

# RECLAMATION

*Managing Water in the West*

## Climate Change Analysis for the Santa Ana River Watershed

**SAWPA - 6/18/2013**

**Kristine Blickenstaff, Ian Ferguson, Laura Condon, Tom Pruitt**

**Subhrendu Gangopadhyay**

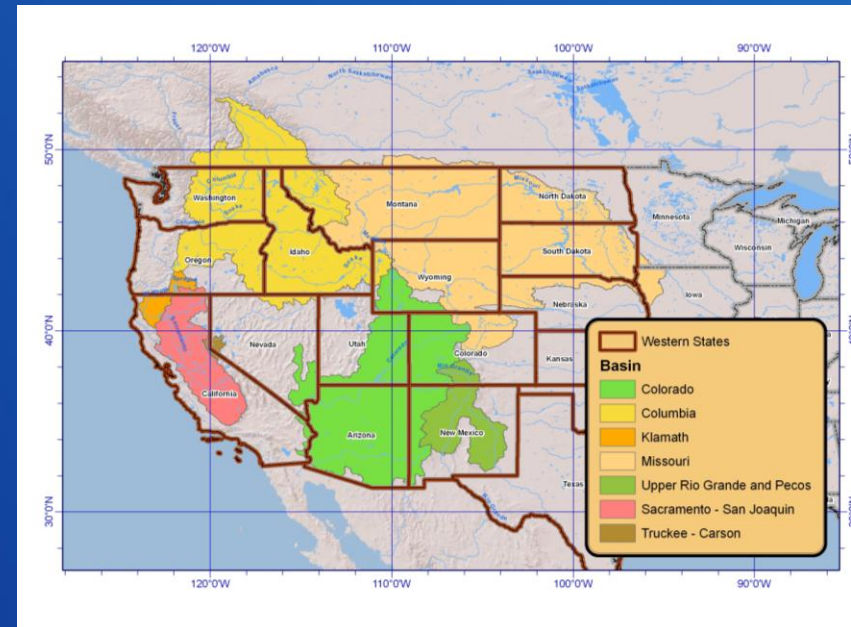
**Reclamation Technical Service Center, Denver**



**U.S. Department of the Interior  
Bureau of Reclamation**

# Background

- Public Law 111-11, Subtitle F (SECURE Water Act, **SWA, 2009**) § 9503.
- Climate change risks for water and environmental resources in “**major Reclamation river basins.**”
- Reclamation’s WaterSMART (**S**ustain and **M**anage **A**merica’s **R**esources for **T**omorrow) program
  1. Basin Studies
  2. West-Wide Climate Risk Assessments (**WWCRAs**)
  3. Landscape Conservation Cooperatives (**LCCs**)



8 major Reclamation River Basin

SECURE – Science and Engineering to Comprehensively Understand and Responsibly Enhance

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## Funded Basin Studies

17 studies have been funded to date starting in 2009.

### 2009

- Colorado River Basin
- Milk/St. Mary Rivers Basin
- Yakima River Basin

### 2010

- Niobrara River Basin
- Truckee River Basin
- Santa Ana River Basin
- Henrys Fork of Snake River
- S.E. California Regional Basin

### 2011

- Lower Rio Grande River Basin
- Santa Fe Basin
- Klamath River Basin
- Hood River Basin

### 2012

- Upper Washita River Basin
- Sacramento-San Joaquin Rivers
- Republican River Basin
- Pecos River Basin
- L.A. Basin

**2013 studies recently announced**



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# Study Motivation

- **Local and Federal partnership** to support the **IRWM** (Integrated Regional Water Management ) process
  - One Water One Watershed (**OWOW**) Plan update
- **Decision Support** Using Climate and Hydrology Projections
  - Respond to specific **IRWM plan** questions
  - Develop **tools** to support decisions

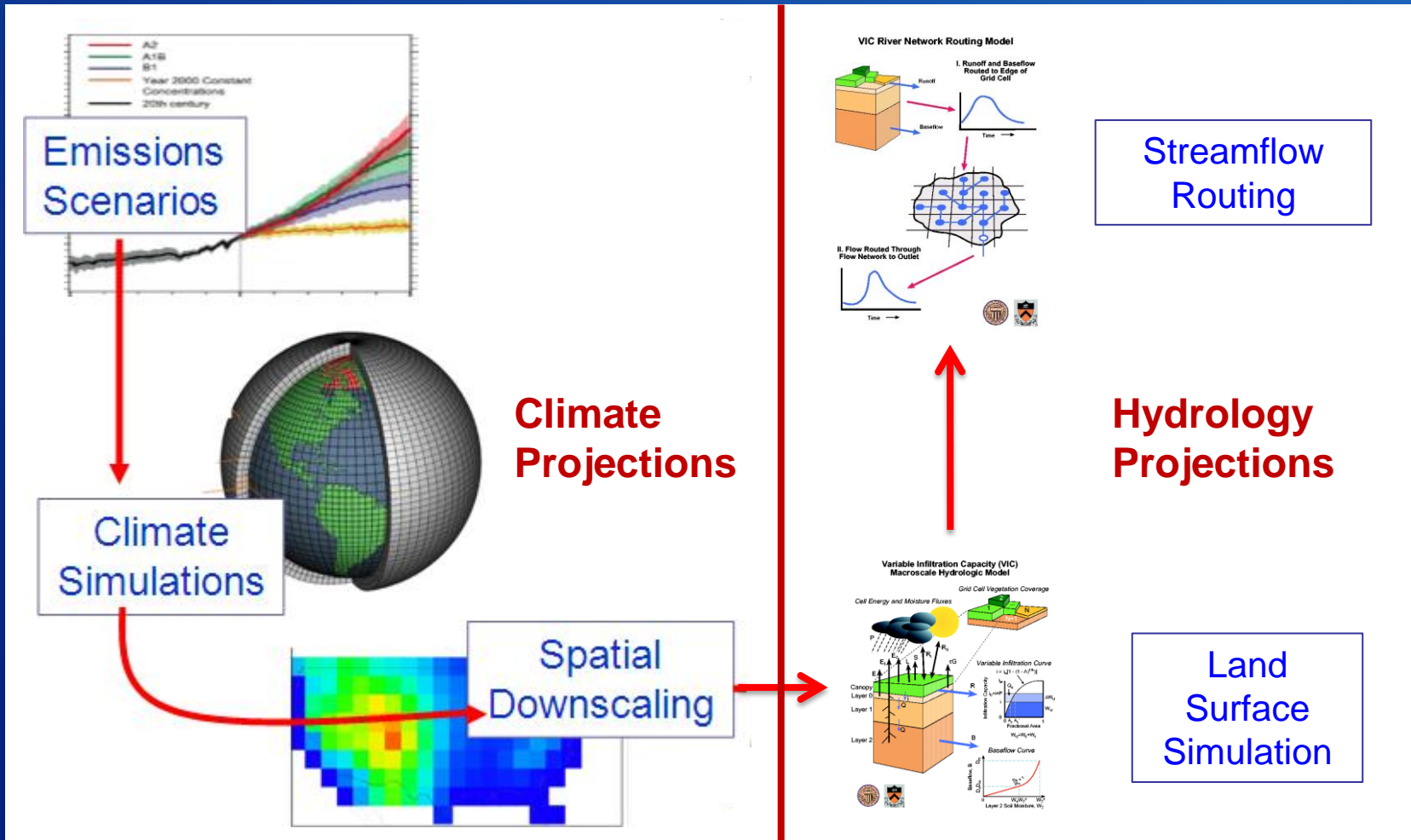
# Outline

- **Climate Projections to Hydrology Projections**
- **Projections**
  - **Hydroclimate (precipitation, temperature, surface water supplies)**
  - **Water Demand**
- **Decision Support Using Climate and Hydrology Projections (examples)**
  - **Flood Frequency**
  - **Temperature Trends**
  - **Recreation**
  - **Groundwater Management (decision support tool)**
  - ...
- **Tool Development**
  - **Groundwater Screening Tool**
  - **GHG Emissions Calculator for the Water Sector**

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# Downscaled BCSD-CMIP3 GCM Output and Hydrologic Modeling

(Bias-Correction Spatial Disaggregation - Coupled Model Intercomparison Project Phase 3 General Circulation Model)



# Online Data Access Climate and Hydrology Projections



## Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections

This site is best viewed with [Chrome](#) (recommended) or [Firefox](#). Some features are unavailable when using Internet Explorer. Requires JavaScript to be enabled.

[Welcome](#) | [About](#) | [Tutorials](#) | [Projections: Subset Request](#) | [Projections: Complete Archives](#) | [Feedback](#) | [Links](#)

Downscaled CMIP5 climate projections' documentation and release notes available [here](#).

### Summary

This archive contains fine spatial resolution translations of climate projections over the contiguous United States (U.S.) developed using two downscaling techniques (monthly BCSD Figure 1, and daily BCCA Figure 2), and hydrologic projections over the western U.S. (roughly the western U.S. Figure 3) corresponding to the monthly BCSD climate projections.

Archive content is based on global climate projections from the [World Climate Research Programme's](#) (WCRP's) [Coupled Model Intercomparison Project phase 3 \(CMIP3\)](#) multi-model dataset referenced in the Intergovernmental Panel on Climate Change Fourth Assessment Report, and the phase 5 (CMIP5) multi-model dataset that is informing the IPCC Fifth Assessment.

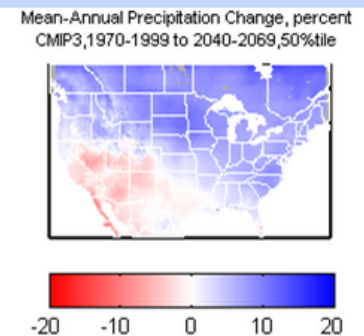
For information about downscaled climate and hydrology projections development, please see the [About](#) page.

### Purpose

The archive is meant to provide access to climate and hydrologic projections at spatial and temporal scales relevant to some of the watershed and basin-scale decisions facing water and natural resource managers and planners dealing with climate change. Such access permits several types of analyses, including:

- assessment of potential climate change impacts on natural and social systems (e.g., watershed hydrology, ecosystems, water and energy demands).
- assessment of local to regional climate projection uncertainty.
- risk-based exploration of planning and policy responses framed by potential climate changes exemplified by these projections.

Figure 1. Central Tendency Changes in Mean-Annual Precipitation over the contiguous U.S. from 1970-1999 to 2040-2069 for BCSD3, BCSD5, and Difference.



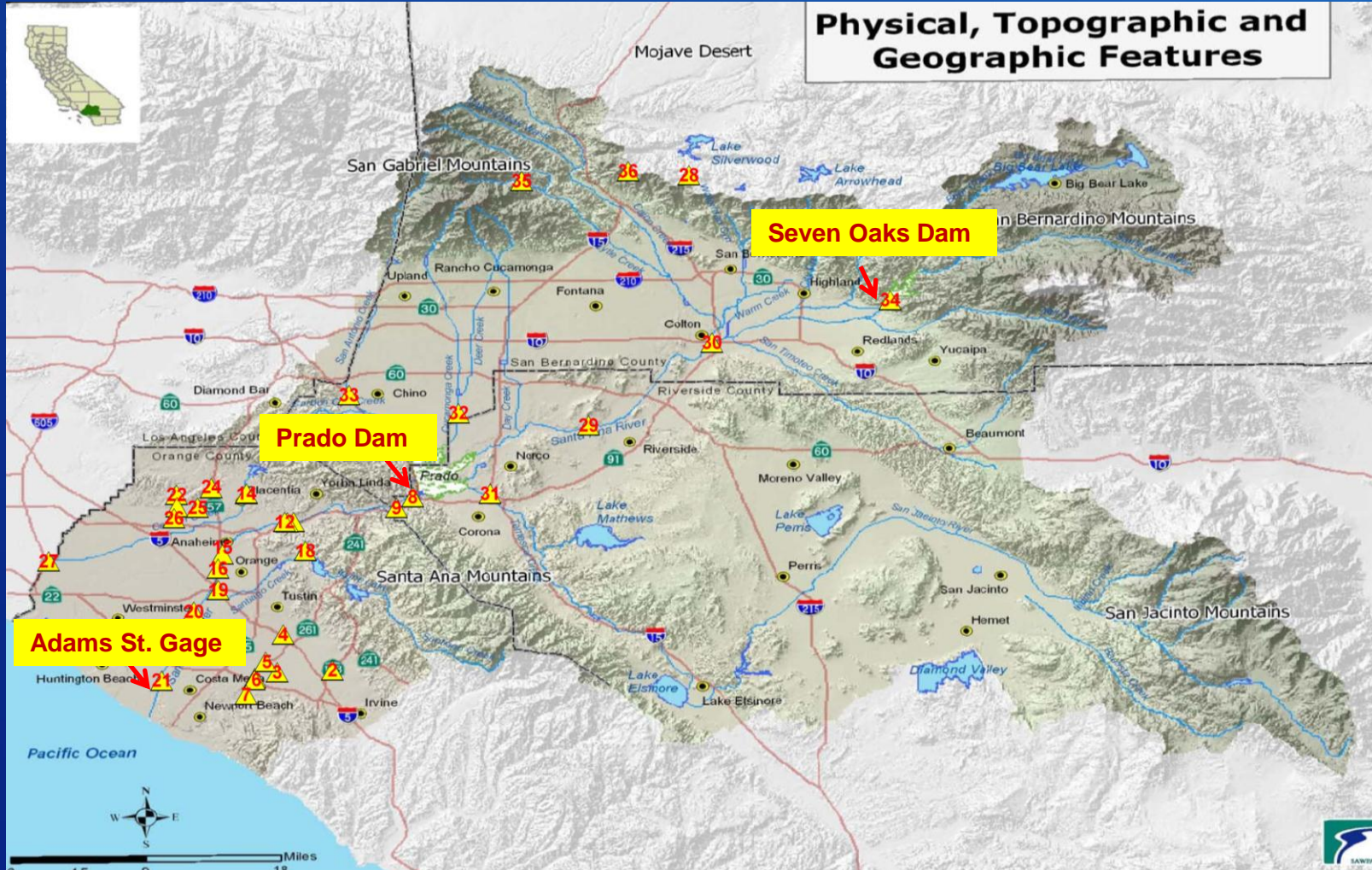
[http://gdo-dcp.ucrlnl.org/downscaled\\_cmip\\_projections/dcplInterface.html#Welcome](http://gdo-dcp.ucrlnl.org/downscaled_cmip_projections/dcplInterface.html#Welcome)

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# Santa Ana River Watershed

## Distribution of routing locations (total 36)

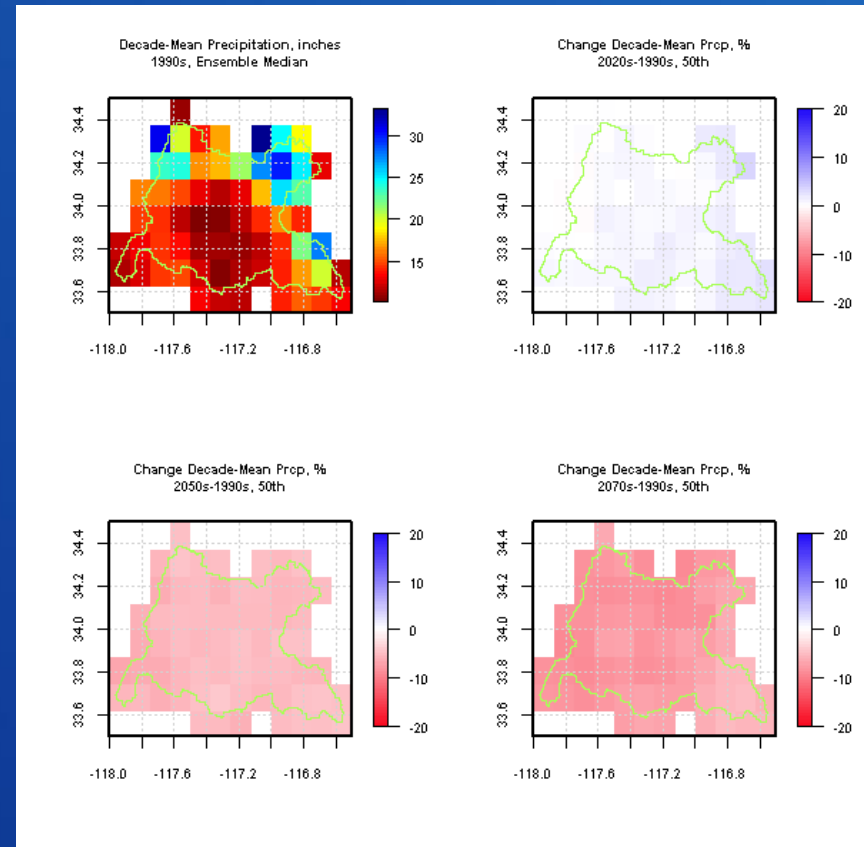


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# Hydroclimate Projections

## Spatial Distribution of Precipitation (P)

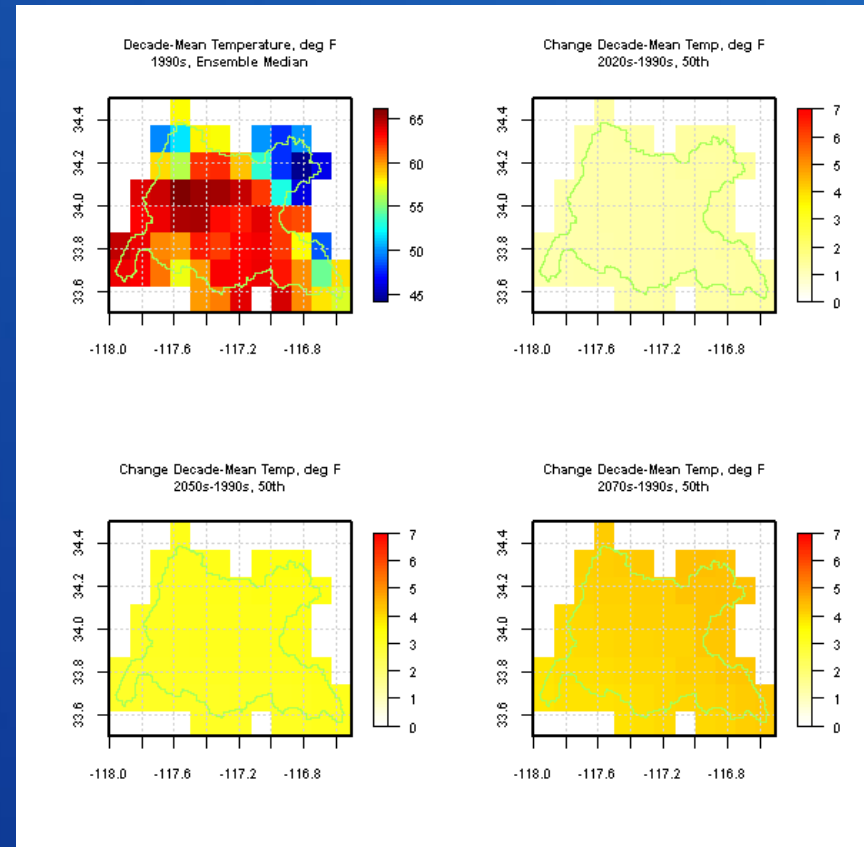
- The ensemble- median change shows some increase in prcp over the basin during the 2020s' decade from the 1990s' reference.
- By the 2050s there is decline in prcp from the 1990s reference decade.
- Increased decline in prcp continues through to the 2070s decade from the 1990s reference decade.



# Hydroclimate Projections

## Spatial Distribution of Temperature (T)

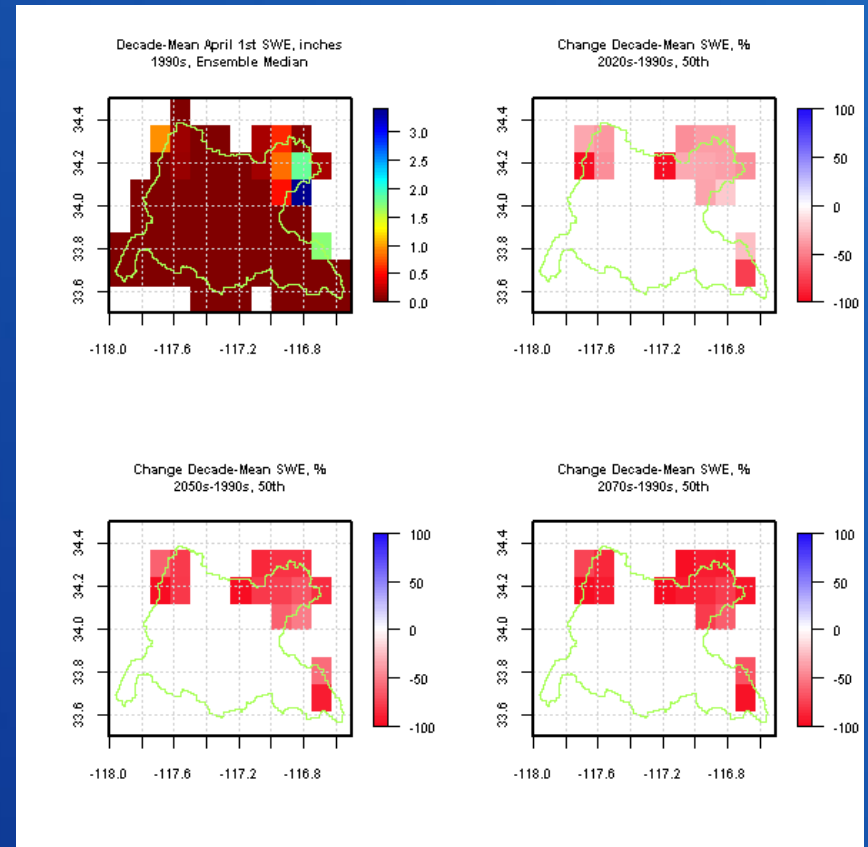
- The ensemble median change for the 2020s', 2050s', and 2070s' decades relative to the 1990s shows an increasing temperature value throughout the Basin.





# Hydroclimate Projections Snow Water Equivalent (SWE)

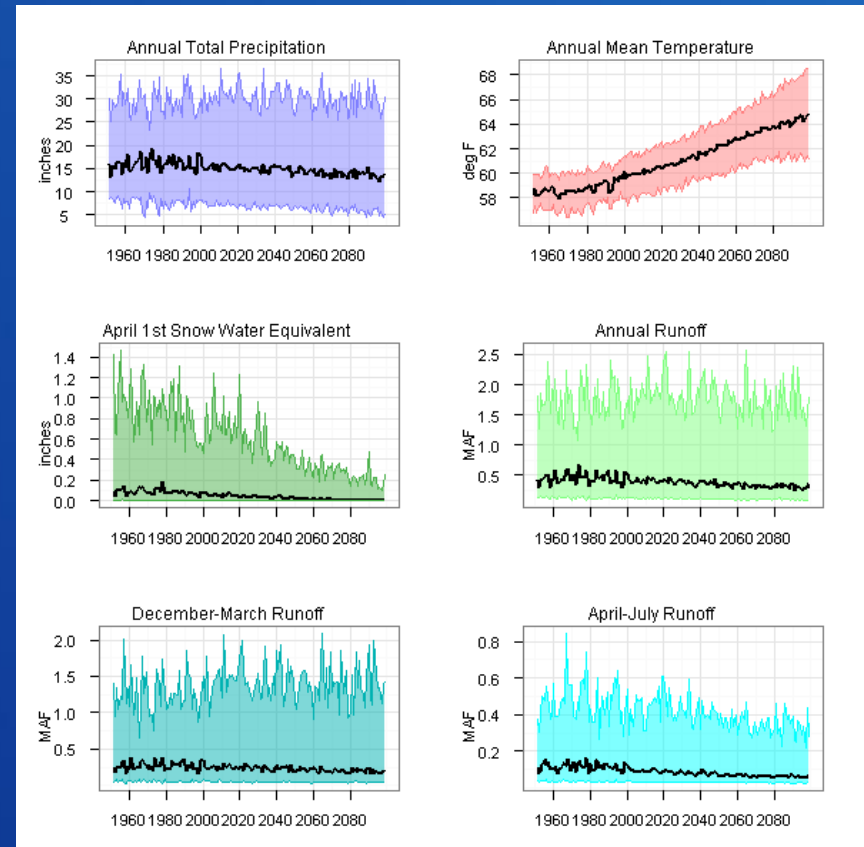
- Spatial distribution of April 1<sup>st</sup> SWE – persistent decline through the future decades (2020s, 2050s, 2070s) from the 1990s' distribution.



# Hydroclimate Projections

## P, T, SWE, Flow

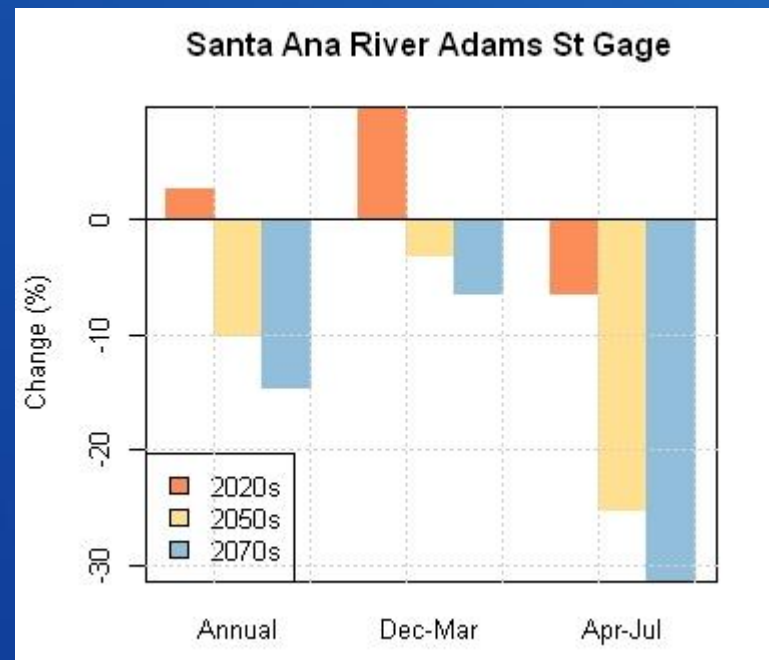
- Temporal trends – solid line is the median, 5<sup>th</sup> and 95<sup>th</sup> percentile bounds.
- P – longer-term somewhat decreasing trend
- T- increasing trend
- SWE - decreasing trend
- Flow – longer-term decreasing trend



# Hydroclimate Projections

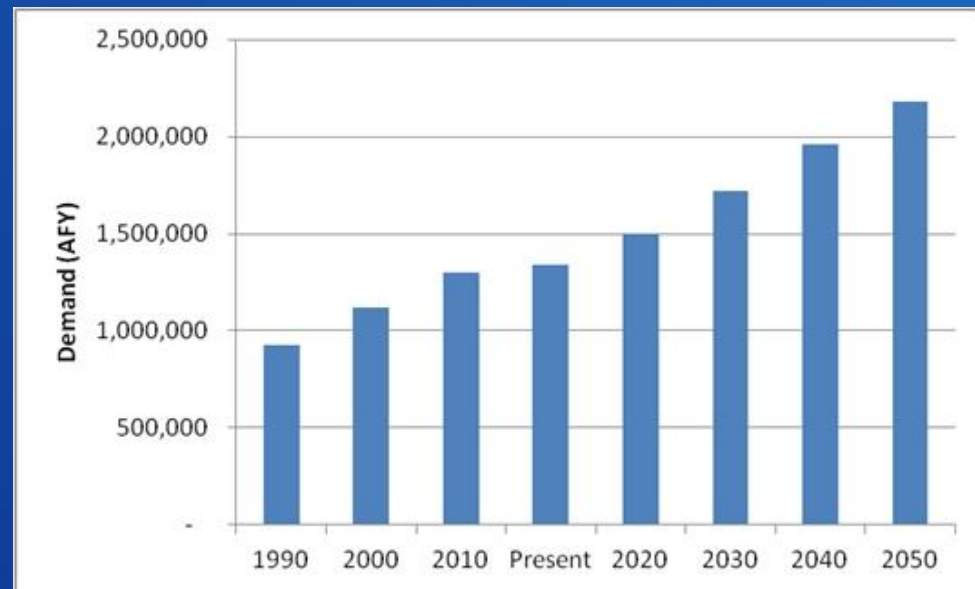
## Flow Impacts

- Annual and seasonal streamflow impacts
- 2020s – increase in annual runoff and winter (Dec-Mar) runoff, decrease in spring-summer (Apr-Jul) runoff from the 1990s reference
- 2050s – decrease in annual, winter, spring-summer runoff from the 1990s reference
- 2070s - decrease in annual, winter, spring-summer runoff from the 1990s reference



# Water Demand

- **Current population ~6.1 million, projected to grow to 9.9 million by 2050.**
- **Projected population was used to estimate demand without accounting for conservation.**





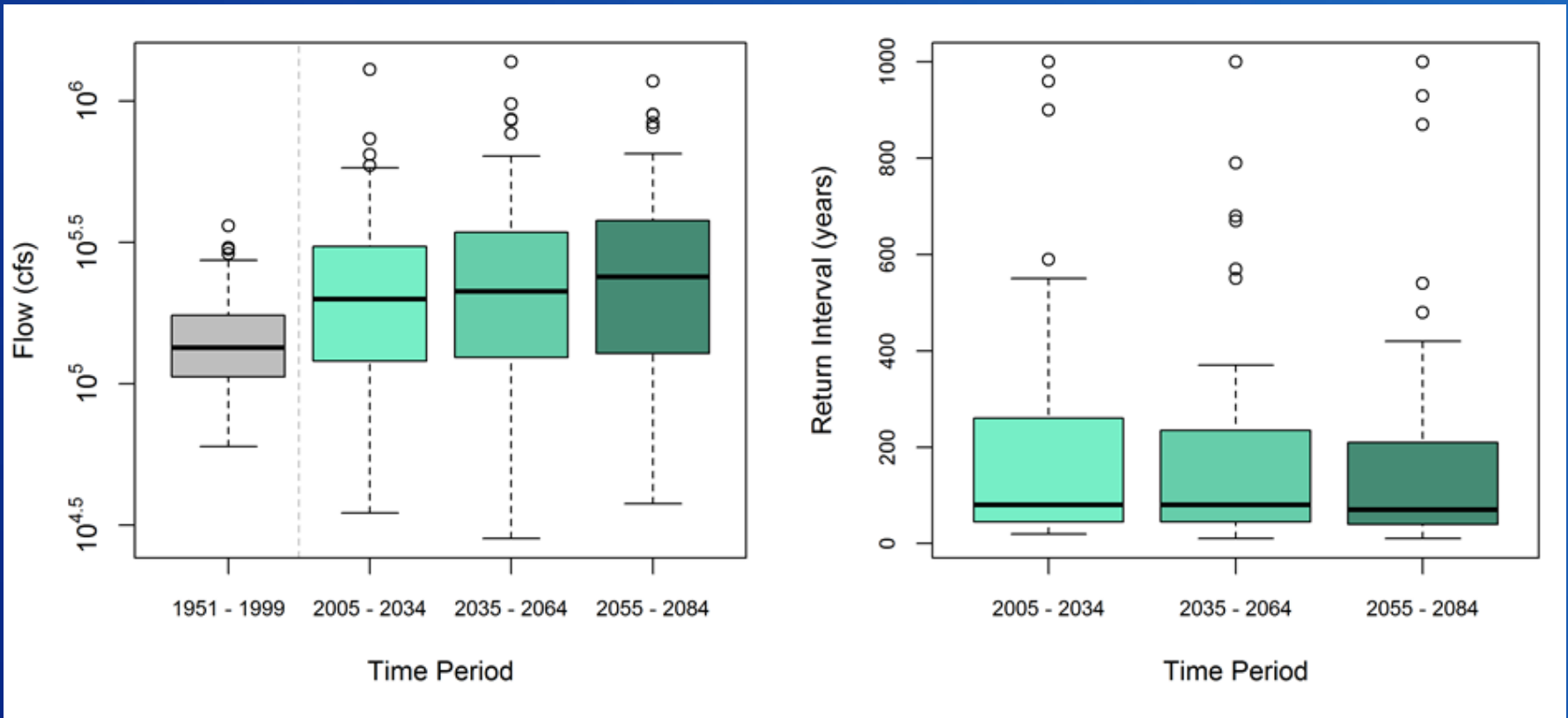
# Summary of Projected Impacts Santa Ana River Watershed

Hydroclimate Metric (change from 1990s)	2020s	2050s	2070s
Precipitation (%)	0.67	-5.41	-8.09
Mean Temperature (°F)	1.22	3.11	4.1
April 1st SWE (%)	-38.93	-80.4	-93.07
Annual Runoff (%)	2.6	-10.08	-14.61
Dec-Mar Runoff (%)	9.82	-3.01	-6.38
Apr-Jul Runoff (%)	-6.35	-25.24	-31.39

	1990	2000	2010	Present	2020	2030	2040	2050
Demand (MAFY)	0.924	1.121	1.298	1.339	1.503	1.723	1.958	2.178

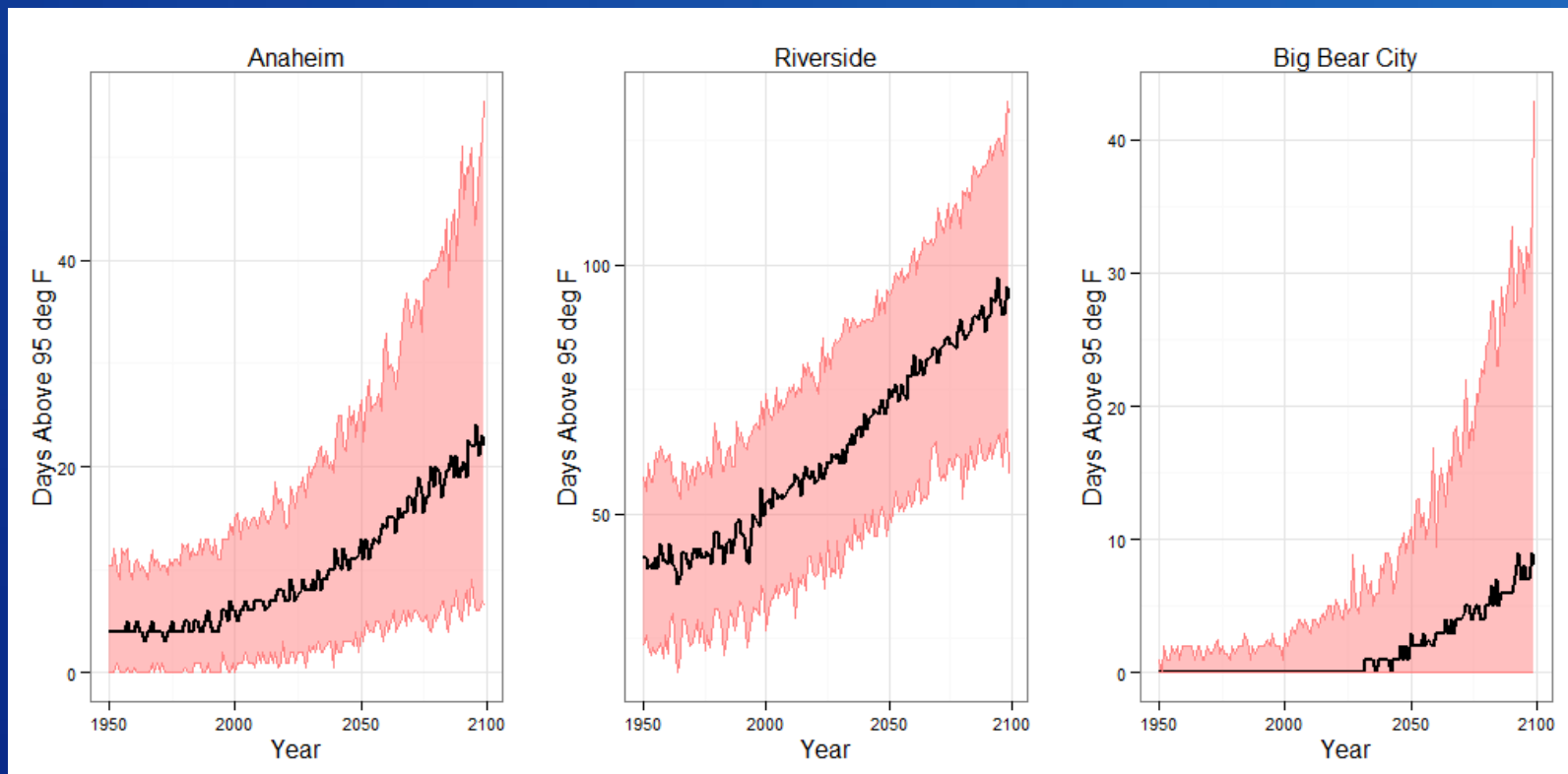
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# Floods – 200-year event, Prado Dam



- More severe floods in the future
- 200 year historical event is likely to be closer to a 100 year event in the future

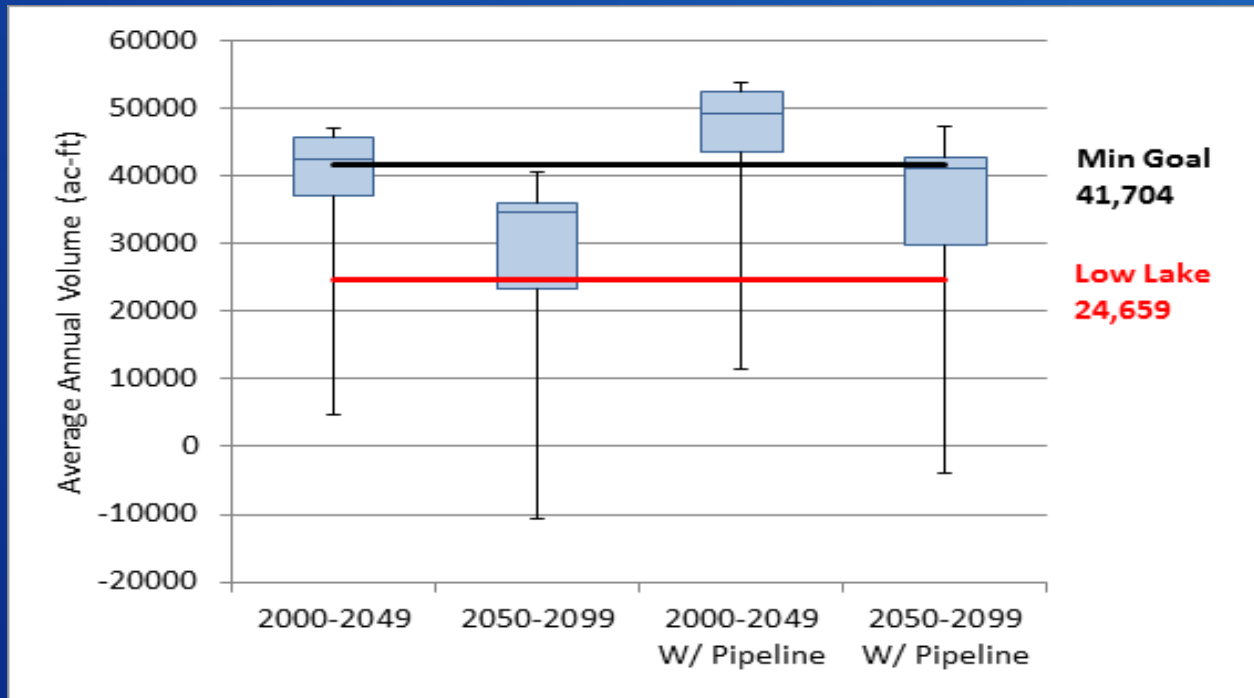
# Days above 95°F



	Historical	2020	2050	2070
Anaheim	4	7	12	16
Riverside	43	58	72	82
Big Bear City	0	0	2	4



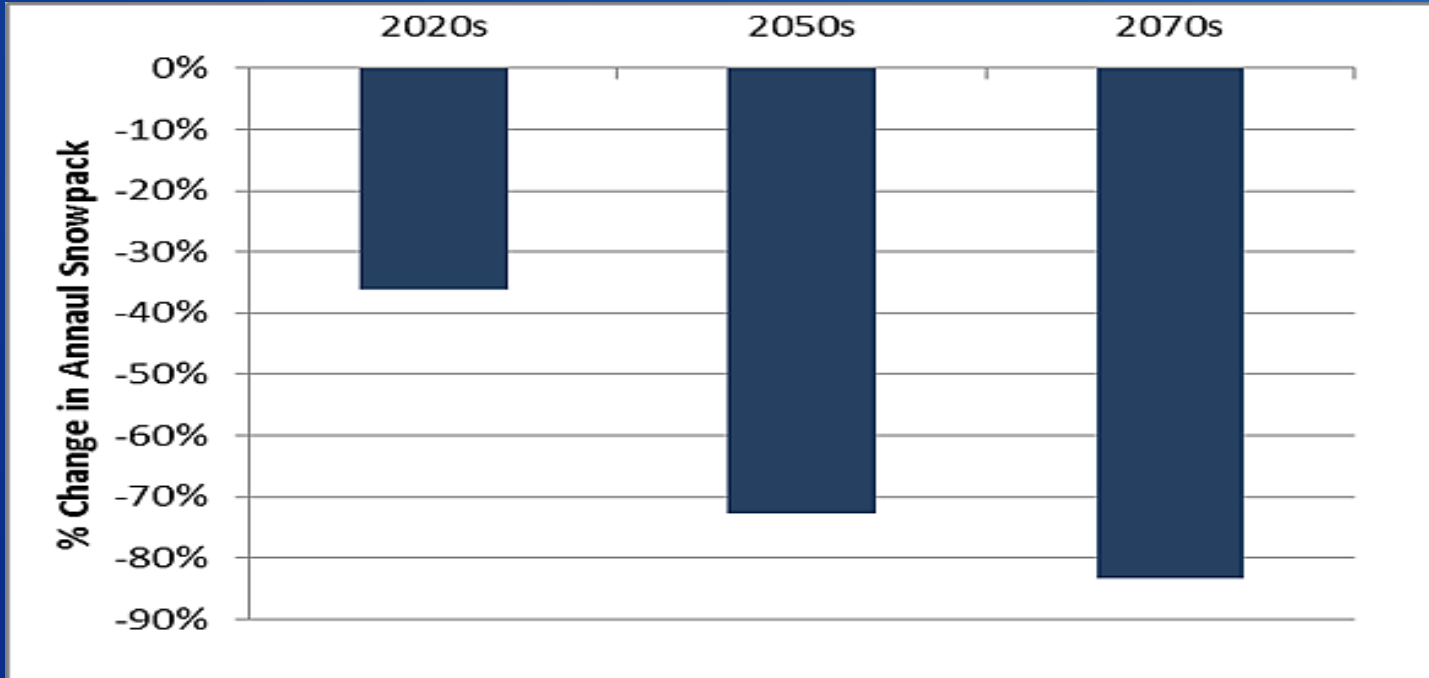
# Lake Elsinore



- 2000-2049, Lake Elsinore has a >75% chance of meeting the minimum elevation goal of 1,240 ft.
- 2050-2099, Lake Elsinore has a >25% chance of meeting the minimum elevation goal of 1,240 ft.
- The Elsinore Valley Municipal Water District (EVMWD) project does aid in stabilizing lake levels.

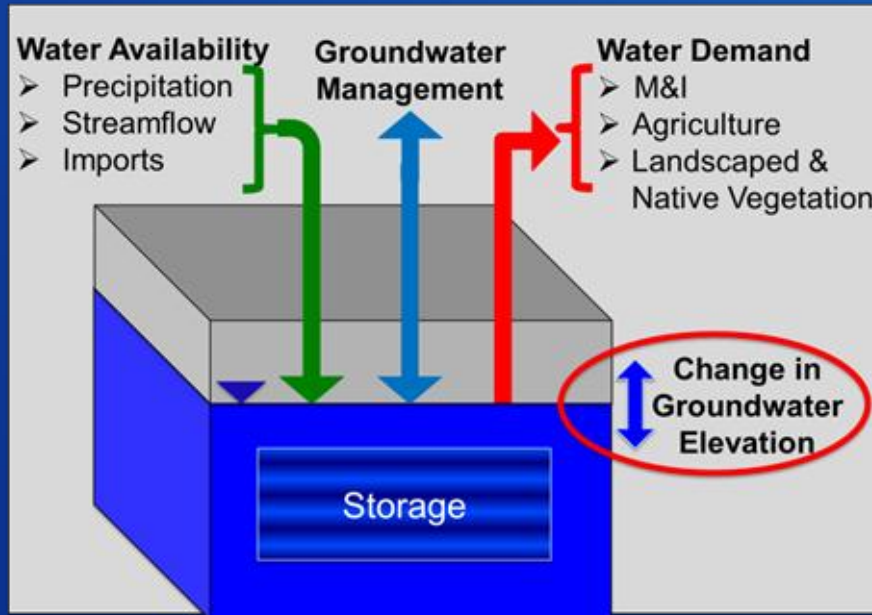
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# Snowpack at Big Bear



- Significant decline in April 1<sup>st</sup> snowpack that amplify throughout the 21<sup>st</sup> century.
- Projected snowpack decline could exceed 70% by 2070.

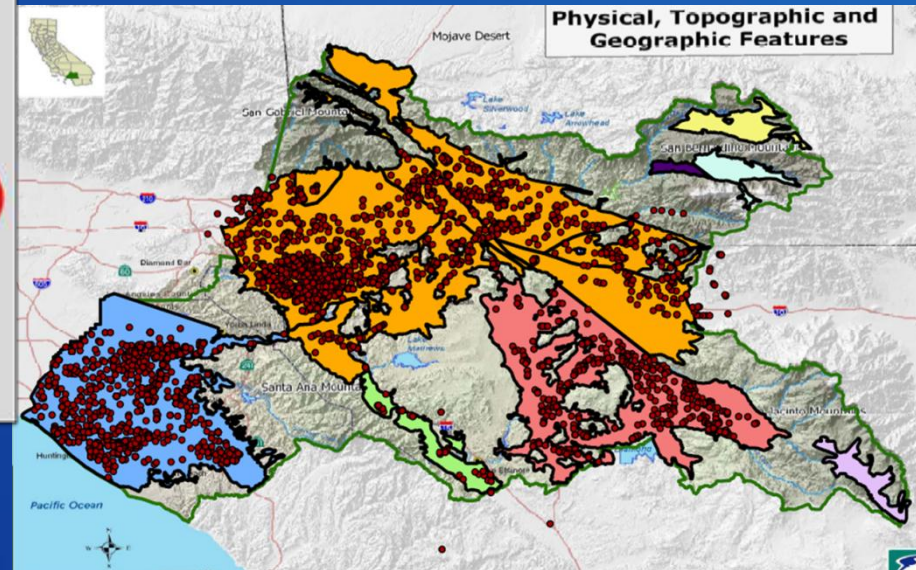
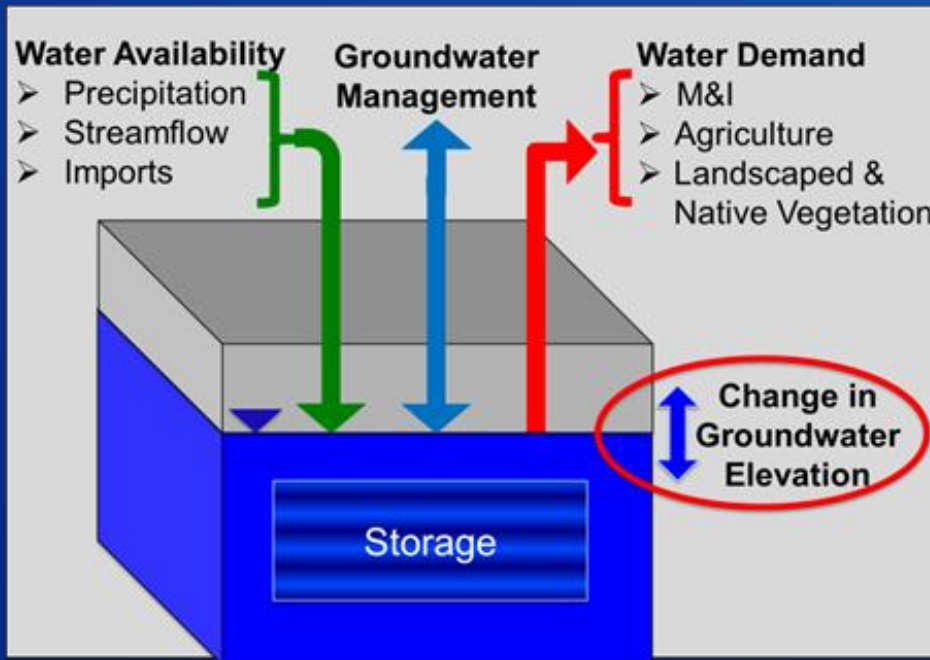
# Groundwater Availability



- Currently provides 54% of total water supply in an average year.
- Projected decreases in precipitation and increases in temperature will decrease natural recharge.
- Groundwater use projected to increase.

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# SAWPA Groundwater Screening Tool



$$\frac{\Delta h}{\Delta t} = (C_1 \cdot P_t) + (C_2 \cdot E_t) + (C_3 \cdot Q_t) + (C_4 \cdot M_t) + (C_5 \cdot A_t) + (C_6 \cdot I_t) + (C_7 \cdot X_t)$$

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# SAWPA Groundwater Screening Tool

- Will a 10% reduction in M&I demand offset the impacts of climate change in my groundwater basin?



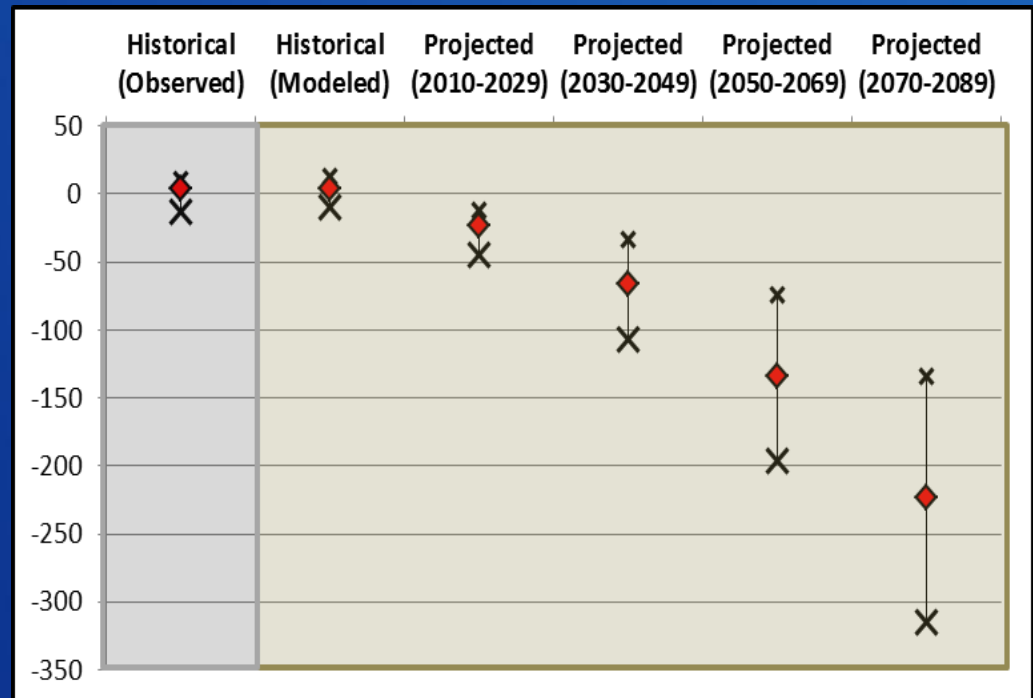
- What is the projected deficit in groundwater storage in my basin by 2050 due to climate change?



# SAWPA Groundwater Screening Tool

- Example:  
Orange County Coastal Plain Groundwater Basin

Estimated decline in basin-averaged groundwater levels due to climate change *without management actions to reduce impacts*



# SAWPA Groundwater Screening Tool

– Example:

## Orange County Coastal Plain Groundwater Basin

Scenario Comparison: Management alternatives to offset projected impacts on groundwater in Orange County

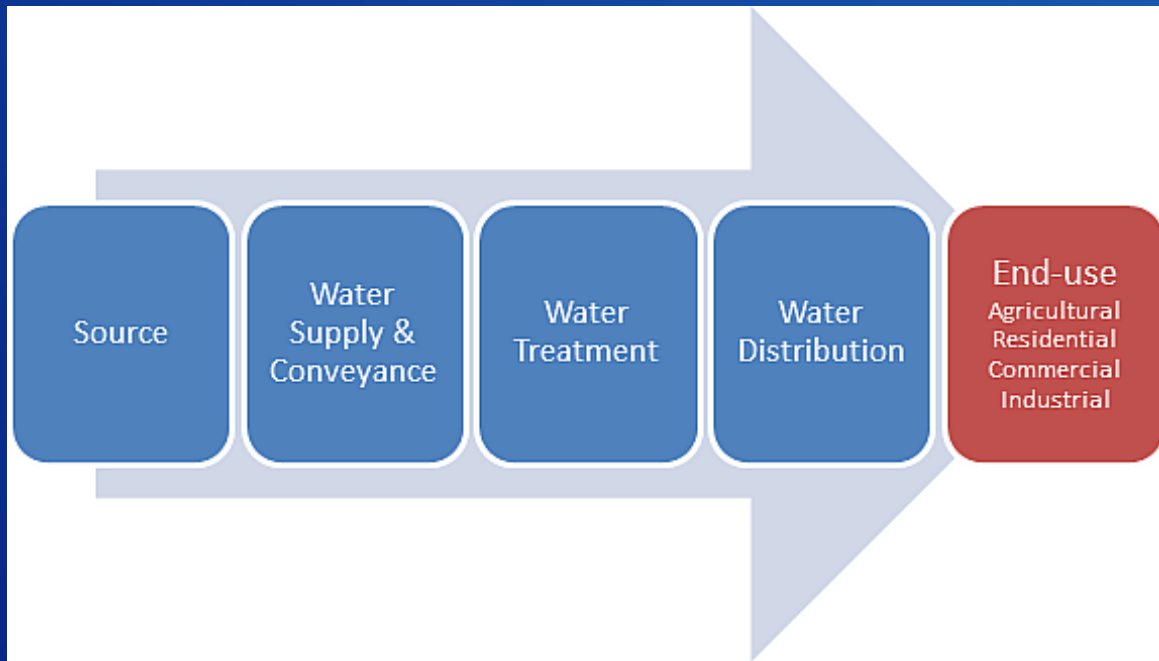
### Conservation

Gradual reduction of approx. 15% by 2020  
(reduce per capita use from ~175 gpd to ~150 gpd)

### Imported Water

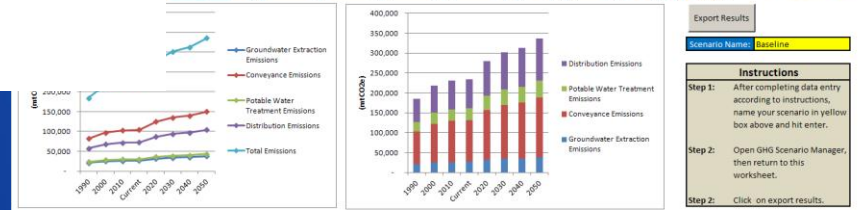
Gradual increase in water imports from Colorado River and/or SWP  
(increase from ~30,000 AF/yr to ~105,000 AF/yr)

# Greenhouse Gas Emissions Calculator for the Water Sector



**Final Values for Computation of Total Annual Emissions**

Groundwater Intensity (KWh/MG)	Supply & Conveyance Intensity (KWh/MG)	Treatment Intensity (KWh/MG)	Distribution Intensity (KWh/MG)	Electricity Emission Factors (kg CO <sub>2</sub> eq./MWh)	Annual Groundwater Extraction Emissions (mtCO <sub>2</sub> e)	Annual Conveyance Emissions (mtCO <sub>2</sub> e)	Annual Treatment Emissions (mtCO <sub>2</sub> e)	Annual Distribution Emissions (mtCO <sub>2</sub> e)	Total Annual Emissions (mtCO <sub>2</sub> e)
540	8900	496	1200	307.9	20,845	82,454	23,756	57,440	184,495
540	8900	496	1200	307.9	24,613	97,158	28,600	67,823	217,944
540	8900	496	1200	307.9	28,031	102,566	29,666	74,729	236,992
540	8900	496	1200	307.9	26,424	104,523	30,115	72,814	233,875
540	8900	496	1200	307.9	31,618	125,069	36,034	87,126	279,848
540	8900	496	1200	307.9	34,089	134,842	38,850	93,935	301,717
540	8900	496	1200	307.9	35,330	136,788	40,284	97,853	312,094
540	8900	496	1200	307.9	37,853	150,127	41,254	104,543	335,917



**Annual CO<sub>2</sub>e emissions = Extraction + Conveyance + Treatment + Distribution**

# Greenhouse Gas Emissions Calculator for the Water Sector

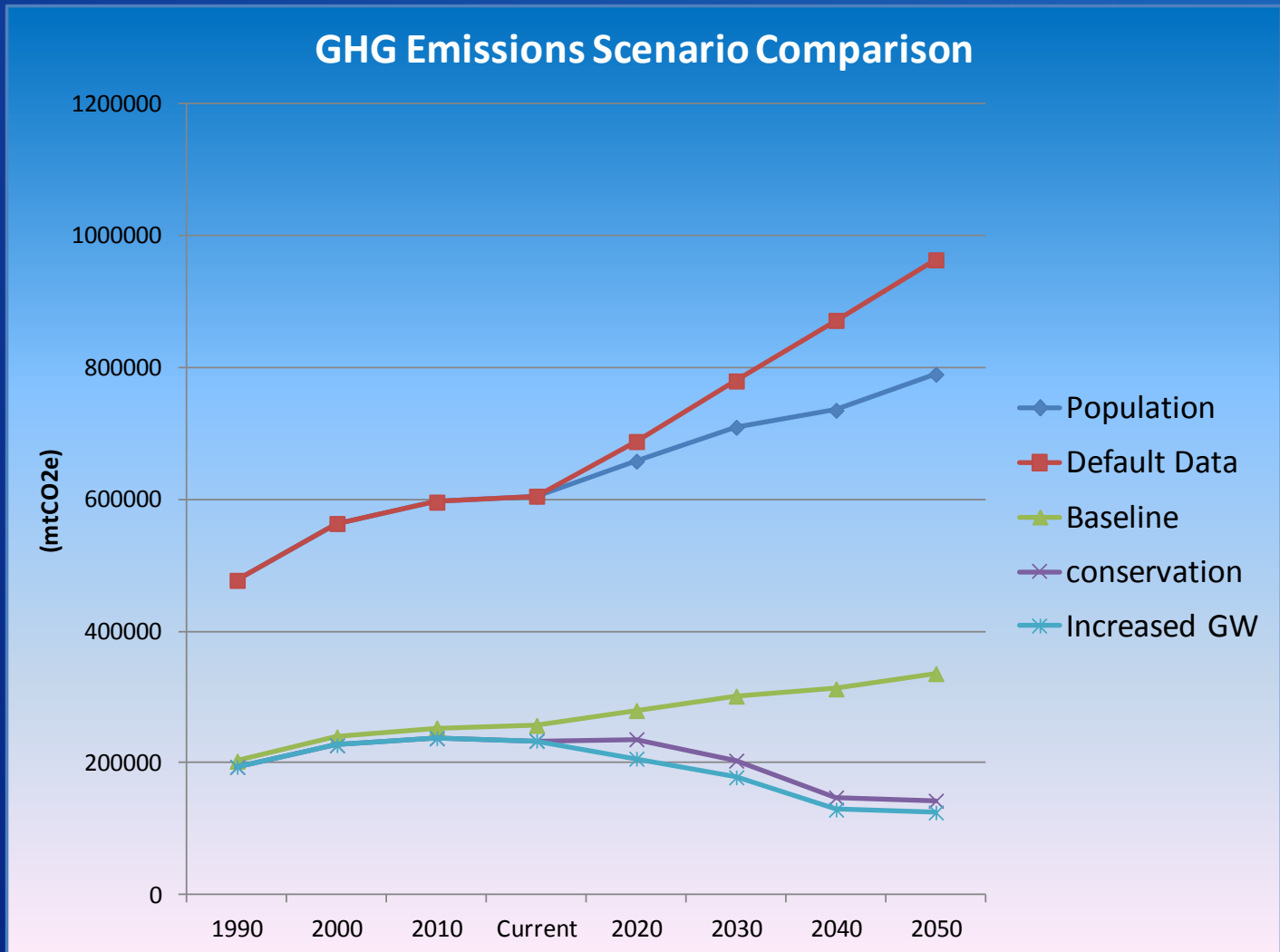
- Addresses AB 32
- Evaluates both supply and demand
- Can be used with 3 levels of data
  - Required Data: population data for 1990, 2000 & 2010
  - Suggested Data: water supply portfolio, per capita water use, projected population, etc.
  - Detail Data: monthly or annual energy and flow data can be entered for each category
- If data is not available So Cal defaults will be used



# GHG Emissions Calculator

- **Uses**
  - Compute total annual CO<sub>2</sub>e emissions for the water sector from 1990-2050
  - Determine emission breakdown from groundwater, conveyance, treatment, distribution, and wastewater
  - Compute projected future water demand
  - Evaluate scenarios for GHG emission reduction by altering either supply or demand
- **Limitations**
  - Accuracy of results is dependent on input data

# Greenhouse Gas Emissions Calculator Scenario Manager



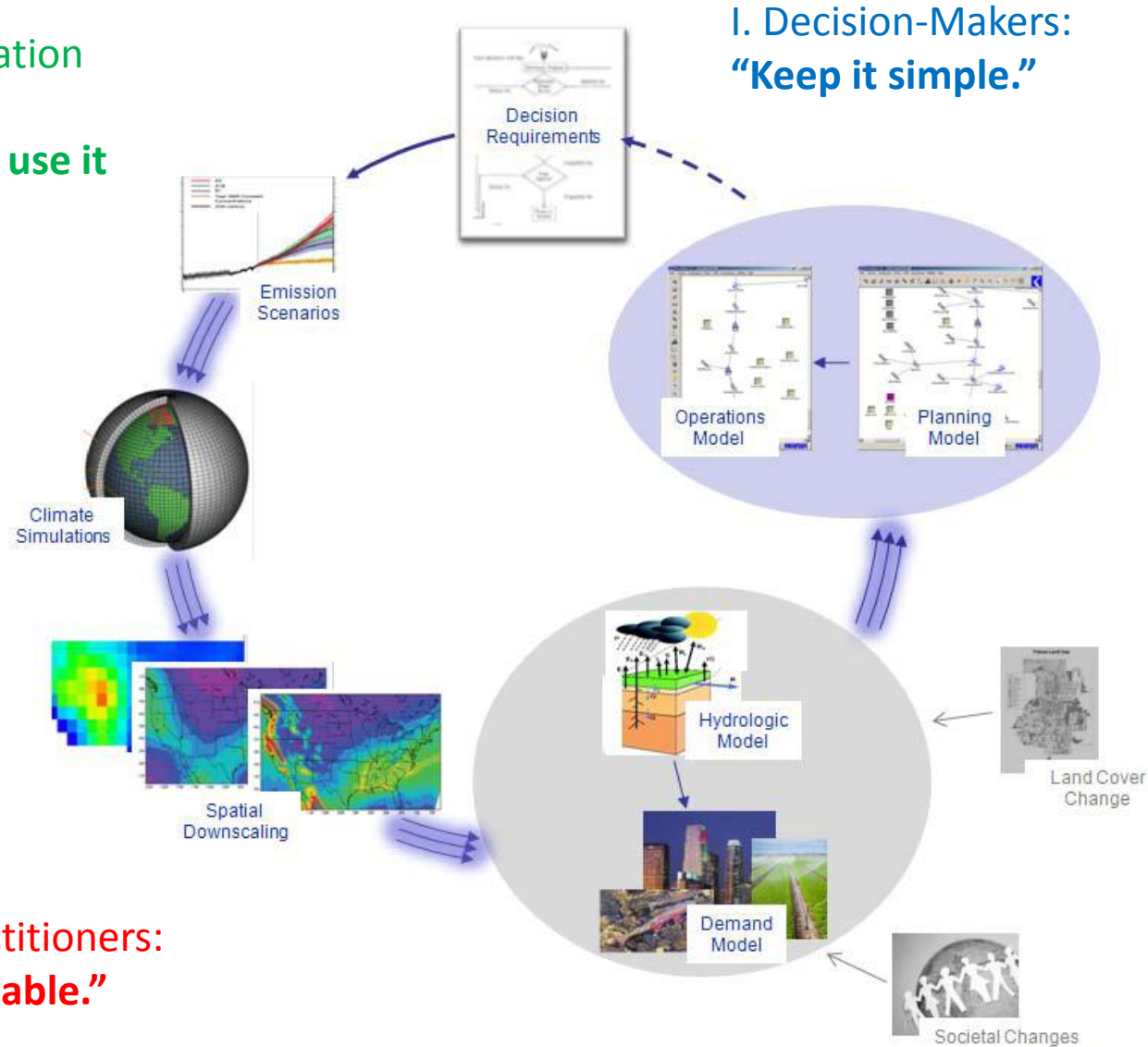
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# Uncertainty Discussions

- **Global Climate Forcings**
- **Global Climate Simulation**
- **Climate Projections Bias**
- **Spatial Downscaling**
- **Watershed Vegetation Changes**
- **Hydrologic Model**
- ...
- **Other approaches to analyzing impacts**

In summary, data selections and method choices are throughout the analysis...

II. Climate Information Providers:  
“Here’s the info... use it wisely.”



III. Technical Practitioners:  
“Keep it Manageable.”

... choices carry uncertainties, we need to understand those uncertainties, and address them in the planning process .

# Thank You!

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