

THE ANALYSIS & TECHNICAL UPDATE TO THE

# COLORADO WATER PLAN



**COLORADO**  
Colorado Water  
Conservation Board  
Department of Natural Resources

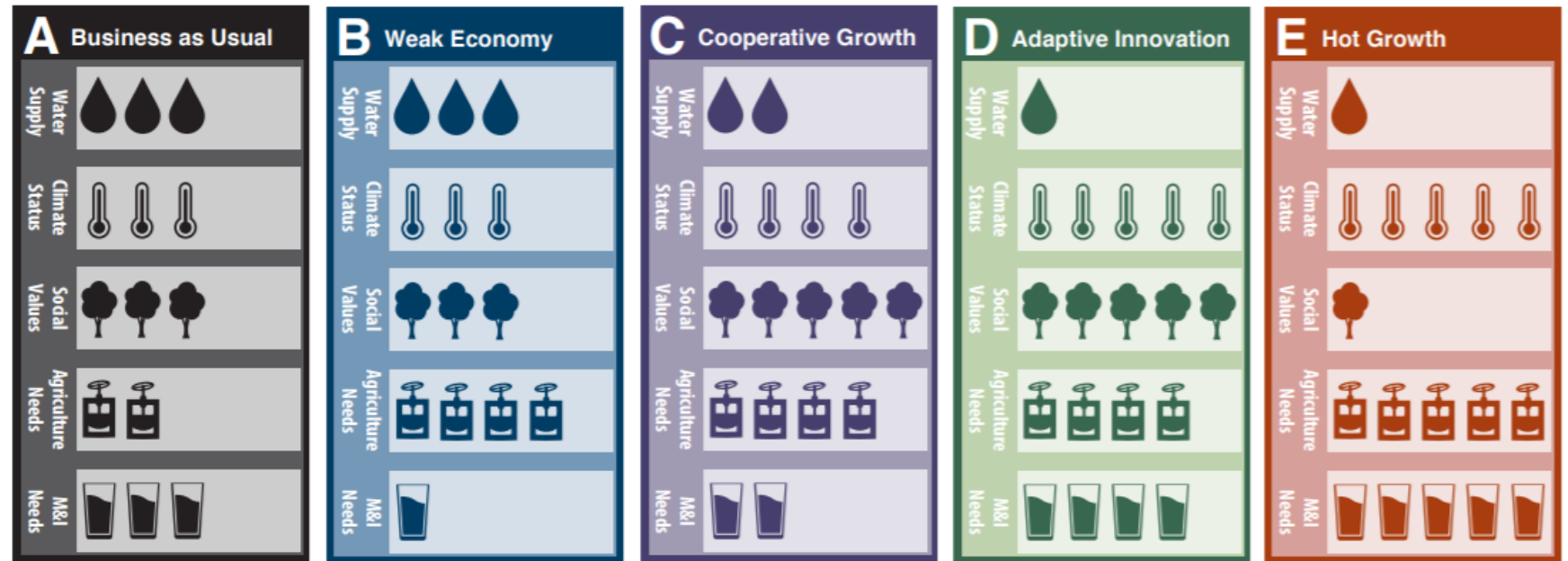
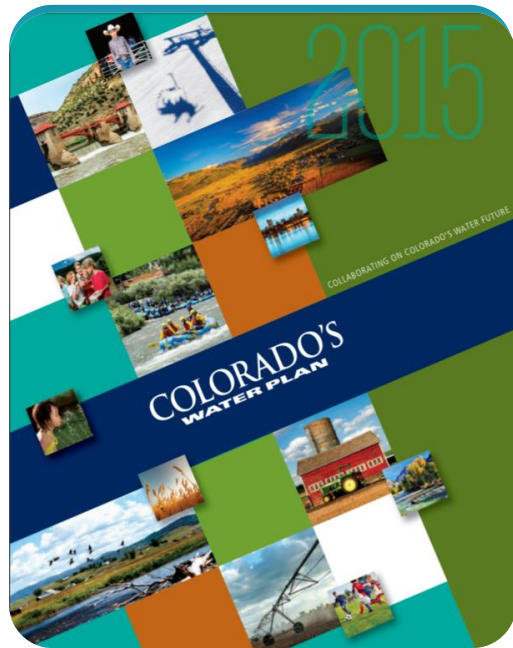
Middle Colorado Integrated Water Management Planning

Greg Johnson & Kara Sobieski

# WHAT'S NEW?

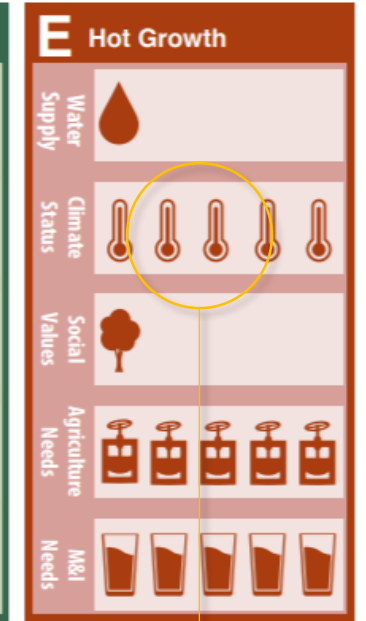
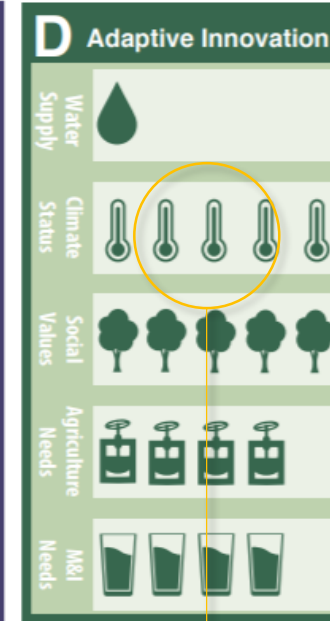
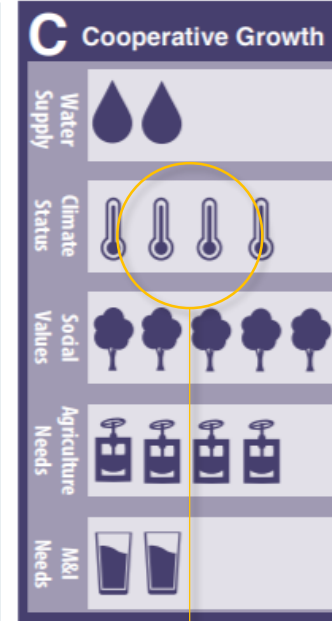
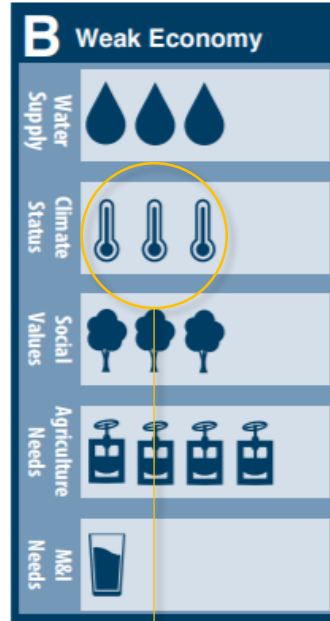
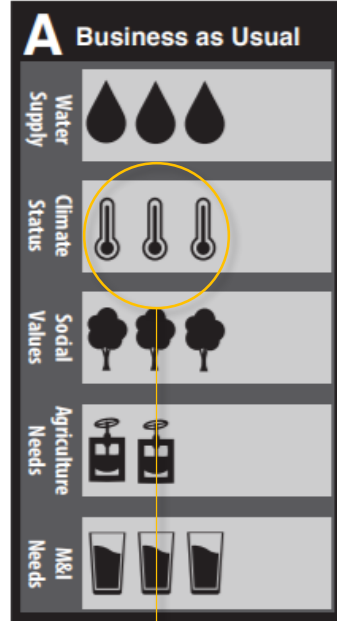
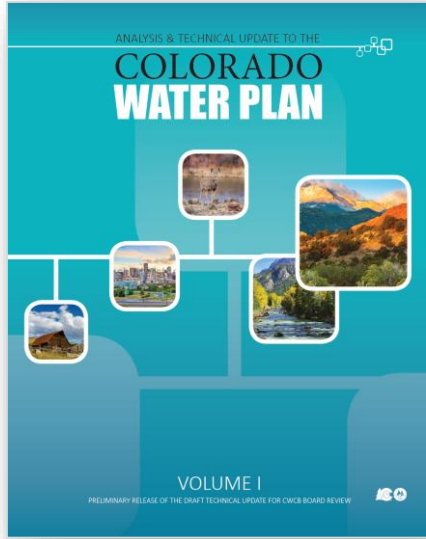
**NEW APPROACHES AND RESULTS IN THE TECHNICAL UPDATE**

# PLANNING SCENARIOS



- Scenarios in the Water Plan were developed with the IBCC and BRTs
- These scenarios represent equally plausible futures
- Challenge to turn “narratives” into “numbers”

# CLIMATE IMPACTS



NO CLIMATE CHANGE

MODERATE CLIMATE CHANGE

SIGNIFICANT CLIMATE CHANGE

**NO CHANGE**

**+ 3.8 °F**

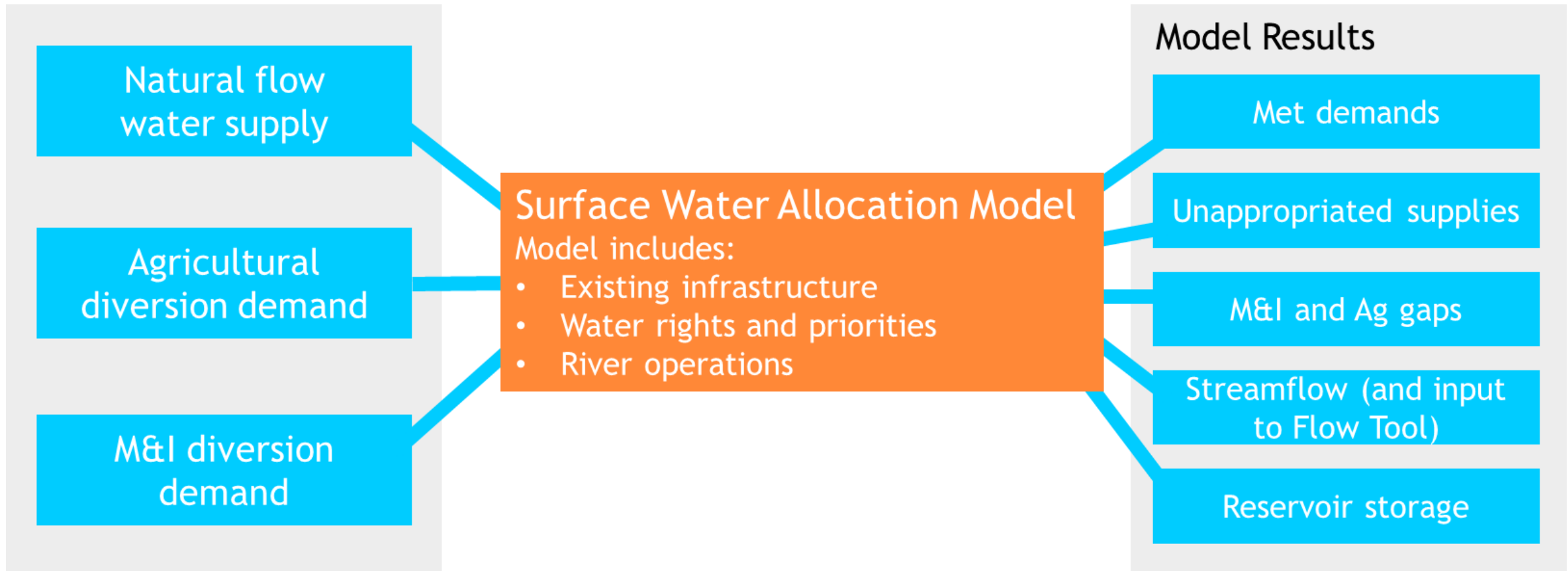
& 5% increase in precip.

**+ 4.2 °F**

& 1% decrease in precip.

# HOW THE GAP IS DEFINED

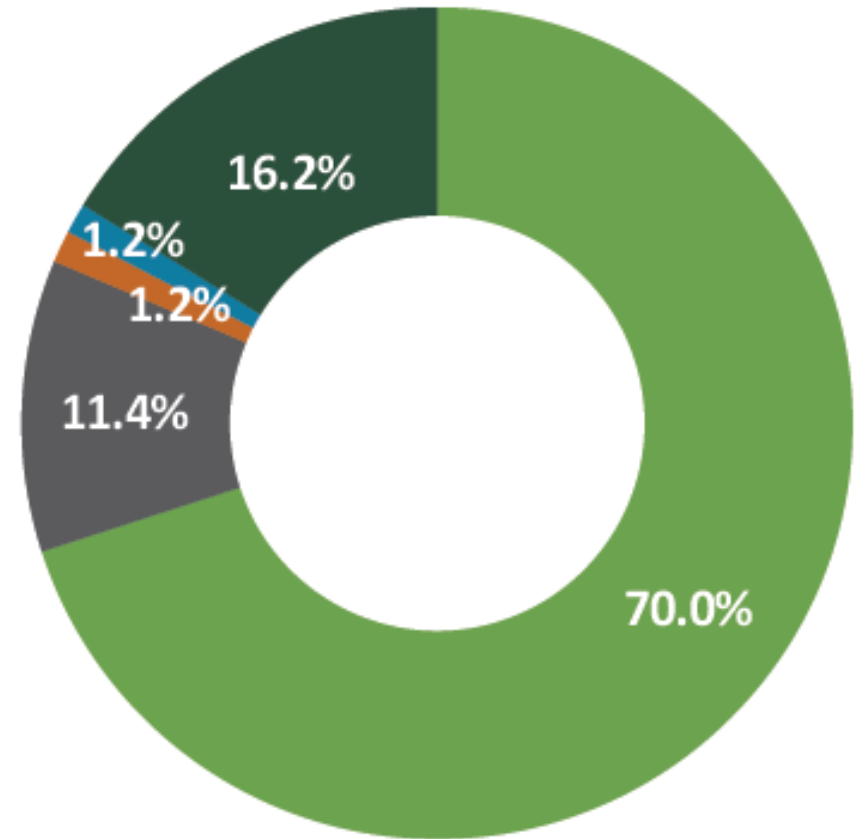
The amount of additional water supply that would need to be diverted or pumped to meet any demand



# MUNICIPAL WATER USE

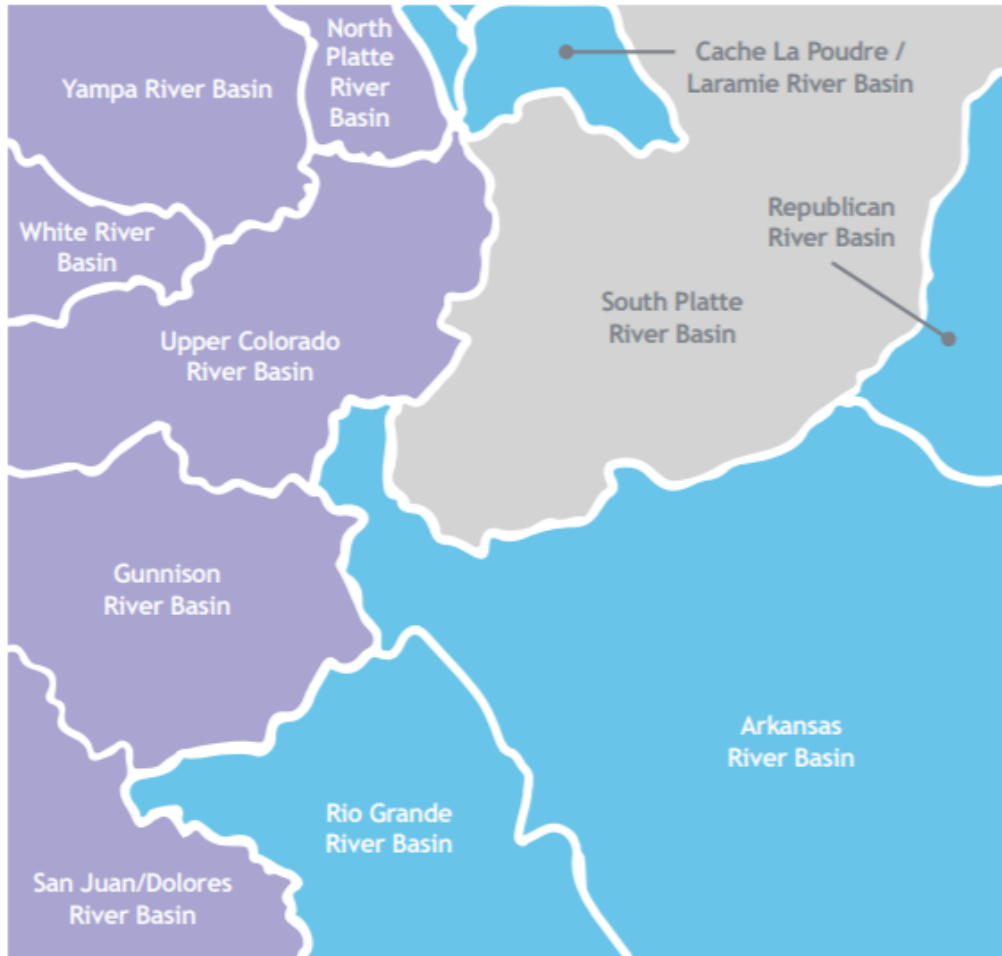
- House Bill 2010-1051 (“1051”)
  - Recent water usage information
  - Collected and reported by water providers
- Incorporated into the Current municipal demands

■ 1051 ■ WEP ■ Outreach ■ BIP ■ Estimated



# METHODOLOGY

## WATER SUPPLY & GAP



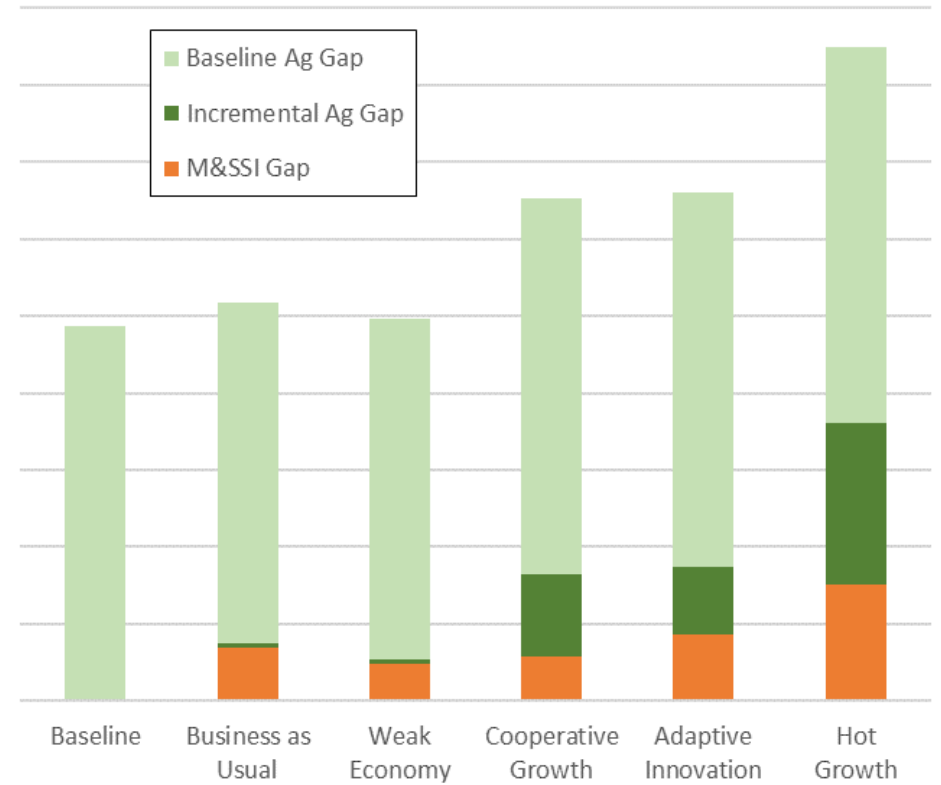
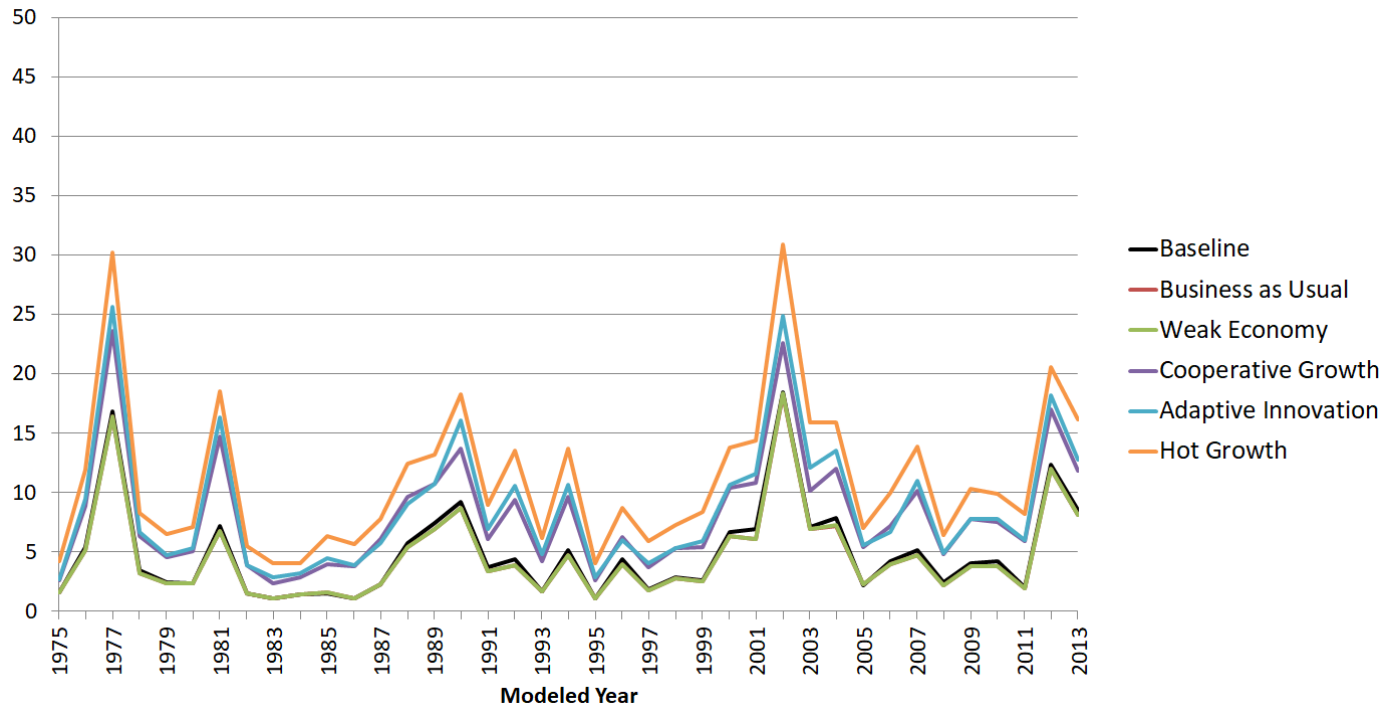
- CDSS Basins with Baseline and Historical StateMod Datasets
- CDSS Basins with only Historical StateMod Datasets
- CDSS Basins with no CDSS StateMod Datasets



- **Basin-wide Planning Models**
  - Monthly time step, regional-level detail
  - Models capture typical operations

# RESULTS

Time series of agricultural, M&I, reservoir, and streamflow results compared across the Planning Scenarios

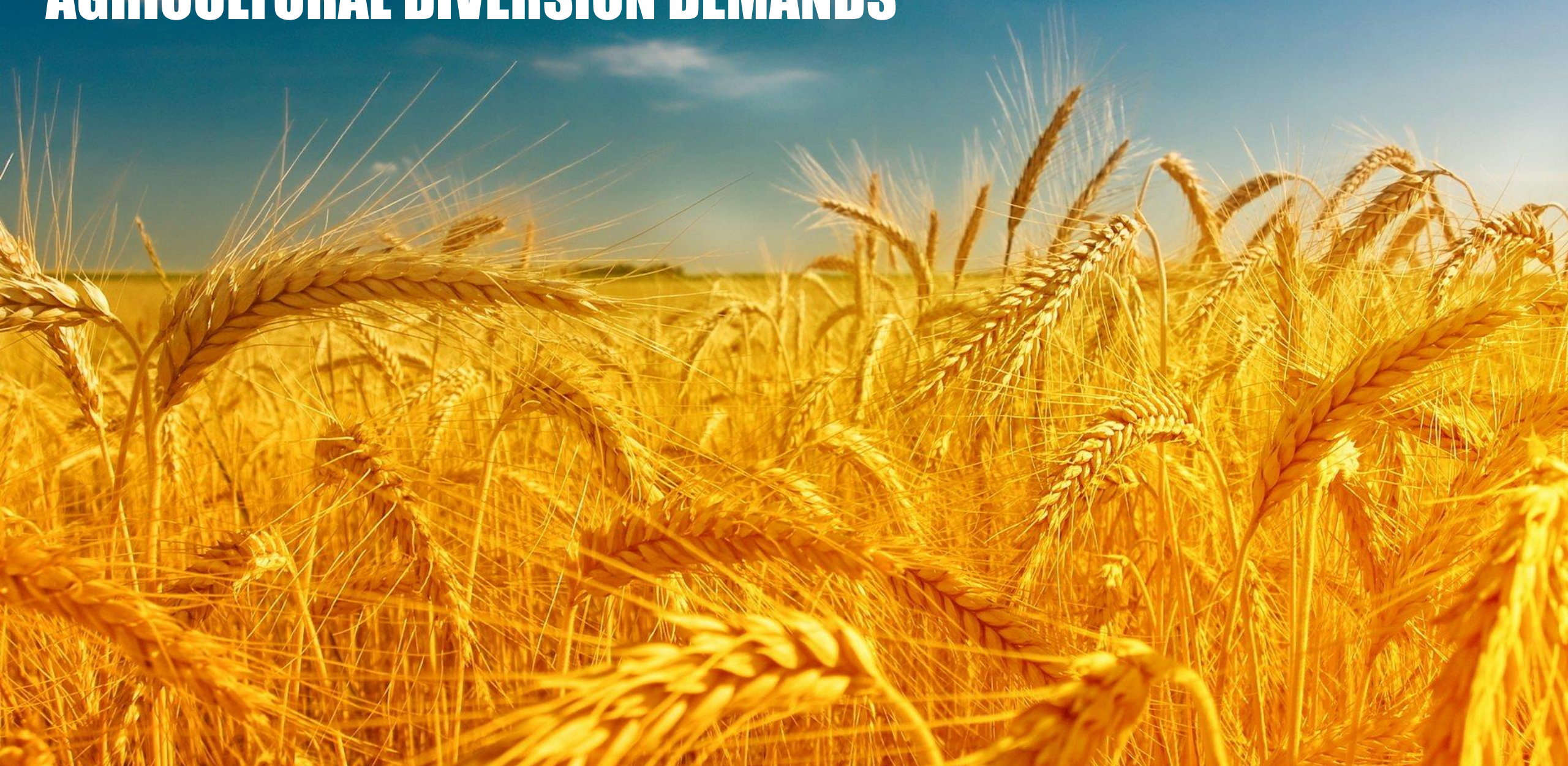




# **METHODOLOGY**

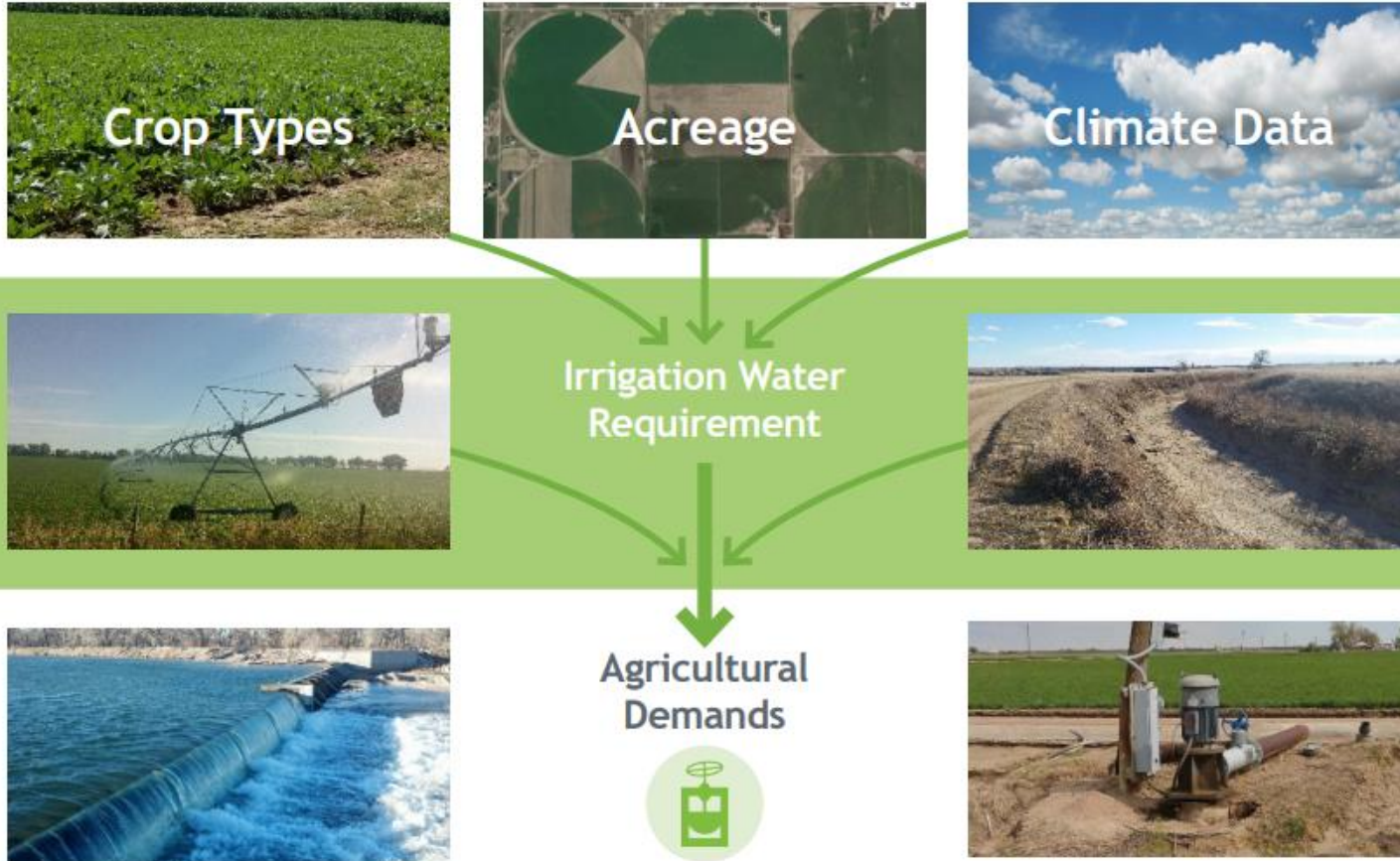
**HOW WAS THE TECHNICAL UPDATE INFORMATION DEVELOPED?**

# AGRICULTURAL DIVERSION DEMANDS



# METHODOLOGY

## AGRICULTURAL DIVERSION DEMANDS



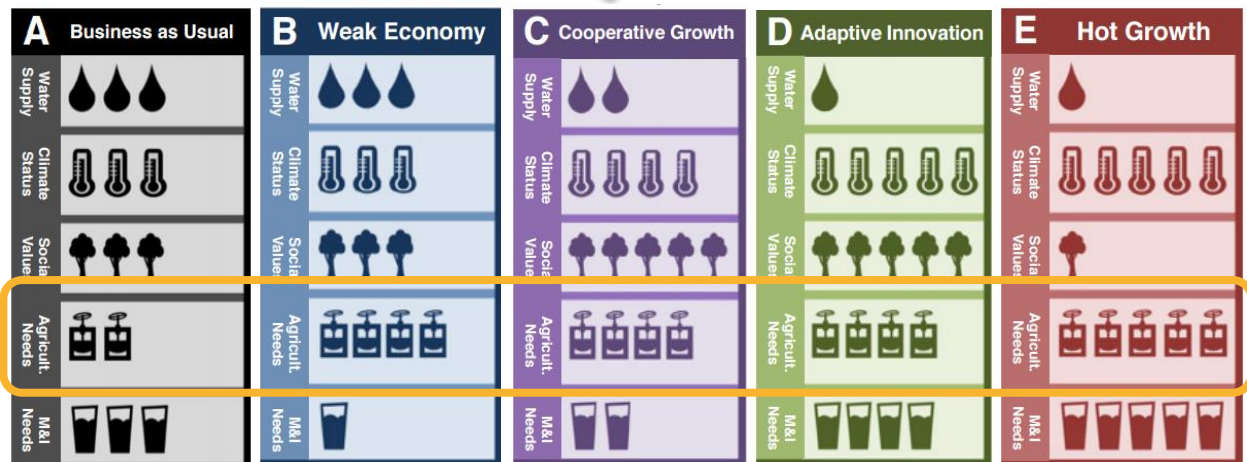
“ The amount of water supply that needs to be diverted or pumped to meet the full crop irrigation water requirement ”

# METHODOLOGY

## PLANNING SCENARIO ADJUSTMENTS

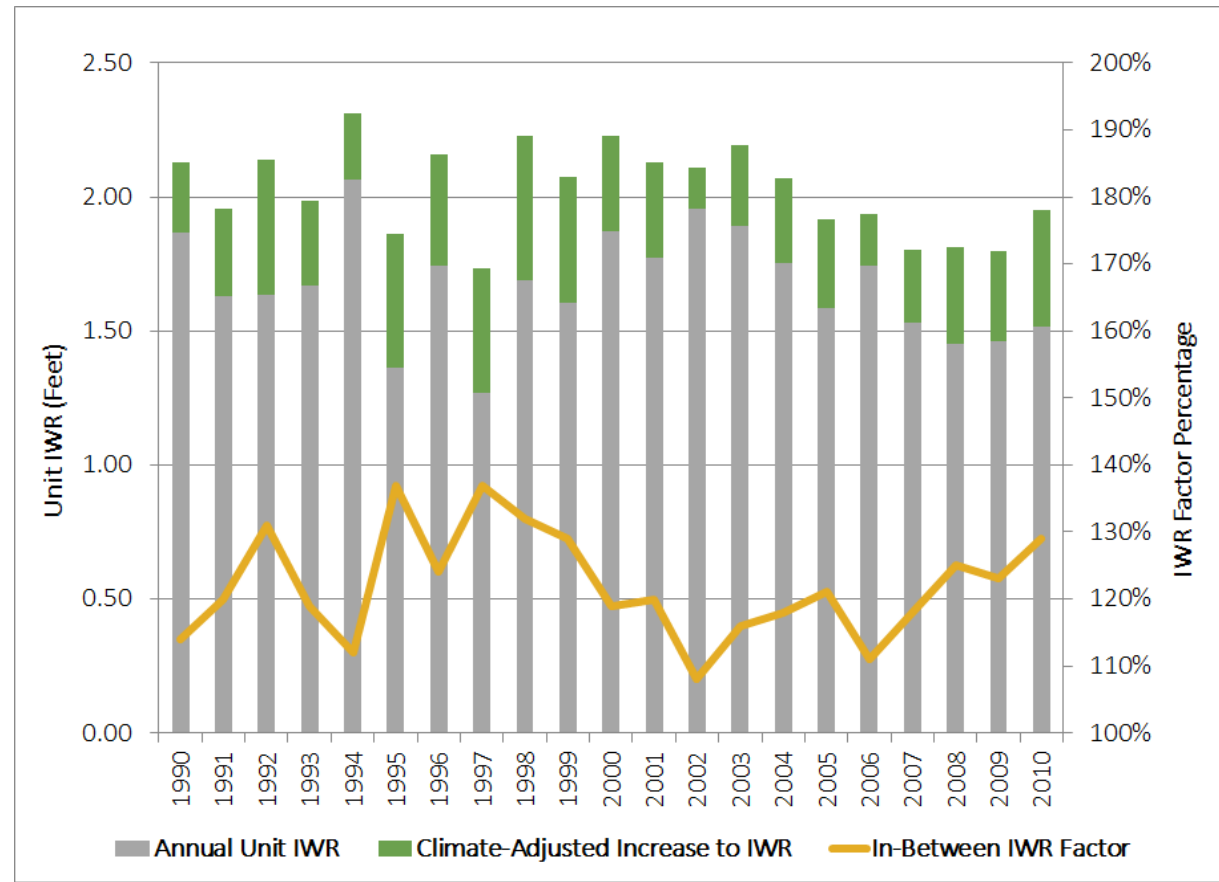
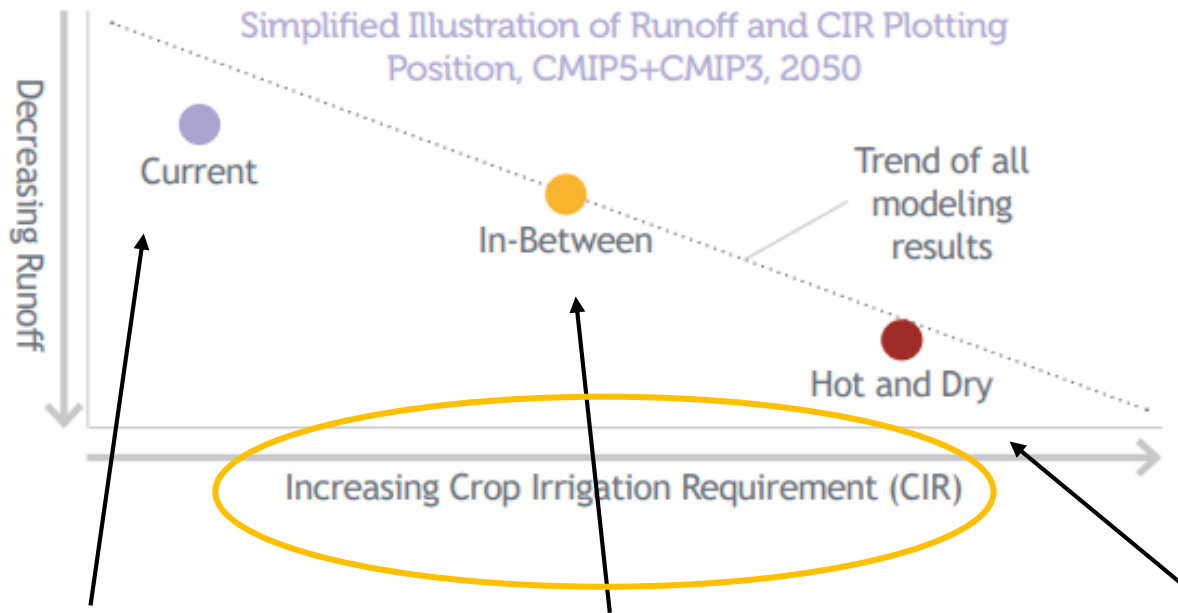
1. Urbanization
2. Planned Agricultural Projects
3. GW Acreage Sustainability
4. Climate
5. Emerging Technologies

- Acreage
- IWR/Crop Demand
- System Efficiency



# METHODOLOGY

## CLIMATE



Business as Usual  
Weak Economy

Cooperative Growth  
(+3.8 °F increase)  
(5% increase in precip)

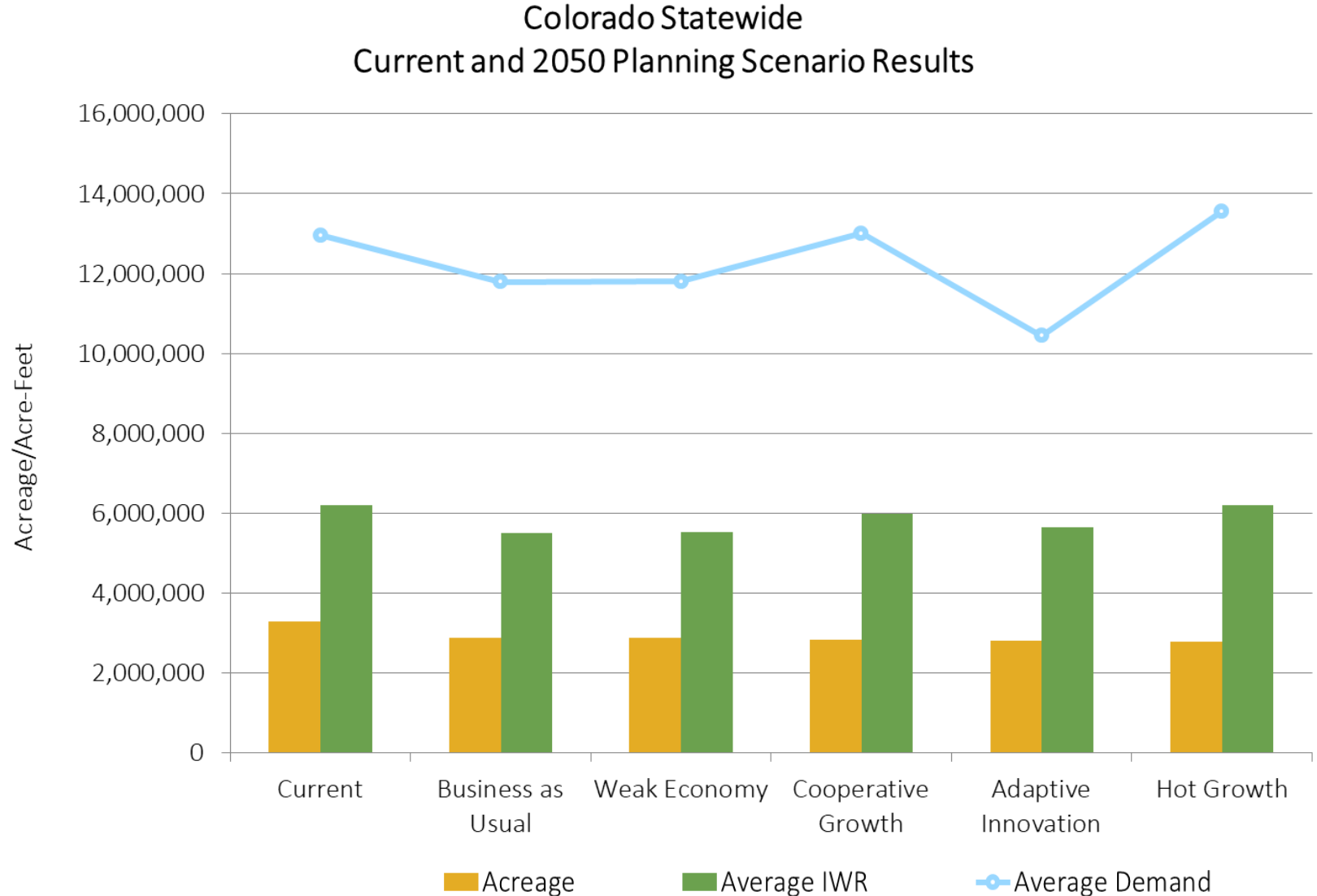
Adaptive Innovation  
Hot Growth  
(+4.2 °F increase)  
(1% decrease in precip)

Average Basin Adjustment	In-Between	Hot and Dry
East Slope	4% - 25%	11% - 39%
West Slope	19% - 26%	30% - 37%
Colorado River Basin	3% - 26%	7% - 40%

# STATEWIDE DEMAND – CURRENT & 2050 PLANNING SCENARIO

By 2050:

- Nearly 10.4 to 13.6 million AF of diversions + pumping
- Will be needed to meet 5.5 to 6.2 million AF of crop demand
- On 2.8 to 2.9 million acres of irrigated acreage

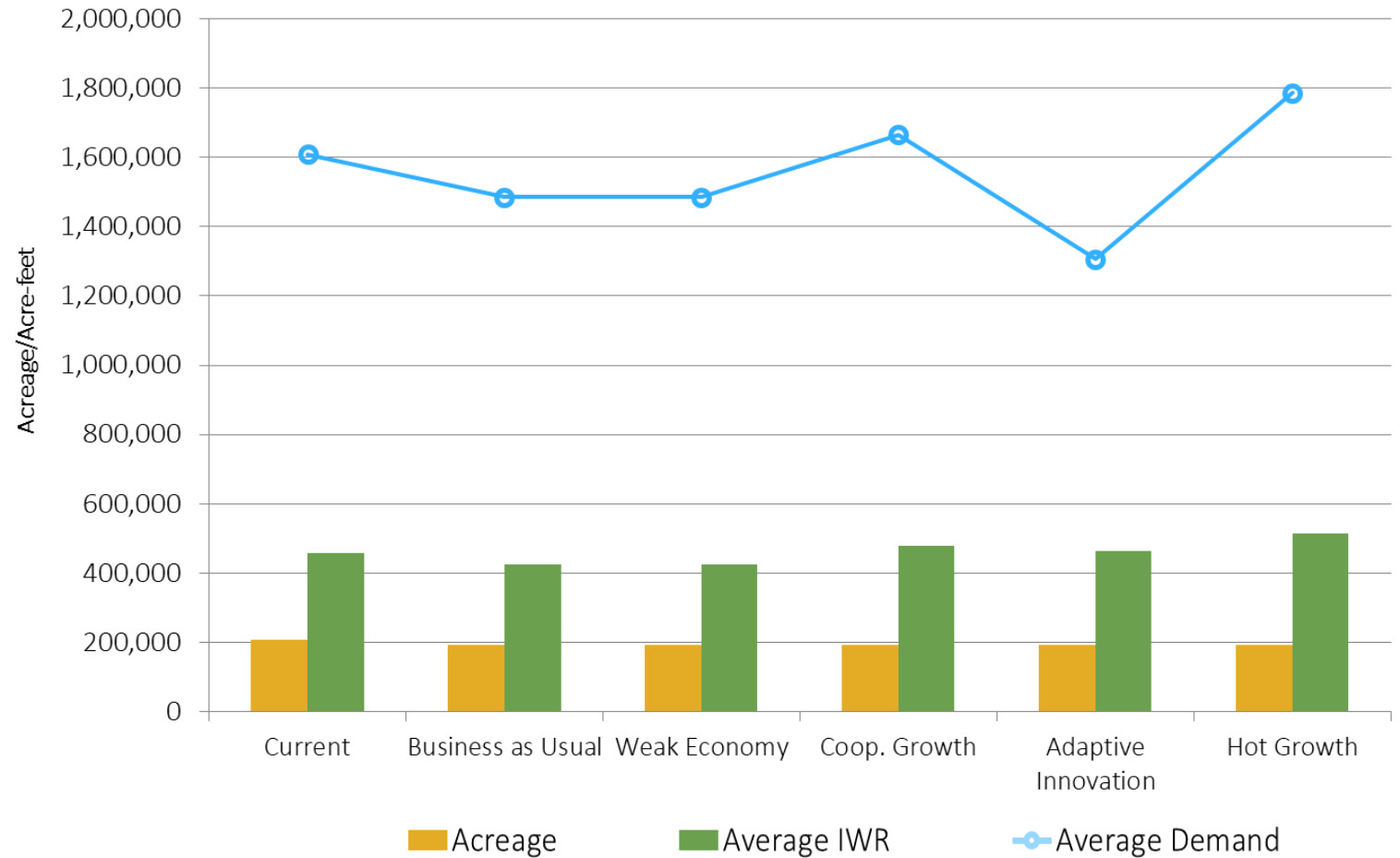


# COLORADO RIVER BASIN – CURRENT & 2050 PLANNING SCENARIO

By 2050:

- 1.3 to almost 1.8 million AF of diversions + pumping
- Will be needed to meet 425,000 to 515,000 AF of crop demand
- On 193,000 acres of irrigated acreage

Colorado River Basin  
Current and 2050 Planning Scenario Results



# MUNICIPAL DEMANDS



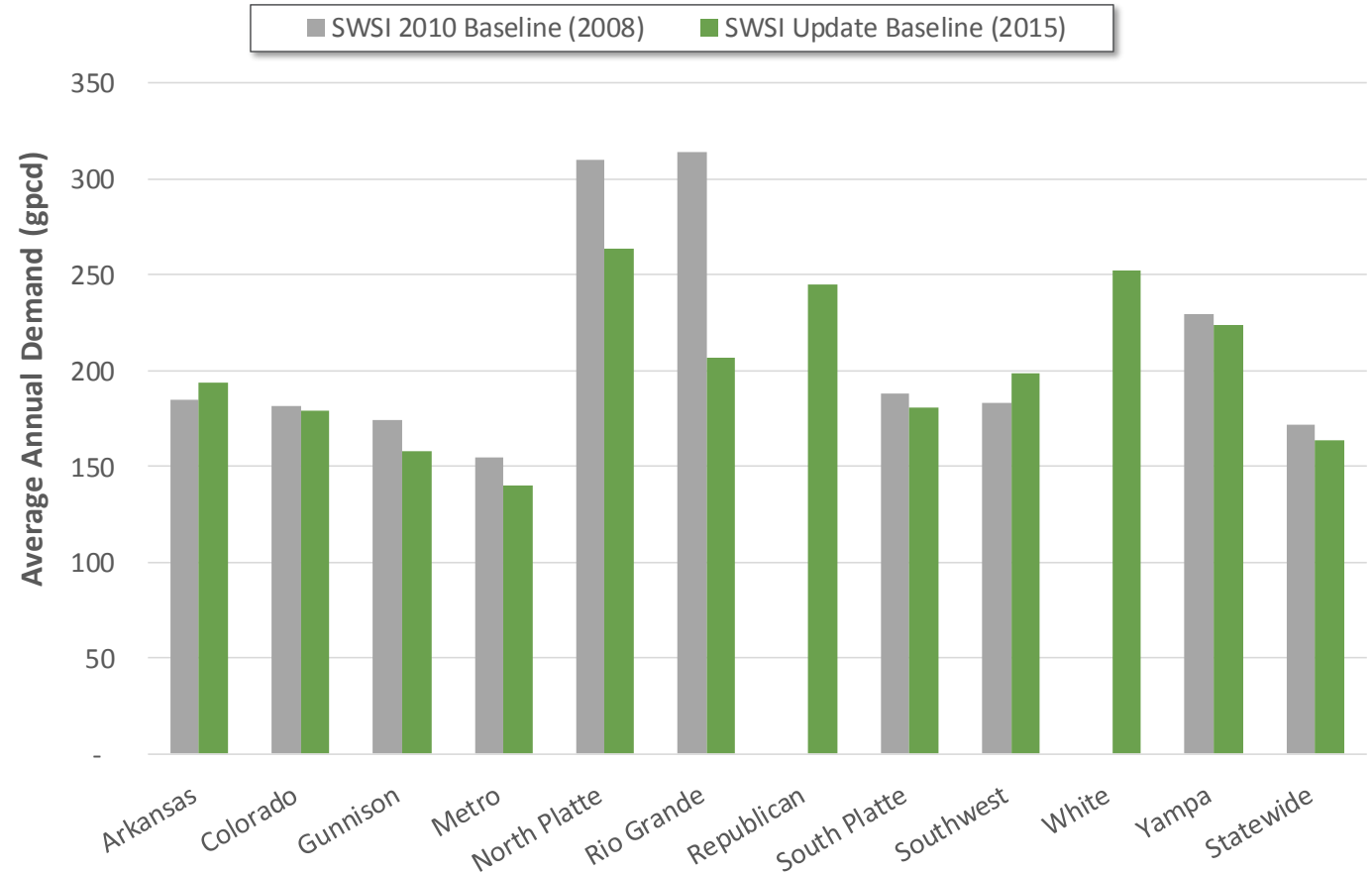


# METHODOLOGY

## MUNICIPAL DEMANDS

- Total Demand = Population \* GPCD
- 5.5 million people in Colorado in 2015
- Updated Baseline Rate of Use
- Statewide per capita demands decreased from 172 to 164 gpcd
- Most water provider per capita demands have decreased

**Municipal Baseline Per Capita Demands by Basin**



# PLANNING SCENARIO ADJUSTMENTS



- Recent **trends continue**
- Regular **economic cycles**
- Slow increase in **denser developments**
- Social values and regs **remain the same**
- Water **conservation efforts** slowly increase
- Climate is **similar**



- Population growth **lower** than currently projected
- Economy **struggles**
- Maintenance of infrastructure becomes **difficult to fund**
- **Little change** in social values, levels of water conservation, urban land use patterns, and environmental regulations
- Climate is **similar**



- Population growth **consistent with current** forecasts
- **Integrated and efficient** planning/development
- More development in **urban centers and mountains**
- Embrace water and energy **conservation**
- New water-saving **technologies**
- **Moderate warming** of climate

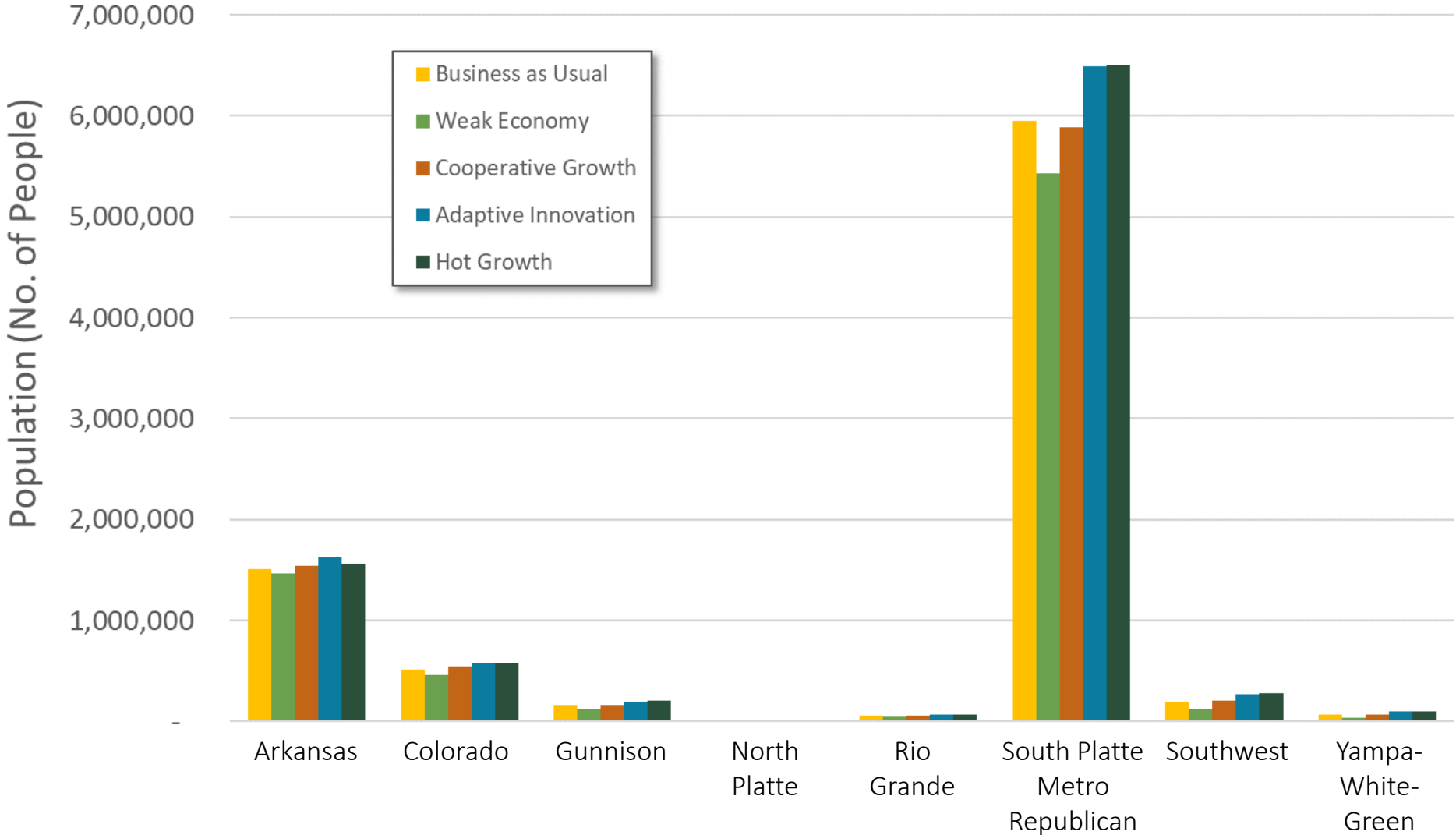


- Population grows **faster** than current
- Social attitudes shift towards **shared responsibility**
- Warmer climate increases irrigation demand, but **technology mitigates increases**
- **Higher water efficiency** helps maintain streamflows
- More **compact urban** development



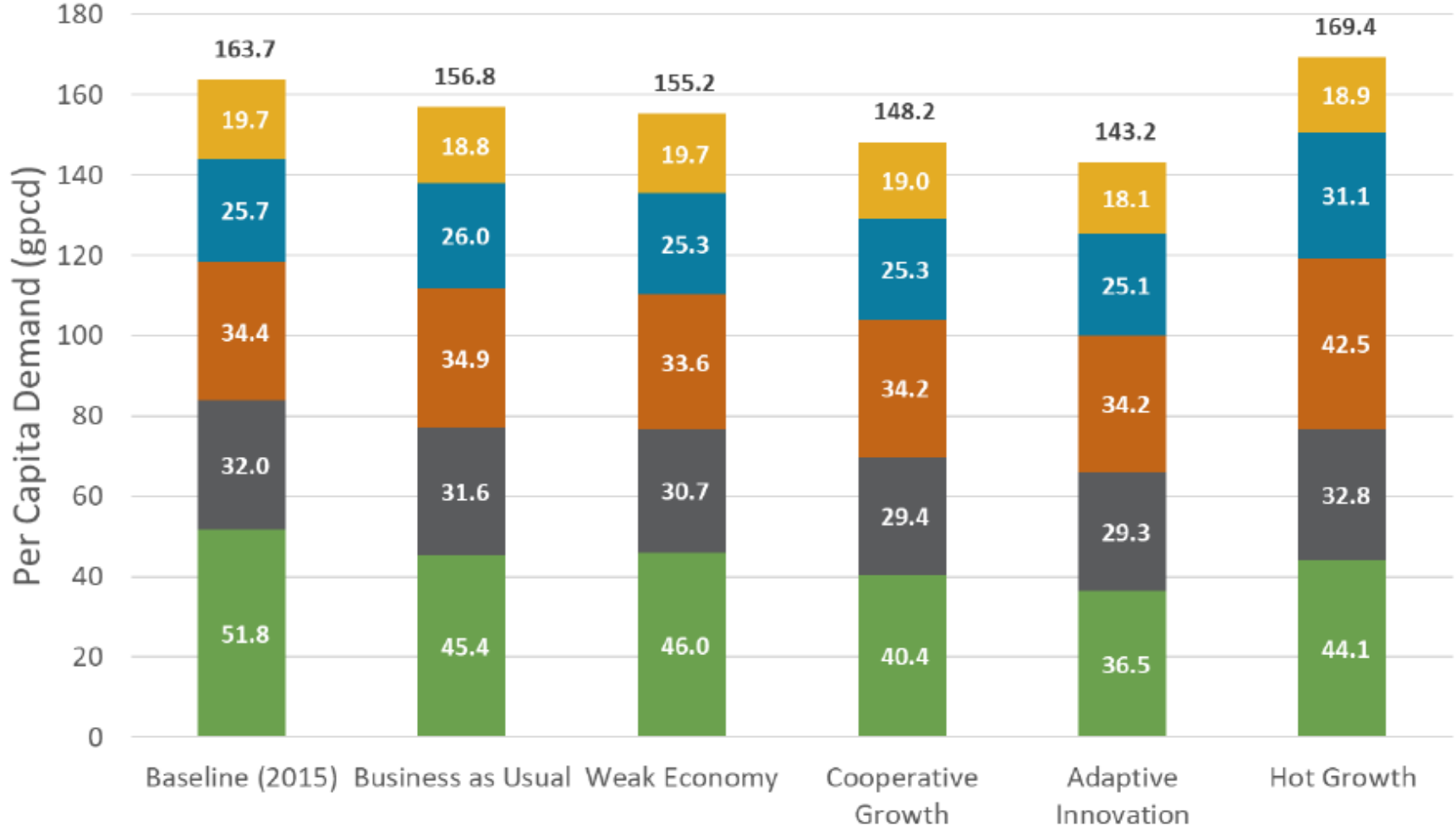
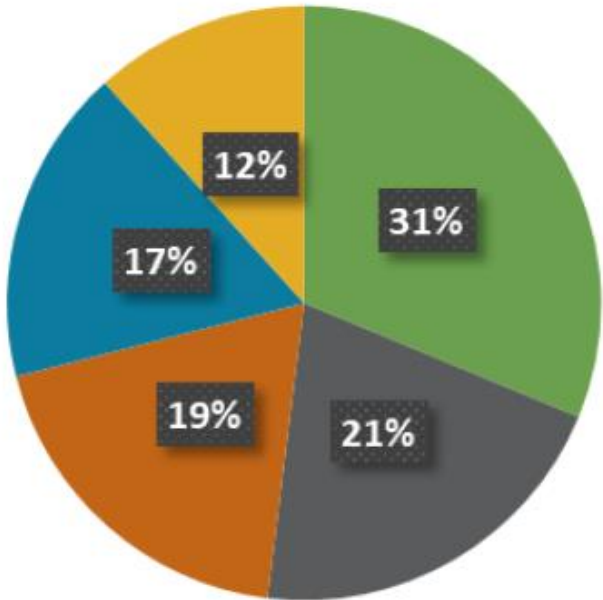
- Vibrant economy **fuels population growth**
- **Regulations are relaxed**
- **Hot and dry** conditions
- Families prefer **low-density housing**

# STATEWIDE POPULATION – CURRENT & 2050 PLANNING SCENARIO

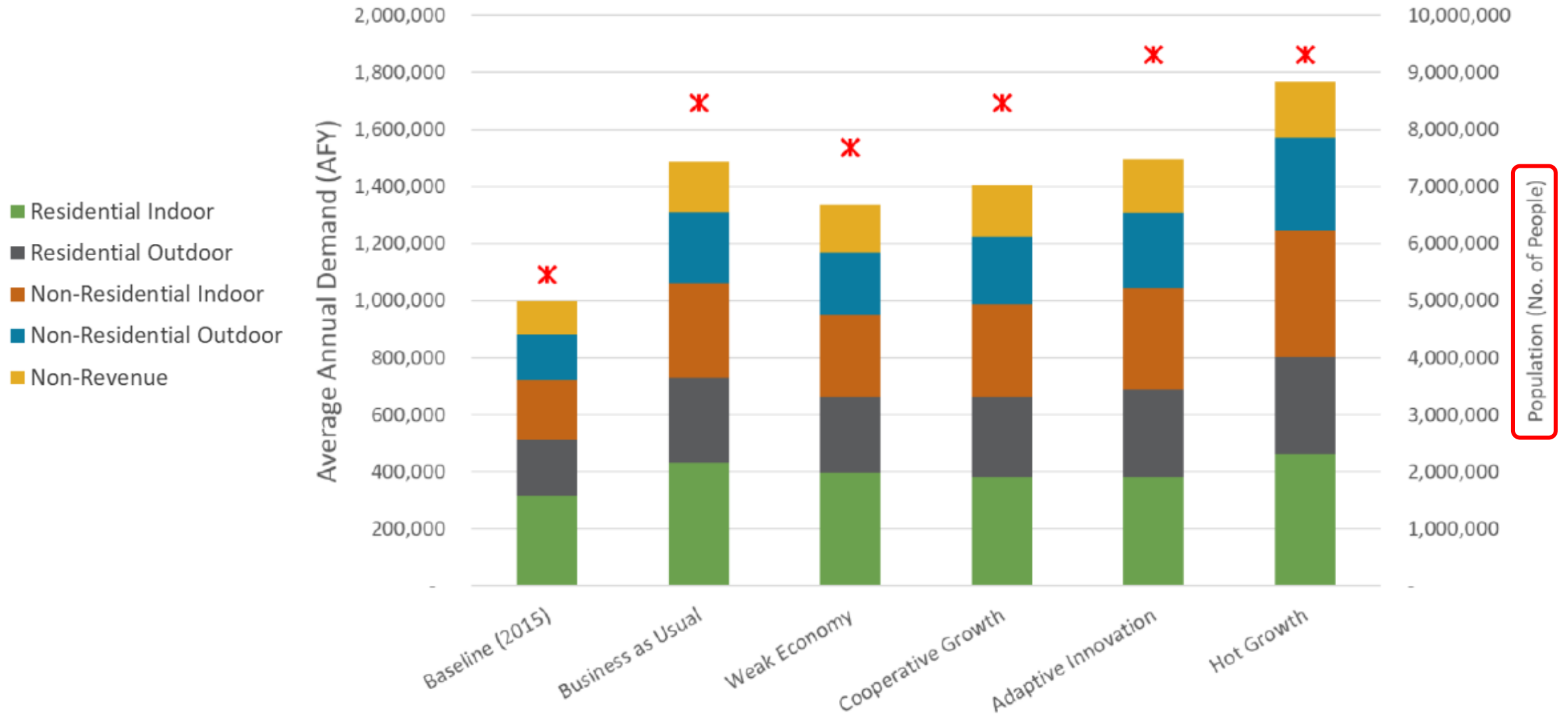


# STATEWIDE GPCD – CURRENT & 2050 PLANNING SCENARIO

- Residential Indoor
- Residential Outdoor
- Non-Residential Indoor
- Non-Residential Outdoor
- Non-Revenue

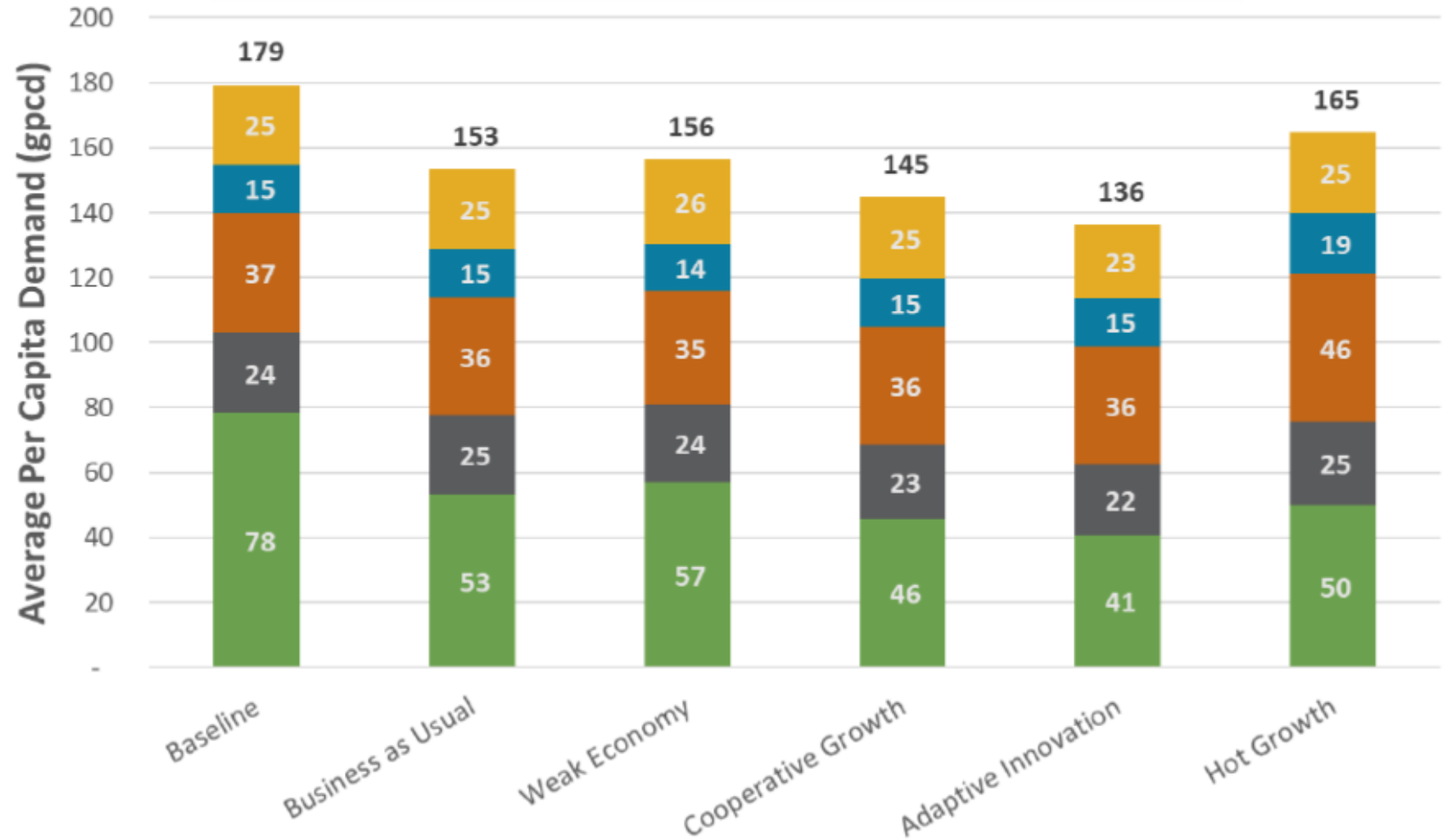
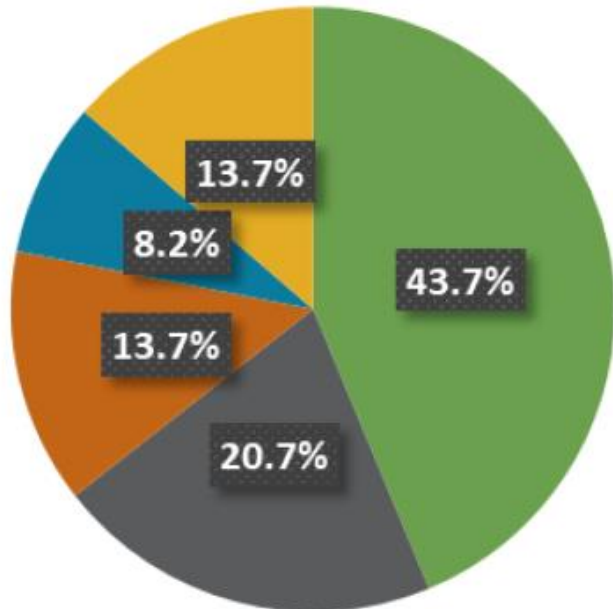


# STATEWIDE DEMAND – CURRENT & 2050 PLANNING SCENARIO

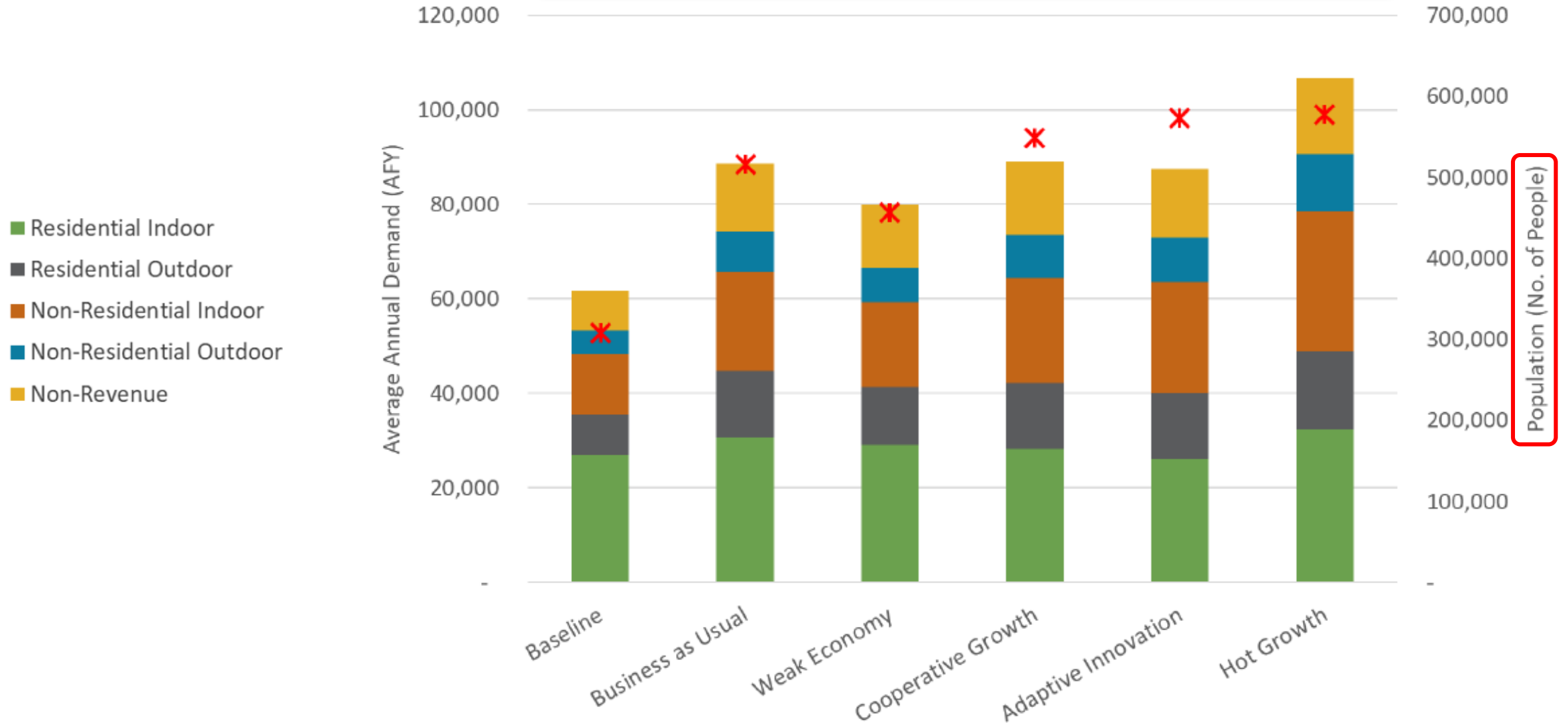


# COLORADO RIVER BASIN GPCD – CURRENT & 2050 PLANNING SCENARIO

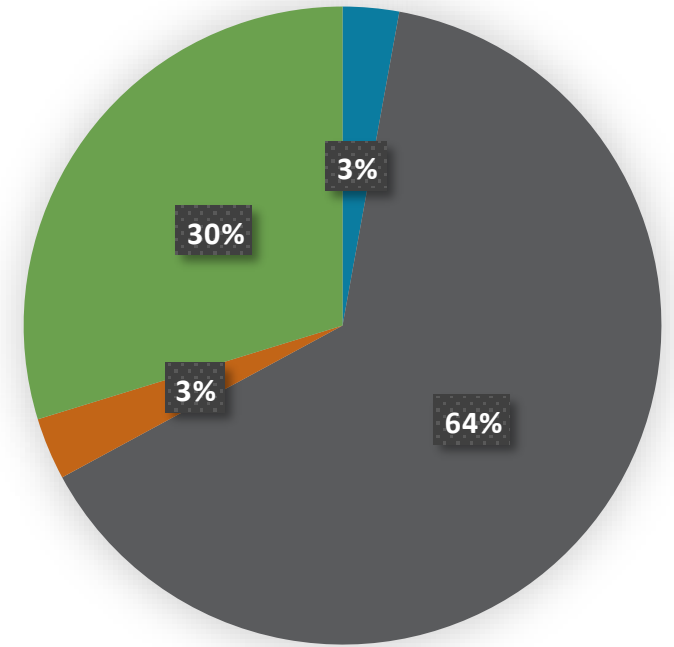
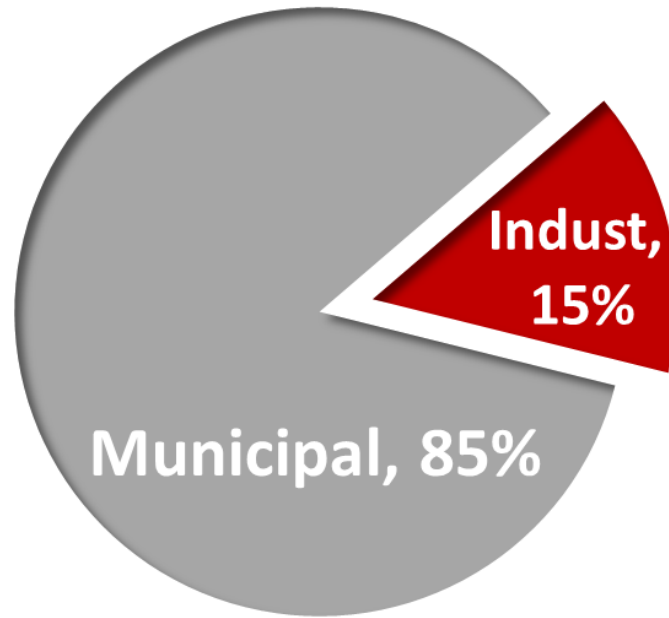
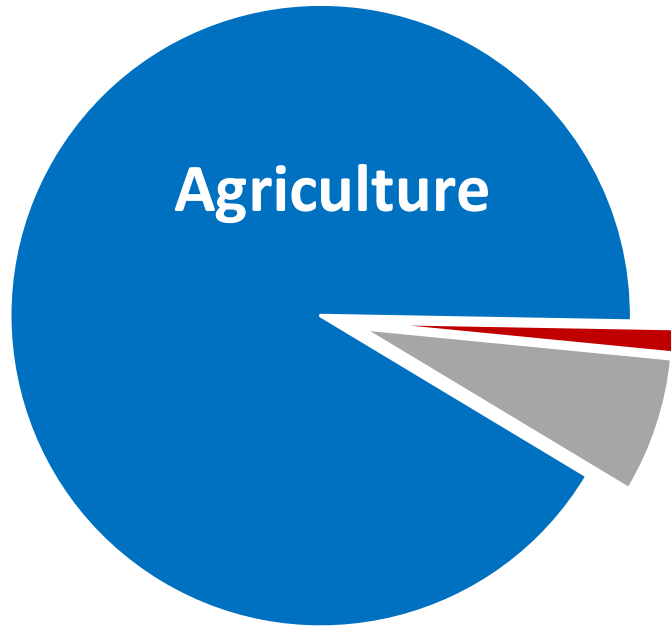
- Residential Indoor
- Residential Outdoor
- Non-Residential Indoor
- Non-Residential Outdoor
- Non-Revenue



# COLORADO RIVER BASIN DEMAND – CURRENT & 2050 PLANNING SCENARIO



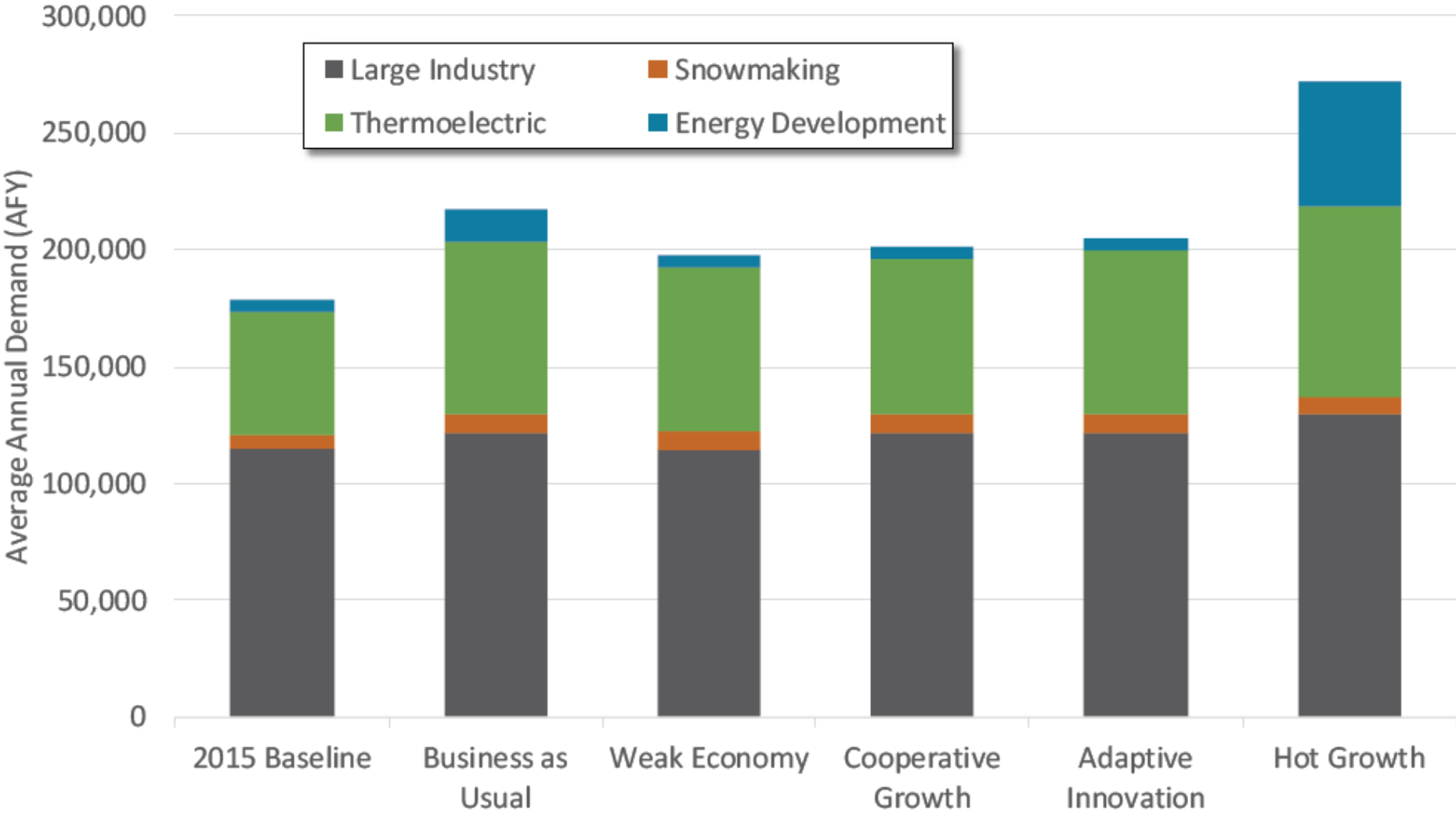
# INDUSTRIAL DEMANDS



- Energy Development
- Snowmaking
- Large Industry
- Thermoelectric



# STATEWIDE DEMAND – CURRENT & 2050 PLANNING SCENARIOS

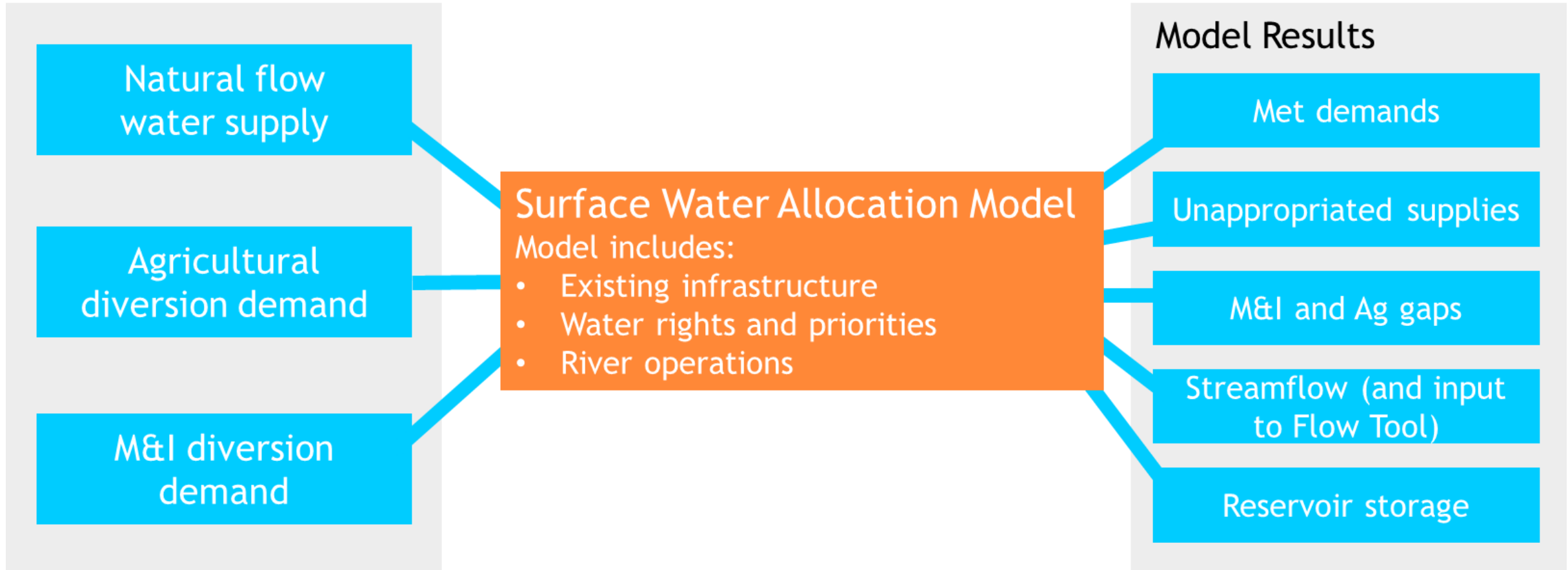


# WATER SUPPLY & GAP

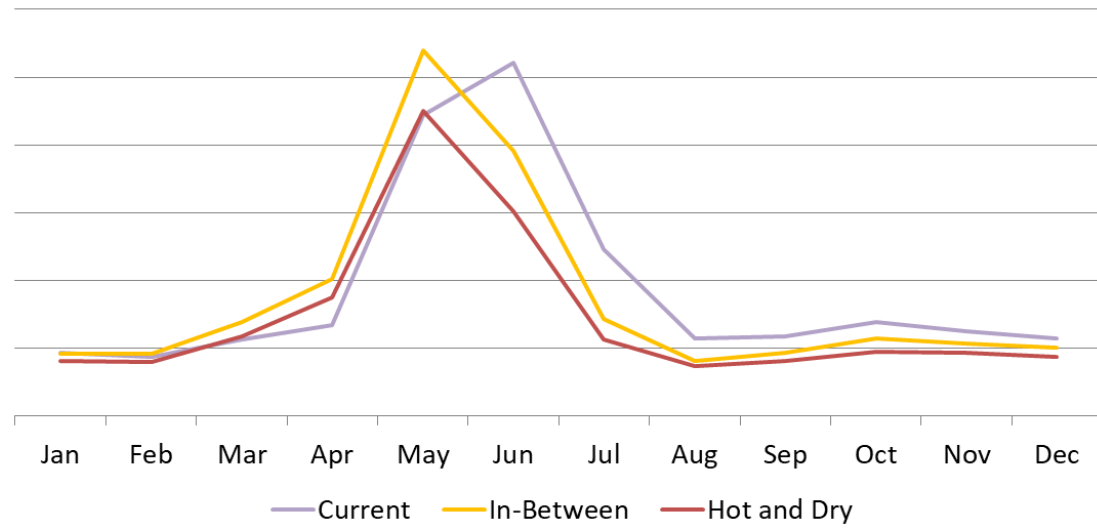


# GAP ANALYSIS

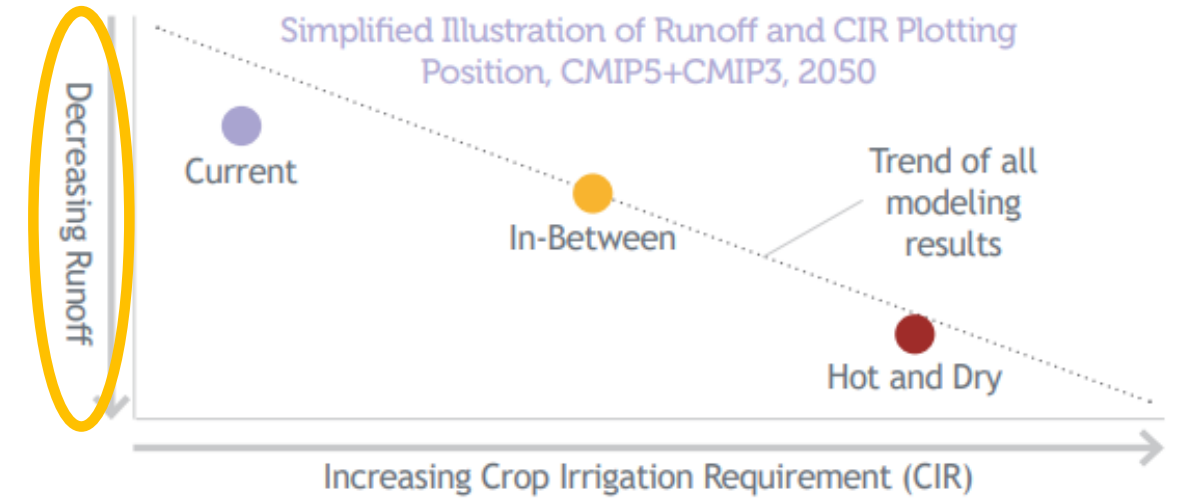
The amount of additional water supply that would need to be diverted or pumped to meet any demand



# CLIMATE ADJUSTED HYDROLOGY



Example Average Monthly Hydrology



Business as Usual  
Weak Economy

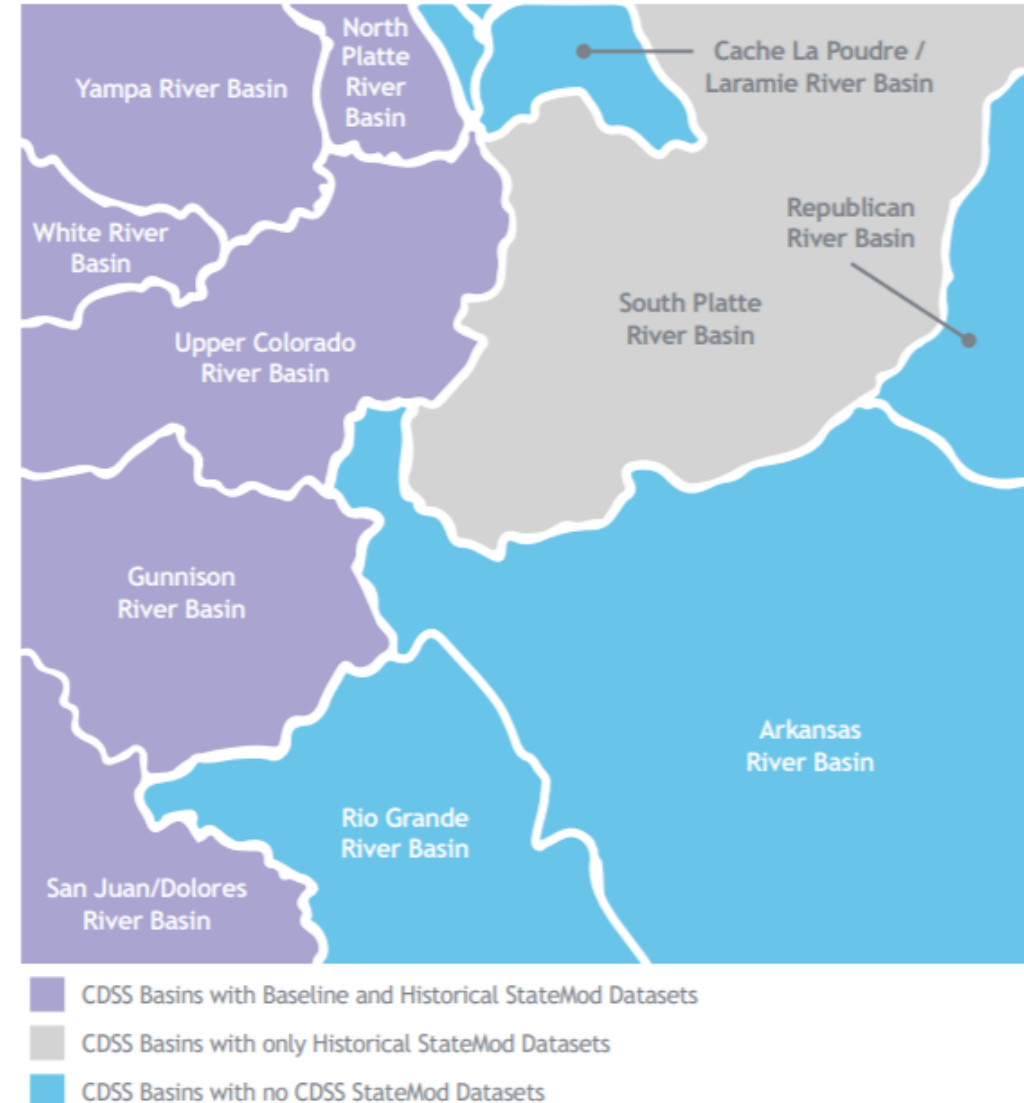
Cooperative Growth

Adaptive Innovation  
Hot Growth

# GAP ANALYSIS

## LIMITATIONS

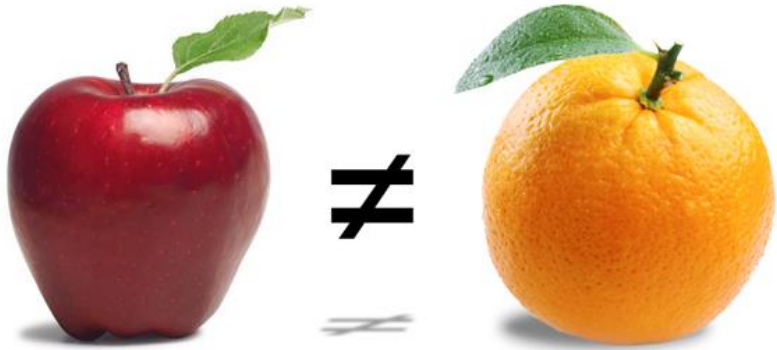
- **Basin-wide Planning Models**
  - Monthly time step, regional-level detail
- **Model calibration**
  - Dependent on input data, appropriate for regional study
- **Representation of operations**
  - Captures typical operations
- **Groundwater pumping and transbasin imports**
  - Reflects current/historical amounts



# **RESULTS**

**OF TECHNICAL UPDATE ANALYSES**

# COMPARING GAP NUMBERS



## COMPARING THE 2015 WATER PLAN GAP NUMBERS TO GAPS IN THE TECHNICAL UPDATE

SIMILAR GAPS. ABSENT PROJECTS. LOWER POPULATION. LOWER DEMANDS.

### 1 Gaps Absent Projects

Gap projections in the Technical Update do not include estimates of basin identified project yields. This is primarily due to a lack of specific project data that would allow projects to be modeled. Forthcoming basin plan updates will reevaluate projects and consider strategies to address gaps.

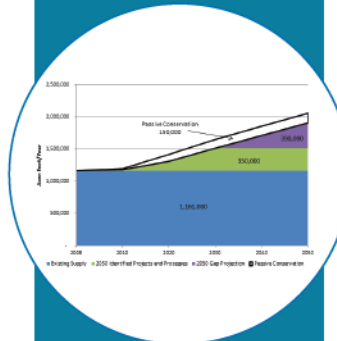
### 2 Gaps Across Scenarios

Unlike past projections which estimated high, medium and low gaps at 2050, the Technical Update identifies 2050 gaps for each of the five scenarios in the Water Plan.

### 3 Gap Influences

Some of the main drivers (population; climate) and assumptions (storage operations) heavily influence the gaps in the Technical Update. Population projections, while lower than in previous analyses, remain a major driver of demands. Climate change is included in three of the five scenarios, which drives irrigation, streamflow and storage timing. Modeled storage operations maximize the use of stored water to meet demands and lower gaps.

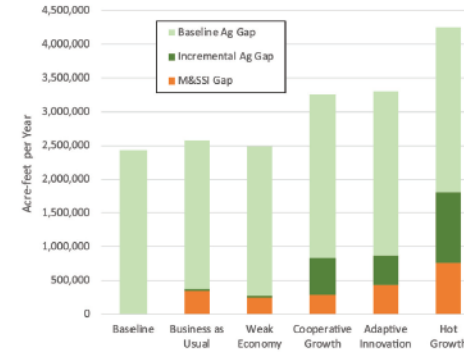
GAPS SHOWN IN THE 2015 WATER PLAN



190K - 630K AFY  
2050 M&I GAP

1,722,000 AFY  
2050 AG SHORTAGE

GAPS SHOWN IN THE 2019 TECHNICAL UPDATE



250K - 750K AFY  
2050 M&I GAP

23,000 - 1,053,000 AFY  
2050 INCREMENTAL AG GAP

### 4 Gap Mitigation

When basins reevaluate plans it will be important to evaluate core projects that represent low-regret actions to meet future needs under any scenario. The Adaptive Innovation scenario, for example, illustrates how adaptive actions (e.g. efficiency) can help offset impacts from climate change and population growth.

### 5 Gaps: Max, Average & Incremental

Gaps are shown in a manner that reflects the difference in how M&I and agriculture plan in any given year. Feedback on earlier studies suggested that agriculture gaps may have been overstated because many agricultural producers live with annual shortages (especially in over-appropriated basins).

To address this, agricultural gaps are expressed in terms of average and incremental gaps — the degree to which gaps may increase in the future. Maximum agricultural gaps can also be found in the Technical Update results. At the same time, M&I gaps are primarily expressed in terms of maximums, which is consistent with firm yield planning.

2020 AG SHORTAGE  
1,722,000 AFY

2020 INCREMENTAL AG GAP  
23,000 - 1,053,000 AFY

# STATEWIDE GAP ANALYSIS RESULTS

## M&I Gap

245,000 to 754,000 AF

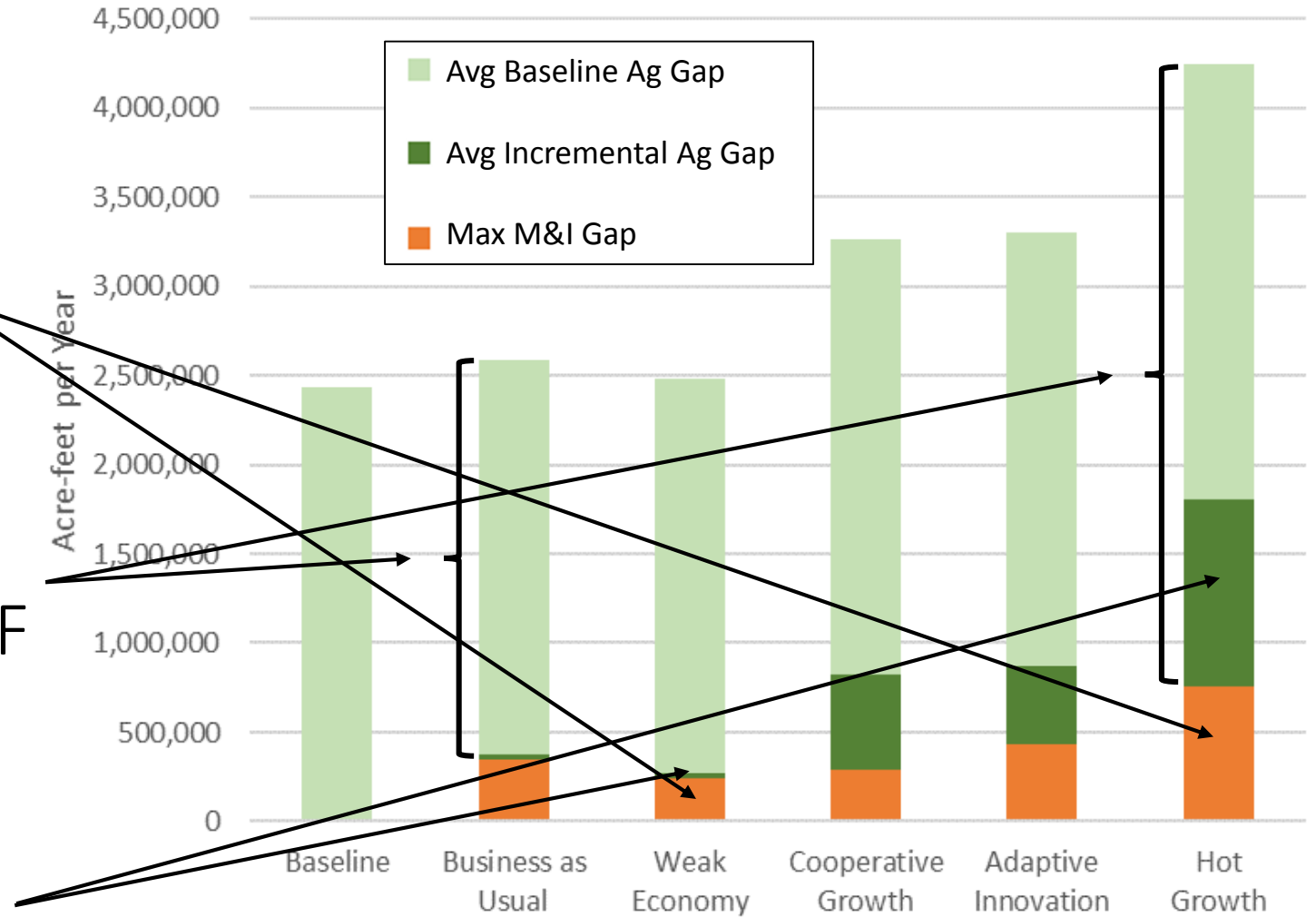
(Does not include projects)

## Total Ag Gap

2,213,000 to 3,379,000 AF

## Incremental Ag Gap

23,000 to 1,053,000 AF

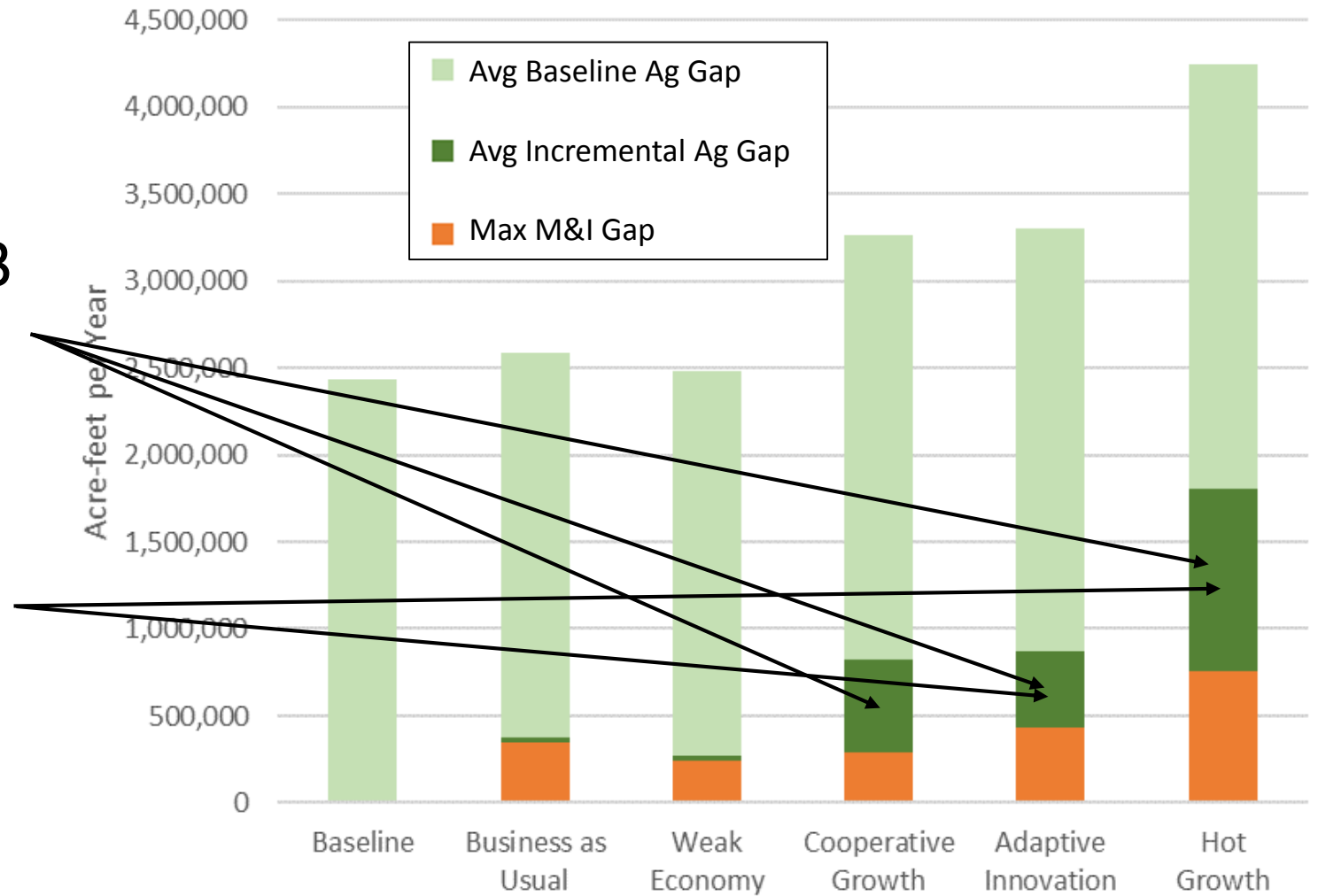




# GAP ANALYSIS OBSERVATIONS

Ag gaps may increase 18 to 43 percent beyond baseline

Ag gaps are less in Adaptive Innovation than Hot Growth despite similar climate

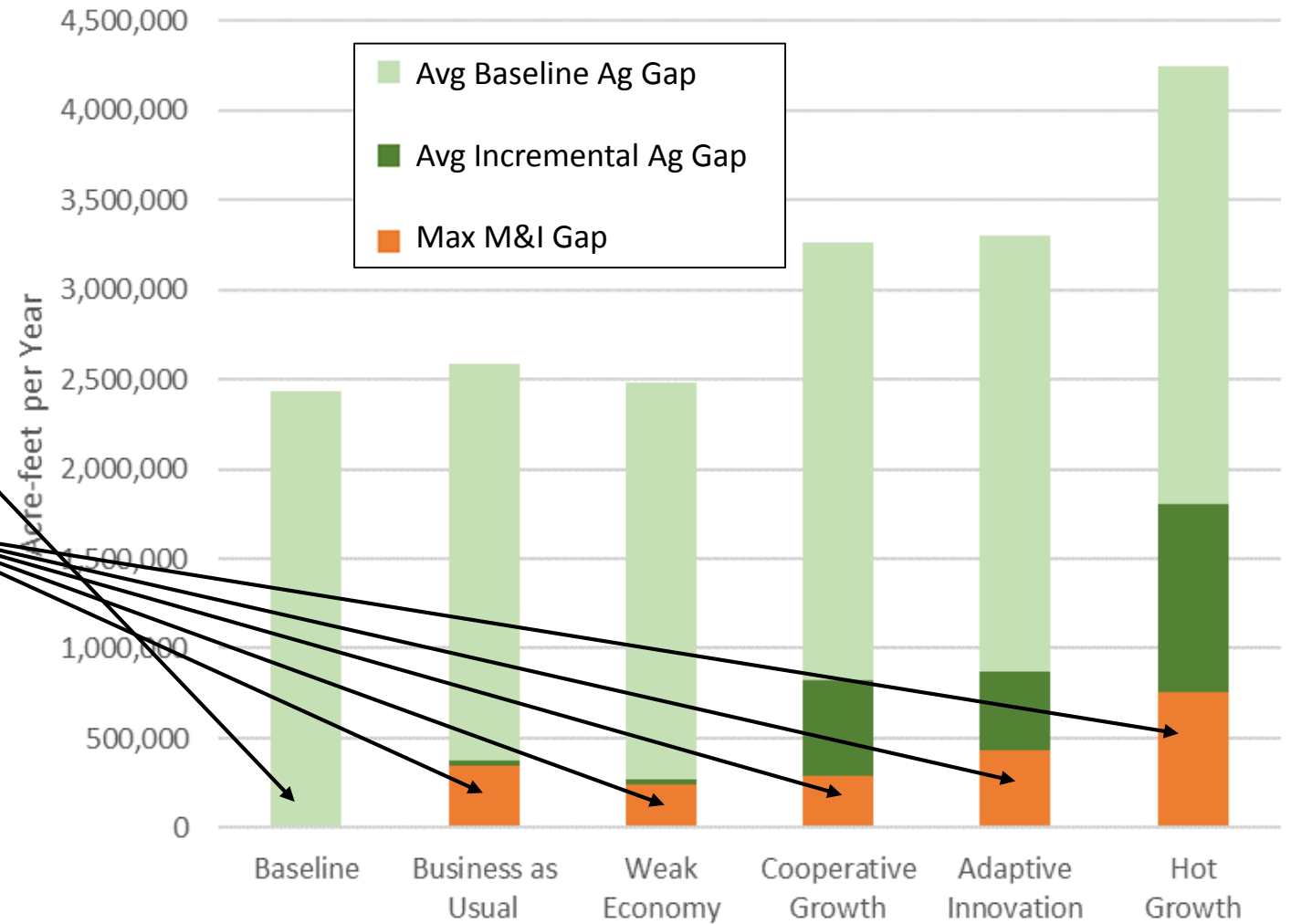


# GAP ANALYSIS OBSERVATIONS

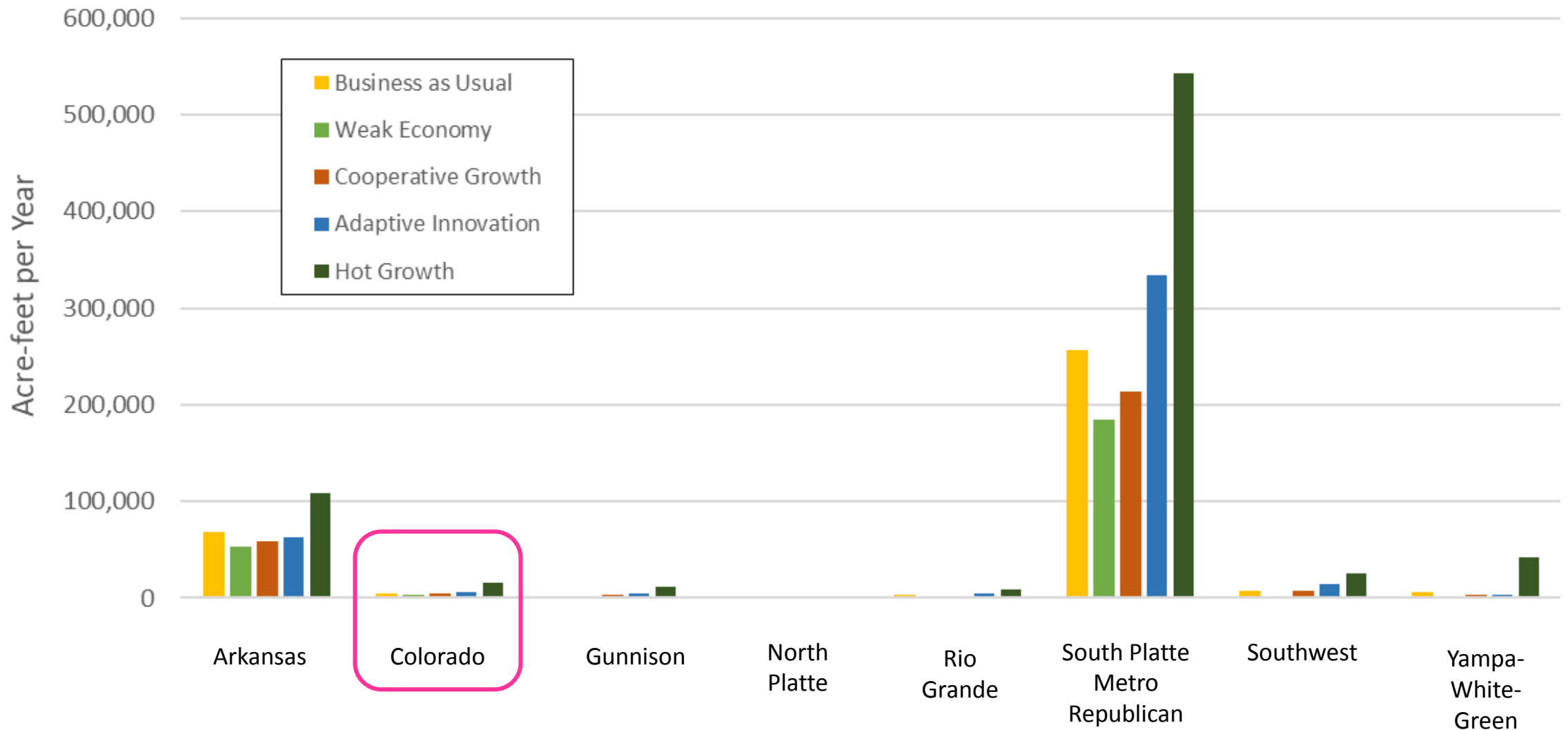
M&I does not currently experience a gap

Increasing population and warmer climate will create gaps in the future despite efforts to conserve

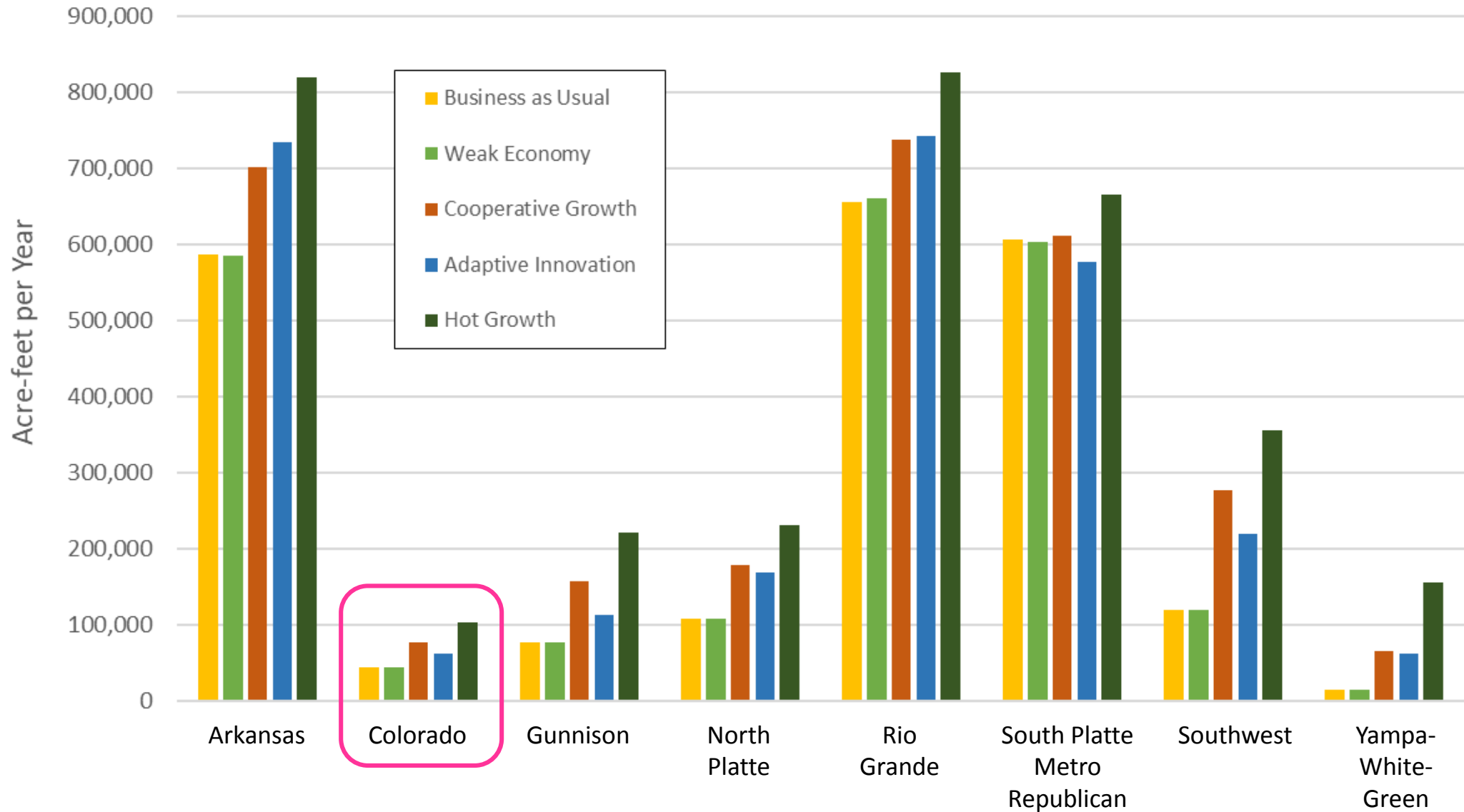
- Additional conservation could be implemented



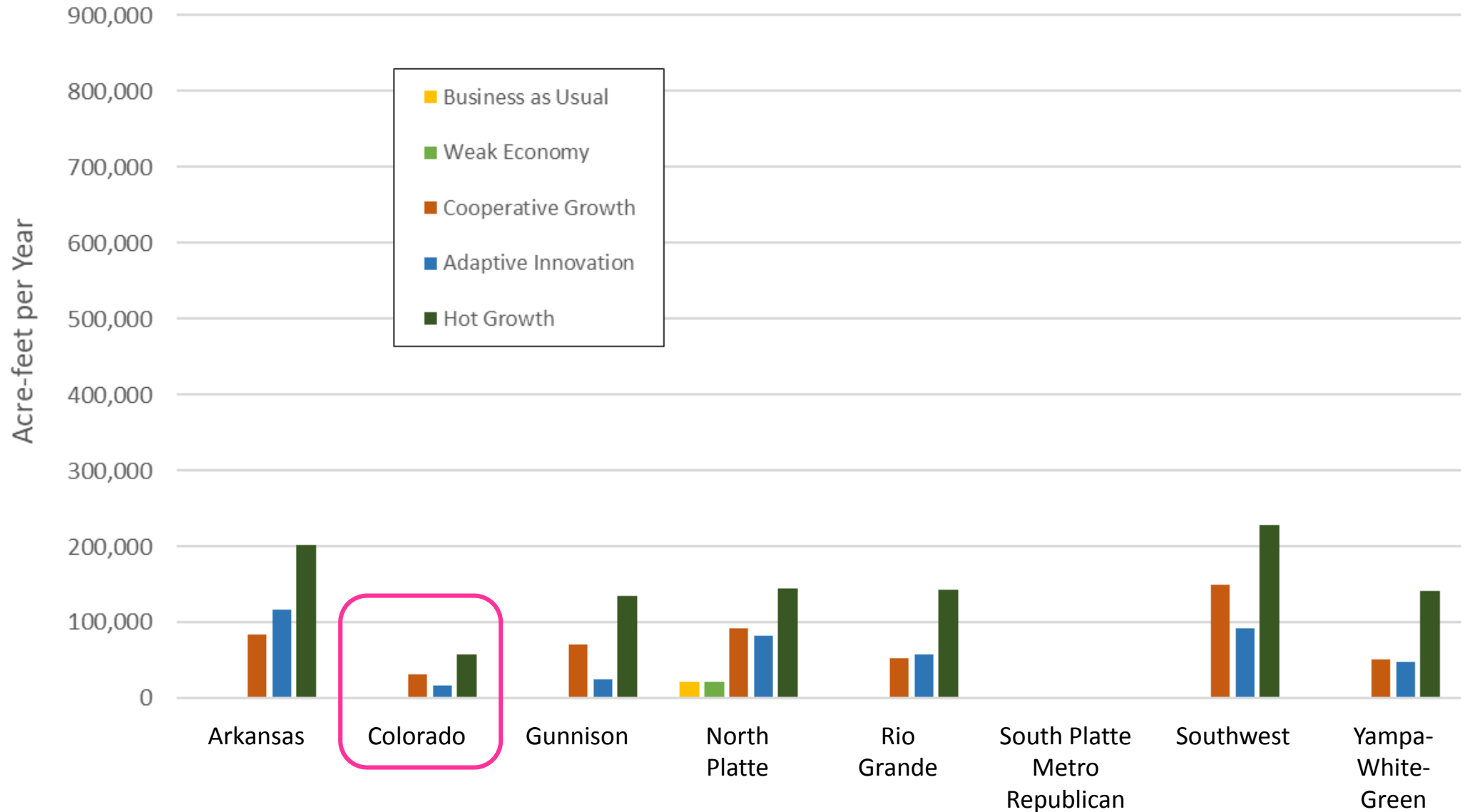
# BASIN-SPECIFIC GAP ANALYSIS RESULTS – MAX M&I GAPS



# BASIN-SPECIFIC GAP ANALYSIS RESULTS – AVERAGE TOTAL AG GAPS



# BASIN-SPECIFIC GAP ANALYSIS RESULTS – AVERAGE INCREMENTAL AG GAPS



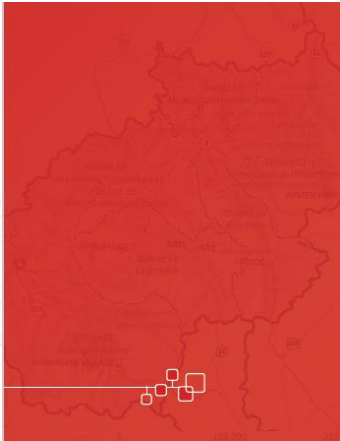
The Arizona River originates in the central mountains of Colorado near Leadville, then flows eastward through the mountain part of Colorado toward the Grand Canyon. The Arizona then supplies the region near basin in Colorado, flowing eighty feet from over half of the state's total area. A large amount of such is devoted to agriculture, with most of it agricultural water requiring irrigation. Irrigation is concentrated in the lower portion of the basin, and in the west part, percent almost half the basin's agricultural land.

The Arizona River Company of 2004 supports the water of the Arizona from between Colorado and Arizona, while providing for the acquisition of water rights. Between 1990 and 2000, Colorado and Arizona have negotiated water agreements. Colorado has made leading to the development of laws and regulations to address the basin's water resources for compliance with the Compact.



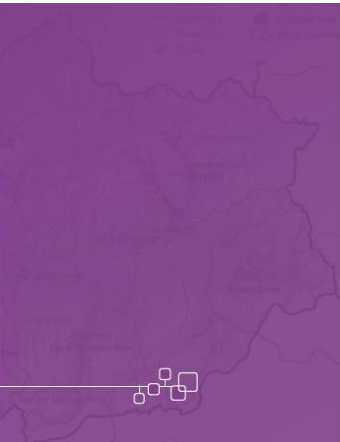
# ARKANSAS

The northern Colorado Basin in Colorado encompasses approximately 8,000 square miles, extending from the Rocky Mountain National Park in the Colorado State north to the Sangre de Cristo Range to the south. The basin is high country in an important water source to both sides of the Continental Divide, as the state's largest mountain elevations are here. Ranching and forested production rights agriculture in the upper reaches of the Colorado Basin are a large portion of food and agriculture production, with major areas as well as housing and fishing opportunities, water drives in both recreation and tourism across throughout the basin.



# COLORADO

The Gunnison Basin involves access across more than 8,000 square miles of western Colorado, extending from the Continental Divide to the southern end of the Colorado and Colorado State and Grand Canyon. The basin is high country, with some country approximately 50 percent of the basin's area. About 50 percent of the basin is forested or planted or cultivated land, and from basin are generally concentrated in the upper reaches of the Colorado Basin, with additional agriculture near Colorado and sections. Key future water management issues in the basin are described in Colorado Water Plan include agricultural water storage and increased growth and agriculture in the mountainous region.



# GUNNISON

The North Platte Basin, also known as North Park, is a high-altitude valley covering about 3,000 square miles in north-central Colorado. It is a sub-basin of the North Platte and the West Platte of the North Platte that contains the North Platte watershed. Both the North Platte and West Platte flow north and west toward the North Platte Basin. The basin is also affected by the North Platte Recovery Implementation Program (NPRIP), which was developed to manage and engage water resources within the North Platte Basin. Water in the basin is used for irrigated pasture associated with grazing operations. The basin also has major wildlife and agriculture in surrounding public lands and recreation opportunities. The basin supports a portion of the basin's water supply, approximately 500,000 acre feet per year.

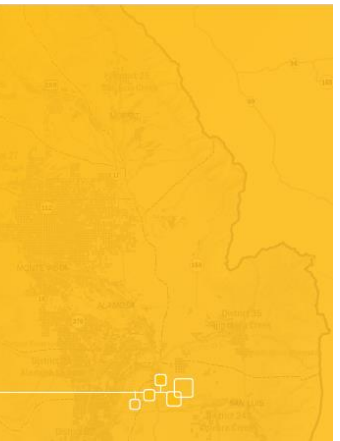


# NORTH PLATTE

The Rio Grande drainage basin in Colorado is bounded by the San Juan Mountains to the west, the Sangre de Cristo Range to the north and east, the Colorado Range to the southeast, and the Colorado River to the south. Between the mountains to the San Juan Valley is a relatively flat area with an average elevation of 7,000 feet, and agricultural production is high. The basin is used for agriculture, with major areas as well as housing and fishing opportunities, water drives in both recreation and tourism across throughout the basin.

The northern third of the valley is a closed basin, meaning that the surrounding mountains and elevations from the Rio Grande mountain range are high enough to block the basin from the north and east. The basin is used for agriculture, with major areas as well as housing and fishing opportunities, water drives in both recreation and tourism across throughout the basin.

The Rio Grande drainage basin in Colorado is bounded by the San Juan Mountains to the west, the Sangre de Cristo Range to the north and east, the Colorado Range to the southeast, and the Colorado River to the south. Between the mountains to the San Juan Valley is a relatively flat area with an average elevation of 7,000 feet, and agricultural production is high. The basin is used for agriculture, with major areas as well as housing and fishing opportunities, water drives in both recreation and tourism across throughout the basin.



# RIO GRANDE

The South Platte Basin is the most productive basin in the state, approximately 88 percent of Colorado's population resides in the South Platte Basin, and the most fertile 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 agricultural characteristics of the South Platte Basin are diverse. The western portion of the basin and its mountainous and sub-basin areas are mostly forested, while the high Plains region is mostly grassland or planted or cultivated land.

The hydrology of the South Platte Basin is highly variable, with an average rate average annual runoff flow volume of 1.4 trillion acre feet. About 800,000 acre feet of runoff water is stored in 20,000 reservoirs in the basin, providing agricultural production and recreation.

The South Platte Basin in Colorado is located on the Northeastern High Plains. Land uses in the basin are primarily agricultural. The hydrology characteristics of the South Platte Basin, which are similar to the high Plains region of the South Platte Basin, consist mostly of grassland or planted or cultivated land. The South Platte Basin in Colorado is a high Plains region, which is one of the largest agricultural basins in the United States, extending from South Dakota to Texas.

The South Platte Basin is highly variable, with an average rate average annual runoff flow volume of 1.4 trillion acre feet. About 800,000 acre feet of runoff water is stored in 20,000 reservoirs in the basin, providing agricultural production and recreation.



# SOUTH PLATTE / METRO

The San Juan Basin, Dolores Basin, and San Miguel River Basins are located in the southwest corner of Colorado and cover an area of approximately 10,000 square miles. The region is high-altitude and mountainous, featuring high mountain ranges and a high elevation in the southern portion of the basin—the Montezuma and the San Juan Mountains. The Southwest Basin is a high-altitude region, with an average elevation of 7,000 feet. The basin is used for agriculture, with major areas as well as housing and fishing opportunities, water drives in both recreation and tourism across throughout the basin.



# SOUTHWEST

The Yampa, White, and Green Basins cover approximately 10,000 acres in northwestern Colorado and south-central Wyoming. The basin is located in a high-altitude region, with an average elevation of 7,000 feet. The basin is used for agriculture, with major areas as well as housing and fishing opportunities, water drives in both recreation and tourism across throughout the basin.

The Technical Update largely maps the extent of the basin's water rights. There are some exceptions where water rights (over land) within of major waterways were more significant. To read more about the water rights in the basin, see the Technical Update's Appendix A, which contains a list of water rights in the basin. In all instances of the report where water rights are included, the Technical Update's Appendix A contains a list of water rights in the basin.

Note that the extent of the Green Basin from the divisions and not from the water right, and these are included in the model for the Yampa Basin. The amount of green water from these divisions are included in the Yampa Basin model.



# YAMPA WHITE GREEN

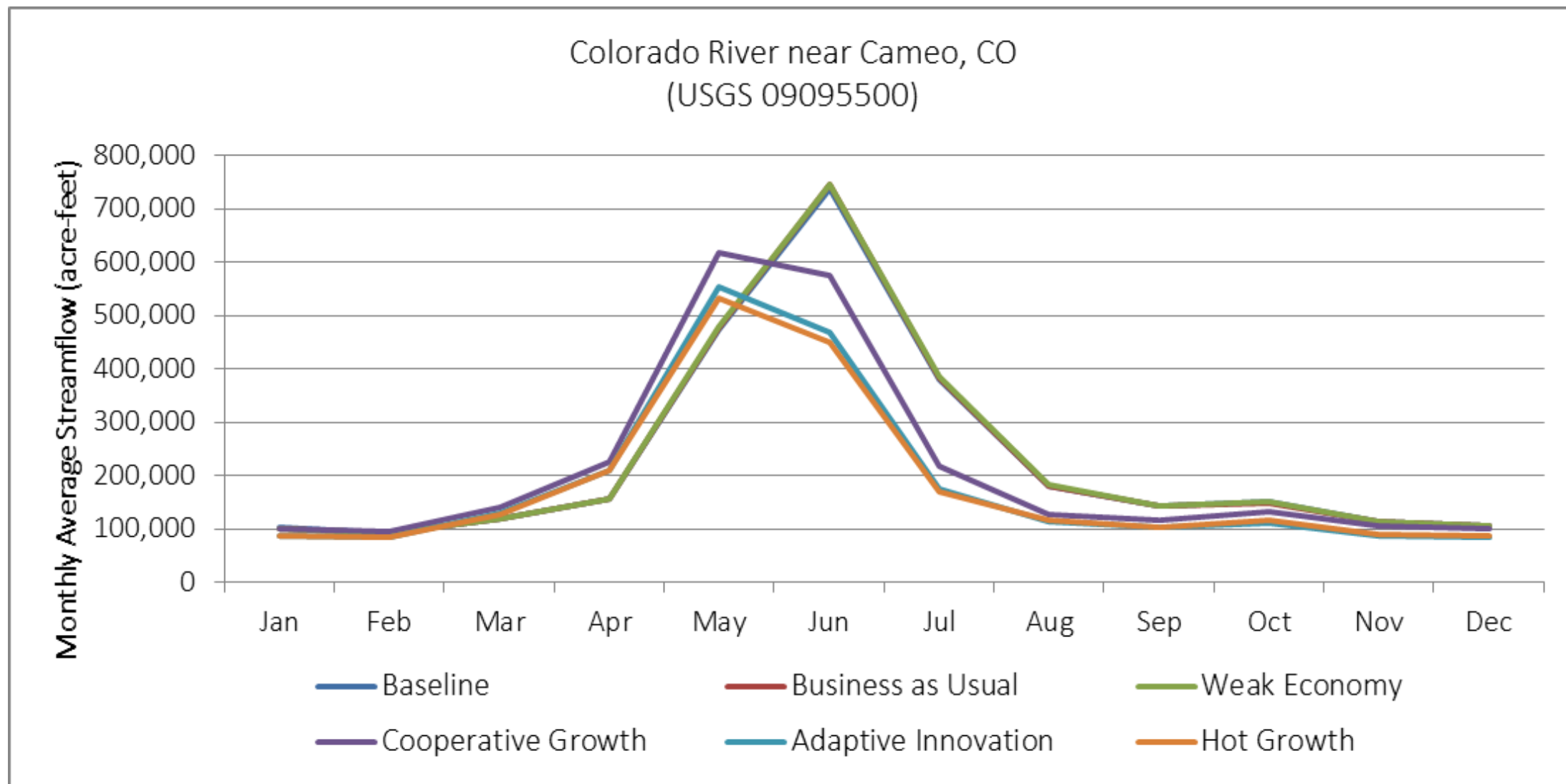
The statewide results and findings of the technical update pertaining to statewide agricultural and field, orchard and grape as well as findings related to environmental and recreational attributes and future conditions are summarized in the following sections, which is followed by a map of each of the state's eight major river basins.



# STATEWIDE

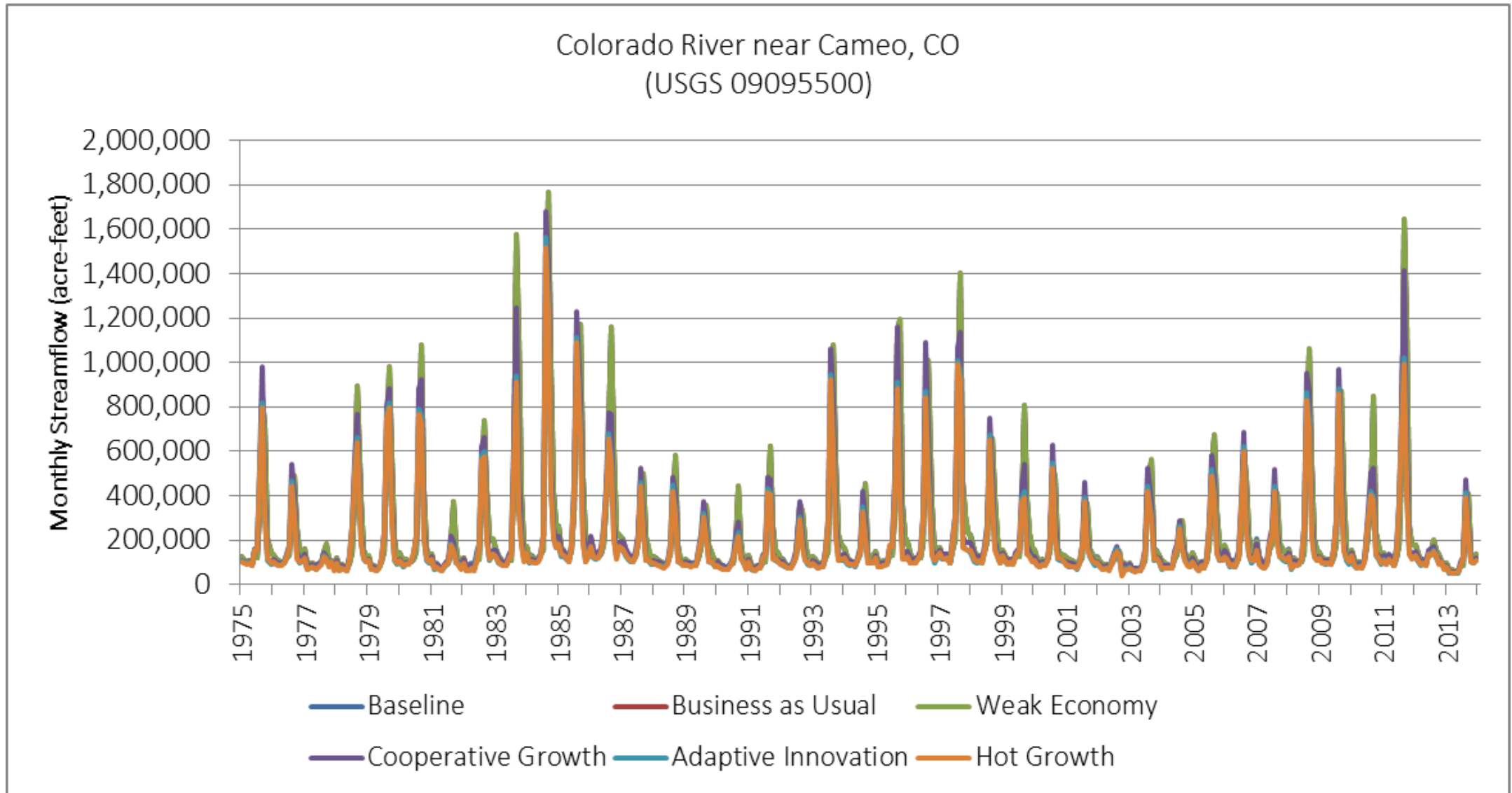


# COLORADO RIVER BASIN – STREAMFLOW





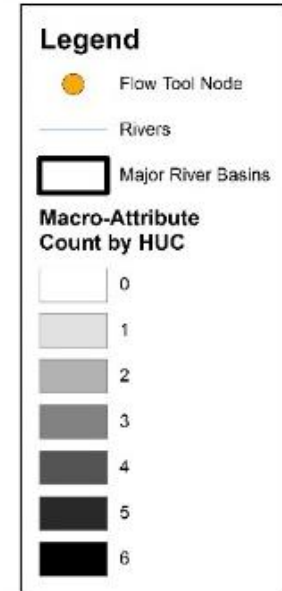
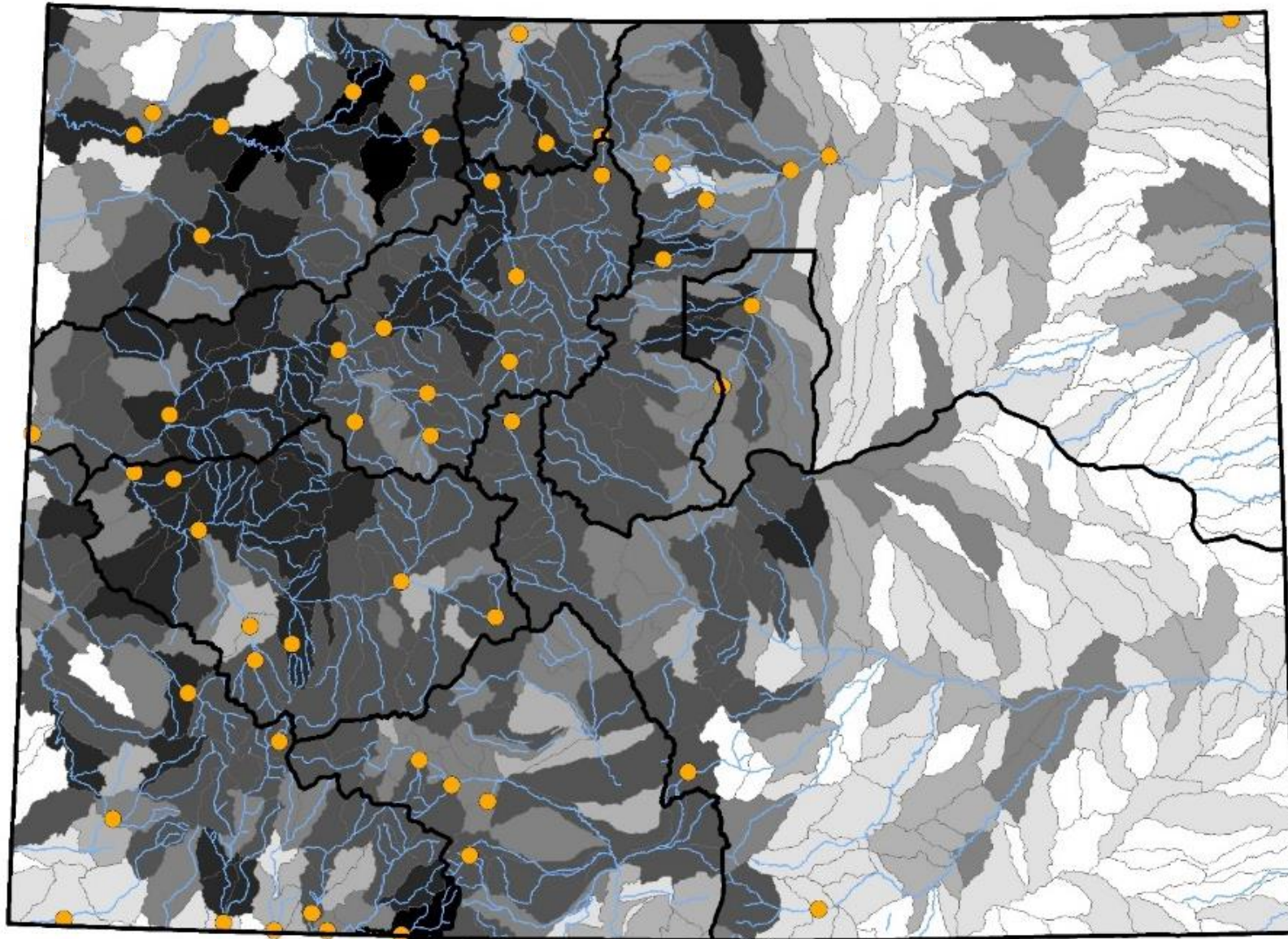
# COLORADO RIVER BASIN – STREAMFLOW



# EVALUATE E&R RISKS WITH NEW TOOLS



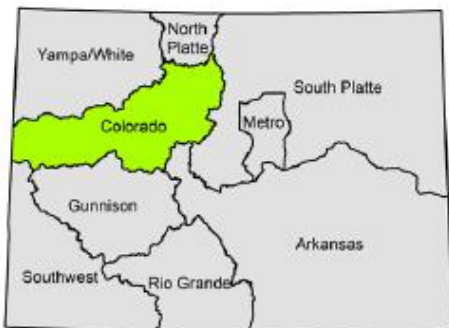
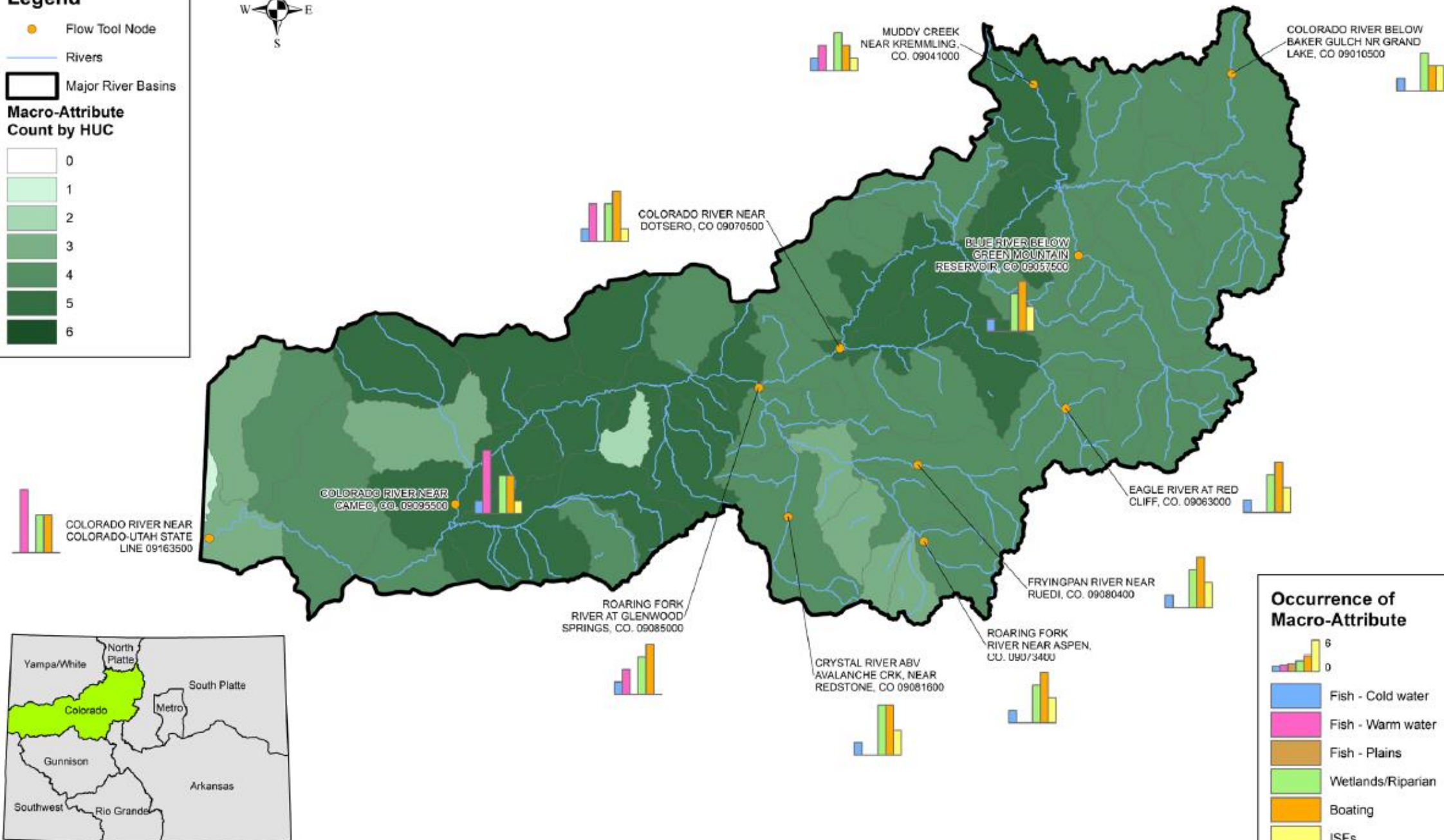
# ENVIRONMENTAL FLOW TOOL



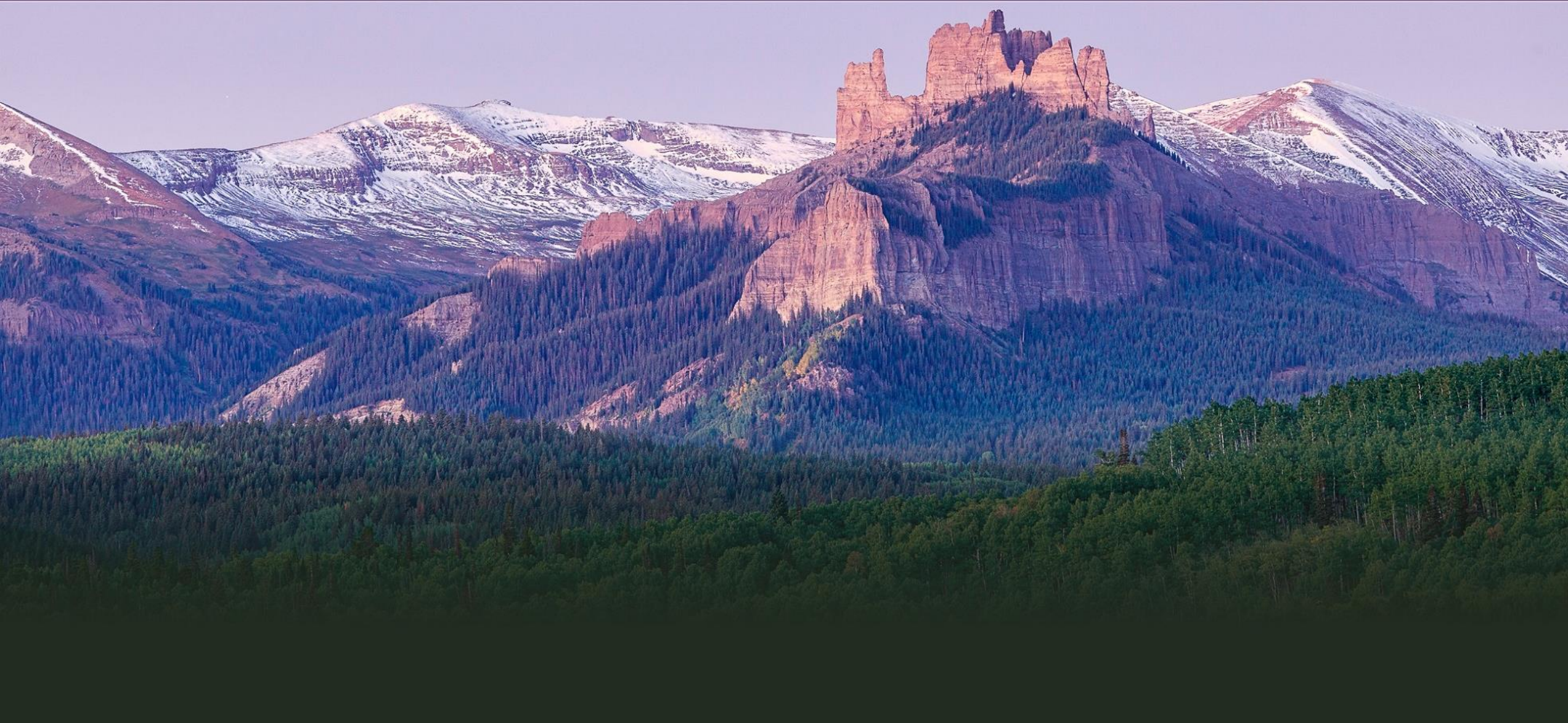
- Macro-Attributes:**
1. Fish - Cold water
  2. Fish - Warm water
  3. Fish - Plains
  4. Wetland
  5. Boating
  6. ISFs

### Legend

- Flow Tool Node
  - Rivers
  - Major River Basins
- Macro-Attribute Count by HUC**
- |   |
|---|
| 0 |
| 1 |
| 2 |
| 3 |
| 4 |
| 5 |
| 6 |

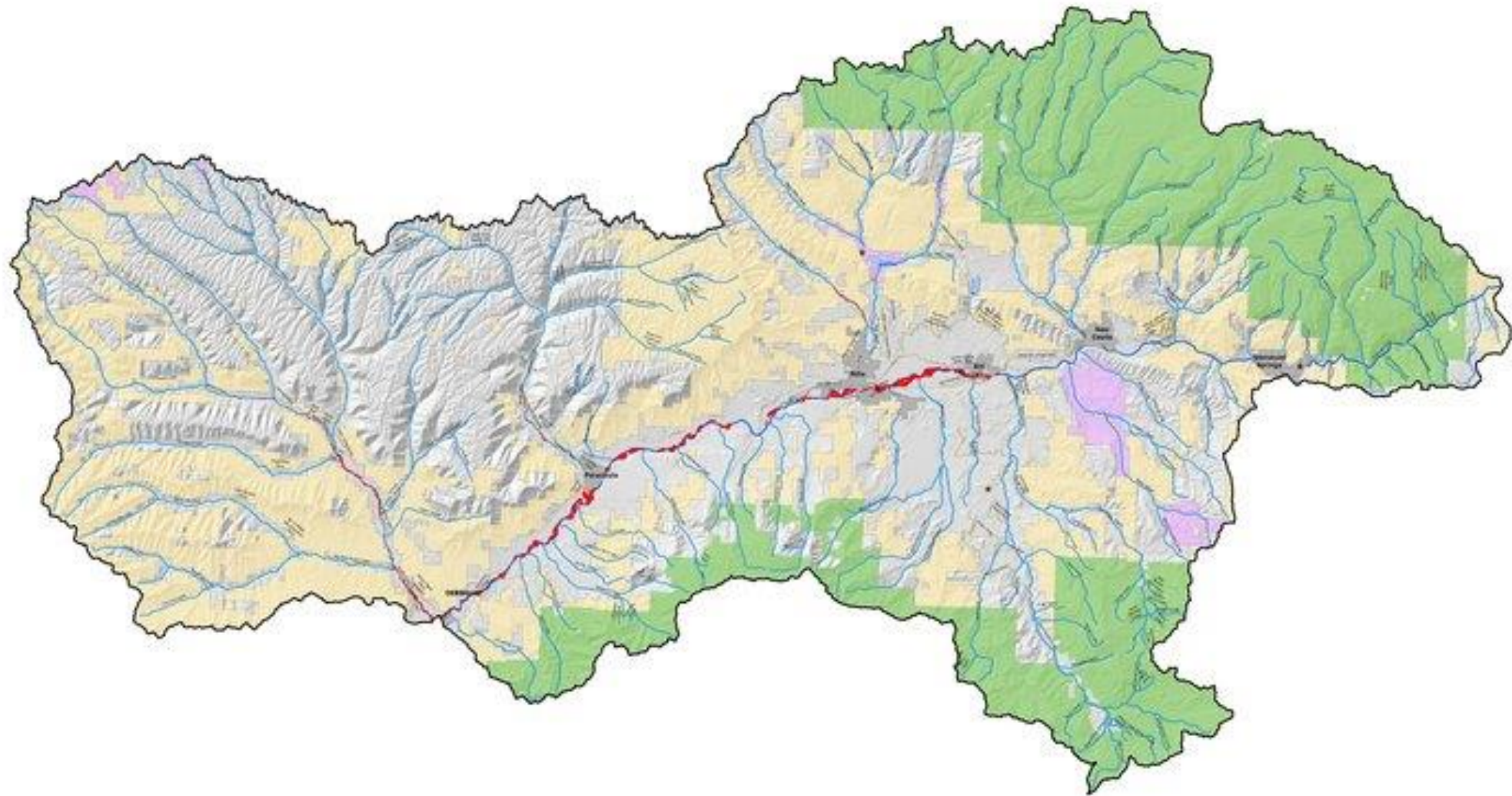






# MIDDLE COLORADO IWMP

# MIDDLE COLORADO BASIN-SPECIFIC RESULTS



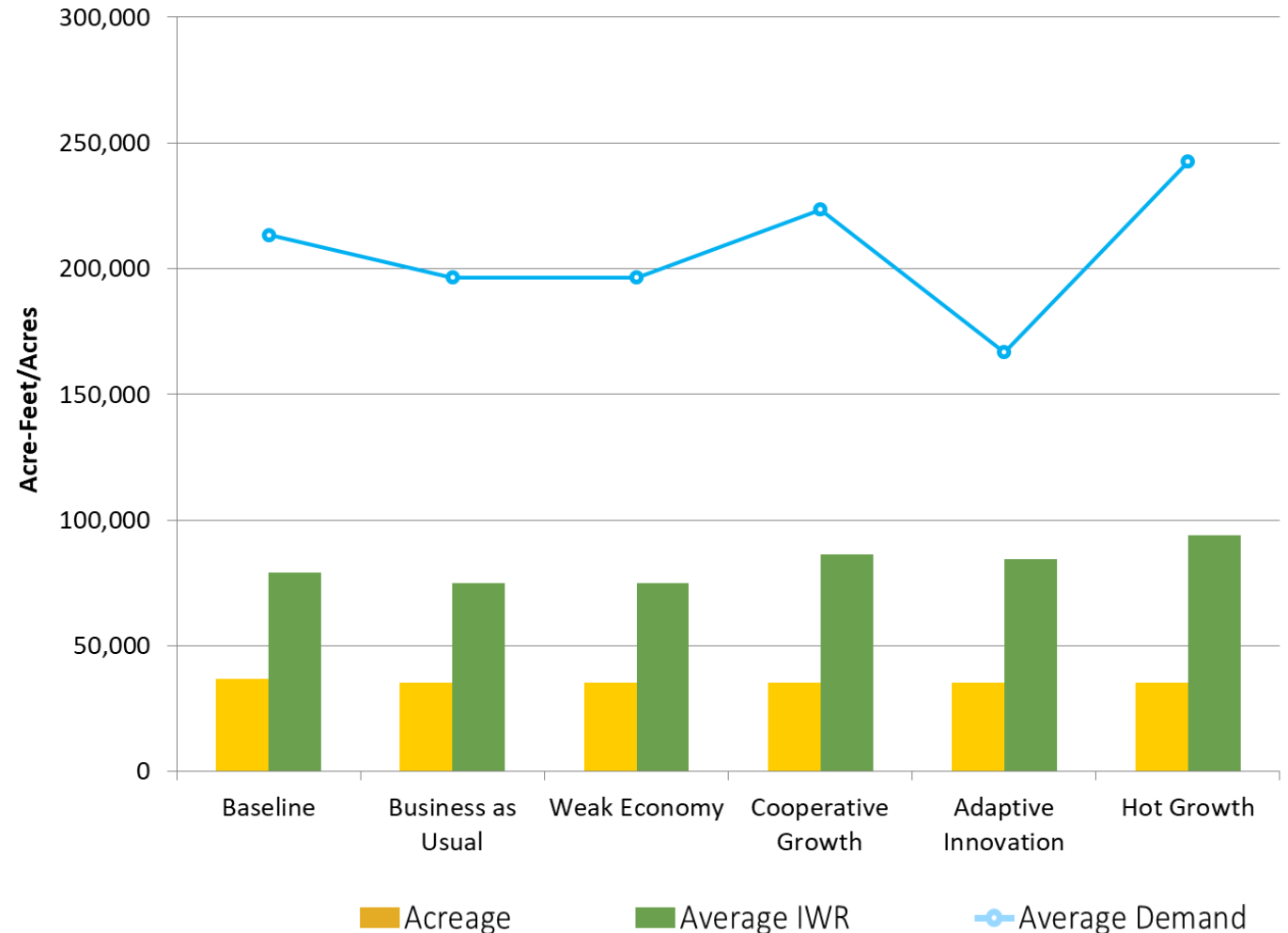
# MIDDLE COLORADO BASIN – AGRICULTURAL DEMAND

## CURRENT & 2050 PLANNING SCENARIO

By 2050:

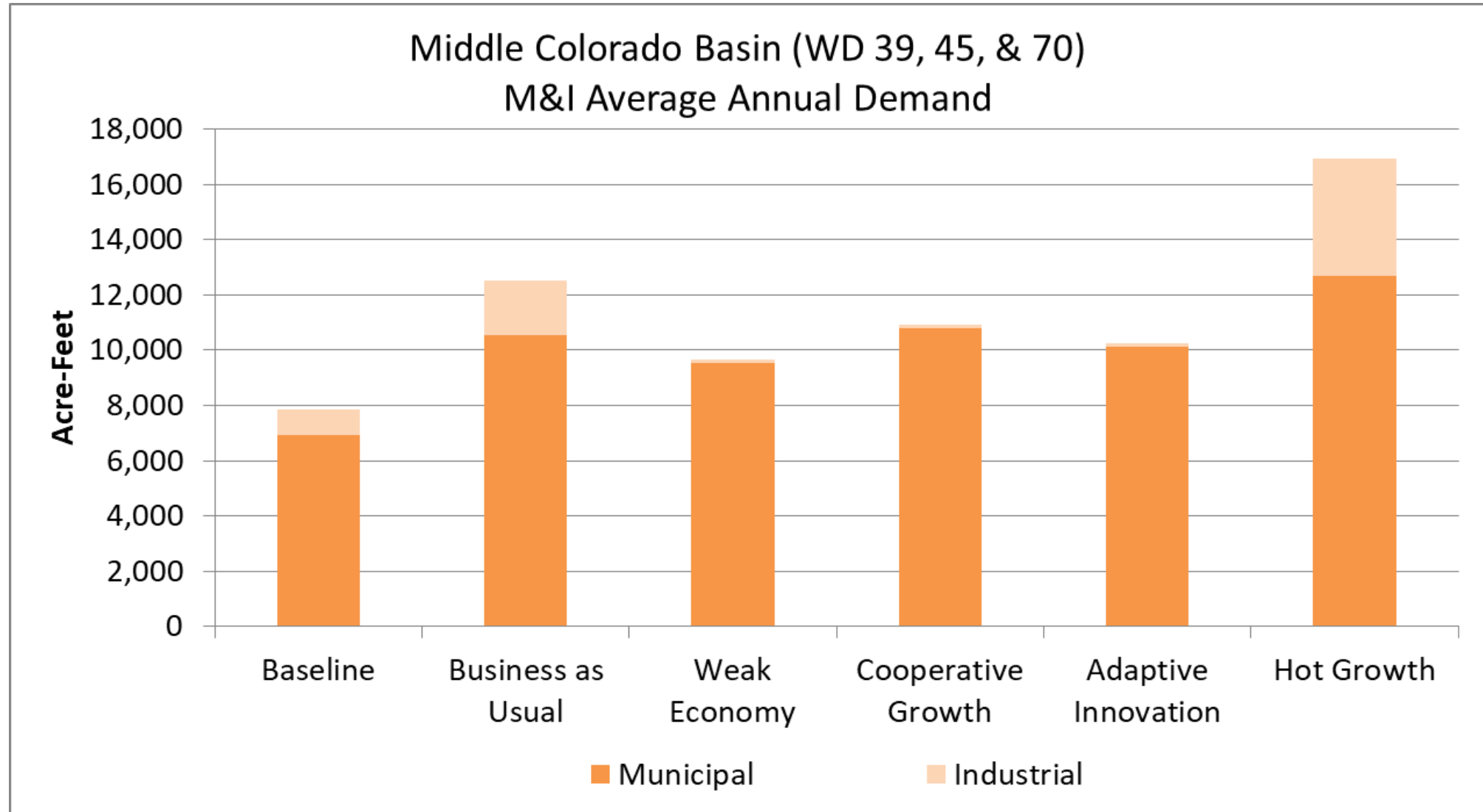
- Between 160,000 to nearly 250,000 AF of diversions + pumping
- Will be needed to meet 75,000 to 94,000 AF of crop demand
- On 36,000 acres of irrigated acreage

Middle Colorado River Basin (WD 39, 45, & 70)  
Current and 2050 Planning Scenario Results





# MIDDLE COLORADO BASIN – M&I DEMAND CURRENT & 2050 PLANNING SCENARIO



# MIDDLE COLORADO BASIN – GAP RESULTS

## M&I Gap

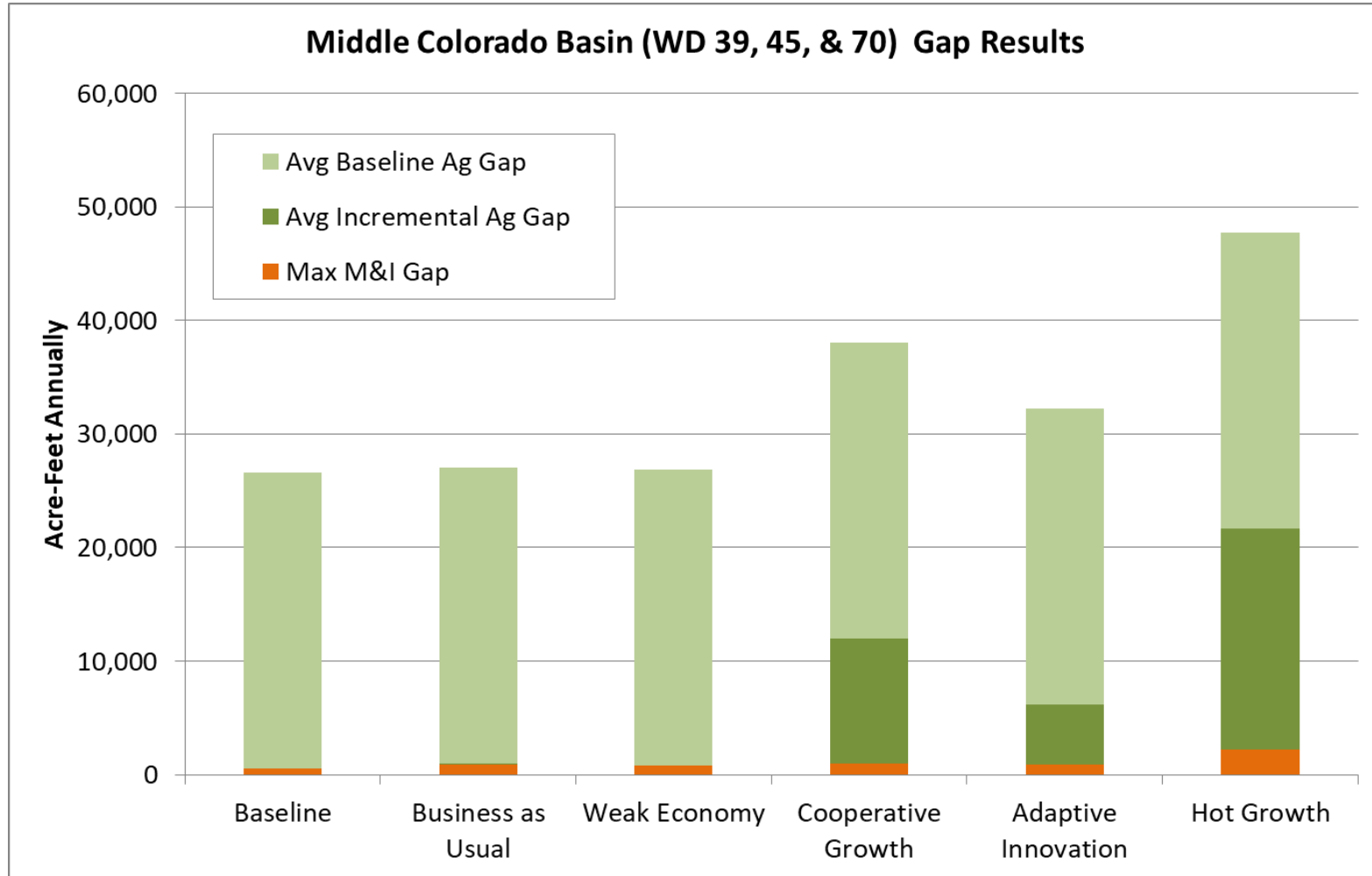
550 to 2,240 AF

## Total Ag Gap

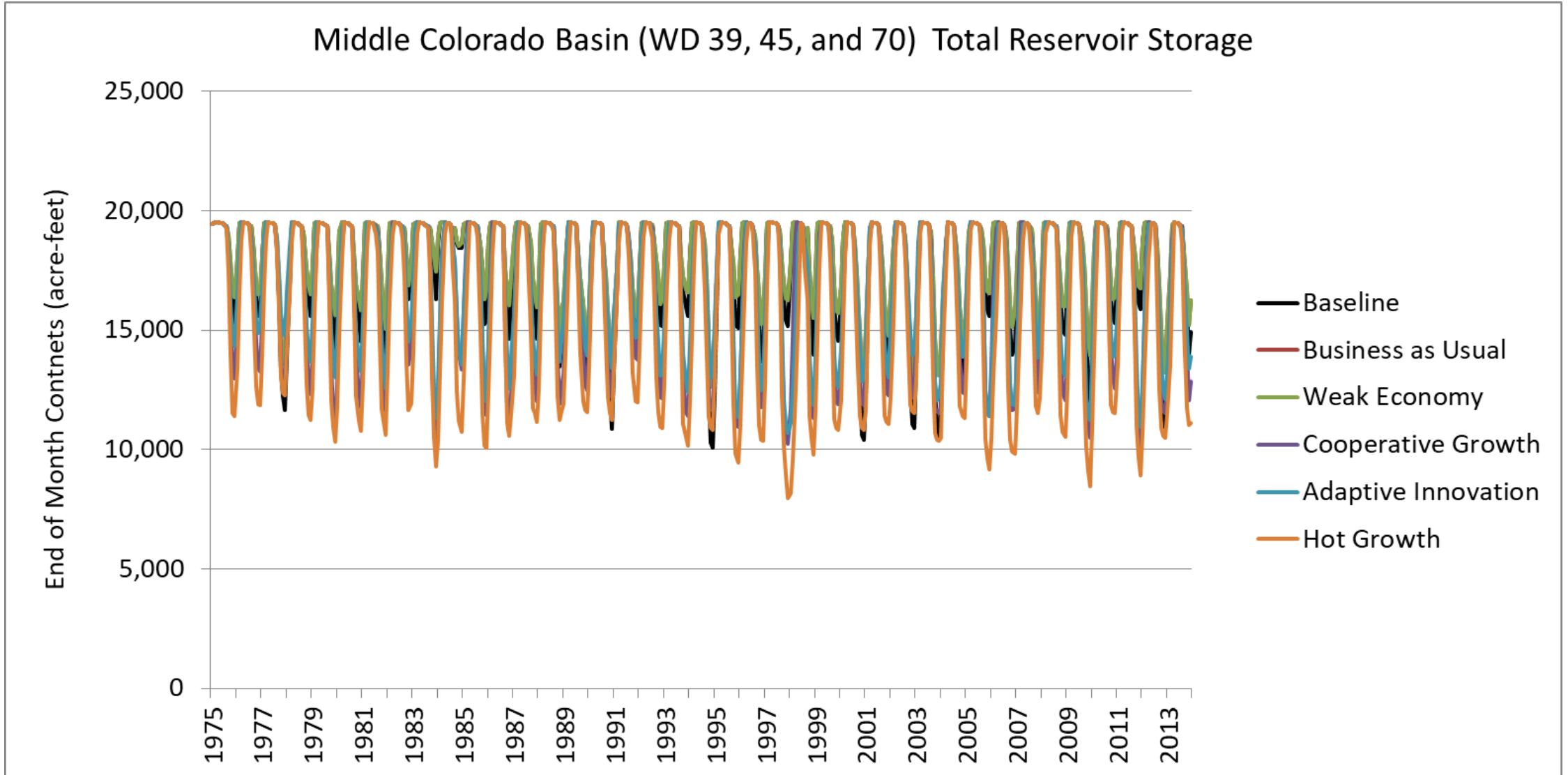
26,000 to 45,000 AF

## Incremental Ag Gap

5,200 to 19,400 AF

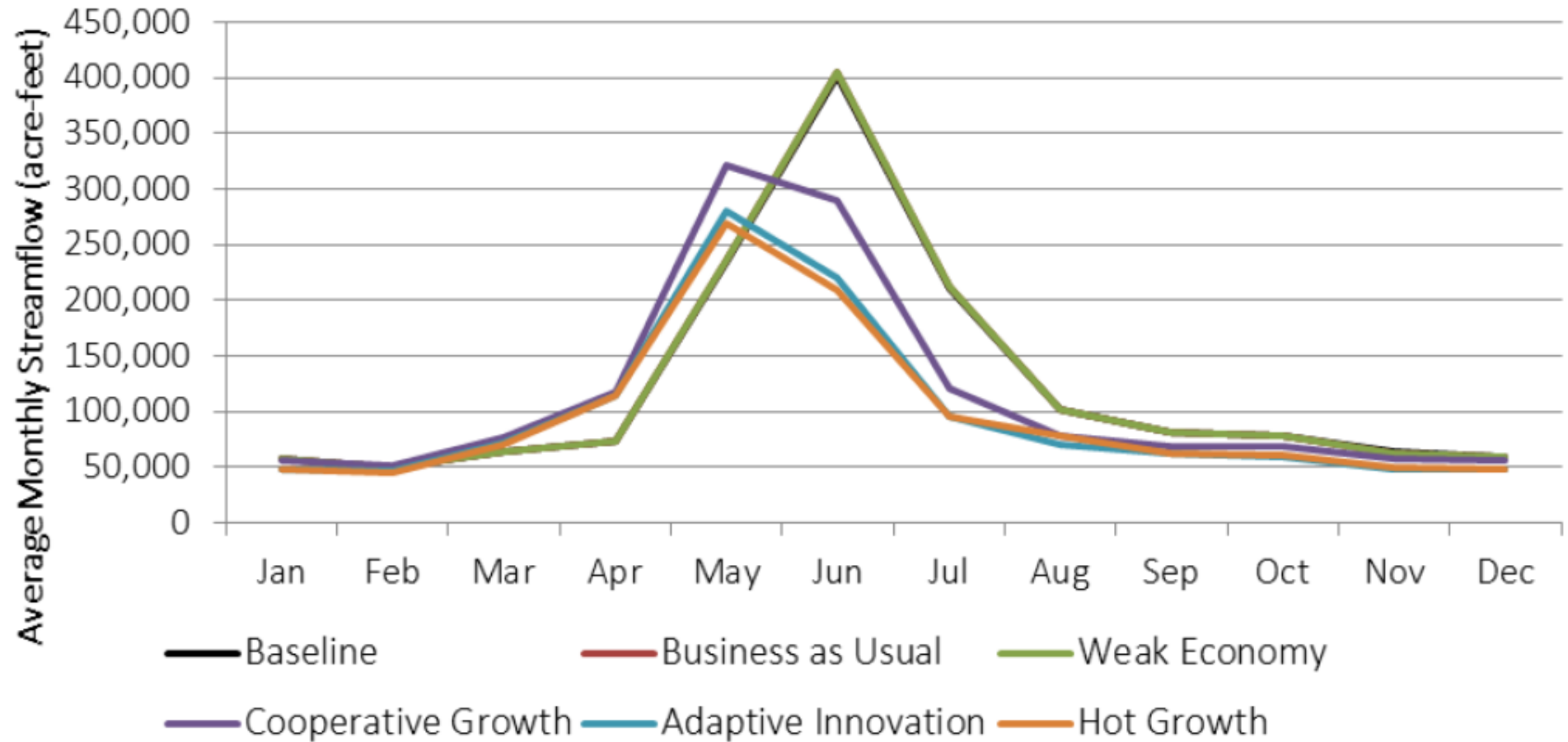


# MIDDLE COLORADO BASIN – RESERVOIR STORAGE RESULTS



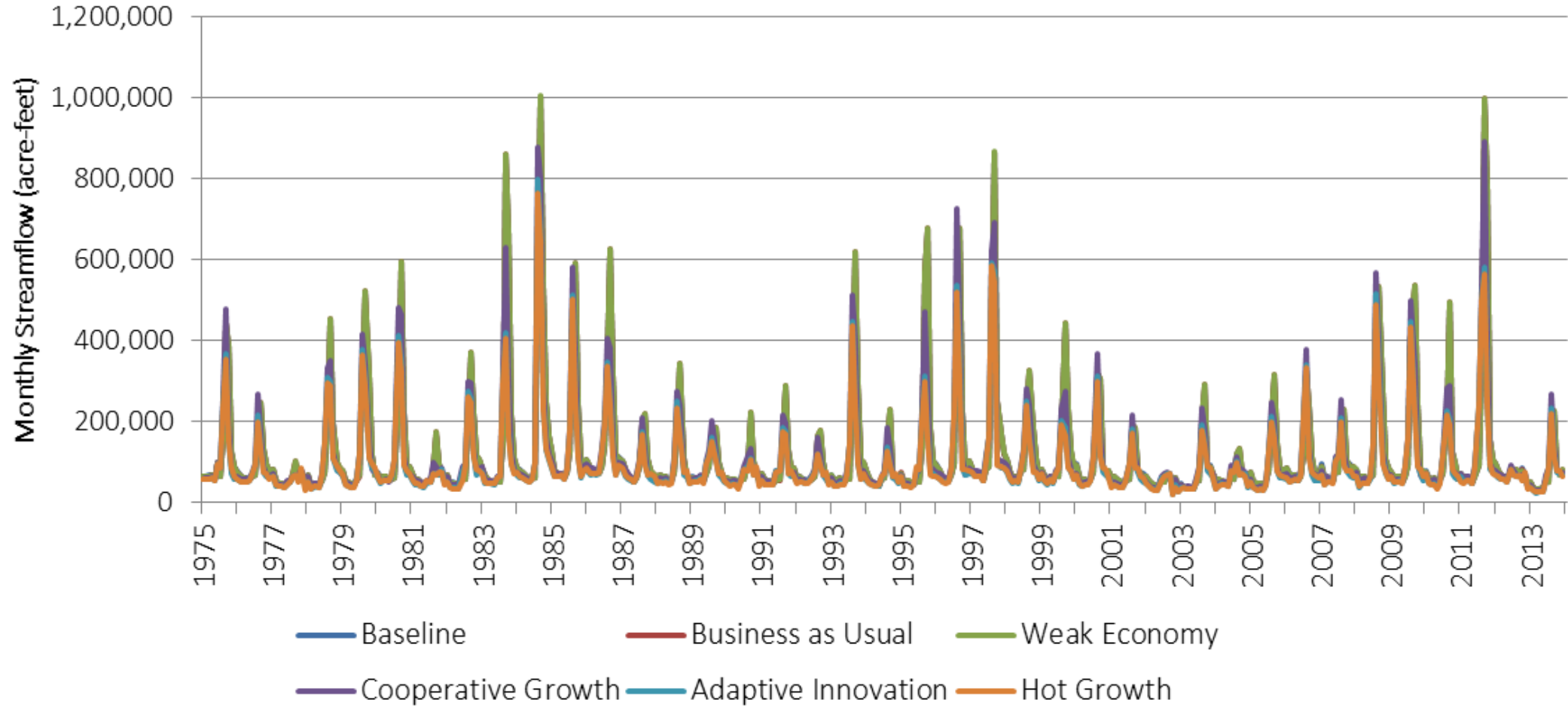
# MIDDLE COLORADO BASIN – STREAMFLOW

Colorado River near Dotsero, CO  
(USGS 09070500)



# MIDDLE COLORADO BASIN – STREAMFLOW

Colorado River near Dotsero, CO  
(USGS 09070500)



# MIDDLE COLORADO IWMP – MODEL CONSIDERATIONS

- Refine current model representation with more detailed information?
  - Agricultural demands
  - Municipal demands & operations
  - Add more reservoirs
  - Add small tributaries
- Use some/all Planning Scenarios?
  - Query model output for area-specific results
- Refine Technical Update 2050 modeling assumptions?
  - Agricultural demands (e.g. urbanization, efficiencies)
  - M & I demands (e.g. population, conservation)
  - Climate-adjusted demands & operations

# QUESTIONS



**COLORADO**  
Colorado Water  
Conservation Board  
Department of Natural Resources