Grand County. This facility was not represented in SWSI 2010 but was added because it is a significant use. Projected large-industry demands range from 1,530 AFY to 1,870 AFY.

The baseline snowmaking demand is 4,340 AFY as compared to 3,180 AFY in SWSI 2010. Projected demands increase to 5,890 AFY under all scenarios.

Energy development demands are located in Garfield and Mesa counties. The baseline energy development demand in the Colorado Basin has been updated to 1,800 AFY from 2,300 AFY in SWSI 2010. Projected demands range from 200 AFY to 10,700 AFY.

Figure 4.4.8 Colorado Basin Self-Supplied Industrial Demands

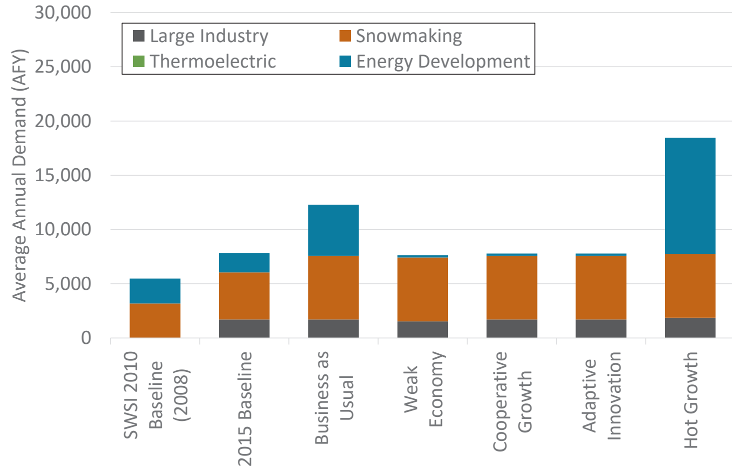


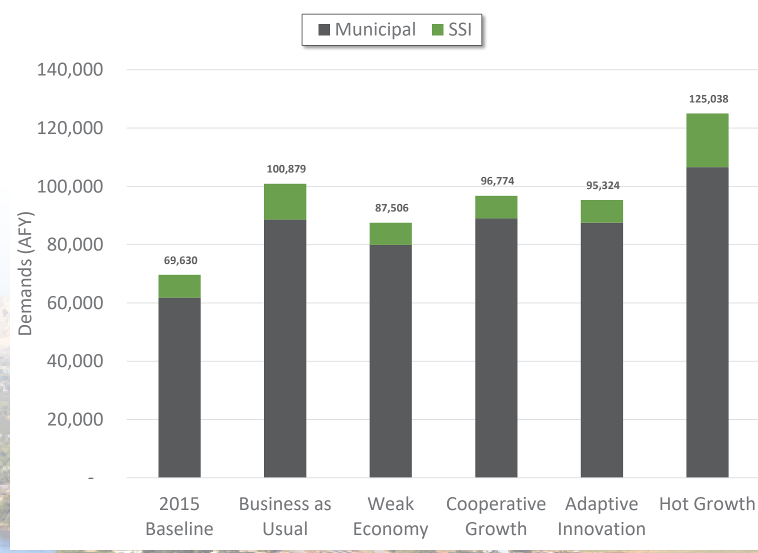
Table 4.4.8 Colorado Basin SSI Baseline and Projected Demands (AFY)

Sub-sector	Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Large Industry	1,700	1,700	1,530	1,700	1,700	1,870
Snowmaking	4,340	5,890	5,890	5,890	5,890	5,890
Thermoelectric	0	0	0	0	0	0
Energy Development	1,800	4,700	200	200	200	10,700
Sub-Basin Total	7,840	12,290	7,620	7,790	7,790	18,460

Total M&I Diversion Demands

Colorado Basin combined M&I diversion demand projections for 2050 range from approximately 88,000 AFY in *Weak Economy* to 125,000 AFY in *Hot Growth*, as shown in Figure 4.4.9. SSI demands account for between 8 and 15 percent of M&I demands. On a basin scale, the demand projections do not follow the statewide sequence of the scenario rankings described in the Water Plan, with *Adaptive Innovation* falling out of sequence.

Figure 4.4.9 Colorado Basin Municipal and Self-Supplied Industrial Demands



4.4.6 Water Supply Gaps

The agricultural and M&I diversion demands were compared against available water supply modeled for current conditions and the five planning scenarios. Gaps were calculated when water supply was insufficient to meet demands.

> **INCREMENTAL GAP**
>
> The incremental agricultural gap quantifies the degree to which the gap could increase beyond what agriculture has historically experienced under water shortage conditions.

Agricultural

The Colorado Basin agricultural diversion demands, demand gaps, and consumptive use gaps for the baseline and planning scenarios are presented in Table 4.4.9 and illustrated on Figure 4.4.10. An annual time series of gaps in terms of percent of demand that was unmet is shown on Figure 4.4.11.

Table 4.4.9 Colorado Basin Agricultural Gap Results (AFY)

		Scenario					
		Scenario	**Business as Usual**	**Weak Economy**	**Cooperative Growth**	**Adaptive Innovation**	**Hot Growth**
Average	Average Annual Demand	1,598,900	1,476,800	1,476,800	1,663,800	1,294,900	1,751,600
	Average Annual Gap	45,300	44,994	43,000	76,200	61,500	103,800
	Average Annual Gap Increase from Baseline	-	-	-	30,900	16,200	58,500
	Average Annual Percent Gap	3%	3%	3%	5%	5%	6%
	Average Annual CU Gap	25,100	24,400	24,400	42,400	40,400	57,800
Maximum	Demand in Maximum Gap Year	1,598,800	1,477,500	1,477,500	1,587,200	1,258,000	1,668,300
	Gap in Maximum Gap Year	148,000	141,100	141,000	166,500	131,400	210,400
	Increase from Baseline Gap	-	-	-	18,500	-	62,400
	Percent Gap in Maximum Gap Year	9%	10%	10%	10%	10%	13%

Study period for Water Supply analysis is 1975-2013, reflecting different baseline demand than described in Agricultural Diversion Demands section.

Figure 4.4.10 Projected Average Annual Agricultural Diversion Demand, Demand Met, and Gaps in the Colorado Basin

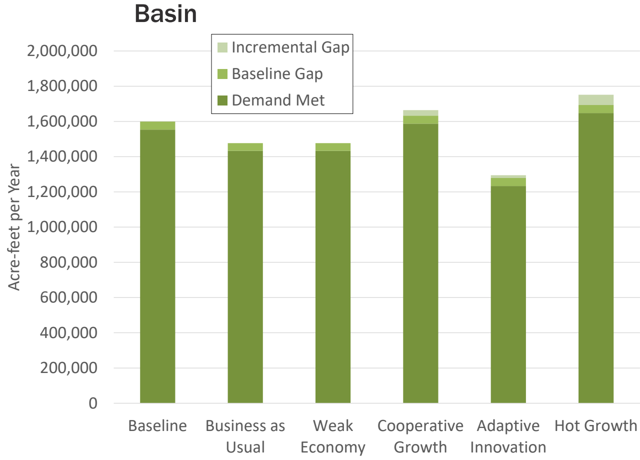
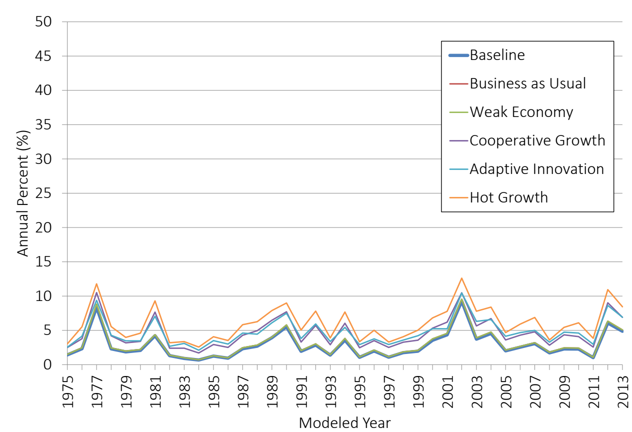


Figure 4.4.11 Annual Agricultural Gaps (expressed as a percentage of demand) for Each Planning Scenario



The following are observations on agricultural diversion demands and gaps:

- Although irrigated area is estimated to decrease by 13,600 acres as cities expand onto irrigated land, basin-wide IWR and diversion demand may increase in a warmer future climate.
- Emerging technologies, including the adoption of more efficient irrigation practices, modernizing irrigation infrastructure (e.g., automation) and crops with lower irrigation requirements, may mitigate climate impacts and reduce demand below baseline.
- The future incremental gap ranges from 0 to 4 percent of baseline demand.
- Scenarios that assume current climate conditions (*Business as Usual* and *Weak Economy*) have agricultural gaps around 3 percent of demand. Gaps (as a percentage of demand) increase in scenarios that assume a warmer and drier future climate.

M&I

The diversion demand and gap results for M&I uses in the Colorado Basin are summarized in Table 4.4.10 and illustrated in Figure 4.4.12. An annual time series of gaps in terms of percent of demand that was unmet is shown in Figure 4.4.13.

Table 4.4.10 Colorado Basin M&I Gap Results (AFY)

		Scenario					
		Scenario	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average	Average Annual Demand	68,500	98,400	85,800	95,400	94,500	121,400
	Average Annual Gap	0*	1,200	800	1,900	2,300	4,700
	Average Annual Percent Gap	0%	1%	1%	2%	2%	4%
Maximum	Demand in Maximum Gap Year	68,500	98,400	85,800	95,400	94,500	121,400
	Gap in Maximum Gap Year	0*	4,200	3,300	5,300	6,600	15,800
	Percent Gap in Maximum Gap Year	0%	4%	4%	6%	7%	13%

**CDSS water allocation model in this basin calculates small baseline M&I gaps, but they are either due to calibration issues or they are reflective of infrequent, dry-year shortages that are typically managed with temporary demand reductions such as watering restrictions.*

Figure 4.4.12 Projected Maximum Annual M&I Demand Met and Gaps in the Colorado Basin

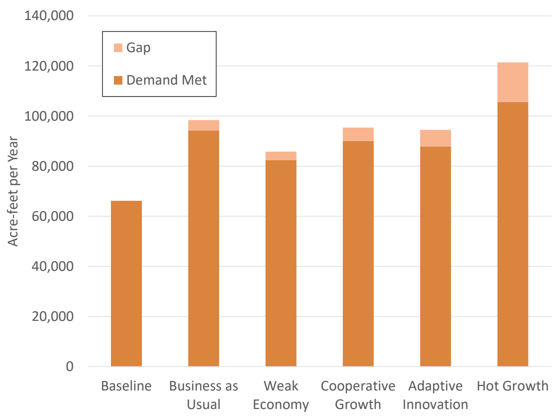
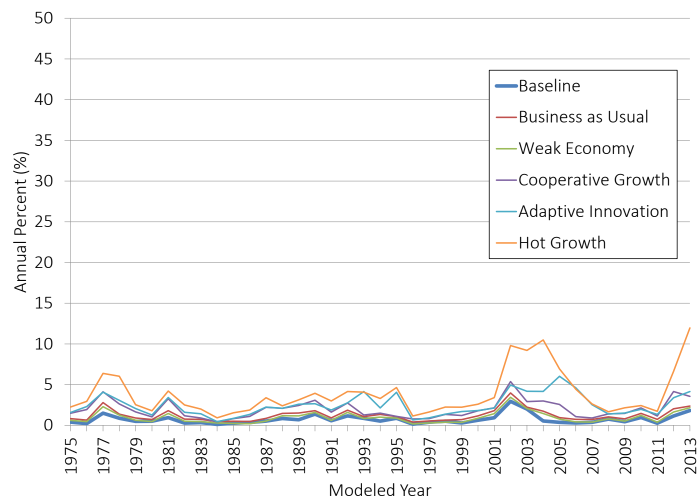


Figure 4.4.13 Annual M&I Gaps (expressed as a percentage of demand) for Each Planning Scenario



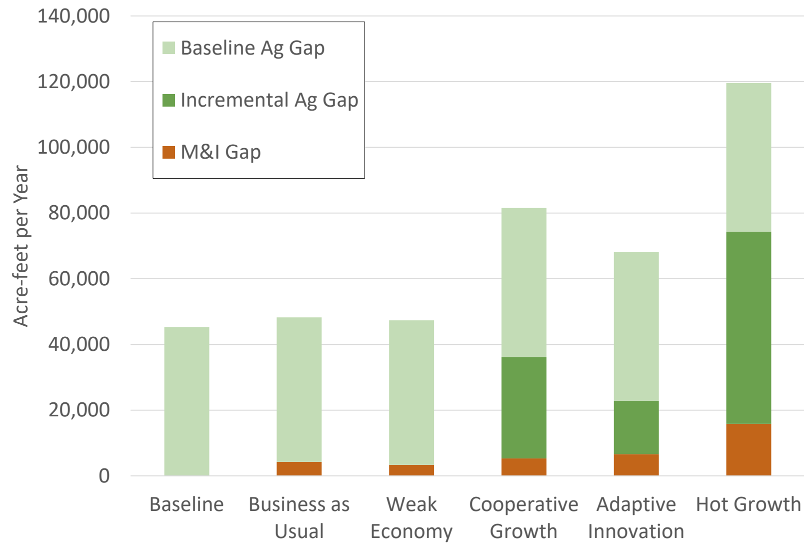
The following are observations on the M&I diversion demands and gaps:

- Average annual M&I gap in the Colorado Basin is far less than the agricultural gap, ranging from 500 AF to more than 4,700 AF.
- The maximum M&I gap for the five planning scenarios ranges from 2,300 AF to nearly 16,000 AF.
- Per capita municipal usage is projected to decrease.
- Overall municipal demand is projected to increase for all scenarios due to increased population; however, except for *Hot Growth*, the systemwide demand projections for all future scenarios are similar.
- Increase in SSI demand in *Business as Usual* and *Hot Growth* represent anticipated energy development.

Total Gap

Figure 4.4.14 illustrates the total combined agricultural and M&I diversion demand gap in the Colorado Basin. The figure combines average annual baseline and incremental agricultural gap and the maximum M&I gap. In *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*, gaps were driven by agricultural demands, which increase in the "In Between" and "Hot and Dry" climate projections.

Figure 4.4.14 Projected Average Annual Agricultural Gaps and Maximum M&I Diversion Demand Gaps in the Colorado Basin



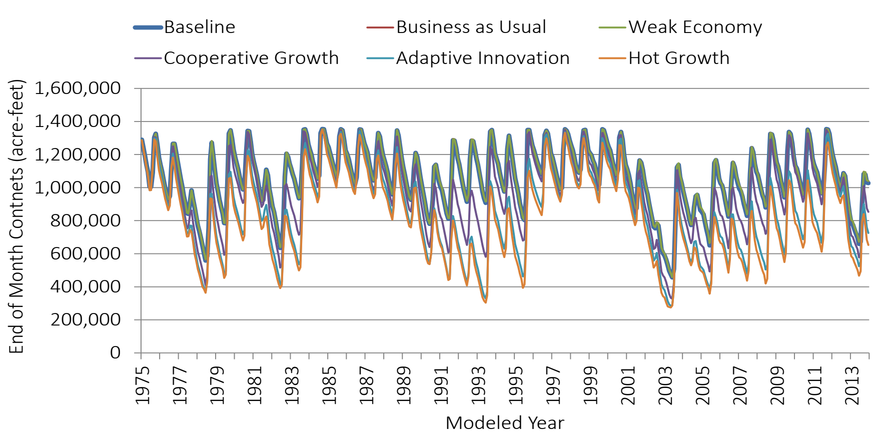
Supplies from Urbanized Lands

By 2050, irrigated acreage in the Colorado Basin is projected to decrease by 13,600 acres due to urbanization. Irrigation supplies for these lands could potentially be used for M&I needs in the future (subject to a variety of unknowns such as seniority and type of water supply, willingness to change the use of water through water court, etc.). The average annual historical consumptive use associated with potentially urbanized acreage for each scenario is reflected in Table 4.4.11. The data in the table represent planning-level estimates of this potential supply and has not been applied to the M&I gaps.

Table 4.4.11 Estimated Consumptive Use from Lands Projected to be Urbanized by 2050 in the Colorado Basin

	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Urbanized Acreage (acres)	13,600	13,600	13,600	13,600	13,600
Estimated Consumptive Use (AFY)	28,300	28,300	30,800	29,700	32,100

Figure 4.4.15. Total Simulated Reservoir Storage in the Colorado Basin



Storage

Total simulated reservoir storage from the Colorado water allocation model is shown on Figure 4.4.15. Baseline conditions show the highest levels of water in storage (in general) and the lowest is in *Hot Growth*. *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth* show lower amounts of water in storage during dry periods than the two scenarios that do not include the impacts of a drier climate; however, storage levels generally recover from dry periods back to baseline levels. Storage in the Colorado Basin is critical to minimizing gaps as described in Section 4.4.3 and as demonstrated by the large degree of fluctuation in basin-wide storage amount.

4.4.7 Available Supply

Figures 4.4.16 through 4.4.19 show simulated monthly available flow for the Colorado Basin at locations representative of the Shoshone Power Plant diversion (near Dotsero) and the “Cameo Call”, which are generally the controlling rights on the mainstem of the Colorado River. Streamflow and available flow nearly double between the upstream and downstream locations due to inflows from the Roaring Fork, Parachute Creek, and Rifle Creek. The figures show that flows are projected to be available each year, though the amounts will vary annually and across scenarios (available flows under the scenarios impacted by climate change are less than in other scenarios). Peak flows are projected to occur earlier in the year under scenarios impacted by climate change.

Figure 4.4.16 Simulated Hydrographs of Available Flow at Colorado River near Dotsero, CO

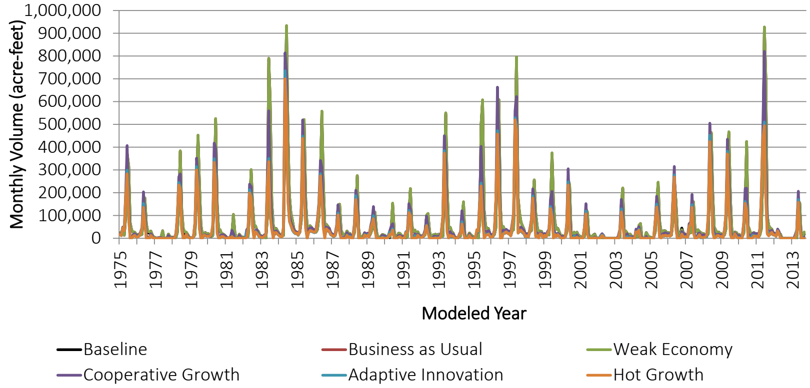


Figure 4.4.17 Average Monthly Simulated Hydrographs of Available Flow at Colorado River near Dotsero, CO

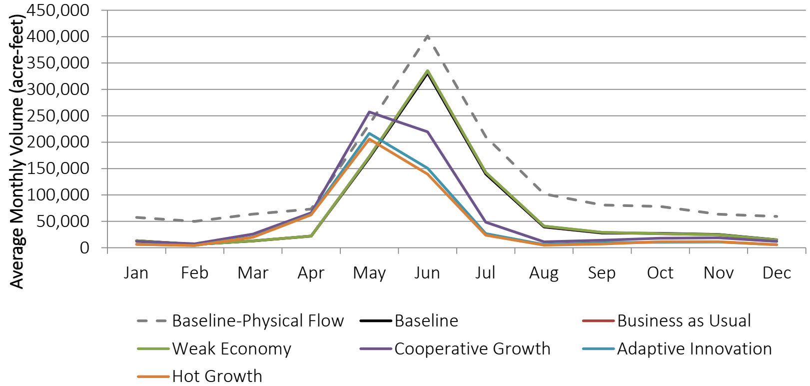


Figure 4.4.18 Simulated Hydrographs of Available Flow at Colorado River near Cameo, CO

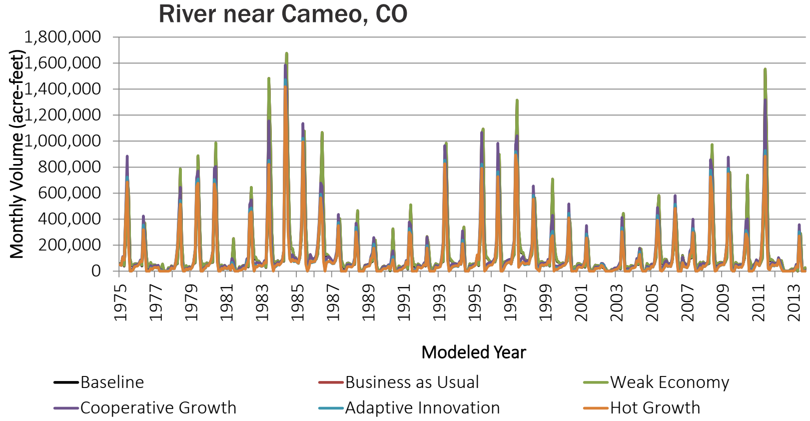
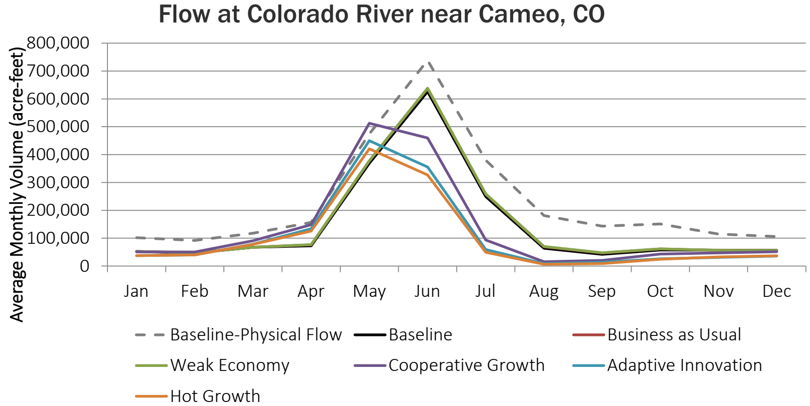


Figure 4.4.19 Average Monthly Simulated Hydrographs of Available Flow at Colorado River near Cameo, CO



4.4.8 Environment and Recreation

A total of eleven water allocation model nodes were selected for the Flow Tool within the Colorado Basin (see Figure 4.4.20). In addition to nodes, Figure 4.4.20 also shows subwatersheds (at the 12-digit HUC level) and the relative number of E&R attributes located in each subwatershed.

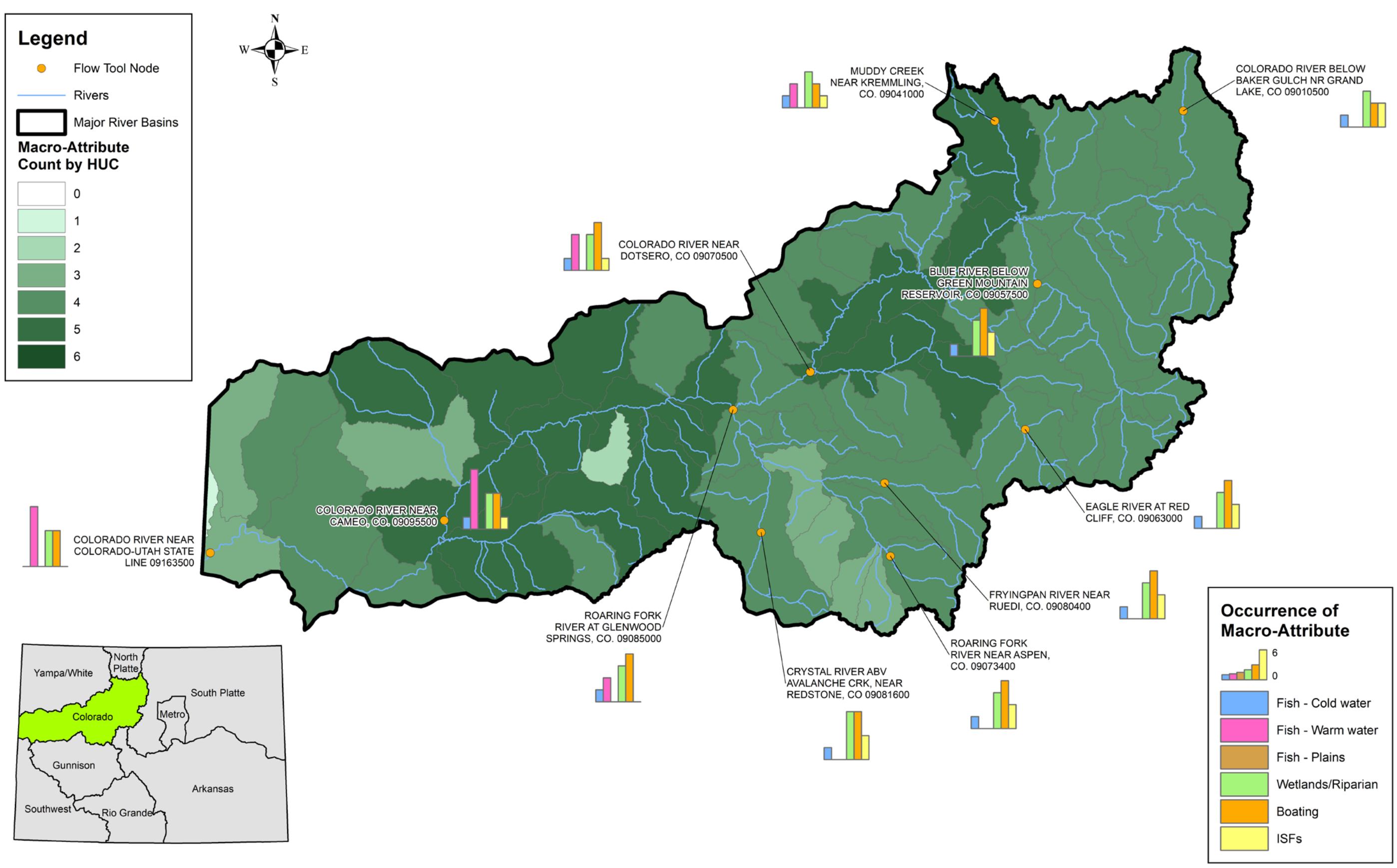
Nodes include:

- Colorado River below Baker Gulch near Grand Lake, Colorado (09010500)
- Muddy Creek near Kremmling, Colorado (09041000)
- Blue River below Green Mountain Reservoir, Colorado (09057500)
- Eagle River at Red Cliff, Colorado (09063000)
- Colorado River near Dotsero, Colorado (09070500)
- Roaring Fork River near Aspen, Colorado (09073400)
- Fryingpan River near Ruedi, Colorado (09080400)
- Crystal River above Avalanche Creek, near Redstone, Colorado (09081600)
- Roaring Fork River at Glenwood Springs, Colorado (09085000)
- Colorado River near Cameo, Colorado (09095500)
- Colorado River near Colorado-Utah State Line (09163500)

NATURALIZED FLOW

Naturalized flows reflect conditions that would occur in the absence of human activities. Baseline flows reflect current conditions as influenced by existing infrastructure and river operations. While observations regarding naturalized flows may be informative, baseline flows reflect actual conditions and the diverse operations of a river's many users.

Figure 4.4.20 Flow Tool Nodes Selected for the Colorado Basin



Results of Flow Tool analyses using flow data developed in the water supply and gap analyses for baseline conditions and the planning scenarios are described below.

Table 4.4.12 Summary of Flow Tool Results in Colorado Basin

Category	Observation
Projected Flows	Annual flow in headwaters (Colorado River below Baker's Gulch) under baseline conditions is below natural conditions, and this departure increases under climate change scenarios. Moving downstream through Dotsero, Cameo, and to the state line, annual flow under baseline conditions rebounds slightly closer to naturalized conditions.
	Under climate change scenarios (*Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*), annual depletions are projected to increase from headwaters to the state line.
	Similar to the alterations in annual flows, peak flow magnitudes on the Colorado River under baseline conditions are below natural conditions from the headwaters through Dotsero, and are closer to natural conditions at lower elevations (Cameo and State Line).
	Under climate change scenarios (*Collaborative Growth*, *Adaptive Innovation*, and *Hot Growth*), peak flow magnitudes on the Colorado River are projected to decrease further below natural conditions. Decreases in peak flows (from naturalized to baseline) are more pronounced at locations below large reservoirs (e.g., Blue River below Green Mountain Reservoir, Fryingpan River below Reudi Reservoir). This dampening of peak flows is projected to worsen under climate driven scenarios. In some locations (notably, Crystal River above Avalanche Creek), peak flow magnitude is projected to increase under some scenarios.
	Under the scenarios with climate change influences, snowmelt and timing of peak flow is projected to shift earlier in the year. In many areas from headwaters to lower elevations, June flows are projected to decrease well below naturalized conditions, while April and May flows could similar to baseline or increase slightly.
	Under baseline conditions, mid- and late-summer flows in headwaters subject to transbasin exports are currently depleted compared to naturalized conditions. The difference between baseline and naturalized conditions lessens farther downstream.
	Under scenarios with climate change, mid- and late-summer flows in headwaters are projected to drop well below naturalized, but farther downstream, this drop is projected to be less pronounced. In many locations, mid- and late-summer flows under climate change scenarios are projected to be well below naturalized. The Fryingpan below Reudi Reservoir is an exception to the large projected decreases in mid- and late-summer flows, because releases are made steadily from the reservoir.
Ecological Risk	Decreased peak flows that are prevalent across the basin under baseline conditions create risk for riparian/wetland plants and fish habitat.
	This risk increases under climate change scenarios. Projected decreases in mid- and late-summer flows create risk for fish from loss of habitat and, in trout regions, increased water temperatures. Downstream from major reservoirs (e.g., Fryingpan, Green Mountain), projected diminished peak flows create increased risk for riparian/wetland vegetation and fish habitat if sediment is not flushed, while projected consistent mid- and late-summer flows keep risk to fish low to moderate.
ISFs and RICDs	Several Instream Flows (ISFs) throughout the basin and Recreational In-channel Diversion (RICD) are likely to be regularly unmet if June-August flows decrease as projected under climate change scenarios.
	In critical habitat for endangered species, projected reduced flows in mid- and late-summer will make it more difficult to meet flow recommendations. For example, projected August flows under climate change scenarios on the Colorado River at Cameo suggest that flow recommendations for endangered fish will not be met during August in approximately one-third of years.
E&R Attributes	Under baseline, *Business as Usual*, and *Weak Economy*, current flow issues related to E&R attributes arise from timing/water delivery issues.
	Under climate change scenarios, the shift in the timing of peak flow, reductions in total runoff, and increasing demands for consumptive uses contribute to reductions in mid- and late-summer flows. Several water management programs implemented in the context of the Upper Colorado Endangered Fish Program (e.g., Coordinated Reservoir Operations Program) have demonstrated that flow timing and magnitude, along with stream temperature, can be improved through water management that explicitly considers the needs of E&R attributes.