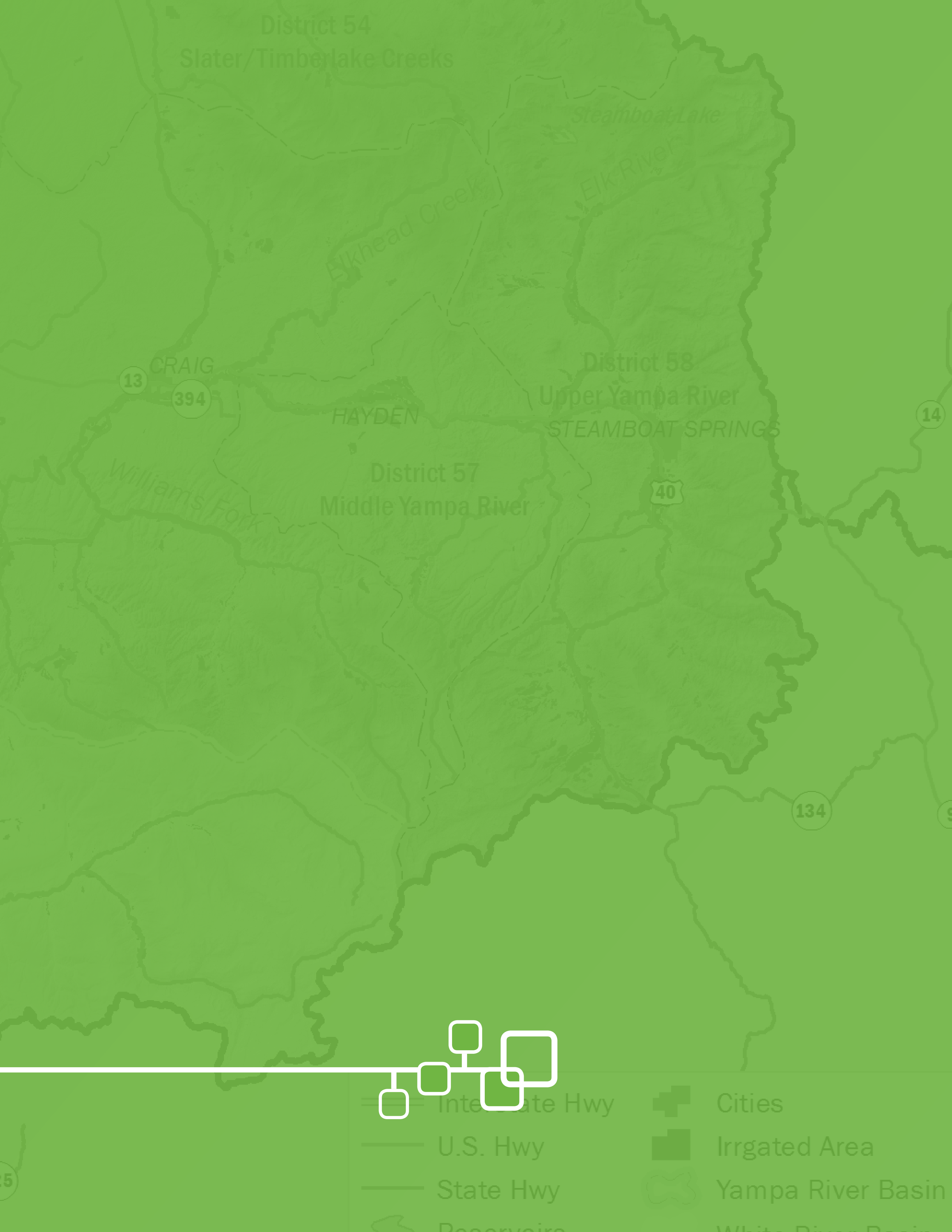
The Yampa, White, and Green Basins cover approximately 10,500 acres in northwestern Colorado and south-central Wyoming. The basin landscape is diverse and includes steep mountain slopes, high plateaus, canyons, and broad alluvial valleys. Livestock, grazing, and recreation are the predominant land uses. Near the towns of Craig, Hayden, Steamboat Springs, Yampa, and Meeker, much of the land is dedicated to agricultural use, and the mountains are covered by forest. The Steamboat Springs area, featuring a destination ski resort, is likely to experience continued and rapid population growth.

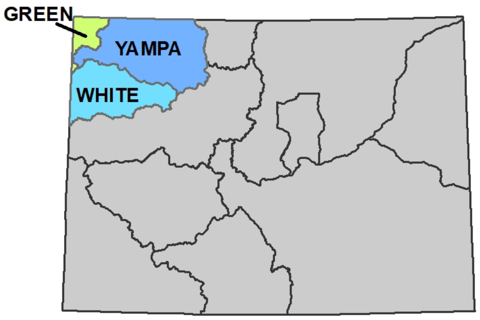
The Technical Update largely keeps the analysis at the basin scale. There are some exceptions where subbasin (river basin) analysis of major waterways was more straightforward. To that end, both the Yampa and the White river basins were explicitly modeled with results that are shown in this section. The combined Yampa-White-Green results are shown where statewide results are described.

Note that tributaries of the Green River have five diversions and one instream flow water right, and these are included in the model for the Yampa Basin. The demands and potential gaps from these structures are included in the Yampa Basin results.

YAMPA WHITE GREEN


District 54
Slater/Timberlake Creeks
Steamboat Lake
Elk River
Elkhead Creek
CRAIG
13
394
HAYDEN
District 58
Upper Yampa River
STEAMBOAT SPRINGS
14
40
District 57
Middle Yampa River
Williams Fork
134
Interstate Hwy
U.S. Hwy
State Hwy
Cities
Irrgated Area
Yampa River Basin

4.10 YAMPA-WHITE-GREEN BASIN RESULTS

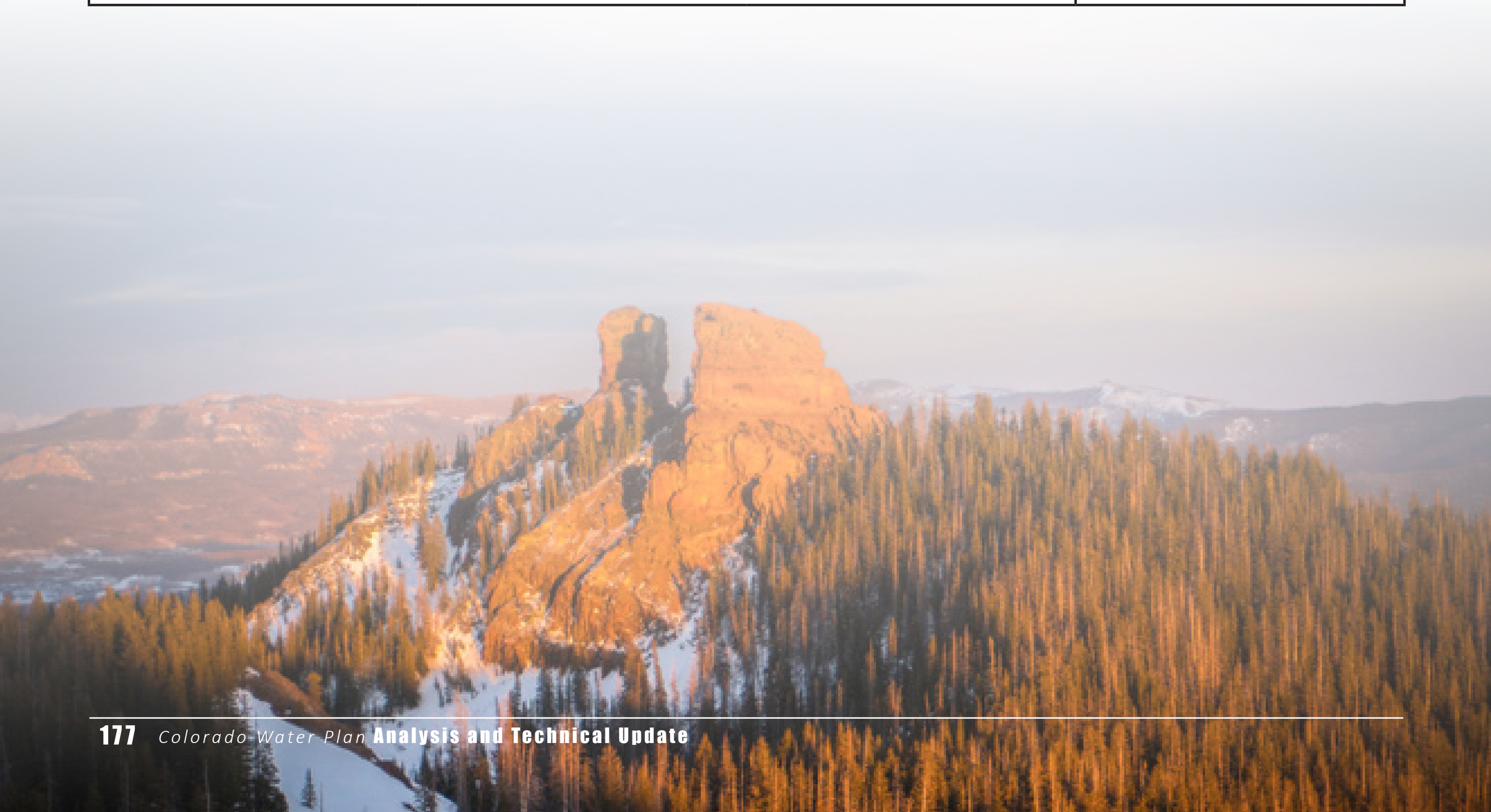


4.10.1 BASIN CHALLENGES

Key future water management issues for this basin include gas and oil shale development and addressing water resources needs for agriculture, tourism and recreation, and protection of endangered species. These challenges are outlined in the Colorado Water Plan and are summarized below.

Table 4.10.1 Key Future Water Management Issues in the Yampa-White-Green Basin

<table>
<tr><th>Agriculture</th><th>Environment and Recreation</th><th>Municipal and Industrial</th><th>Compacts and Administration</th></tr>
<tr><td>• Agricultural producers would like to increase irrigated land by 14,000 acres but lack finances to do so.</td><td>• Implementation of a successful Upper Colorado River Endangered Fish Recovery Program is vital to ensuring protection of existing and future water uses.</td><td>• The emerging development of gas and oil shale resources is affecting water demand, for both direct production and the associated increase in municipal use.
• Industrial uses, especially power production, are a major water use. Future energy development is less certain.</td><td rowspan="2">• While rapidly growing in the Steamboat Springs area, the basin as a whole is not developing as quickly as other portions of the state. Concerns have arisen that the basin will not get a “fair share” of water under the Colorado River Compact in the event of a compact call.</td></tr>
<tr><td colspan="3">• Agriculture, tourism, and recreation are vital components of this basin’s economy. As the needs of communities and industry grow, competition among sectors could increase.</td></tr>
</table>



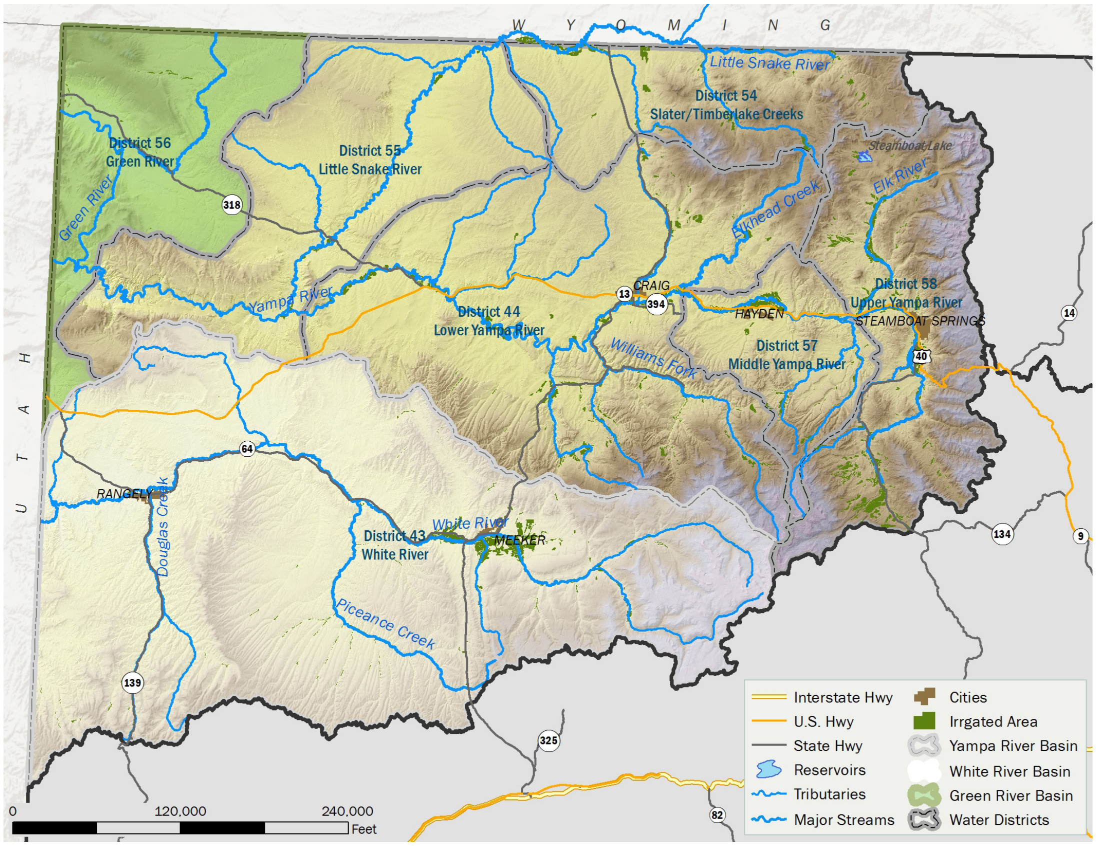


Figure 4.10.1 Map of the Yampa-White-Green Basin

4.10.2 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 4.10.2.

Table 4.10.2 Summary of Key Results in the Yampa-White-Green Basin



Agriculture	Environment and Recreation	Municipal and Industrial
• Agricultural gaps may increase significantly in the Yampa Basin if water demands increase because of new acreage and higher IWR. • Gaps in the Yampa and White basins may also increase if stream flow is diminished via climate change. • Agricultural gaps in the White Basin are not projected to be as significant as in the Yampa	• In most locations, summer flows may be depleted significantly in climate-impacted scenarios, which creates high to very high risk for coldwater and warmwater fish. • Stream flows may be substantially below flow recommendations in some locations under climate-impacted scenarios.	• M&I demand for the combined basin ranges between 6 to 10 percent of agricultural demand. • Water supply gaps in the White Basin show a large increase in *Hot Growth* mainly due to potential increased energy development demand. • Increased population and thermoelectric demand drive increasing M&I gaps in the Yampa Basin.

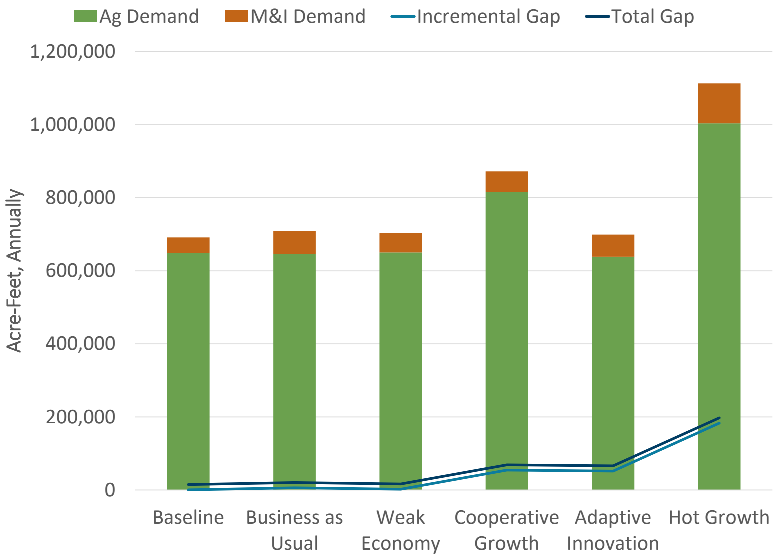
Results describing current and potential future M&I and agricultural demands and gaps are summarized in Table 4.10.3 and in Figure 4.10.2.

Table 4.10.3 Summary of Diversion Demand and Gap Results in the Yampa-White-Green Basin

		Current (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Yampa	**Average Annual Demand**						
	Agricultural (AFY)	402,500	403,600	403,600	522,500	461,000	684,300
	M&I (AFY)	36,900	53,300	46,700	48,900	53,000	68,300
	Gaps						
	Ag (avg %)	3%	3%	3%	12%	13%	22%
	Ag (incremental-AFY)	-	400	300	49,800	45,700	136,800
	Ag (incremental gap as % of current demand)	-	0%	0%	12%	11%	34%
	M&I (max %)	0%	3%	1%	3%	5%	12%
	M&I (max-AF)	0*	1,600	700	1,600	2,500	8,200
White	**Average Annual Demand**						
	Agricultural (AFY)	246,700	242,900	246,700	293,900	177,800	319,700
	M&I (AFY)	5,300	10,000	6,100	6,900	7,700	41,000
	Gaps						
	Ag (avg %)	0%	1%	0%	1%	2%	2%
	Ag (incremental-AFY)	-	-	-	1,900	2,100	4,600
	Ag (incremental gap as % of current demand)	-	0%	0%	1%	1%	2%
	M&I (max %)	0%	39%	15%	13%	17%	82%
	M&I (max-AF)	0	3,900	900	900	1,300	33,500
Total	**Average Annual Demand**						
	Agricultural (AFY)	649,200	646,500	650,400	816,300	638,700	1,004,000
	M&I (AFY)	42,200	63,400	52,800	55,900	60,600	109,300
	Gaps						
	Ag (avg %)	2%	2%	2%	8%	10%	16%
	Ag (incremental-AFY)	-	400	300	51,700	47,800	141,400
	Ag (incremental gap as % of current demand)	-	0%	0%	8%	7%	22%
	M&I (max %)	0%	9%	3%	5%	6%	38%
	M&I (max-AF)	0*	5,600	1,600	2,600	3,800	41,700

** 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 4.10.2 Summary of Diversion Demand and Gap Results in the Yampa-White-Green Basin



Summary of Environmental and Recreational Findings

- In most stream locations, peak flows may be modestly depleted with low to moderate risk to riparian/wetlands and fish habitat. Peak flows may 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.
- In most stream locations, including those with current low risk during mid- and late-summer, summer flows may be depleted 65 to 90 percent under *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*, which could create high to very high risk for coldwater and warmwater fish.
- The recreational in-channel diversion in Steamboat Springs could be at risk of being unmet often in mid- to late-summer, and Instream Flow water rights in most areas could be at greater risk of not being met, especially under *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*.
- In critical habitat for endangered species, extremely reduced flows in mid- and late-summer (greater than 90 percent reduction in July on the Yampa River near Maybell; greater than 80 percent reduction in July and August on the White River near Watson) may result in the flows in most years being substantially below flow recommendations. On the Yampa, in addition to loss of habitat for endangered fish, extremely low flows favor non-native fish reproduction and survival.

4.10.3 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 Yampa-White-Green Basin are listed below:

- The Yampa-White-Green has published a follow-on report to their BIP, which has different results based on different modeling objectives, assumptions, and inputs (e.g., climate assumptions around paleohydrology are different than the assumptions in the Technical Update; see section 2.2.1).
- The Technical Update used water allocation models that reflect a strict application of water administration. In the Yampa-White-Green basin, some water users refrain from placing a call to share the benefit of available supplies.
  - » As an example, in the White Basin, Kenney Reservoir is used for hydropower production. If future water shortages occur that might impact energy development, it is very possible that hydropower operators would choose to reduce generation as opposed to curtailing energy development uses.
- The Yampa-White-Green SSI demands for energy production could be further researched.
- Projected gaps in several scenarios are low relative to other basins. The result is consistent with expectations because supplies in the Yampa-White-Green have historically met demands. The first mainstem call on the Yampa occurred in 2018.
- Current Elkhead Reservoir operations related to the Yampa Programmatic Biological Opinion (PBO) are included in the Yampa model. The White PBO is in progress and was not included in the model. Future water supply projects and strategies were not included in the analysis.

GREEN RIVER DEMANDS

Tributaries of the Green River have five diversions and one instream flow water right, and these are included in the model for the Yampa Basin. The demands and potential gaps from these structures are included in the Yampa Basin results.

4.10.4 AGRICULTURAL DIVERSION DEMANDS

Agricultural Setting

Yampa Basin

Agriculture is a primary focus in the Yampa Basin. Irrigated acreage in the basin consists primarily of high mountain meadows and cattle ranches in the upper reaches of the basin along Elk Creek and the Yampa River. Irrigated acreage is also located along the Little Snake River as it meanders between Colorado and Wyoming.

White Basin

Approximately 60 percent of the irrigated acres in the White Basin are concentrated along the river near the Town of Meeker. The remaining acreage is located along tributaries and spread along the lower mainstem. Grass pasture is the dominant crop in the basin, and alfalfa is also grown. These forage crops support cattle grazing and ranching operations in the basin, which is a major economic driver. Mining and oil and gas extraction are also important elements of the basin's economy.

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 Yampa-White-Green Basin focused on urbanization, potential future climate conditions, and implementation of emerging technologies.

Yampa Basin

The Yampa-White-Green basin roundtable completed an Agricultural Water Needs Study in 2010 that identified 14,805 acres of potentially irrigable land in the Yampa Basin. For the Technical Update effort, the Yampa/White/Green basin roundtable contemplated how the irrigable land could be developed under the planning scenarios, recognizing that growth could vary depending on the future demand and economics for hay crops and cattle production. The stakeholders in the basin provided a varying amount of acreage and crops types for planned agricultural projects in each planning scenario in the Yampa Basin as reflected in Table 4.10.4.

Population projections anticipate significant growth in the Yampa Basin. The impact to irrigated areas, however, will be limited because the three largest municipal centers in the basin (Steamboat Springs, Hayden, and Craig) are not surrounded by irrigated agricultural areas.

White Basin

Future urbanization of irrigated lands is expected to be relatively limited in the basin, with 360 acres total in and around the towns of Meeker and Rangely projected to be urbanized. Population projections in Rio Blanco County are expected to decline in *Weak Economy*, and urbanization in this scenario was set to zero. Table 4.10.4 provides a summary of the adjustments to agricultural diversion demand drivers based for each planning scenario.

Table 4.10.4 summarizes the planning scenario adjustments described above and other adjustments that impact agricultural diversion demands in the various scenarios.

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

Table 4.10.4 Planning Scenario Adjustments for Agricultural Demands in the Yampa and White Basins

Sub-basin	Adjustment Factor*	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Yampa	Change in Irrigated Land due to Urbanization	1,500 Acre Reduction	1,500 Acre Reduction	1,500 Acre Reduction	1,500 Acre Reduction	1,500 Acre Reduction
	Planned Agricultural Development Projects	1,000 Acre Increase 100% Alfalfa	1,000 Acre Increase 100% Alfalfa	5,000 Acre Increase 50/50 Grass Pasture/Alfalfa	14,805 Acre Increase 50/50 Grass Pasture/Alfalfa	14,805 Acre Increase 50/50 Grass Pasture/Alfalfa
	IWR Climate Factor	-	-	19%	34%	34%
	Emerging Technologies	-	-	-	10% IWR Reduction 10% System Efficiency Increase	-
White	Change in Irrigated Land due to Urbanization	360 Acre Reduction	-	360 Acre Reduction	360 Acre Reduction	360 Acre Reduction
	IWR Climate Factor	-	-	22%	37%	37%
	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 4.10.5 and Figures 4.10.3 and 4.10.4 summarize the acreage, IWR, and the agricultural diversion demand for surface water supplies in both the White and Yampa Basins for current conditions and the five planning scenarios. The largest variation in the White Basin occurred in *Adaptive Innovation* due to 10 percent reduction in IWR and 10 percent increase to system efficiency. In this basin, the combined impact of *Adaptive Innovation* adjustments resulted in an agricultural diversion demand that is lower than the current demand. The Yampa Basin saw the greatest increase in demand for *Hot Growth*, which assumed a large increase in irrigated acres.

Table 4.10.5 Summary of Agricultural Diversion Demand Results in the Yampa and White Basins

		Current	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Yampa	Irrigated Acreage (acres)	78,900	78,400	78,400	82,400	92,300	92,300
	Average IWR (AFY)	150,600	150,000	150,000	188,000	209,000	232,000
	Diversion Demand						
	Average Year (AFY)	402,000	403,000	403,000	518,000	456,000	679,000
	Wet Yr. Change	-4%	-3%	-3%	0%	1%	2%
	Dry Yr Change	0%	0%	0%	-1%	-2%	-3%
White	Irrigated Acreage (acres)	28,100	27,700	28,000	27,700	27,700	27,700
	Average IWR (AFY)	46,400	45,800	46,400	55,700	55,900	62,100
	Diversion Demand						
	Average Year (AFY)	243,000	239,000	243,000	293,000	180,000	324,000
	Wet Yr. Change	3%	3%	3%	4%	3%	6%
	Dry Yr Change	0%	0%	0%	-5%	-4%	-6%

Average agricultural diversion demand was calculated using the average hydrologic years (i.e., years classified as neither wet or dry) from 1950-2013

Figure 4.10.3 Agricultural Diversion Demands and IWR Results in the Yampa Basin

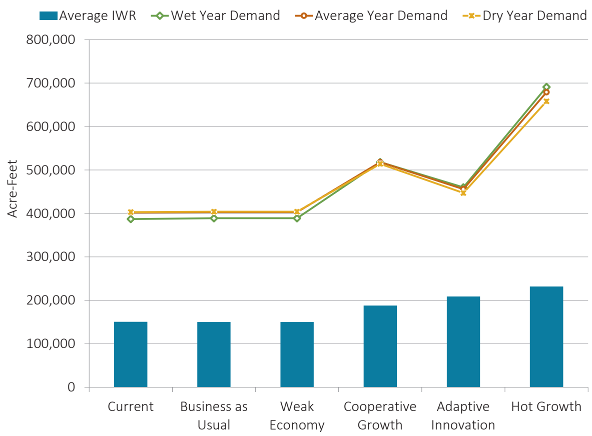
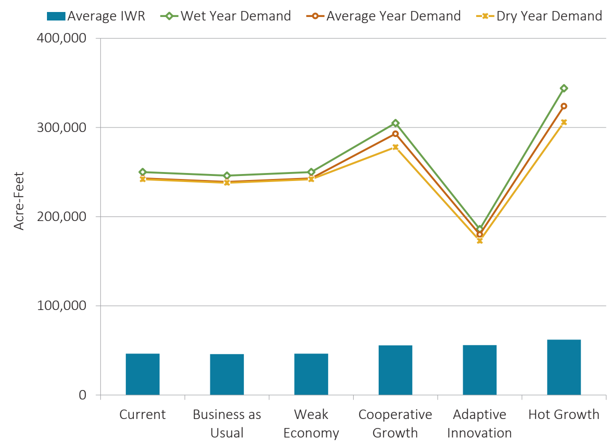


Figure 4.10.4 Agricultural Diversion Demands and IWR Results in the White Basin



4.10.5 Municipal and Self-Supplied Industrial Diversion Demands

Population Projections

The combined Yampa-White Basin currently includes less than 1 percent of the statewide population. Between the years 2015 and 2050, it is projected to change from approximately 44,000 to between 39,000 and 103,000 people in the low and high growth projections, respectively. Table 4.10.6 shows how population growth is projected to vary across the planning scenarios for White and Yampa basins.

Table 4.10.6 Yampa-White Basin 2015 and Projected Populations

Sub-basin	Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Yampa	37,200	59,900	34,400	63,500	86,000	91,900
White	6,500	7,400	4,200	7,000	10,600	11,300
Yampa-White Total	43,700	67,200	38,600	70,400	96,600	103,200

Current Municipal Demands

Sources of water demand data such as 1051 or WEP data were scarce in the Yampa and White Basins, and baseline water demands were largely estimated as shown on Figure 4.10.5.

Figure 4.10.6 summarizes the categories of municipal, baseline water usage in the Yampa and White Basins. In the Yampa Basin, and on a basin-scale, the residential indoor demand as a percentage of the systemwide demands is the highest reported throughout the state, at more than 50 percent. Conversely, the baseline residential outdoor water demand is the lowest statewide, at approximately 15 percent of the systemwide demands.

Figure 4.10.5 Sources of Water Demand Data in the Yampa-White Basin

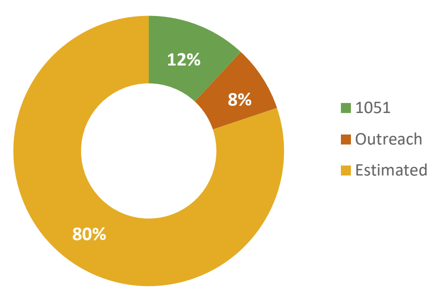
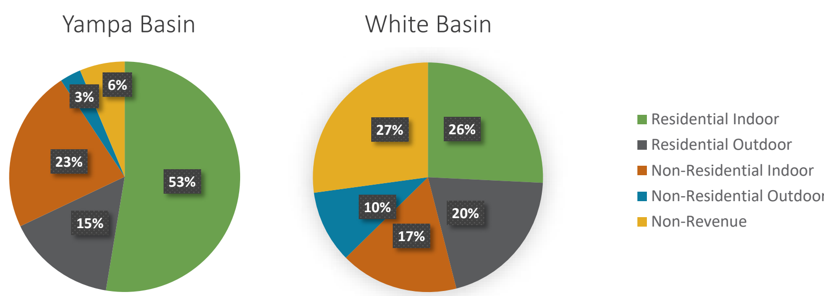


Figure 4.10.6 Categories of Water Usage in the Yampa-White Basin



Projected Municipal Demands

Figure 4.10.7 provides a summary of per capita baseline and projected water demands for the Yampa Basin. Systemwide, the projected per capita demands decrease relative to the baseline under all scenarios.

Figure 4.10.8 shows a summary of per capita baseline and projected water demands for the White Basin. Systemwide, the estimated per capita demands are projected to decrease relative to the baseline except in *Weak Economy* and *Hot Growth*. Consistently across all scenarios, the non-revenue water is the greatest demand category.

DECREASING GPCD

The Yampa-White Basin average baseline per capita systemwide demand has decreased slightly from 230 gpcd in SWSI 2010 to approximately 228 gpcd.

The relative proportions of various demand categories were estimated to be somewhat different in the White and Yampa Basins. Much of the difference is related to lack of representative data. In the White Basin, some usage data was derived from targeted outreach, but most of the data was filled (based on the outreach). In the Yampa Basin, some data were available via 1051 reporting, water efficiency plans, and targeted outreach, but much of the data was filled based on results from the available sources. Basin roundtables could work to acquire better data during the BIP update process.

Figure 4.10.7 Yampa Basin Municipal Baseline and Projected per Capita Demands by Water Demand Category

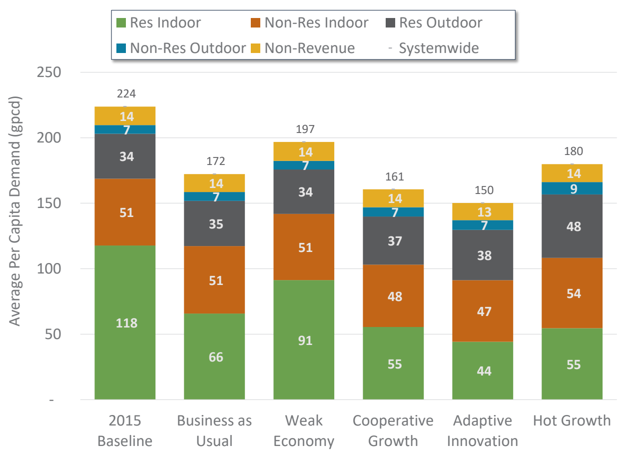


Figure 4.10.8 White Basin Municipal Baseline and Projected per Capita Demands by Water Demand Category

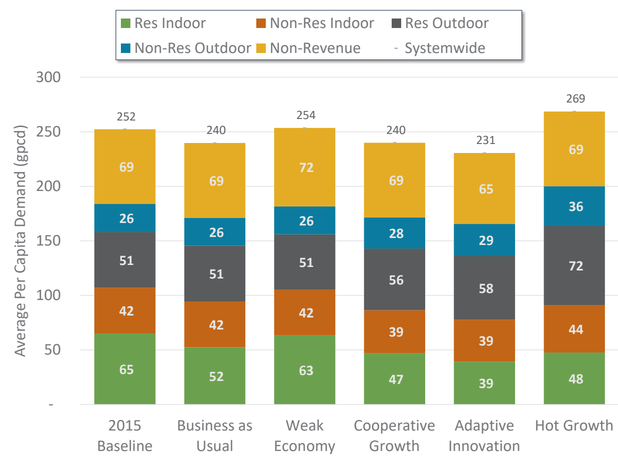


Table 4.10.7 Yampa-White Basin Municipal Baseline and Projected Demands (AFY)

Sub-basin	Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Yampa Basin	9,300	11,600	7,600	11,400	14,500	18,500
White Basin	1,800	2,000	1,200	1,900	2,700	3,400
Yampa-White Basin Total	11,200	13,500	8,800	13,300	17,200	21,900

Figure 4.10.9 Combined Yampa-White Basin Baseline and Projected Population and Municipal Demands

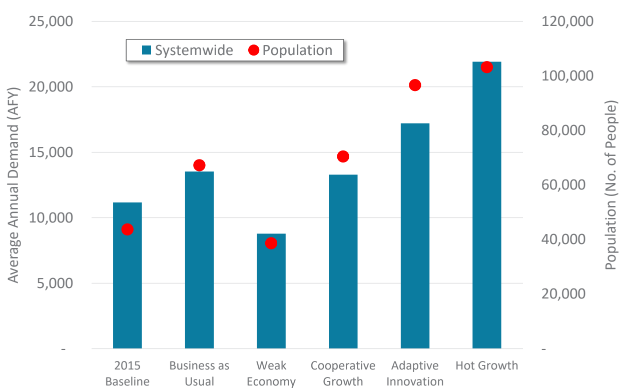
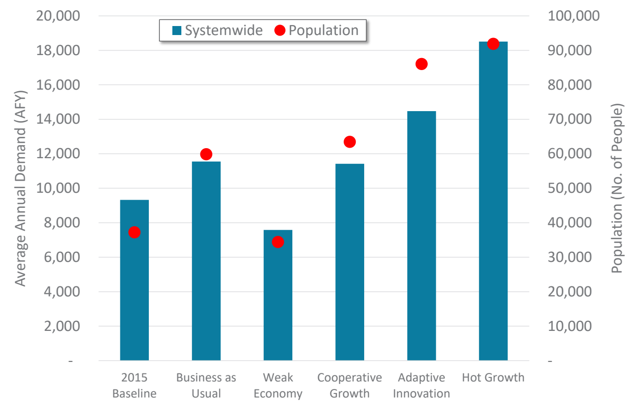


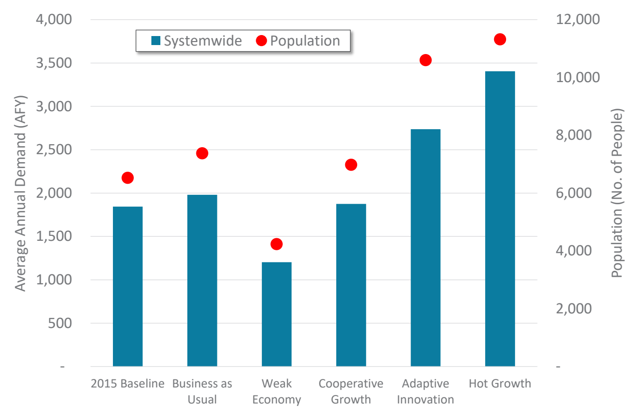
Figure 4.10.10 Yampa Basin Baseline and Projected Population and Municipal Demands



The Yampa-White Basin municipal baseline and projected demands are provided in Table 4.10.7, showing the combined effect of population and per capita demands. Municipal demands are projected to grow from approximately 11,000 AFY in 2015 to between 9,000 and 22,000 AFY in 2050.

The baseline and projected demand distributions are shown on Figures 4.10.9 through 4.10.11. Projected demands in *Business as Usual* and *Cooperative Growth* are nearly identical. All of the projection scenarios except for *Weak Economy* result in an increase relative to the baseline. Demands generally follow the population patterns, which shows the influence that population has within this region. *Adaptive Innovation* demands are an exception to this in that they are lower than *Hot Growth*. *Adaptive Innovation* demands include higher levels of water conservation, which keep demands lower despite similar assumptions of high population growth used in *Hot Growth*. Projected demands and populations in *Business as Usual* and *Cooperative Growth* are similar, with a slightly more noticeable distinction with the White Basin.

Figure 4.10.11 White Basin Baseline and Projected Population and Municipal Demands

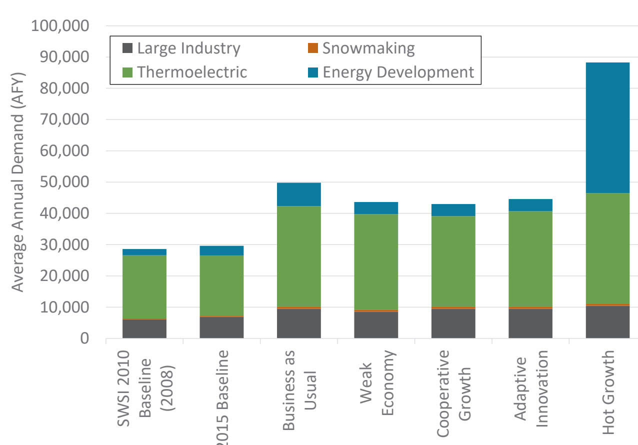


Self-Supplied Industrial Demands

The Yampa-White Basin includes about 17 percent of the statewide SSI demand. Approximately 93 percent of the baseline SSI demands are in the Yampa Basin and 7 percent are in the White Basin. SSI demands in the Yampa-White Basin are associated with all four sub-sectors. Basin-scale SSI demands are shown on Figure 4.10.12 and are summarized in Table 4.10.8.

Large Industry demands in this basin are located in Moffat and Routt counties. All baseline demands were based on SWSI 2010 and are related to mining in Moffat County and mining and golf courses in Routt County.

Figure 4.10.12 Total Yampa-White Basin SSI Baseline and Projected Demands



The baseline snowmaking demand is 290 AFY, which is the same as in SWSI 2010 because there has been no increase in snowmaking acreage. Projected demands are 570 AFY and were not varied by scenario.

Thermoelectric demands are related to two facilities. Baseline demands for the facility on Routt County were updated based on information from Xcel. Baseline demands for the facility in Moffat County were updated based on the BIP.

Table 4.10.8 Yampa-White SSI Baseline and Projected Demands (AFY)

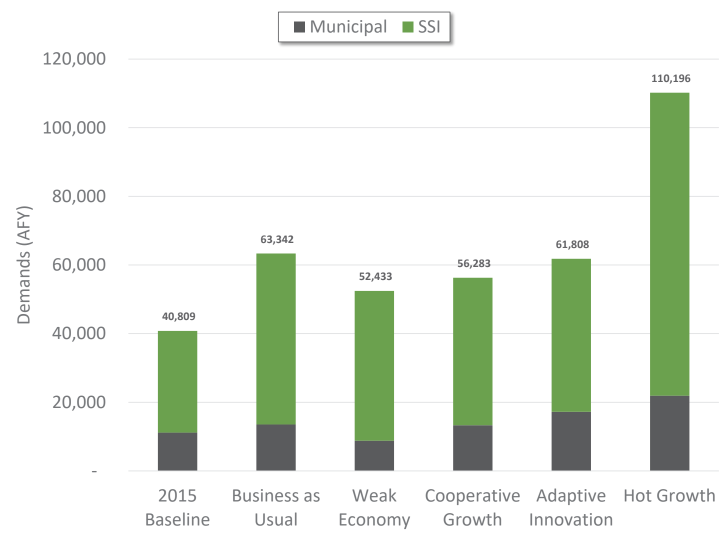
	Sub-sector	Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Yampa Basin	Large Industry	6,900	9,500	8,550	9,500	9,500	10,450
	Snowmaking	290	570	570	570	570	570
	Thermoelectric	19,350	32,240	30,630	29,020	30,630	35,460
	Energy Development	1,500	1,700	900	900	900	3,900
	Sub-Basin Total	28,040	44,010	40,650	39,990	41,600	50,380
White Basin	Large Industry	-	-	-	-	-	-
	Snowmaking	-	-	-	-	-	-
	Thermoelectric	-	-	-	-	-	-
	Energy Development	1,600	5,800	3,000	3,000	3,000	37,900
	Sub-Basin Total	1,600	5,800	3,000	3,000	3,000	37,900
	Basin Total	**29,640**	**49,810**	**43,650**	**42,990**	**44,600**	**88,280**

Energy development demands are located in Moffat, Rio Blanco, and Routt counties. Energy development demands in the White Basin for *Hot Growth* are much higher than for other scenarios but are consistent with high estimates of demands in Rio Blanco County used in SWSI 2010.

Total M&I Diversion Demands

Yampa-White Basin combined M&I demand projections for 2050 range from approximately 52,000 AFY in the *Weak Economy* to 110,000 AFY in *Hot Growth*, as shown on Figure 4.10.13. Under every planning scenario, SSI demands exceed the municipal. This is influenced by SSI use in the Yampa Basin and is the only basin in the state in which SSI demands exceed municipal. Self-supplied industrial demands make up approximately 70 percent to 80 percent of the total M&I demands in the Yampa-White Basin, depending on planning scenario. On a basin scale, the demand projections do not follow the statewide sequence of the scenario rankings described in the CWP, with the *Adaptive Innovation* falling out of sequence.

Figure 4.10.13 Yampa-White Basin Municipal and Self-Supplied Industrial Demands



4.10.6 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.

In general, agricultural diversion demands gaps in the Yampa Basin are projected to be relatively low on an average annual basis in *Business as Usual* and *Weak Economy*, but gaps may be more significant in climate-impacted scenarios. Additional observations on the modeling results are summarized below.

Yampa Basin Gaps

Agricultural

The Yampa Basin agricultural diversion demands, demand gaps, and consumptive use gaps for the baseline and planning scenarios are presented in Table 4.10.9 and illustrated on Figure 4.10.14. An annual time series of gaps in terms of percent of demand that was unmet is shown in Figure 4.10.15. Agricultural diversion demand and consumptive use gap estimates were influenced by a number of drivers including climate, urbanization, planned agricultural projects, and emerging technologies.

Table 4.10.9 Yampa Basin Agricultural Gap Results (AFY)

		Scenario					
		Scenario	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average	Average Annual Demand	402,500	403,600	403,600	522,500	461,000	684,300
	Average Annual Gap	13,300	13,600	13,600	63,100	58,900	150,000
	Average Annual Gap Increase from Baseline	-	400	300	49,800	45,700	136,800
	Average Annual Percent Gap	3%	3%	3%	12%	13%	22%
	Average Annual CU Gap	7,400	7,600	7,600	34,400	37,800	81,500
Maximum	Demand in Maximum Gap Year	448,900	450,500	450,500	533,000	463,800	667,500
	Gap in maximum Gap Year	55,600	55,400	55,200	123,400	97,700	246,500
	Increase From Baseline Gap	-	-	-	67,900	42,200	191,000
	Percent Gap in Maximum Gap Year	12%	12%	12%	23%	21%	37%

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

Figure 4.10.14 Projected Average Annual Agricultural Diversion Demand Met, Baseline Gaps, and Incremental Gaps in the Yampa Basin

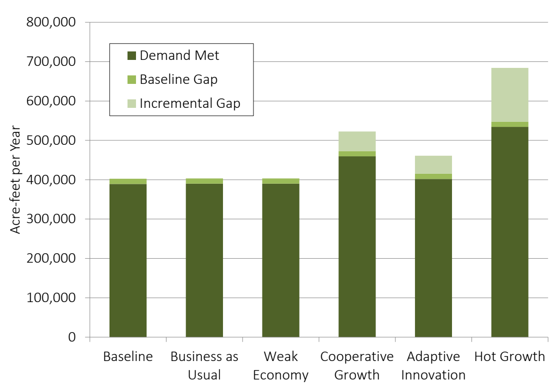
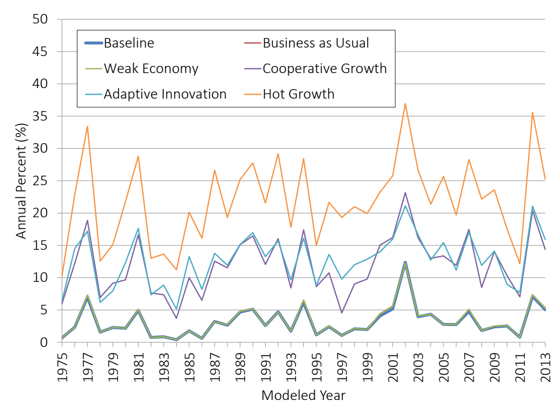


Figure 4.10.15 Annual Agricultural Gaps for Each Planning Scenario



- The Yampa Basin currently experiences an agricultural diversion demand gap, but the gap was not projected to significantly increase under the *Business as Usual* or *Weak Economy* scenarios.
- Agricultural diversion demand gaps increased in *Cooperative Growth*, *Adaptive Innovation* and *Hot Growth* due to additional demand from planned agricultural projects with junior water rights and higher IWR with concurrent lower water supply due to a drier and warmer climate.
- Climate conditions in *Adaptive Innovation* were hotter and drier than the *Cooperative Growth* scenario, but gaps were projected to be similar. Strategies associated with higher system efficiencies and the adoption of emerging technologies such as irrigation schedulings tended to offset climatic and hydrologic drivers that would have otherwise increased gaps in the *Adaptive Innovation* scenario.
- Agricultural water users do not have access to significant reservoir storage in the Yampa Basin. Gaps in *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth* were impacted by earlier runoff seasons and lower water availability during the latter part of the growing season.

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 water supply and gap results for M&I in the Yampa Basin are summarized Table 4.10.10 and illustrated on Figure 4.10.16. An annual time series of gaps in terms of percent of demand that was unmet is shown on Figure 4.10.17.

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

- The modeling suggests M&I gaps occur under baseline conditions, but this result is due to minor model calibration issues and does not currently occur.
- M&I providers and systems with more robust water rights portfolios and access to storage (i.e. systems that were explicitly modeled) will likely have lower gaps than other providers without access to supplemental supplies.
- In general, projected M&I gaps under the scenarios are projected to be relatively modest with the exception of *Hot Growth*.
- Higher M&I diversion demands along with lower water availability due to climate impacts drive higher estimated gaps in the *Hot Growth* scenario

Table 4.10.10 Yampa Basin M&I Gap Results (AFY)

		Scenario					
		Scenario	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average	Average Annual Demand	36,900	53,300	46,700	48,900	53,000	68,300
Average	Average Annual Gap	0*	600	200	800	1,400	4,800
Average	Average Annual Percent Gap	0%	1%	0%	2%	3%	7%
Maximum	Demand in Maximum Gap Year	36,900	53,300	46,700	48,900	53,000	68,300
Maximum	Gap in Maximum Gap Year	0*	1,600	700	1,600	2,500	8,200
Maximum	Percent Gap in Maximum Gap Year	0%	3%	1%	3%	5%	12%

** 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, reflecting 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 4.10.16 Projected Maximum Annual M&I Diversion Demand, Demand Met, and Gaps in the Yampa Basin

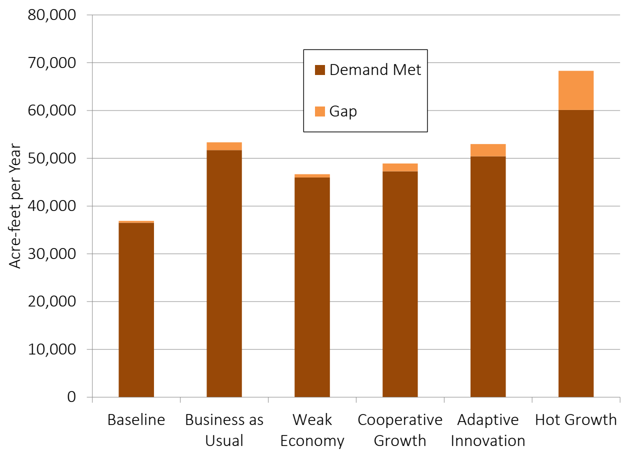
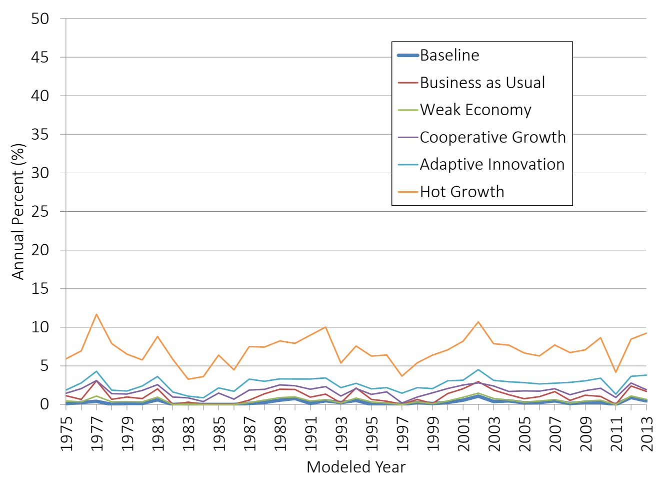


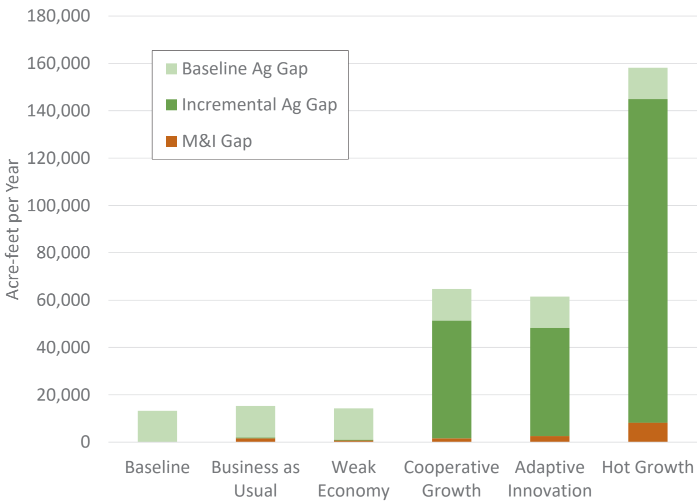
Figure 4.10.17 Annual M&I Gaps for Each Planning Scenario



Total Gap

Figure 4.10.18 illustrates the total combined agricultural and M&I diversion demand gap in the Yampa Basin. The figure combines the average annual baseline and incremental agricultural gap and the maximum M&I gap. Total gaps were driven by agriculture and were projected to be the highest in *Hot Growth*, which includes the highest amount of additional demand from planned agricultural projects and the most severe climate impacts.

Figure 4.10.18 Projected Average Annual Agricultural Gaps and Maximum M&I Diversion Demand Gaps in the Yampa Basin



Supplies from Urbanized Lands

By 2050, irrigated acreage in the Yampa Basin is projected to decrease by 1,500 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 4.10.11. The data in the table represent planning-level estimates of this potential supply and has not been applied to the M&I gaps.

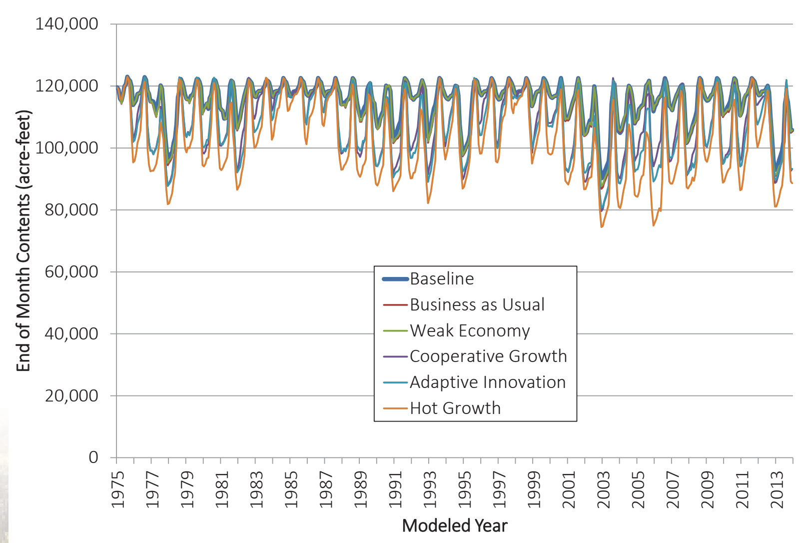
Table 4.10.11 Estimated Consumptive Use from Lands Projected to be Urbanized in the Yampa Basin

	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Urbanized Acreage (acres)	1,500	1,500	1,500	1,500	1,500
Estimated Consumptive Use (AFY)	2,700	2,700	2,800	2,800	2,400

Storage

Total simulated reservoir storage from the Yampa River water allocation model is shown on Figure 4.10.19. 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 back to baseline levels after dry periods.

Figure 4.10.19 Total Simulated Reservoir Storage in the Yampa Basin



White Basin Gaps

Agricultural

The White Basin agricultural diversion demands, demand gaps, and consumptive use gaps for the baseline and planning scenarios are presented in Table 4.10.12 and illustrated on Figure 4.10.20. An annual time series of gaps in terms of percent of demand that was unmet is shown on Figure 4.10.21.

Table 4.10.12 White Basin Agricultural Gap Results (AFY)

		Scenario					
		Scenario	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average	Average Annual Demand	246,700	242,900	246,700	293,900	177,800	319,700
	Average Annual Gap	1,200	1,200	1,200	3,200	3,400	5,800
	Average Annual Gap Increase from Baseline	-	-	-	1,900	2,100	4,600
	Average Annual Percent Gap	0%	0%	0%	1%	2%	2%
	Average Annual CU Gap	700	700	700	1,700	2,200	3,200
Maximum	Demand in Maximum Gap Year	242,300	238,500	242,300	281,400	174,300	307,600
	Gap in maximum Gap Year	6,000	6,000	6,000	9,500	8,500	12,200
	Increase from Baseline Gap	-	-	-	3,500	2,500	6,200
	Percent Gap in Maximum Gap Year	2%	3%	2%	3%	5%	4%

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

Figure 4.10.20 Projected Average Annual Agricultural Diversion Demand, Demand Met, and Gaps in the White Basin

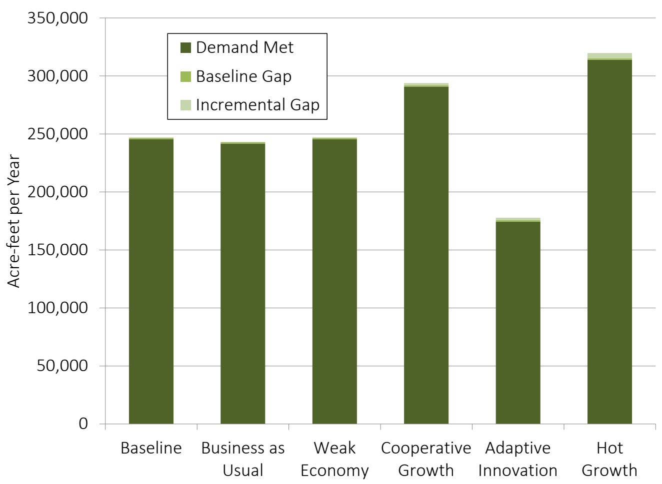
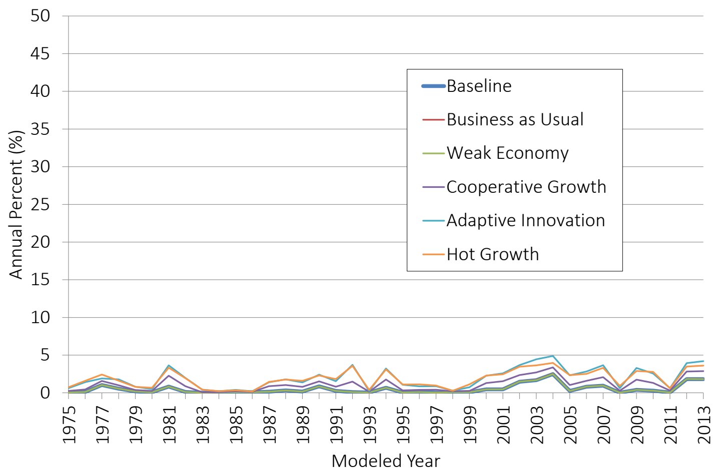


Figure 4.10.21 Annual Agricultural Gaps for Each Planning Scenario



In the White Basin, the current agricultural gap is small, and gaps are not projected to increase greatly in the planning scenarios. Agricultural gaps are greater in dry years. The largest annual, modeled gap occurred in *Hot Growth*, but it was small relative to demands at approximately 4 percent.

M&I

The diversion demand and gap results for M&I uses in the White Basin are summarized Table 4.10.13 and illustrated on Figure 4.10.22. An annual time series of gaps in terms of percent of demand that was unmet is shown in Figure 4.10.23.

Table 4.10.13 White Basin M&I Gap Results (AFY)

		Scenario					
		Scenario	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average	Average Annual Demand	5,300	10,000	6,100	6,900	7,700	41,000
	Average Annual Gap	0	3,000	700	700	800	27,500
	Average Annual Percent Gap	0%	30%	12%	10%	10%	67%
Maximum	Demand in Maximum Gap Year	5,300	10,000	6,100	6,900	7,700	41,000
	Gap in Maximum Gap Year	0	3,900	900	900	1,300	33,500
	Percent Gap in Maximum Gap Year	0%	39%	15%	13%	17%	82%

Figure 4.10.22 Projected Maximum Annual M&I Demand Met and Gaps in the White Basin

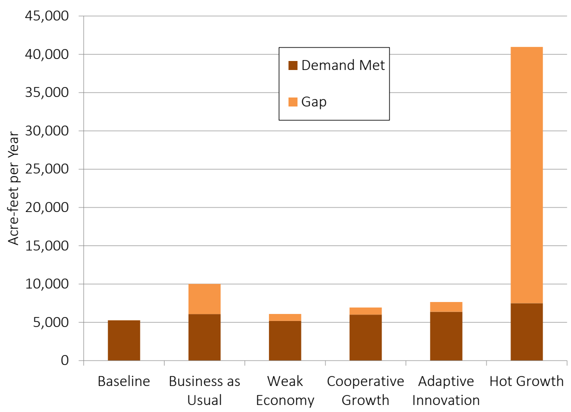
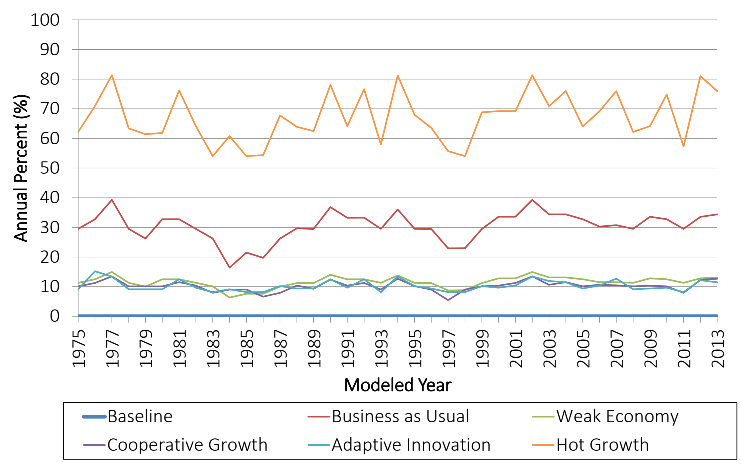


Figure 4.10.23 Annual M&I Gaps for Each Planning Scenario



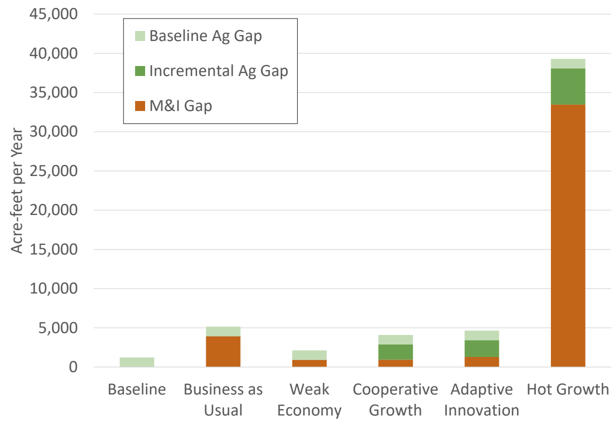
The following are observations on the M&I diversion demands and gaps:

- The average annual M&I gap in the White Basin is greater than the agricultural gap, ranging from about 700 AF for *Weak Economy*, *Cooperative Growth*, and *Adaptive Innovation* up to 27,500 AF for *Hot Growth*.
- The maximum M&I gap for the five planning scenarios ranges from 900 AF to more than 33,000 AF.
- The M&I gaps were modeled to be largest in the *Business as Usual* and *Hot Growth* scenarios and were driven by relatively large energy development demands (especially in *Hot Growth*).

Total Gap

Figure 4.10.24 illustrates the total combined agricultural and M&I diversion demand gap in the White Basin. The figure combines the average annual baseline and incremental agricultural gaps and the maximum M&I gap. In *Business as Usual* and *Hot Growth*, gaps were driven by relatively high SSI demands. In *Weak Economy*, *Cooperative Growth*, and *Adaptive Management*, agricultural gaps were greater than M&I gaps.

Figure 4.10.24 Projected Average Annual Agricultural Gaps and Maximum M&SSI Diversion Demand Gaps in the White Basin



Supplies from Urbanized Lands

By 2050, irrigated acreage in the White Basin is projected to decrease by 360 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 4.10.14. The data in the table represent planning-level estimates of this potential supply and has not been applied to the M&I gaps.

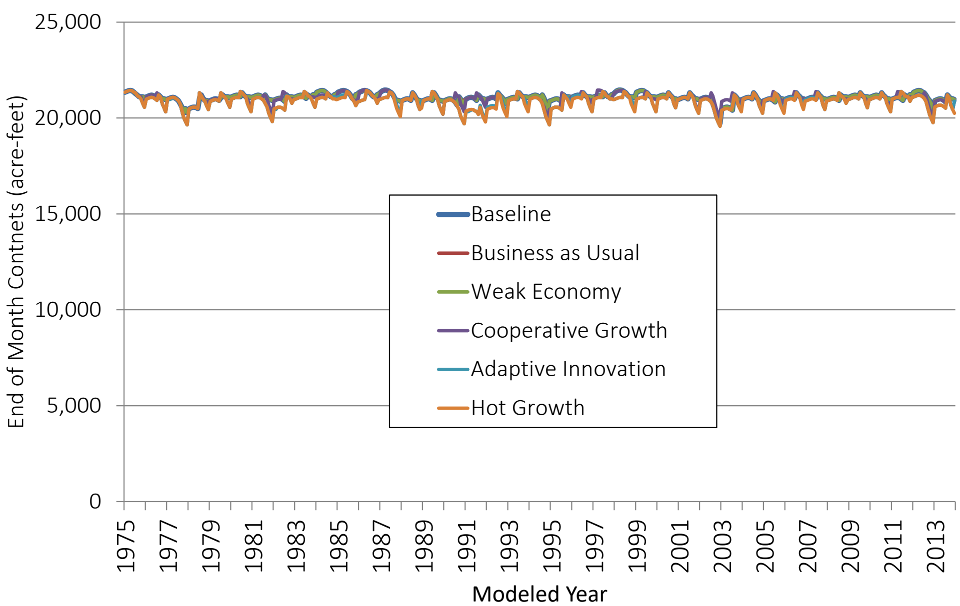
Table 4.10.14 Estimated Consumptive Use from Lands Projected to be Urbanized in the White Basin

	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Urbanized Acreage (acres)	360	-	360	360	360
Estimated Consumptive Use (AFY)	600	-	700	700	800

Storage

Total simulated reservoir storage from the White River water allocation model is shown on Figure 4.10.25. Basinwide storage levels do not significantly change in any of the planning scenarios, because agricultural and municipal water users in the basin do not typically use storage.

Figure 4.10.25 Total Simulated Reservoir Storage in the White Basin



Combined Yampa-White Basin Gaps

Table 4.10.15 summarizes the total M&I and agricultural demands in the Yampa-White Basin along with a summary of gaps. It should be noted that the Yampa and White Basins were modeled independently, and 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 Yampa-White 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 4.10.15 Summary of Total Yampa-White Basin Demands and Gaps

	Current (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average Annual Demand						
Agricultural (AFY)	649,200	646,500	650,400	816,300	638,700	1,004,000
M&I (AFY)	42,200	63,400	52,800	55,900	60,600	109,300
Gaps						
Ag (avg %)	2%	2%	2%	8%	10%	16%
Ag (incremental-AFY)	-	400	300	51,700	47,800	141,400
Ag (incremental gap as % of current demand)	-	0%	0%	8%	7%	22%
M&I (max %)	0%	9%	3%	5%	6%	38%
M&I (max-AF)	01	5,600	1,600	2,600	3,800	41,700

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.

4.10.7 Available Supply

Figures 4.10.26 and 4.10.27 show simulated monthly available flow for the Yampa Basin near the Maybell Canal, which is typically the senior calling right in the basin. Available flow at this location is very near to the physical flow in the stream, meaning that the Maybell Canal does not have a large impact on the available flow upstream. 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 4.10.26 Simulated Hydrographs of Available Flow at Yampa River Near Maybell

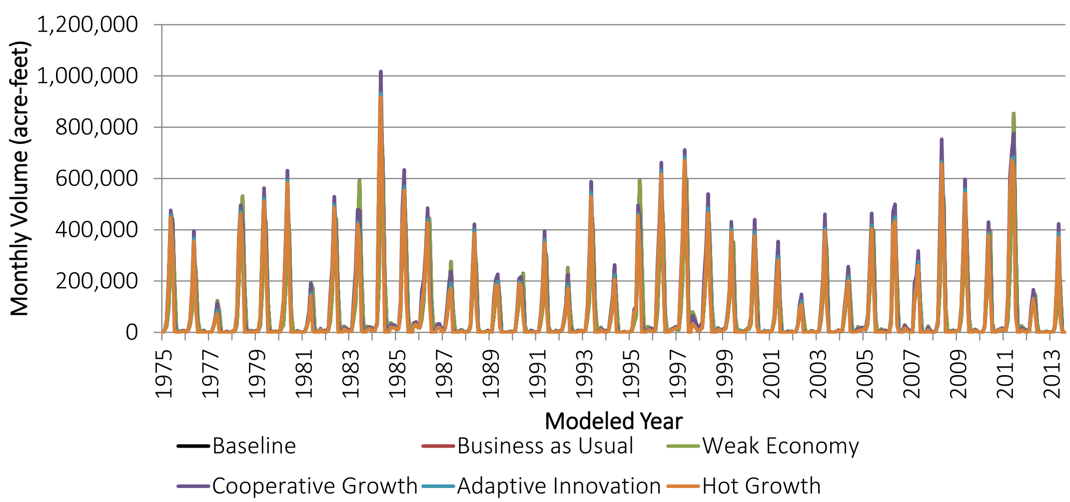
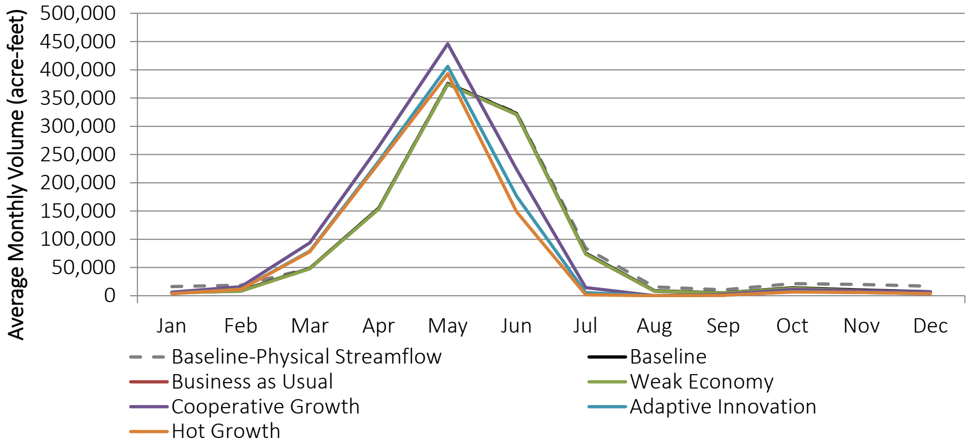


Figure 4.10.27 Average Monthly Simulated Hydrographs of Available Flow at Yampa River near Maybell



Figures 4.10.28 and 4.10.29 show simulated monthly available flow on the White River below Boise Creek, which is just above Kenney Reservoir. The reservoir has a hydropower water right that is not fully satisfied and serves as the calling right in the model. The figures show that flows are projected to be available in most years, though the amounts will vary annually and across scenarios (available flows under the scenarios impacted by climate change are less than in other scenarios). In some years, very little to no flow is available under current and future conditions at this location. Peak flows are projected to occur earlier in the year under scenarios impacted by climate change.

Figure 4.10.28 Simulated Hydrographs of Available Flow at White River Below Boise Creek

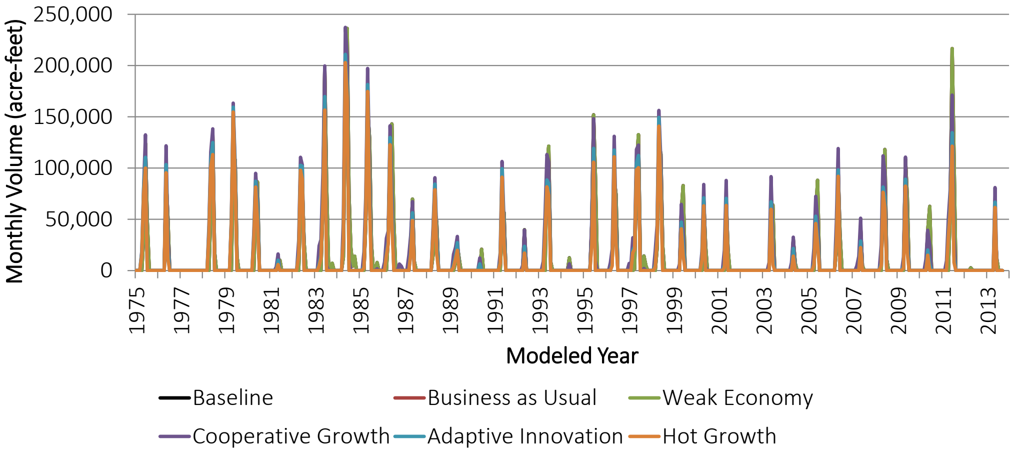
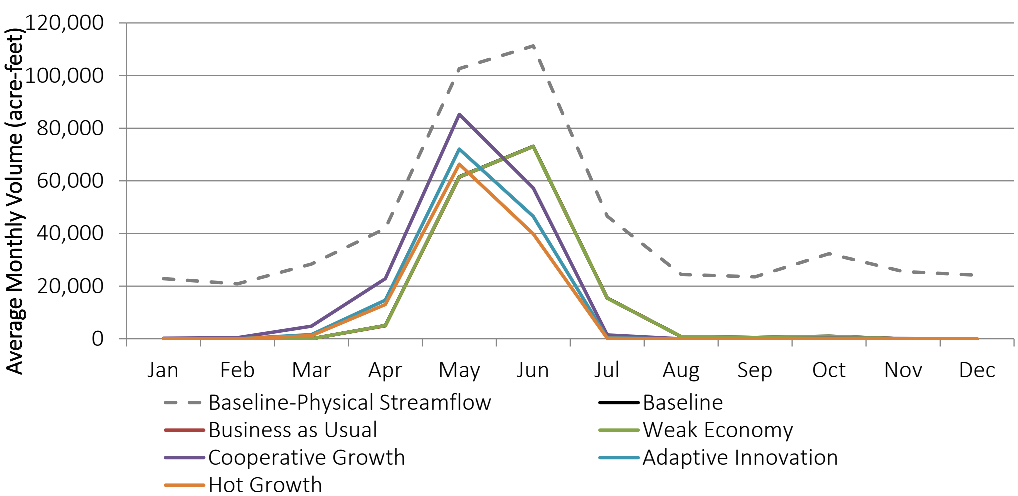


Figure 4.10.29 Average Monthly Simulated Hydrographs of Available Flow at White River Below Boise Creek



4.10.8 Environment and Recreation

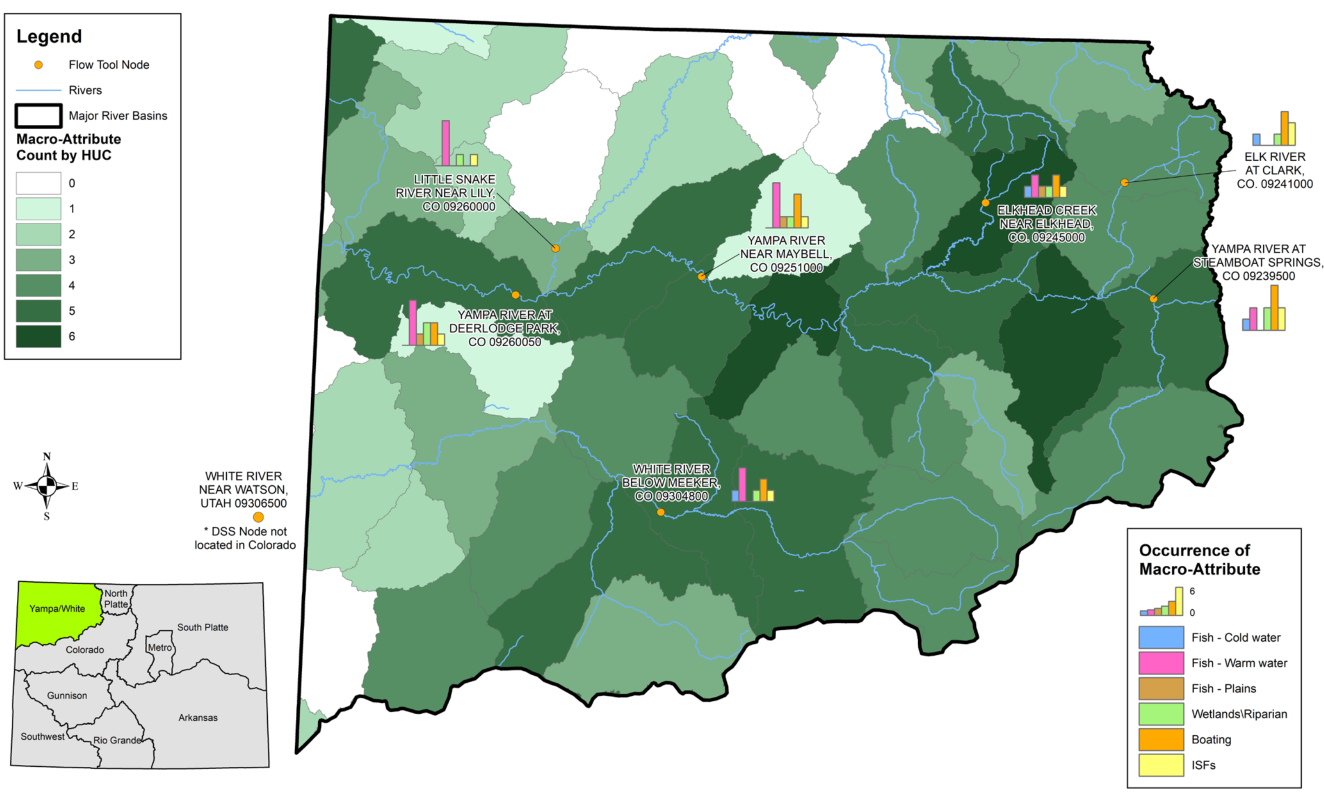
A total of eight water allocation model nodes were selected for the Flow Tool within the Yampa-White-Green Basin (see list below and Figure 4.10.30). Figure 4.10.30 also shows subwatersheds (at the 12-digit HUC level) and the relative number of E&R attributes located in each subwatershed.

- Yampa River at Steamboat Springs, Colorado (09239500)
- Elk River at Clark, Colorado (09241000)
- Elkhead Creek near Elkhead, Colorado (09245000)
- Yampa River near Maybell, Colorado (09251000)
- Little Snake River near Lily, Colorado (09260000)
- Yampa River at Deerlodge Park, Colorado (09260050)
- White River below Meeker, Colorado (09304800)
- White River near Watson, Utah (09306500)

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 4.10.30 Flow Tool Nodes Selected for the Yampa/White Basin



Results and observations regarding 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 4.10.16 below.

Table 4.10.16 Summary of Flow Tool Results in the Yampa-White-Green Basin

Category	Observation
Projected Flows	On the Yampa and White Rivers, peak flow magnitudes under baseline conditions are only slightly reduced (10 percent) from naturalized conditions. A similar status holds for *Business as Usual* and *Weak Economy*. Under *Hot Growth*, total peak flows decline approximately 10 percent.
	At all locations, the timing of peak flow is projected to move earlier in the year under all climate change impacted scenarios (*Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*). Under these scenarios, June flow may decrease approximately 30 percent at higher elevations (e.g., Elk River at Clark) and continue to decrease more at lower elevations (e.g., Yampa River at Deerlodge Park). Under these same scenarios, April flows may increase at a similar rate. May flows may increase or decrease depending on location and scenario.
	Under baseline conditions, mid- and late-summer flows are minimally depleted at higher elevations under naturalized conditions, are reduced further through mid-elevations (e.g., Steamboat Springs), and continue to decline through low-elevations (e.g., White River below Meeker and Yampa River at Deerlodge Park). Under all climate change scenarios, in most locations, mid- and late-summer flows are projected to have a wide departure from naturalized conditions.
Ecological Risk	Despite declines in peak flow magnitude, flow-related risk to riparian/wetland plants remains low to moderate across the basin. However, flow-related risk to warmwater fish is projected to increase, with the most risk occurring under *Hot Growth*. The change in timing for peak flows may result in mismatches between peak flow timing and species' needs.
	Projected reductions in mid- and late-summer flows may result in increased risks for trout at high and mid-elevations and for warmwater fish at low elevations. Increased risk would be caused by reduction in habitat under reduced flows.
	For trout, increased stream temperatures under low-flow conditions also increases risks, as has been the case in some recent years in Steamboat Springs. Additionally, the projected reductions in flows in mid- and late-summer may result in flows that are below the recommendations for endangered fish. For comparison, flows in August and September of 2018 were among the lowest flows on record and resulted in the first ever call on the Yampa River.
	September flows are projected to be similarly low in nearly one-quarter of all years under *Cooperative Growth* and nearly one-third of all years under *Adaptive Innovation* and *Hot Growth*. These low flows lead to a loss of habitat for endangered fish and favor reproduction and survival of non-native fish that prey upon endangered fish.
ISFs and RICDs	ISFs and RICDs are at risk of being met less often in mid- to late-summer under all future scenarios that include climate change (*Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*). An example of an ISF at risk is the 65 cfs ISF on the Elk River. This ISF is met in July in every year under the baseline scenario; however, under *Cooperative Growth*, average July flow is projected to drop below 65 cfs in approximately one-third of years and is unmet in approximately half of the modeled years under *Adaptive Innovation* and *Hot Growth*. In August, the Elk River ISF is projected to be unmet in nearly every year under all climate change scenarios.
	The total amount of boating flows during runoff may not change significantly if peak flow magnitude does not decline substantially, but the timing of boating opportunities will shift to earlier in the year under all climate change scenarios. An example of a RICD at risk is for the whitewater park in Steamboat Springs. The August RICD decreed flow of 95 cfs is often not met under baseline conditions. Under *Adaptive Innovation* and *Hot Growth*, the August RICD decree is almost never met.
E&R Attributes	Under baseline conditions and *Business as Usual*, and *Weak Economy*, current flow risk related to E&R attributes arises primarily because of depletions that increase moving downstream.
	Under climate change scenarios, both the projected shift in the timing of peak flow and reductions in total runoff may contribute to reductions in mid- and late-summer flows.