Simulating Future Runoff and Water Use in the Carson River Basin

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Funded by:
NSF/USDA

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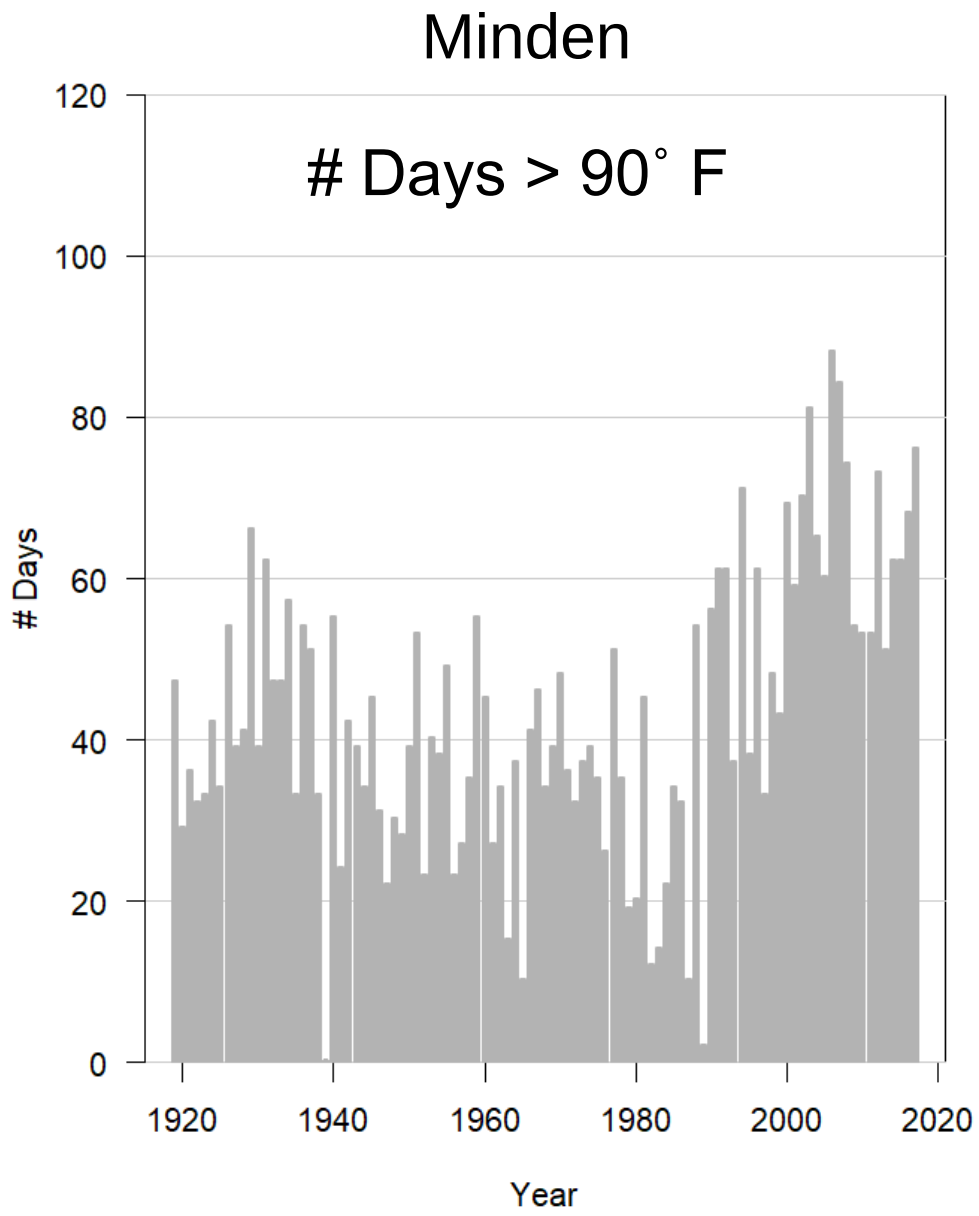
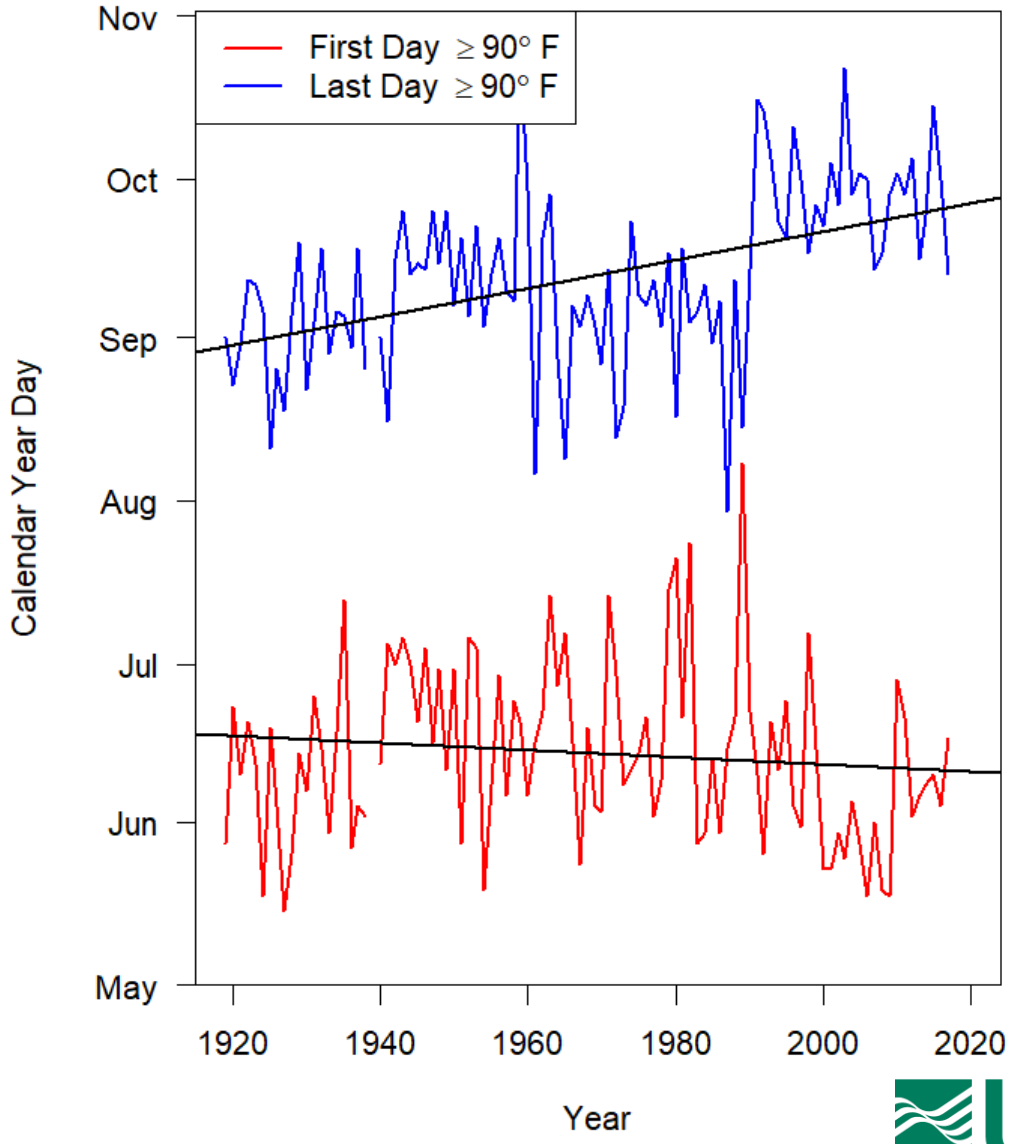
Overview

- What does the historical data suggest?
- What adjustments do our models need to account for changing runoff patterns?
- How does the system respond?
- Who is affected?

Establish what existing trends are telling us





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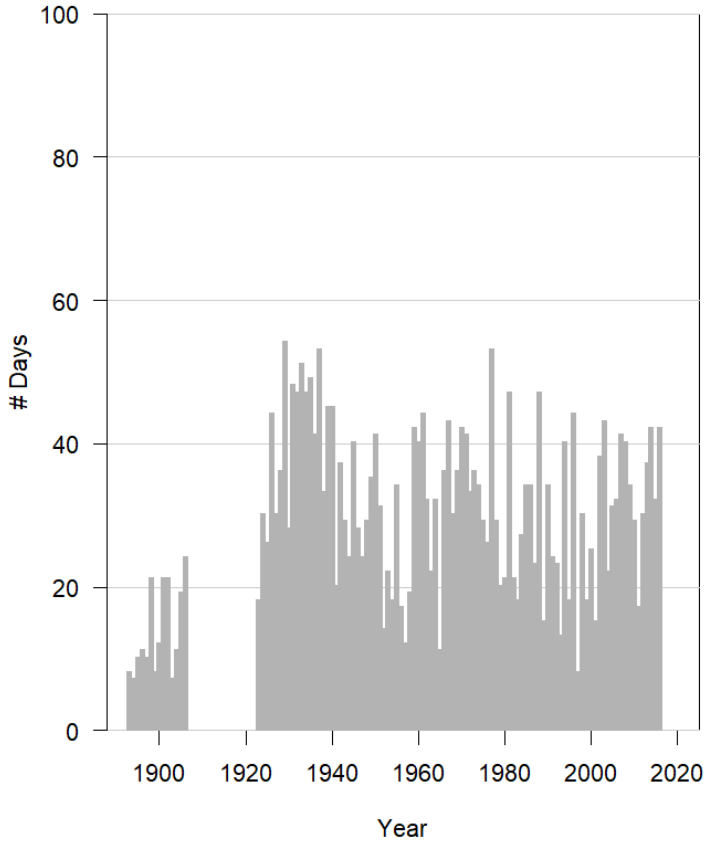
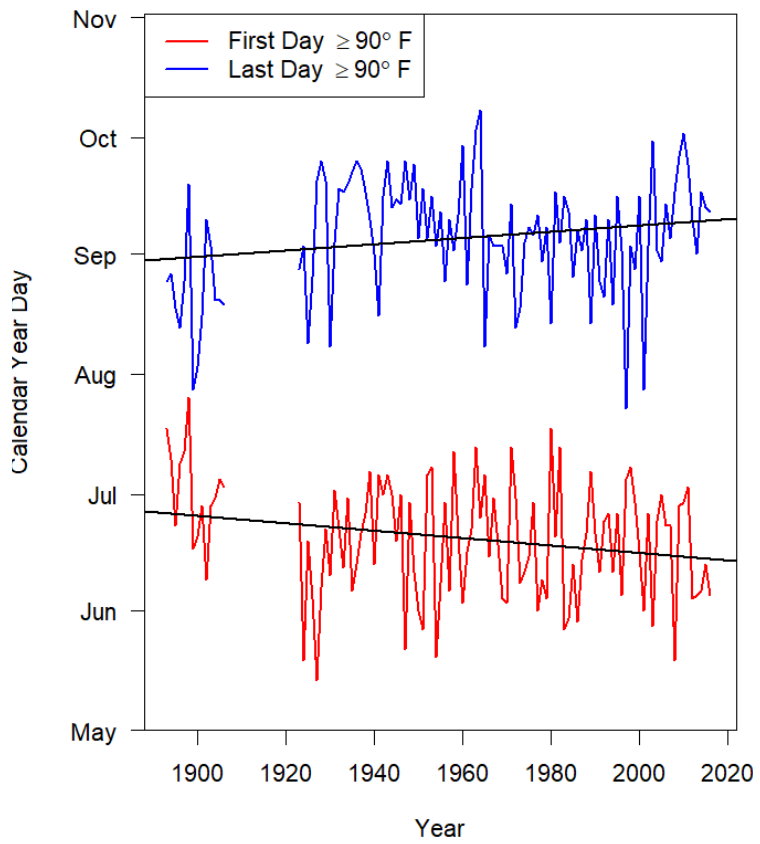
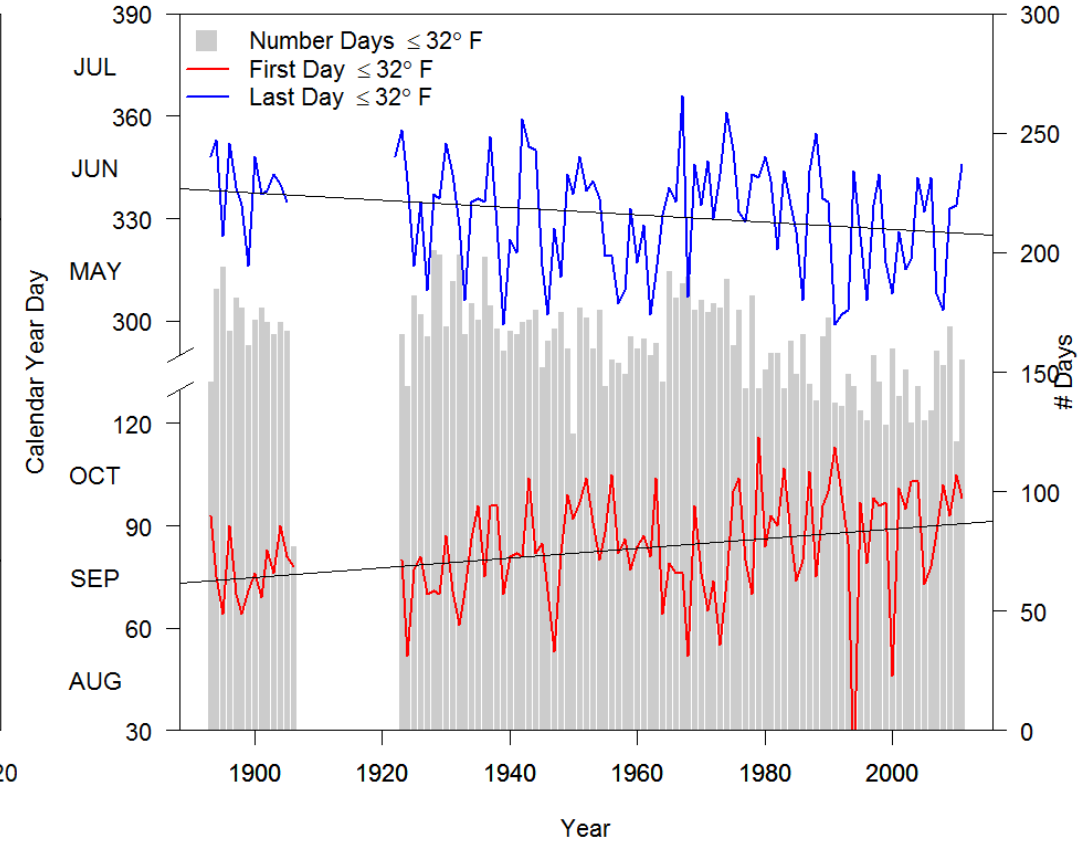
Establish what existing trends are telling us

Days > 90˚ F







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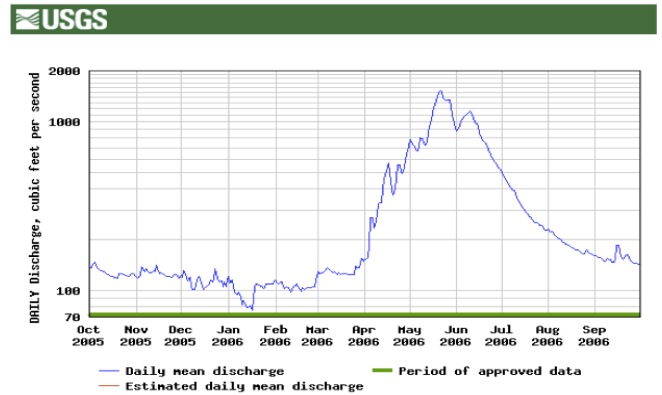
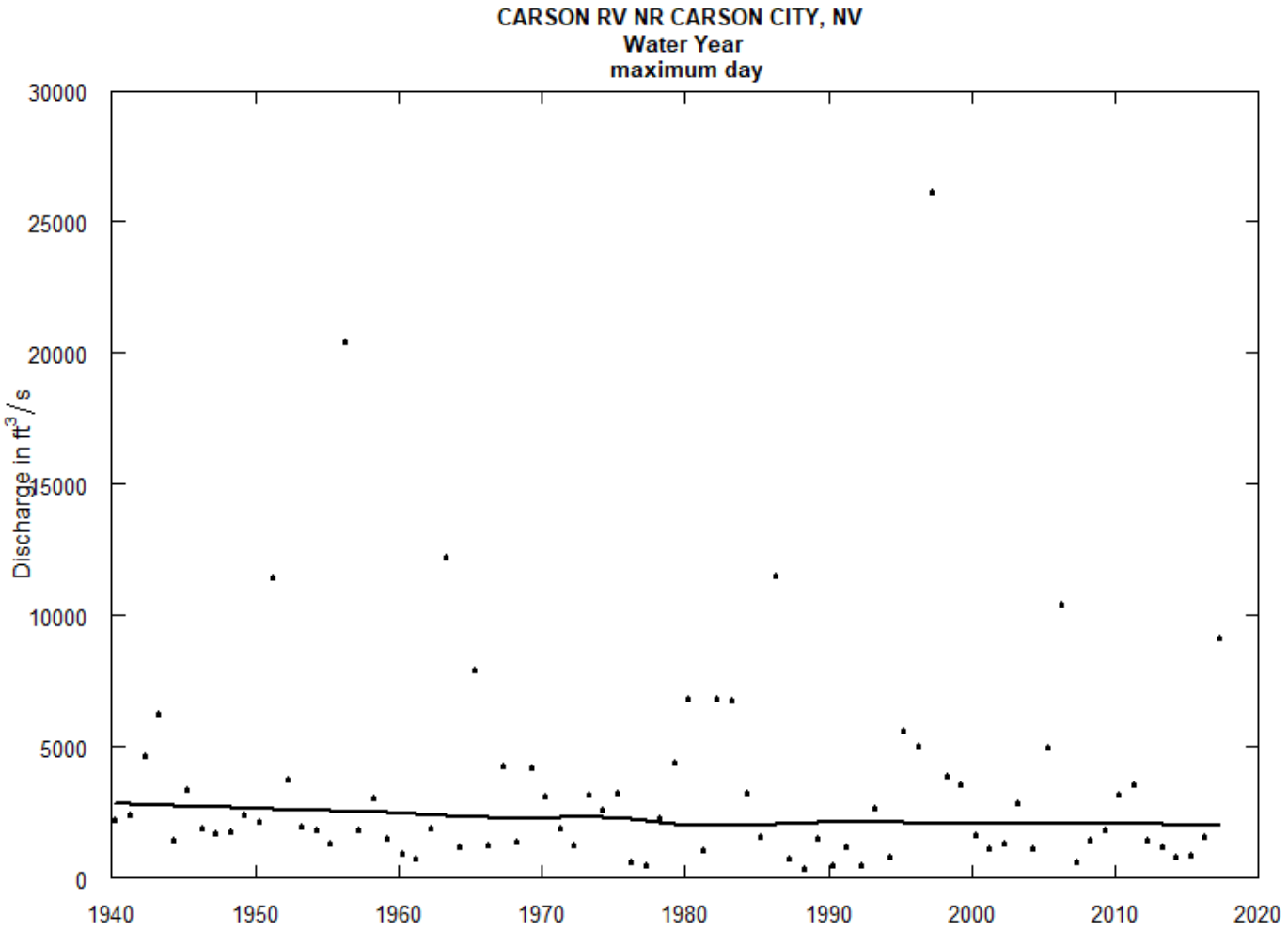
Examine long-term trends of different flow regimes





Maximum 1-Day Flow

-0.6 %/yr

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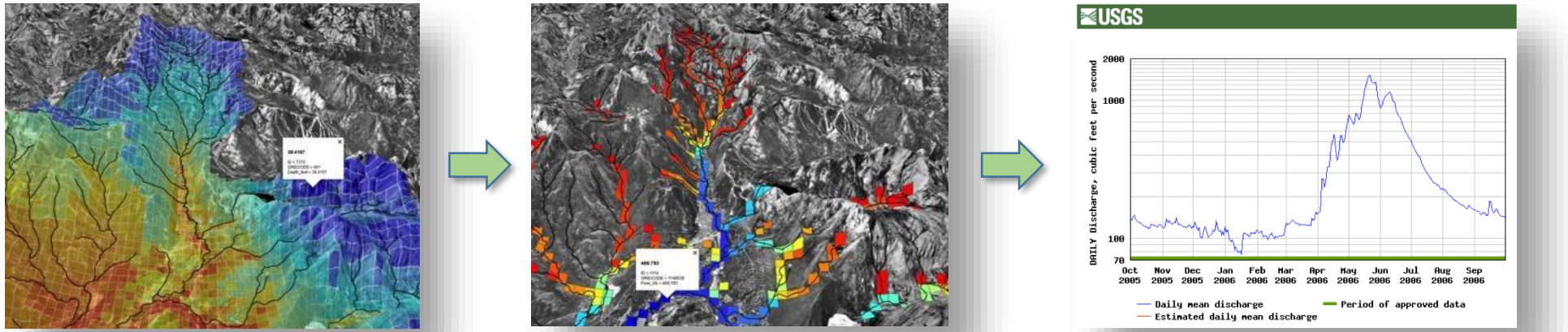
Modeling Introduction

3-prong modeling approach

1. Focus on hydrology



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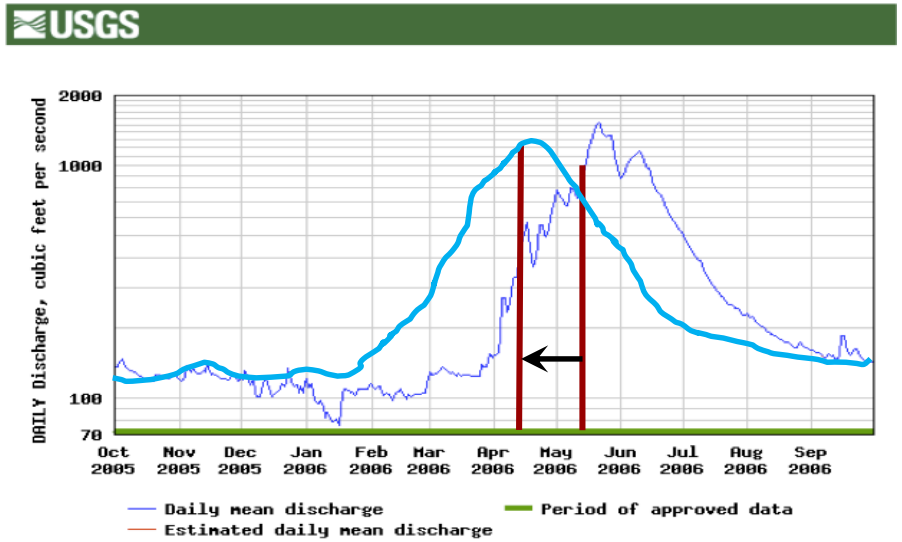
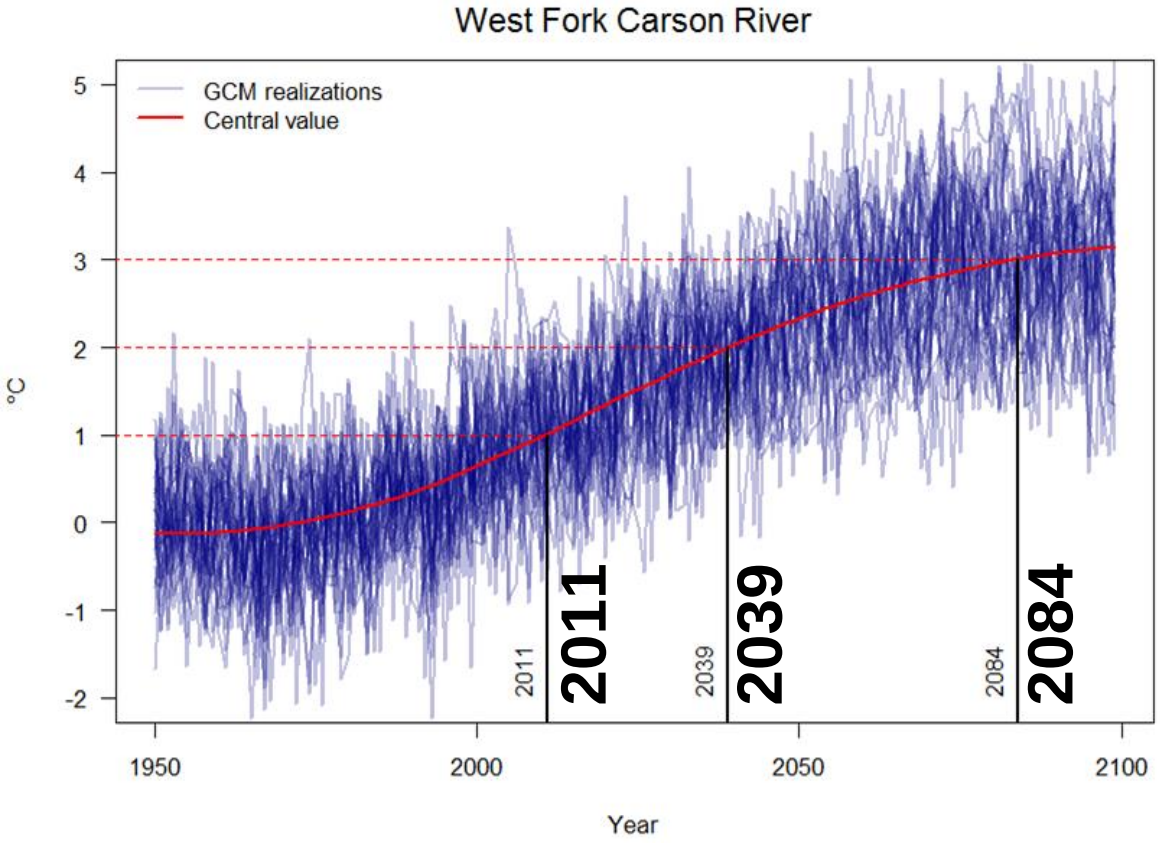
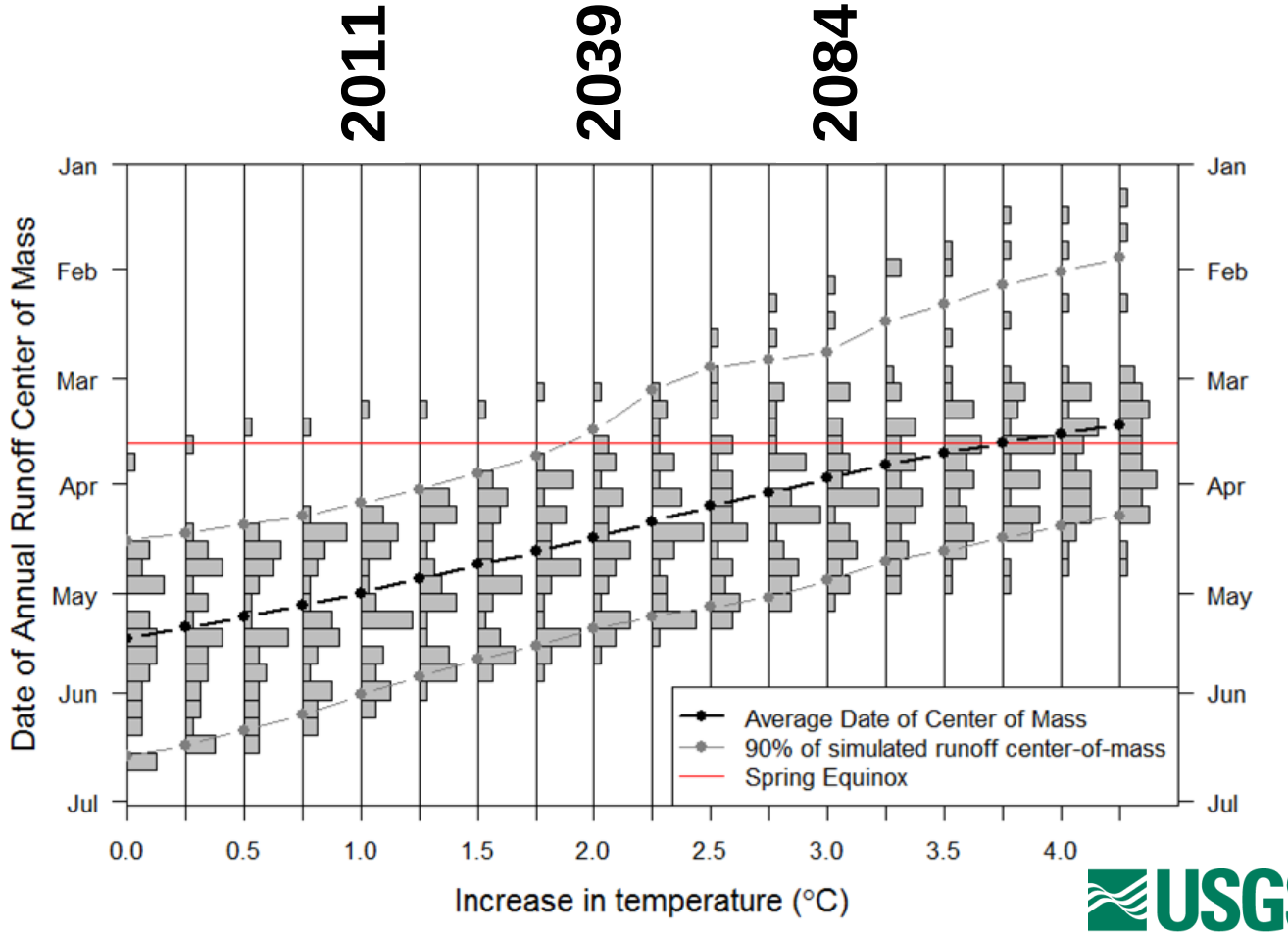
Julian day of 50% of total annual runoff for different levels of warming







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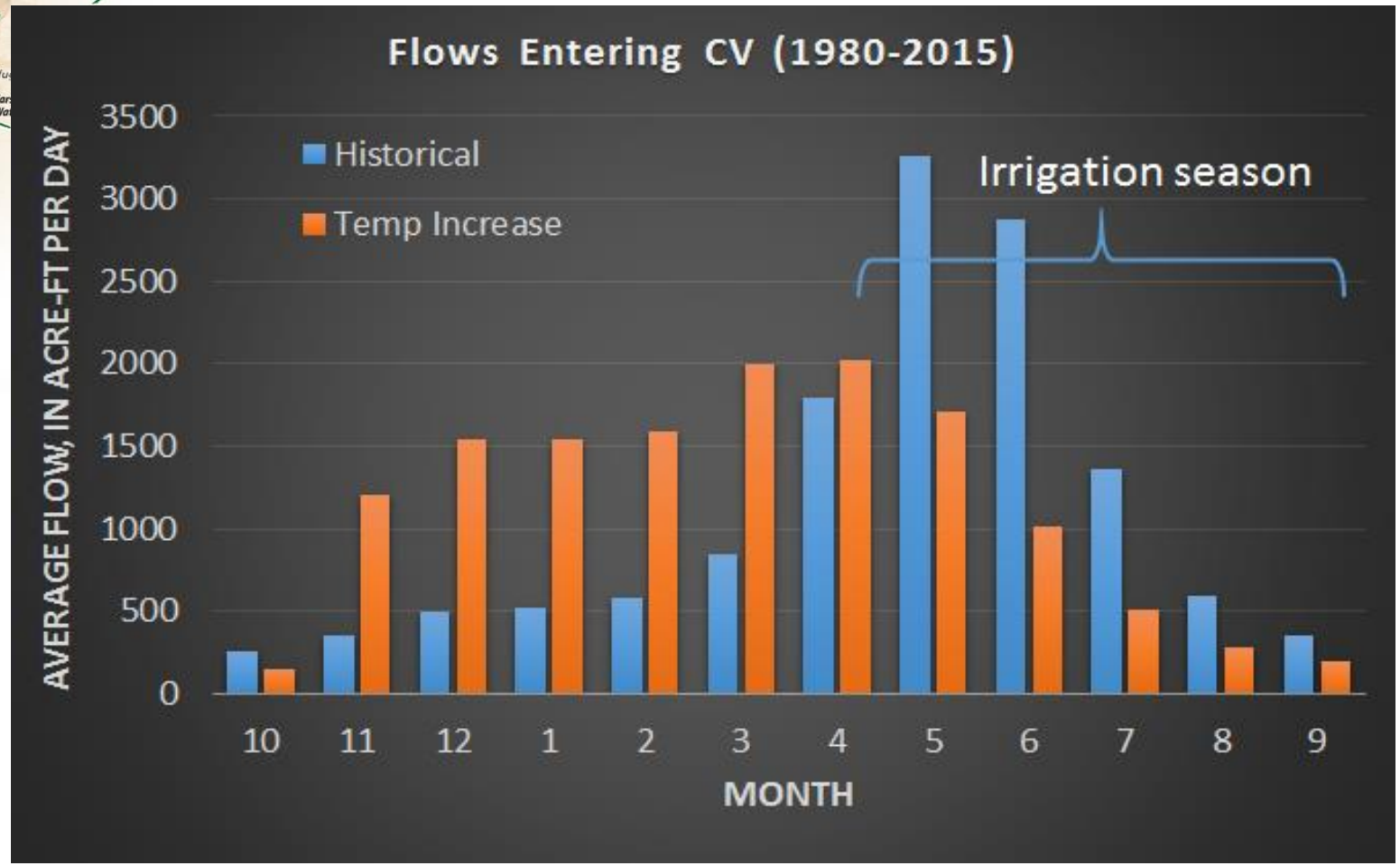
Impacts of Warming on Inflows to Carson Valley



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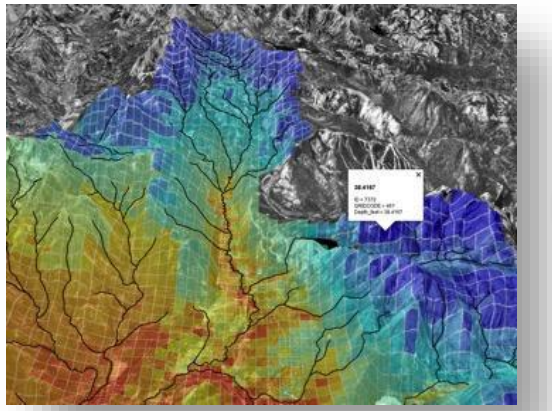
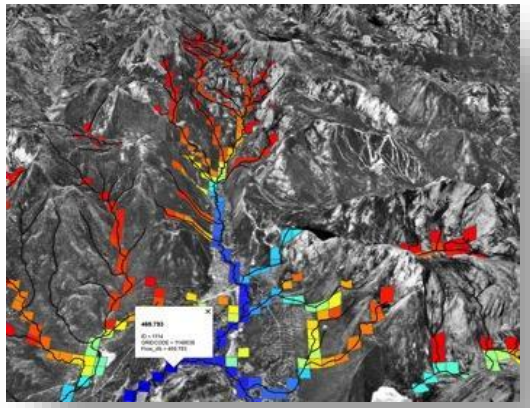
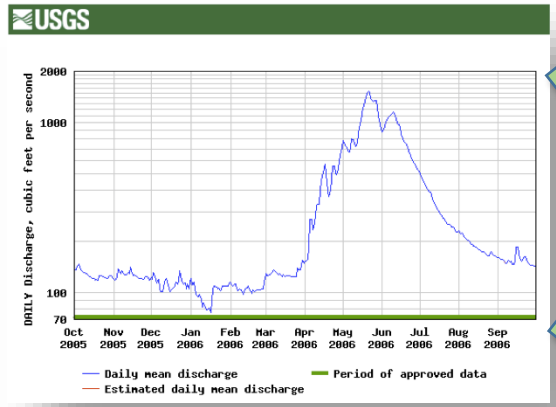
Modeling Operations

3-prong modeling approach

1. Focus on hydrology

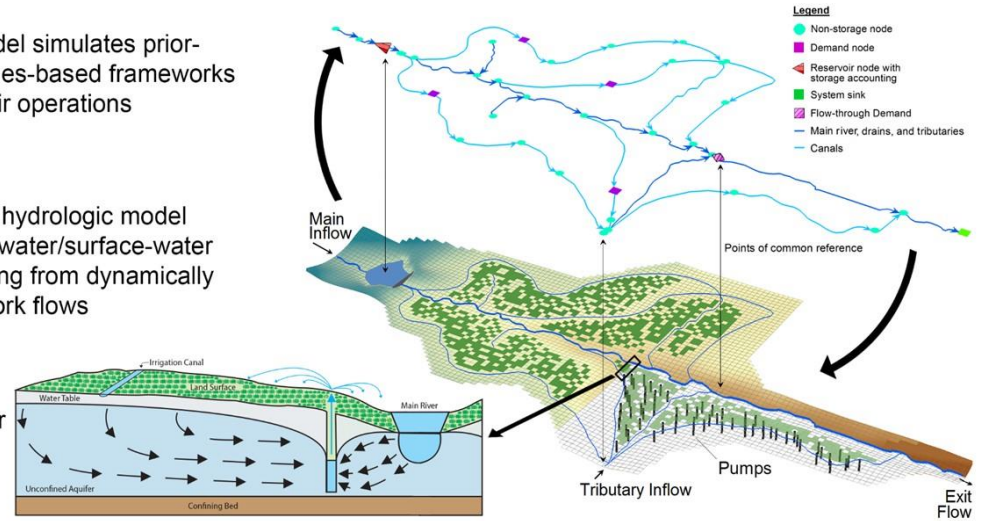






2. Focus on river operations

- Network flow model simulates prior-appropriations/rules-based frameworks including reservoir operations
- Physcially-based hydrologic model simulates groundwater/surface-water interaction resulting from dynamically determined network flows
- Conjunctive water use modeling



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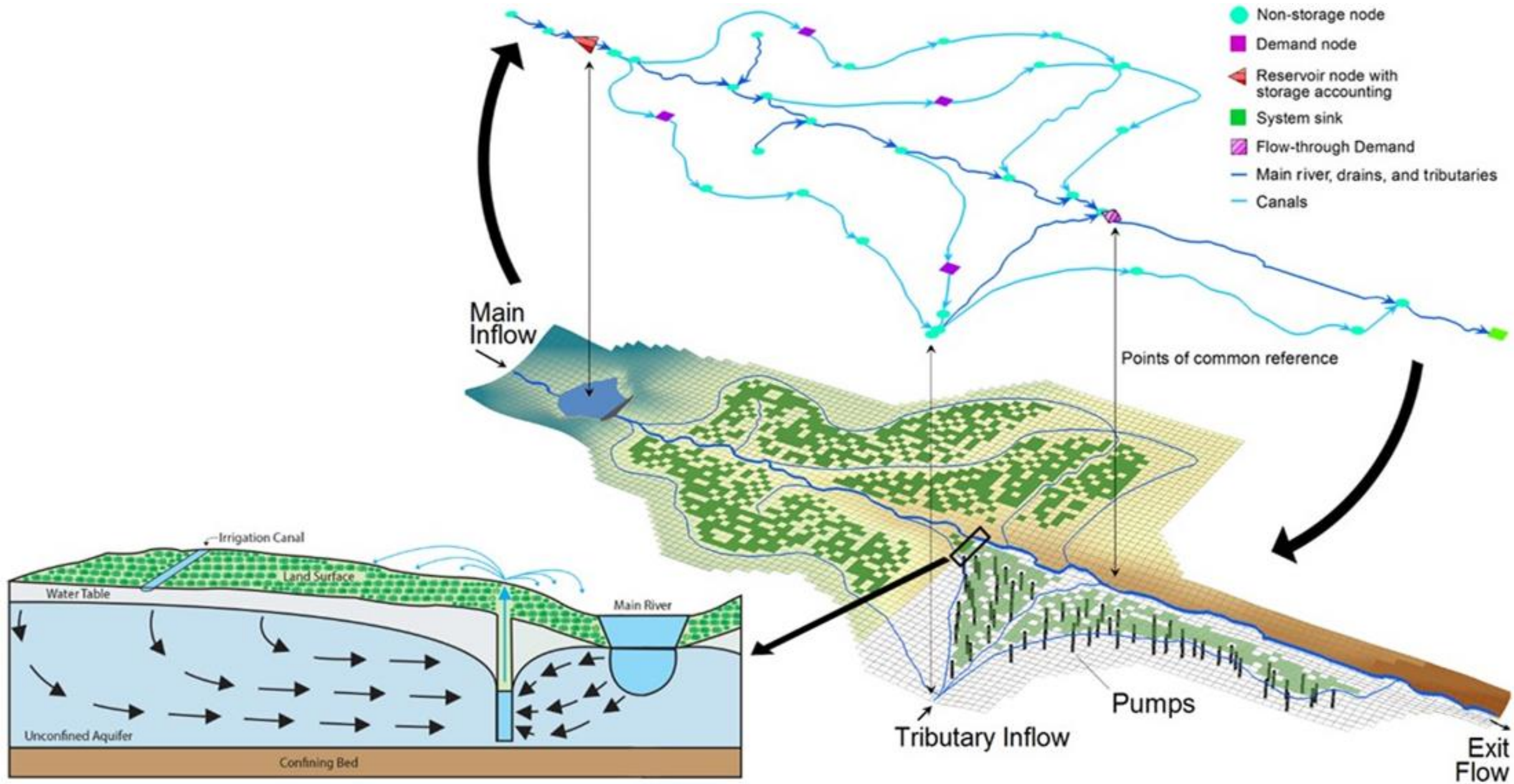
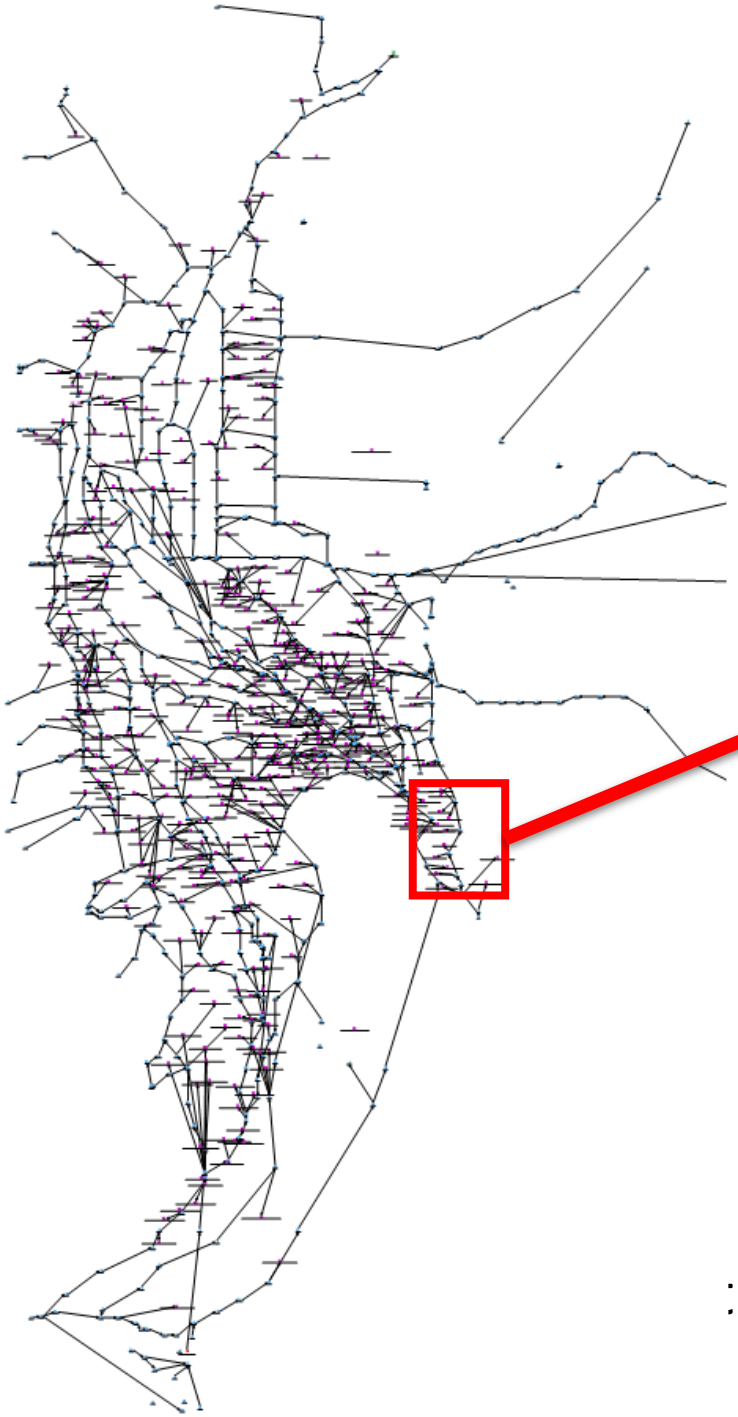
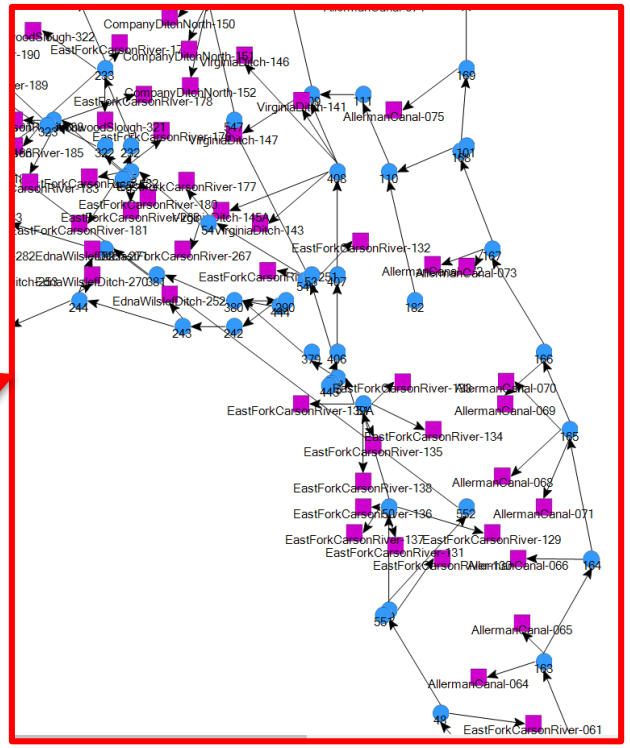

Non-storage node
Demand node
Reservoir node with storage accounting
System sink
Flow-through Demand
Main river, drains, and tributaries
Canals
Main Inflow
Points of common reference
Irrigation Canal
Land Surface
Water Table
Main River
Unconfined Aquifer
Confining Bed
Tributary Inflow
Pumps
Exit Flow

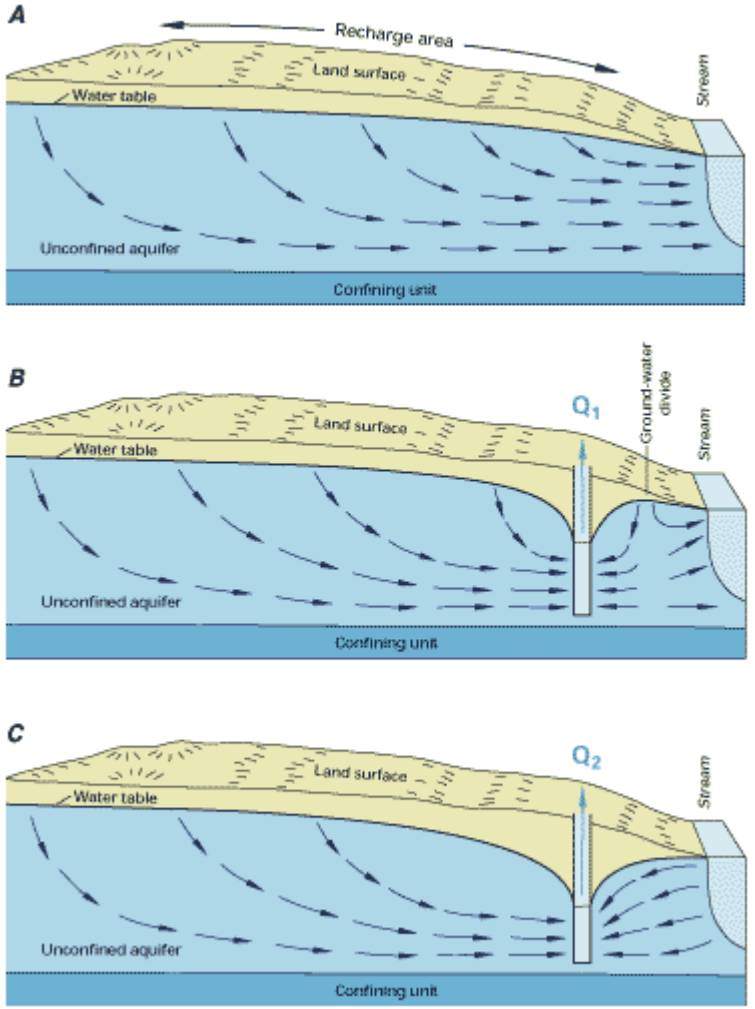
Carson River Operations Model





MODSIM

:p://modsim.engr.colostate.edu/



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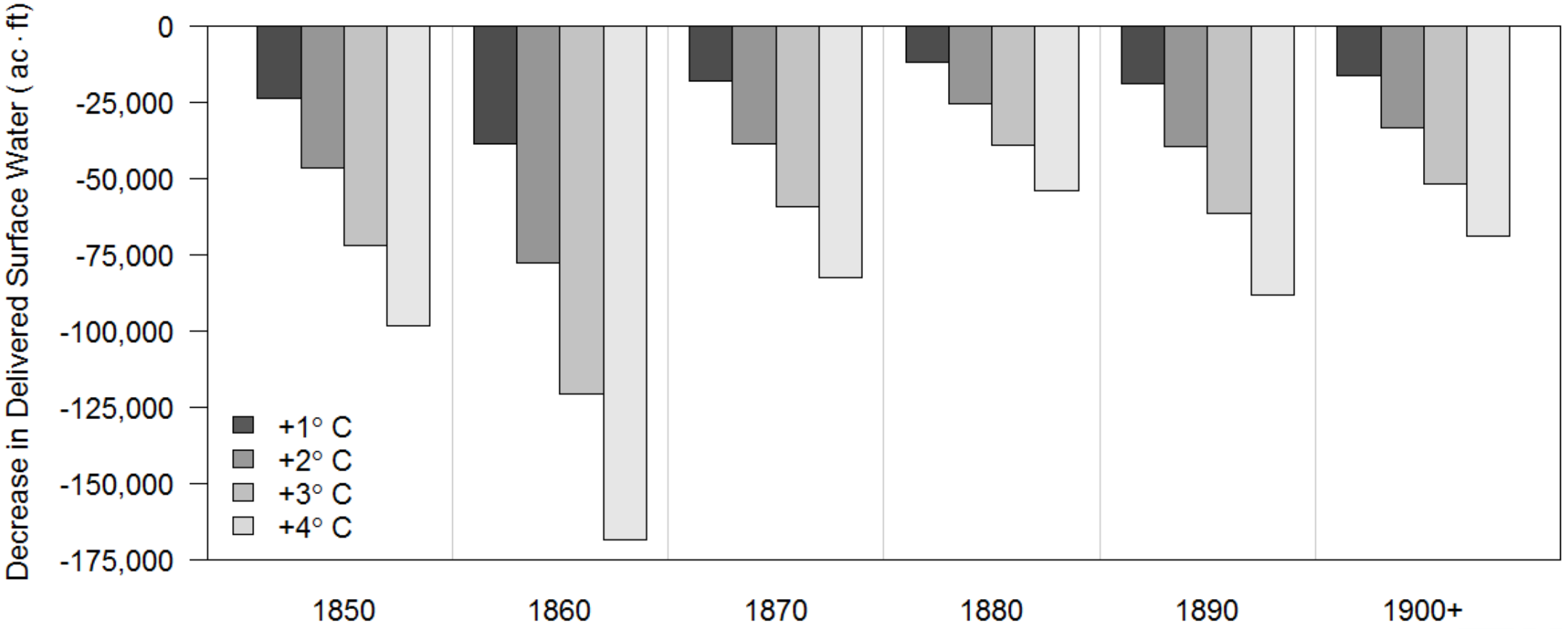
Total Delivery – All Decades
Simulations for 1980-2015
All Results are differenced from Historical +0C



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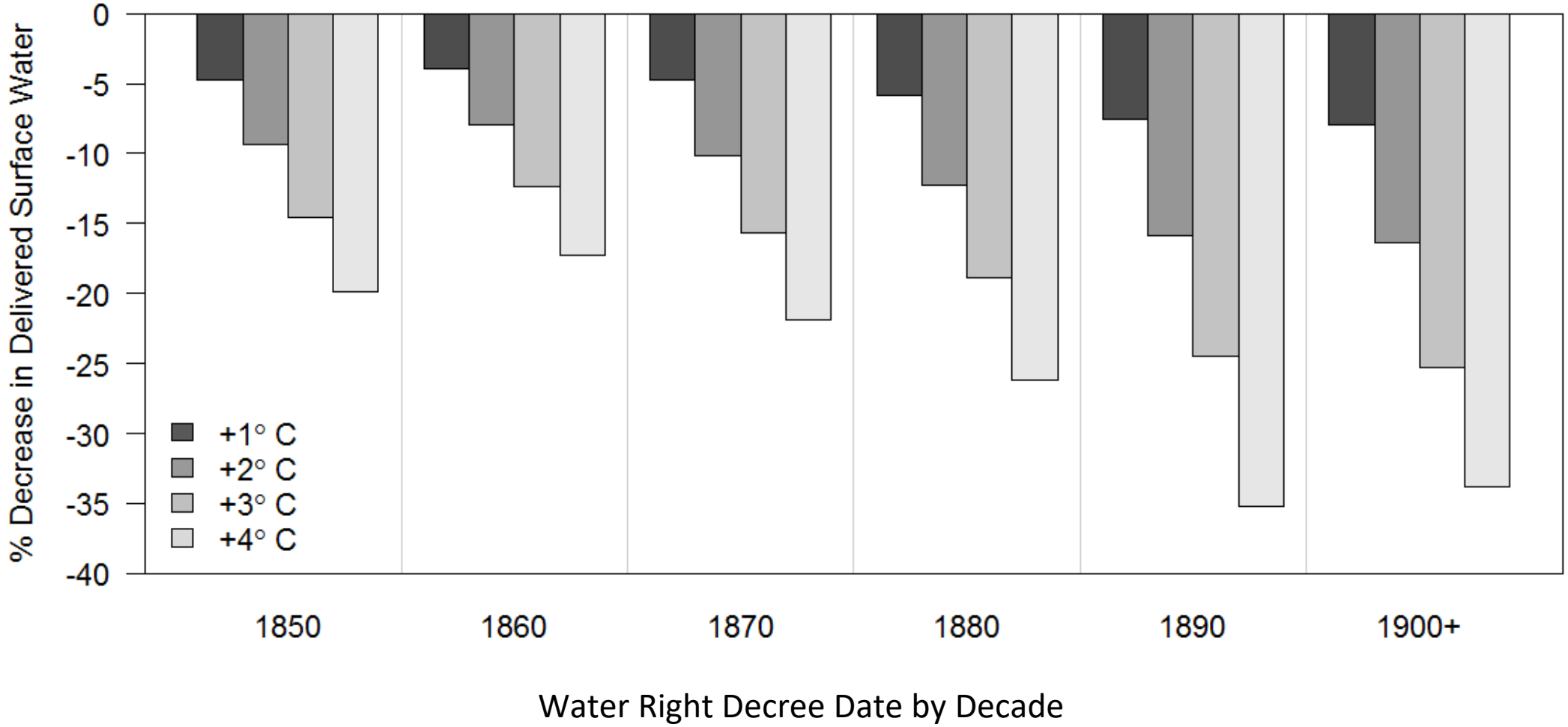
% Change in Delivery – All Decades



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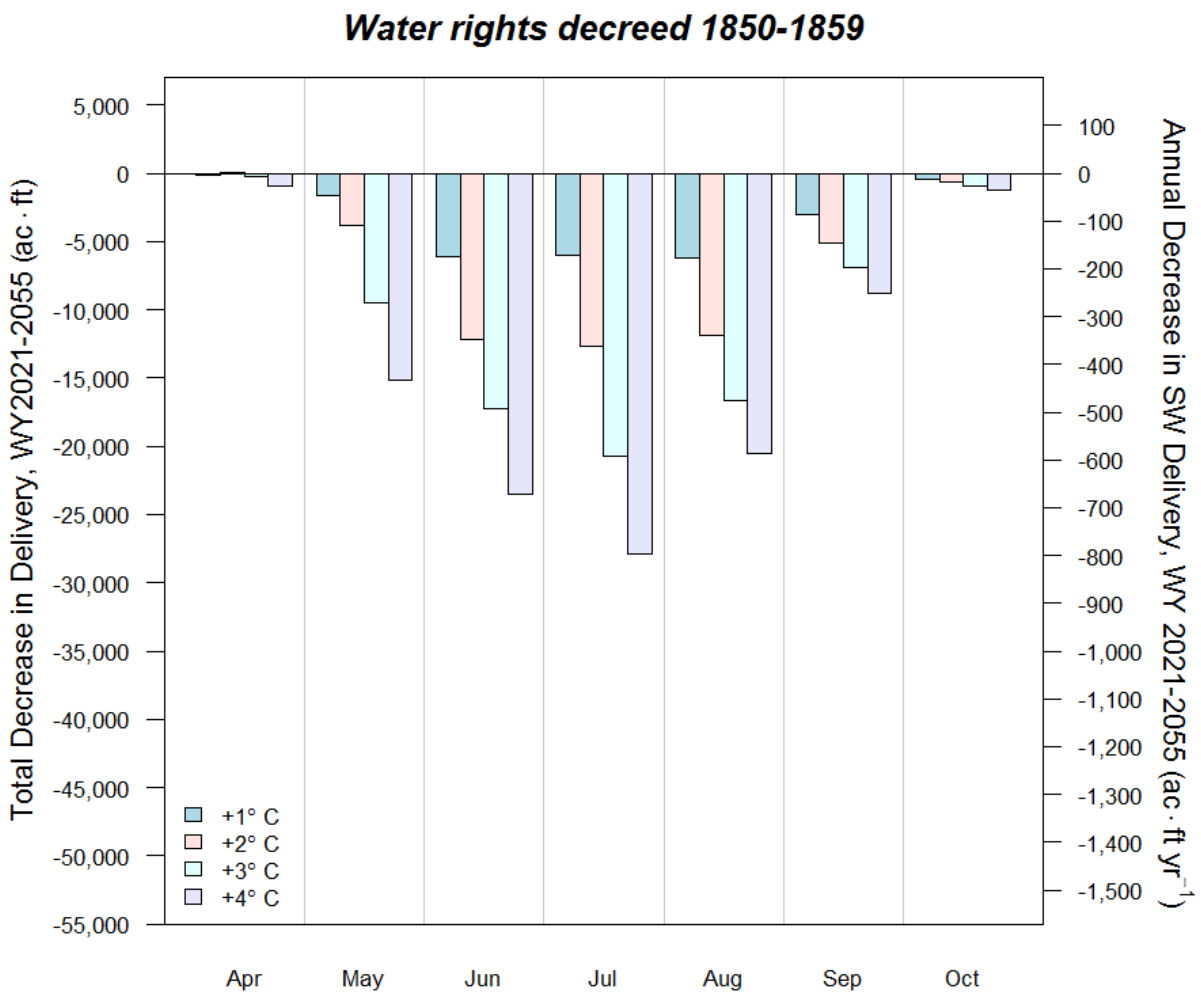
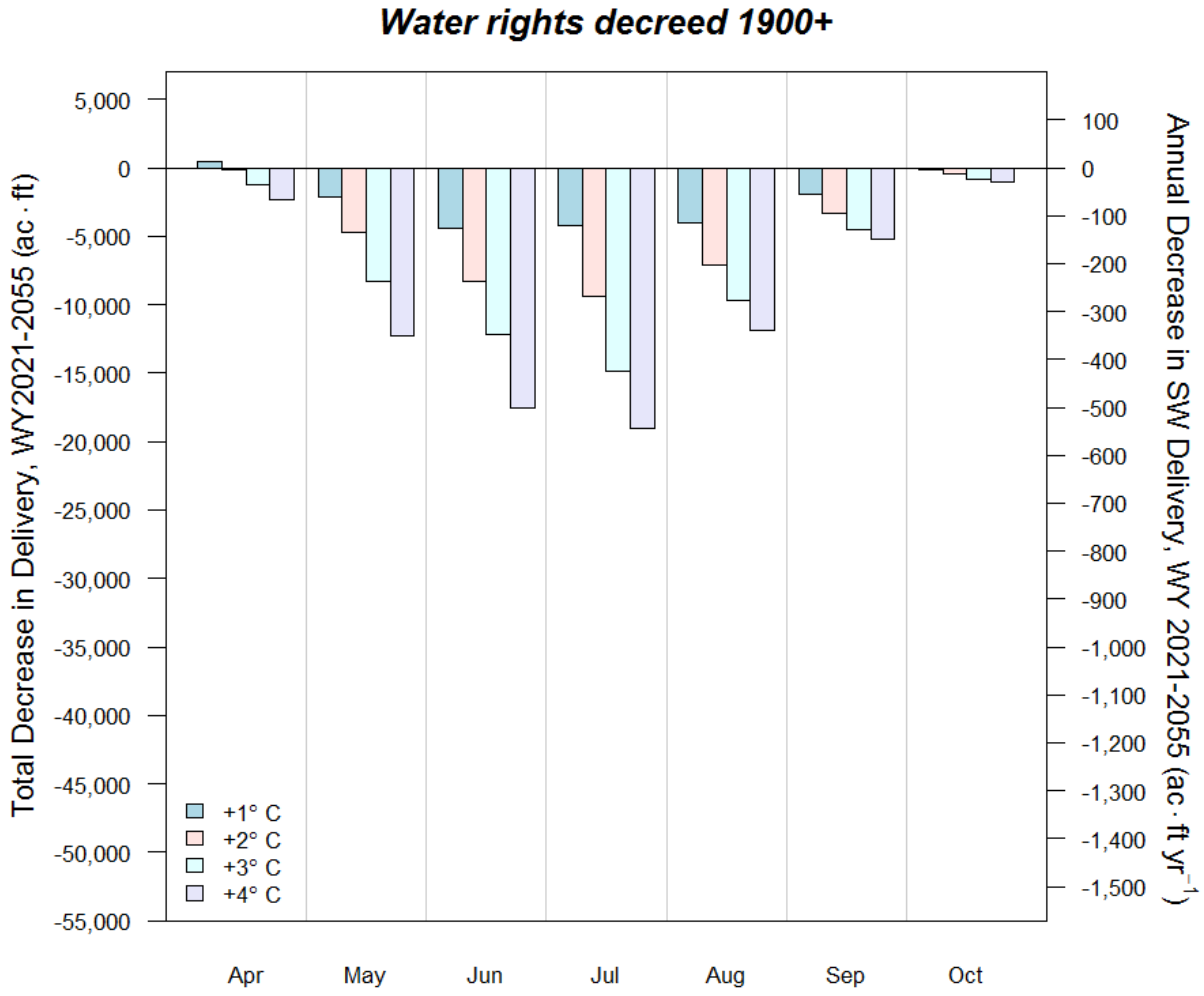
Total Delivery – first/last decade of decreed WRs





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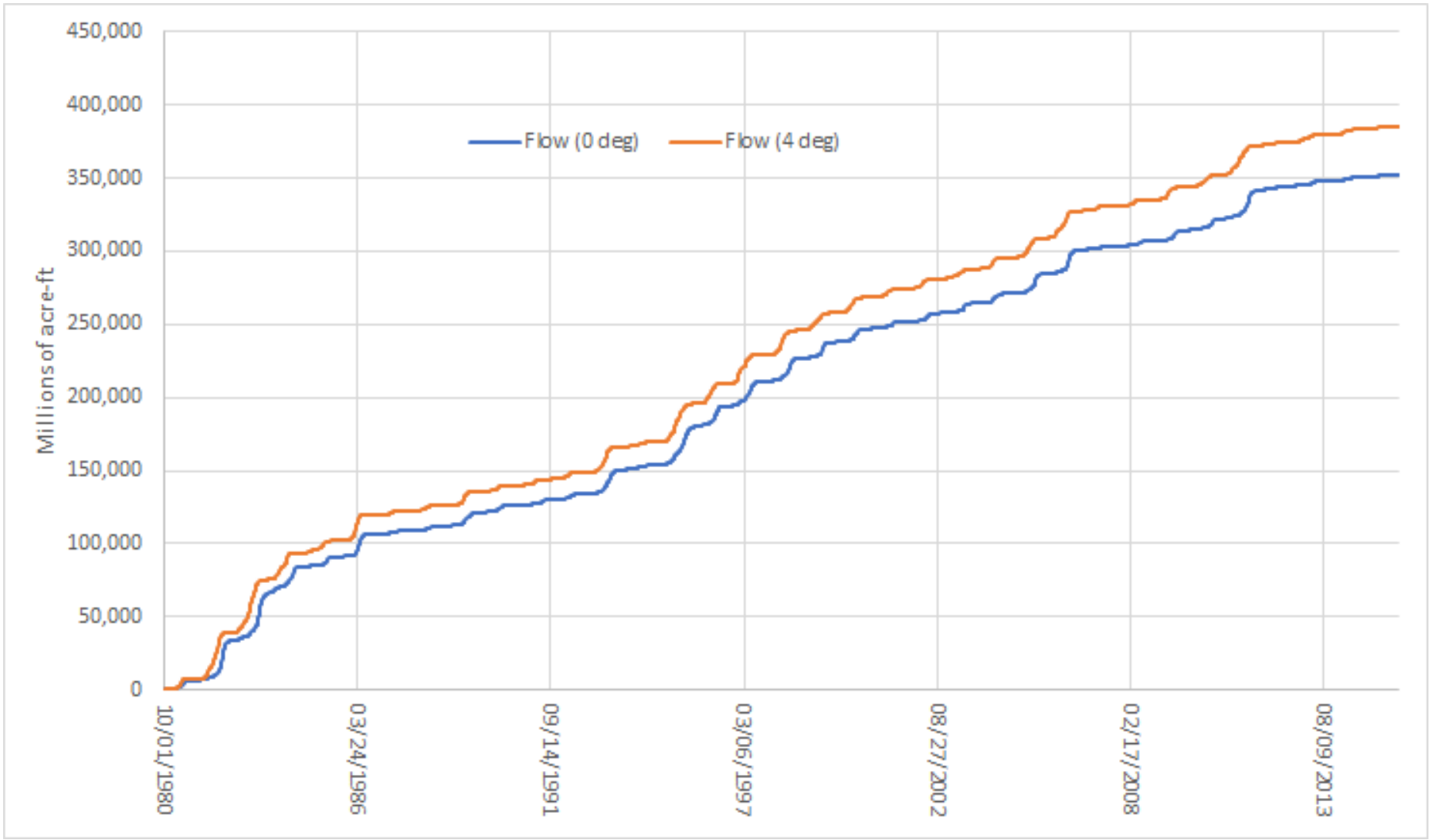
Cumulative Flows at Ft. Churchill



Average increase of 22,000 acre-ft per year of water flowing to Lahontan

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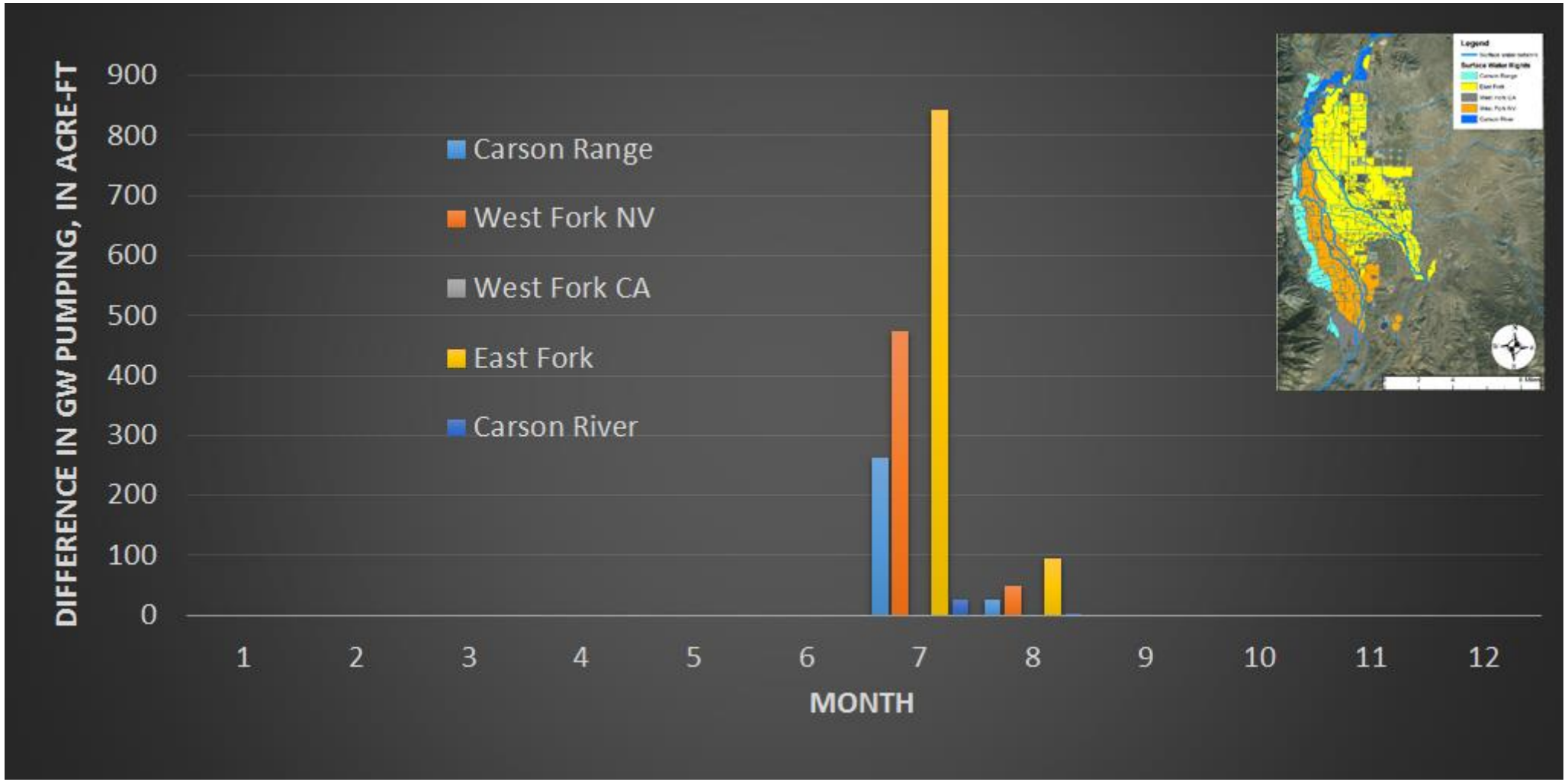
Increases in Supplementary Pumping



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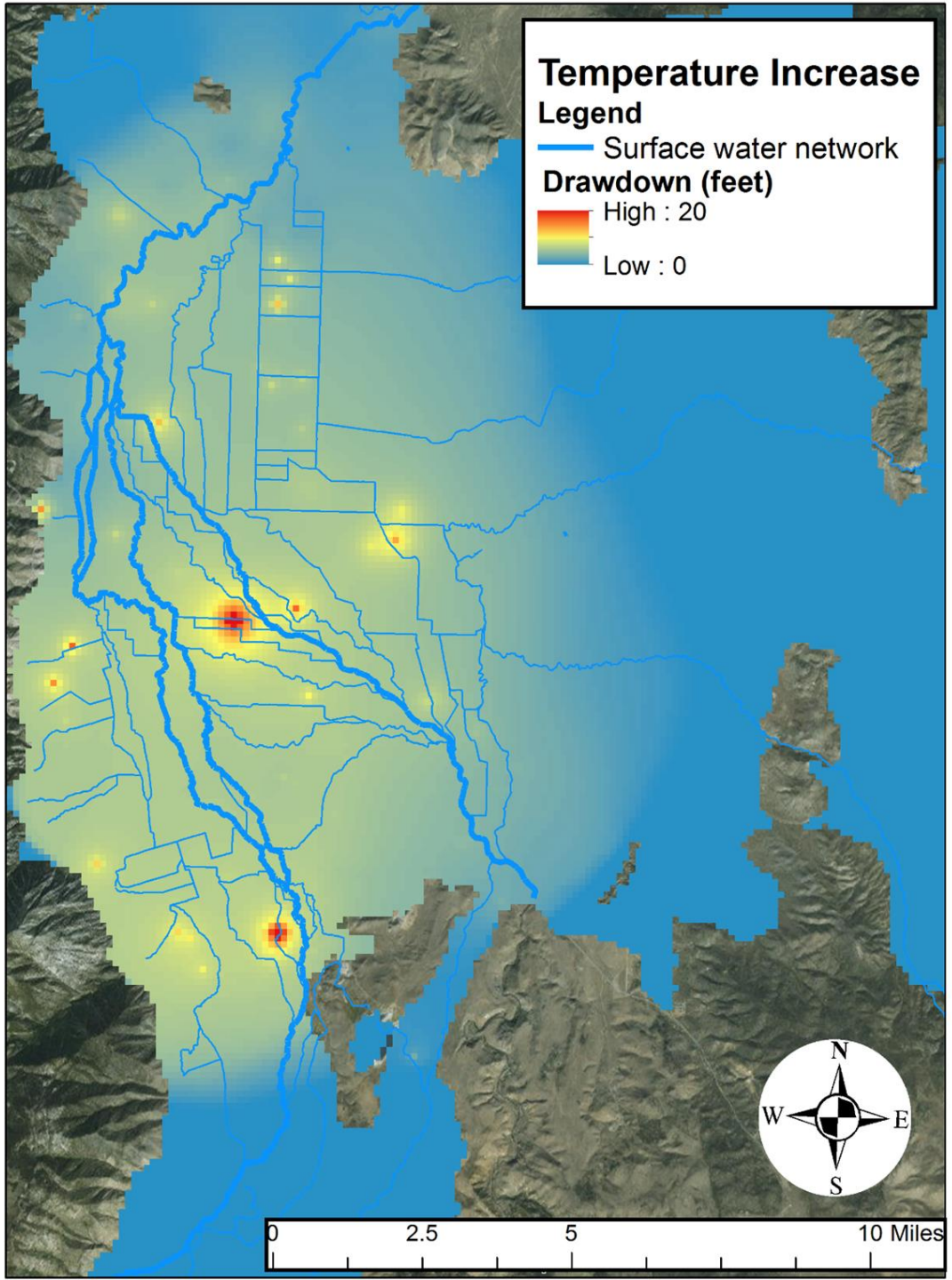

Differences in GW drawdown (+4.3C)

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Thank you

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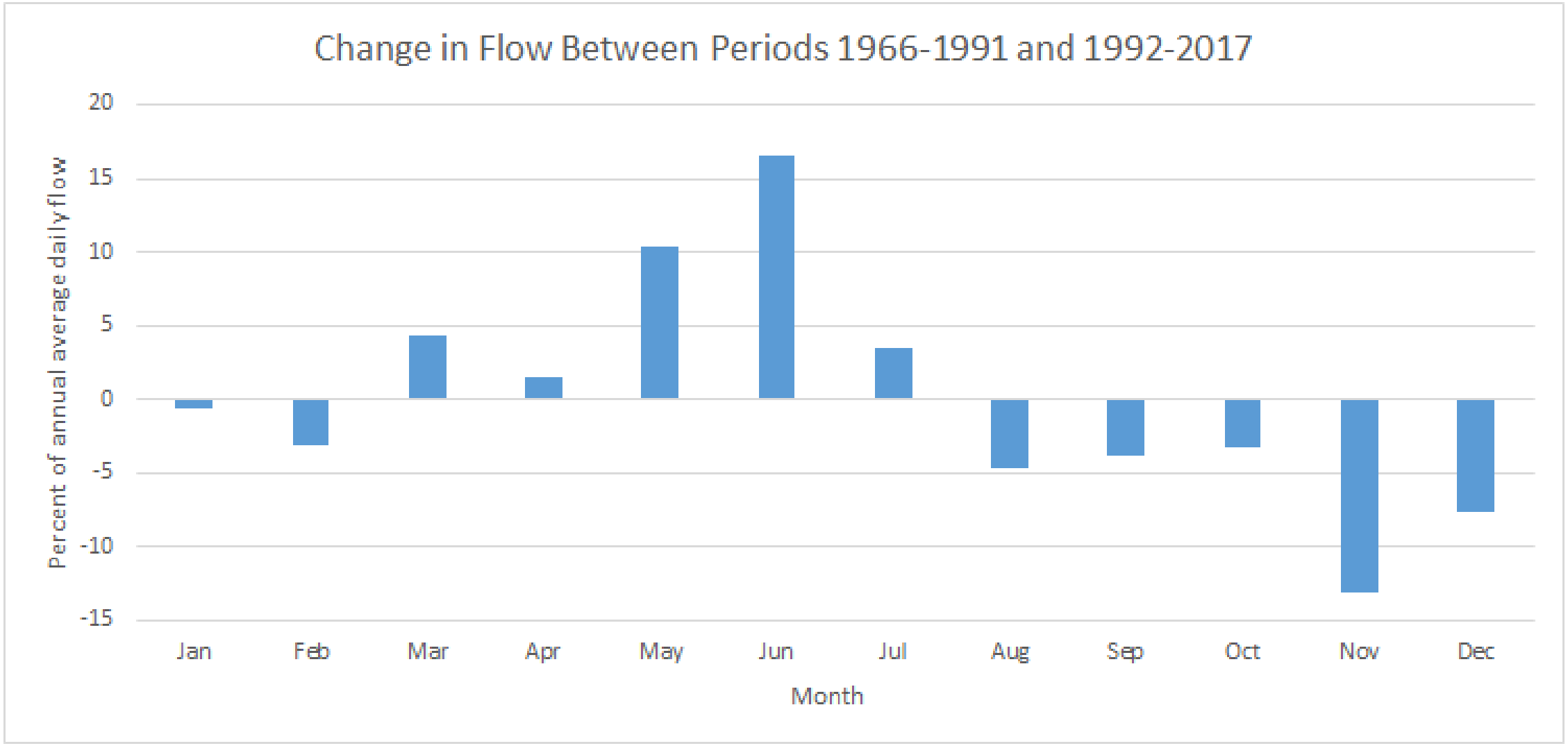
Review Historical Data

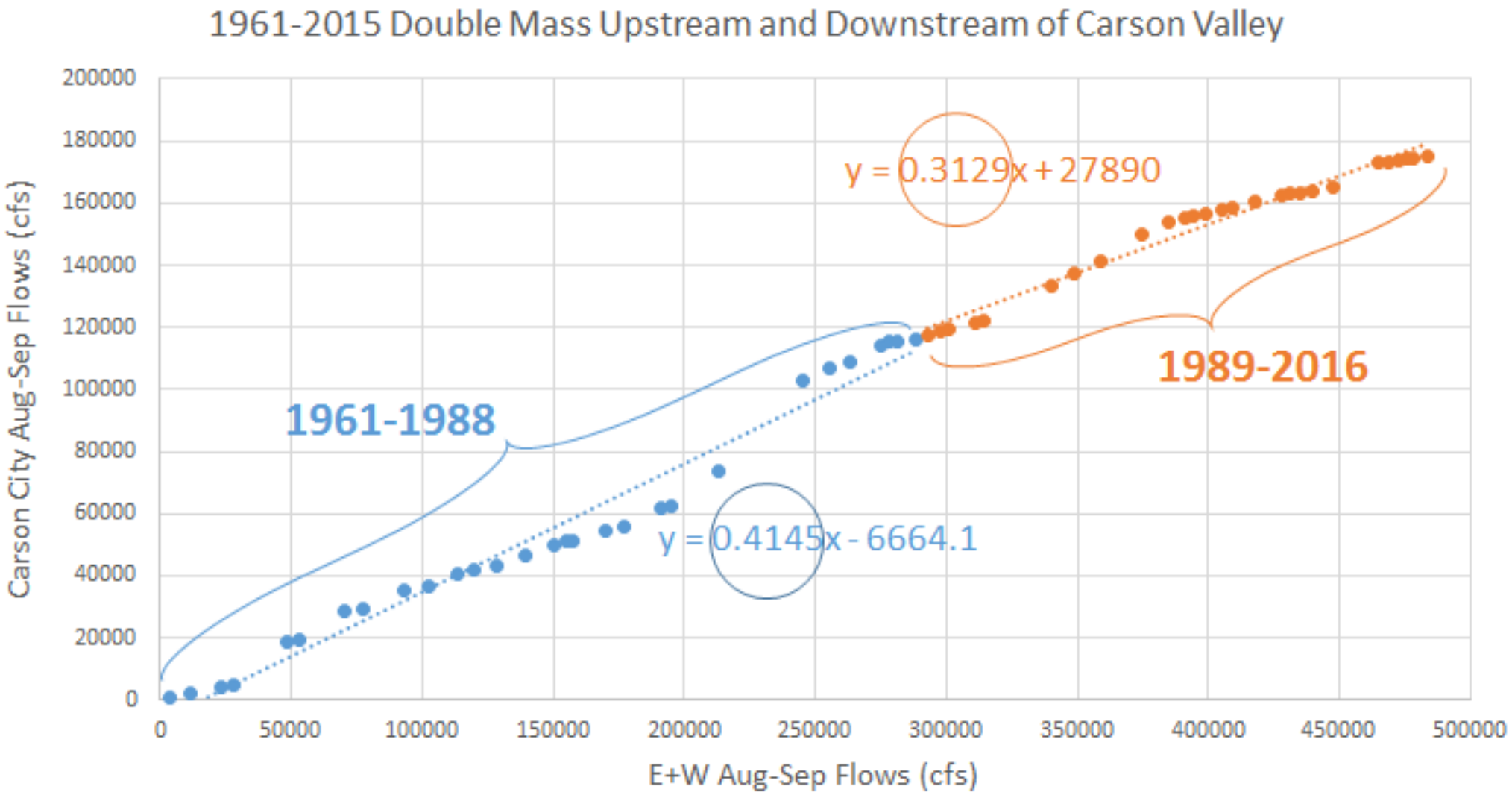
Is historical water use sustainable?

Can we already see the impacts of climate change?

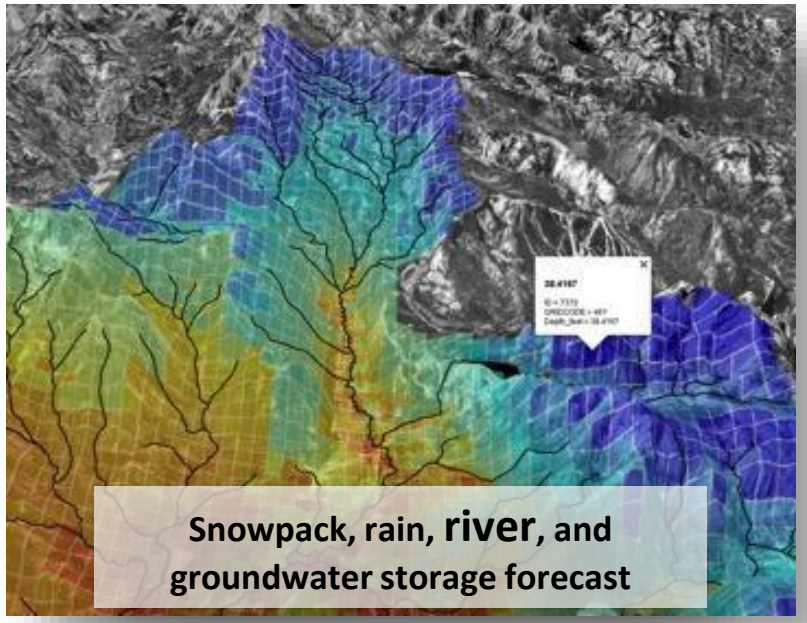
Measured flows on East Fork Carson at Gardnerville

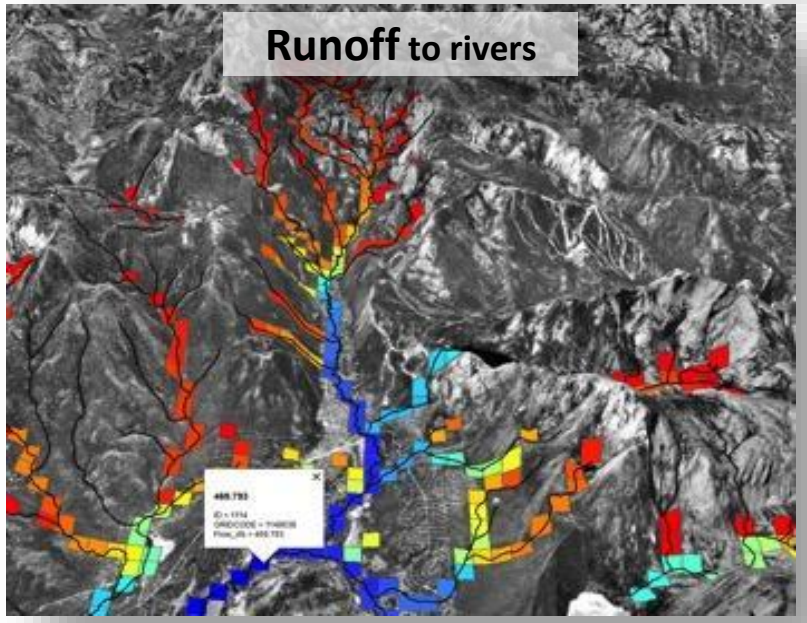


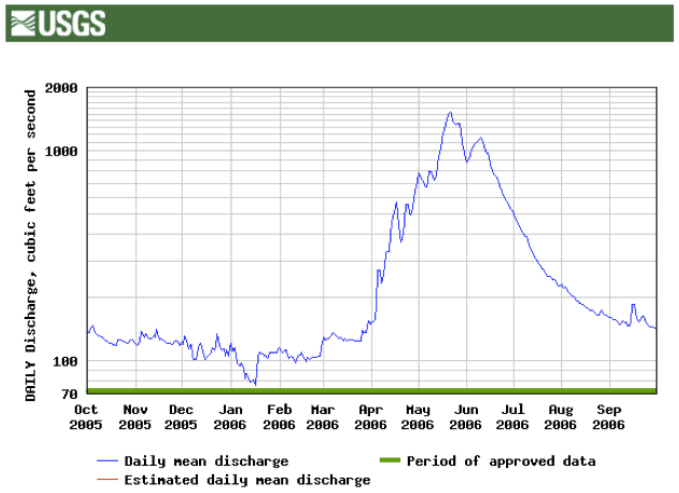
Relationship between inflows and outflows through Carson Valley has Changed (Aug-Sep)



Components of water supply and consumption

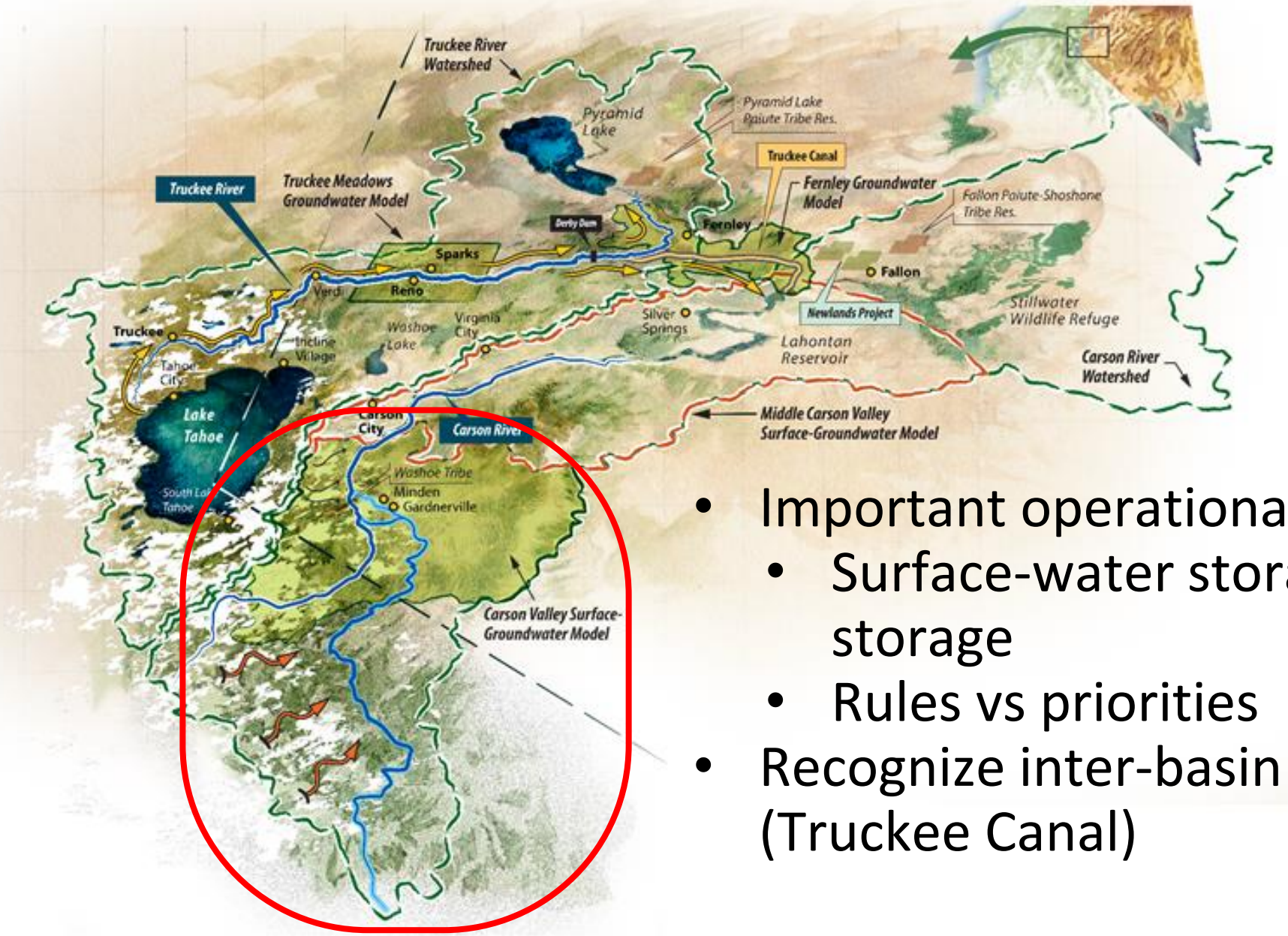






Water allocations for agricultural, municipal, and industrial uses; conjunctive use

Truckee-Carson System



- Important operational differences
  - Surface-water storage vs groundwater storage
  - Rules vs priorities
- Recognize inter-basin dependencies (Truckee Canal)

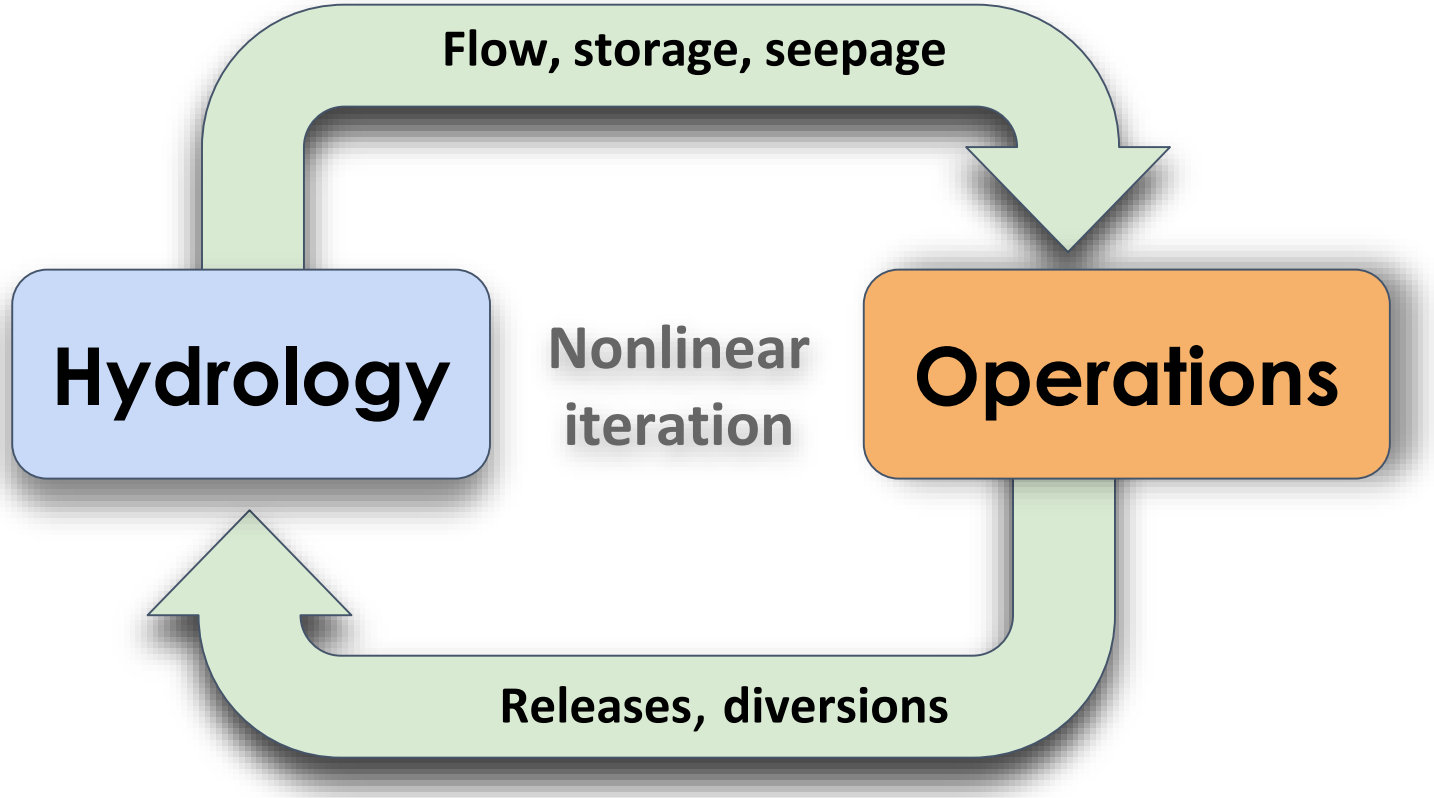
Introduction

- **Operations modeling benefits from hydrology model**
  - more realistic representation of SW-GW exchanges,
  - account for impacts of GW pumping on surface-water operations
  - conjunctive use (track GW supplies)
  - dynamic inflows (watershed, tributary inflows)

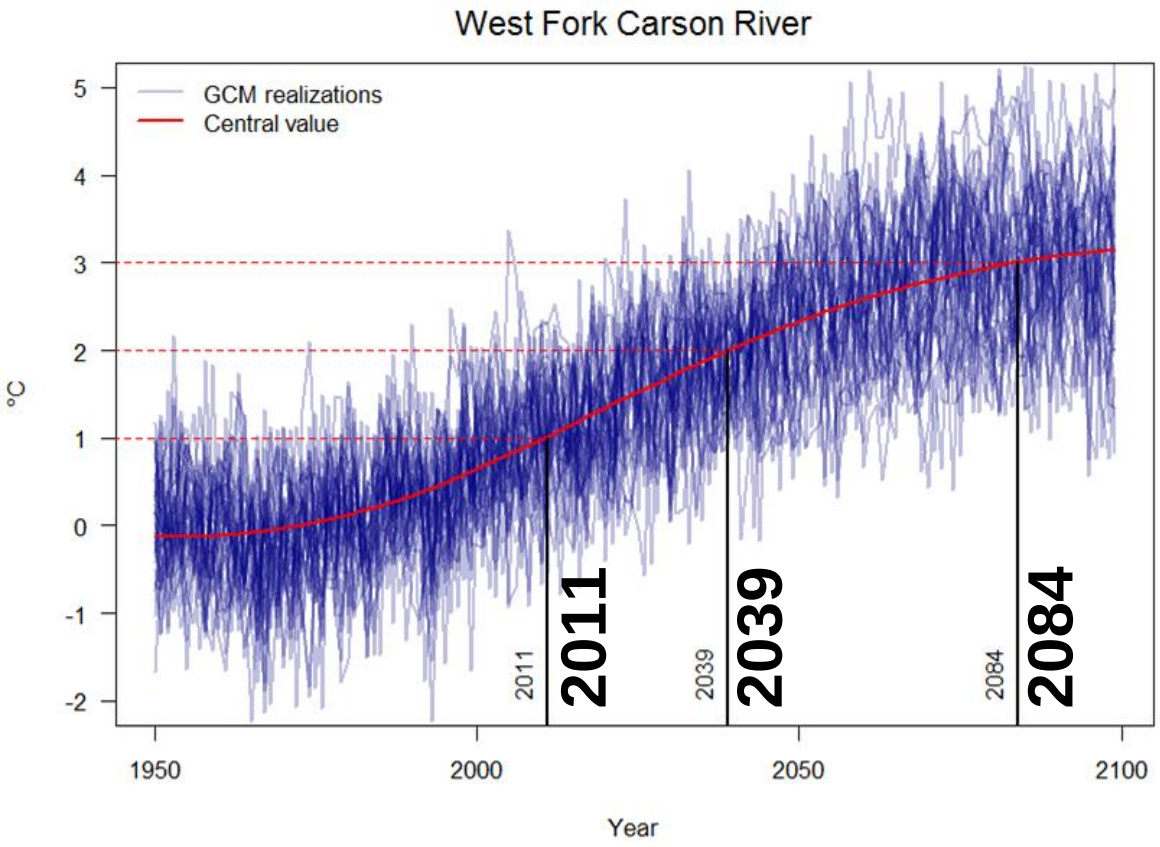
- **Hydrology modeling benefits from operations model**
  - Reservoir operations
  - Distributed diversions, water governance (priorities, rules, banking)
  - Water use
  - Water markets
  - 3rd-party impacts

Integrated Hydrology-Operations Model that Considers Nonlinear Feedbacks

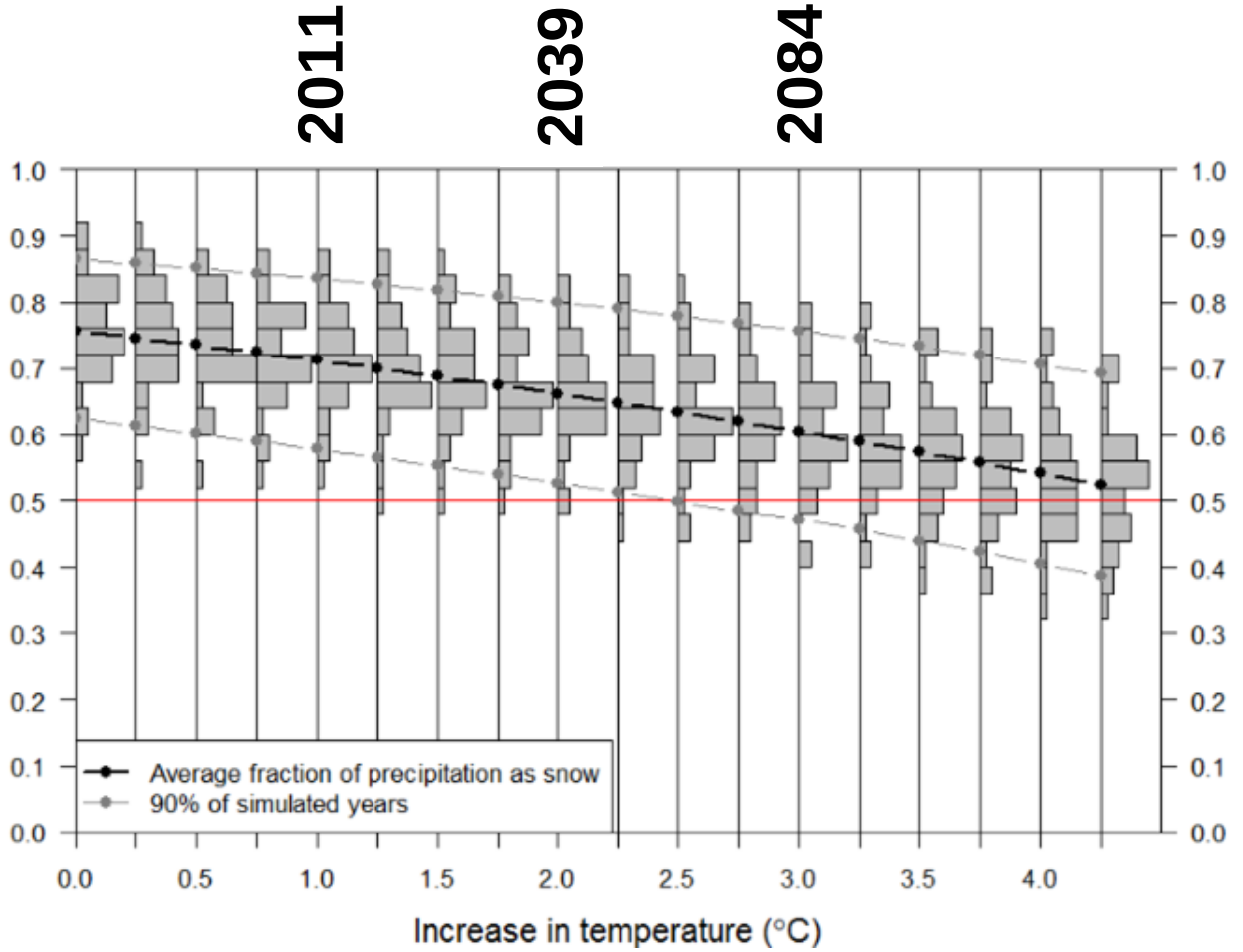
Nonlinear feedbacks illustrated by changes in diversions between iterations

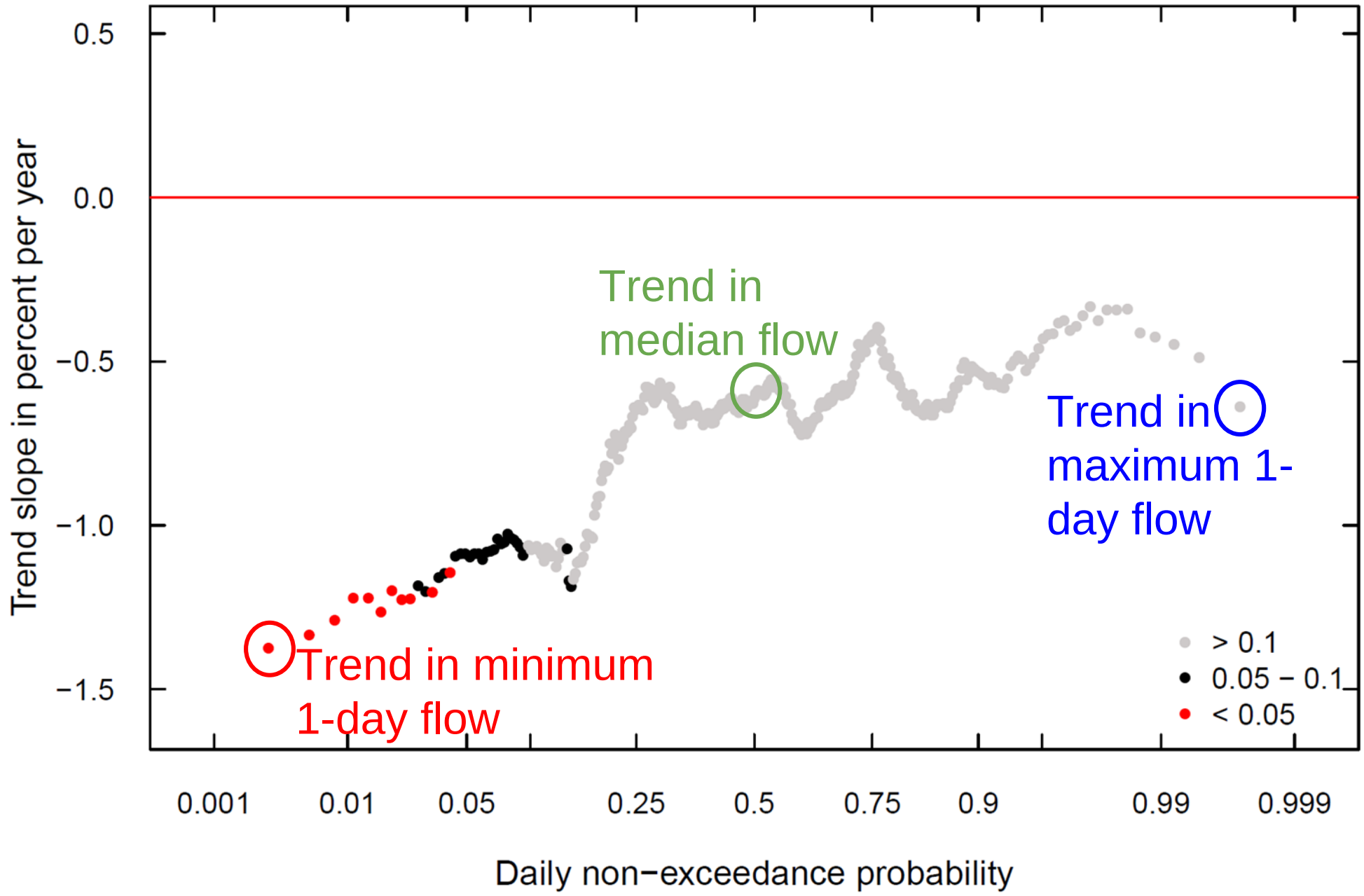


GCM projected increase in temperature for next century for Carson River headwaters



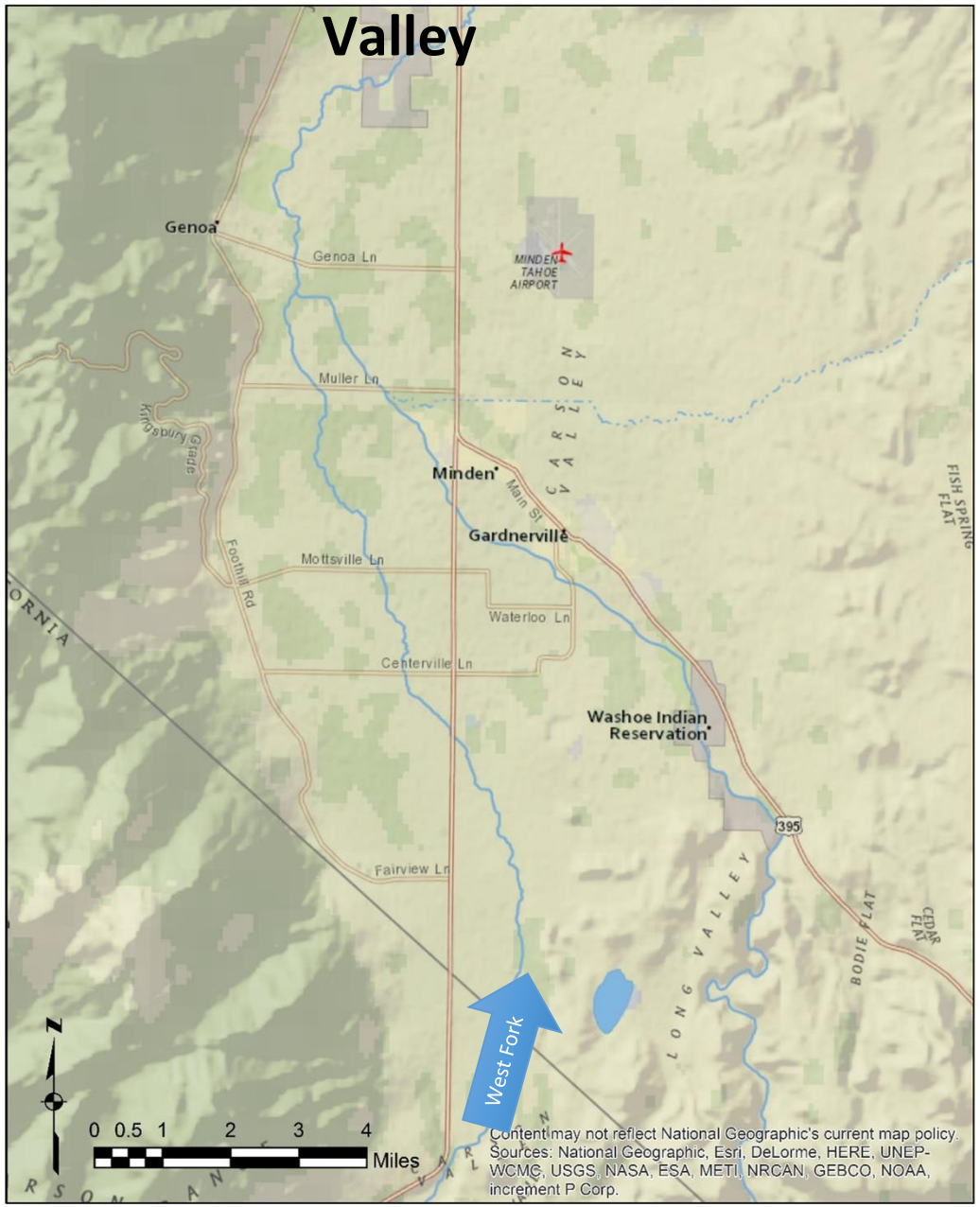
Change in fraction of snow versus rain for different levels of warming



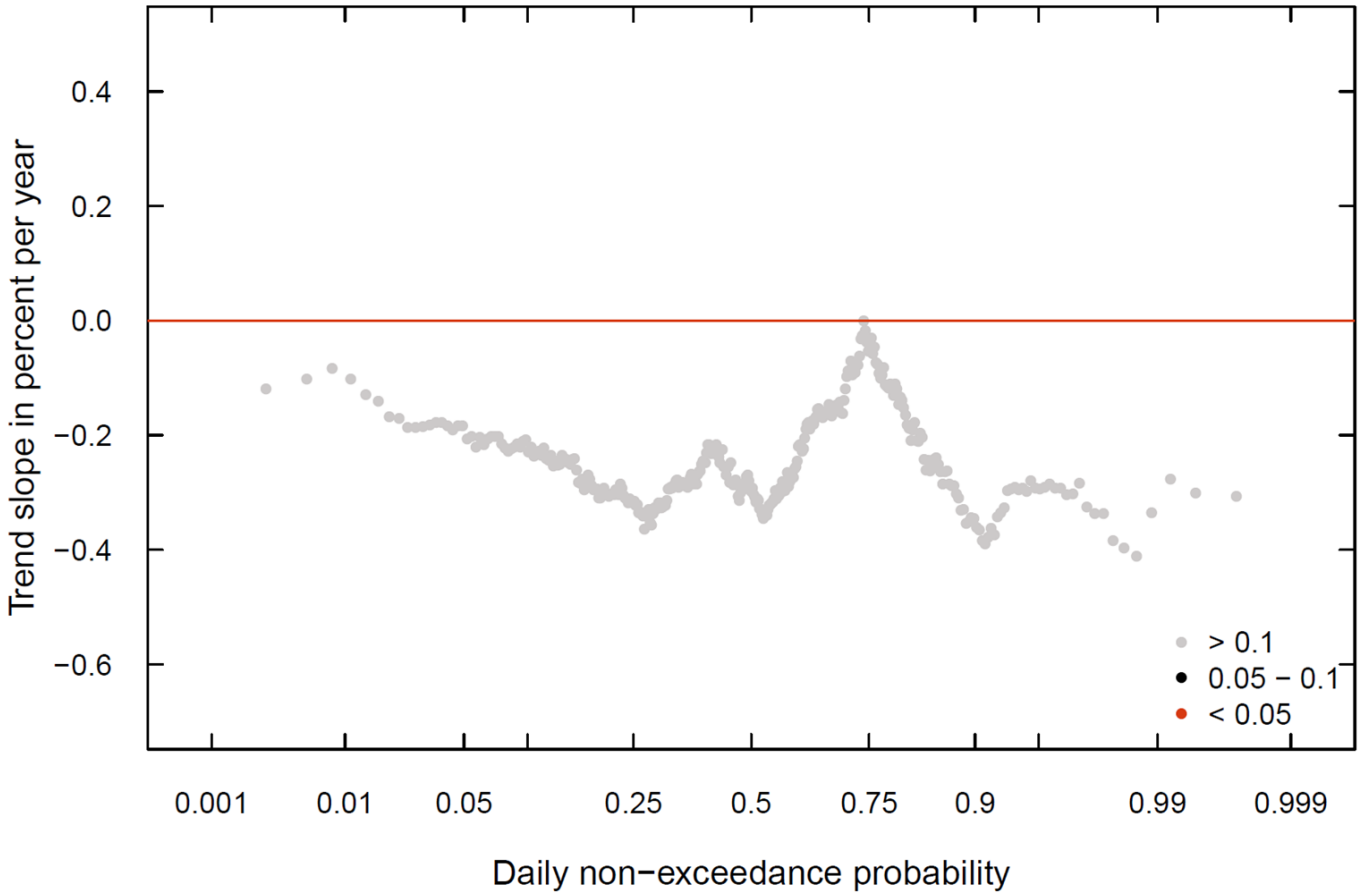


Source: Robert Hirsch, USGS

Carson Valley



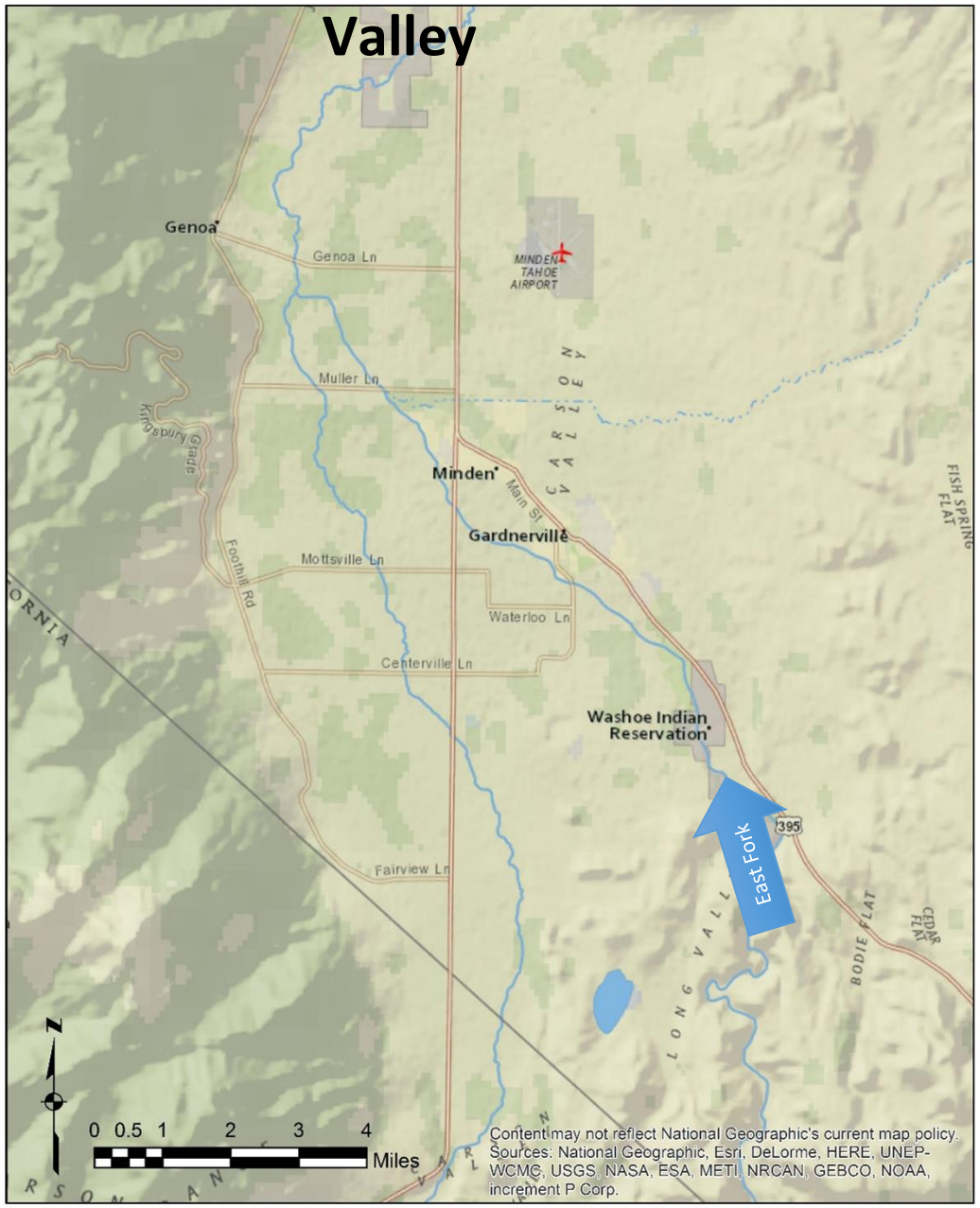
West Fork Inflows



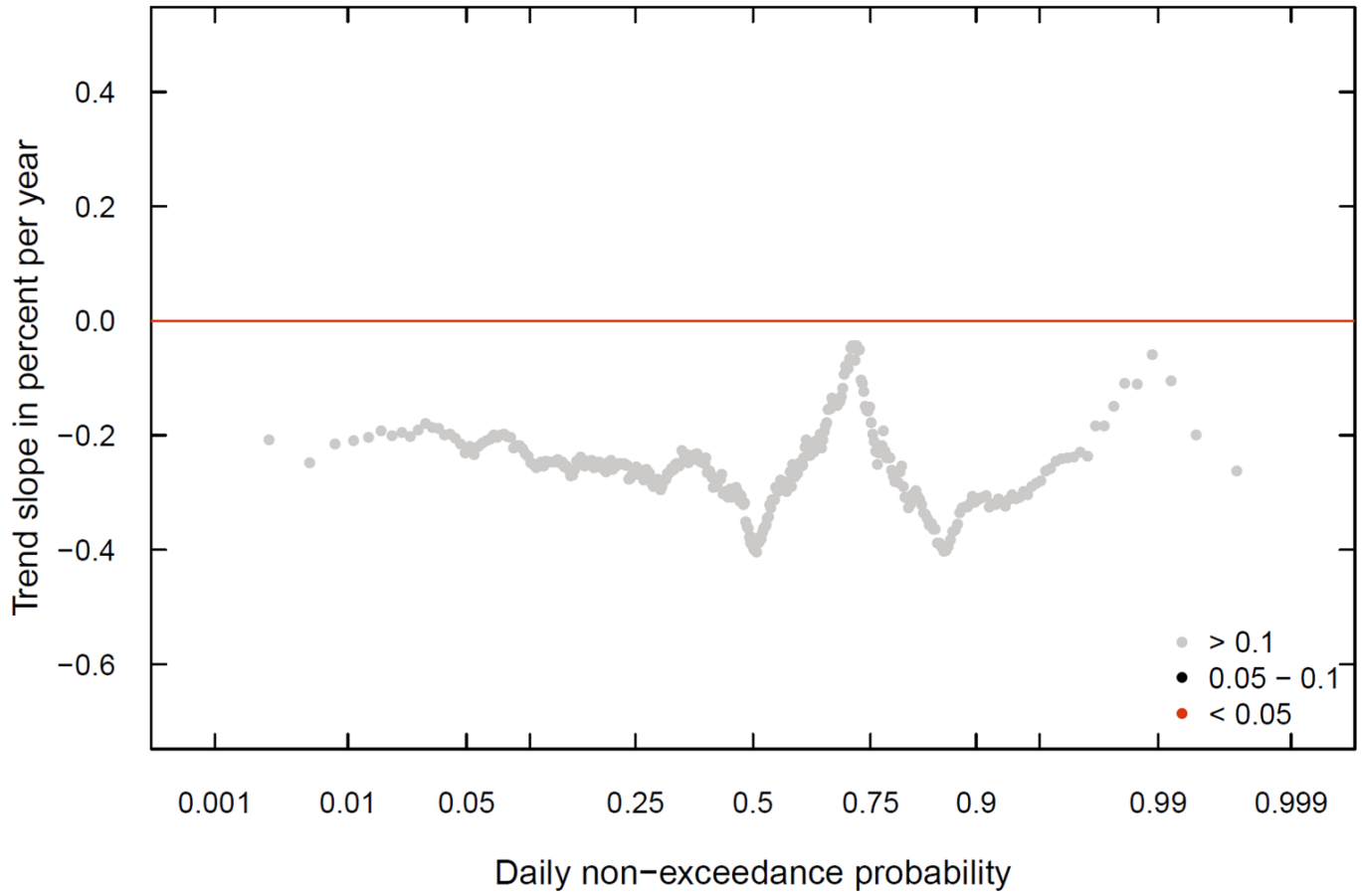
- Ranked each water year's daily flows, starting in 1939
- Trend calculated as percent change per year for each exceedance probability

Source: Robert Hirsch, USGS

Carson Valley

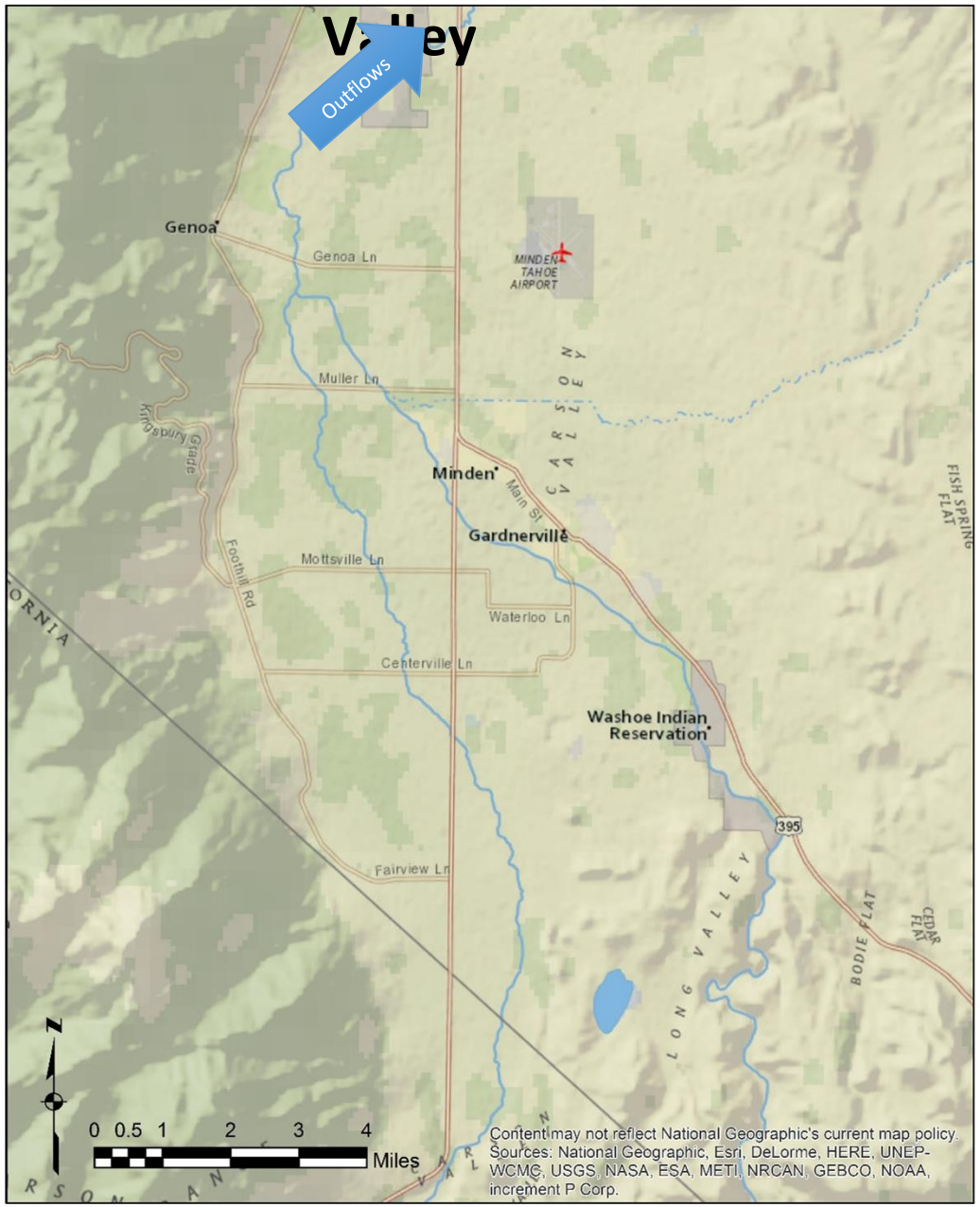


East Fork Inflows

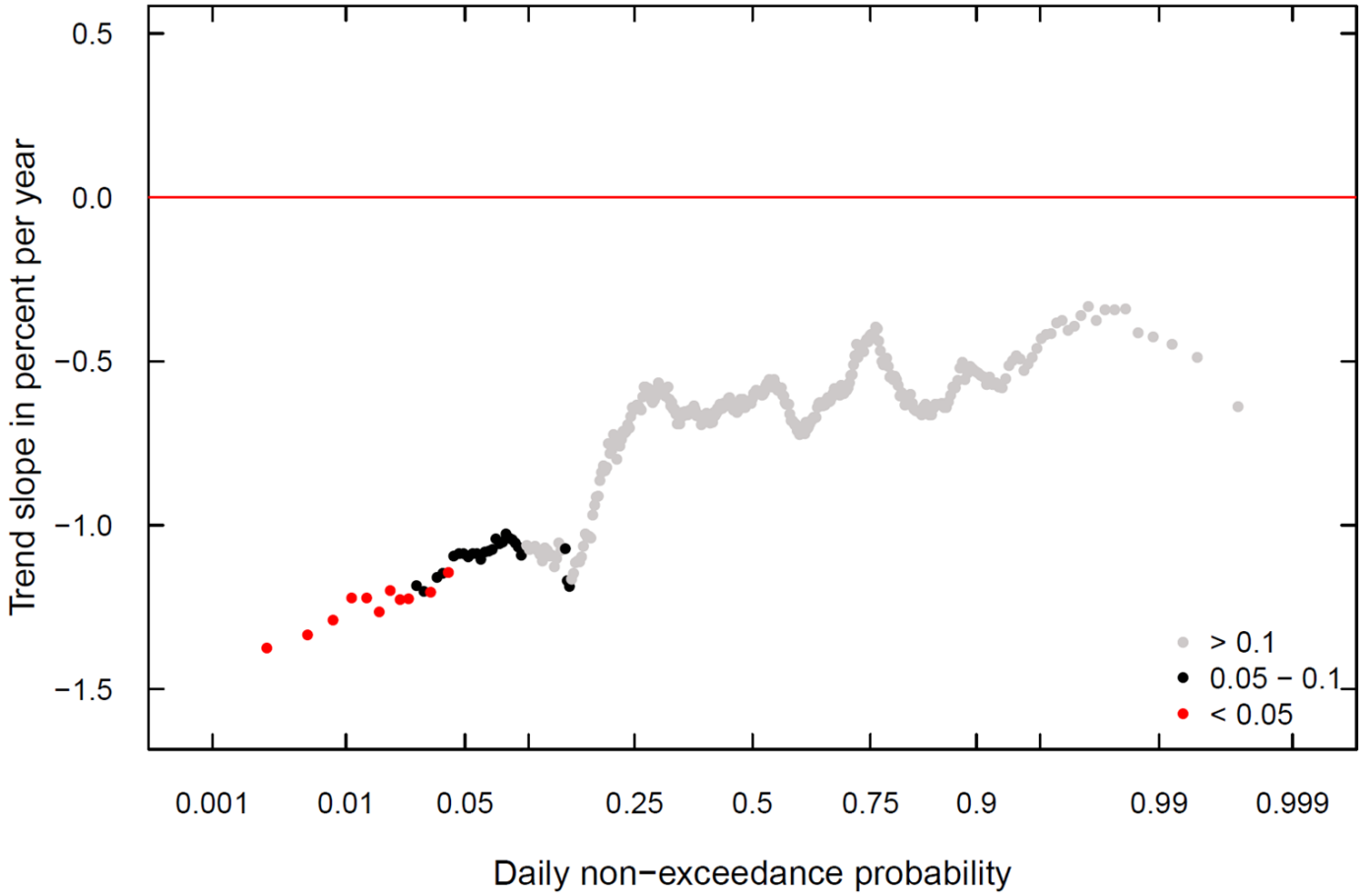


Source: Robert Hirsch, USGS

Carson Valley



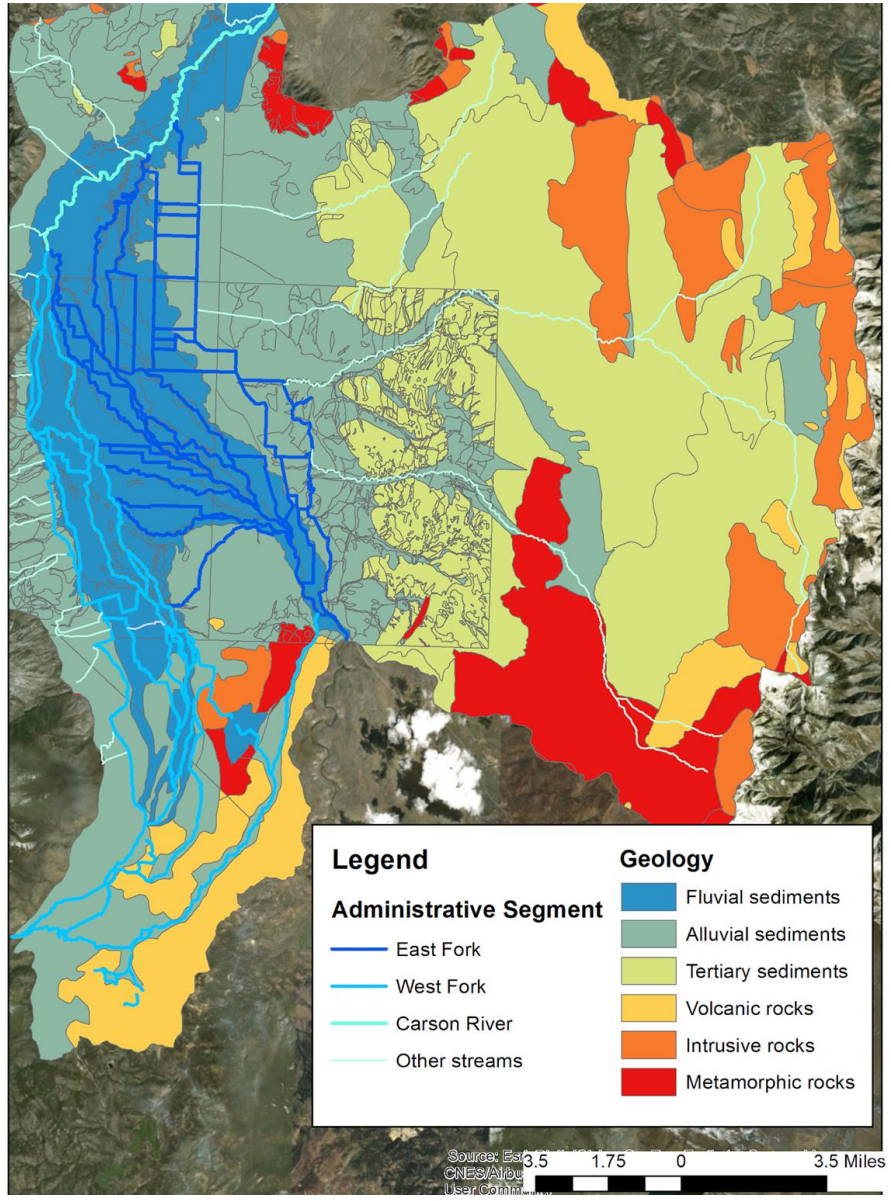
Outflows

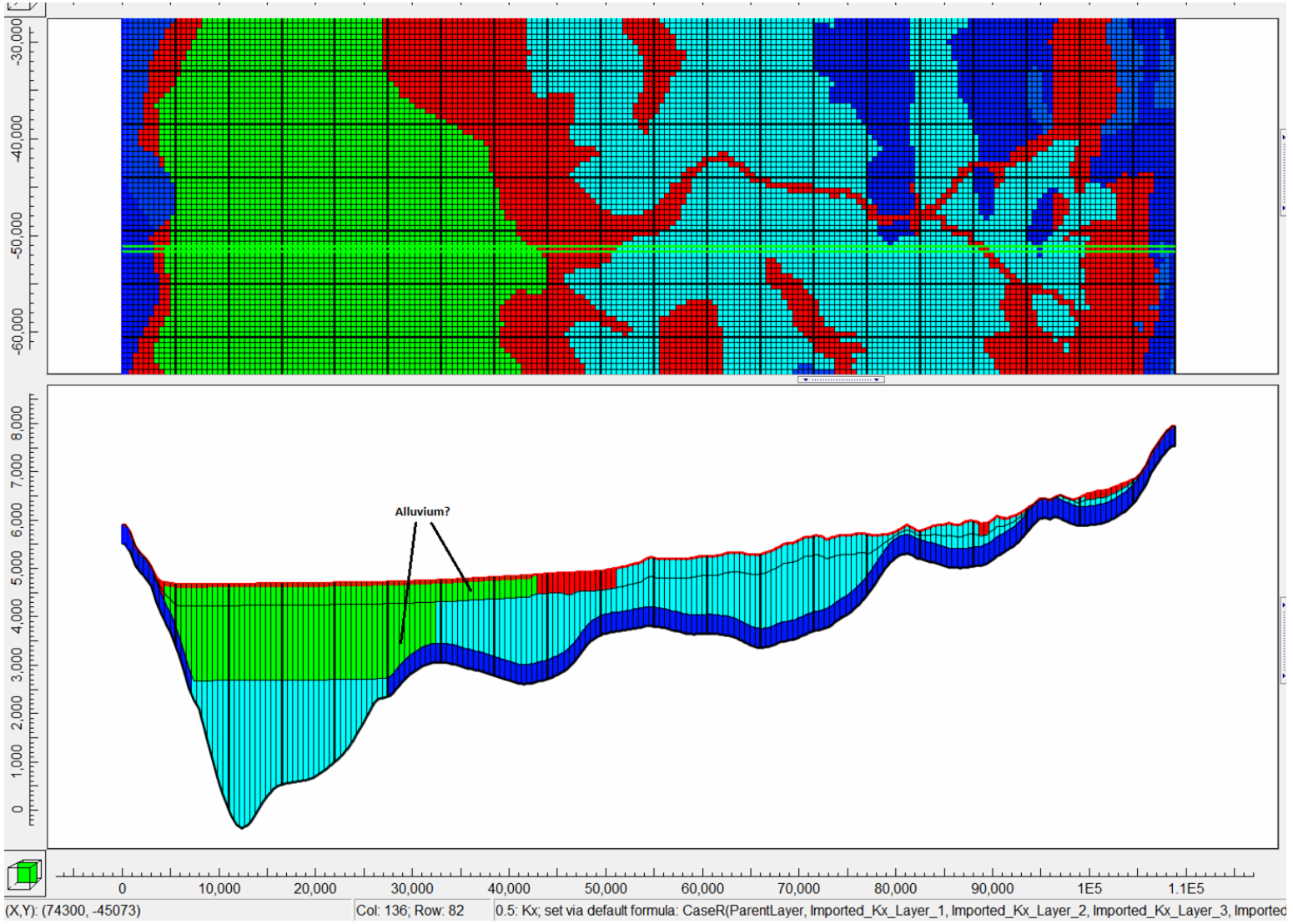


- Low flows (< 0.05) are decreasing at an average annual rate of 1-1.3%"

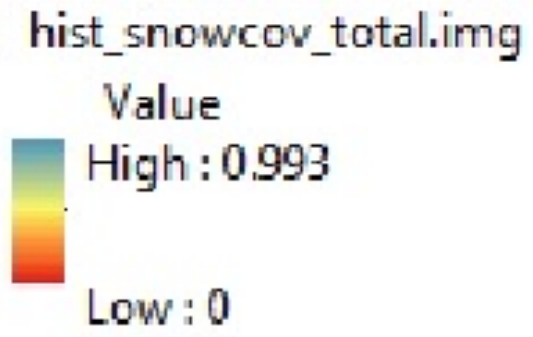
Source: Robert Hirsch, USGS

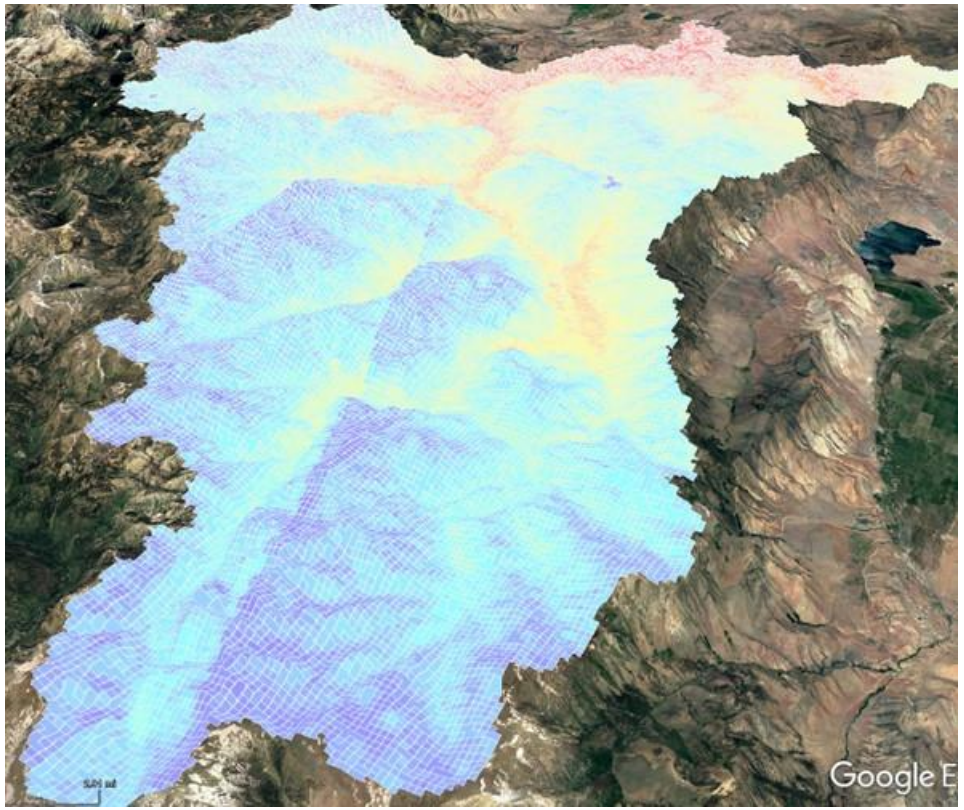
Upper Catchment & Carson Valley Hydrology Models



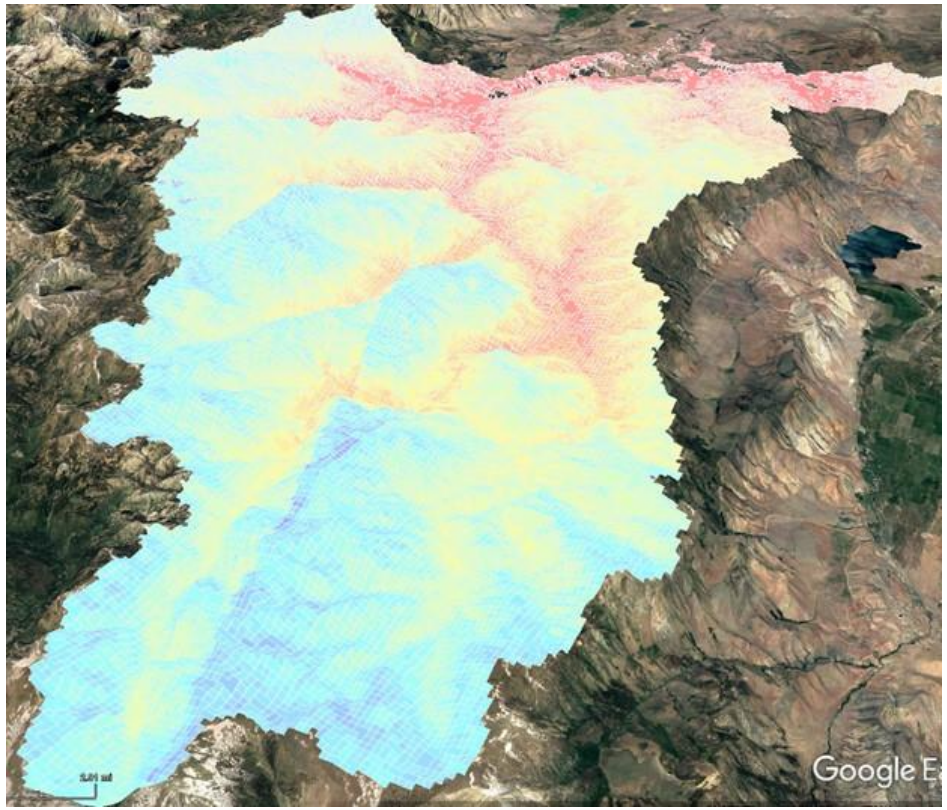


Average Snow Covered Area for Period 1980-2015





Historical



Historical +4.3C

Review Results from SAG4

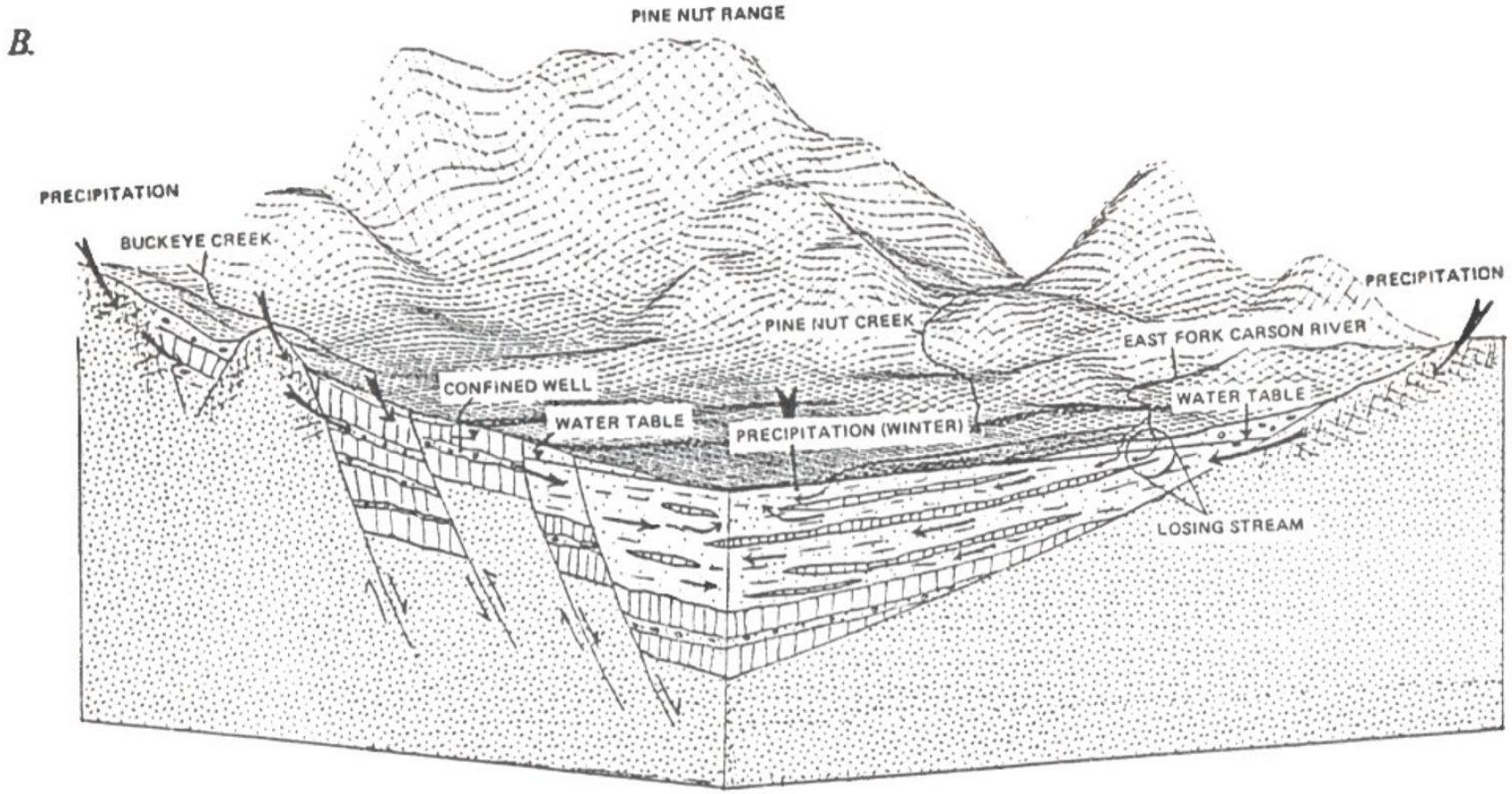
1. +4.3 degree historical simulation

1. Results presented as decreases in water delivery by administration segments

1. Increases in pumping; overdrafted aquifers; not sustainable

1. Runoff occurs during winter before irrigation season; increase in flow to Lahontan

Schematic of Pine Nuts – East Valley



From: Maurer, 1986

How much will fit?

- Rough estimate:
  - 5600 acres
  - 20% specific yield (porosity)
  - Increase water levels 20’ on average
  - Answer: about 22,400 acre-feet
- Complex geology presents site-specific issues
  - Requires site-specific evaluation
- Simulations are an improvement of “rough estimate” and help focus “site-specific” evaluations
  - Includes estimate of uncertainty in parameters (hydrologic properties)

Potential Impacts

- Elevated groundwater levels
  - Flooding
  - Water logging
  - Keep wells saturated
  - Increase soil moisture
- Potential impacts to municipal wells
  - Arsenic (??)
  - Replenish aquifer with fresh water
- Previously unirrigated lands
  - Legal and logistical issues with winter irrigation on “new” land
  - Undocumented hydrologic response
  - Increased knowledge of the system

Sept 1999

- Old surface storage
- Seeps near airport

Oct 2006

- Phase out old storage
- New lined storage
- Increased GW use
- Seeps fading

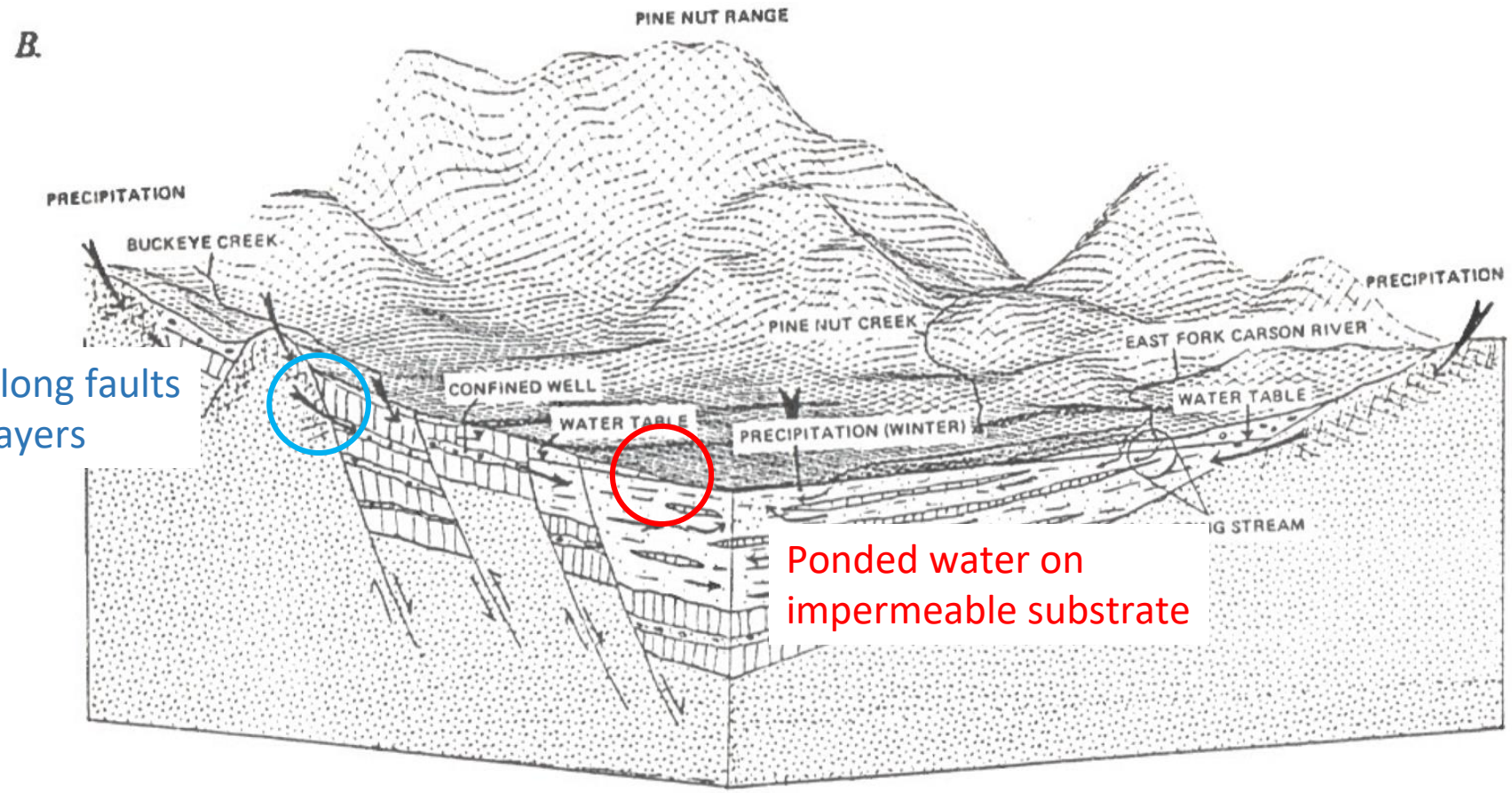
Sept 2008

- Seeps gone


Pine Nut Creek
Buckeye Creek
Old DCSID holding pond
New DCSID holding pond
Allerman Canal
South Reservoir
Virginia Canal
Old Dangberg 3
Google Earth

Aug 2017

Schematic of Pine Nuts – East Valley



Focus recharge along faults into permeable layers

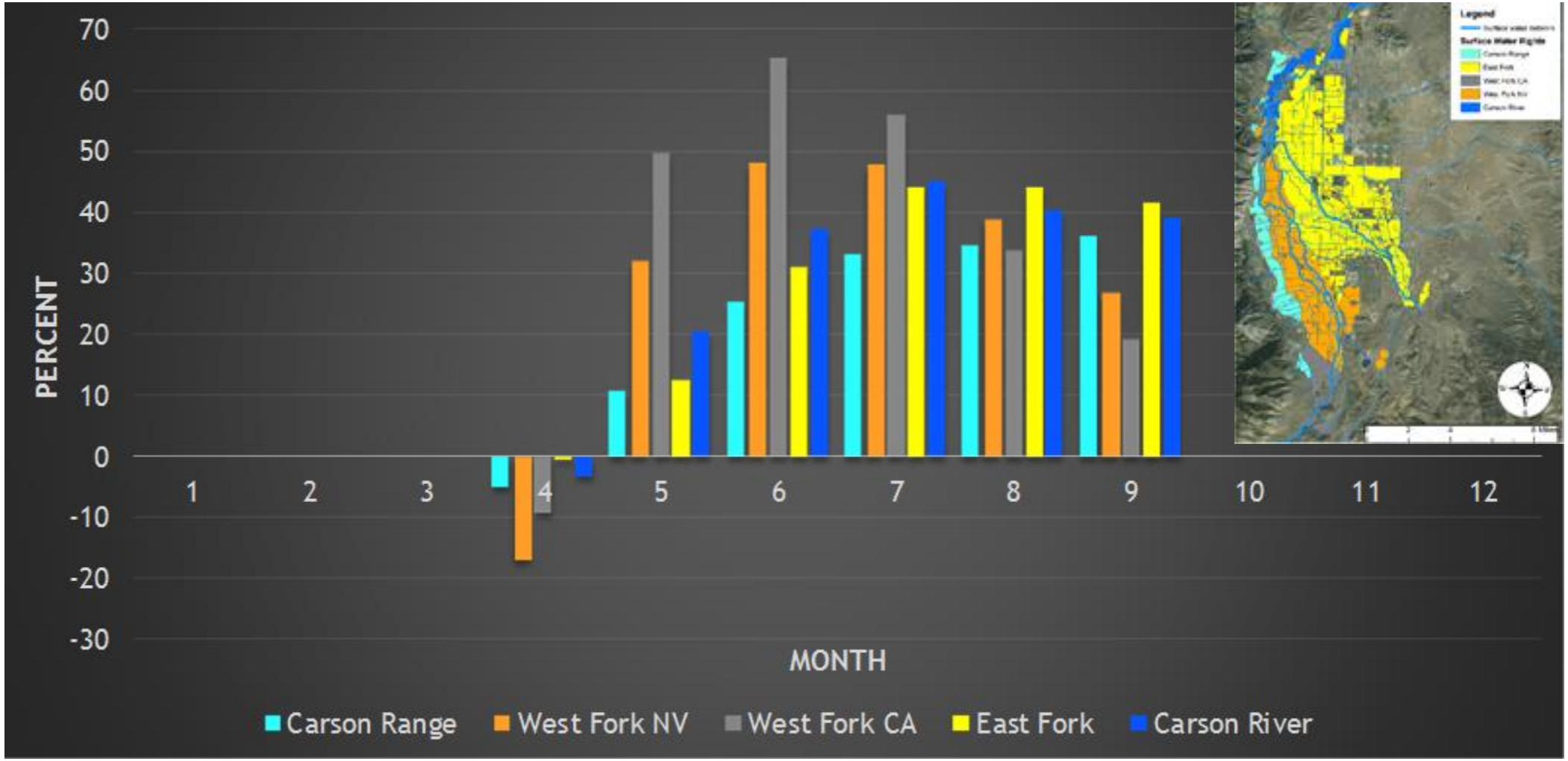
Ponded water on impermeable substrate

From: Maurer, 1986

Successful MAR in the Pine Nuts

- Find suitable locations
  - Coarse grained deposits
  - Recharge along faults
- Current modeling effort
  - Uncertainty analysis to bound potential amounts
  - Data worth analysis to guide potential exploration
  - Identify location where GW levels rise to surface
  - Explore timing for maximum benefit, minimum adverse impact

Broad Reductions in Surface Water Delivery



Greater Losses in Carson River Low Flows (Aug-Sep) in Carson Valley

Possible causes:

1) Earlier snow melt and associated earlier onset of aquifer drainage

2) Reductions in bank storage due to flashier hydrograph

3) Increases in groundwater pumping in CV

4) Increases in crop consumptive use and decreases in groundwater recharge (laser leveling, sprinklers, etc.)

Simulation of Climate Change Impacts

- Results were reported by administrative segments in previous SAG
  - Junior rights on East Fork considered regardless of priority on Main Carson
  - Junior rights on West Fork considered regardless of priority on Main Carson
- Results now reported by water right priority year (Alpine Decree)
- Future: Google Earth interface where resulting deliveries for each water right can be explored by the user?

Managed Aquifer Recharge in Carson Valley

Where would the water come from?

- Earlier snowmelt increases pass-through water (22k acre-ft by 2084)

- Simulations indicate decreases in ET in East and West Fork Watersheds (5-7% or 16,000 to 23,000 acre-feet per year)

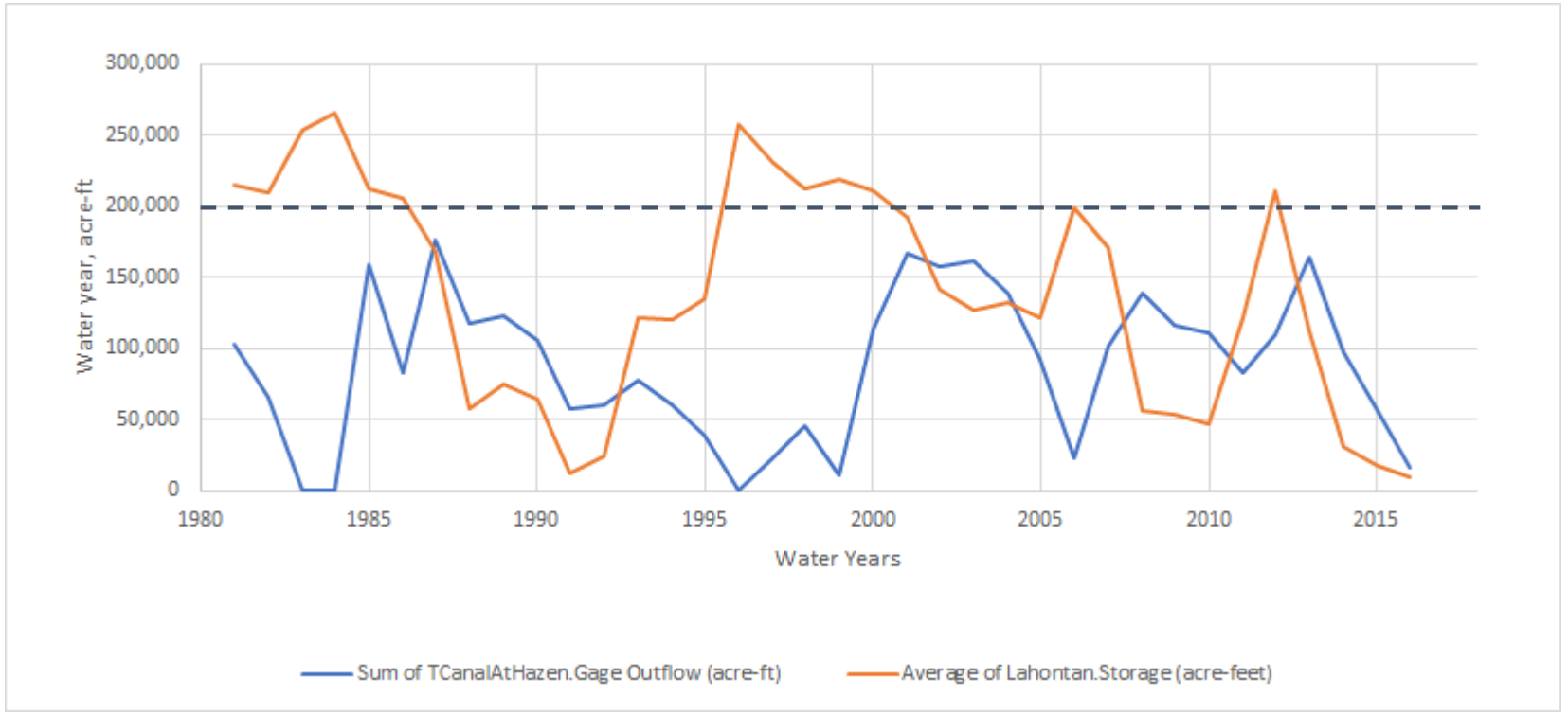
- Capture winter floodwaters that would otherwise exit Lahontan

Scheduling MAR (Years)

Average Lahontan storage of 200,000 acre-ft used as a MAR threshold

Potential years for MAR

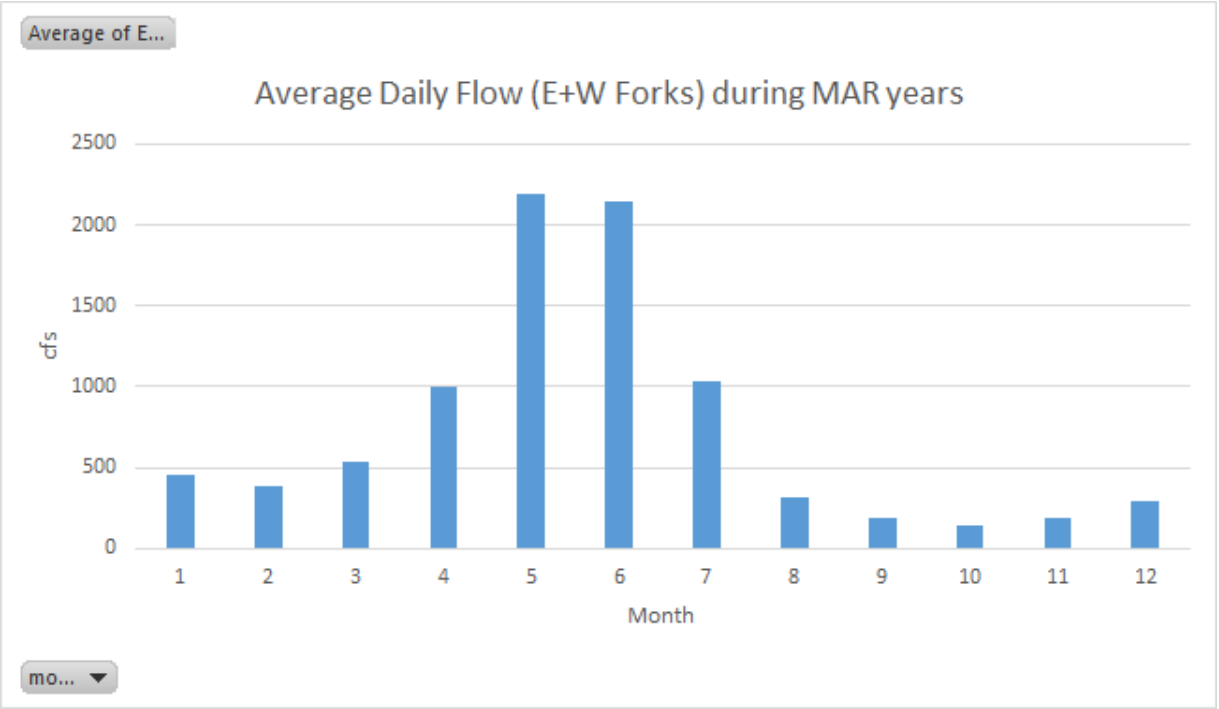
Water Year
1982
1983
1985
1995
1996
1997
1998
2005
2006
2011



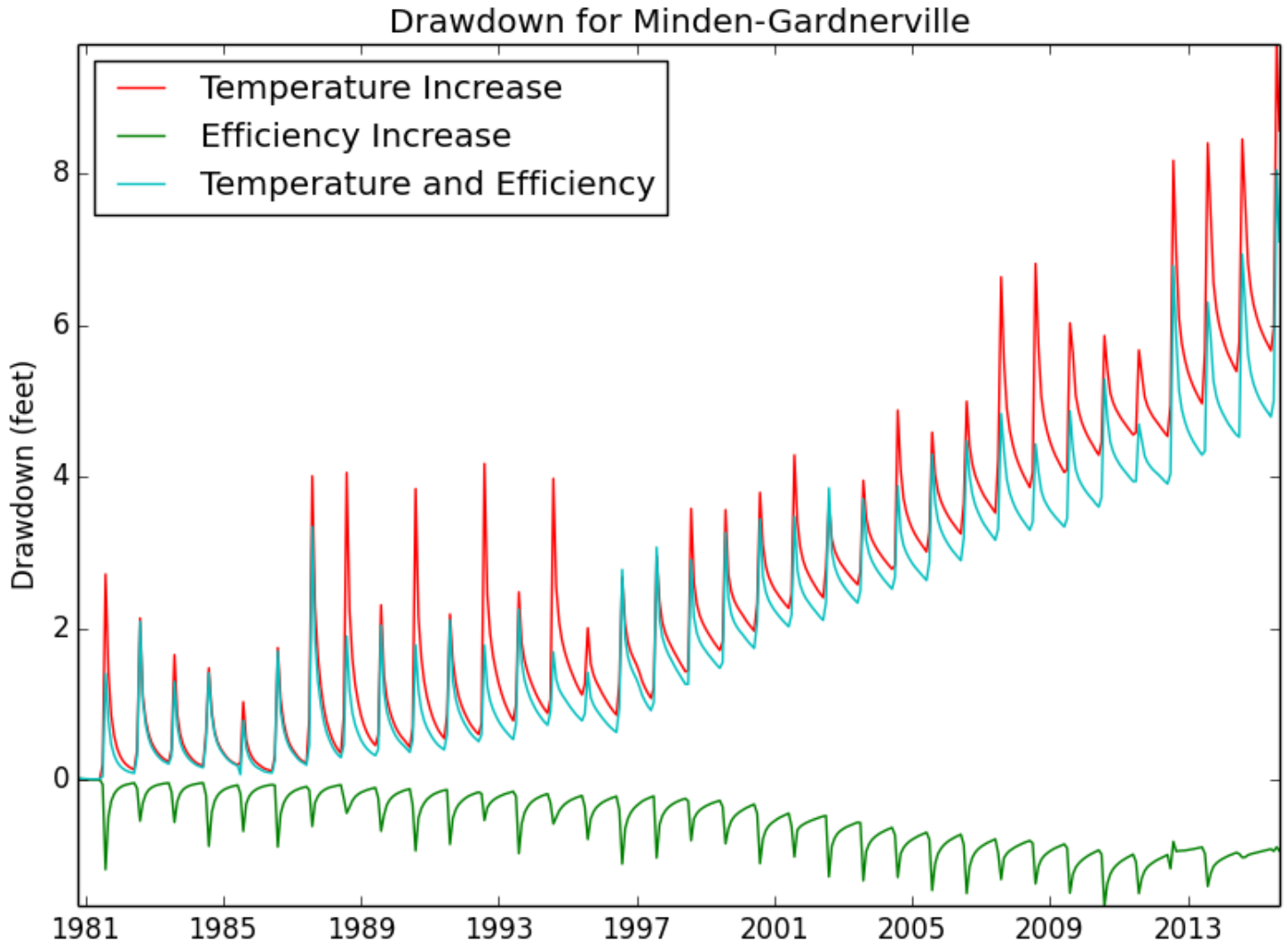
Proposed MAR Scheduling (Seasonal)

Scheduling MAR during Feb-March with Dec-Jan hindsight

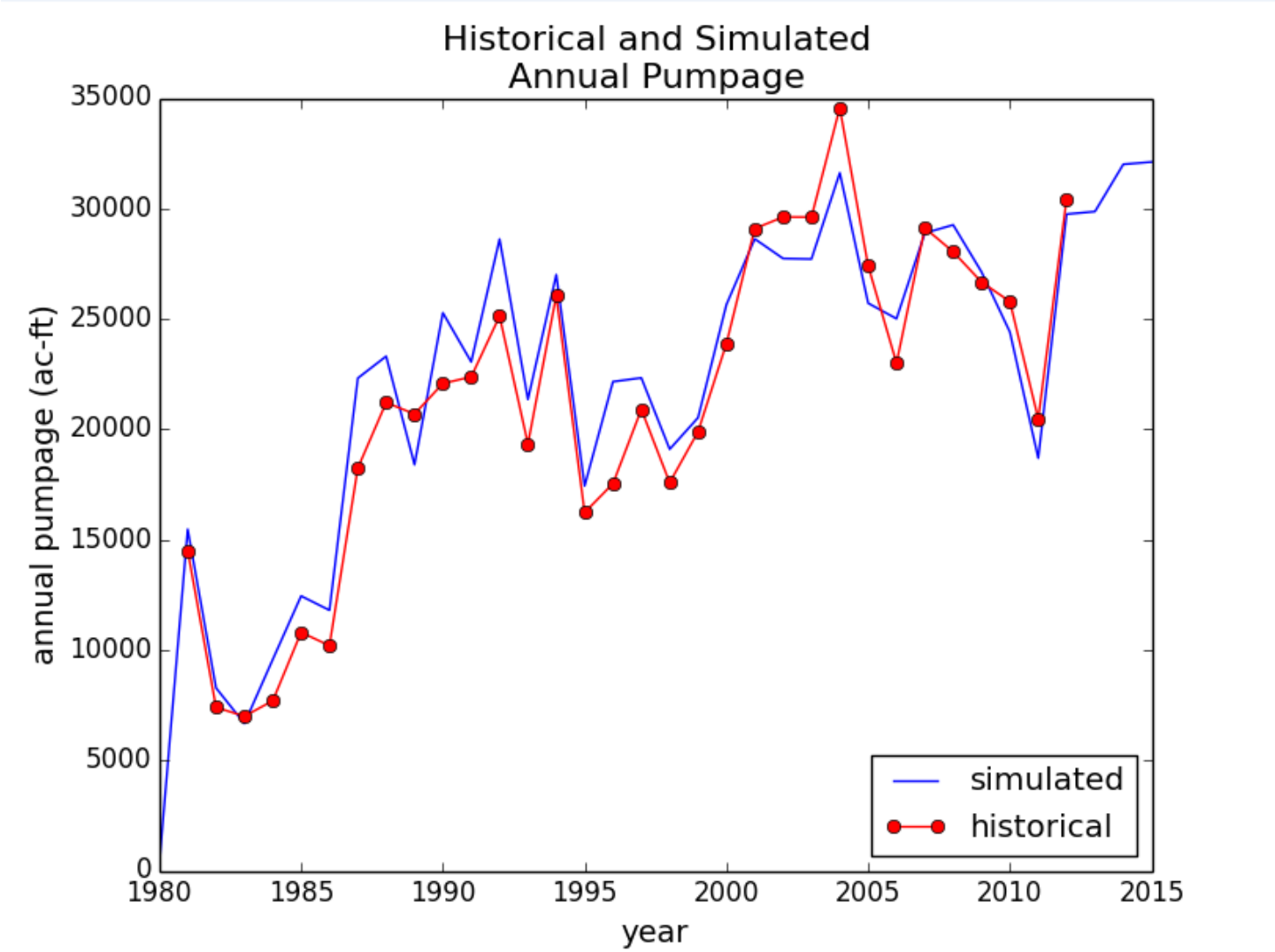
Proposed diverted MAR flows are 15-20% of flows during MAR winters



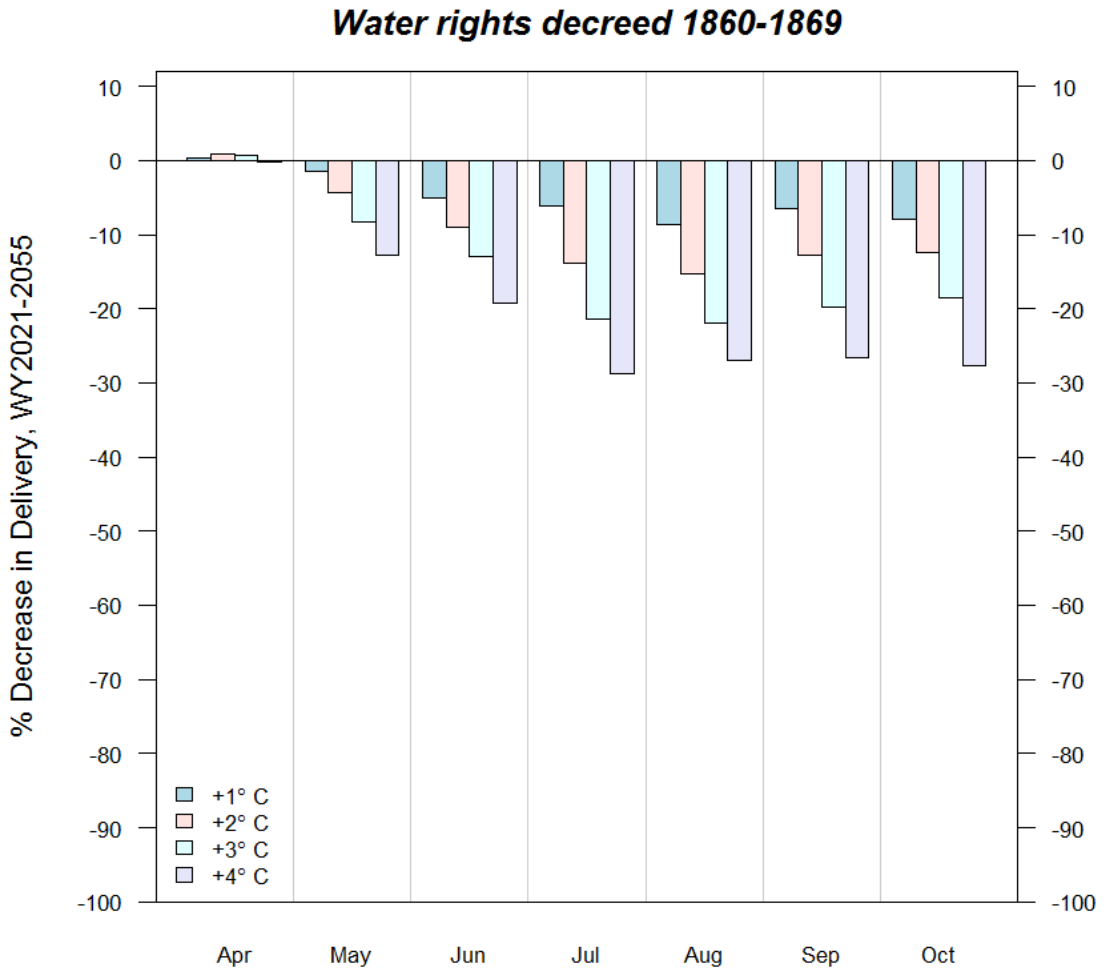
Changes in GW Head Minden-Gardnerville

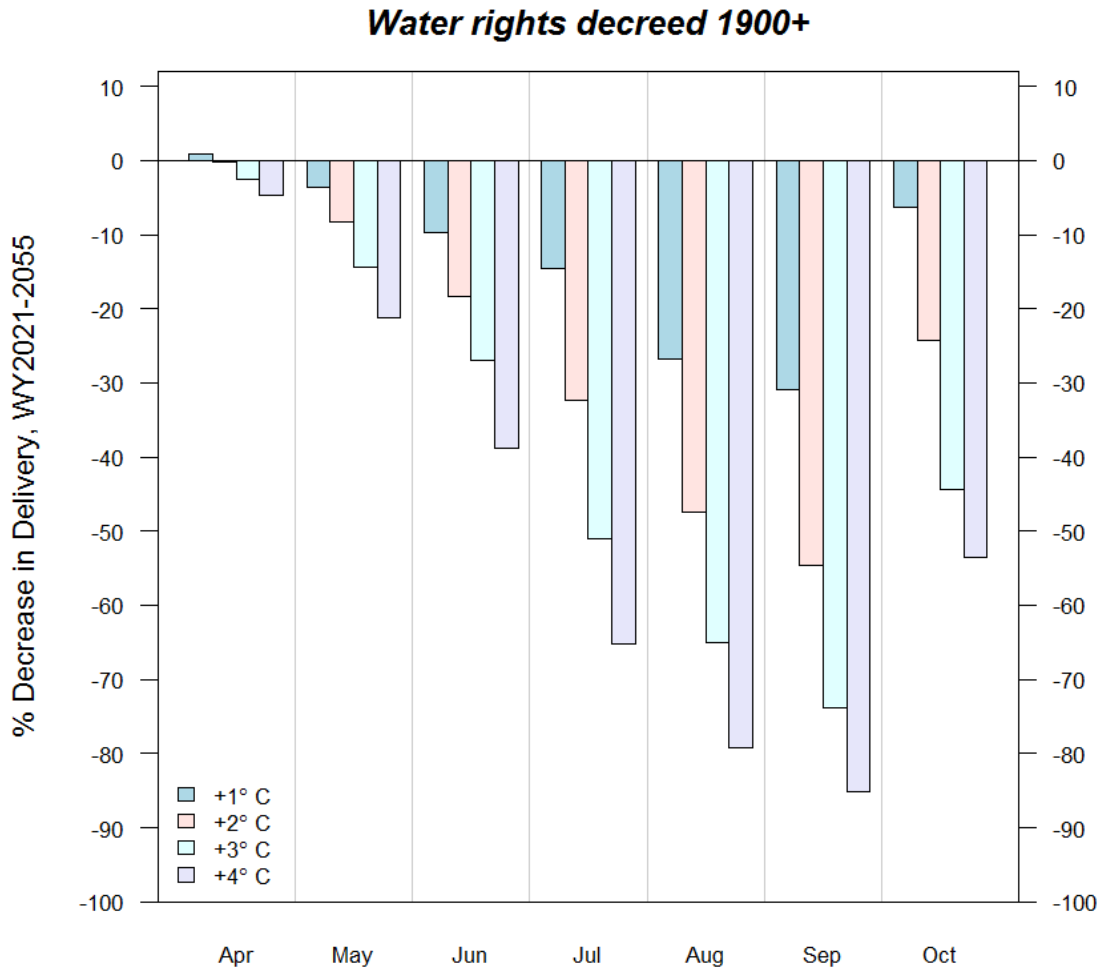


Significant Increases in Pumping Starting Late ‘80s

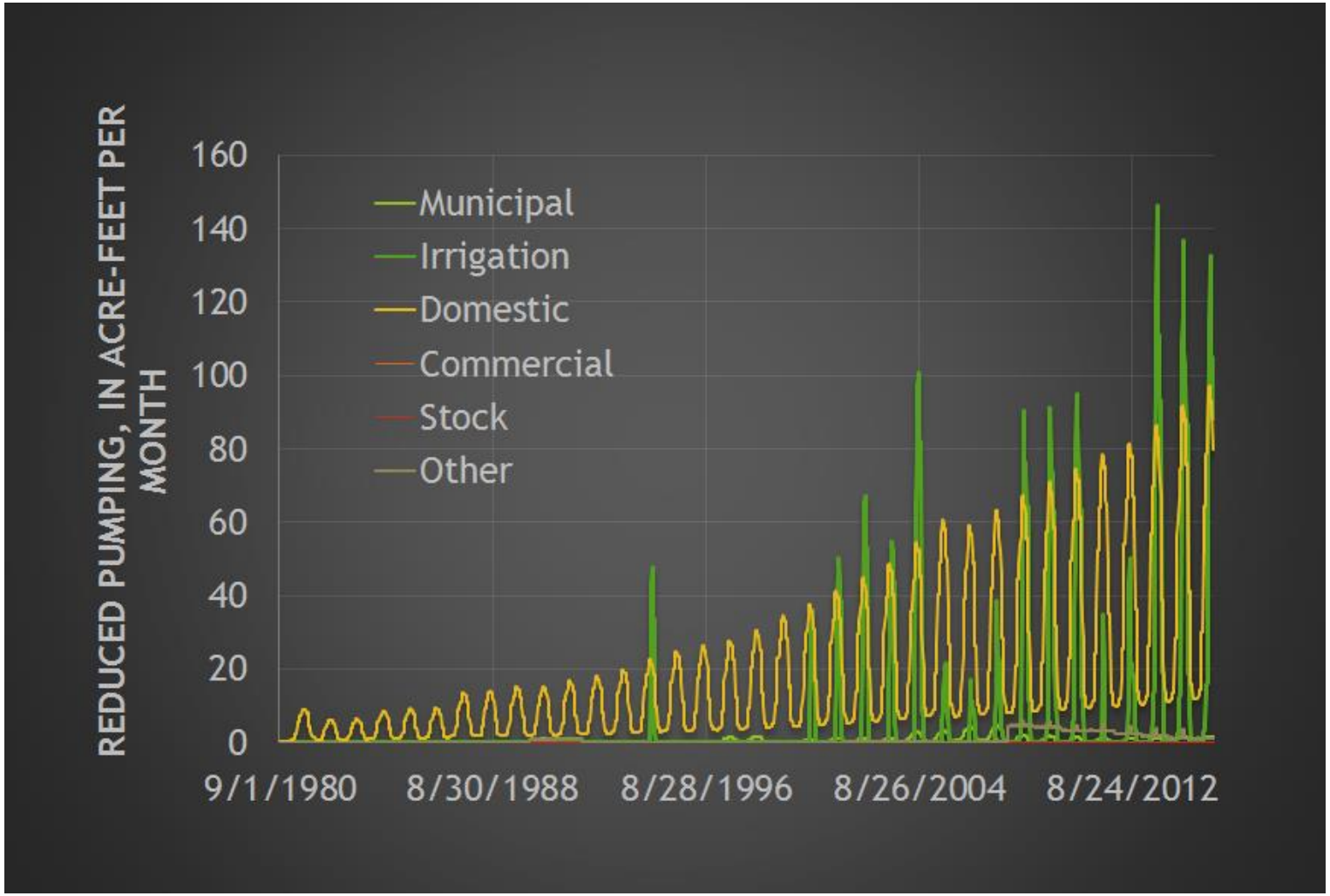


% Change in Delivery – first/last decade of decreed WRs





Cascading Impacts of Agricultural Pumping

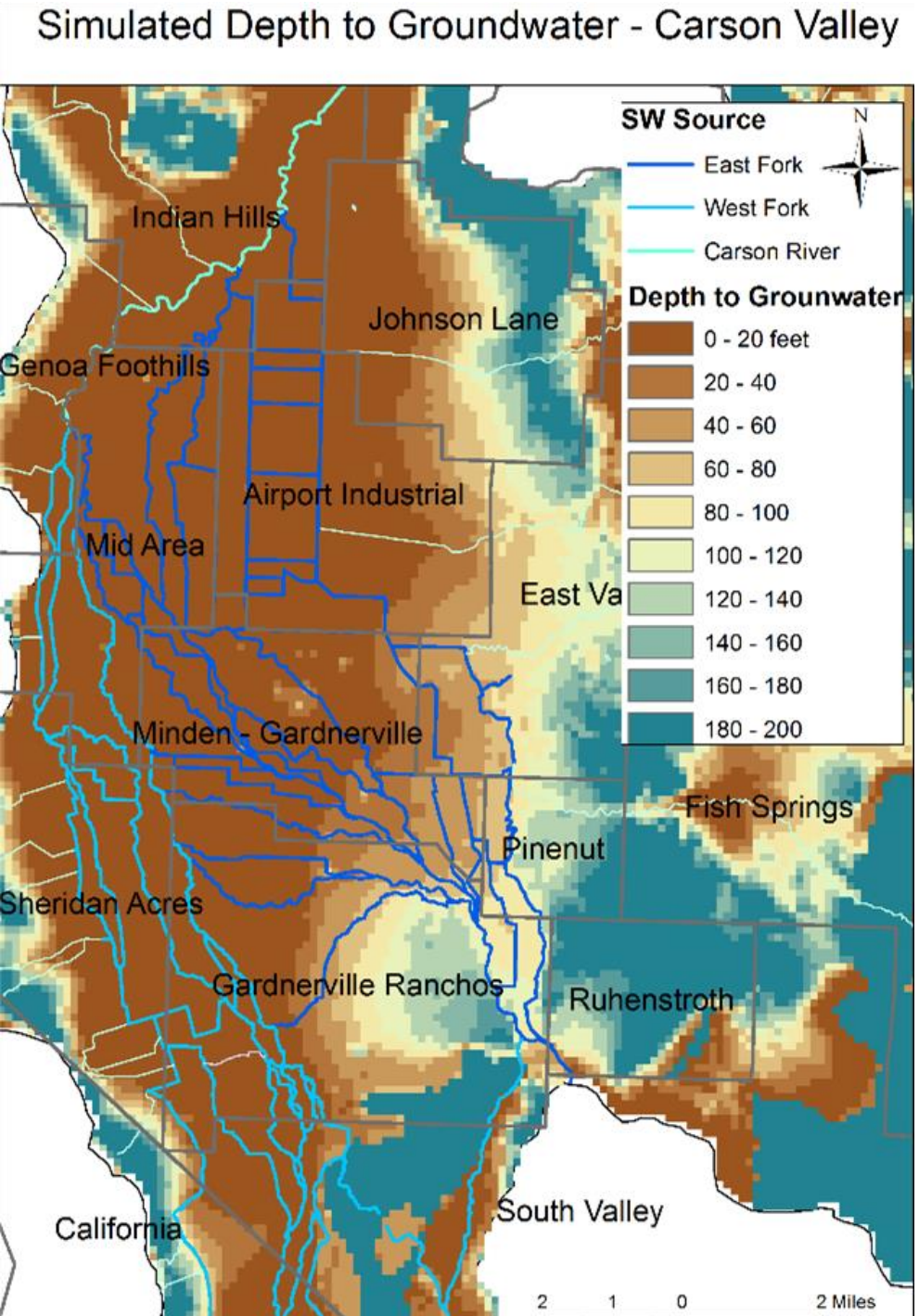


Reductions in GW pumping due to excessive drawdown and dewatering of well screens

Managed Aquifer Recharge in Carson Valley

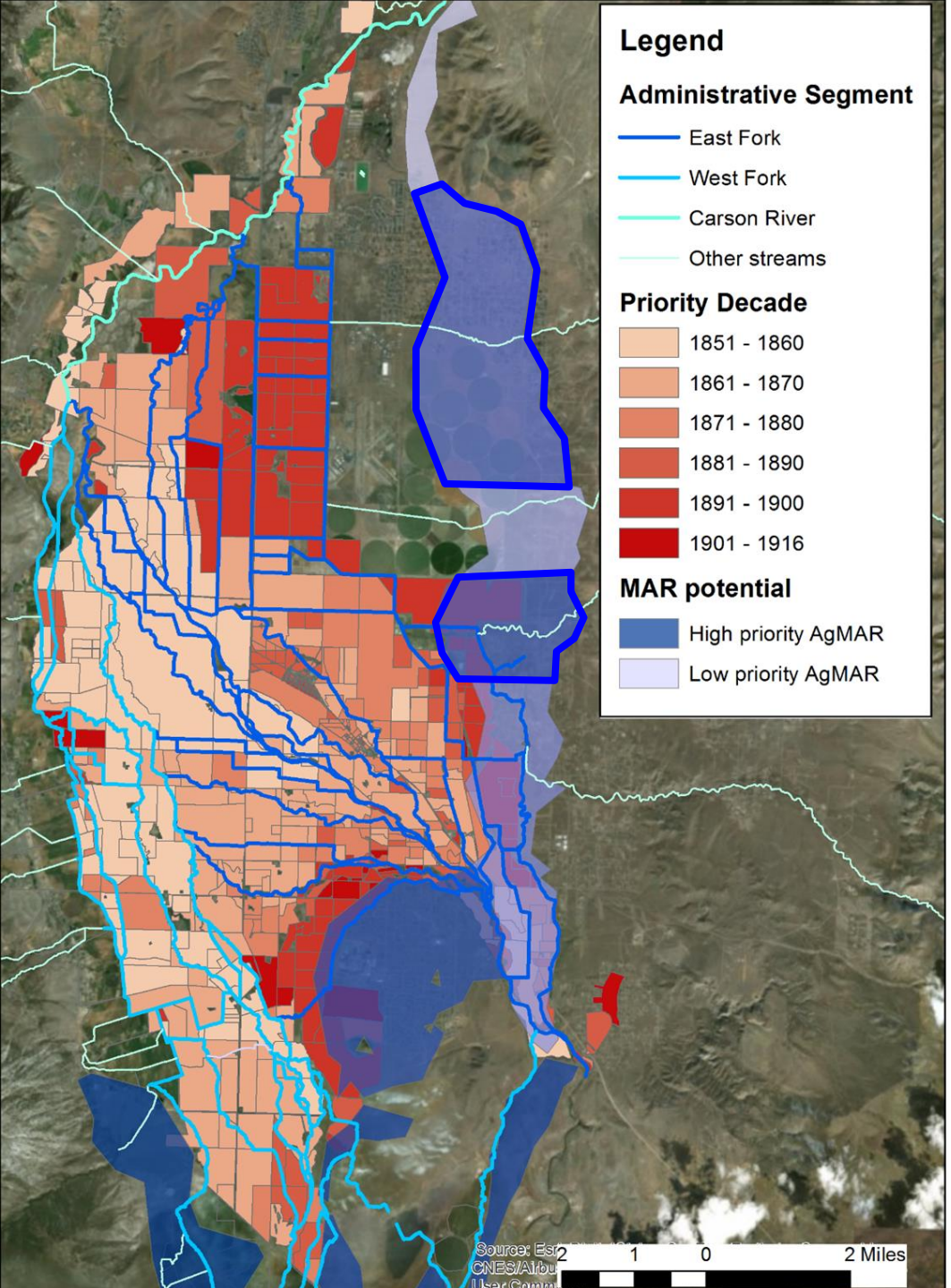
Where would the water be applied?

- Deep groundwater
- Areas with existing irrigation infrastructure
- Areas below a certain elevation for gravity driven delivery
  - Would require investment in infrastructure (i.e. pipeline, etc)



Identifying Suitable MAR Sites

- Shallow groundwater throughout the Carson Valley
- Deeper groundwater in the east and south
- Existing infrastructure vs. new infrastructure



- Potential MAR sites considered
  - Groundwater deeper than 20’
  - Below 4930’ (inflow of East Fk)
- Some overlap of existing water rights and potential MAR sites
- New MAR land would require new infrastructure (i.e. pipeline)
- Proposed MAR over 5600 acres for simulations
  - Johnson Lane
  - Between Alllerman and Airport