The South Platte Basin is the most populous basin in the state. Approximately 85 percent of Colorado's population resides in the South Platte Basin, and the Front Range area of the basin is Colorado's economic and social engine. The basin also has the greatest concentration of irrigated agricultural lands in Colorado.

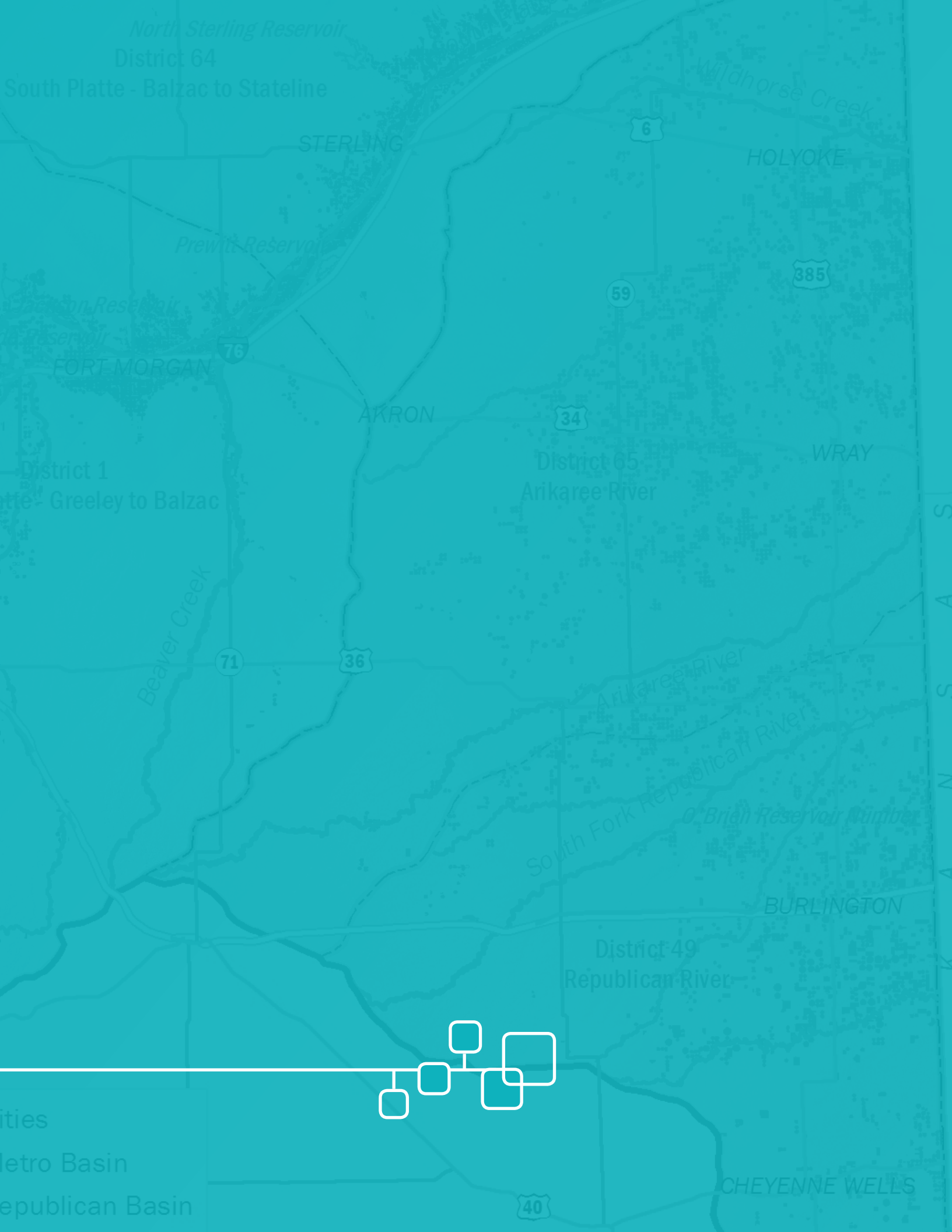
The topographic characteristics of the South Platte Basin are diverse. The western portions of the basin and its mountainous and subalpine areas are mostly forested, while the High Plains region is mainly grassland and planted or cultivated land.

The hydrology of the South Platte Basin is highly variable, with an approximate average annual native flow volume of 1.4 million AF About 400,000 AF of transmountain imports and 30,000 AF from nontributary groundwater aquifers supplement the water supply in the South Platte Basin. Yet, surface-water diversions in the South Platte Basin average about 4 million AF annually, with groundwater withdrawals totaling an additional annual 500,000 AF on average. The amount of diversion in excess of native flow highlights the return flow-dependent nature of the basin's hydrology, and the basinwide efficient use and reuse of water supplies.

The Republican Basin in Colorado is located on the Northeastern High Plains. Land uses in the basin are primarily agricultural. The topographic characteristics of the Republican Basin, which are similar to the High Plains region of the South Platte Basin, consist mainly of grassland and planted or cultivated land. The Republican Basin in Colorado is underlain by the High Plains or Ogallala aquifer, which is one of the largest aquifer systems in the United States, extending from South Dakota to Texas.

The Technical Update largely keeps the analysis at the basin scale. There are some exceptions where subbasin (river basin) analysis of major waterways was more straightforward. To that end, both the South Platte, Metro and Republican basins were explicitly analyzed where possible. Those results are shown in the following sections. In other sections, of this report where statewide analysis is shown, the entire South Platte Basin (with values from the South Platte, Metro and Republican combined) are shown.

SOUTH PLATTE / METRO


North Sterling Reservoir
District 64
South Platte - Balzac to Stateline
STERLING
Wildhorse Creek
HOLYOKE
6
Prewitt Reservoir
385
59
FORT MORGAN
76
AKRON
34
District 65
Arikaree River
WRAY
District 1
Greeley to Balzac
Beaver Creek
71
36
Arikaree River
South Fork Republican River
O'Brien Reservoir Number
BURLINGTON
District 49
Republican River
ities
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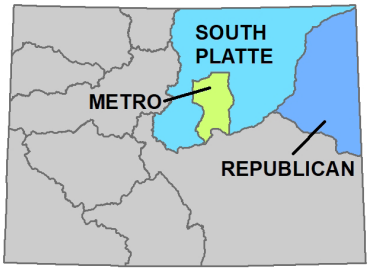
CHEYENNE WELLS
40

4.8 SOUTH PLATTE BASIN RESULTS



4.8.1 BASIN CHALLENGES

Key future water management issues in this basin will be focused on meeting future water supply demands for a variety of sectors while complying with interstate compacts and maintaining Coloradans' quality of life. These challenges are described in the Colorado Water Plan and are summarized below.

Table 4.8.1 Key Future Water Management Issues in the South Platte Basin

Agriculture	Environment and Recreation	Municipal and Industrial	Compacts and Administration
• Agriculture is the dominant water use in the basin, but agricultural water transfers are likely to have negative effects on rural communities and the environment. • Depletions to the Ogallala Aquifer and long-term impacts to water supplies are a concern to agricultural viability.	• Environmental and recreational features in the basin are important to Colorado's quality of life and tourism economy.	• Competition for additional M&I supplies is substantial and increases costs to customers. • Lack of new storage projects has led to reliance on non-renewable groundwater supplies in quickly-urbanizing areas of the South Metro region. • Value judgements regarding irrigated landscaping complicate discussions about water development.	• A significant amount of the South Platte Basin's supply originates in the Colorado Basin and is subject to compact compliance. • Aquifer storage, while promising, poses control and administrative issues. • Republican River Compact compliance. • Coordination among water authorities in the Republican Basin is a challenge.
• Water quality will continue to be a challenge for all segments of water use. • Increases in M&I water use efficiency is critical but will reduce the quantity of water available for agriculture and the environment.			

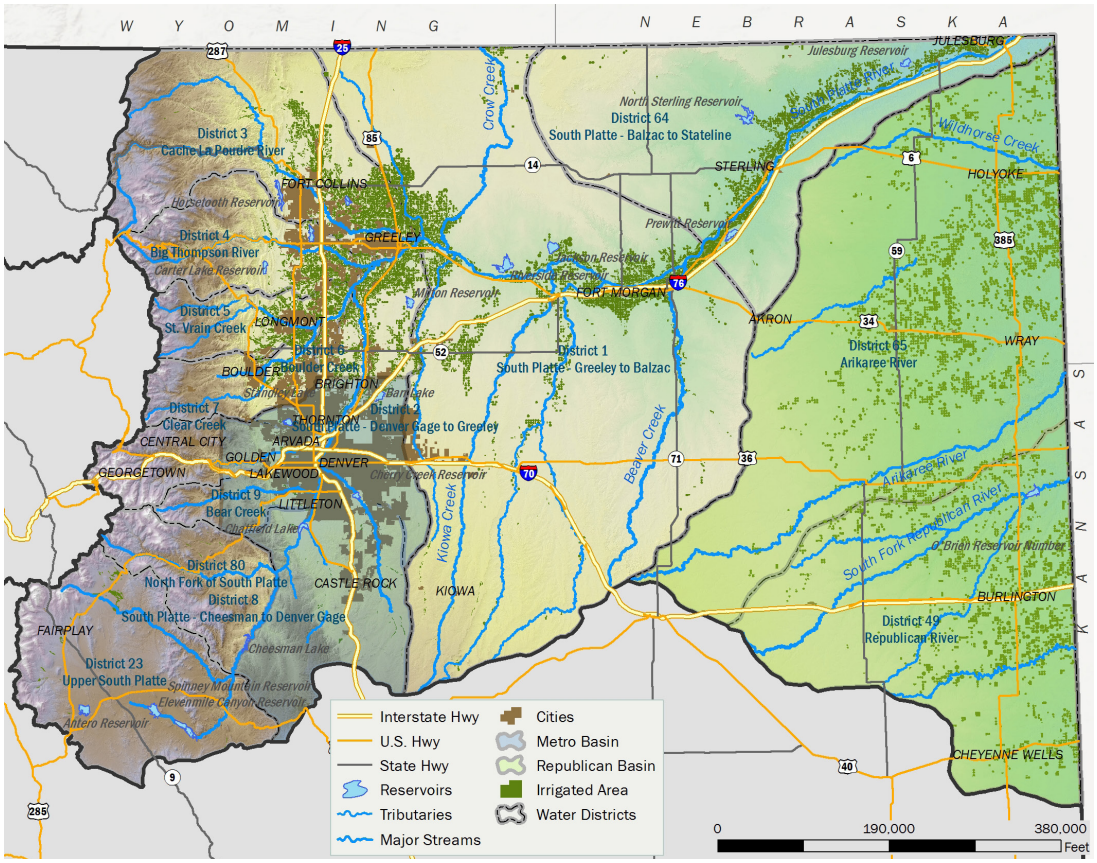


Figure 4.8.1 Map of the South Platte Basin

4.8.2 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 environment and recreation attributes and future conditions are summarized below in Table 4.8.2.

Table 4.8.2 Summary of Key Results in the South Platte and Republican Basins

Agriculture	Environment and Recreation	Municipal and Industrial
• Future agricultural demands in the South Platte Basin are projected to decrease due to loss of irrigated lands from lack of groundwater sustainability. • Future agricultural demands in the South Platte Basin are projected to decrease due to loss of irrigated lands from urbanization and agricultural water transfers. • Agricultural gaps as a percentage of total demand in the South Platte Basin are not projected to greatly increase.	• In several locations in the mountains and foothills, climate-impacted scenarios show variable responses in peak flows. • On the plains, especially east of Interstate 25, flow conditions are projected to be poor for all aspects of ecosystem health. • In the mountains and foothills, climate-impacted scenarios show diminished mid- and late-summer flows.	• M&I demands in Adaptive Innovation are projected to be very similar to Business as Usual despite higher population and hotter/drier climate assumptions in Adaptive Innovation. This result demonstrates the value of higher levels of conservation. • Significant future gaps are estimated for each planning scenario, and they could be exacerbated by reductions in West Slope supplies.

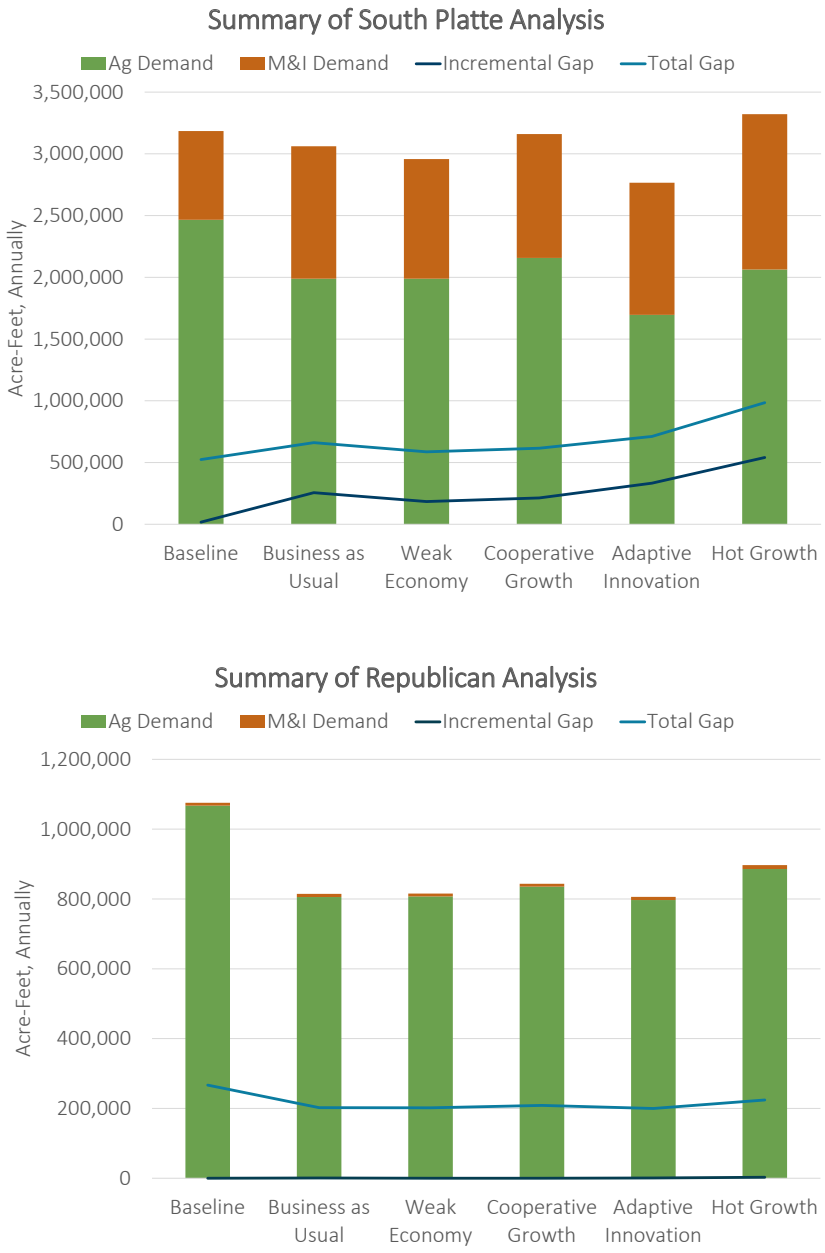
Results describing current and potential future M&I and agricultural demands and gaps are summarized in Table 4.8.3 and Figure 4.8.2.

Table 4.8.3 Summary of Diversion Demand and Gap Results in the South Platte and Republican Basins

		Current (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
South Platte	**Average Annual Demand**						
	Agricultural (AFY)	2,465,800	1,988,700	1,988,700	2,157,400	1,696,500	2,063,100
	M&I (AFY)	718,700	1,073,000	968,900	1,002,800	1,070,100	1,257,700
	Gaps						
	Ag (avg %)	21%	20%	20%	19%	22%	22%
	Ag (incremental-AFY)	-	-	-	-	-	-
	Ag (incremental gap as % of current demand)	-	-	-	-	-	-
	M&I (max %)	0%	24%	19%	21%	31%	43%
	M&I (max-AF)	0*	256,300	184,500	213,300	333,200	540,700
Republican	**Average Annual Demand**						
	Agricultural (AFY)	1,067,200	805,500	807,500	835,300	797,200	885,800
	M&I (AFY)	8,400	9,200	7,900	8,100	8,900	11,200
	Gaps						
	Ag (avg %)	25%	25%	25%	25%	25%	25%
	Ag (incremental-AFY)	-	-	-	-	-	-
	Ag (incremental gap as % of current demand)	-	-	-	-	-	-
	M&I (max %)	0%	8%	0%	0%	6%	25%
	M&I (max-AF)	-	700	-	-	500	2,800
Total	**Average Annual Demand**						
	Agricultural (AFY)	3,533,000	2,794,200	2,796,100	2,992,700	2,493,700	2,948,900
	M&I (AFY)	727,100	1,082,200	976,800	1,010,900	1,079,100	1,268,900
	Gaps						
	Ag (avg %)	22%	22%	22%	20%	23%	23%
	Ag (incremental-AFY)	-	-	-	-	-	-
	Ag (incremental gap as % of current demand)	-	-	-	-	-	-
	M&I (max %)	0%	24%	19%	21%	31%	43%
	M&I (max-AF)	0*	257,100	184,500	213,300	333,700	543,500

**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 4.8.2 Summary of Diversion Demand and Gap Results in the South Platte and Republican Basins



Summary of Environment and Recreation Findings

- In several locations in the mountains and foothills, *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth* project variable responses to peak flows, in some cases increasing peak flow (thus improving or maintaining risk to plants and fish habitat) and in other cases diminishing peak flows and increasing risk to riparian/wetlands and fish habitat to high or very high.
- In the mountains and foothills, *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth* project diminished mid- and late-summer flows, increasing risk to fish. This risk may remain moderate; however, the metric used to assess risk for fish does not include the month of July because historically July flows are sufficient. Under *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*, July flows may drop substantially, increasing risk for fish.
- On the plains, especially east of Interstate 25, flow conditions are projected to be poor for all aspects of ecosystem health. Peak flows for riparian/wetlands are high risk under baseline conditions and are projected to remain so under all scenarios. Mid- and late-summer flows are very high risk for plains fishes and risk is projected to increase under all future scenarios.
- The recreational in-channel diversions may be met less often in the future.

4.8.3 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 South Platte Basin are listed below:

- Imports from transmountain diversion projects were set at historical levels and reflect historical operations. In climate-impacted scenarios, transmountain imports are projected to decrease, which could increase agricultural and M&I gaps. Gaps in the South Platte Basin would likely increase more than the reduction in transmountain imports because return flows from transmountain imports are used to extinction within the South Platte Basin by either the importing entity or by downstream agricultural and M&I water users.
- Stakeholders in the South Platte Basin suggested that purchase and transfer of senior irrigation water rights resulting in permanent reductions in irrigated acreage to municipal uses will continue through 2050 even though alternative water transfers have the potential to reduce reliance on transfers resulting in permanent dry up. Stakeholder estimates of acreage associated with these transfers were accounted for in the agricultural diversion demand and the modeling effort the same way urbanized lands were considered. Acreage purchased, transferred, and/or urbanized was quantified, but was not modeled as a future water supply strategy in this effort as it was unknown what municipal entity may benefit from resulting supply.
- Aquifer sustainability will be a primary focus of future water management strategies and activities in the Republican Basin.
- Due to on-going permitting efforts in the basin, the Cache La Poudre basin (Water District 3) was excluded from the CDSS surface water allocation model. Shortages to agriculture and M&I demands within the basin were informed by the results from nearby basins with similar characteristics (e.g. storage, C-BT supplies) to reflect the impact of climate adjustments on hydrology.
- No groundwater modeling was performed in either the South Platte or Republican basin. Groundwater pumping in the planning scenarios was estimated based on the premise that current groundwater pumping would either stay the same or be reduced in the future based on sustainability of groundwater supplies. Groundwater pumping was effectively reduced to account for sustainability concerns by removing acreage served by groundwater supplies.

4.8.4 AGRICULTURAL DIVERSION DEMANDS

Agricultural Setting

South Platte Basin

Approximately 854,000 acres are irrigated in the South Platte Basin. It is the highest producing basin in the state in terms of the value of agricultural products sold. Irrigated lands are located along and adjacent to the South Platte River and its tributaries and stretch to the state line.

Farmers divert surface water and pump groundwater. In many cases, both sources of supply are available to irrigate South Platte Basin farms. Much of the surface water supply in the basin is generated via return flows as an upstream irrigators' inefficiencies become the water supply for downstream irrigators.

The amount of irrigated land in the basin is anticipated to decrease in the future. Urbanization will impact irrigated lands in and around the basin's municipalities by 2050. The majority of urbanization of irrigated land (60 percent) is projected to occur in the St. Vrain River, Big Thompson River, and Cache La Poudre River basins. These basins have some of the highest concentrations of irrigated land adjacent to municipalities that are projected to increase in population. Although large population increases are also anticipated in and around the Denver Metropolitan area, the concentration of irrigated land that could be urbanized is less. Acquisition of senior water rights by "buy and dry" methods is also expected to reduce the amount of irrigated land in the basin.

Republican Basin

The Republican Basin has nearly 580,000 irrigated acres, making it one of the highest producing basins of irrigated crops in the state. The basin has very limited surface water supplies. As a result, irrigators rely on groundwater supplies from the High Plains Aquifer (also known as the Ogallala Aquifer). Approximately 10 percent of total pumping is subject to the Republican River Compact, with the remaining 90 percent pumped from "storage" in the High Plains Aquifer. Groundwater pumping is managed by several groundwater management districts in the basin.

The current amount of irrigated land in the basin is expected to decline in the future. Absent the development of an alternative means to reduce consumptive use, irrigated lands will need to be retired to maintain compliance with the Republican River Compact. In addition, declining saturated thickness in the High Plains Aquifer will also lead to the retirement of groundwater-irrigated lands.

Planning Scenario Adjustments

South Platte Basin

The South Platte Basin is expected to experience the largest municipal growth in the state by 2050, straining already limited water supplies and increasing competition among municipal, industrial, agricultural, environmental and recreation users in the basin. The planning scenarios contemplate various pressures that may affect basin agriculture and consider increased urbanization of irrigated lands, increased municipal conversions of agricultural water supplies, limited augmentation supplies, and higher irrigation demands due to a warmer climate.

Adjustments to agricultural diversion demands were made to reflect the above considerations. Stakeholder outreach was conducted to estimate the amount of irrigated land that could be lost from transfers of water from agriculture to municipal providers and the loss of groundwater-irrigated land due to insufficient augmentation supplies. In addition, the Agricultural Technical Advisory Group provided input on the level of future increases in irrigation efficiency and reductions in future IWR due to advances in agronomic technologies. Table 4.8.4 summarizes the adjustments that were made in each of the planning scenarios to reflect assumed future conditions in agriculture.

Republican Basin

The sustainability of groundwater supplies will be the primary source of future pressure to irrigated agriculture in the Republican Basin. As described previously, irrigated lands are likely going to be retired to comply with the Republican River Compact and also as a result of declining water levels in the High Plains Aquifer. Stakeholder outreach informed the assumptions that were used to reduce irrigated acreage under each of the planning scenarios. Table 4.8.4 summarizes the planning scenario adjustments used to reflect these conditions and other adjustments that impact agricultural diversion demands basin

Table 4.8.4 Planning Scenario Adjustments for Agricultural Demands in the South Platte and Republican Basins

Sub-basin	Adjustment Factor*	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
South Platte	Change in Irrigated Land due to Urbanization & Municipal Transfers	105,900 Acre Reduction	105,900 Acre Reduction 20% SW Acre Reduction (WD 1 & 64)	105,900 Acre Reduction 20% SW Acre Reduction (WD 1 & 64)	105,900 Acre Reduction 20% SW Acre Reduction (WD 1 & 64)	105,900 Acre Reduction 20% SW Acre Reduction (WD 1 & 64)
	Groundwater Acreage Sustainability	20% GW-Only Acre Reduction (Central)	20% GW-Only Acre Reduction (Central)	20% GW-Only Acre Reduction (Central)	20% GW-Only Acre Reduction (Central)	20% GW-Only Acre Reduction (Central)
	IWR Climate Factor	-	-	15%	24%	24%
	Emerging Technologies	85% GW Only Acreage in Sprinkler	85% GW Only Acreage in Sprinkler	90% GW Only Acreage in Sprinkler	90% GW Only Acreage in Sprinkler 10% IWR Reduction 10% System Efficiency Increase	90% GW Only Acreage in Sprinkler
Republican	Change in Irrigated Land due to Urbanization	1,410 Acre Reduction	-	1,410 Acre Reduction	1,410 Acre Reduction	1,410 Acre Reduction
	Groundwater Acreage Sustainability	135,420 Acre Reduction	135,420 Acre Reduction	135,420 Acre Reduction	135,420 Acre Reduction	135,420 Acre Reduction
	IWR Climate Factor	-	-	4%	11%	11%
	Emerging Technologies	-	-	-	10% IWR Reduction	-

**See section 2.2.3 for descriptions of adjustment methodologies and assumptions*

Agricultural Diversion Demand Results

Table 4.8.5 and Figures 4.8.3 and 4.8.4 summarize the acreage, IWR, and agricultural diversion demand in both the South Platte and Republican basins for current conditions and the five planning scenarios. Note that in the South Platte Basin, surface water and groundwater sources are used for irrigation, and a breakout of diversion demand for these sources is included in the technical memorandum *Current and Projected Planning Scenario Agricultural Diversion Demands* (see Volume 2). All agricultural diversion demands in the Republican Basin were from groundwater sources.

SYSTEM EFFICIENCY

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

Future agricultural diversion demands in both the South Platte and Republican Basins are anticipated to be lower in the future due primarily to the loss of irrigated land. While assumptions of a warmer climate increase IWR in *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*, the loss of irrigated land may offset the additional IWR demand, resulting in lower future demands. Projected increases in IWR due to a warmer climate are the same in *Adaptive Innovation* and *Hot Growth*, but the agricultural diversion demand is lower in *Adaptive Innovation* due to the assumed 10 percent reduction in IWR from emerging technologies and a 10 percent increase in system efficiency. Agricultural diversion demands in the South Platte are relatively consistent in wet, average, and dry years due to surface water irrigation system efficiencies that fluctuate in differing hydrologic conditions. Republican Basin irrigation is provided from groundwater, and system efficiencies of wells do not fluctuate. As a result, agricultural diversion demands in the Republican Basin change to a greater degree in response to hydrologic conditions.

Table 4.8.5 Summary of Agricultural Diversion Demand Results in the South Platte and Republican Basins

		Current	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
South Platte	Irrigated Acreage (acres)	854,300	701,100	701,100	722,400	722,400	679,900
	Average IWR (AFY)	1,500,000	1,225,000	1,225,000	1,341,000	1,264,000	1,323,000
	Total Surface Water and Groundwater Diversion Demand						
	Average Year (AFY)	2,589,000	2,081,000	2,081,000	2,268,000	1,771,000	2,202,000
	Wet Yr. Change	-6%	-6%	-6%	-4%	-4%	-4%
	Dry Yr Change	2%	2%	2%	1%	2%	-1%
Republican	Irrigated Acreage (acres)	578,800	442,000	443,400	442,000	442,000	442,000
	Average IWR (AFY)	837,000	635,000	636,000	661,000	649,000	721,000
	Groundwater Diversion Demand						
	Average Year (AFY)	1,056,000	800,000	802,000	833,000	799,000	888,000
	Wet Yr. Change	-14%	-15%	-15%	-14%	-13%	-13%
	Dry Yr Change	20%	21%	21%	18%	14%	14%

Figure 4.8.3 Agricultural Diversion Demands and IWR Results in the South Platte Basin

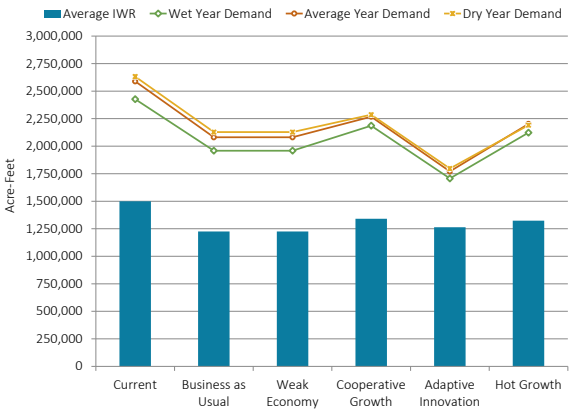
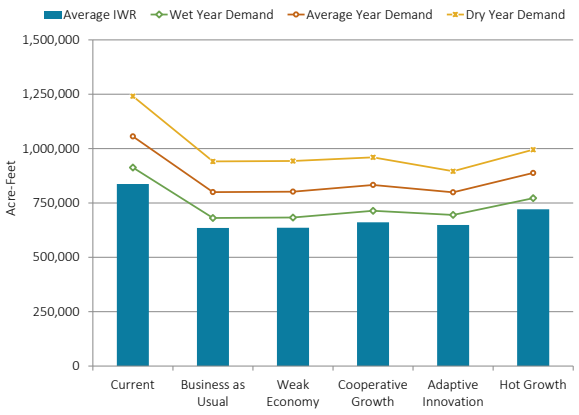


Figure 4.8.4 Agricultural Diversion Demands and IWR Results in the Republican Basin



4.8.5 Municipal and Self-Supplied Industrial Diversion Demands

For purposes of the M&I demand reporting, the South Platte Basin includes three sub-basins—the Metro Region as defined by the basin roundtables, the Republican Basin, and the remainder of the South Platte Basin. SWSI 2010 included the Republican Basin demands in the reporting of the South Platte Basin demands, but separately reported M&I demands for the Metro Region. The Republican Basin was evaluated separately in the water supply and gap analysis in the Technical Update, and the Metro Region demands were analyzed in the South Platte Basin modeling of water supplies and gaps. The three sub-basins are each summarized in the following subsections, along with the combined South Platte Basin.

Population Projections

The South Platte Basin as a whole is currently the most populous basin and includes about 70 percent of the statewide population. The Metro Region holds the majority of the population at 51 percent of the statewide total. The remaining portion of the South Platte Basin has 19 percent of the statewide population, and the Republican Basin has less than 1 percent.

Between the years 2015 and 2050, the South Platte Basin as a whole is projected to grow from approximately 3.8 million people to between 5.4 million and 6.5 million people in the low and high growth scenarios, respectively, which represents an increase in population of 42 to 70 percent. Table 4.8.6 shows how population growth is projected to vary across the planning scenarios for the South Platte Basin.

Table 4.8.6 South Platte Basin 2015 and Projected Populations

Sub-basin	Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Metro Region	2,768,000	4,062,000	3,817,000	3,922,000	4,162,000	4,318,000
Republican Basin	32,000	35,000	30,000	34,000	38,000	41,000
Remaining South Platte Basin	1,030,000	1,857,000	1,586,000	1,929,000	2,292,000	2,149,000
Total South Platte Basin	3,830,000	5,954,000	5,433,000	5,884,000	6,492,000	6,508,000

Current Municipal Demands

The Metro Region baseline water demands were largely based on water provider-reported data and had the highest representation of 1051 data for any basin or region in the state. The Republican Basin baseline water demands were largely estimated, and the remaining South Platte Basin baseline demands were largely based on water provider-reported data (see figures below).

Figure 4.8.5 Sources of Water Demand Data in the Metro Region

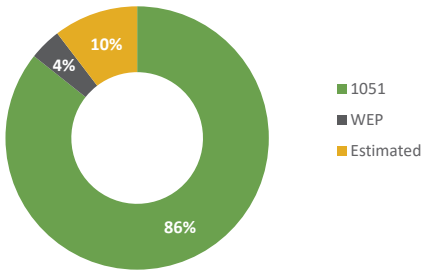


Figure 4.8.6 Sources of Water Demand Data in the Republican Basin

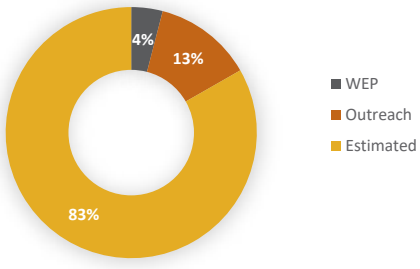


Figure 4.8.7 Sources of Water Demand Data in the Remaining South Platte Basin

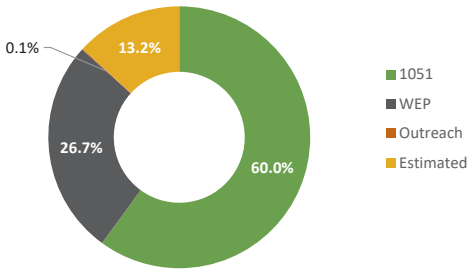
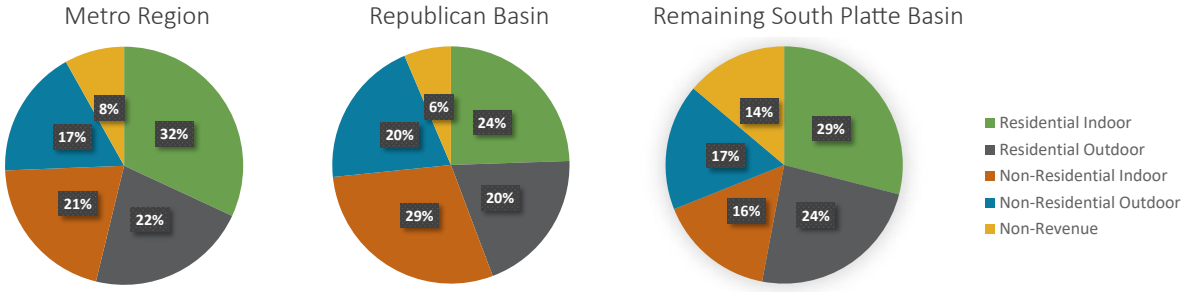


Figure 4.8.8 summarizes the categories of municipal, baseline water usage in the Metro Region, Republican Basin, and the remaining South Platte Basin. In the Metro Region and Republican Basin, non-revenue water as a percentage of systemwide demands is among the lowest in the state (with the Republican Basin being the lowest). Usage percentages in the Metro Region have a significant impact on statewide average, because a significant portion of the state population is located in the Metro Region.

Figure 4.8.8 Categories of Water Usage in the South Platte Basin



Projected Municipal Demands

Figures 4.8.9 through 4.8.11 provide summaries of per capita baseline and projected water demands for the Metro Region, Republican Basin, and the remaining South Platte Basin, respectively. In each basin, systemwide projected per capita demands decrease relative to the baseline except for *Hot Growth*. Additionally, the assumption of a hot and dry climate in *Hot Growth* is projected to cause a significant increase in outdoor demands in each region. Additional observations regarding the demand categories specific to each region are described below:

Metro Region

Consistently across all scenarios, residential indoor demand is the greatest individual demand category; non-revenue water is the lowest.

Republican Basin

Non-residential indoor demand is the greatest individual demand category; non-revenue water is the lowest in all of the scenarios.

Remaining South Platte Basin

The residential indoor demand is the greatest demand category in the baseline, but the residential outdoor demand is projected to exceed the residential indoor demand in *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*.

DECREASING GPCD

The Metro Region average baseline per capita systemwide demand has decreased from 155 gpcd in SWSI 2010 to approximately 141 gpcd. Other areas of the South Platte cannot be directly compared because of differences in reporting.

Figure 4.8.9 Metro Region Municipal Baseline and Projected Per Capita Demands by Water Demand Category

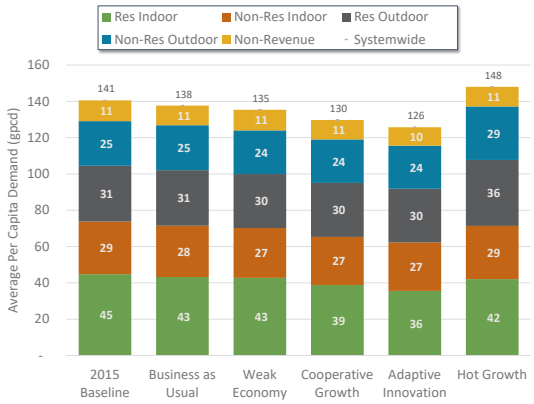


Figure 4.8.10 Republican Basin Municipal Baseline and Projected Per Capita Demands by Water Demand Category

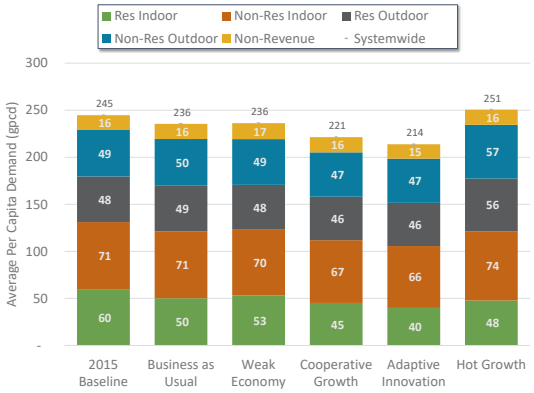
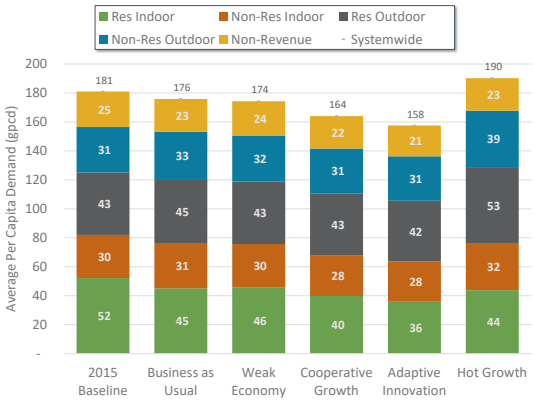


Figure 4.8.11 Remaining South Platte Basin Municipal Baseline and Projected Per Capita Demands by Water Demand Category



The South Platte Basin municipal baseline and projected demands are provided in Table 4.8.7, which shows the combined effect of population and per capita demands. Municipal demands are projected to grow from approximately 653,000 AFY in 2015 to between 897,000 and 1,185,000 AFY in 2050.

Table 4.8.7 South Platte Basin Municipal Baseline and Projected Demands (AFY)

Sub-basin	Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Metro Region	436,000	627,000	579,000	570,000	586,000	716,000
Republican Basin	9,000	9,000	8,000	8,000	9,000	12,000
Remaining South Platte Basin	209,000	366,000	310,000	354,000	405,000	458,000
Total South Platte Basin	653,000	1,002,000	897,000	933,000	1,000,000	1,185,000

The baseline and projected demand distributions for each region and for the South Platte Basin as a whole are shown in Figures 4.8.12 through 4.8.15.

Figure 4.8.12 Metro Region Baseline and Projected Population and Municipal Demands

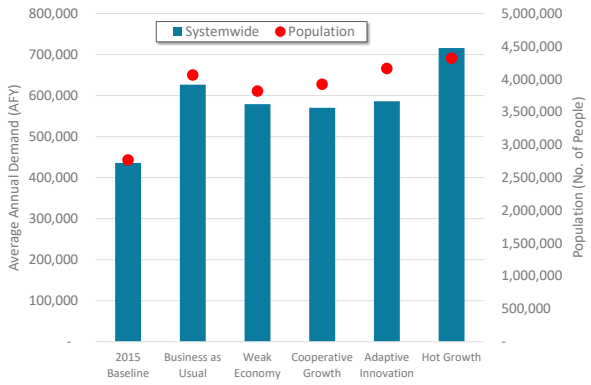


Figure 4.8.13 Republican Baseline and Projected Population and Municipal Demands

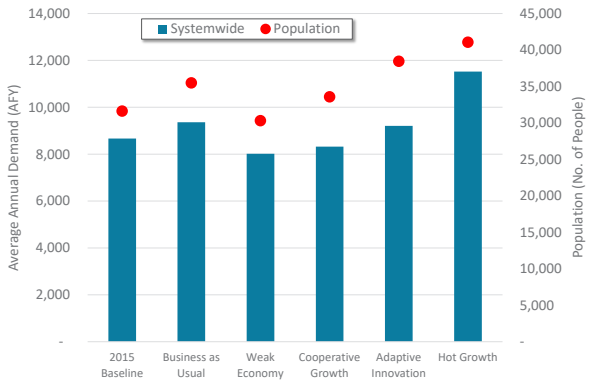


Figure 4.8.14 Remaining South Platte Baseline and Projected Population and Municipal Demands

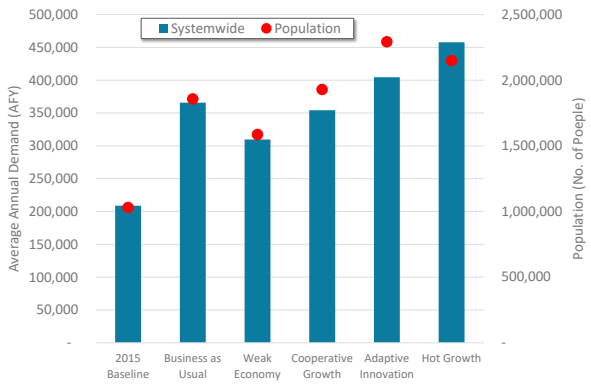
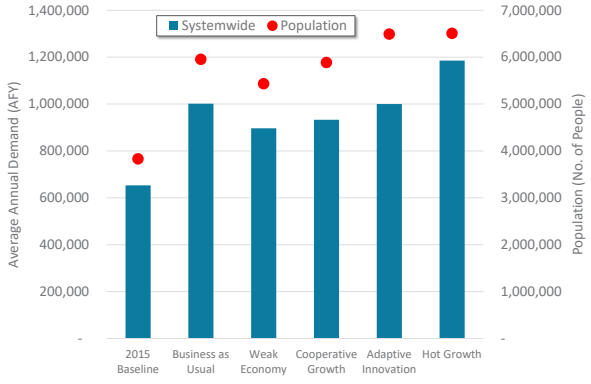


Figure 4.8.15 Total South Platte Basin Baseline and Projected Population and Municipal Demands



Below are some observations on the projected demands and population projections:

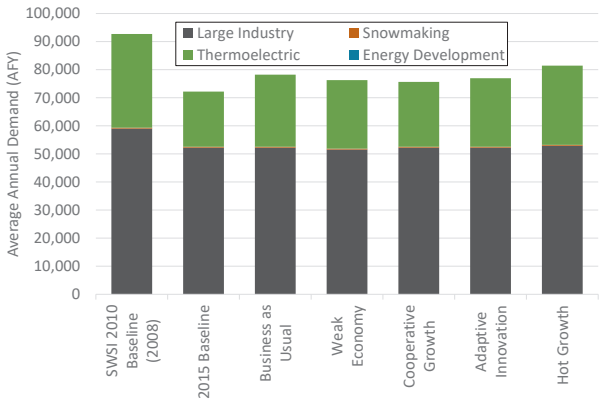
Table 4.8.8 Observations on South Platte Basin M&I Demands

Metro Region	Republican Basin	Remaining South Platte Basin	South Platte Basin/Basin-wide
• All of the planning scenarios result in an increase relative to the baseline. • Projected demand for *Weak Economy, Cooperative Growth, and Adaptive Innovation* are all within 3% of each other, even though each scenario has a different population projection.	• Demands are projected to decrease relative to the baseline in *Weak Economy and Cooperative Growth*.	• All of the planning scenarios result in an increase relative to the baseline. • Projected demands tend to follow population trends, except for *Adaptive Innovation* in which the population exceeds *Hot Growth* but the systemwide demand projection is lower, which shows the influence of projected per capita demands for this basin.	• All of the projection scenarios result in an increase relative to the baseline. • Projected demands in *Business as Usual* and *Adaptive Innovation* are similar, although population projected for *Adaptive Innovation* is about 10% higher.

Self-Supplied Industrial Demands

The South Platte Basin includes about 40 percent of the statewide SSI demand. Approximately 67 percent of the baseline SSI demands are in the Metro Region and 33 percent are in the remaining South Platte Basin. There are no SSI demands in the Republican Basin. SSI demands in the South Platte Basin are associated with the Large Industry, Snowmaking, and Thermoelectric sub-sectors. No demands were projected for the Energy Development sub-sector because no reliable data were available. Basin-scale SSI demands are shown on Figure 4.8.16 and Table 4.8.9.

Figure 4.8.16 Total South Platte Basin Self-Supplied Industrial Demands



Large Industry demands in this basin are located in three counties. Baseline demands in Jefferson County were based on data from an existing hydrologic model, and projected demands were not varied by scenario at the direction of the water user. Large Industry demands in Morgan and Weld counties were based on SWSI 2010. The baseline demand has decreased relative to SWSI 2010 due to reductions in Jefferson County.

The baseline snowmaking demand is 300 AFY (slightly less than in SWSI 2010 due to a reduction in snowmaking acres). Projected demands are 320 AFY and were not varied by scenario.

Thermoelectric demands are related to eight facilities in seven counties. Baseline demands for seven of the eight facilities were updated based on information from Xcel Energy.

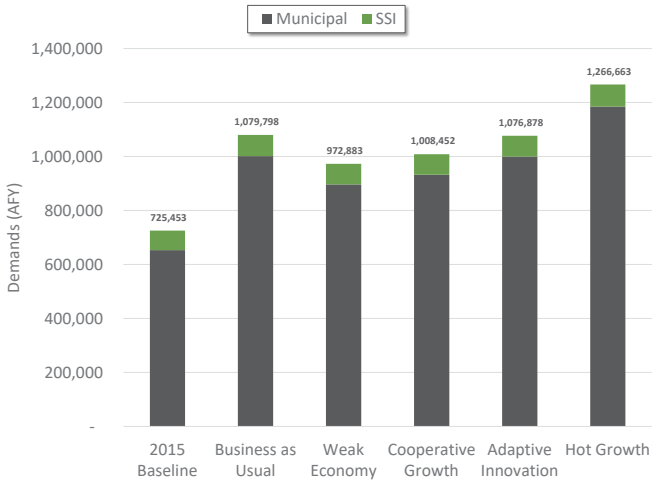
Table 4.8.9 Total South Platte Basin SSI Baseline and Projected Demands (AFY)

	Sub-sector	Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Metro Region	Large Industry	45,630	45,630	45,630	45,630	45,630	45,630
	Snowmaking	0	0	0	0	0	0
	Thermoelectric	3,040	3,040	2,890	2,740	2,890	3,350
	Energy Development	0	0	0	0	0	0
	Sub-Basin Total	48,670	48,670	48,520	48,370	48,520	48,980
Remaining South Platte Basin	Large Industry	6,600	6,600	5,940	6,600	6,600	7,260
	Snowmaking	300	320	320	320	320	320
	Thermoelectric	16,630	22,630	21,500	20,370	21,500	24,890
	Energy Development	0	0	0	0	0	0
	Sub-Basin Total	23,530	29,550	27,760	27,290	28,420	32,470
	Basin Total	**72,200**	**78,220**	**76,280**	**75,660**	**76,940**	**81,450**

Total M&I Diversion Demands

South Platte Basin combined M&I demand projections for 2050 range from approximately 970,000 AFY in *Weak Economy* to 1.27 million AFY in *Hot Growth*, as shown in Figure 4.8.17. SSI demands account for 6 to 10 percent of the M&I demands. On a basin scale, the demand projections do not follow the statewide sequence of the scenario rankings described in the CWP, with *Adaptive Innovation* falling out of sequence.

Figure 4.8.17 South Platte Basin Municipal and Self-Supplied Industrial Demands



4.8.6 Water Supply Gaps

Water supply gap estimates for the five planning scenarios were calculated differently for the South Platte and Republican basins as described in Section 2 and are, therefore, presented separately. In addition, while the CDSS water allocation models used for the water supply gap analysis in the South Platte Basin are able to generate a rich set of demand, supply, and gap data, it is difficult to parse results according to the boundaries of the Metro Region and remaining South Platte Basin. As a result, water supply gaps are described for the combined Metro Region and remaining South Platte Basin.

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.

South Platte Basin Gaps

Agricultural

The South Platte Basin agricultural diversion demands, demand gaps, and consumptive use gaps for the baseline and planning scenarios are presented in Table 4.8.10 and illustrated in Figure 4.8.18. An annual time series of gaps in terms of percent of demand that was unmet is shown in Figure 4.8.19.

Table 4.8.10 South Platte Basin Agricultural Gap Results (AFY)

		Scenario					
		Scenario	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average	Average Annual Demand	2,465,800	1,988,700	1,988,700	2,157,400	1,696,500	2,063,100
	Average Annual Gap	506,700	404,900	402,100	402,100	378,300	444,000
	Average Annual Gap Increase from Baseline	-	-	-	-	-	-
	Average Annual Percent Gap	21%	20%	20%	19%	22%	22%
	Average Annual CU Gap	278,000	220,400	218,700	220,300	237,800	247,600
Maximum	Demand in Maximum Gap Year	2,982,300	2,411,200	2,411,200	2,419,700	2,006,200	2,360,900
	Gap in Maximum Gap Year	1,206,100	978,400	960,700	901,900	824,800	1,064,000
	Percent Gap in Maximum Gap Year	-	-	-	-	-	-
	Increase from Baseline Gap	40%	41%	40%	37%	41%	45%

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

Figure 4.8.18 Projected Average Annual Agricultural Diversion Demand, Demand Met, and Gaps in the South Platte Basin

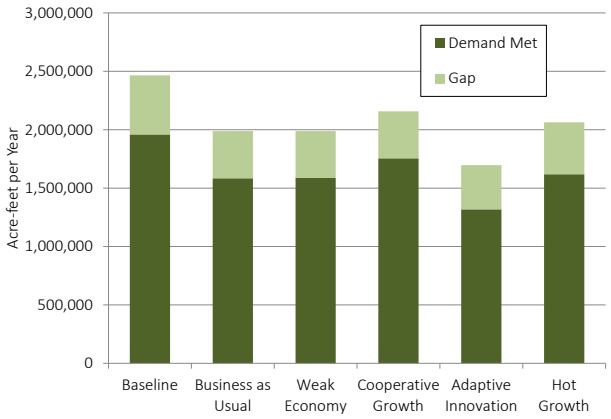
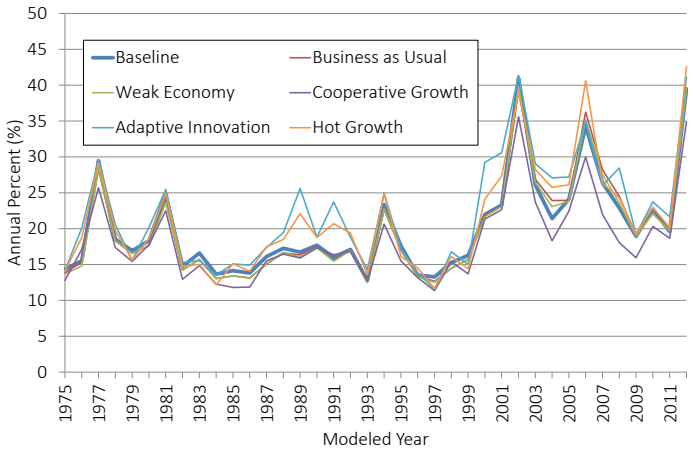


Figure 4.8.19 Annual Agricultural Gaps (expressed as a percentage of demand) for Each Planning Scenario



The following are observations on the agricultural diversion demand and gap results:

- In the South Platte Basin, the current agricultural gap is significant but is not projected to increase greatly in the future as a percentage of demand.
- On a volumetric basis, gaps are projected to decrease as agricultural diversion demands decrease, primarily from urbanization and potential conversion of agricultural water rights to municipal use.
- As shown in Figure 4.8.18, current and future agricultural gap simulation results hovered at around 15 percent of total demand in normal to wetter periods but increased during dry periods.
- In many years, the agricultural gaps in *Adaptive Innovation* and *Hot Growth* are projected to be higher than in other scenarios because of higher irrigation demands and lower supplies associated with the hot and dry future climate assumption. Overall, however, gaps in *Adaptive Innovation* are lower than *Hot Growth* because of the adoption of emerging technologies that lower demand.

M&I

The diversion demand and gap results for M&I uses in the South Platte Basin are summarized in Table 4.8.11 and illustrated in Figure 4.8.20. An annual time series of gaps in terms of percent of demand that was unmet is shown in Figure 4.8.21.

Table 4.8.11 South Platte Basin M&I Gap Results (AFY)

		Scenario					
		Scenario	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average	Average Annual Demand	718,700	1,073,000	968,900	1,002,800	1,070,100	1,257,700
	Average Annual Gap	0*	192,800	136,600	159,800	221,400	390,600
	Average Annual Percent Gap	0%	18%	14%	16%	21%	31%
Maximum	Demand in Maximum Gap Year	720,000	1,074,300	970,200	1,004,100	1,070,200	1,257,700
	Gap in Maximum Gap Year	0*	256,300	184,500	213,300	333,200	540,700
	Percent Gap in Maximum Gap Year	0%	24%	19%	21%	31%	43%

**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.*

Study period for Water Supply Analysis is 1975-2013, which reflects a different baseline demand than described in M&I Demand section. Baseline demand also may vary slightly from previous section due to differences in geographic distribution of demand for counties that lie in multiple basins.

Figure 4.8.20 Projected Maximum Annual M&I Diversion Demand, Demand Met, and Gaps in the South Platte Basin

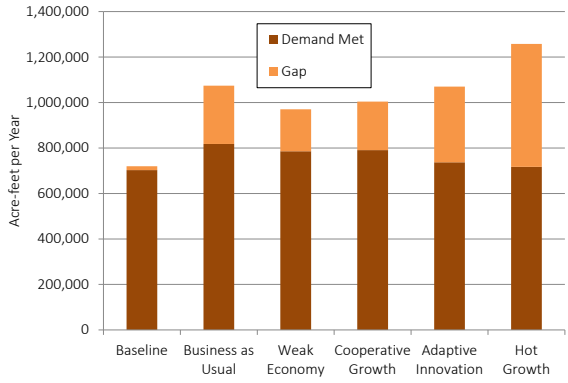
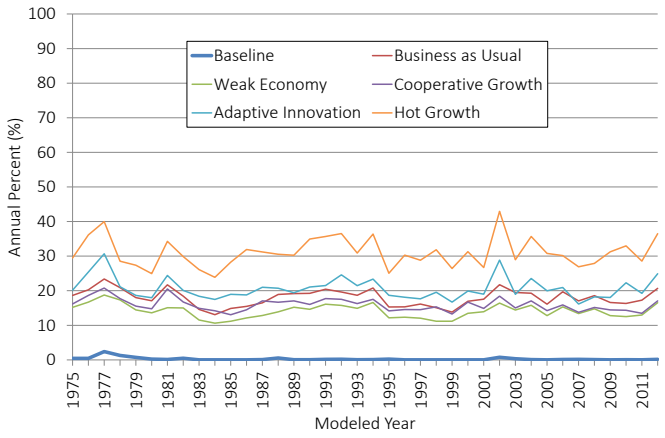


Figure 4.8.21 Annual M&I Gaps (expressed as a percentage of demand) for Each Planning Scenario



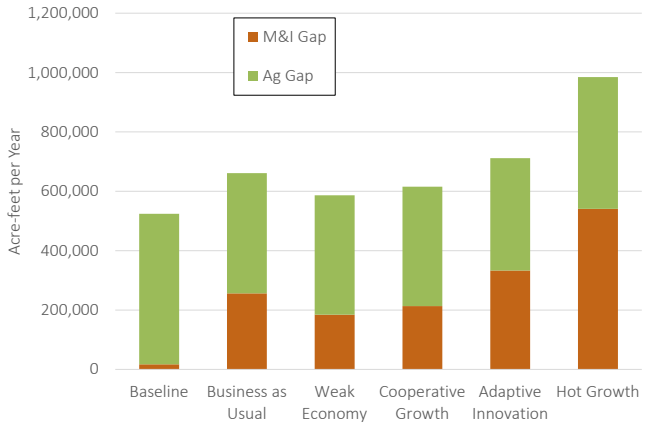
The following are observations on the M&I diversion demand and gap results:

- Gaps under *Hot Growth* are projected to be significantly higher than in other scenarios.
- *Adaptive Innovation* includes similar assumptions to *Hot Growth* in terms of future climate conditions and population projections; however, annual gaps and maximum gaps (as shown in Figure 4.8.19) are projected to be much less, which demonstrates the value of conservation. In addition, the gaps for *Business as Usual* and *Adaptive Innovation* are projected to be very similar even though *Adaptive Innovation* incorporates high population growth and a hot and dry future climate condition. The similarity in gaps suggests that additional conservation on a basinwide scale will help offset additional demands from population growth and climate change. Nonetheless, gaps in *Adaptive Innovation* are projected to be significant and point to the need for developing additional water supplies.
- The persistent nature of the time series of gaps in Figure 4.8.20 points to the need for projects that will provide firm yield.
- Figure 4.8.20 also shows that gaps can increase significantly during dry periods, especially in *Adaptive Management* and *Hot Growth* (the scenarios most severely impacted by future climate assumptions). Projects and water management strategies will be needed to meet periodic maximum M&I gaps.

Total Gap

Figure 4.8.22 illustrates the total combined agricultural and M&I diversion demand gap in the South Platte Basin. The figure combines the average annual agricultural gaps and the maximum M&I gap. Note that agricultural gaps are projected to decrease in the future, and therefore an incremental gap is not shown in the figure.

Figure 4.8.22 Projected Average Annual Agricultural Gaps and Maximum M&I Diversion Demand Gaps in the South Platte Basin.



Supplies from Urbanized Lands and Planned Transfers

The planning scenarios assumed between 127,100 and 169,600 acres of irrigated agricultural land will be urbanized or no longer irrigated because of planned water right transfers from agricultural to municipal use in the South Platte Basin. Irrigation supplies for urbanized 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.). Acreage associated with planned transfers was derived based on stakeholder input.

The average annual historical consumptive use associated with potentially urbanized acreage and planned water right transfers for each scenario is reflected in Table 4.8.12. The data in Table 4.8.12 represents planning-level estimates of this potential supply and has not been applied to the M&I gaps. The data in the table do not represent supplies from permanent water transfers that may be considered by a basin roundtable as a future strategy to meet gaps (note that SWSI 2010 included estimates of permanent transfers beyond those currently planned as a strategy for meeting potential future M&I gaps).

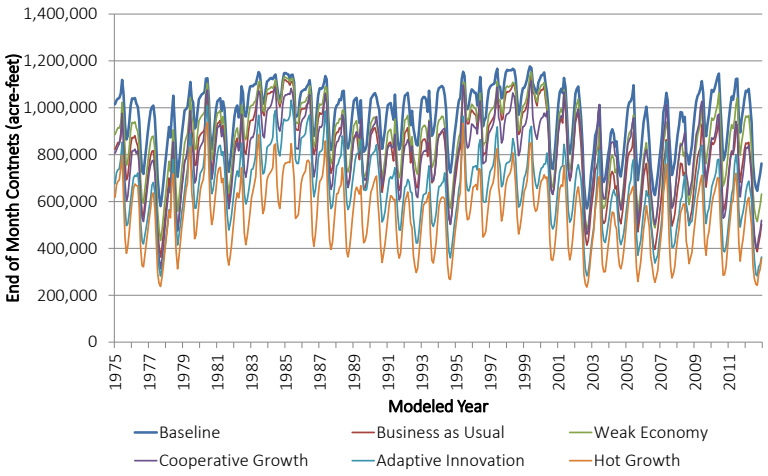
Table 4.8.12 Estimated Consumptive Use from Lands Projected to be Urbanized by 2050 and Planned Transfers in the South Platte Basin

	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Urbanized Acreage and Lands Subject to Planned Transfers (acres)	148,400	148,400	127,100	127,100	169,600
Estimated Consumptive Use (AFY)	209,800	210,200	179,400	172,700	238,600

Storage

Total reservoir storage output from the South Platte water allocation model is shown on Figure 4.8.23. 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 than the two scenarios that do not include the impacts of a drier climate. The results indicate that, without new projects, higher demands will draw storage down to lower levels. Concurrent drier conditions will impede full recovery of reservoirs. Lower demands in *Adaptive Innovation* help reservoir levels stay somewhat higher than in *Hot Growth*. It should be noted that the water allocation model allows reservoirs to be drawn down to the full extent water rights and storage amounts allow. Water providers would likely not be comfortable operating with chronically lower amounts of water in storage and would seek to acquire additional supplies or build new projects to boost reserves.

Figure 4.8.23 South Platte Basin Total Reservoir Storage (not including Water District 3)



Republican Basin Gaps

Agricultural

The Republican Basin agricultural diversion demands, demand gaps, and consumptive use gaps for the baseline and planning scenarios are presented in Table 4.8.13 and illustrated in Figure 4.8.24.

Table 4.8.13 Republican Basin Agricultural Gap Results (AFY)

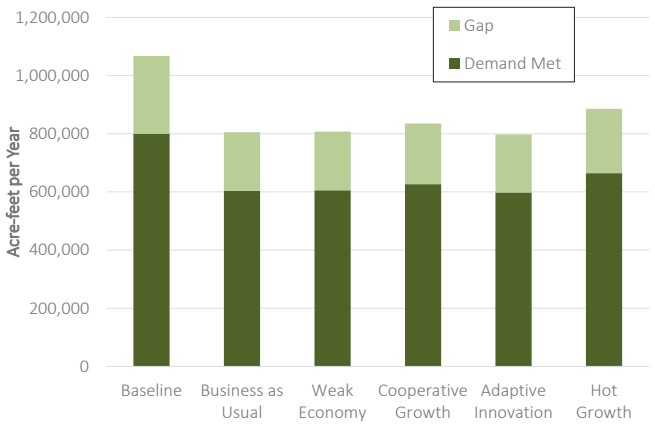
		Scenario					
		Scenario	**Business as Usual**	**Weak Economy**	**Cooperative Growth**	**Adaptive Innovation**	**Hot Growth**
Average	Average Annual Demand	1,067,200	805,500	807,500	835,300	797,200	885,800
	Average Annual Gap	266,800	201,400	201,900	208,800	199,300	221,400
	Average Annual Gap Increase from Baseline	-	-	-	-	-	-
	Average Annual Percent Gap	25%	25%	25%	25%	25%	25%
	Average Annual CU Gap	211,400	159,800	160,200	165,700	161,600	179,600
Maximum	Demand in Maximum Gap Year	1,445,200	1,113,000	1,114,700	1,113,200	1,014,400	1,127,100
	Gap in Maximum Gap Year	361,300	278,300	278,700	278,300	253,600	281,800
	Increase from Baseline Gap	-	-	-	-	-	-
	Percent Gap in Maximum Gap Year	25%	25%	25%	25%	25%	25%

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

The following are observations on agricultural diversion demands and gaps:

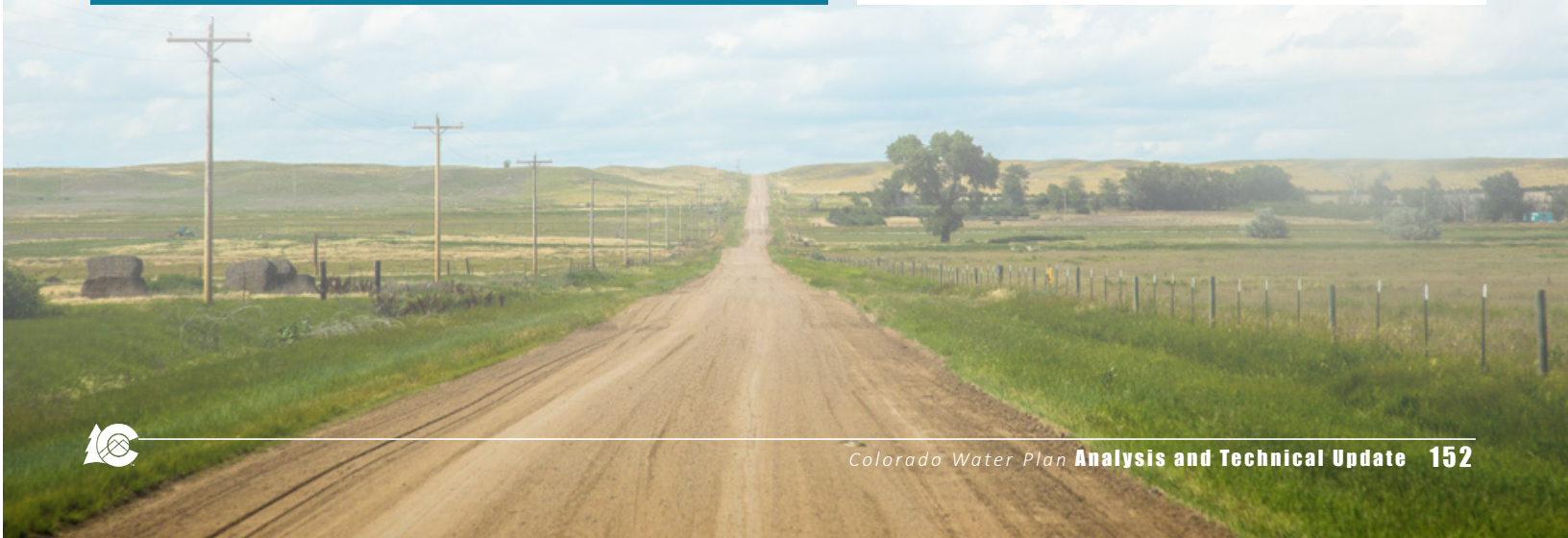
- Both diversion demands and gaps will likely decrease in the future due to reduction of irrigated lands in order to comply with the Republican River Compact and also as a result of declining water levels in the High Plains Aquifer.
- Even with reduced demand, reduced supplies will result in a fairly consistent gap in the future of approximately 25 percent of demand.

Figure 4.8.24 Projected Average Annual Agricultural Diversion Demand, Demand Met, and Gaps in the Republican Basin



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.



M&I

The diversion demand and gap results for M&I uses in the Republican Basin are summarized Table 4.8.14 and illustrated in Figure 4.8.25.

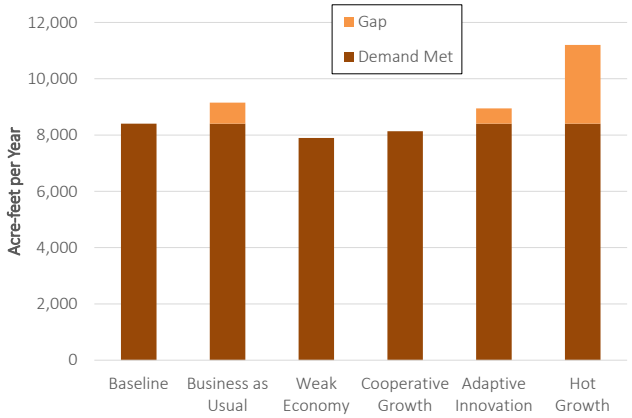
Table 4.8.14 Republican Basin M&I Gap Results (AFY)

		Scenario					
		Scenario	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average	Average Annual Demand	8,400	9,200	7,900	8,100	8,900	11,200
	Average Annual Gap	-	1,300	-	-	1,100	3,300
	Average Annual Percent Gap	0%	14%	0%	0%	12%	30%
Maximum	Demand in Maximum Gap Year	8,400	9,200	7,900	8,100	8,900	11,200
	Gap in Maximum Gap Year	-	1,300	-	-	1,100	3,300
	Percent Gap in Maximum Gap Year	0%	14%	0%	0%	12%	30%

Total Gap

Figure 4.8.26 illustrates the total combined agricultural and M&I diversion demand gap in the Republican Basin. The figure combines the average annual agricultural gaps and the maximum M&I gap. Note that agricultural gaps are projected to decrease in the future, and therefore an incremental gap is not shown in the figure.

Figure 4.8.25 Projected Maximum Annual M&I Demand Met and Gaps in the Republican Basin



Supplies from Urbanized Lands

The planning scenarios assumed 1,400 acres of irrigated agricultural land will be urbanized in the Republican Basin. 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 4.8.15. The data in Table 4.8.15 represents planning-level estimates of this potential supply and has not been applied to the M&I gaps.

Figure 4.8.26 Projected Average Annual Agricultural Gaps and Maximum M&I Diversion Demand Gaps in the Republican Basin.

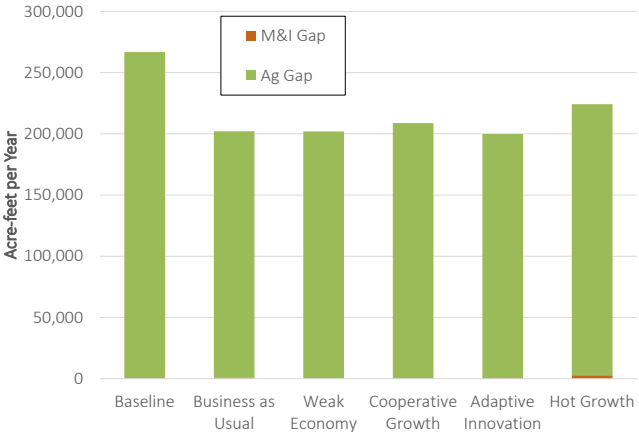


Table 4.8.15 Estimated Consumptive Use from Lands Projected to be Urbanized by 2050 in the Republican Basin

	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Urbanized Acreage (acres)	1,400	-	1,400	1,400	1,400
Estimated Consumptive Use (AFY)	1,500	-	1,600	1,600	1,700

Combined South Platte and Republican Basin Gaps

Table 4.8.16 summarizes the total M&I and agricultural demands in the South Platte and Republican Basins along with a summary of gaps. It should be noted that the South Platte and Republican basins were assessed independently; some of the results from each basin may not be wholly additive in some circumstances. For example, the maximum M&I gap may not occur in the same year in each sub-basin. As a result, the basin as a whole may not experience a year in the future when the total maximum M&I gap corresponds to the sum of the maximum gaps in both sub-basins; however, the sum of the maximum sub-basin gaps does describe the total amount of water that would be needed to fully satisfy all M&I demands in each individual sub-basin, even if the gaps do not simultaneously occur in the sub-basins.

Table 4.8.16 Summary of Total South Platte and Republican Basin Demands and Gaps

	Current (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average Annual Diversion Demand						
Agricultural (AFY)	3,533,000	2,794,200	2,796,100	2,992,700	2,493,700	2,948,900
M&I (AFY)	727,100	1,082,200	976,800	1,010,900	1,079,100	1,268,900
Gaps						
Ag (avg %)	22%	22%	22%	20%	23%	23%
Ag (incremental-AFY)	-	-	-	-	-	-
Ag (incremental gap as % of current demand)	-	-	-	-	-	-
M&I (max %)	0%	24%	19%	21%	31%	43%
M&I (max-AF)	0*	257,100	184,500	213,300	333,700	543,500

**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.*

4.8.7 Available Supply

Figures 4.8.27 through 4.8.30 show simulated available at two locations on the South Platte River, the South Platte River at Denver and South Platte River at Kersey. The Denver location, upstream of the Burlington Ditch, is the primary calling right on the mainstem of the Upper South Platte River. The Kersey gage reflects the impact to available flow downstream of the confluence, with the Cache La Poudre River and the Lower South Platte River calling rights for storage and irrigation. Available flow at both locations is generally only available during high flow years and for relatively short periods of time. In scenarios with impacts of climate change, available flows are projected to diminish, and peak flows are projected to occur earlier in the runoff season.

Figure 4.8.27 Simulated Hydrographs of Available Flow at South Platte River at Denver

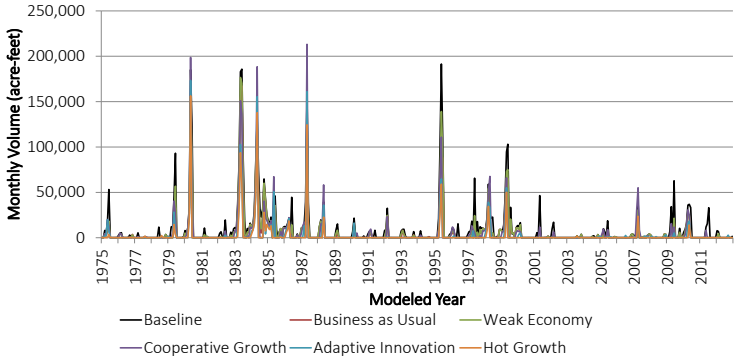


Figure 4.8.28 Average Monthly Simulated Hydrographs of Available Flow at South Platte River at Denver

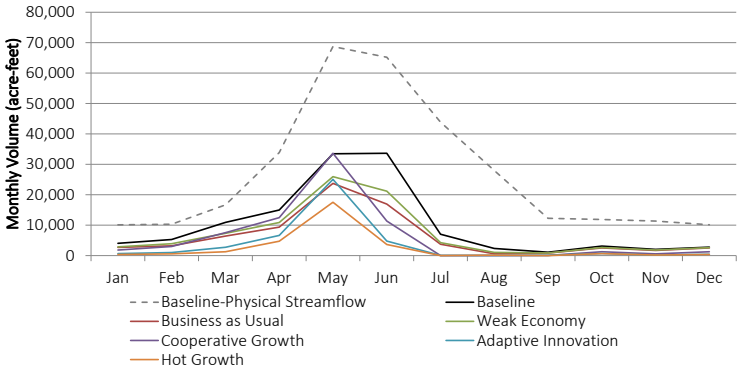


Figure 4.8.29 Simulated Hydrographs of Available Flow at South Platte River at Kersey, CO

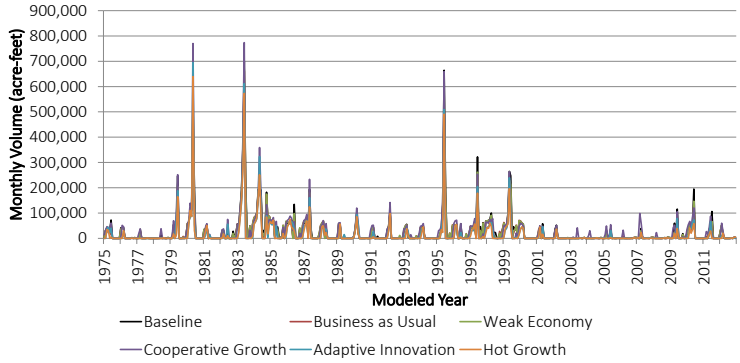
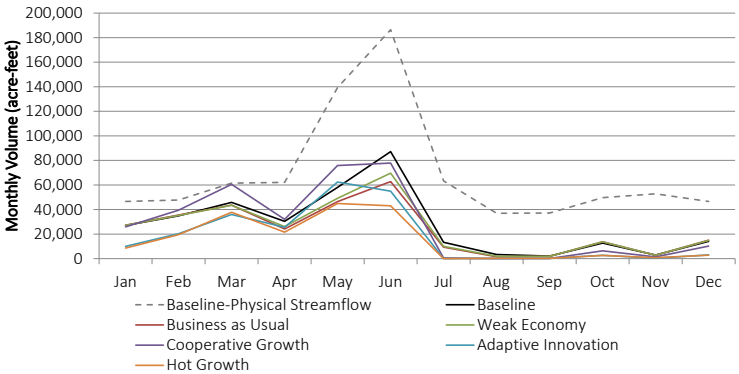


Figure 4.8.30 Average Monthly Simulated Hydrographs of Available Flow at South Platte River at Kersey, CO



4.8.8 Environment and Recreation

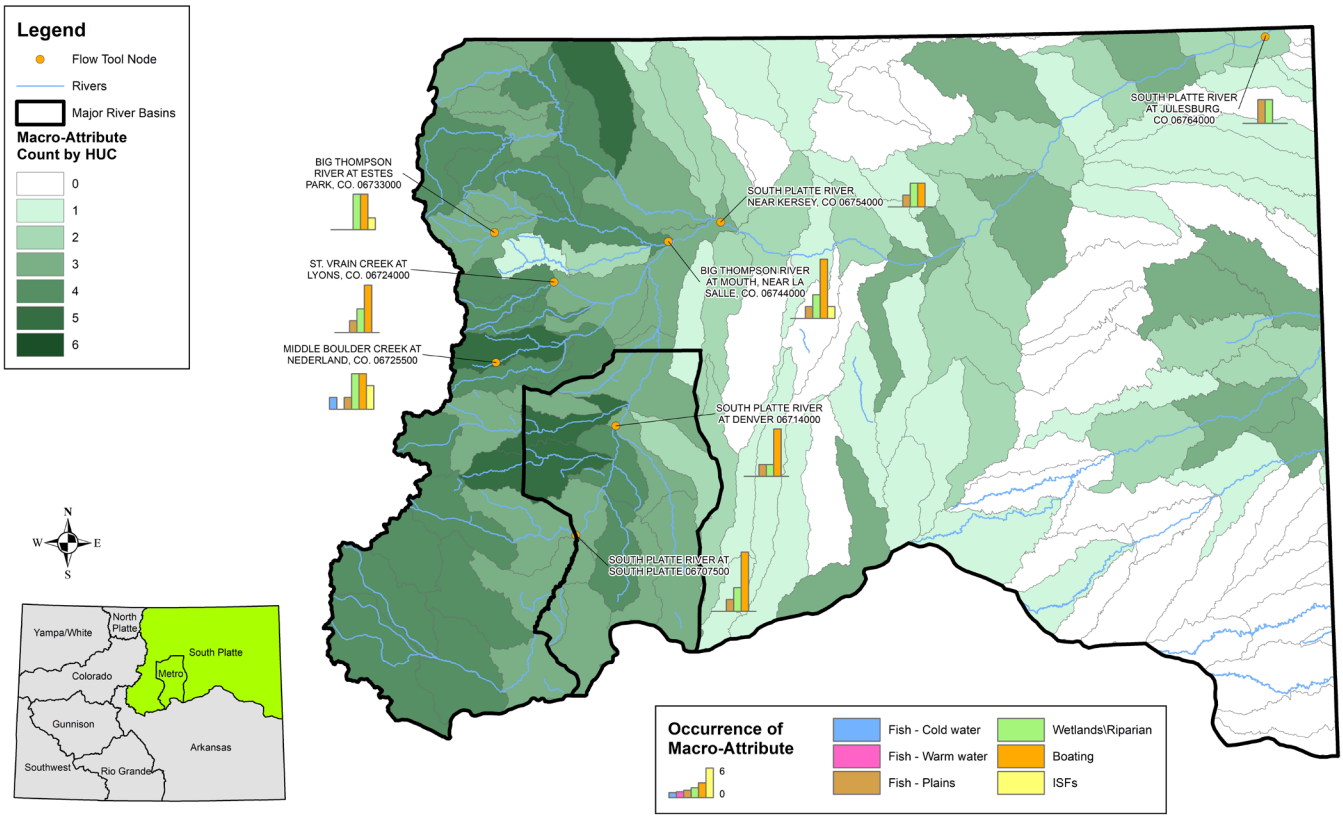
A total of eight water allocation model nodes were selected for the Flow Tool within the South Platte Basin (see list below and Figure 4.8.31). Figure 4.8.31 also shows subwatersheds (at the 12-digit HUC level) and the relative number of E&R attributes located in each subwatershed.

- South Platte River at South Platte (06707500)
- South Platte River at Denver (06714000)
- St Vrain Creek at Lyons, Colorado (06724000)
- Middle Boulder Creek at Nederland, Colorado (06725500)
- Big Thompson River at Estes Park, Colorado (06733000)
- Big Thompson River at Mouth, near La Salle, Colorado (06744000)
- South Platte River near Kersey, Colorado (06754000)
- South Platte River at Julesburg, Colorado (06764000)

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 4.8.31 Flow Tool Nodes Selected for the South Platte Basin



Results and observations from Flow Tool analyses using flow data developed in the water supply and gap analyses for baseline conditions and the planning scenarios are described in Table 4.8.17 below.

Table 4.8.17 Summary of Flow Tool Results in the South Platte Basin

Category	Observation
Projected Flows	Patterns of peak flows are highly variable across locations in the basin.
	Baseline flow patterns diverge the most from naturalized conditions in the Foothills and on the Plains.
	The magnitude of flows on the South Platte in Denver in May and June (historically the months of peak runoff) under baseline conditions are reduced from naturalized conditions, and the divergence from naturalized conditions increases as the South Platte flows through Julesburg. In these locations, peak flow magnitude under the various future scenarios is projected to increase, stay the same, or decrease further depending on location.
	In the mountains (e.g., South Platte River at South Platte, Middle Boulder Creek at Nederland), baseline peak flow magnitudes are only minimally below naturalized peak flow magnitude. Projected changes to peak flow magnitude in these mountain locations also vary depending on location, with minimal changes to peak flow magnitude in some locations and larger declines elsewhere.
	Mountain locations demonstrate a projected pattern under the climate change scenarios where the timing of peak flows shifts earlier in the year, from June to May. The change in timing for peak flows may result in mismatches between peak flow timing and species' needs.
	Mid- and late-summer flows are also highly variable across locations in the basin. On the plains, baseline low flows vary in range below naturalized conditions.
	Under future scenarios, this range is expected to further departed from naturalized conditions in climate-impacted scenarios (*Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*) causing the greatest decline in flows.
	In the mountains, climate change scenarios may cause a decline in low flows (e.g., Middle Boulder Creek at Nederland), while in other areas (e.g., South Platte River at South Platte) declines may be less pronounced due to transbasin imports and releases of stored water.
Ecological Risk	In the Foothills and on the Plains, especially east of Interstate 25, decreased peak flow magnitudes under baseline conditions and all future scenarios may put many aspects of ecosystem function (e.g., over-bank flooding to support riparian plants, sediment transport to maintain fish habitat) at risk. Projected changes to mid- and late-summer flows may also create risk for plains fishes.
	In the mountains, peak flow and low flows generally create low to moderate risk for riparian plants and fish, although these risks may increase under climate change scenarios.
ISFs and RICDs	There are numerous ISF reaches in the mountains and foothills, and several RICDs in the South Platte Basin. The location of modeled flow points does not allow specific insight into what future scenarios imply for these locations, but the general pattern of diminished flows, especially diminished flows under climate change scenarios, suggests that the flow targets for ISFs and RICDs may be met less often.
E&R Attributes	Increasing risk to E&R attributes arise from several sources. Changes in flow timing through water management (e.g., storage of peak flows) can reduce ecosystem functions that are dependent on high flows (e.g., sediment transport) and can reduce boating opportunities. Changes in timing under climate change scenarios (early peak flow) can also increase risk for ecosystems and species.
	Under all scenarios in most locations, ecological and recreational risk may be increased by depletions from increasing human water consumption and decreasing supply under a changing climate. Water management (e.g., reservoir releases) has the potential to mitigate negative impacts.