

# Climate Change in Colorado

*What the CWCB is doing to address potential impacts*



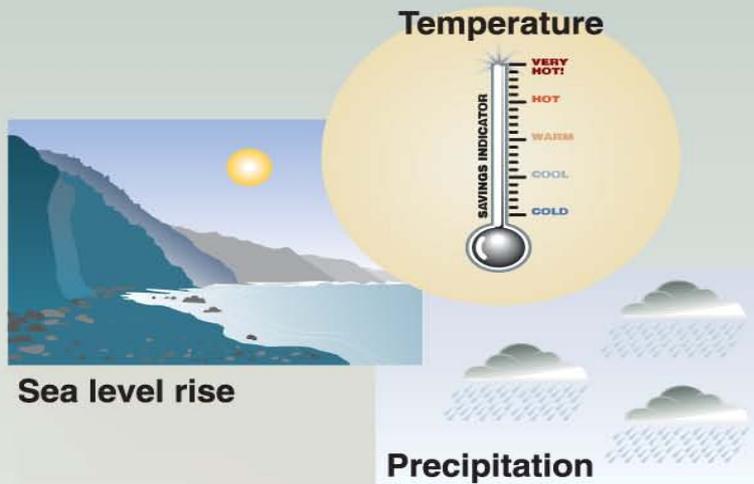
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Colorado Water Conservation Board

January 16, 2014



# Potential climate changes impact



## Impacts on...

### Health



Weather-related mortality  
 Infectious diseases  
 Air-quality respiratory illnesses

### Agriculture



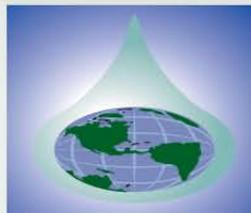
Crop yields  
 Irrigation demands

### Forest



Forest composition  
 Geographic range of forest  
 Forest health and productivity

### Water resources



Water supply  
 Water quality  
 Competition for water

### coastal areas



Erosion of beaches  
 Inundation of coastal lands  
 additional costs to protect coastal communities

### Species and natural areas

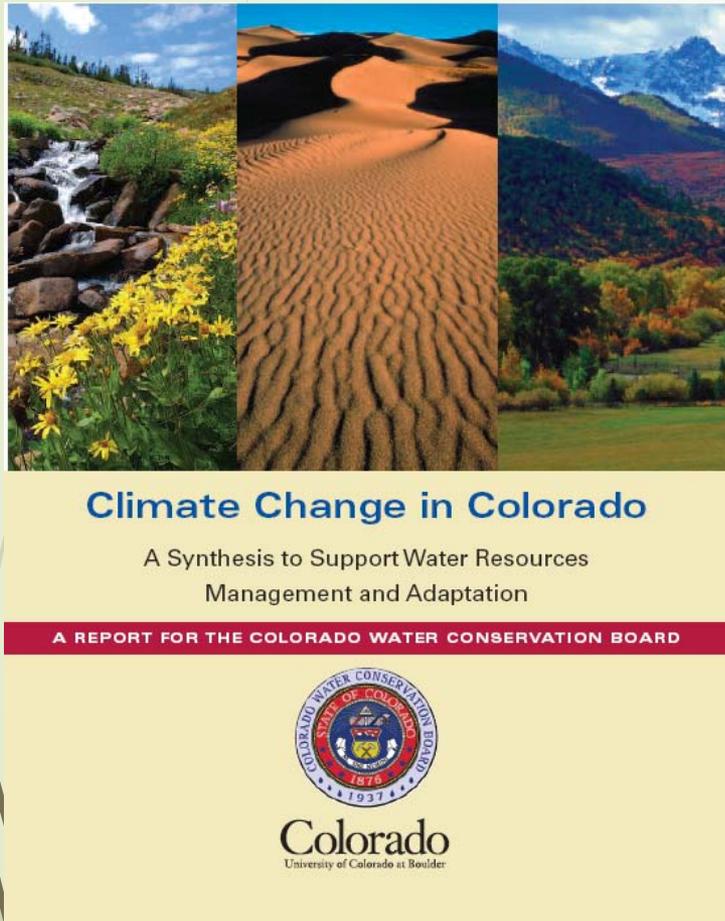


Loss of habitat and species  
 Cryosphere: diminishing glaciers

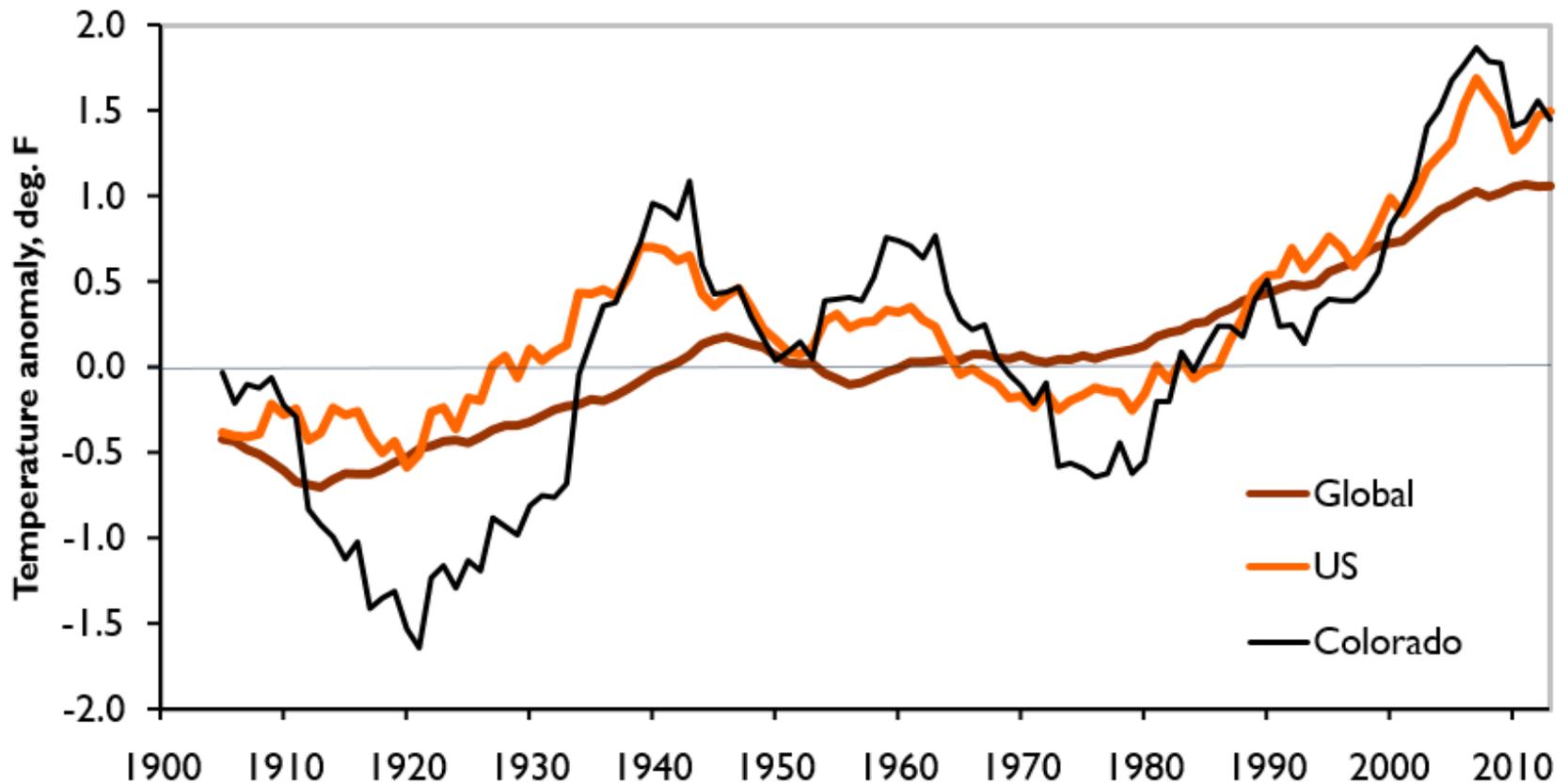
# How does the CWCB address climate change?

- **Climate Change in Colorado Report:** An update to the 2008 report looking at the science of climate change and the affects that it may have on Colorado. Focus on water supply.
- **Colorado River Basin Water Supply and Demand Study:** defines current and future imbalances in water supply and demand in the Colorado River Basin for approximately the next 50 years, and develops and analyzes adaptation and mitigation strategies.
- **The Colorado River Water Availability Study:** The study aims to find out how much water from the Colorado River Basin System is available to meet Colorado's current and future water needs.
- **The Joint Front Range Climate Change Vulnerability Study:** The study provided the education, tools and methodology necessary to examine the possible effects of climate change on several common watersheds.
- **Colorado Climate Preparedness Project:** The project provides a catalog of climate impacts and adaptation activities and options in five climate sensitive sectors in the state: water, wildlife, ecosystems and forests, electricity, agriculture and outdoor recreation. An associated online database is also available.
- **The Colorado Drought Mitigation and Response Plan:** The plan provides a road map to assist the state with reducing the impact of water shortages over the short and long-term.
- **Drought Spell Statistics:** The study aims to examine what drought might look like in the future under alternate climates scenarios.
- **Climate Change Vulnerability Study:** Qualitative assessment of how vulnerable Colorado may be to climate change impacts.
- **Colorado River Basin Water Supply & Demand Study:** Asses future water supply and demand imbalances, partnership with basin states.
- **The Colorado Water Plan/ SWSI 2016:** The plan utilizes the above studies to incorporate climate change into long term water supply planning.

# Currently Updating the Climate Change in Colorado Report

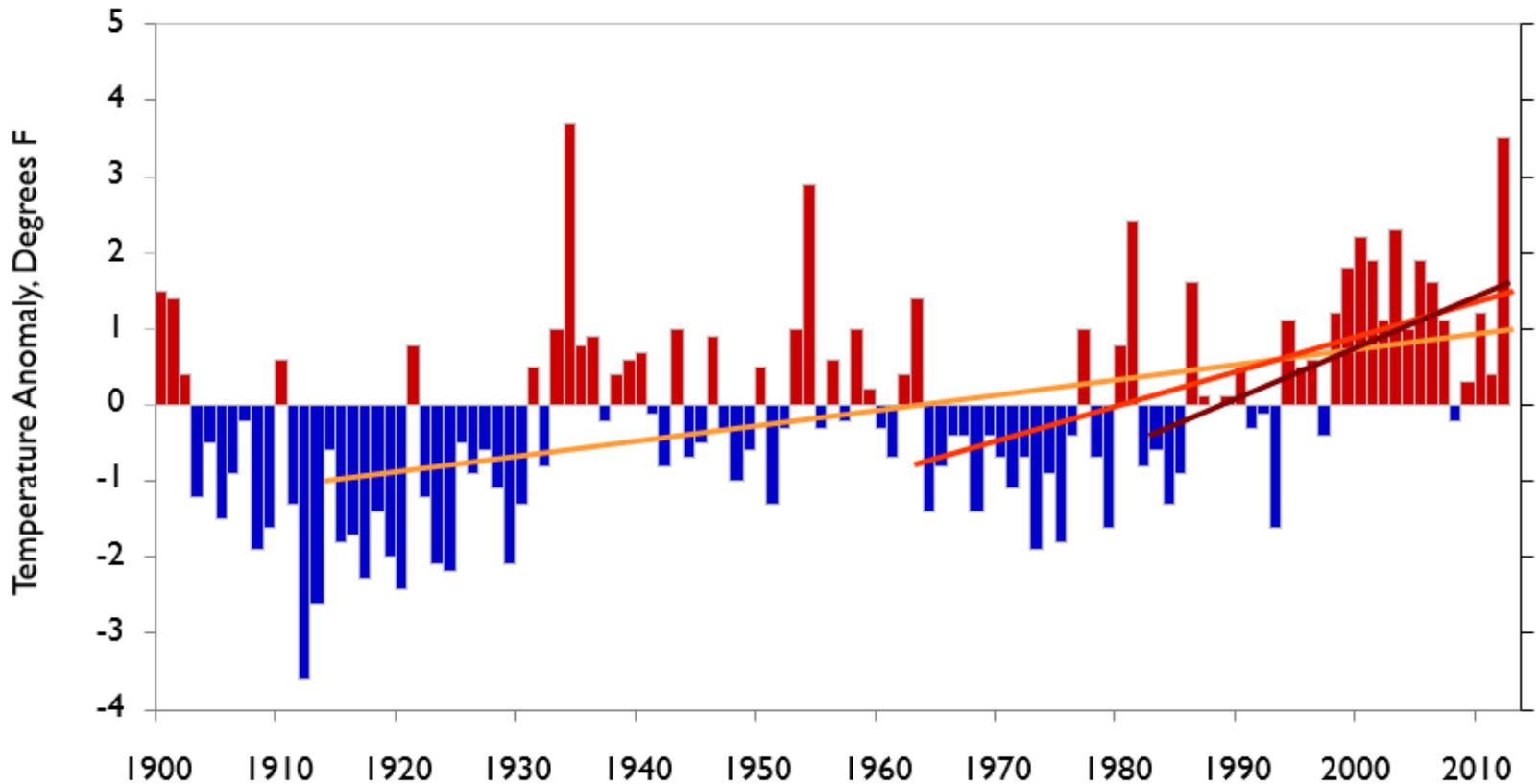


- A synthesis of climate change science important for Colorado's water supply.
- Observed trends, modeling, and projections of temperature, precipitation, snowmelt, and runoff.
- Colorado-specific findings from peer-reviewed regional studies
- Presents new graphics derived from existing datasets.
- Will utilize CMIP 5 data rather than CMIP3



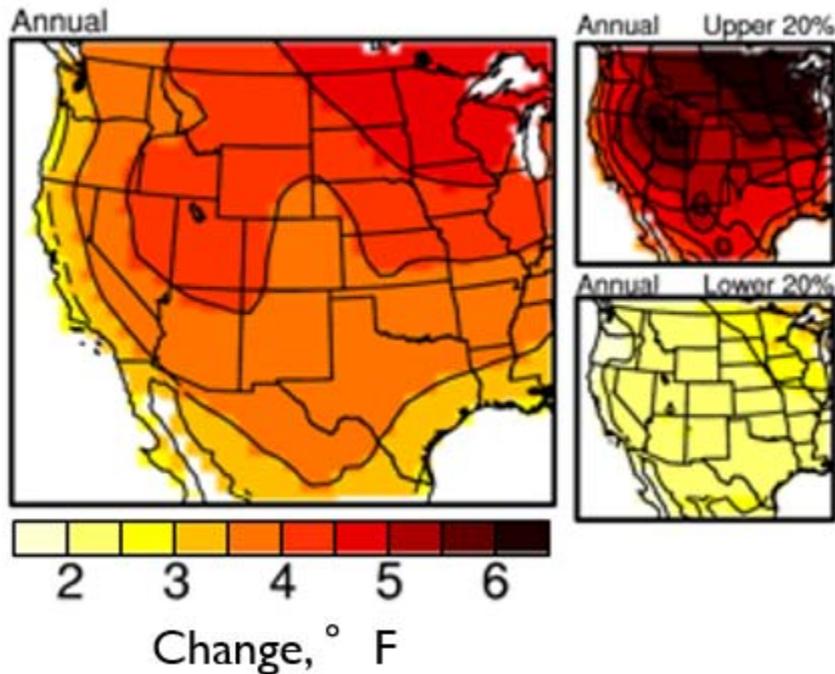
***Observed temperature departures for Colorado, the US, and globally, smoothed with a 10-year running mean. Climate variability is relatively larger at smaller scales, as seen in the US and Colorado time-series. You shouldn't judge the global trends from what is going on in Colorado. But all three records have followed a similar trajectory since 1900.***

# Colorado Temperature Trends

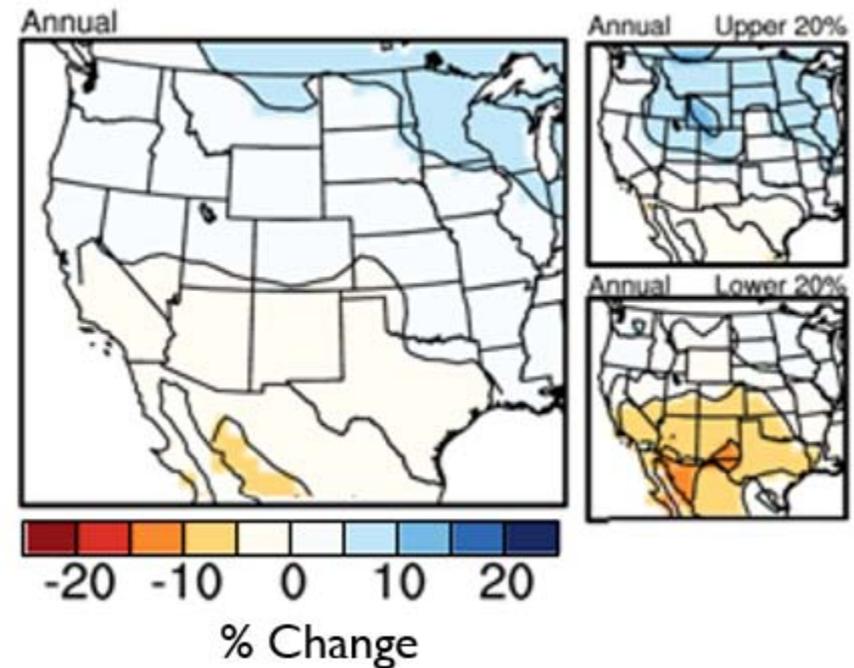


***Colorado average annual temperatures ( ° F) from 1900 to 2012. Annual temperatures are shown as departures from a 1971-2000 reference period. The orange, red, and dark-red lines are the 100-year, 50-year, and 30-year trends, respectively. All three are statistically significant. (Source: NOAA NCDC)***

## Temperature change by 2050



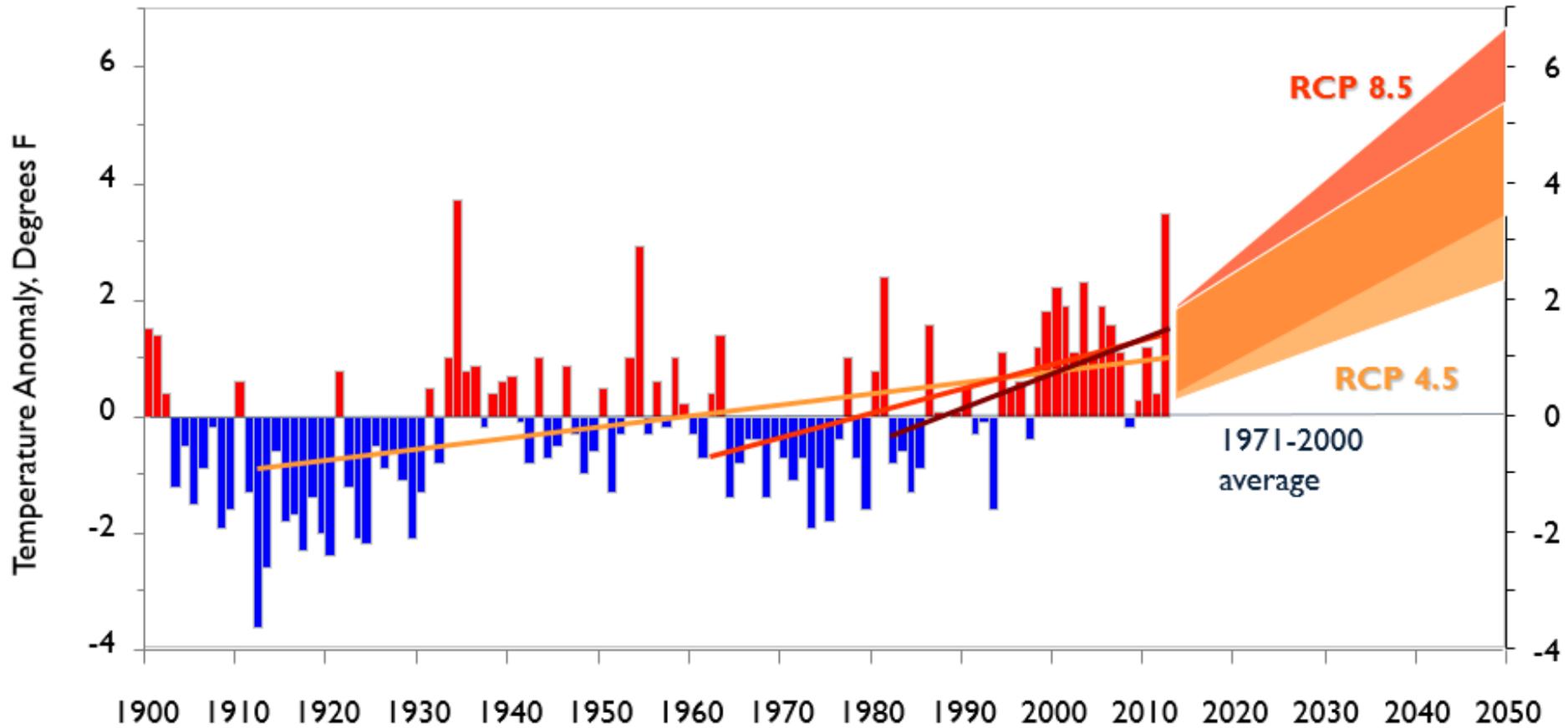
## Precipitation change by 2050



***Projected annual temperature and precipitation changes by 2050 over the western US by an ensemble of 37 climate models under RCP 4.5.*** The large maps show the average of the entire ensemble, and the small maps show the averages of the lower 20% and upper 20% of the models, based on the statewide change for Colorado in each model.

TEMP: The warmer models project a >5 degree warming for CO, while the cooler models project a >2 degree warming (ensemble mean: ~4 degrees). PRECIP: The wetter models project a 5-10% increase in precipitation, while the drier models project a 5-10% decrease (ensemble mean: virtually no change)

# Observed Colorado temperatures and projected temperatures by 2050



# Temperature Projections in Context

*If the statewide warming by 2050 is:*

**2° F:** Denver's seasonal temperature cycle will become more like **Pueblo** today



**4° F:** Denver's seasonal temperature cycle will become more like **Lamar** today

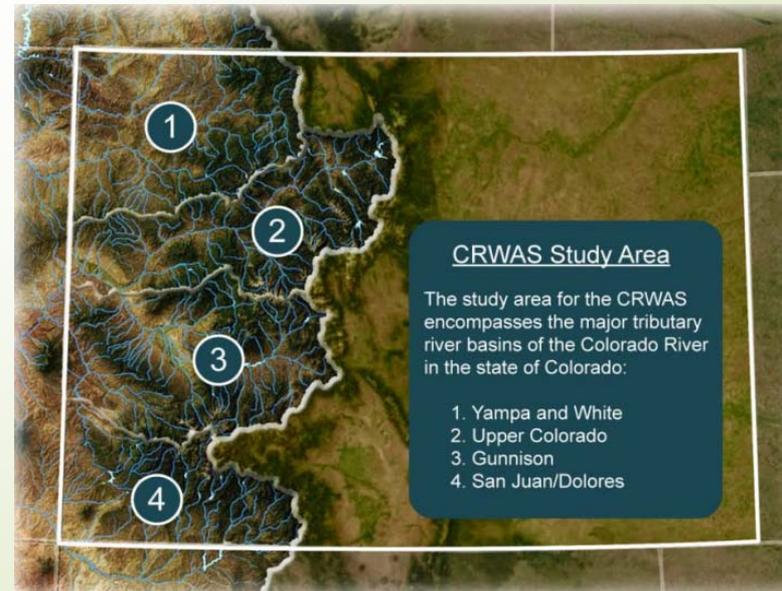


**6° F:** Denver's seasonal temperature cycle will become more like **Albuquerque** today



# Colorado River Water Availability Study

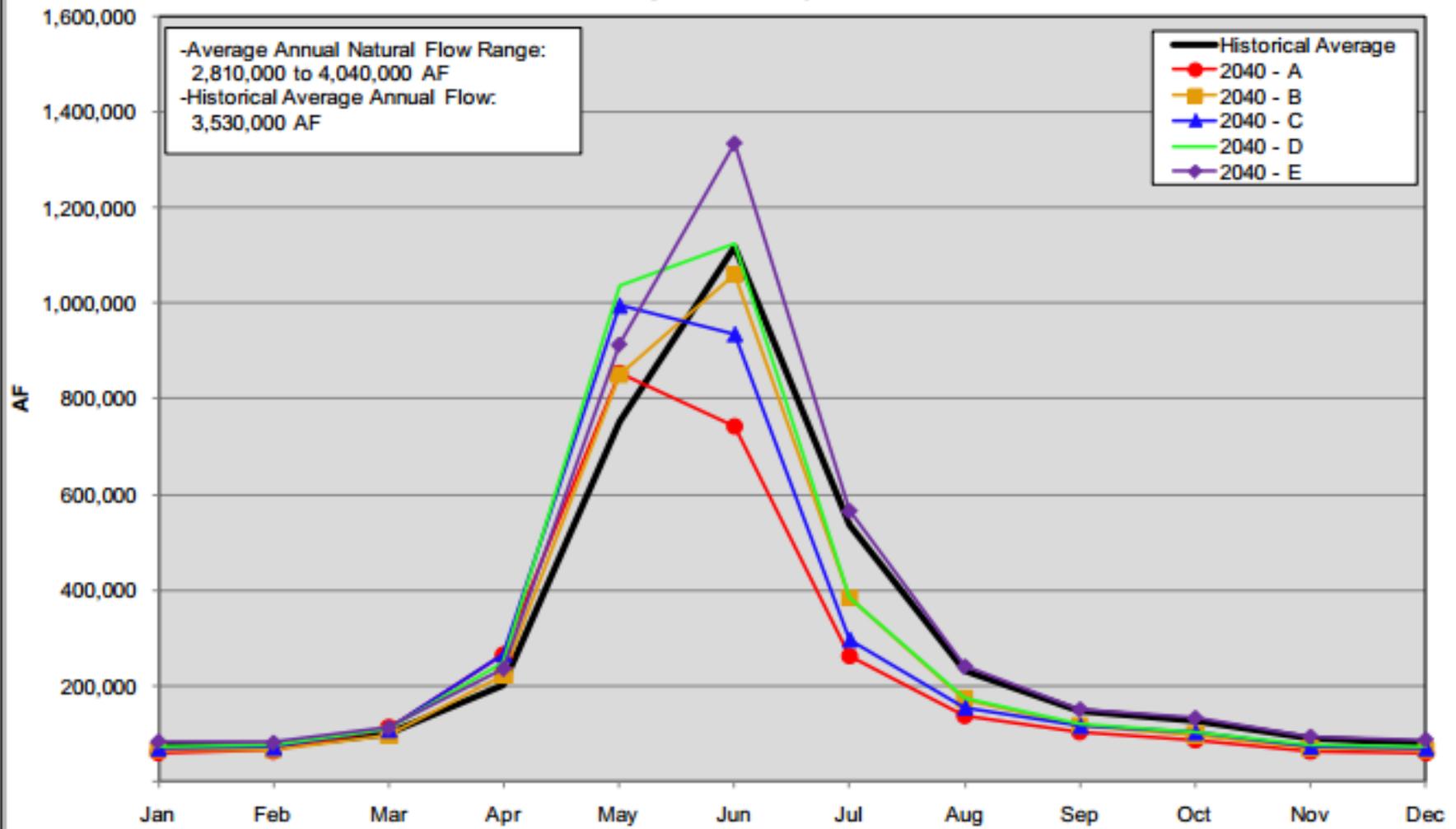
How much water is available for new development in the Colorado?



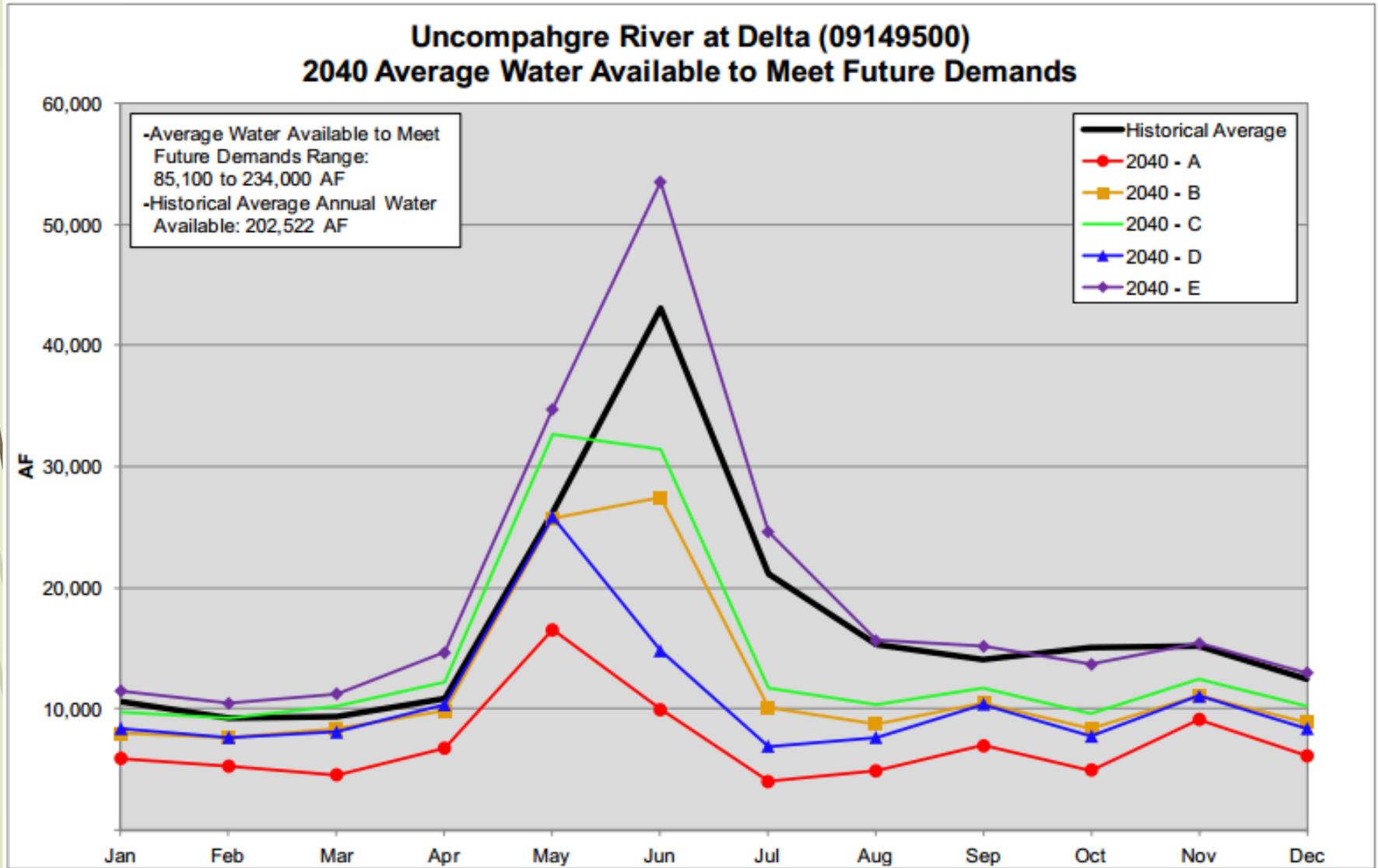


# Climate Change Impacts on Natural Flow

**Colorado River near Cameo (09095500)**  
**2040 Average Monthly Natural Flow**



# Climate Change Impacts on Water Availability

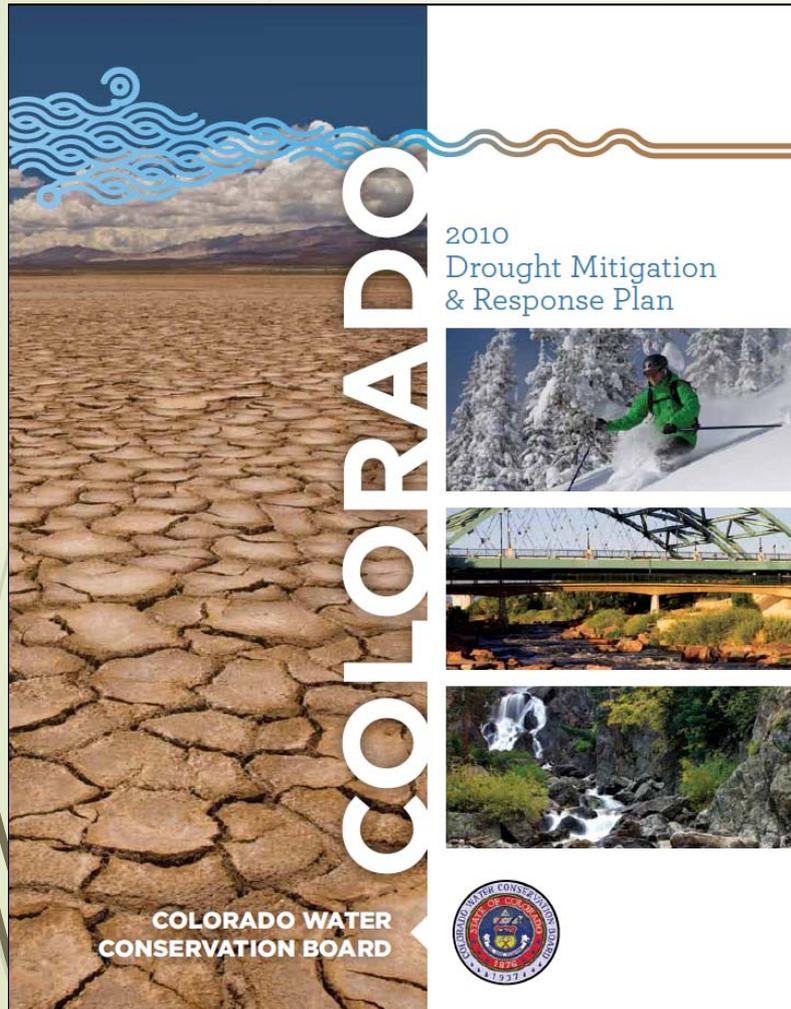


# Next steps

- Currently updating hydrology based on CMIP 5 data for the entire state
- Developing additional information and analysis regarding potential impacts to reservoirs, CIR and streamflows
- Utilizing analysis from this study for incorporation into SWSI 2016 and the Colorado Water Plan



# Colorado Drought Mitigation & Response Plan

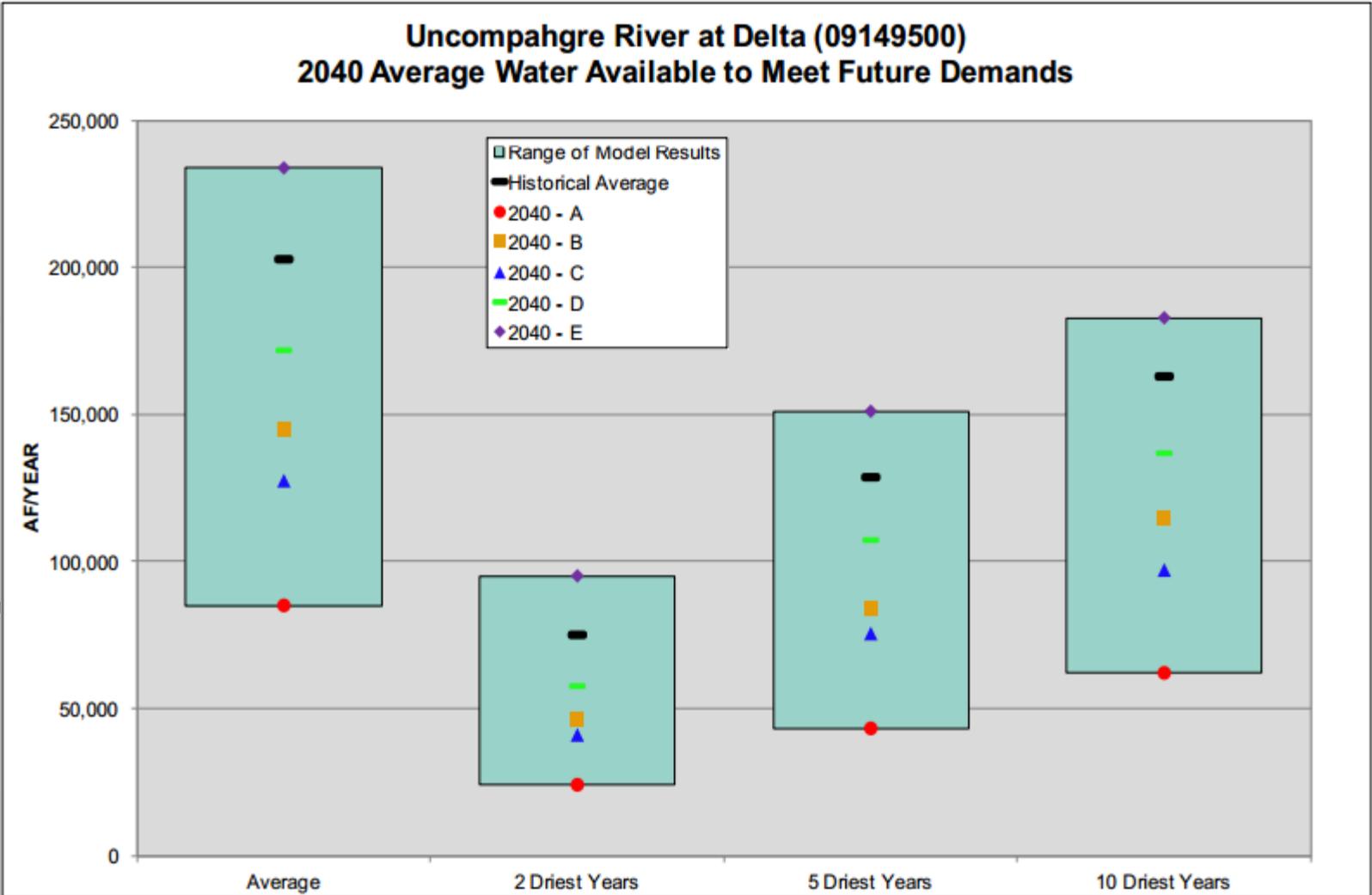


- Vulnerability Assessment, examines climate change impact of drought frequency
- Examines climate projections in the context of paleo observations
- Outlines state drought planning efforts
- Prioritizes mitigation actions
- Provides local drought planning tool
- Provides a framework for drought response

# What Could Drought Look Like in the Future?

- Drought profile analysis using Colorado River Water Availability Study results for 2040
- Six scenarios from Colorado River Water Availability Study considered
- 100 paleo re-sequenced traces for each scenario
- Calculated maximum drought duration and intensity for each trace
- Drought calculations done relative to the mean of each scenario
- Exceedance probability is the chance that the maximum drought length will be greater than the observed median drought length given 100 traces

# Water Availability & Drought



## Longest observed drought : 6 Years

	Average length of maximum drought (years)	Maximum drought length (years)	Chance of drought longer than observed
Alternate Historical Hydrology	5.8	15	58.3%
Climate Scenario 1	6.5	13	56.7%
Climate Scenario 2	6.1	15	54.0%
Climate Scenario 3	6.2	12	50.5%
Climate Scenario 4	6.5	12	55.4%
Climate Scenario 5	6.4	12	54.3%

Colorado River near Cameo

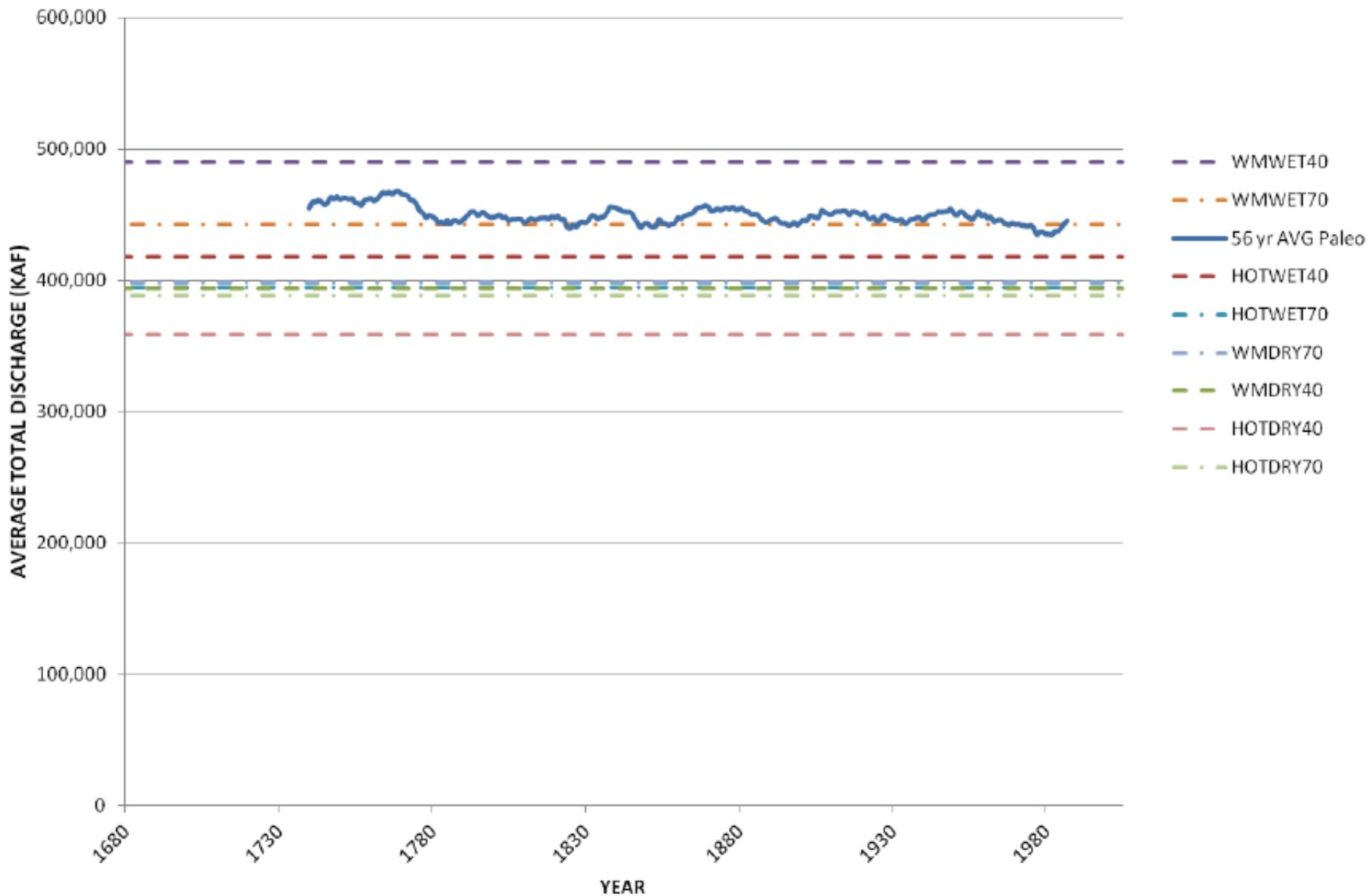
# Spell return intervals and average intensities

## 09095500 Colorado River near Cameo

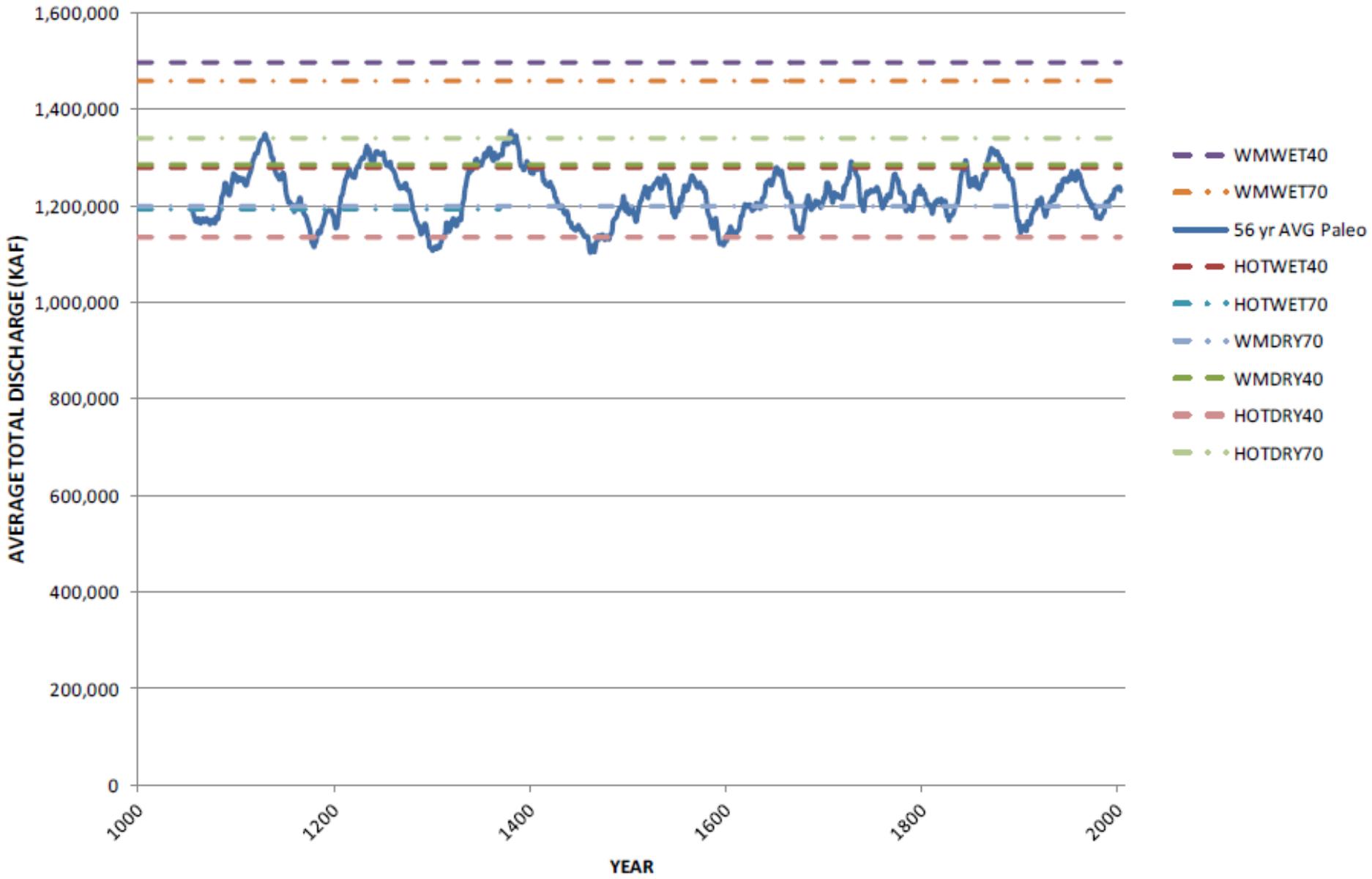
	Observed Spells			
	Length of Spell (years)		Intensity of Spell (% of mean)	
	Drought	Surplus	Drought	Surplus
	6	5	-19%	46%

Alternative Hydrology Spells				
Case	Return Interval of historic spell length (years)		Average Annual Deficit/Surplus (% of mean)	
	Drought	Surplus	Drought	Surplus
Alternative Historical	31	19	-24%	27%
2040 Climate A	6	933	-30%	23%
2040 Climate B	27	47	-29%	19%
2040 Climate C	22	49	-28%	18%
2040 Climate D	53	20	-25%	29%
2040 Climate E	800	6	-19%	36%
2070 Climate F	6	5600	-31%	24%
2070 Climate G	12	267	-31%	18%
2070 Climate H	27	66	-32%	17%
2070 Climate I	30	22	-23%	27%
2070 Climate J	127	13	-19%	38%

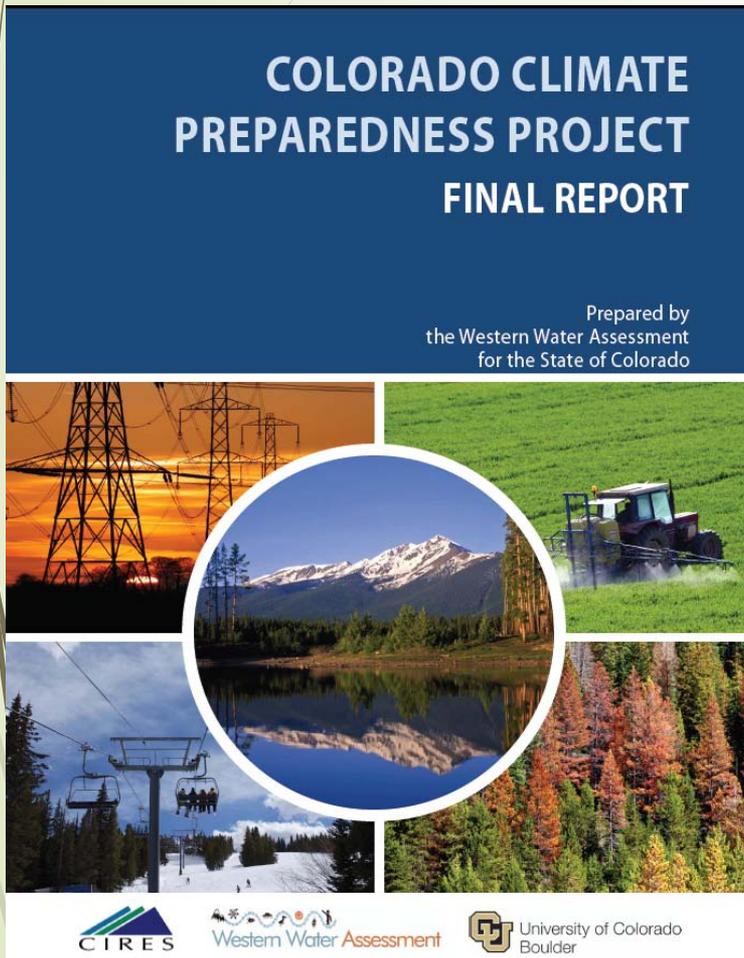
# Arkansas River at Salida 56-Year Average Flow - Paleo Reconstructions and Average Sacramento Projections



# Yampa R at Maybell 56-Year Average Flow - Alternate Paleo Reconstructions and Average CRWAS Projections



# Colorado Climate Preparedness Report



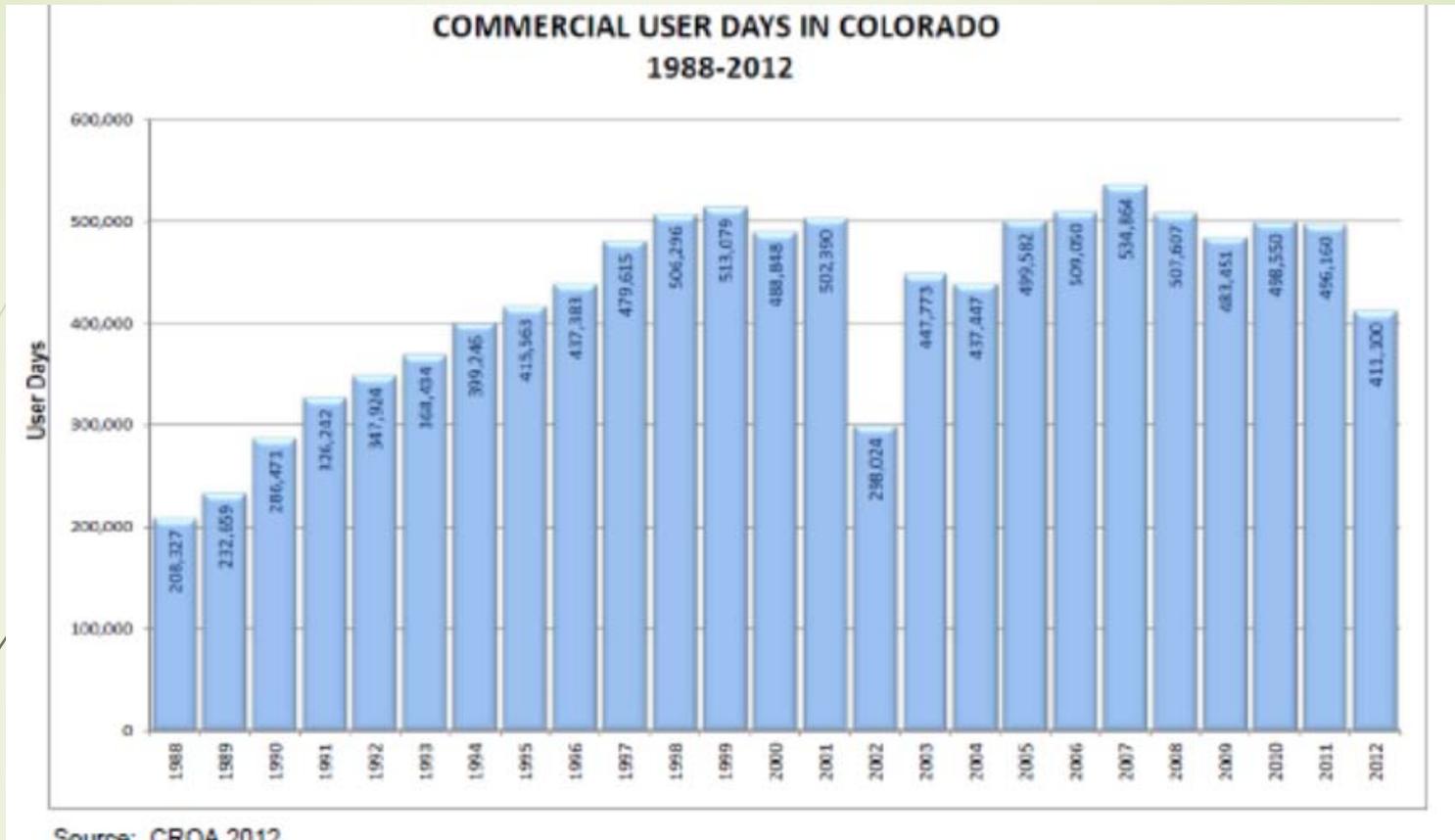
- Adaptation will require coordination
- Monitoring is a critical element of climate adaptation
- Additional research
- More complete impacts and vulnerability assessment is needed to prioritize Colorado's key climate threats and vulnerabilities
- Climate impacts on water resources—e.g., changes in runoff patterns, snowpack, and storage—are a significant source of impacts
- The state is already engaged in many activities
- Inherent uncertainty of long-term climate projections and the incompatibility of the timescales of climate change with existing planning regimes.



# Colorado Climate Change Vulnerability Study



- Rising temperatures not only threaten available habitat for native cold water cutthroat trout, but can also lower water tables in stream headwaters, resulting in increased concentrations of metals harmful to aquatic life.
- Parts of the state that rely heavily on groundwater resources, like the San Luis Valley or the South Metro region, may face a two-fold challenge:
  - in a warmer future: higher evapotranspiration rates could reduce groundwater recharge
  - greater demands on surface water supplies could result in greater use of groundwater supplies.



Climate projections indicate a distinct possibility of reduced streamflow and earlier snowmelt timing in Colorado. This is a potentially serious concern for the state's rafting industry, which saw major declines in user days during the dry years of 2002 and 2012.

# Colorado River Basin Water Supply and Demand Study

- Study Objective
  - Assess future water supply and demand imbalances over the next 50 years
  - Develop and evaluate opportunities for resolving imbalances
- Study conducted by Reclamation and the Basin States, in collaboration with stakeholders throughout the Basin
- Began in January 2010 and completed in December 2012
- A planning study – does *not* result in any decisions, but will provide the technical foundation for future activities

## Cost-Share Partners

Arizona Department of Water Resources

(California) Six Agency Committee

Colorado Water Conservation Board

New Mexico Interstate Stream Commission

Southern Nevada Water Authority

Utah Division of Water Resources

Wyoming State Engineer's Office

Reclamation's Upper and Lower Colorado Regions

RECLAMATION

# Final Study Reports

- The final Study is a collection of reports available at:  
<http://www.usbr.gov/lc/region/programs/crbstudy/report1.html>

Executive Summary

Study Report

Technical Report A – Scenario Development

Technical Report B – Water Supply Assessment

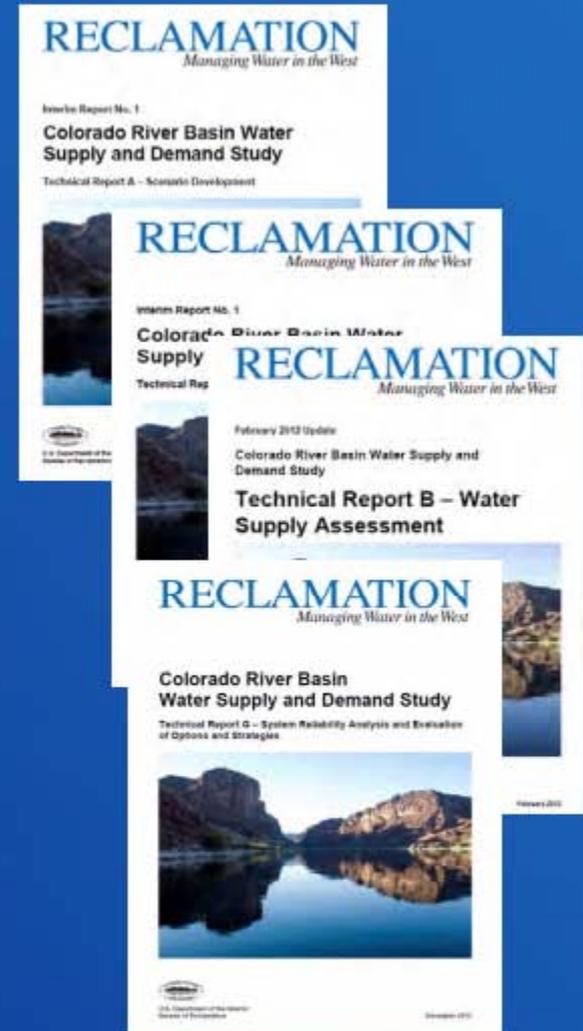
Technical Report C – Water Demand Assessment

Technical Report D – System Reliability Metrics

Technical Report E – Approach to Develop and Evaluate Opportunities to Balance Supply

Technical Report F – Development of Options and Strategies

Technical Report G – System Reliability Analysis and Evaluation of Options and Strategies



# RECLAMATION

# Role of Climate Change in Long Term Water Planning

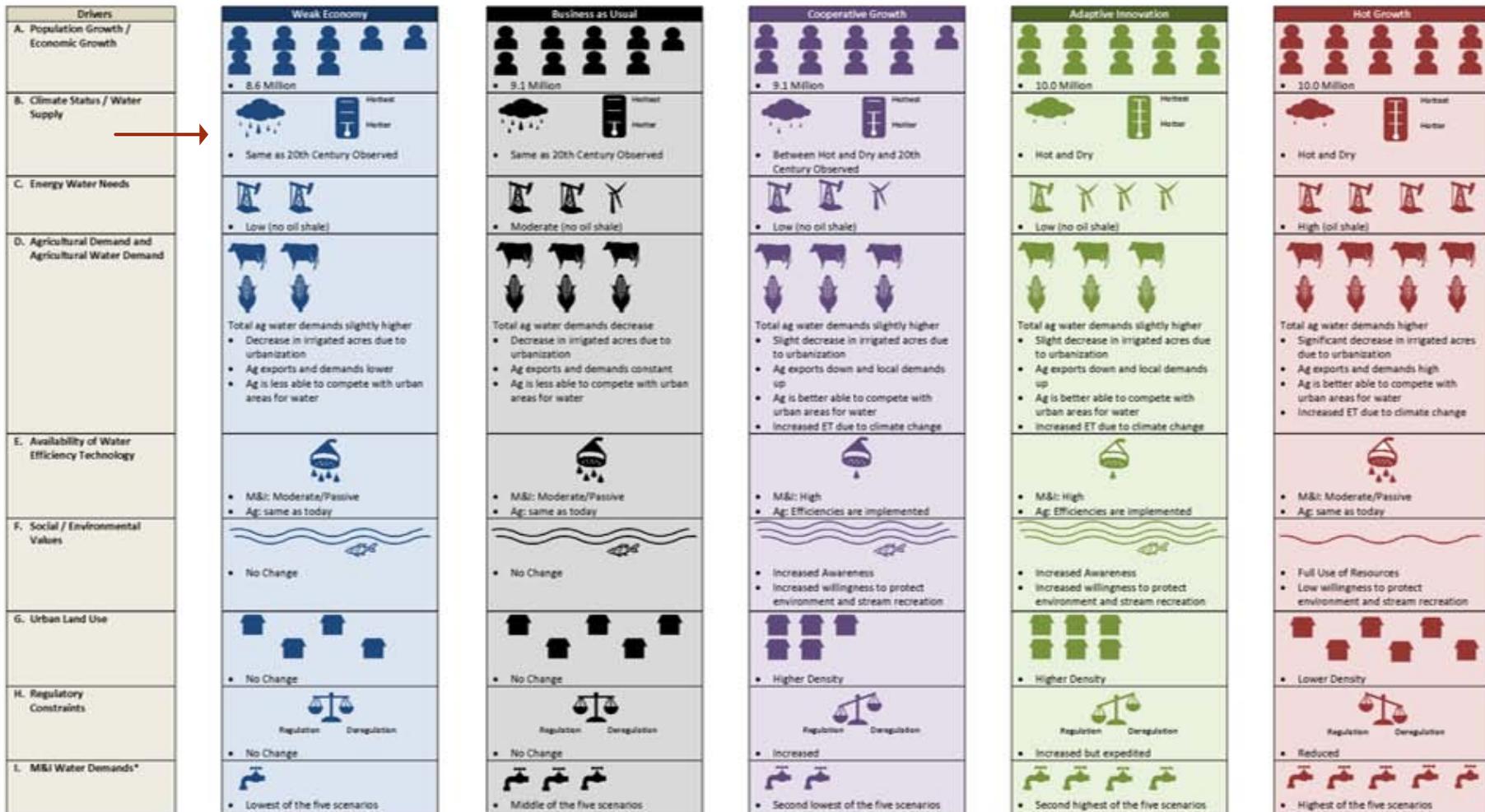


Figure 1. State of Colorado Future Water Supply Scenarios



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