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*serving water needs*

# Welcome to the USGS Cooperative Water Program Webinar – *Managing Water Above and Below*

***For your enjoyment and courtesy to other participants, please place your phone on "mute."***

***Questions will be entertained after the presentations – please submit your question(s) at any time during the webinar in the "GO TO Meeting" box labeled "Send questions to staff"***

***The webinar will begin shortly.***

# USGS Cooperative Water Program Webinar –

## *Managing Water Above and Below*

Pixie Hamilton, National Coordinator
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http://water.usgs.gov/coop
March 21, 2012

# Yakima River Basin--Science and Management

- Tom Ring, Yakama Nation

- Tom Tebb, Washington State Department of Ecology

- Matt Ely, USGS Washington Water Science Center

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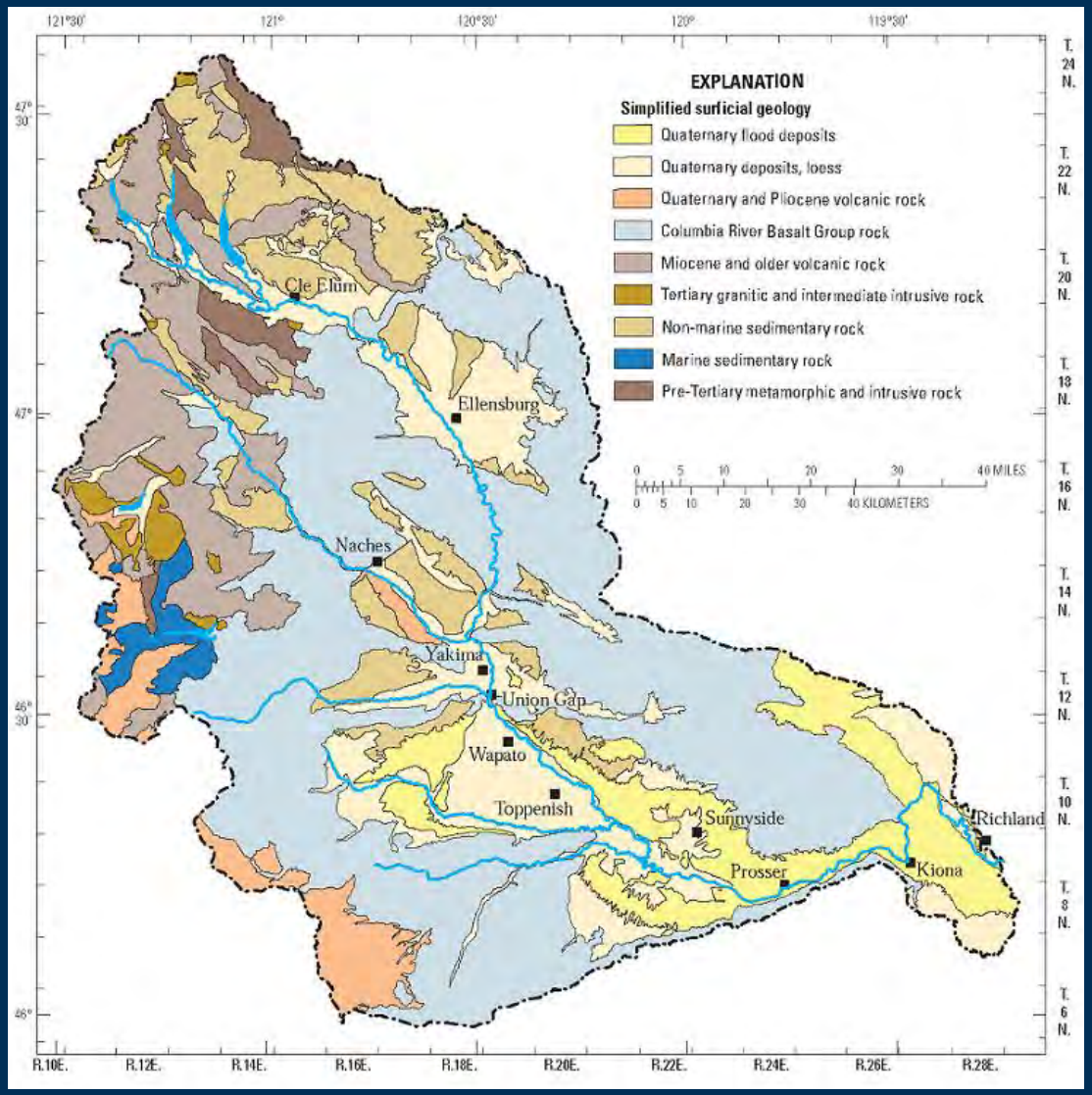
# Aspects of Groundwater and Surface-Water Interaction in the Yakima River Basin, WA

Matt Ely, USGS Washington Water Science Center
Tom Ring, Yakama Nation
Tom Tebb, Washington State Department of Ecology

# Groundwater Occurrence

- **Rainfall**
  - Mostly in upland bedrock areas
- **Snowmelt**
  - Provides most river flow during summer months
- **Irrigation, starting in the late 1800s**
  - Mostly surface water, but some groundwater

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# The First Economy of the Northwest

Salmon from the Yakima River have sustained the economy, diet and culture of the Yakama People since Time Immemorial

For 30 years, the Yakama Nation has been restoring once decimated runs

The YN Treaty Right for instream flow is the senior water right in the basin

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*Photo: Sockeye Salmon, Cle Elum River*

# The New Economy of the Northwest

In 1905 Reclamation withdrew unappropriated water and began building a system of reservoirs to catch available runoff. Eventually half a million acres, including 140,000 acres on the Yakama Reservation, were under irrigation driving a multi-billion dollar basin-wide agricultural economy.

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# Why is the Yakama Nation concerned about groundwater pumping?

**Both Tribal economies are threatened by capture of surface water by wells**

*Photo: Fishing Platforms and Wapato Irrigation Project Diversion Dam*

- **Treaty Water Rights for fish and other aquatic life**
- **Treaty Irrigation Rights, a large share of which are prorated in drought years**

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# The Appeals

- Hundreds of well permits queued up
- Ring literature review: Impairment
- Meeting (intervention?) with Dept of Ecology
  - How much pumping? "I don't know, a lot."
  - Effects of pumping on river "would take hundreds or even thousands of years"
- Message (37 copies) not received
  - 43 water right appeals in 1993
  - 1999 Changes in attitudes
    - The MOA "The beginning of a beautiful friendship"
    - The USGS study

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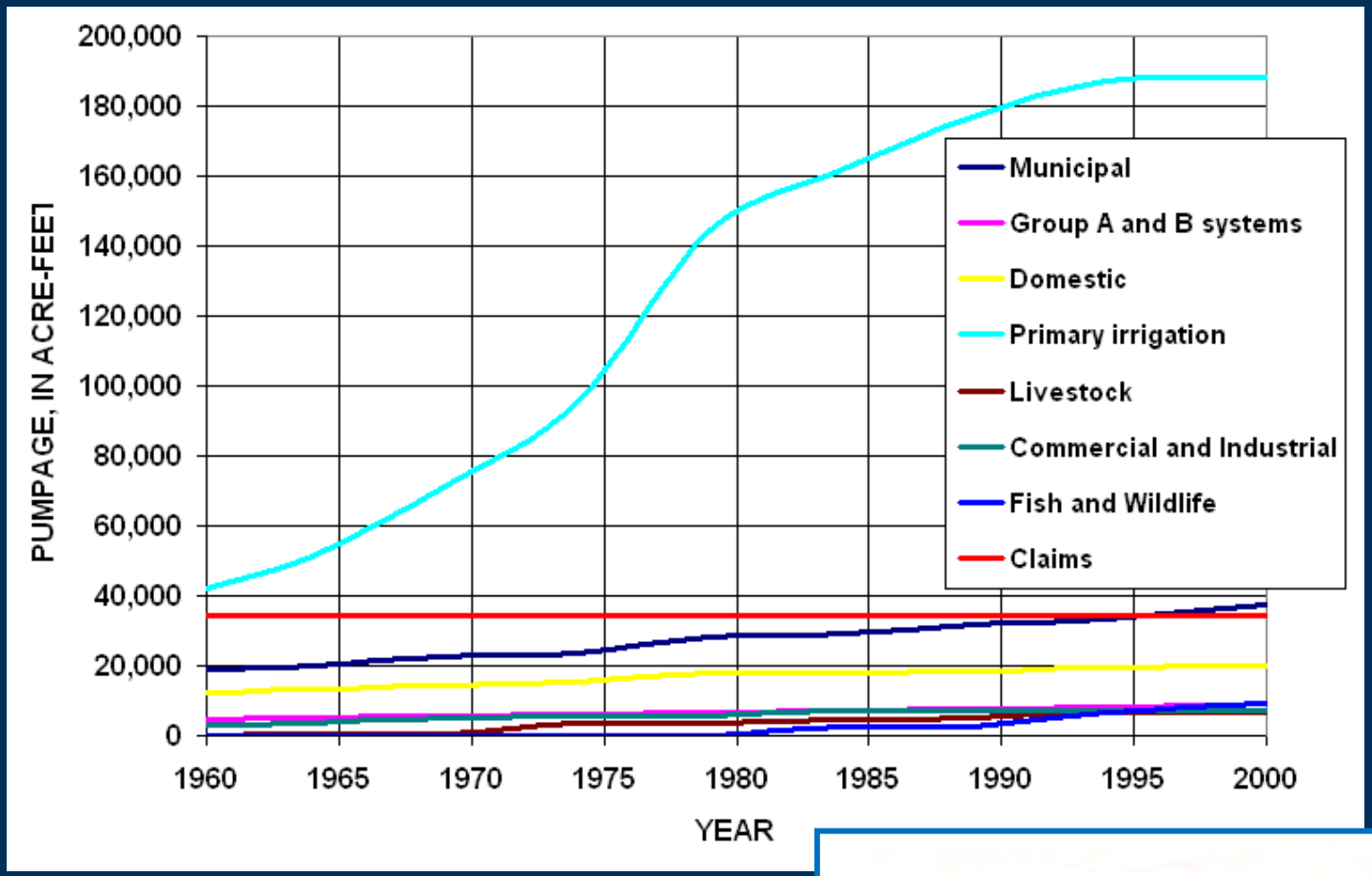
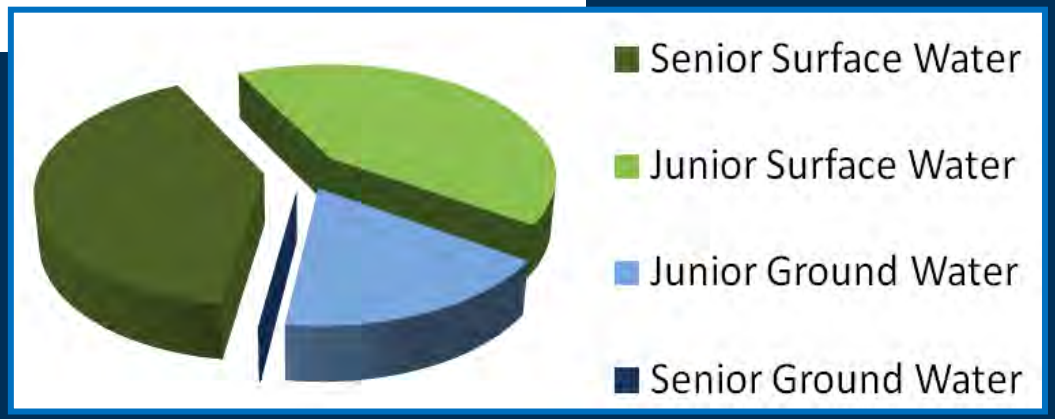
# Groundwater Usage in Yakima River Basin

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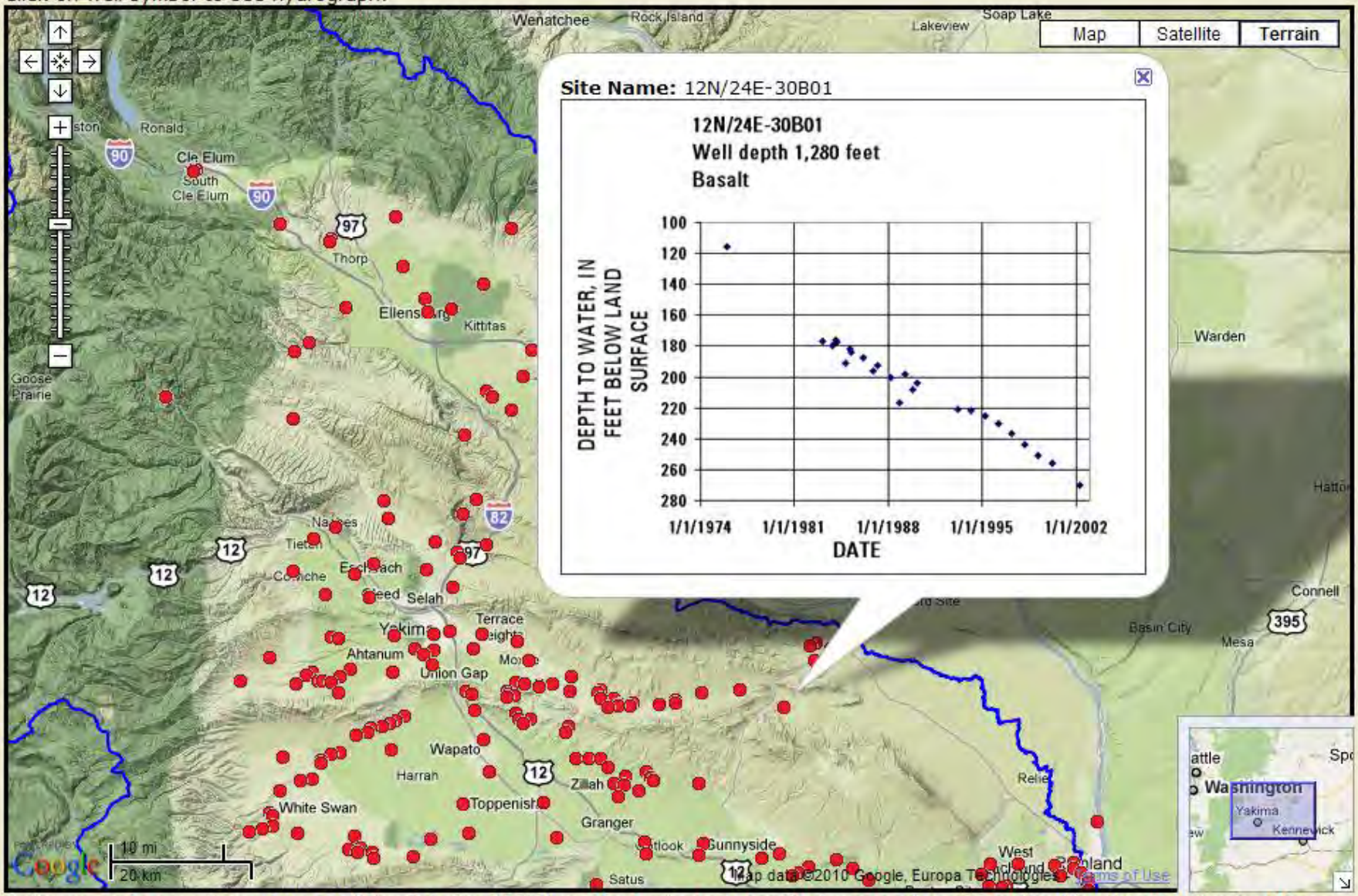
Click on well symbol to see hydrograph.




**References to non-Department of the Interior (DOI) products do not constitute an endorsement by the DOI. By viewing the Google Maps API on this web site the user agrees to these TERMS.**

Explanation

Yakima River basin boundary

Ground-water monitoring well

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# Historical management of water resources in Yakima Basin

- 1855 – United States enters into Treaty with the Yakima Nation
- 1863 – Washington territorial water law incorporates the use of the riparian doctrine
- 1873 – Washington recognizes the prior appropriation doctrine for water right allocation in arid parts of the state to facilitate irrigation projects
- 1889 – Washington gains statehood
- 1891 – Water code consisted of posting notice, recording at county and proceed
- 1905 – U.S. Supreme Court affirms Indian treaty fishing rights and grants access to “usual and accustomed” fishing sites
- 1905 – (May 10) under RCW 90.40 State Legislature enabled Bureau of Reclamation to reserve water while planning reclamation projects under 1902 federal law

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# Historical management of water resources in Yakima Basin (cont.)

- 1917 – Washington State Surface Water Code – first time permission required prior to use. Establishes prior appropriation system as exclusive means
- 1945 – Federal Court Consent Decree – established the notion of Total Water Supply Available and Parker Dam as its control point
- 1945 – RCW 90.44 State Legislature extends prior appropriation system to groundwater of the state and is supplemental (junior) to surface water code of 1917 (RCW 90.03)
- 1967 – Department of Water Resources is created to assume management of state water resources
- 1971- Water Resources Act sets out fundamentals of water resource policy to ensure that water of the state are protected and fully utilized for the greatest benefit to the people of Washington (RCW 90.54)
- 1977 - Yakima Basin Adjudication filed
- 1979 – Congress enacts bill to support a study of ways to enhance water supplies in the Yakima Basin (PL 96-162)

USGS

# Historical management of water resources in Yakima Basin (cont.)

- 1980 – U.S. District Court Judge Quackenbush orders water released from Yakima Project reservoir to protect salmon eggs, based on Indian Treaty fishing rights.
- 1993 – Yakama Nation files appeals 80 affirmative decisions on groundwater applications
- 1994 – Congress passes Yakima River Basin Water Enhance Project (YRBWEP) enabling legislation
- 1999 – Ecology, YN, and USBR enter into a Settlement Agreement, established the need for technical study (USGS) and resulted in 30+ permits being issued with mitigation
- 2001, 2005 – Supplemental MOA for mitigated emergency permits during drought
- 2001 – Yakima Basin Water Transfer Working Group established
- 2009 – Upper Kittitas Groundwater rule and development of water markets for domestic uses
- 2010-11 USGS study and model completed

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# Study Components

- Hydrogeologic framework
- Groundwater recharge
- Groundwater pumpage
- Groundwater / Surface-water interaction
- Groundwater flow model
- Model Applications

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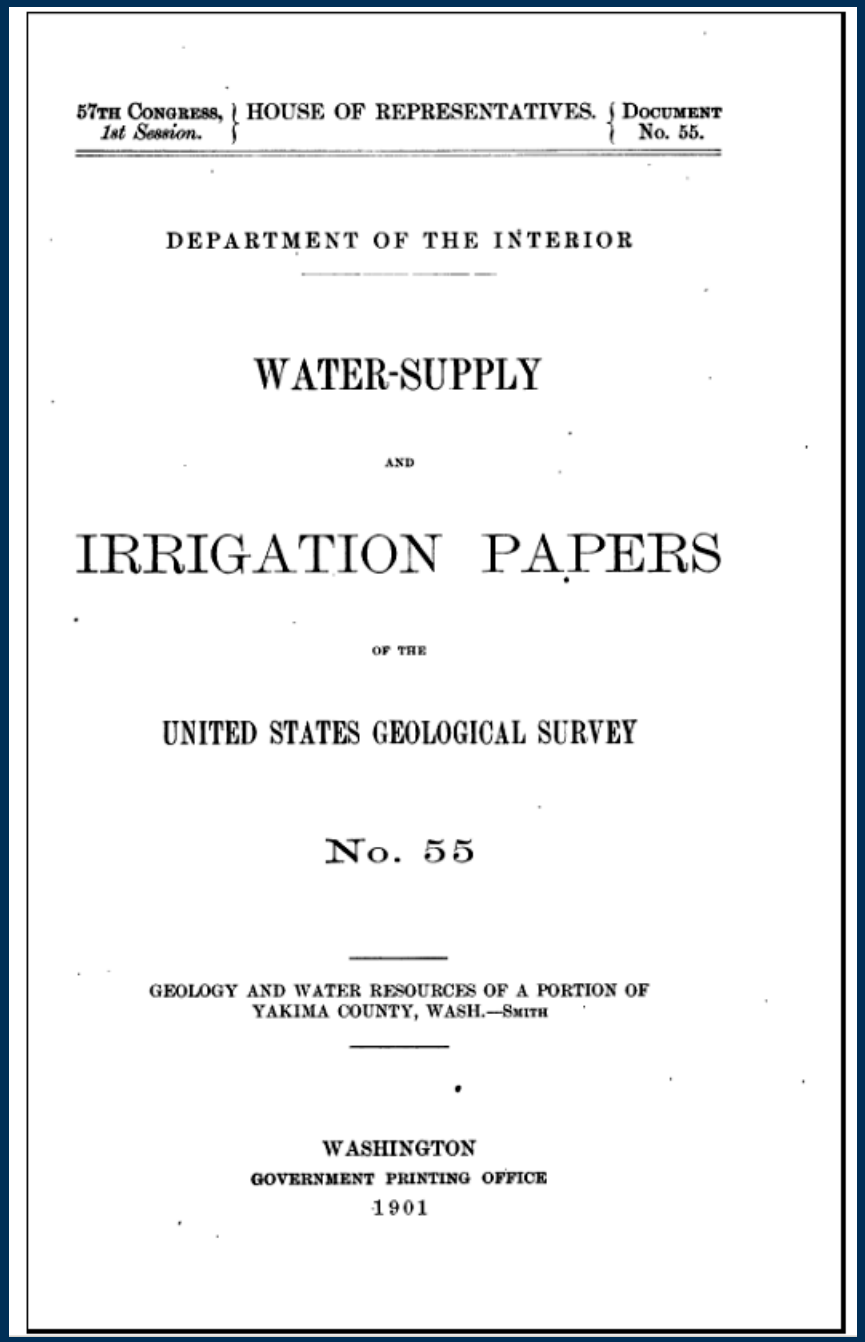


57TH CONGRESS, 1st Session. | HOUSE OF REPRESENTATIVES. | DOCUMENT No. 55.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 55

GEOLOGY AND WATER RESOURCES OF A PORTION OF YAKIMA COUNTY, WASH.—SMITH

WASHINGTON
GOVERNMENT PRINTING OFFICE
1901

**"But as further demands are made upon the underground supply of water, the time must come when it will be a survival of the fittest…"**

**George Otis Smith**
**1901**

USGS

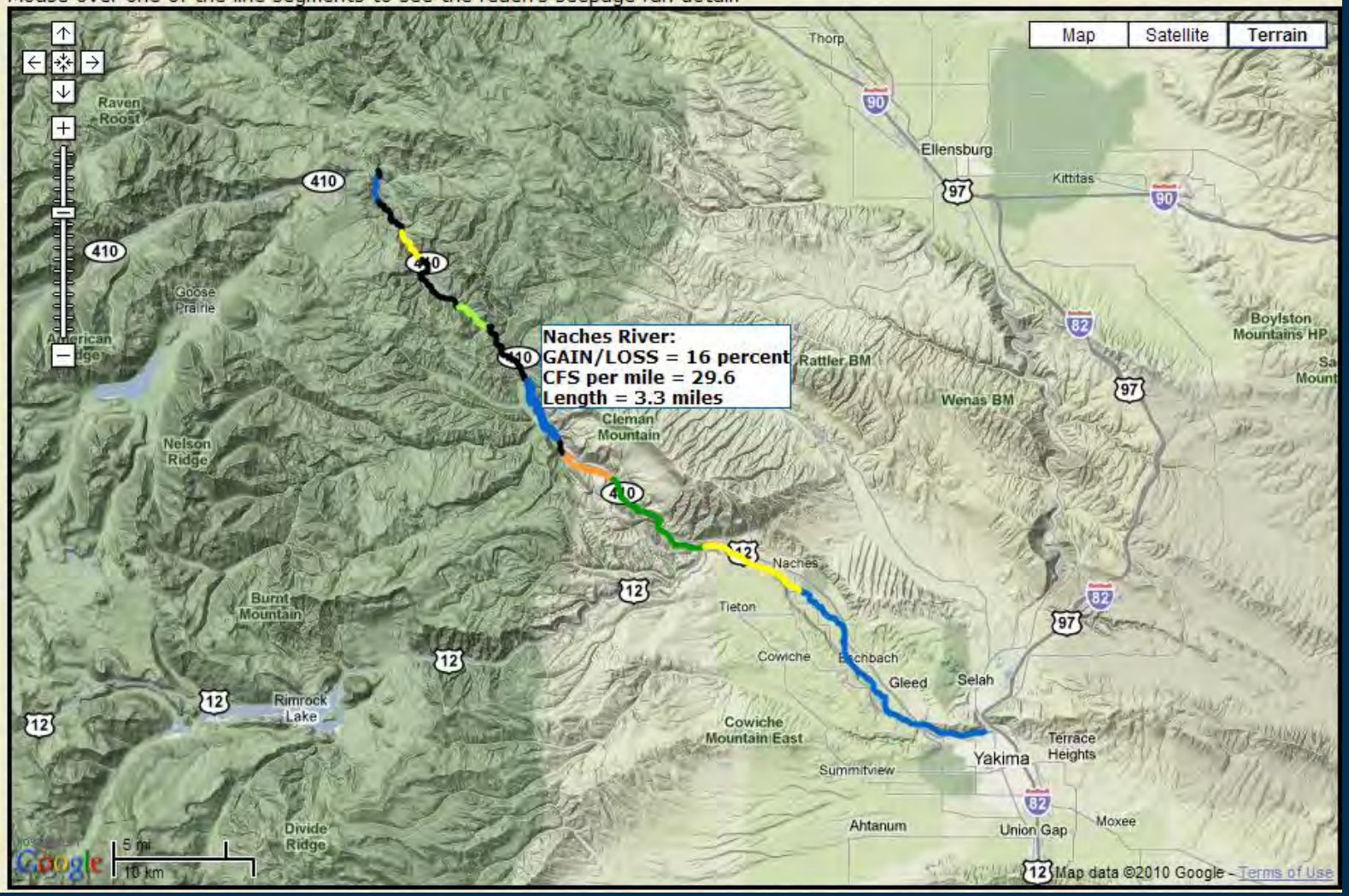
# Seepage maps for Yakima River Basin

## Naches River July 2004 Seepage Run

Select a river segment from the drop down list to see the seepage investigation details.

Select a river segment

Mouse over one of the line segments to see the reach's seepage run detail.

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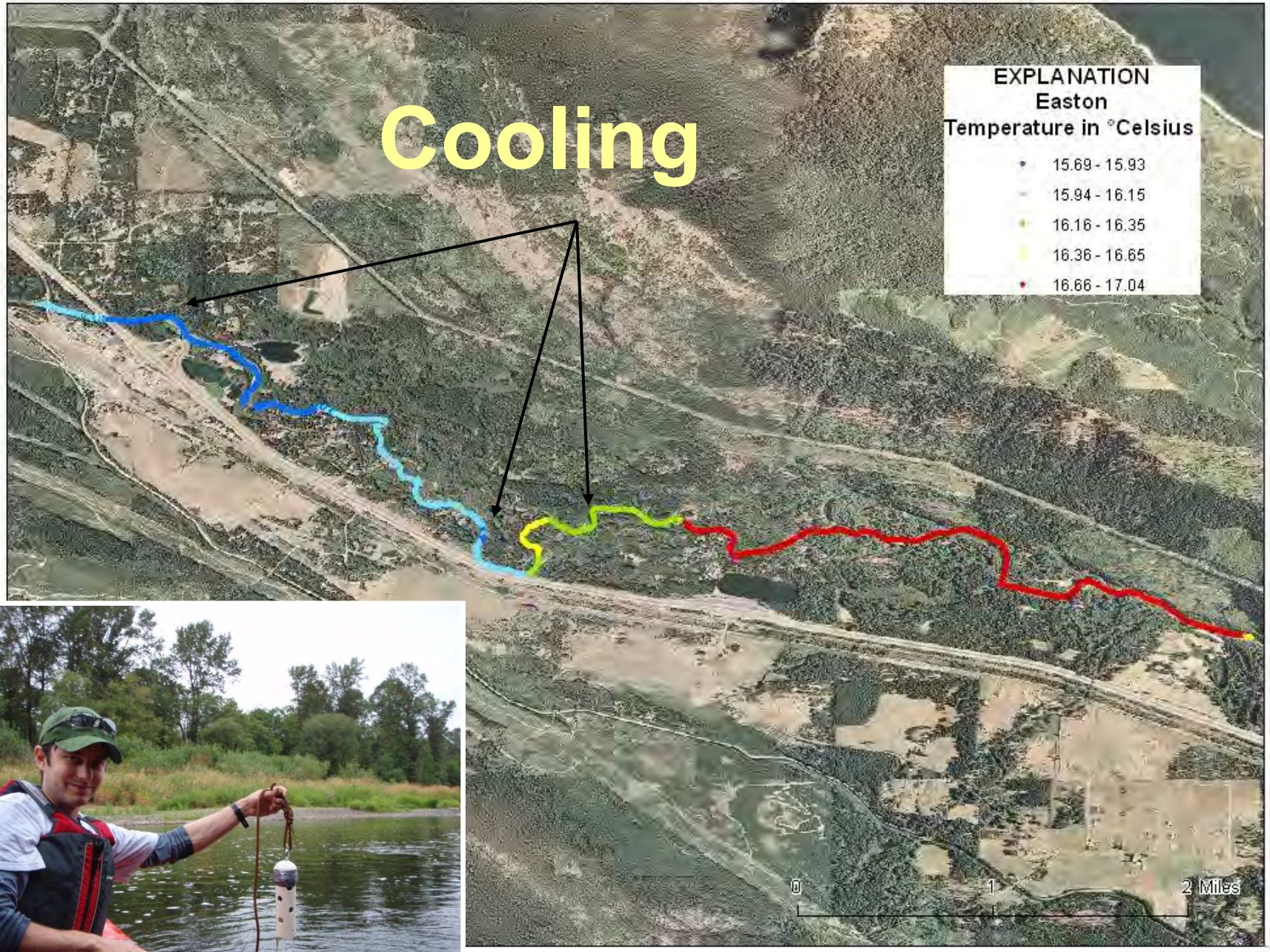
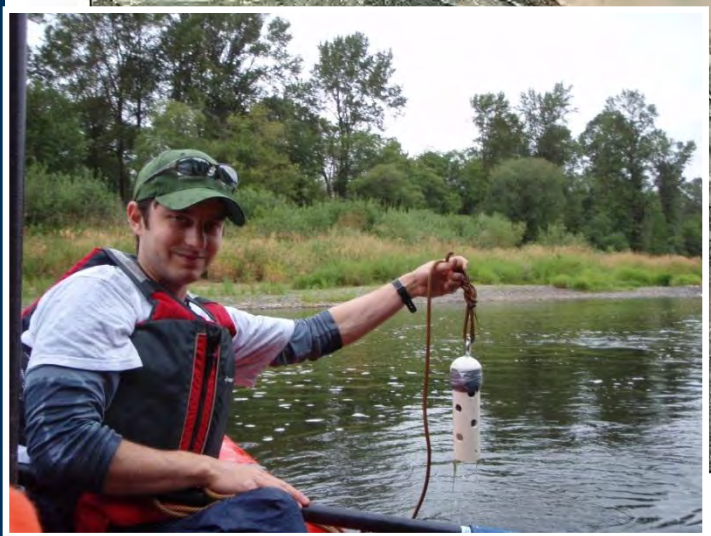
# Cooling



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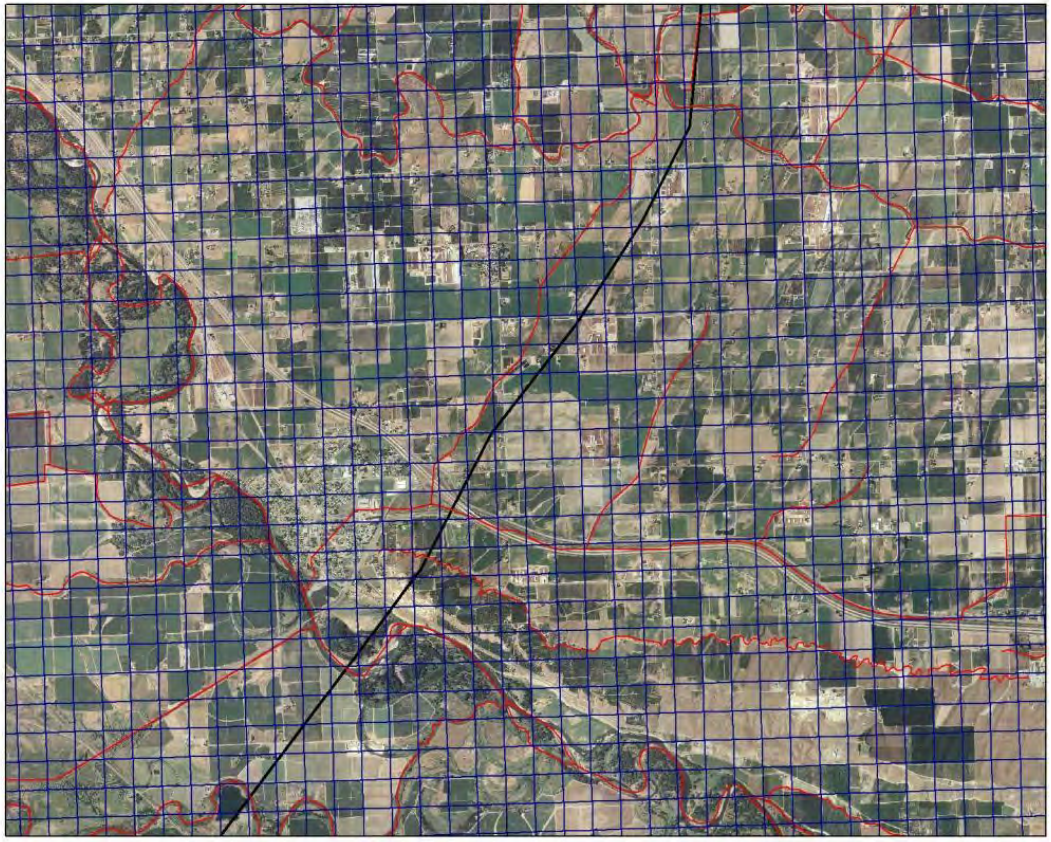
# Yakima River Basin Regional Groundwater Flow Model



- Incorporates the important aspects of the conceptual model and other information previously published in the study reports
- Simplified representation of a highly complex system
- Built in a way that is customized to the model's intended use

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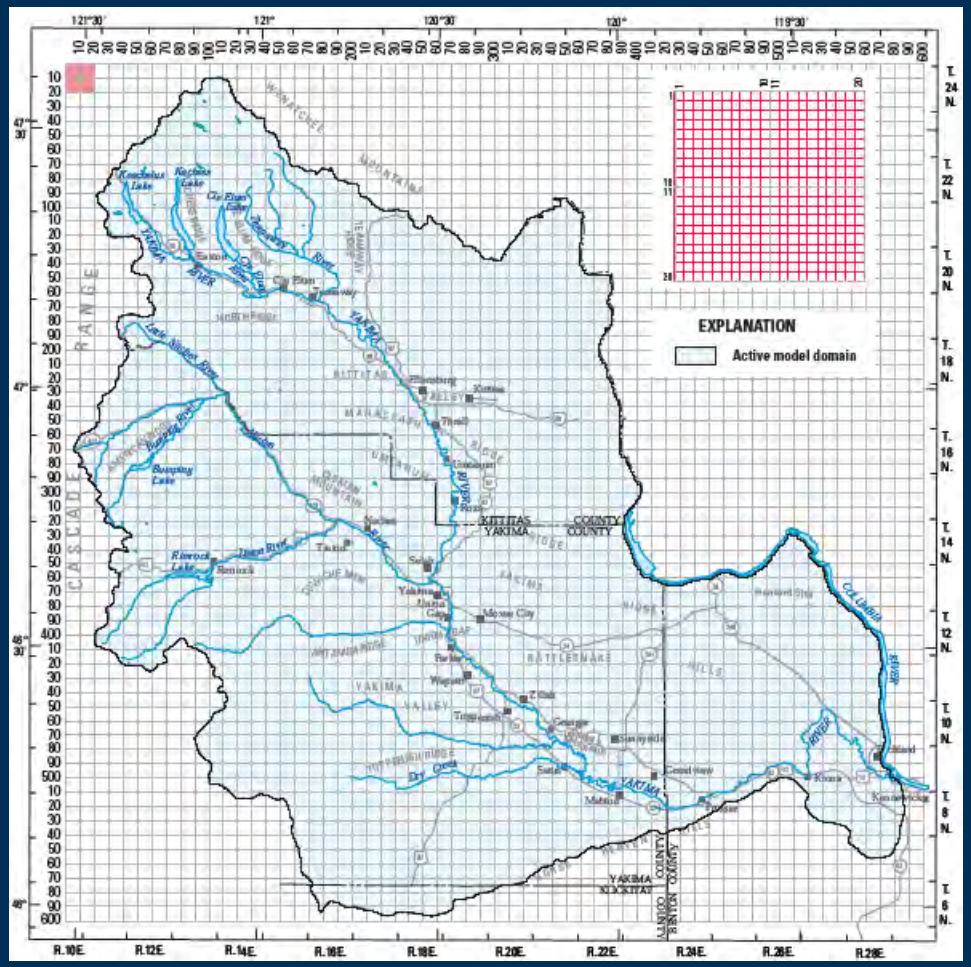
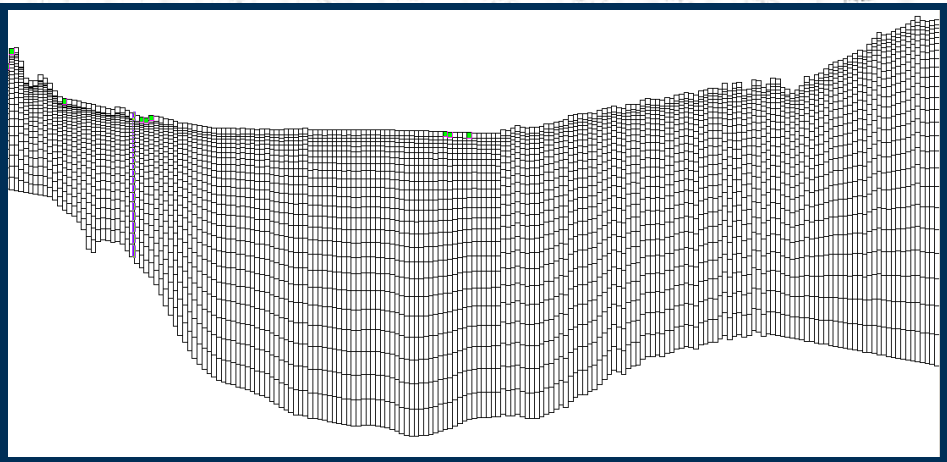
# Model Dimensions

- 600 x 600 grid (1,000 ft cells)
- 24 model layers

  Layer thickness: 18 - 866 ft

  Total thickness: 1,780 - 8,800 ft
- 4.6 million active cells
- Simulation Period: 1960 - 2001
- Daily time steps
- Data input is 504 monthly means
- 48 hydrogeologic units
- 5,575 cubic miles of aquifer material



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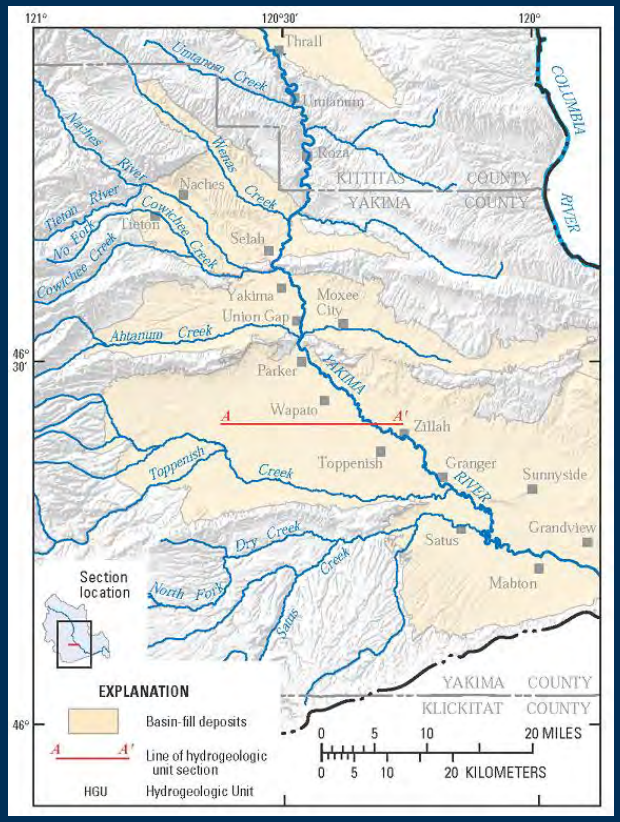
121°
120°30'
120°
Thrall
Umtanum Creek
Umtanum
Naches River
Wenas Creek
Roza
KITTITAS COUNTY
YAKIMA COUNTY
COLUMBIA RIVER
Naches
Tieton River
Cowiche Creek
Tieton
No Fork
Selah
Yakima
Moxee City
Union Gap
Ahtanum Creek
46° 30'
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Toppenish
Granger
Sunnyside
Grandview
Dry Creek
Satus
Mabton
North Fork
Satus Creek
Section location
EXPLANATION
Basin-fill deposits
Line of hydrogeologic unit section
HGU Hydrogeologic Unit
YAKIMA COUNTY
KLICKITAT COUNTY
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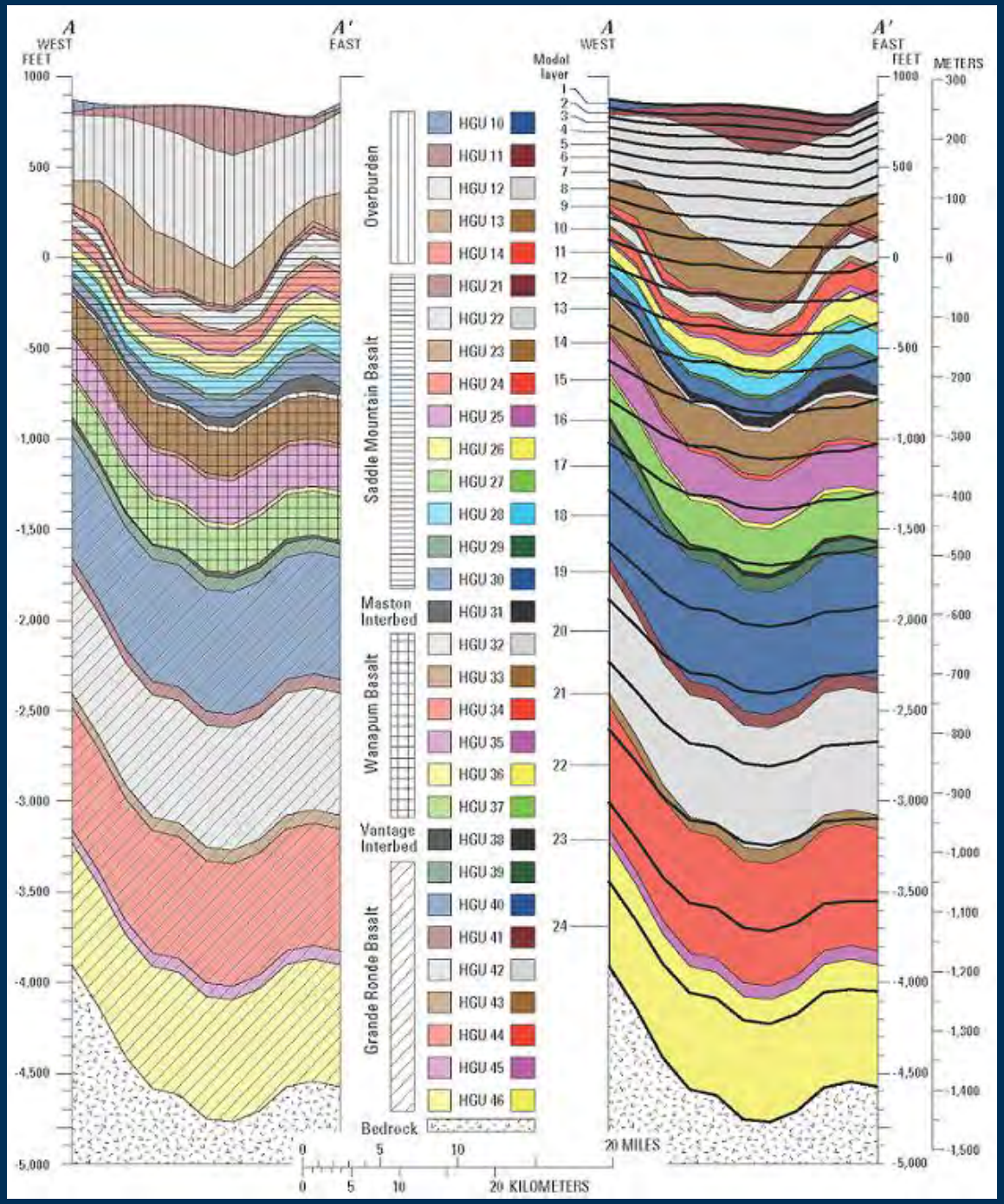
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Saddle Mountain Basalt
Maston Interbed
Wanapum Basalt
Vantage Interbed
Grande Ronde Basalt
Bedrock
HGU 10
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Model layer
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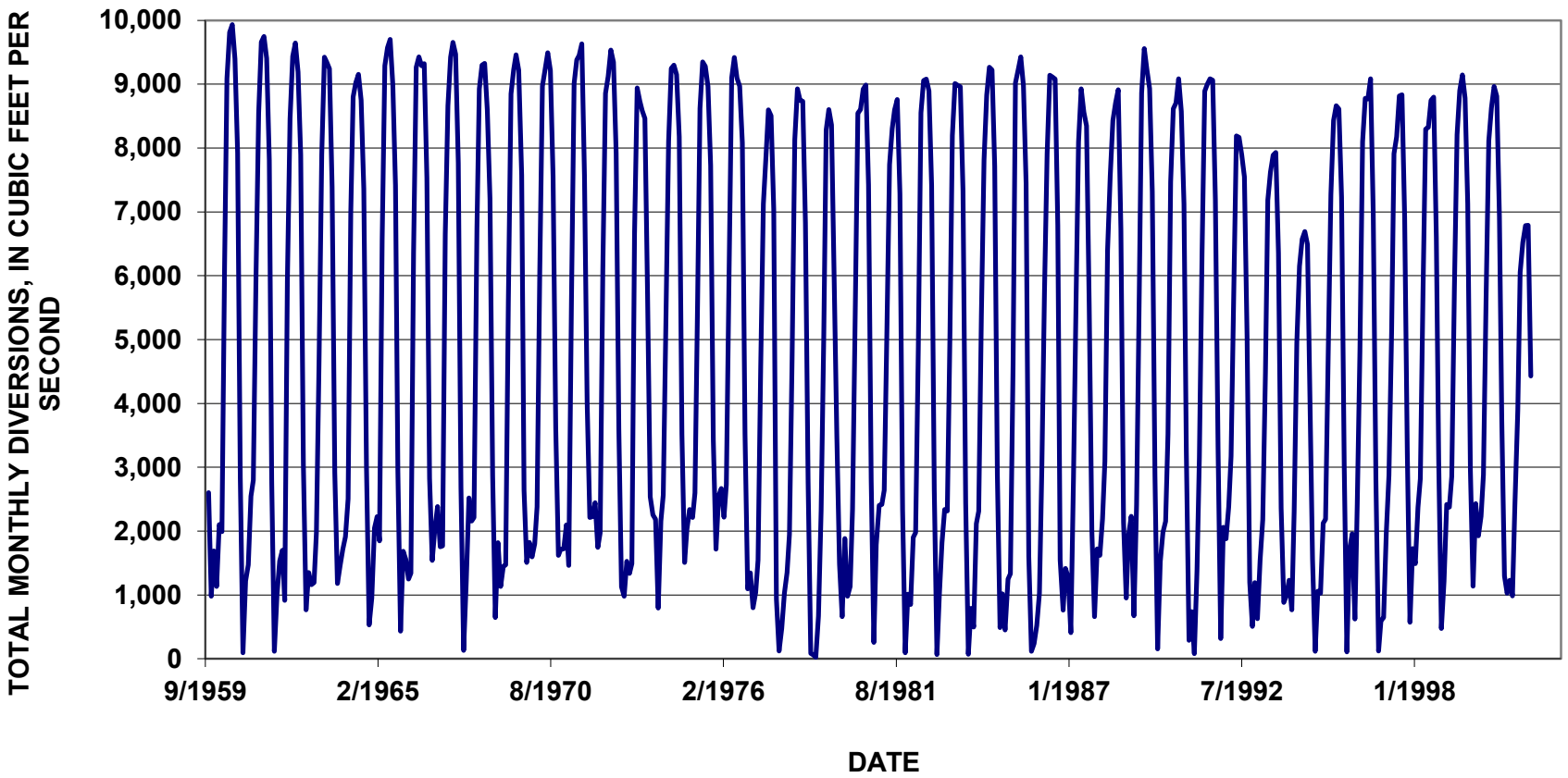
0 5 10 20 KILOMETERS

# Total Surface-Water Diversions

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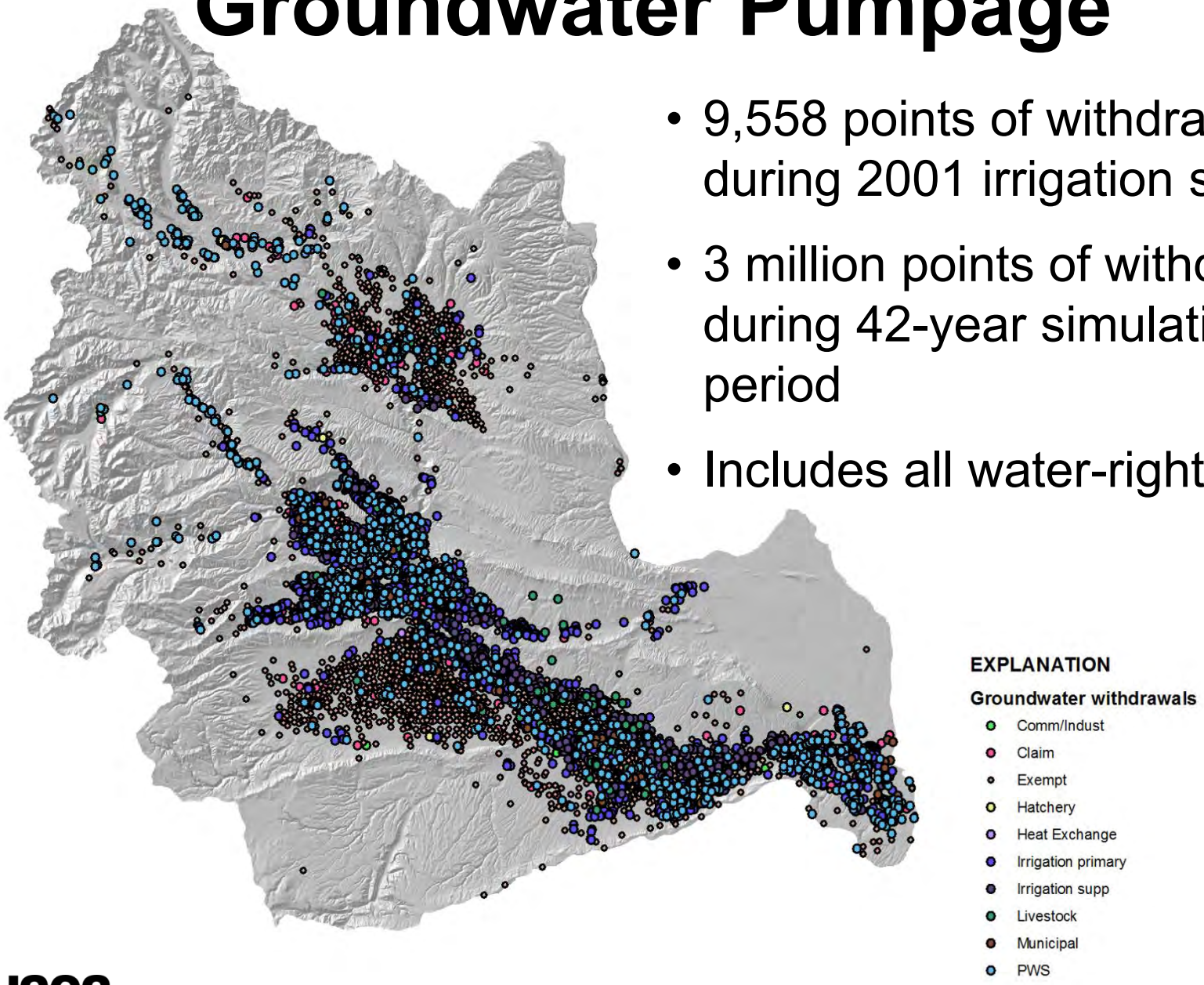
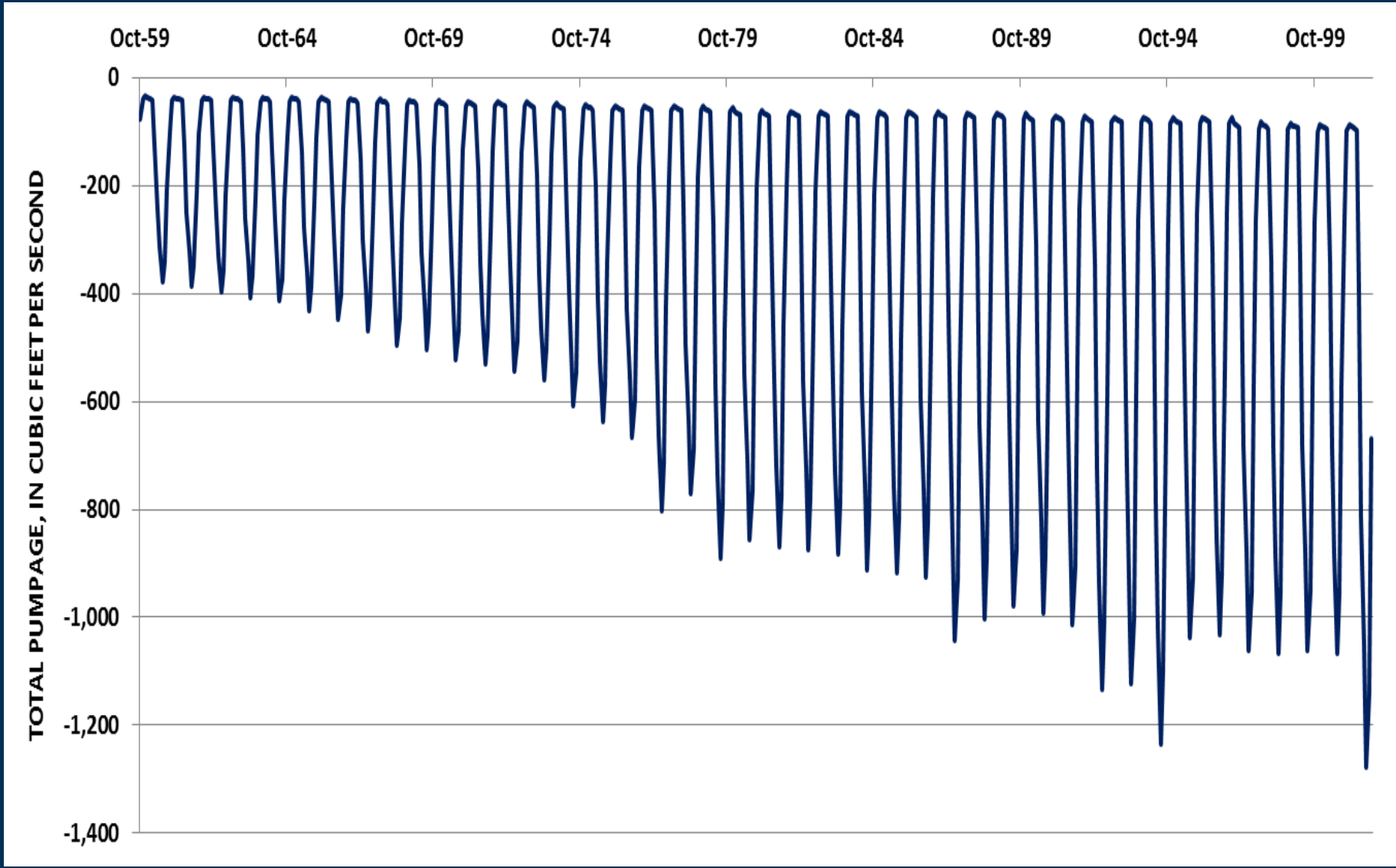
# Groundwater Pumpage




- 9,558 points of withdrawal during 2001 irrigation season
- 3 million points of withdrawal during 42-year simulation period
- Includes all water-right wells

USGS

# Total Groundwater Pumpage

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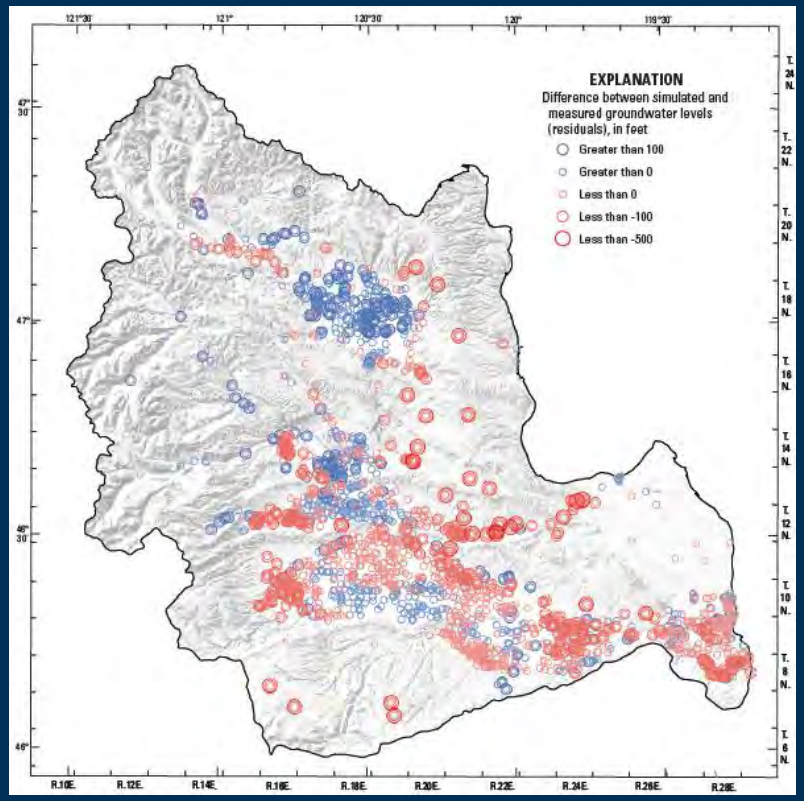
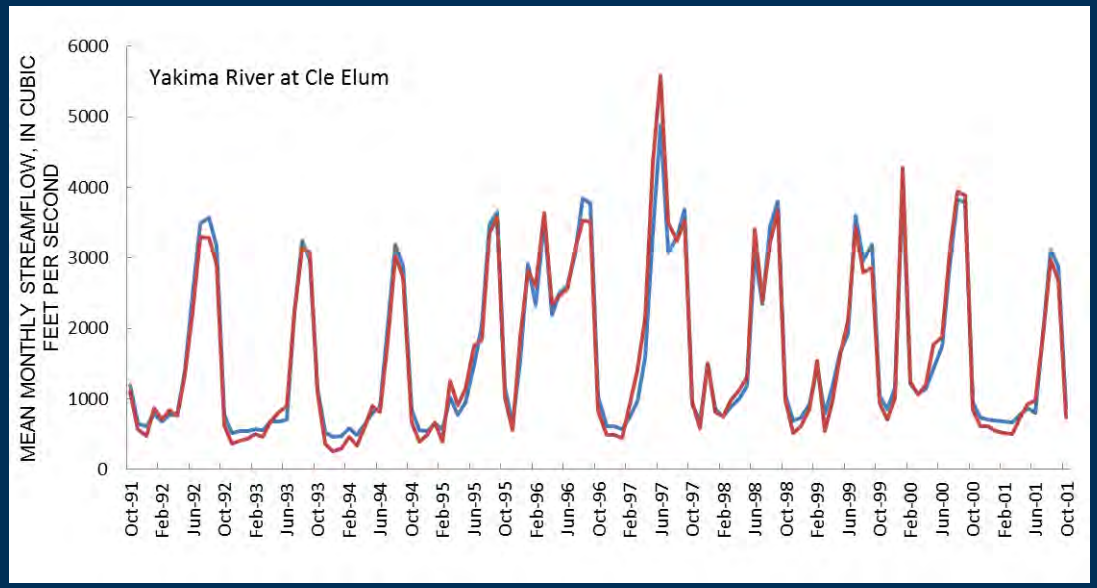
# Measures of Model Fit

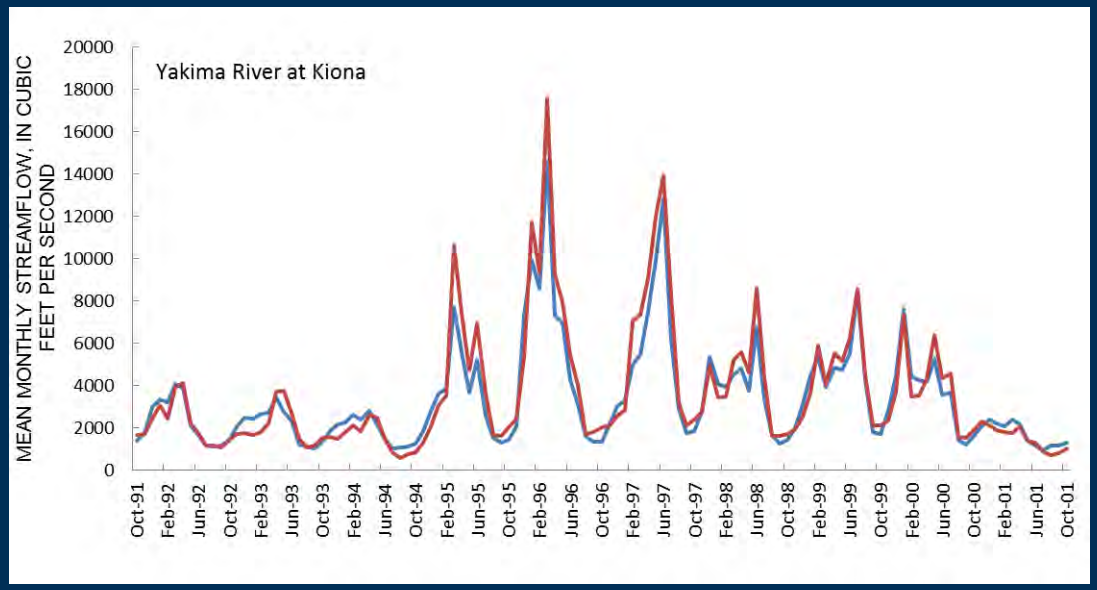



Differences between simulated and measured

Yakima River at Cle Elum




Yakima River at Kiona

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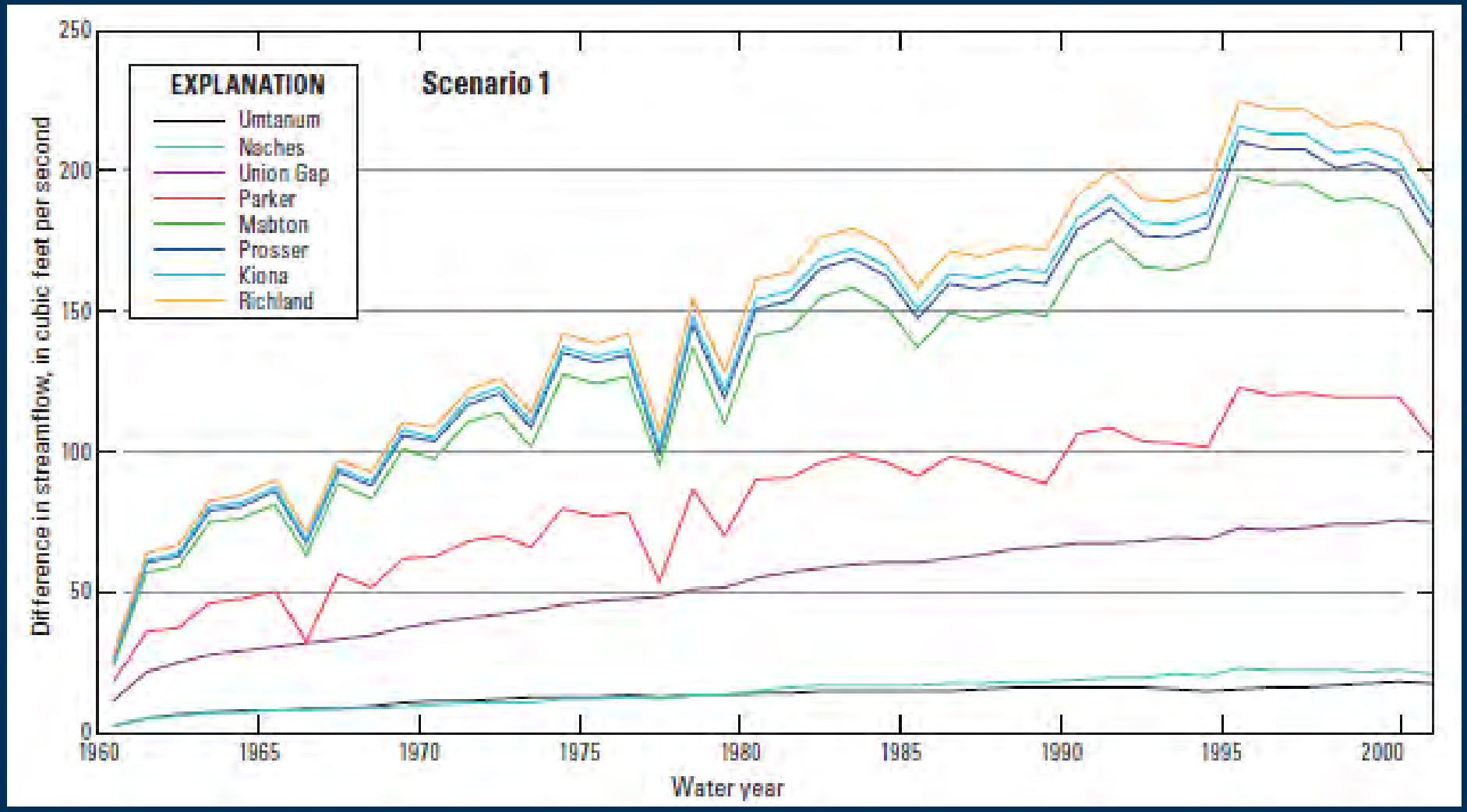
# Locations of streamflow observations for scenario results

USGS

# Difference in simulated mean annual streamflow between existing conditions and existing conditions without groundwater pumping

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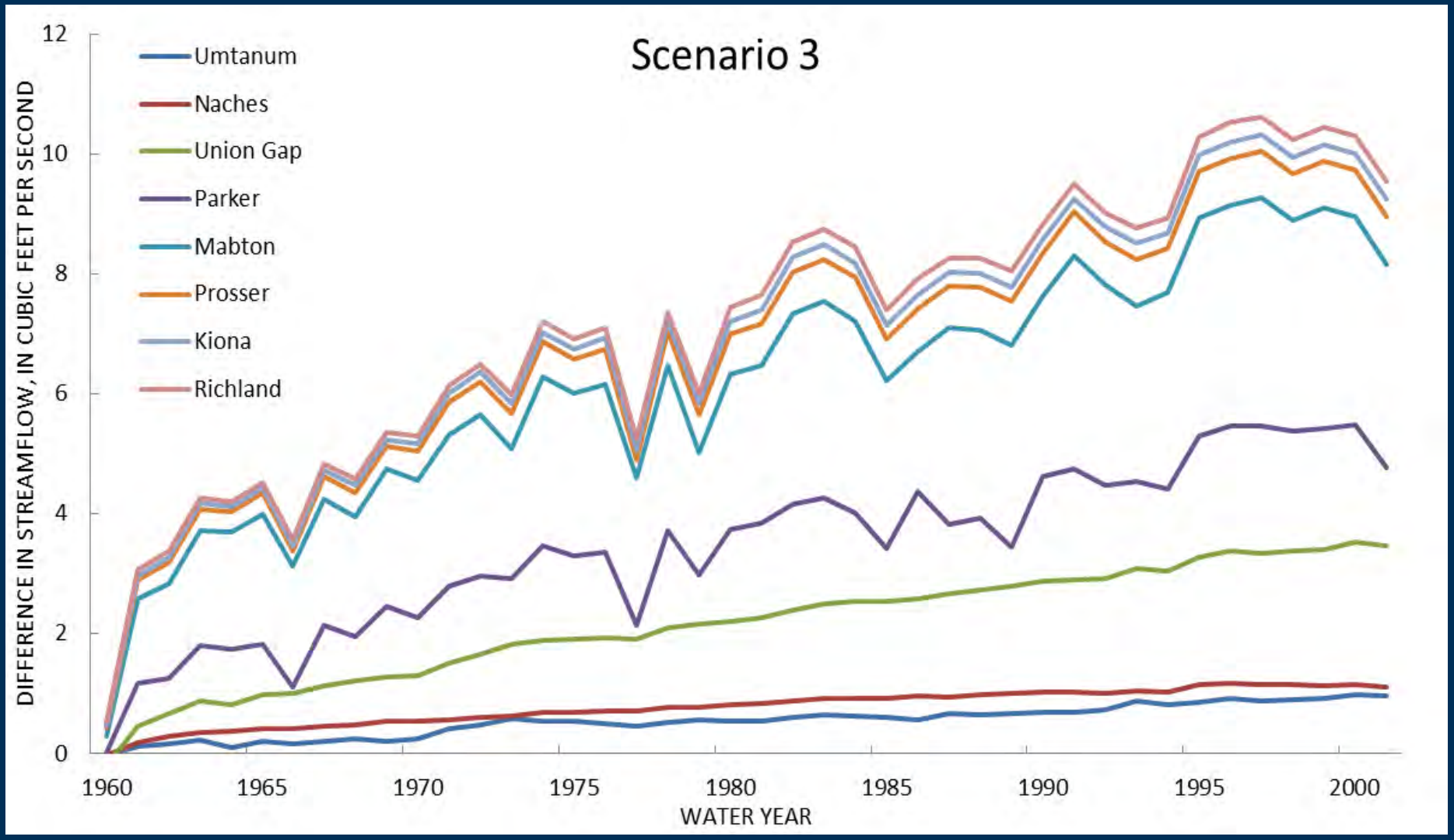
# Simulated mean annual difference in streamflow without exempt pumpage

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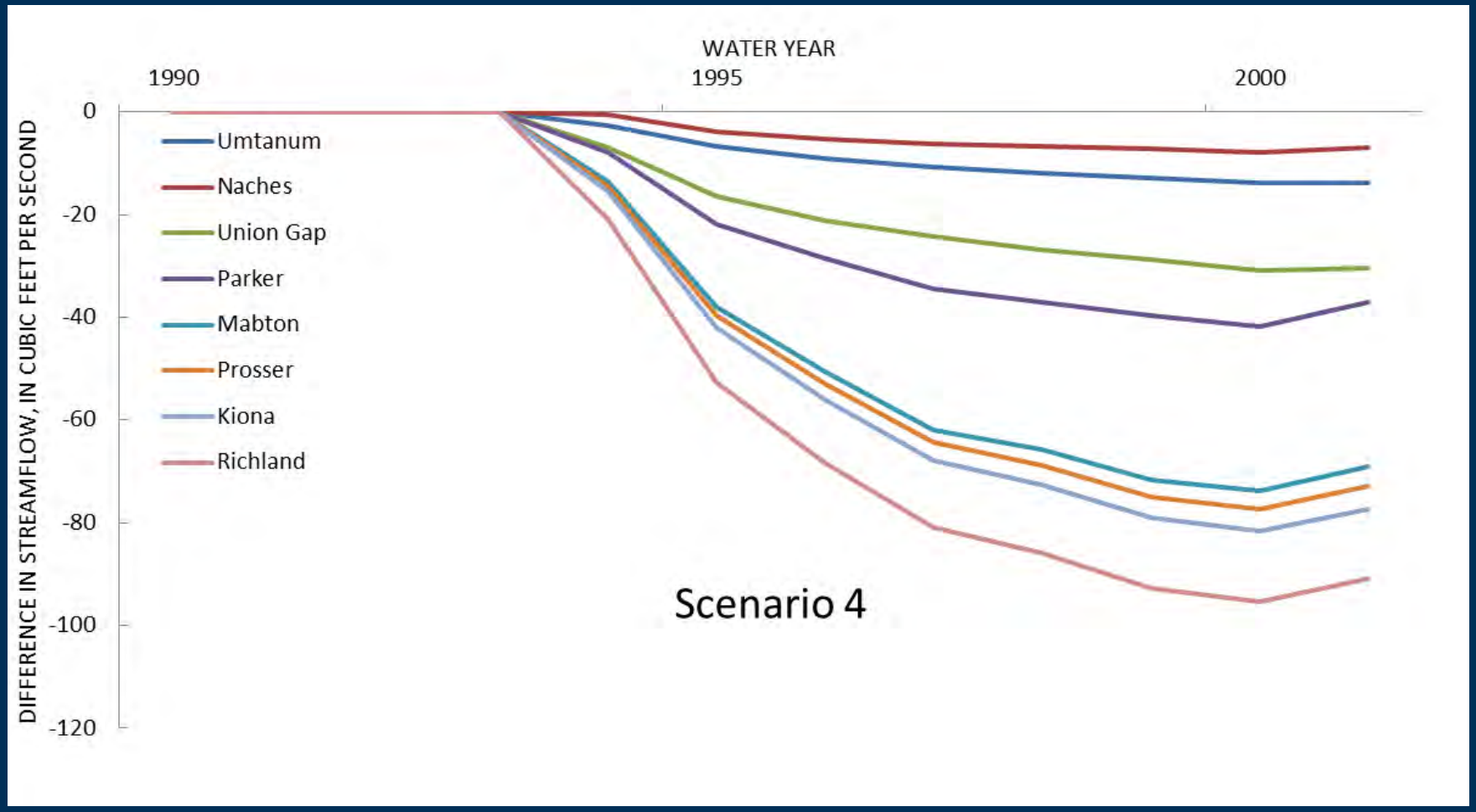
# Simulated mean annual difference in streamflow with additional 886 pending groundwater application pumpage

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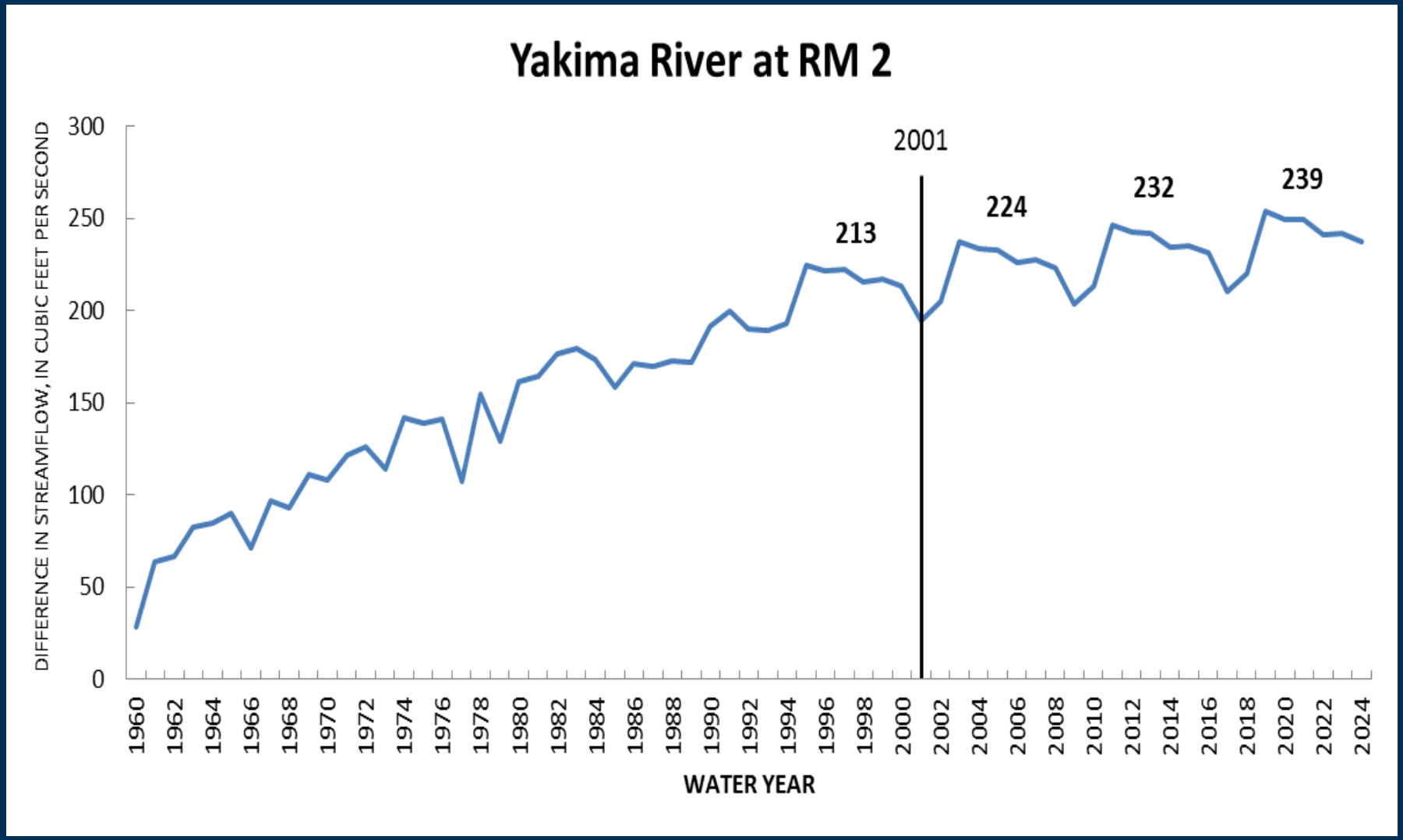
# Simulated mean annual difference in streamflow without pumpage projected 24 years into the future

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# Future Applications

- Study Team scoped model to go well beyond answering the questions posed by litigation
- Detailed shallow aquifer and surface water characterization intended for use answering questions about
  - Effects of agricultural water conservation
  - Hyporheic zone processes and restoration
  - Conjunctive use of surface and groundwater
  - Artificial groundwater storage

USGS

# Aquifer Storage Component of Yakima Basin Integrated Plan

- Store water in aquifers pre-storage control (define) when flow > ecosystem needs
- Use water post-storage control in lieu of reservoir releases
- Benefits to irrigation and instream flow
- The USGS gw model would be used
  - To simulate the behavior of the recharge mound
  - To determine favorable locations and types of recharge and recovery facilities
  - In tandem with Reclamation models to estimate effectiveness in terms of carryover, drought abatement, and flow augmentation

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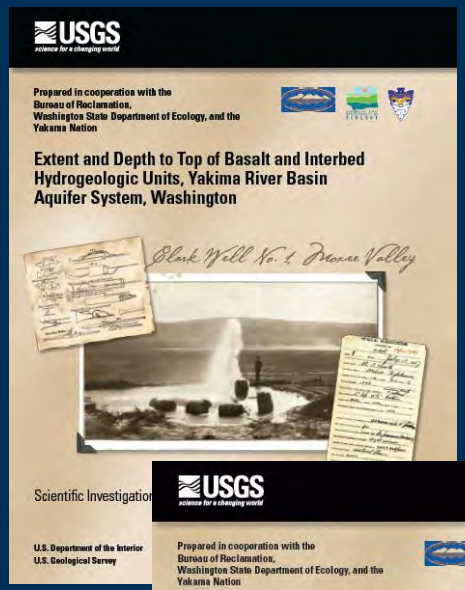
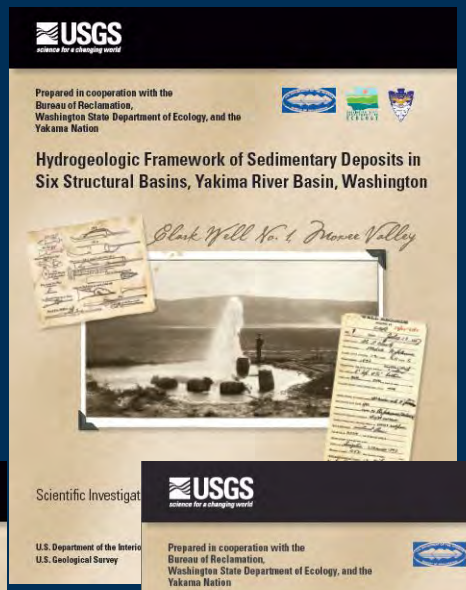
# Ecology's core values in moving forward in the Yakima Basin

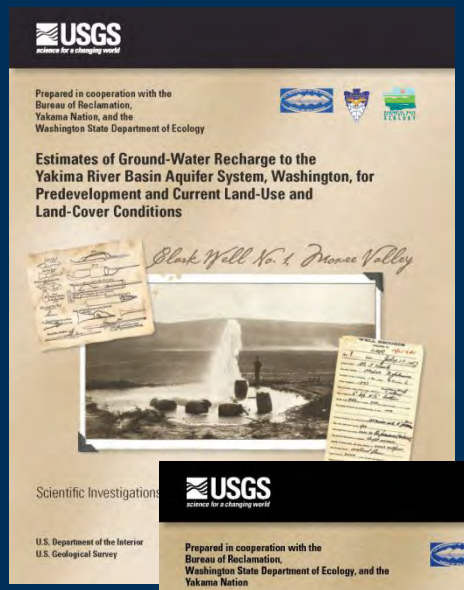
- Future groundwater management will protect senior water rights, flows for fish and economic development
- Ecology shall build upon the broad based support for the Yakima Basin Integrated Water Management Plan
- Ecology will seek solutions that address uncertainty and exposure faced by existing post 1905 groundwater users (most everyone)

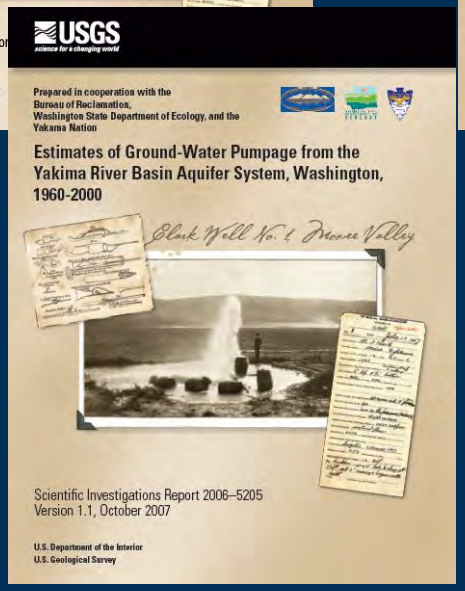
# Next steps and confronting the scientific and policy realities of the study results

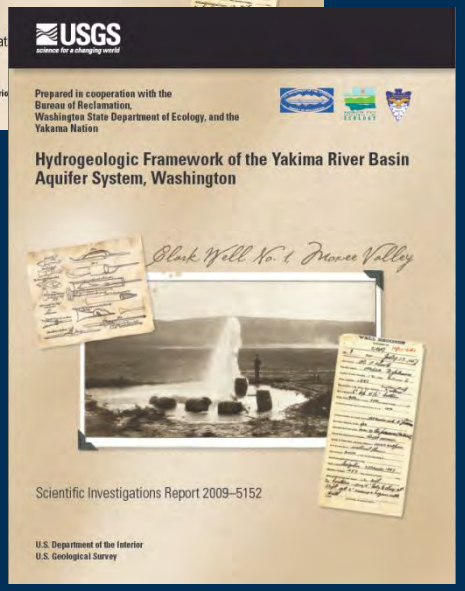
- Yakima USGS Groundwater study and model will serve as Best Available Science for Water Rights processing
- Ecology shall make measureable progress in addressing the water management challenges ahead in the Yakima Basin
- Ecology shall address the -200 cfs hole through aggressive pursuit of the Yakima Basin Water Management Integrated Plan and continued investments in YRBWEP II
- Ecology shall begin to process the 1161 surface and groundwater applications in the Yakima Basin
- Ecology shall initiate facilitated discussions with key stakeholders in addressing new groundwater withdrawals
- Ecology is committed to transparency and open communication throughout the process

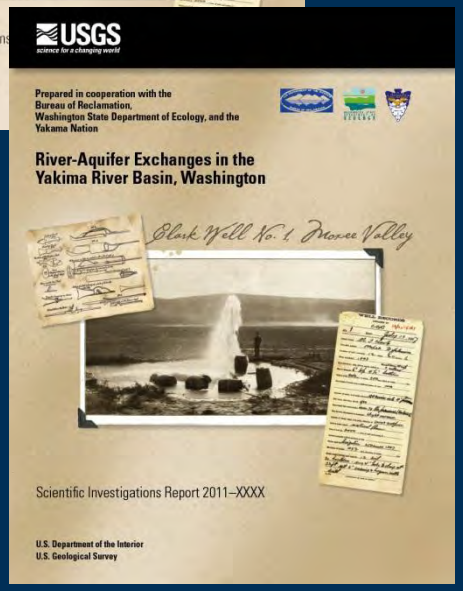



http://wa.water.usgs.gov/projects/yakimagw

USGS

# *Sonoma County, Washington - Science and Management*

- **Jay Jaspers, Sonoma County**

- **Marcus Trotta, Sonoma County**

- **Joe Hevesi and Linda Woolfenden, CA Water Science Center**

# Cooperative USGS Studies on Groundwater and Surface Water Resources in Sonoma County

***Jay Jasperse, PE – Chief Engineer***
***Marcus Trotta, PG, CHg - Hydrogeologist***
***Sonoma County Water Agency***


www.sonomacountywater.org

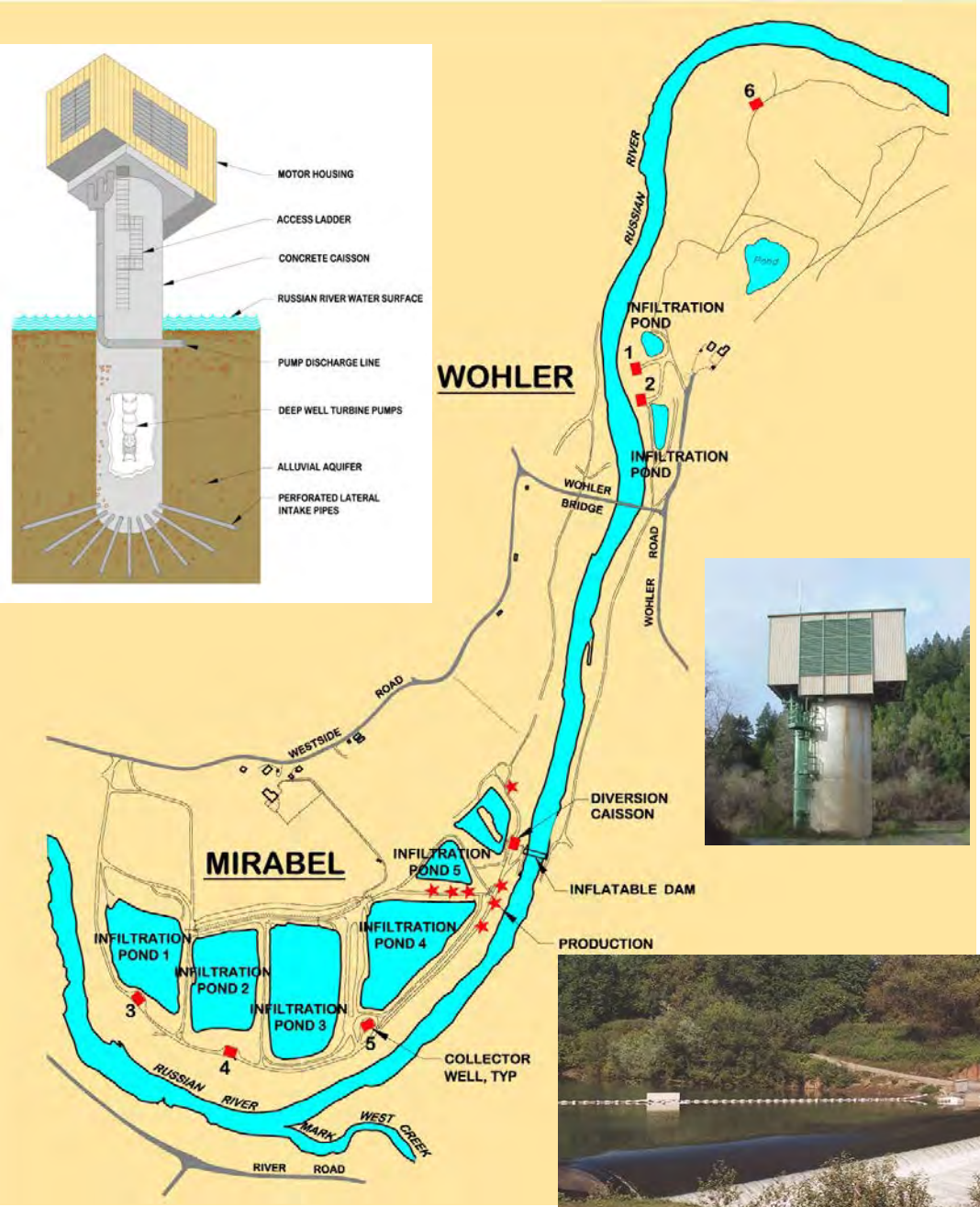
# Sonoma County Water Agency Overview

- Wholesale Water Supplier for ~600,000 people
  - Russian River Primary Supply with Supplemental Groundwater
- Wastewater Collection and Treatment
  - Recycled Water Distribution
- Flood Protection Services
- Environmental Resources
  - Fishery monitoring and enhancement projects
- Power Generation

# Russian River
# Riverbank Filtration System

- **One of the largest riverbank filtration systems in the world**
- **Treatment accomplished via natural filtration.**






- 6 Collector Wells
- 5 Infiltration Ponds
- Inflatable Dam

## USGS Data for Operations

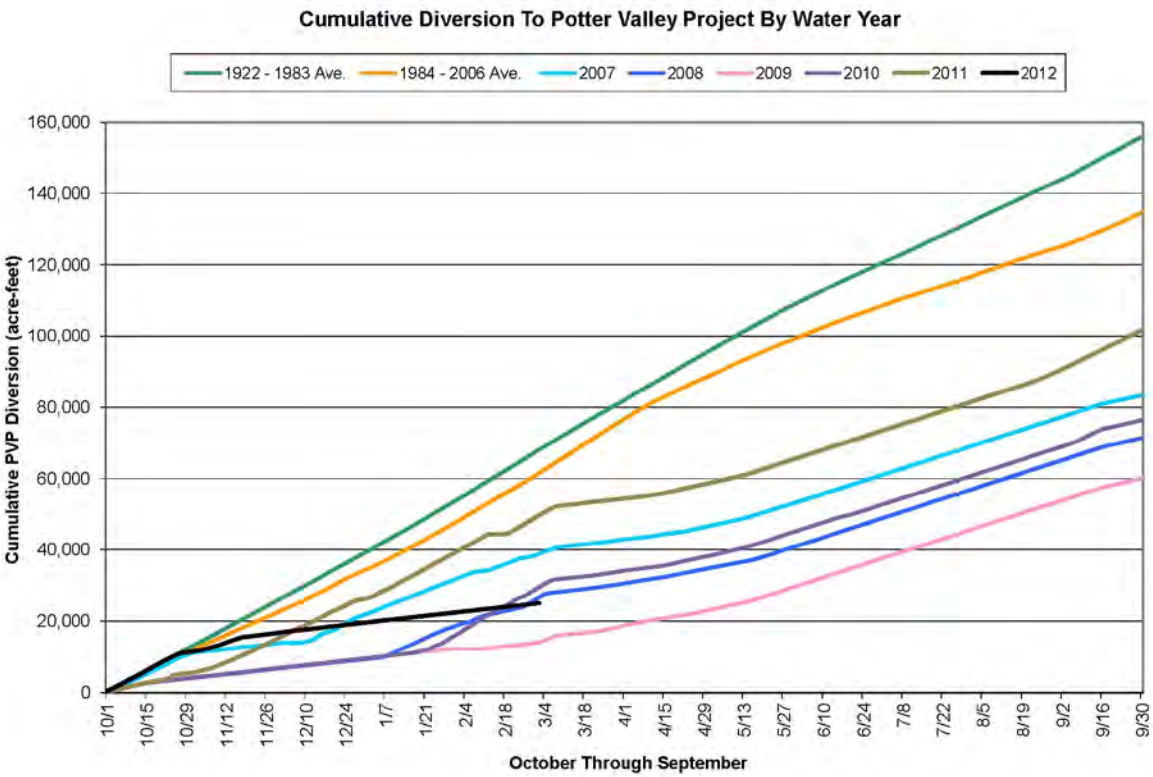
- SW-GW Interaction and Water Quality Studies
- Reliance on USGS Stream Gauges

SONOMA COUNTY WATER AGENCY

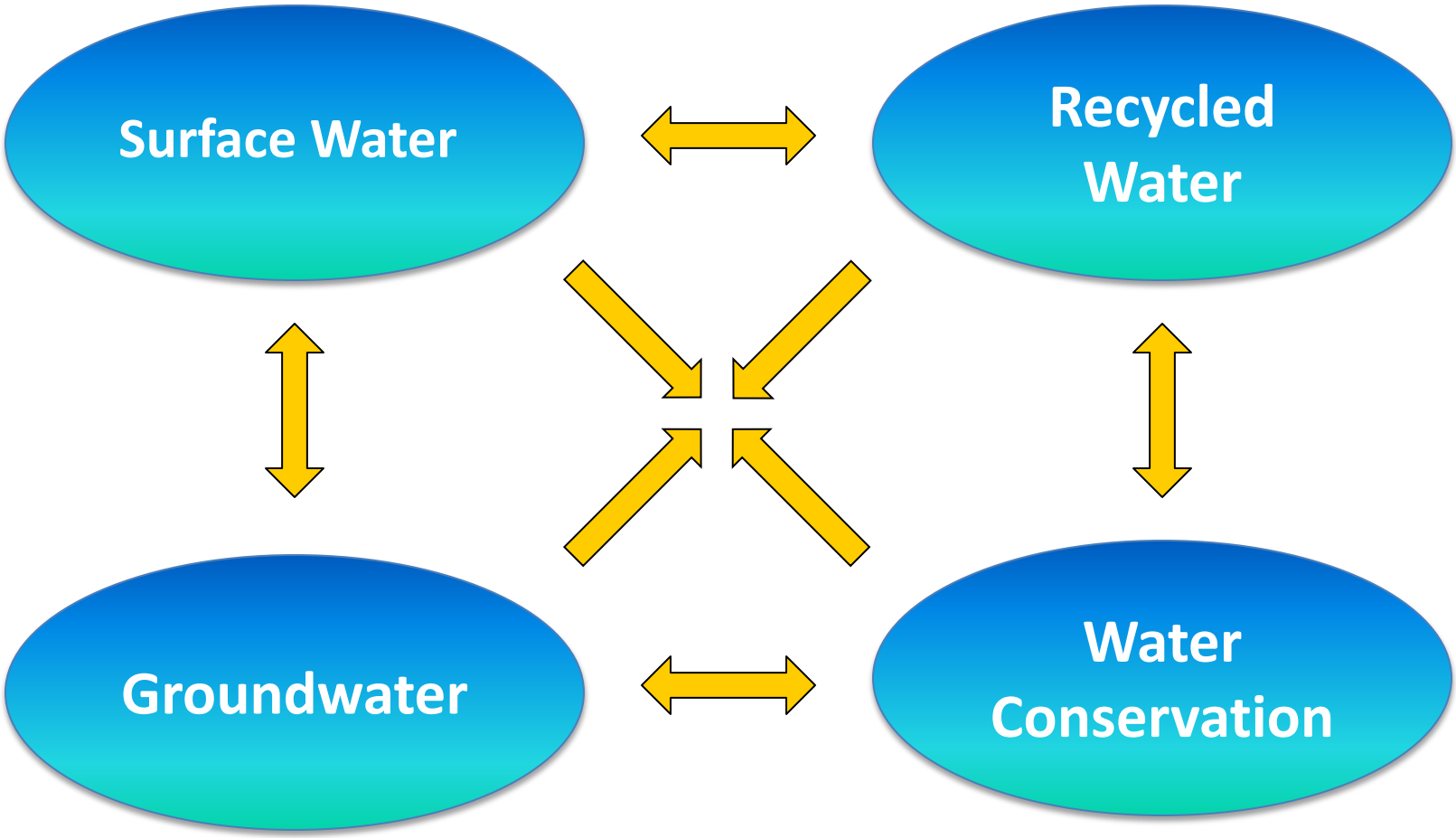
# Water Supply Issues & Challenges

- Drought
- Climate Change
- NMFS Biological Opinion (2008)
  - Requires flow <u>reductions</u> in Russian River and possibly major tributary (Dry Creek) during summer months
- Dry Creek Enhancement or Reduced Flows
- Reduced Potter Valley Diversions

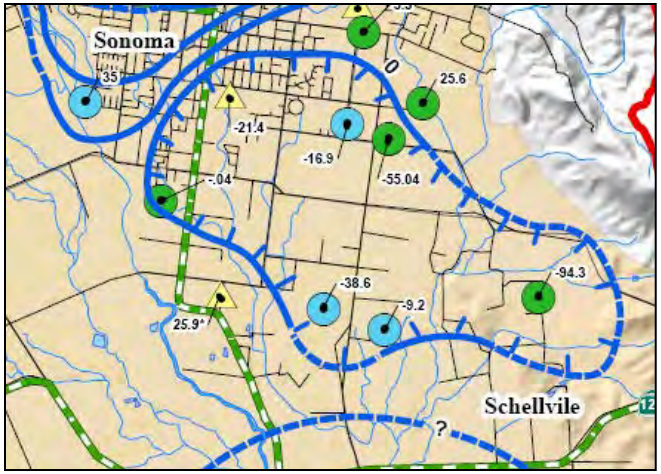
# Russian River Watershed – Potter Valley Diversion Reductions



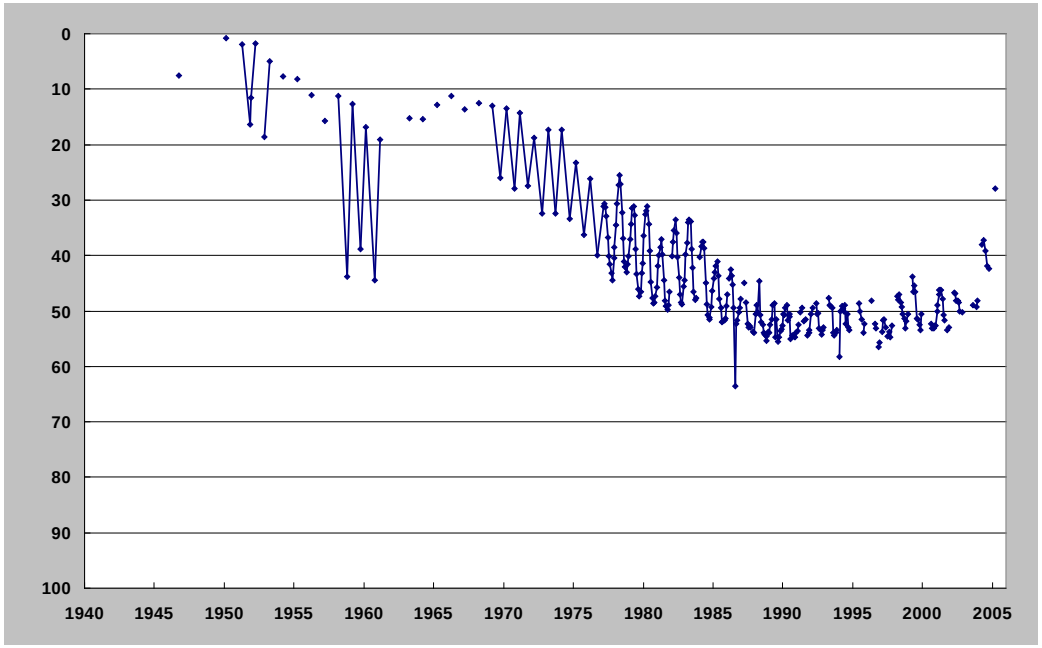
# Four Ways to Meet Water Demand

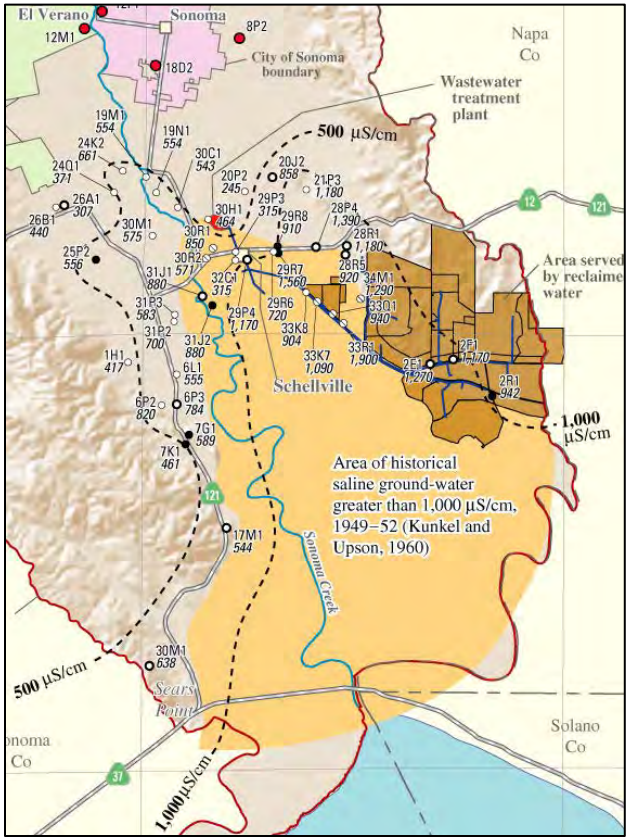


# Groundwater Issues



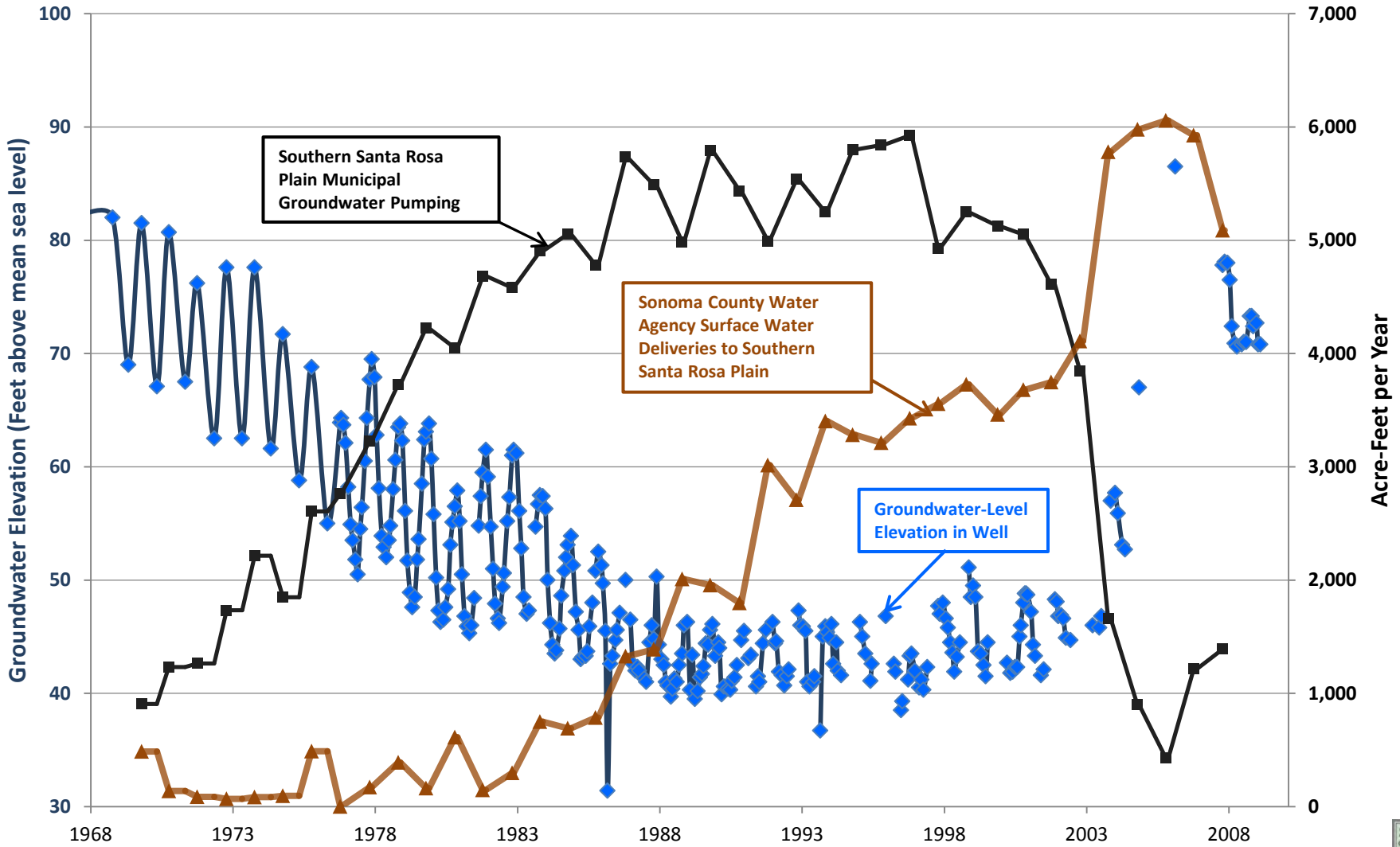

**Declining groundwater-levels: locally below sea level**

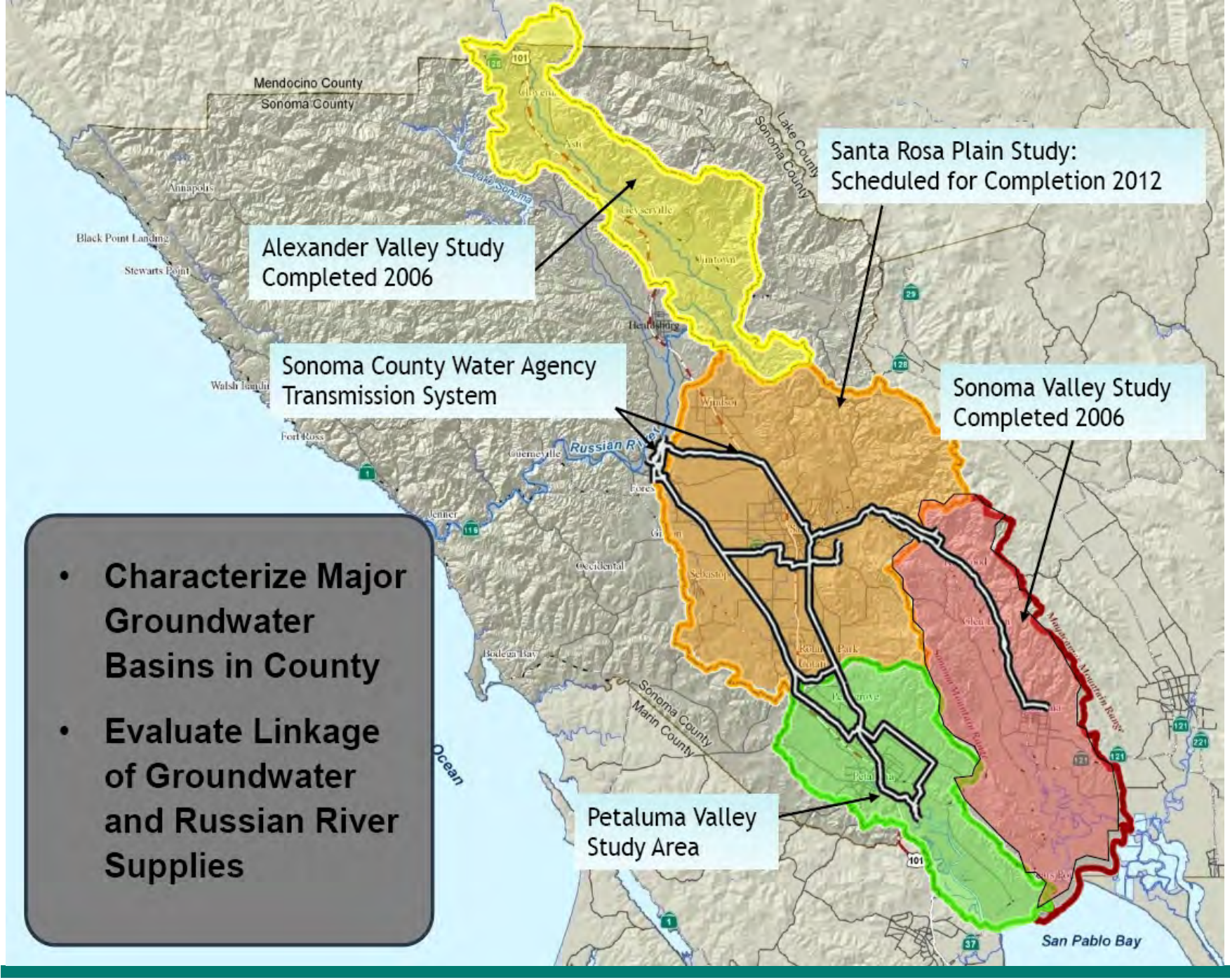



**Increasing TDS levels**

# Historical Conjunctive Management: Connection Between Groundwater & Water Agency Supplied Water






- **Characterize Major Groundwater Basins in County**
- **Evaluate Linkage of Groundwater and Russian River Supplies**

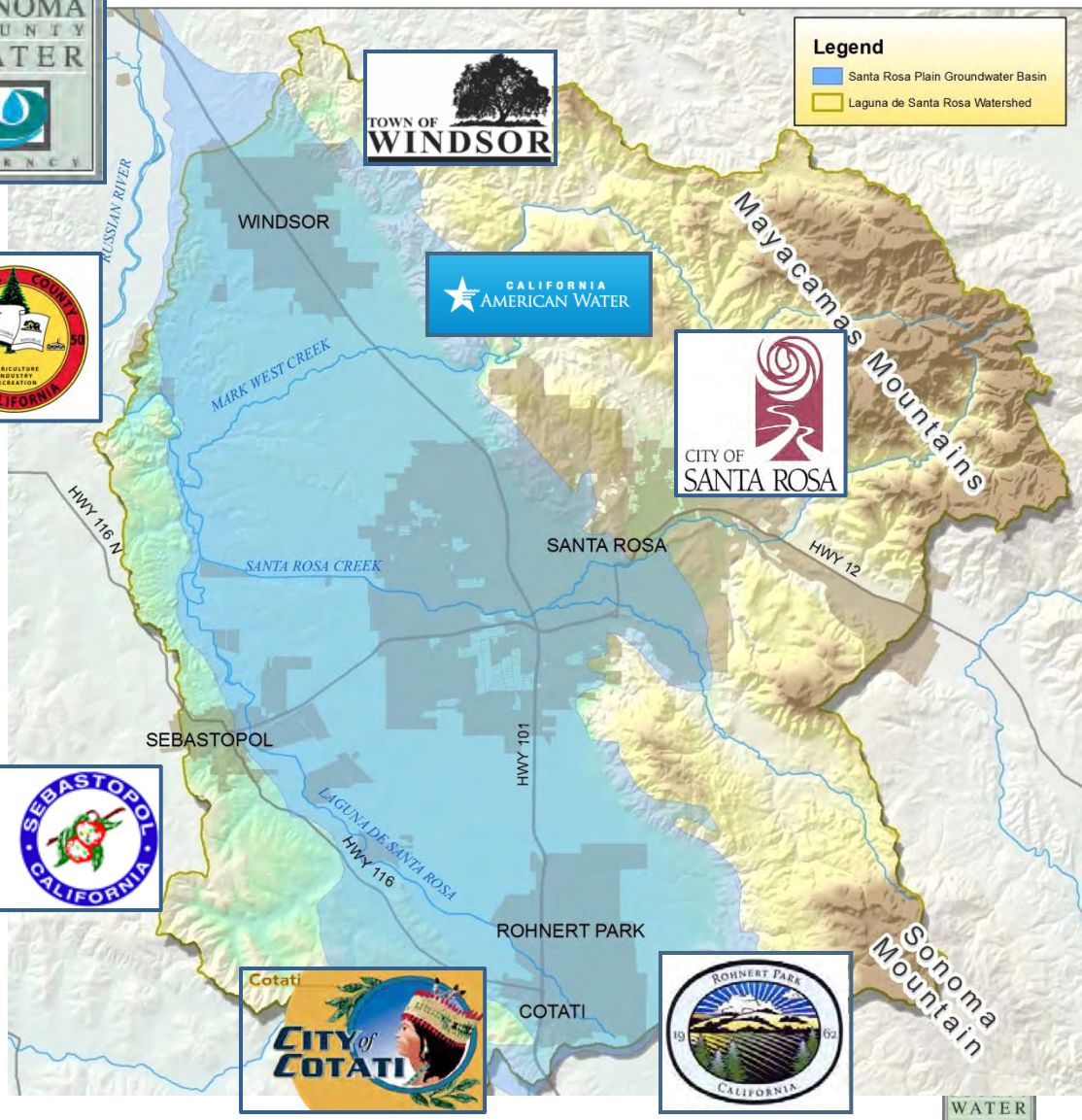
**Santa Rosa Plain Groundwater Study Due 2012**

**$2.2M Study ($1.5M local funding, $0.7M USGS)**

## OBJECTIVES

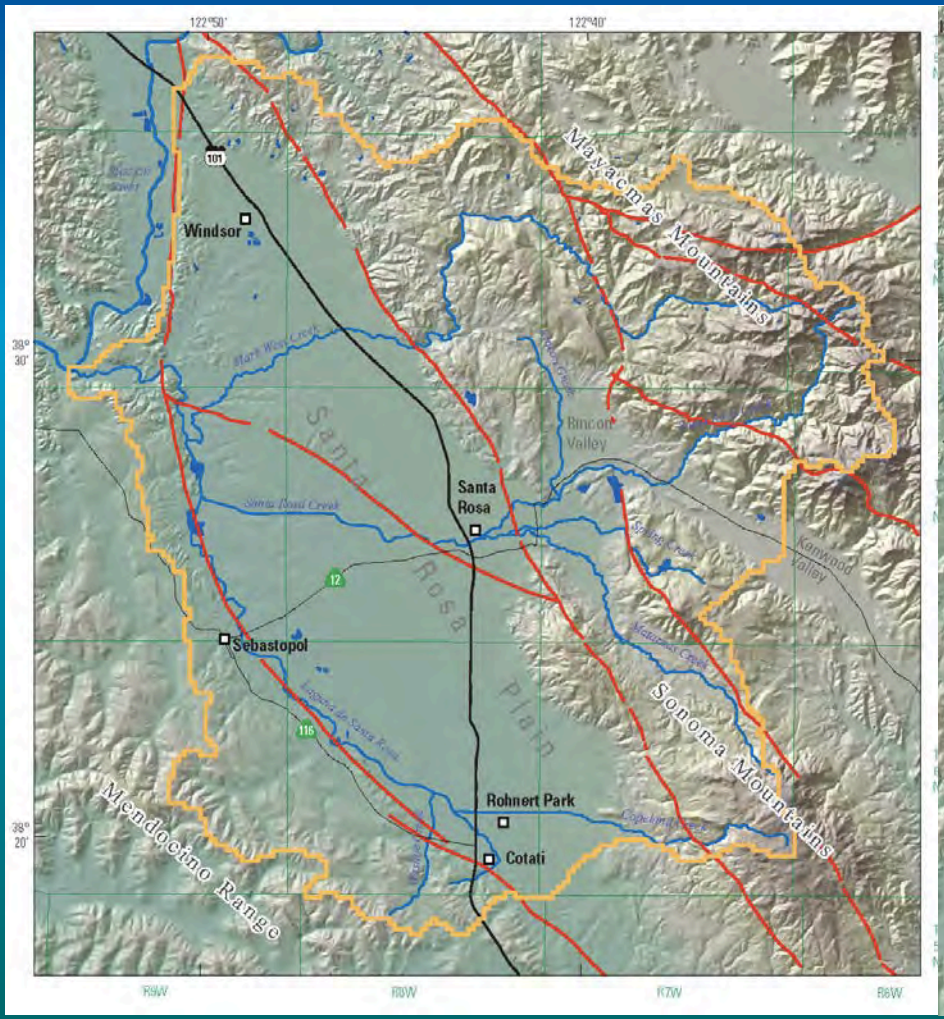
**Hydrogeology and Groundwater Quality**

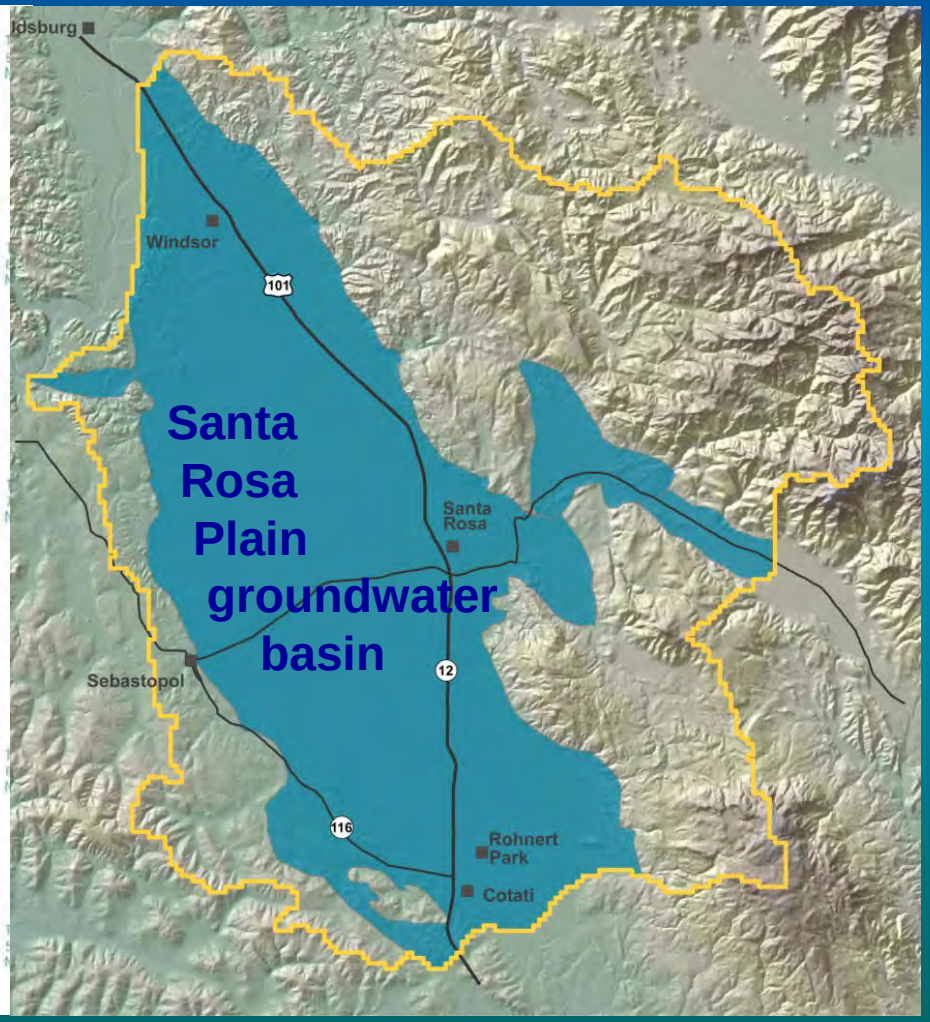
**Develop Coupled Surface Water-Groundwater Model**



# GSFLOW Model of the Santa Rosa Plain Watershed, California

*Linda Woolfenden, Joseph Hevesi (Sacramento, CA)*
*Tracy Nishikawa (San Diego, CA)*

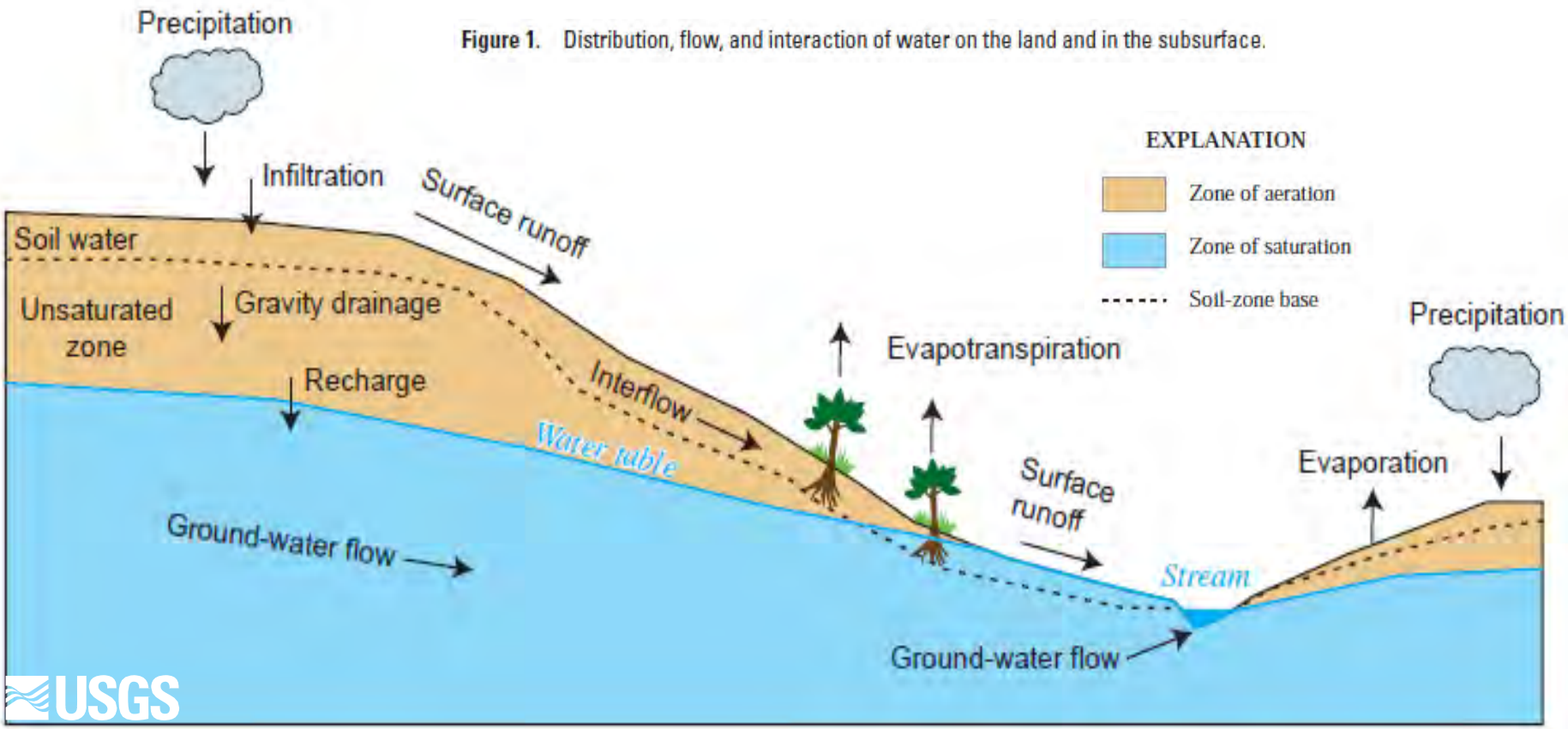


# GSFLOW—Coupled Ground-Water and Surface-Water Flow Model Based on the Integration of the Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW-2005)

By Steven L. Markstrom, Richard G. Niswonger, R. Steven Regan, David E. Prudic, and Paul M. Barlow

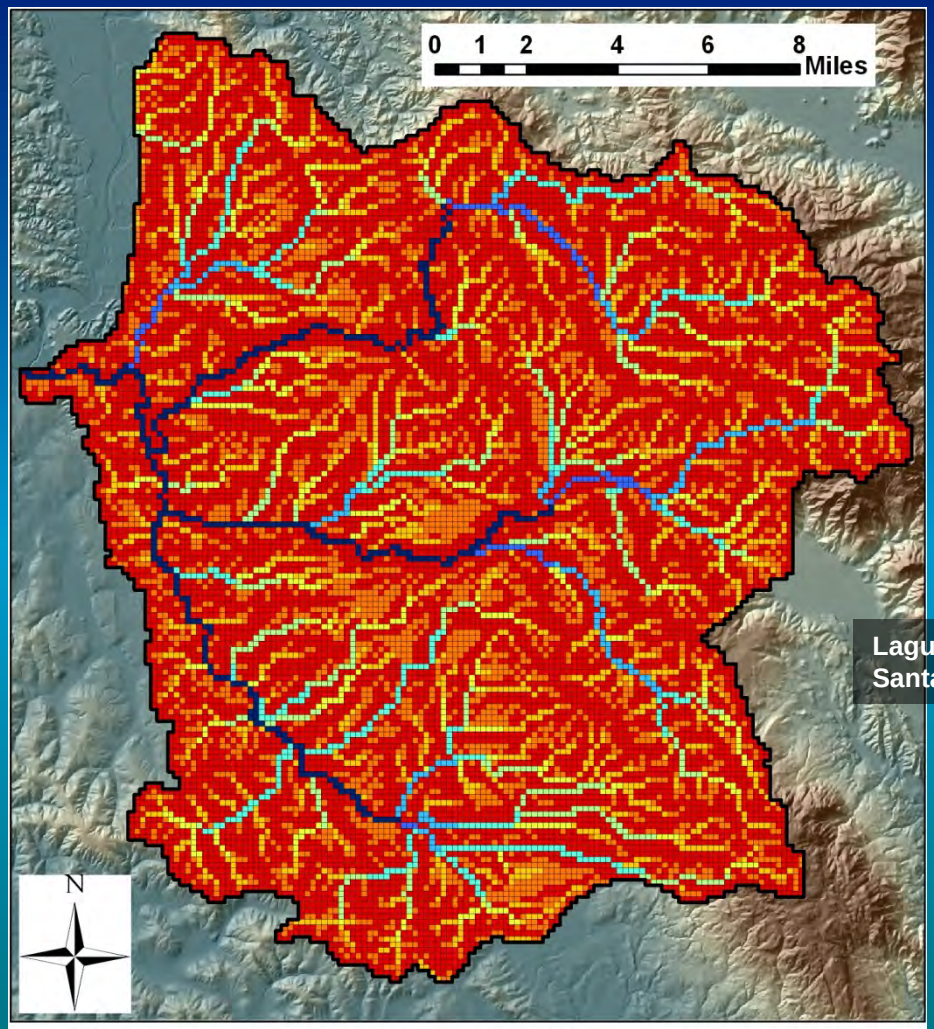
**Figure 1.** Distribution, flow, and interaction of water on the land and in the subsurface.




USGS

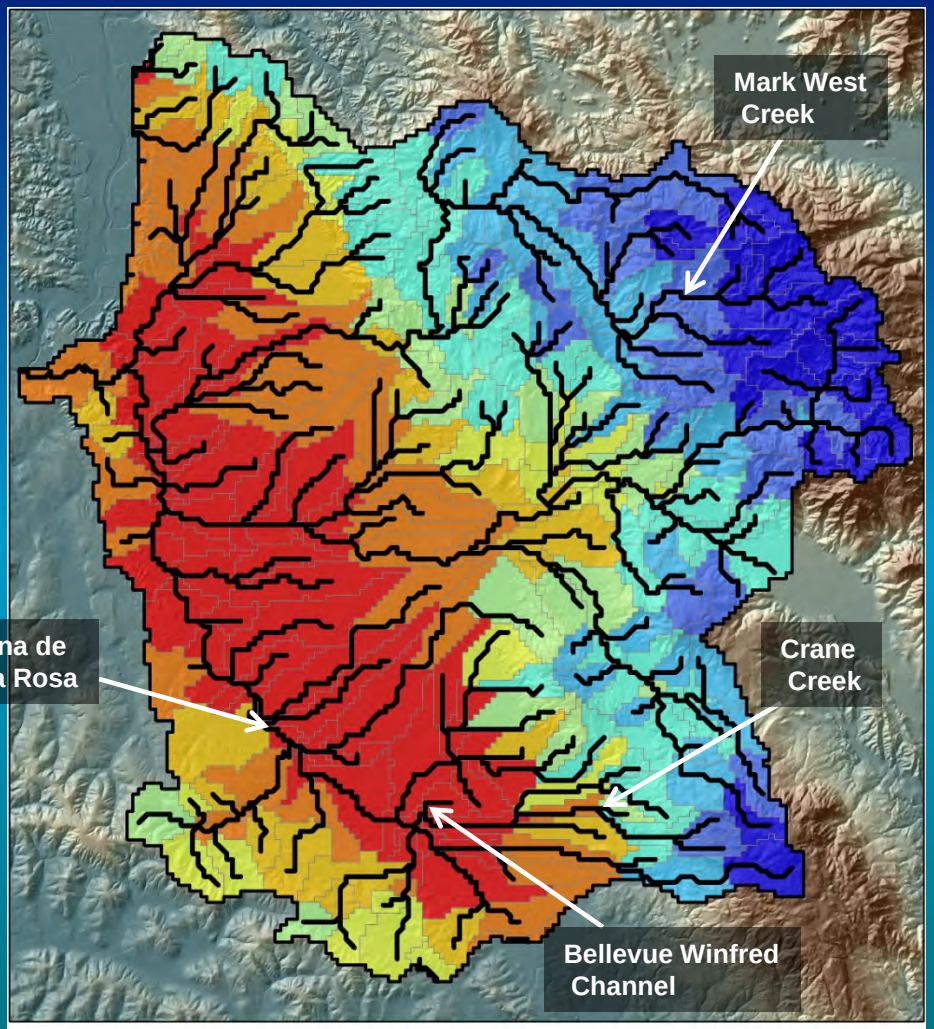
# GSFLOW model layout

**16,741 Hydrologic Response Units (HRUs), Grid-based HRUs (660 x 660 ft cells), 324 stream segments**




Number of upstream Hydrologic Resonse Units (HRUs)

| | | |
|---|---|---|
| 0 - 1 | 51 - 100 | 501 - 1,000 |
| 2 - 10 | 101 - 200 | 1,001 - 2,000 |
| 11 - 50 | 201 - 500 | 2,001 - 16,287 |




Average elevation of stream-segment catchment (feet)

| | | |
|---|---|---|
| 59 - 119 | 258 - 356 | 732 - 1010 |
| 120 - 182 | 357 - 507 | 1011 - 1374 |
| 183 - 257 | 508 - 731 | 1375 - 2076 |

Mark West Creek

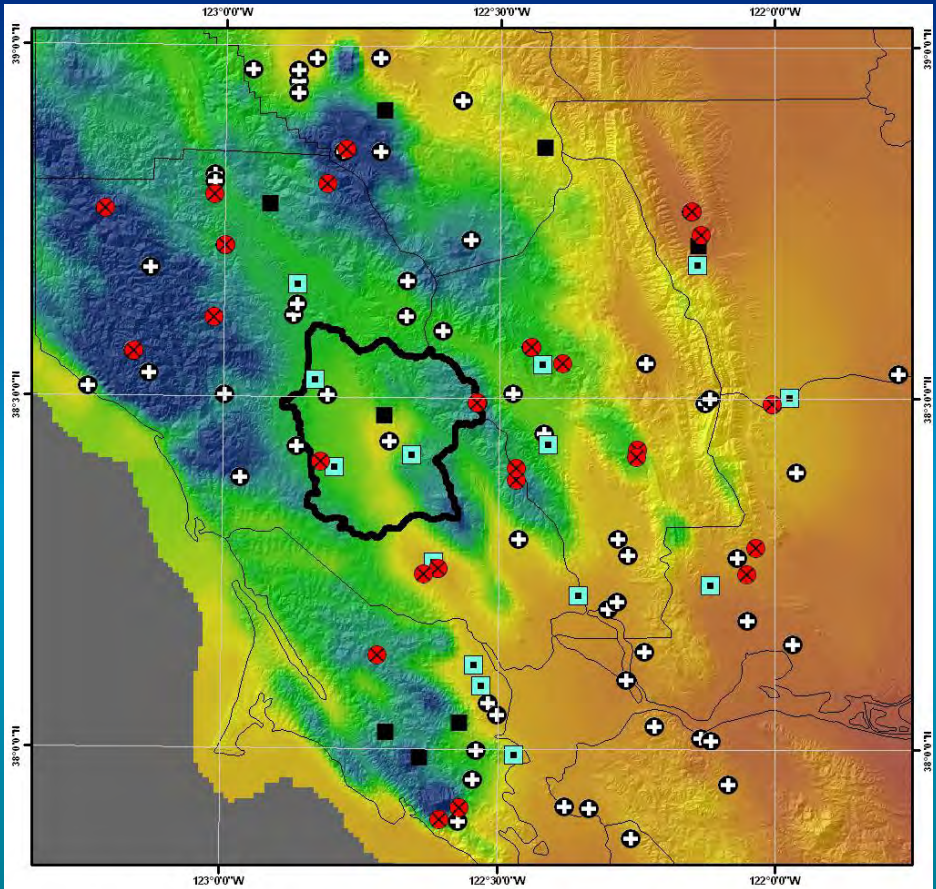
Crane
Creek

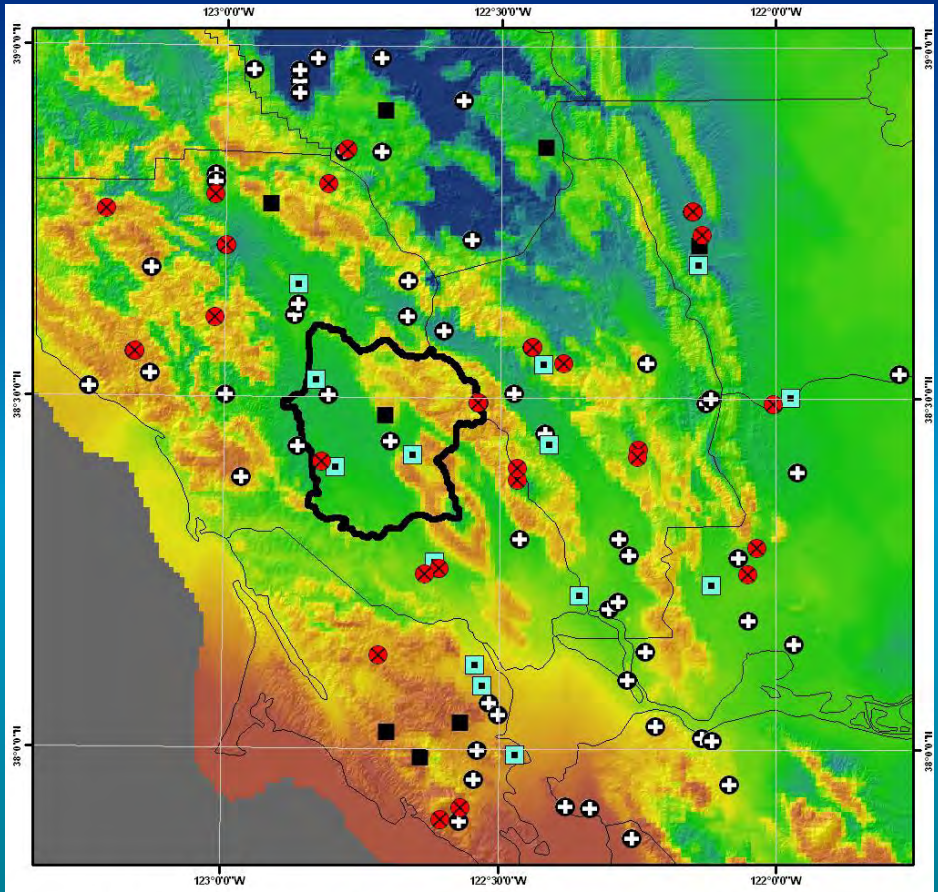
Laguna de
Santa Rosa

Bellevue
Wilfred
Channel

# Model inputs: Daily precipitation and air temperature

PRISM average monthly results used to spatially distribute daily climate records



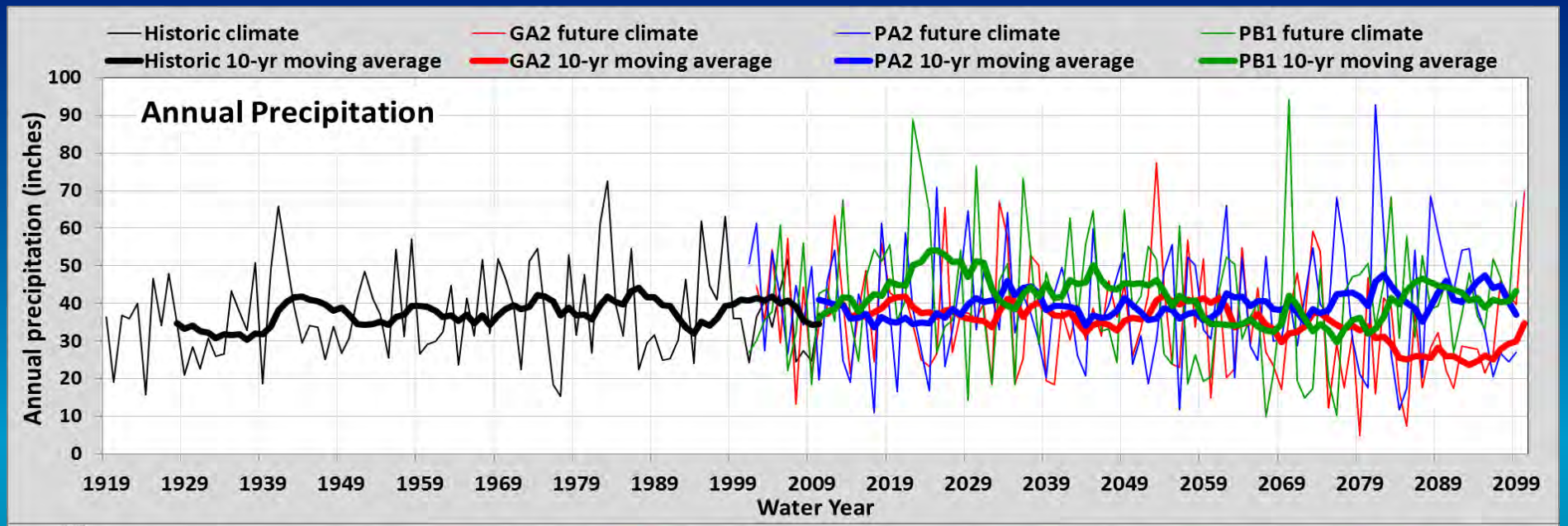



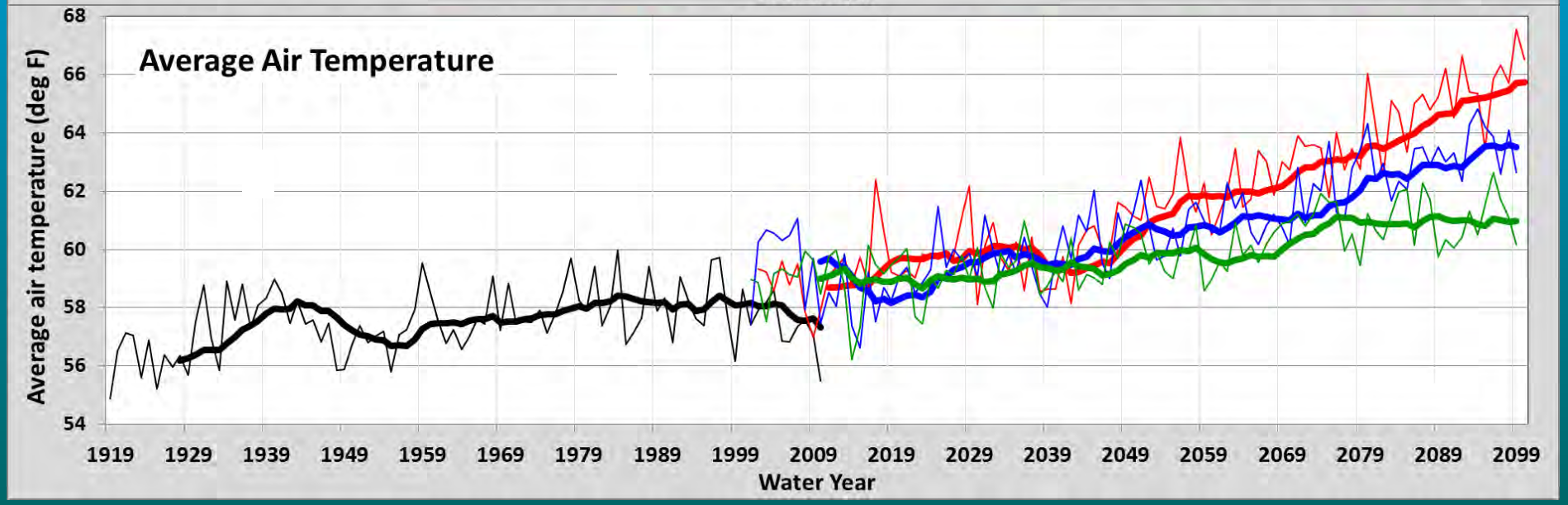

USGS

**Interpolated Historic Climate, 1919-2010**

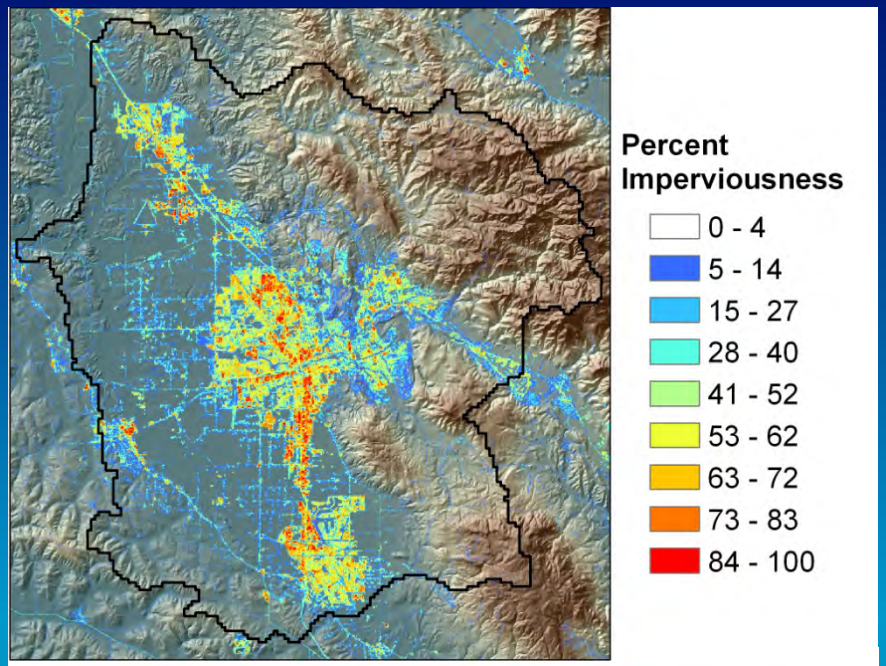
**Future Climate Scenarios, 2000-2100**

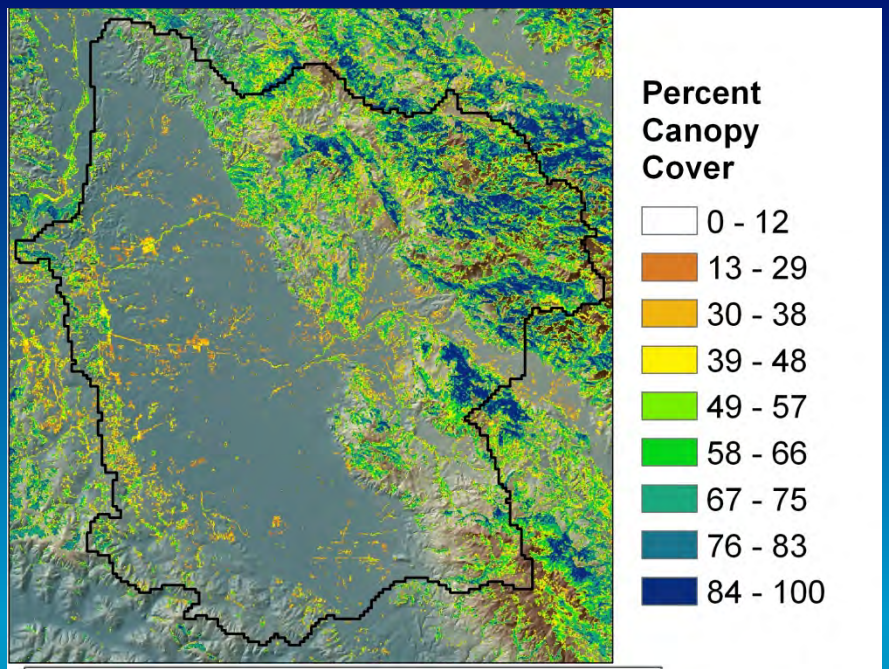
*Flint and Flint Ecological Processes 2012, 1:1*
*http://www.ecologicalprocesses.com/1/1/2*

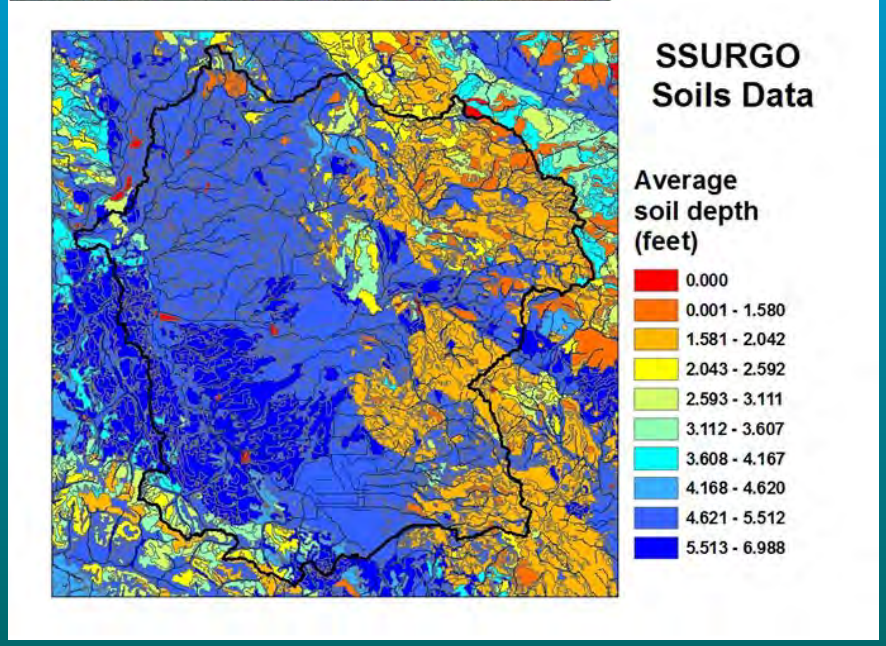


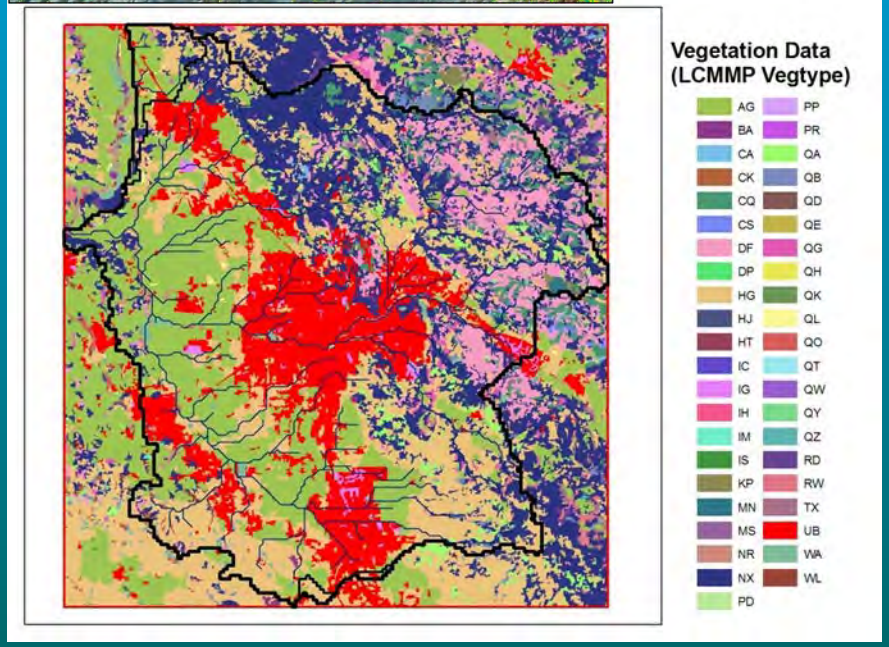



# GSFLOW / PRMS model inputs: land cover and soil characteristics

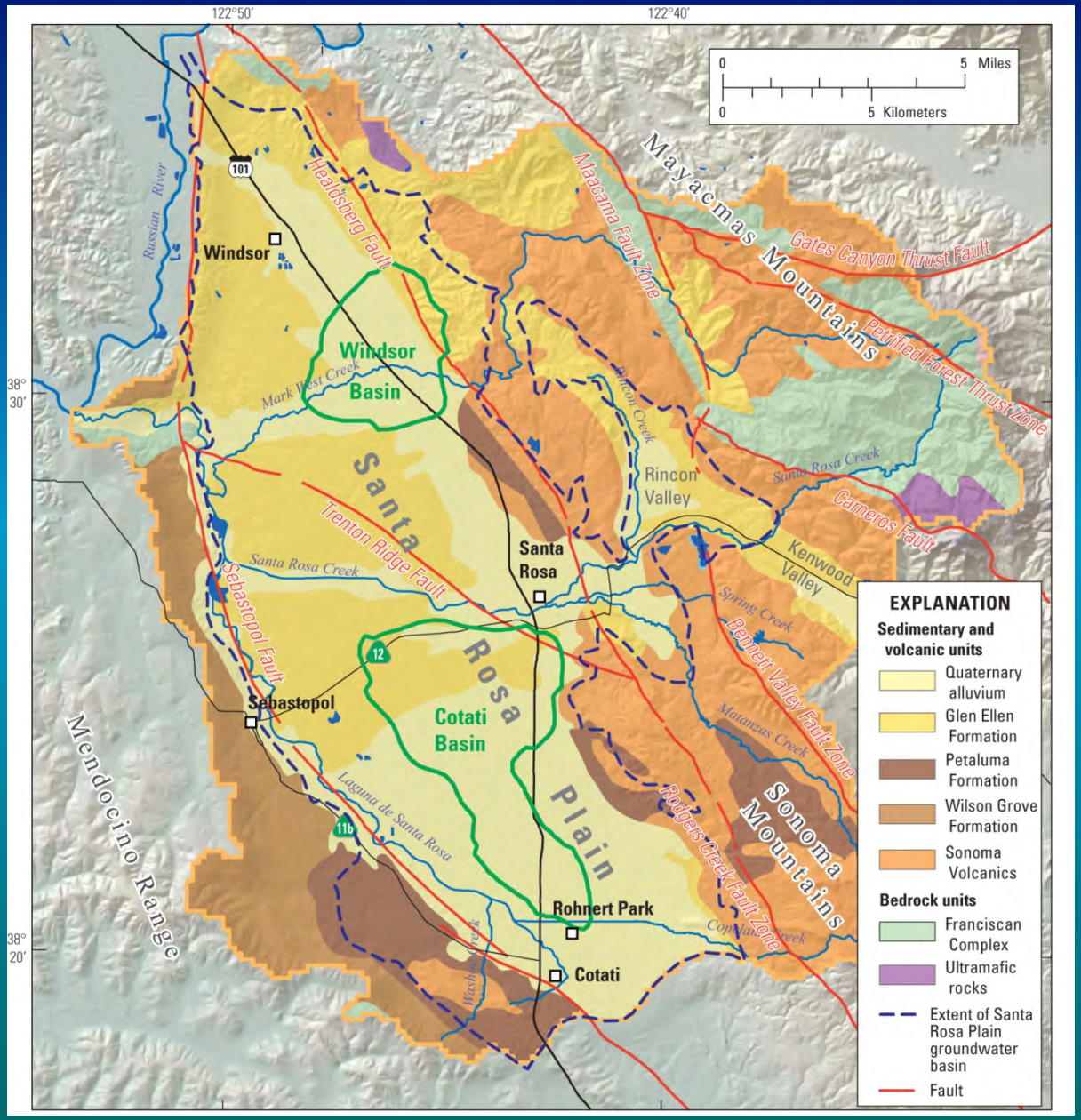


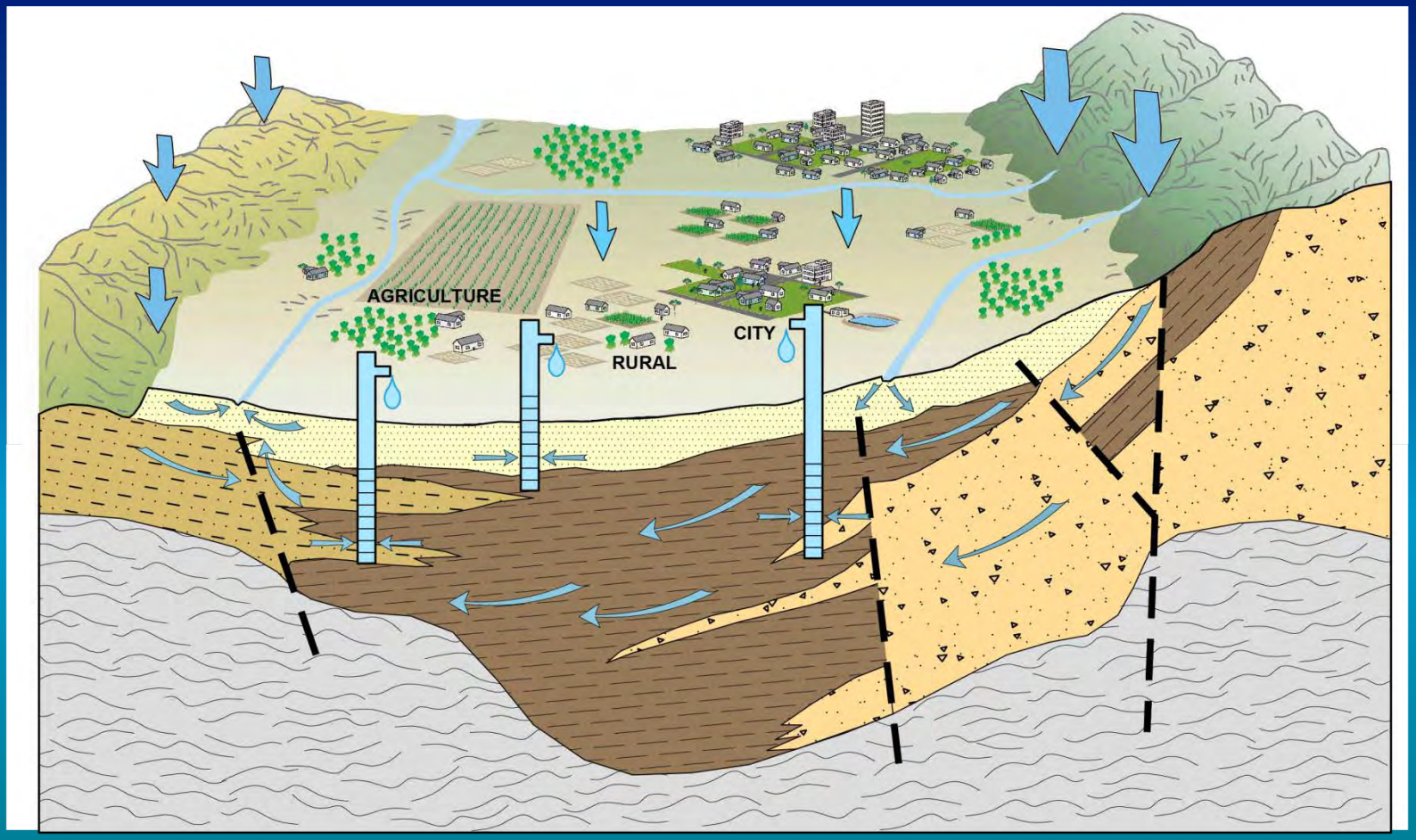



# Surface Geology




USGS

# Conceptual model of groundwater system




ALLUVIUM & GLEN ELLEN FORMATION

WILSON GROVE FORMATION

PETALUMA FORMATION

SONOMA VOLCANICS

BEDROCK

FAULT ZONE

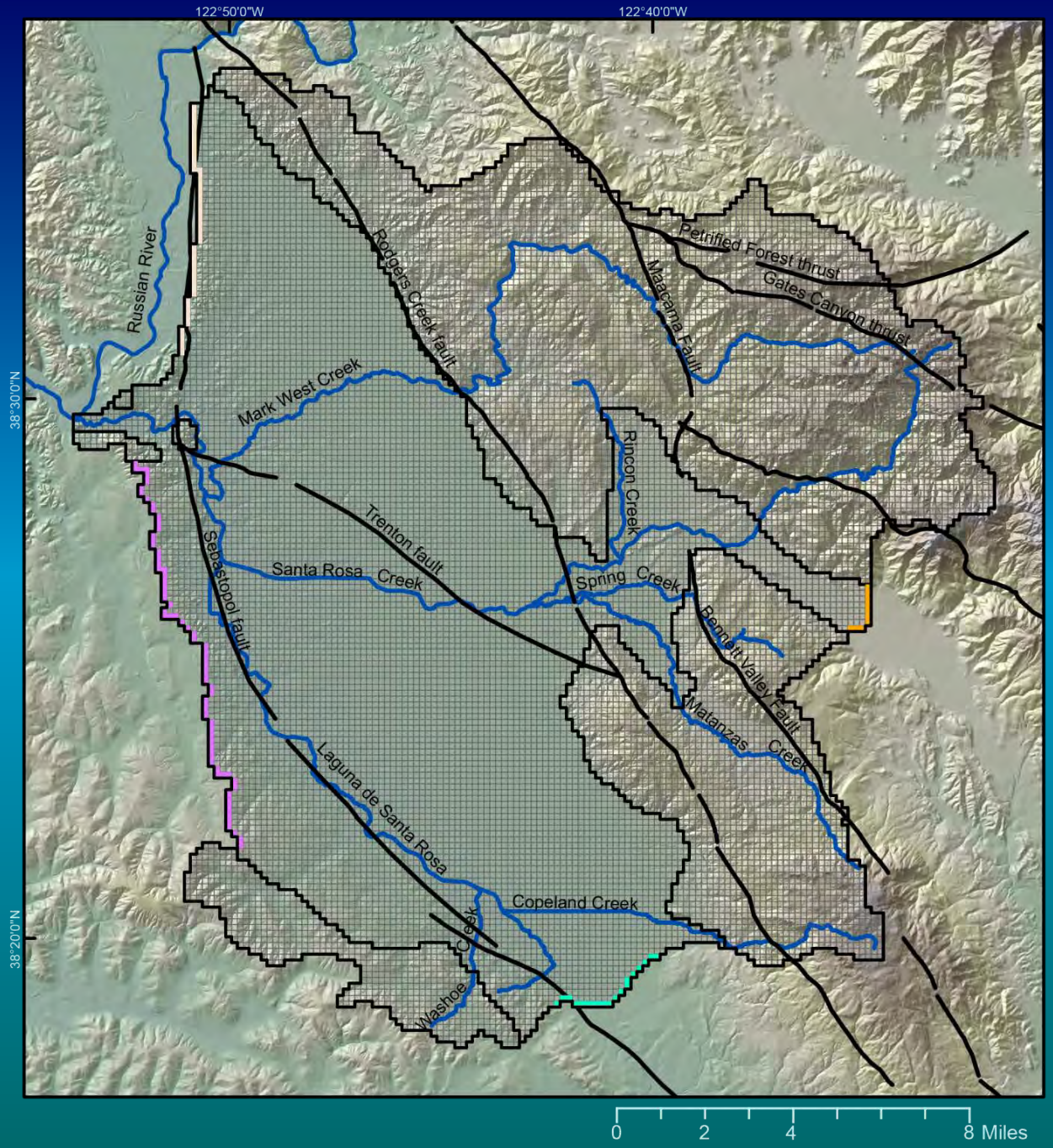
GENERAL DIRECTION OF GROUNDWATER MOVEMENT

RECHARGE OF GROUNDWATER

USGS

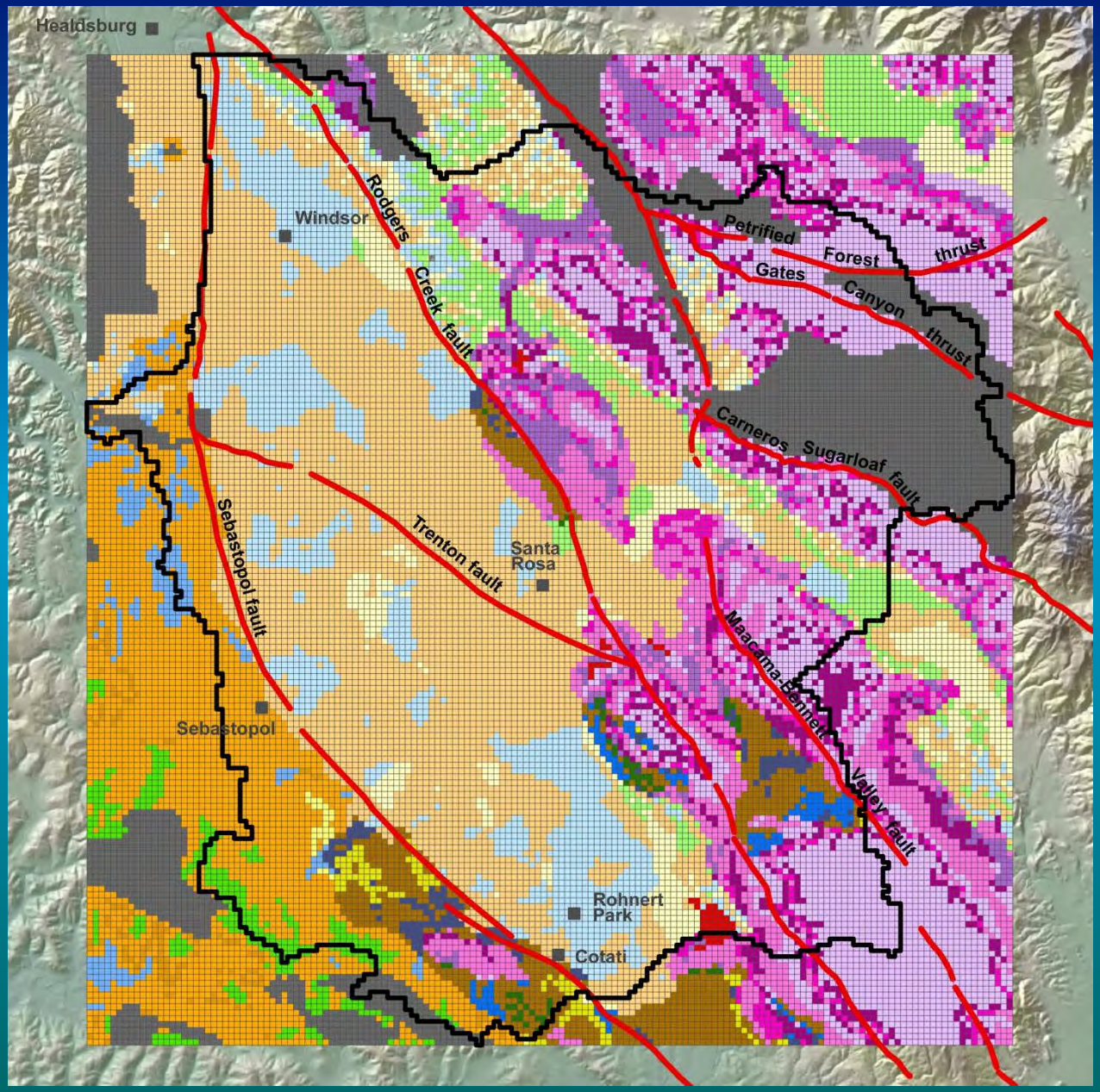
# Model grid and boundaries

- **Grid**
  - 660 ft by 660 ft cells
  - 168 rows, 57 columns
  - 8 layers
  - 1,850 ft total thickness
- **Simulation period**
  - 1975-2010
- **Boundaries**
  - Head-dependent and no-flow
- **Major faults are simulated**




USGS

# Texture-based aquifer properties

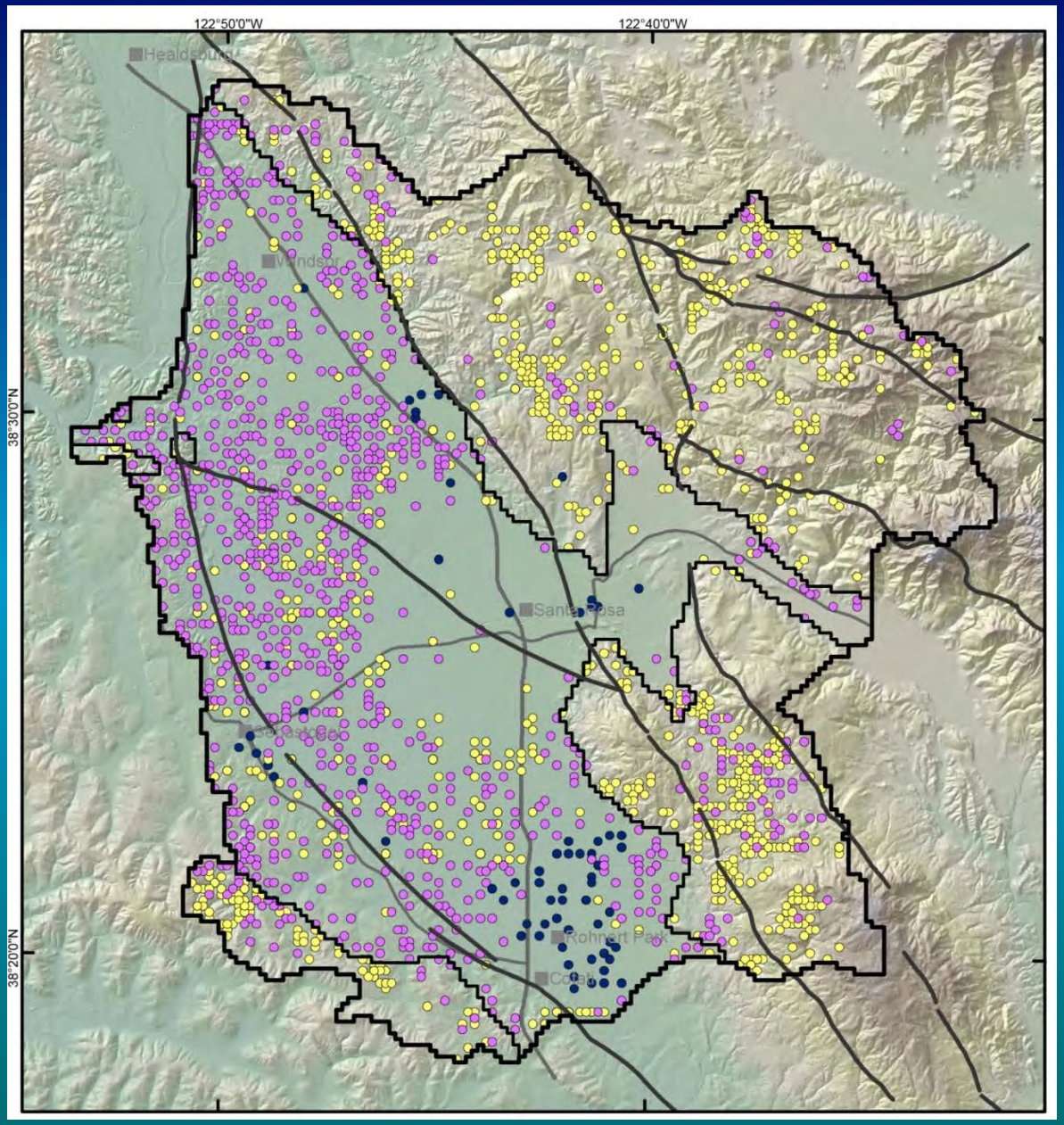



USGS

# Location of pumping wells used in the model

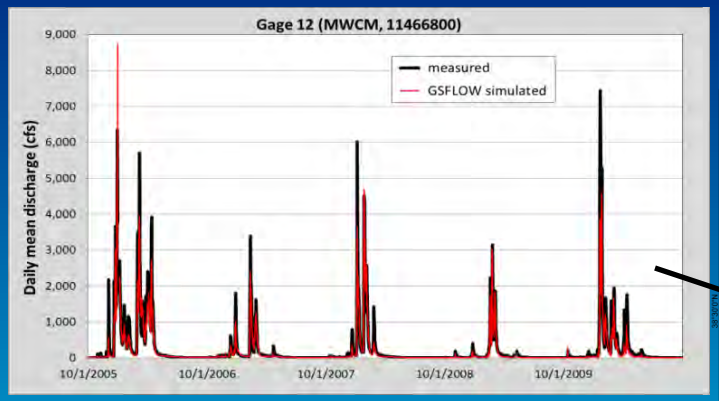
- Municipal (70) -reported
- Private (3,163) - estimated
- Agricultural (1,027) - estimated

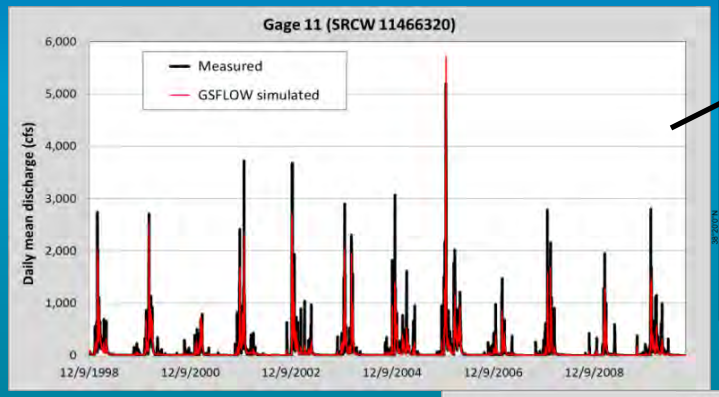
| Average | Range |
|---|---|
| 47,717 ac-ft | 23,056 - 78,107 ac-ft |

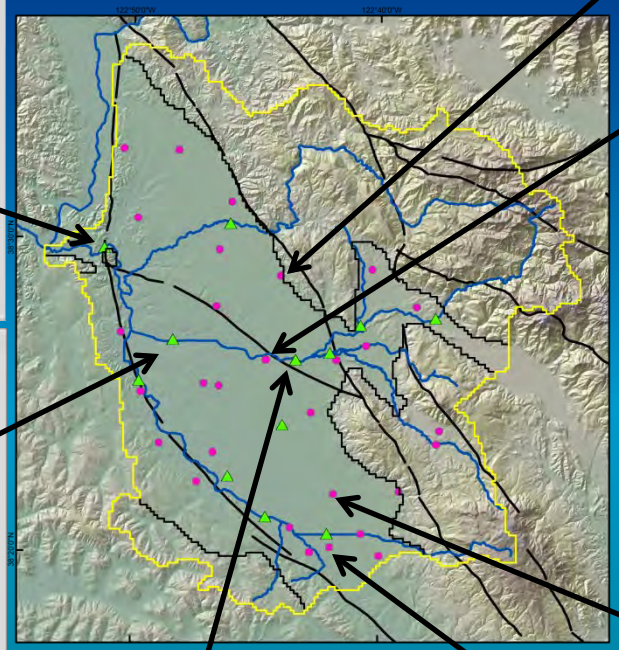


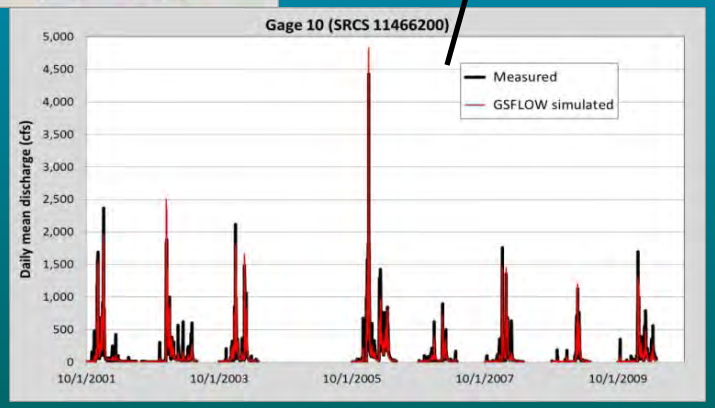

USGS

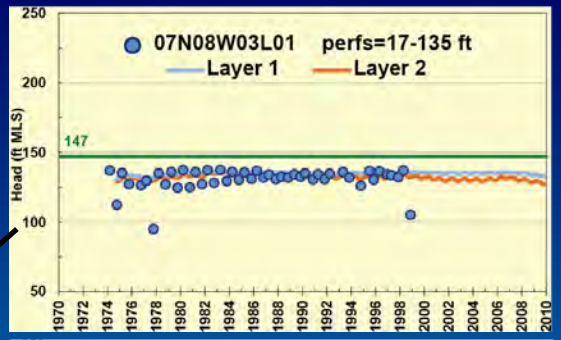
# Selected surface-water and groundwater calibration hydrographs

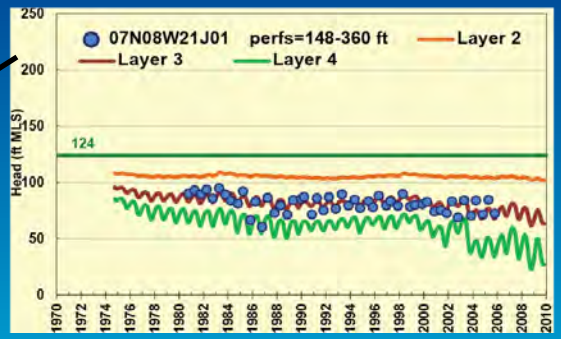


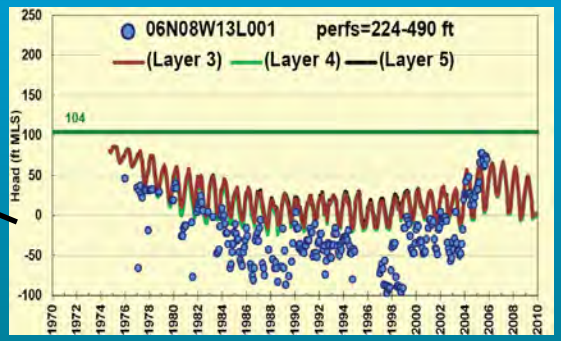



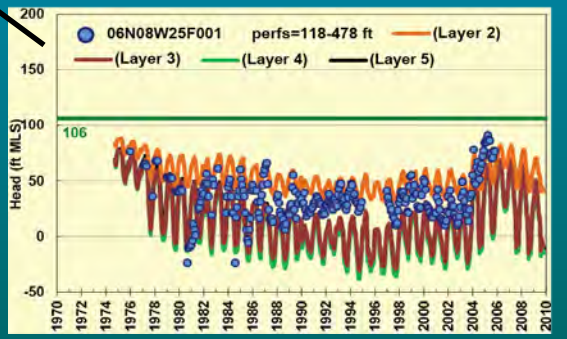





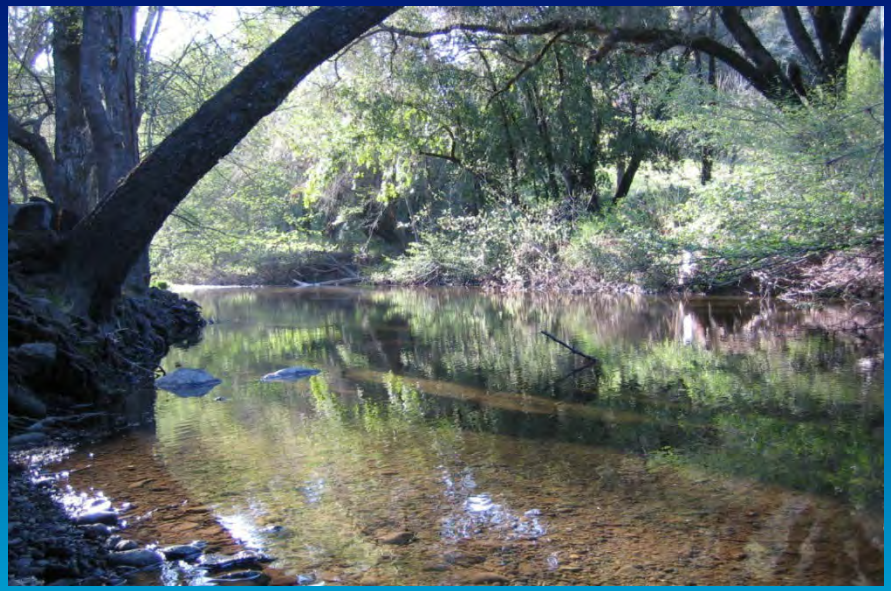



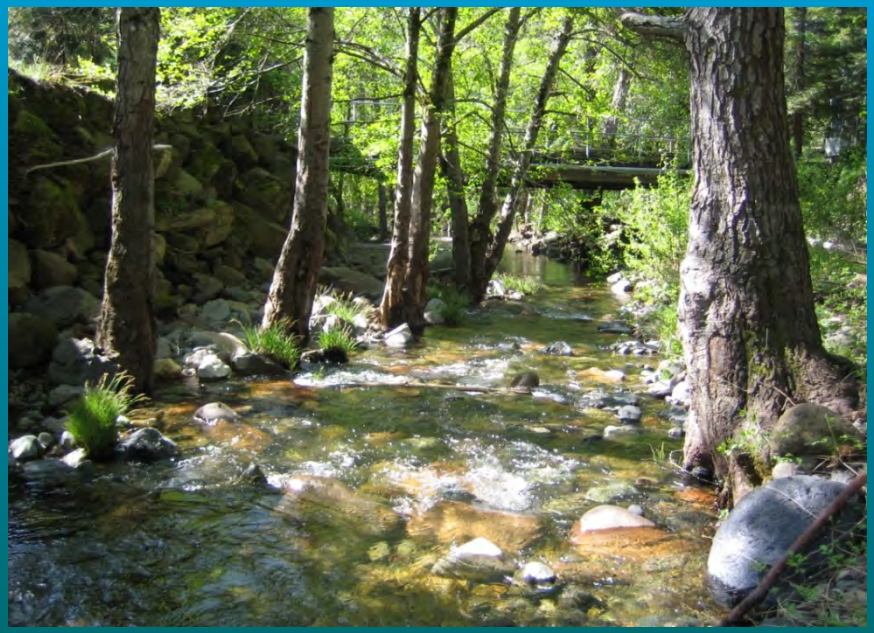




USGS

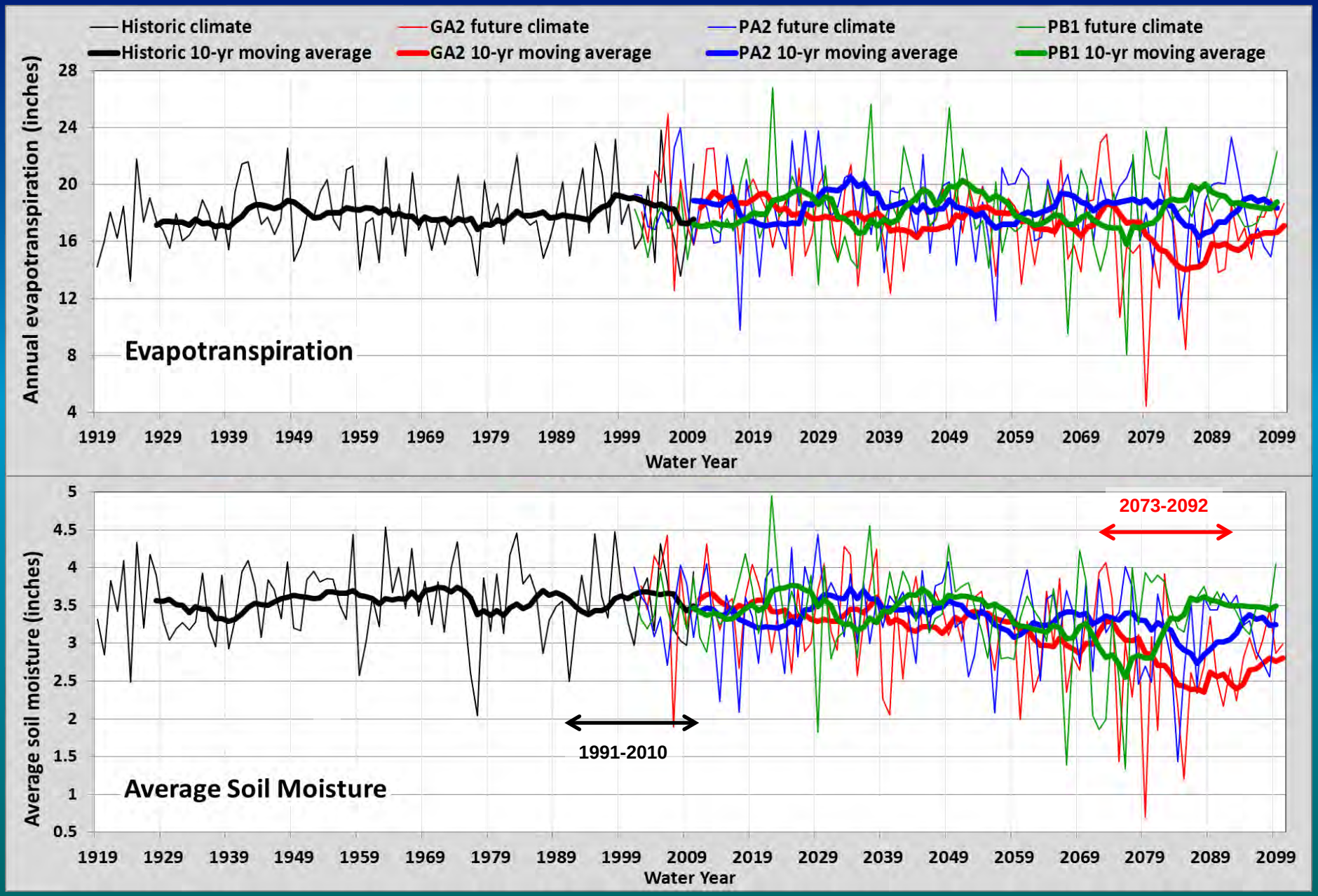
# Preliminary Results





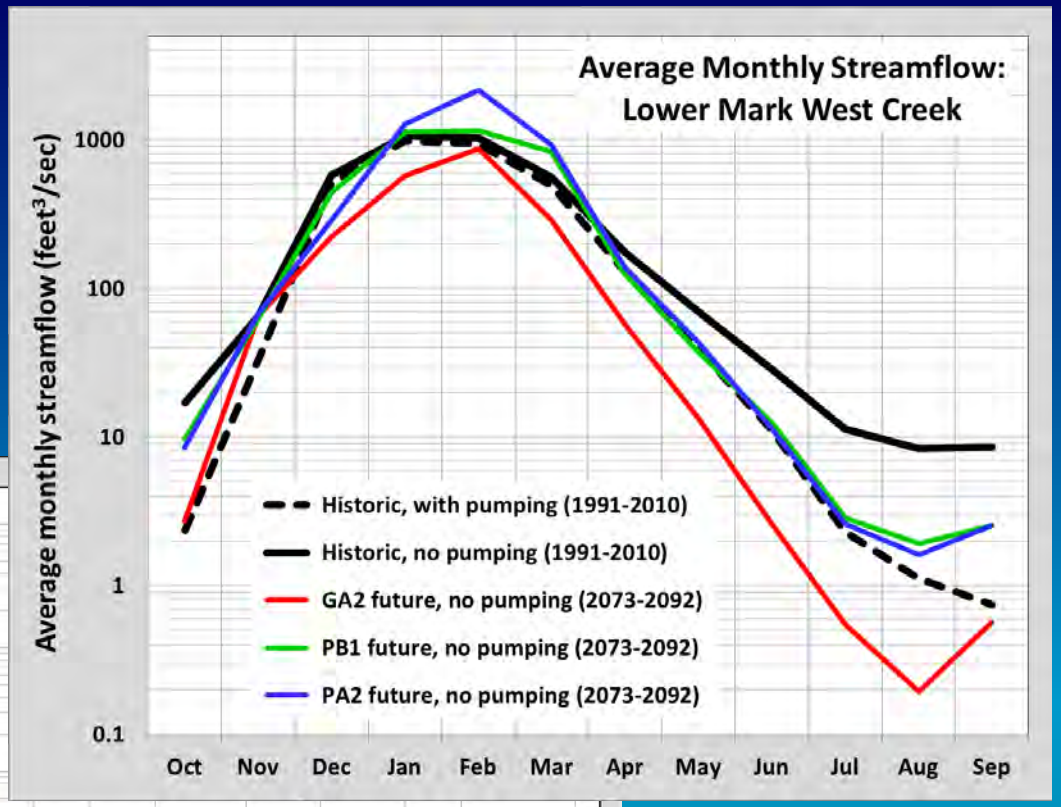
USGS

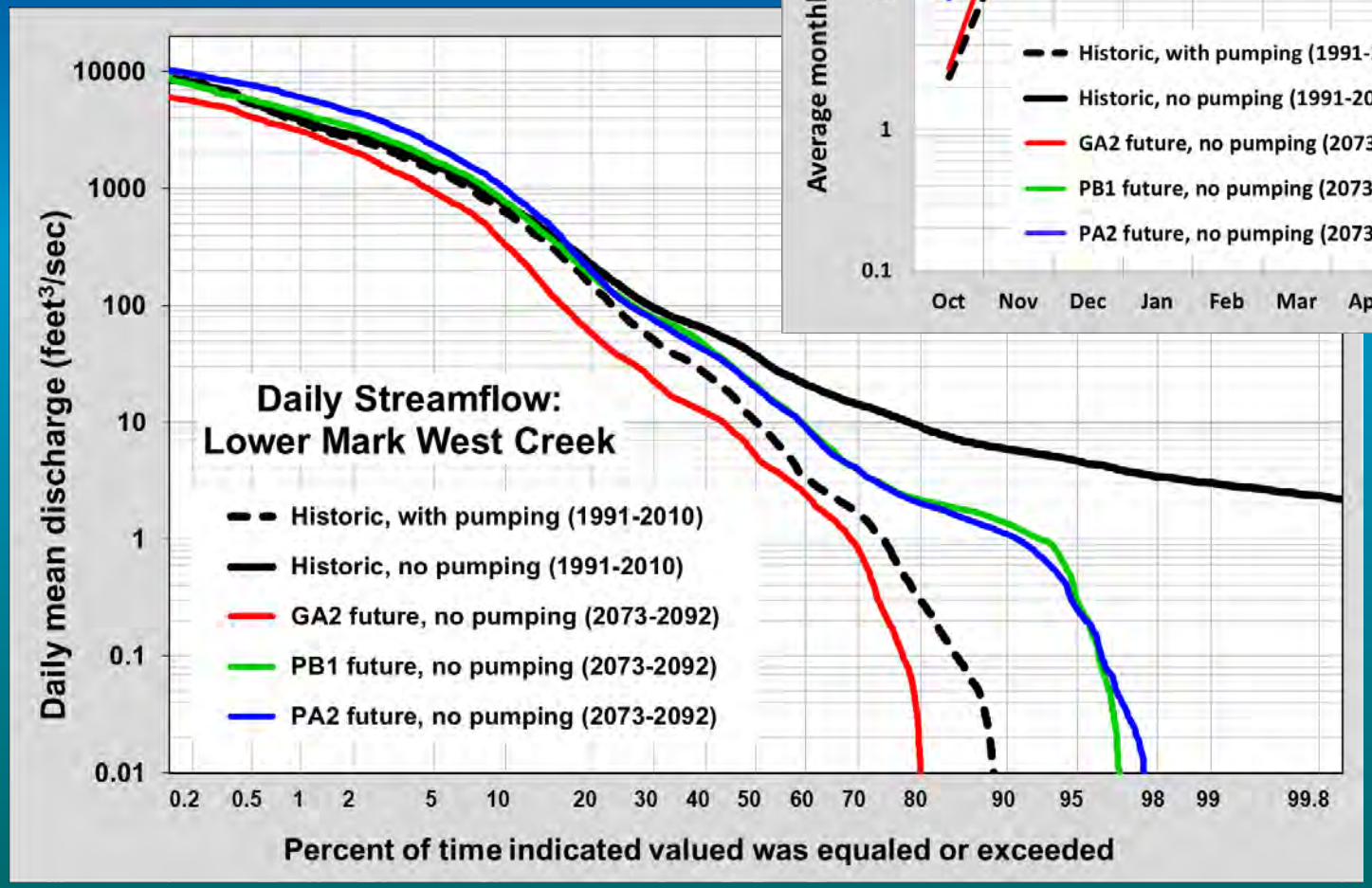
# Simulated evapotranspiration and soil moisture: Evaluating hydrologic response to climate variability



# GSFLOW Simulated Streamflow

**Comparison of climate and pumping scenarios**




**Changes in streamflow from pumping and variations in climate**

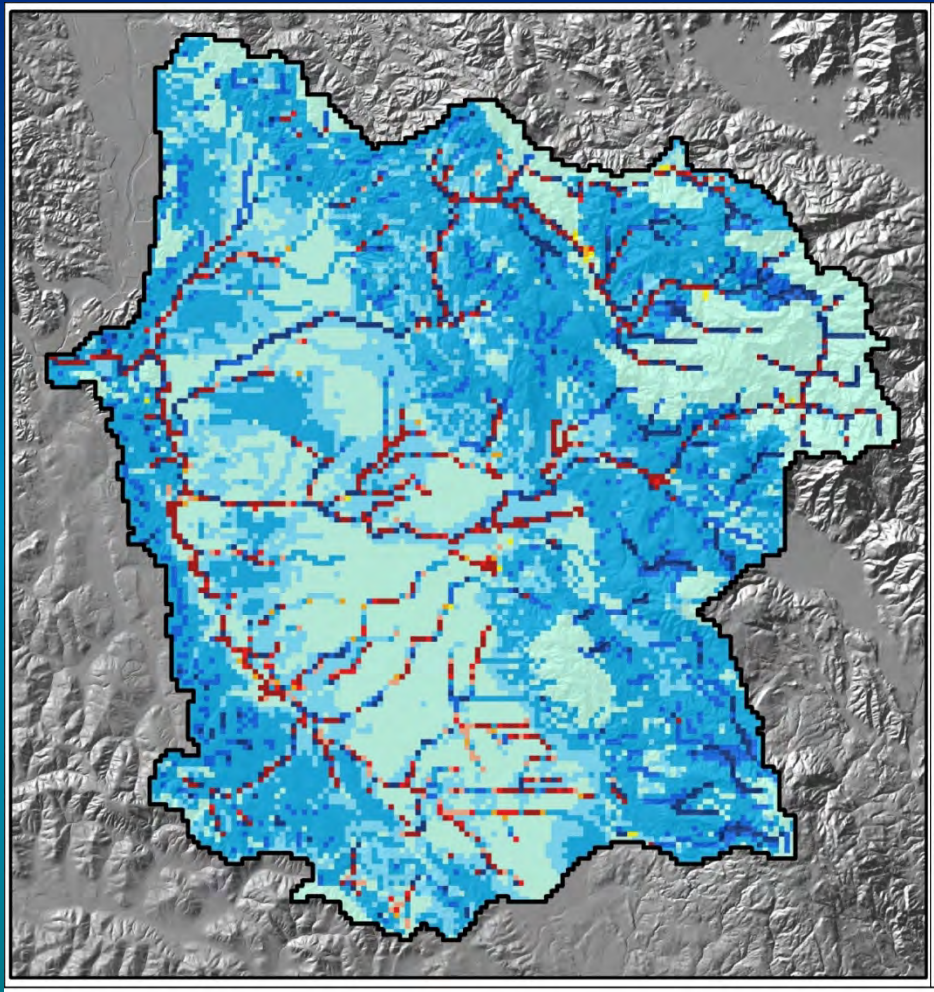
USGS

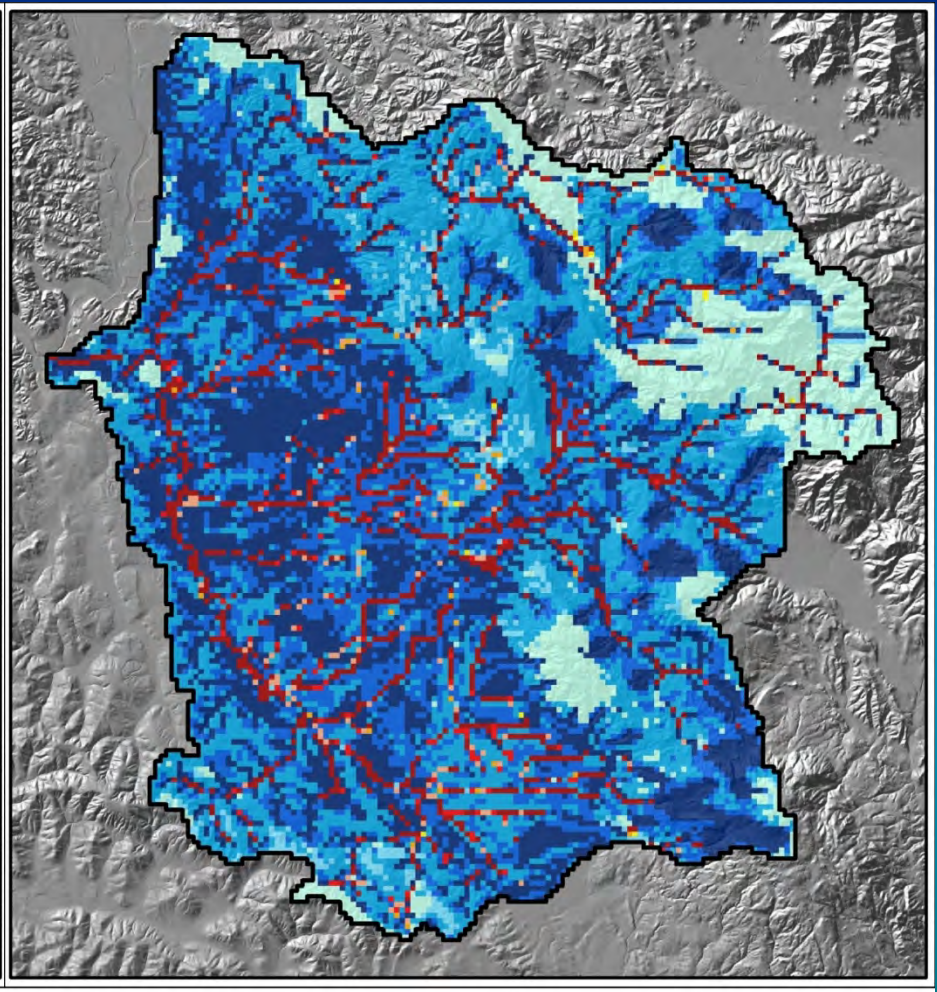
# Simulated 1977 net recharge

Precipitation = 15.2 in/yr
Net recharge = 0.9 in/yr

# Simulated 1983 net recharge

Precipitation = 72.5 in/yr
Net Recharge = 7.56 in/yr





**Water year 1977 net recharge (inches/year)**

< -10 | -5 - -1 | -0.01 - 0 | 0.1 - 1 | 5 - 10
-9 - -5 | -1 - -0.1 | 0 - 0.1 | 1 - 5 | > 10

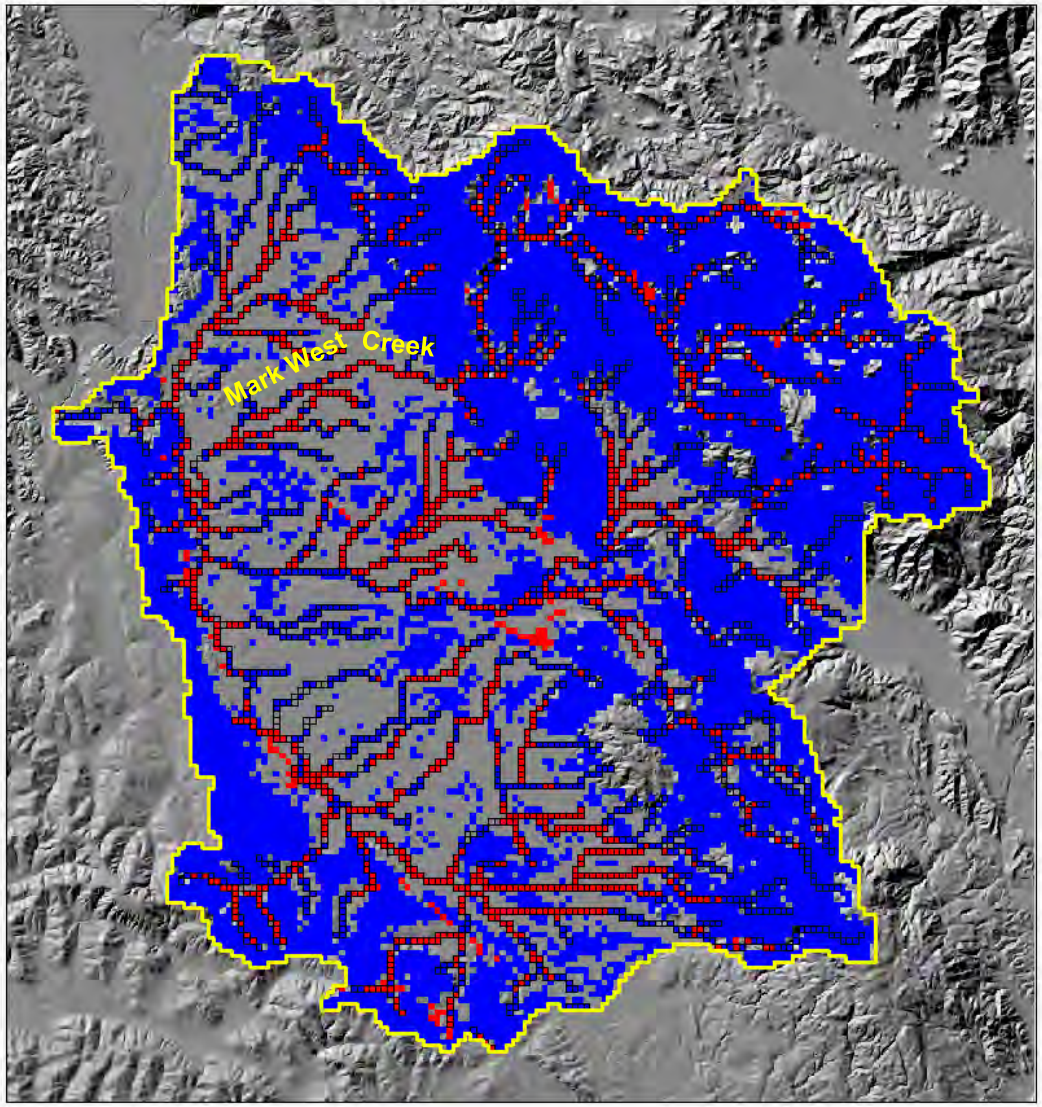
**Water year 1983 net recharge (inches/year)**

< -10 | -5 - -1 | -0.01 - 0 | 0.1 - 1 | 5 - 10
-9 - -5 | -1 - -0.1 | 0 - 0.1 | 1 - 5 | > 10

# NET FLUX ACROSS WATER TABLE, WATER YEARS 1990-95

Dry years
1990-92, 1994

Wet years
1993, 1995

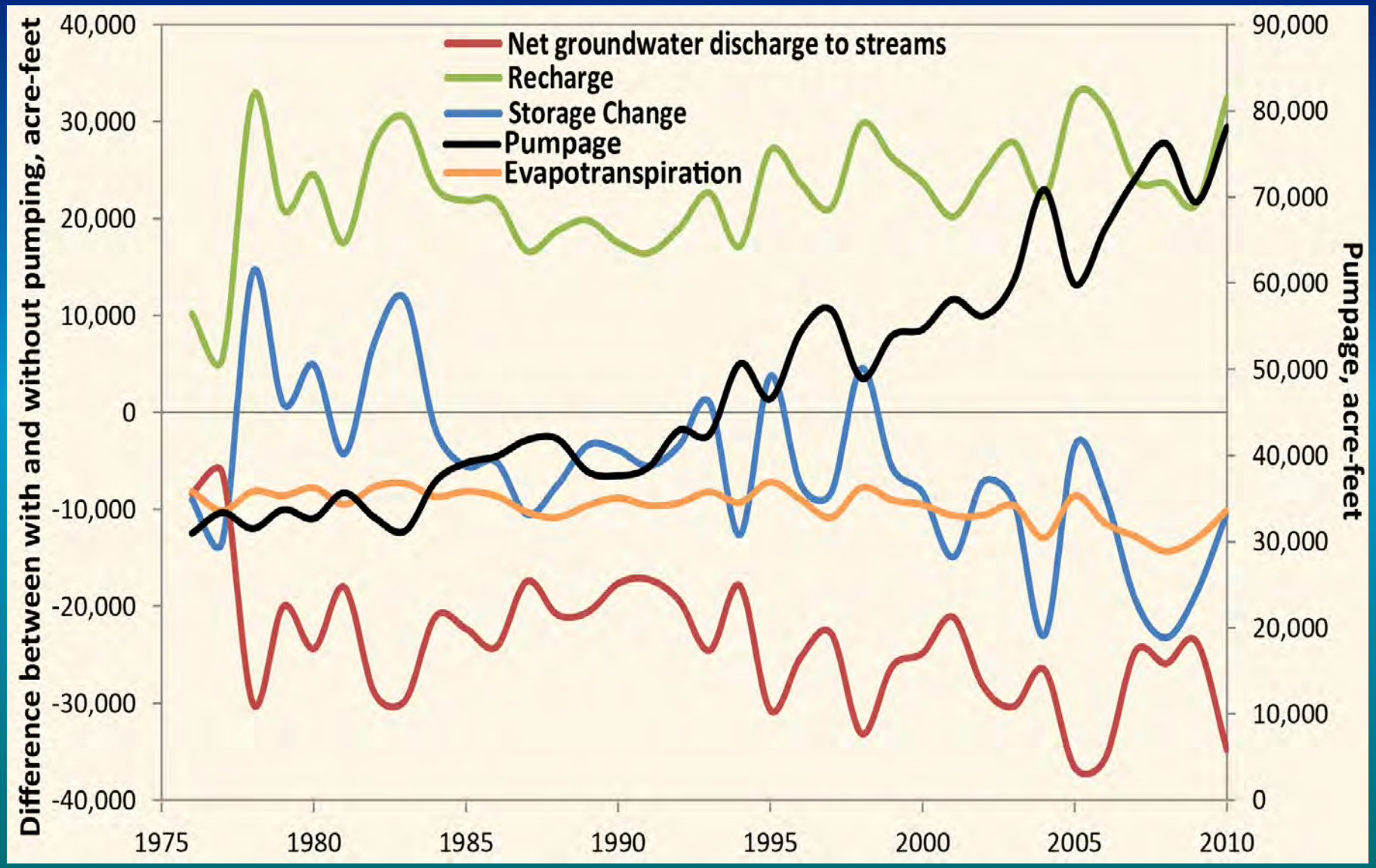



Legend
Display
<VALUE>
Discharge
Zero net flux
Recharge

Time: Fall 1989

USGS

# Effects of pumping on selected groundwater budget components



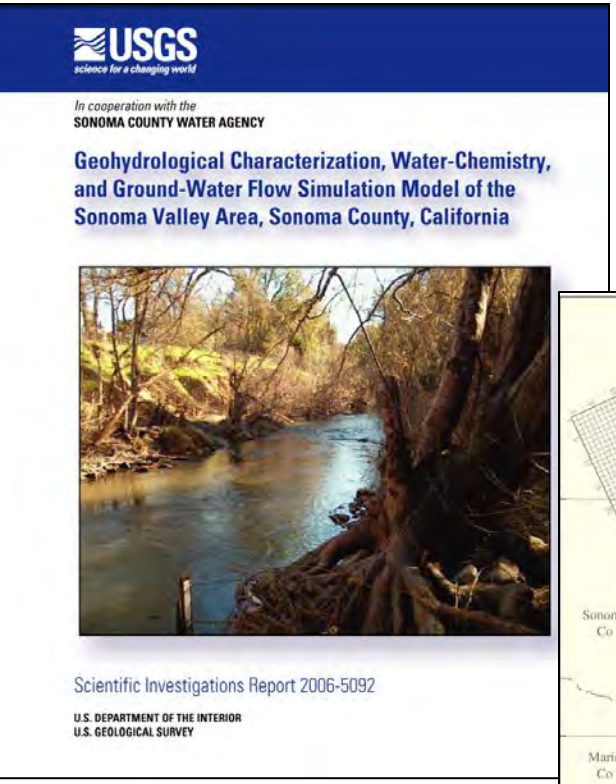

USGS

# Model Applications

- Simulate storm-flow diversion for recharge enhancement
- Simulate Aquifer Storage and Recovery (ASR)
- Evaluate changes in pumping
- Effects of climate variability
- Effects of land use change

USGS

# USGS Studies and Development of Tools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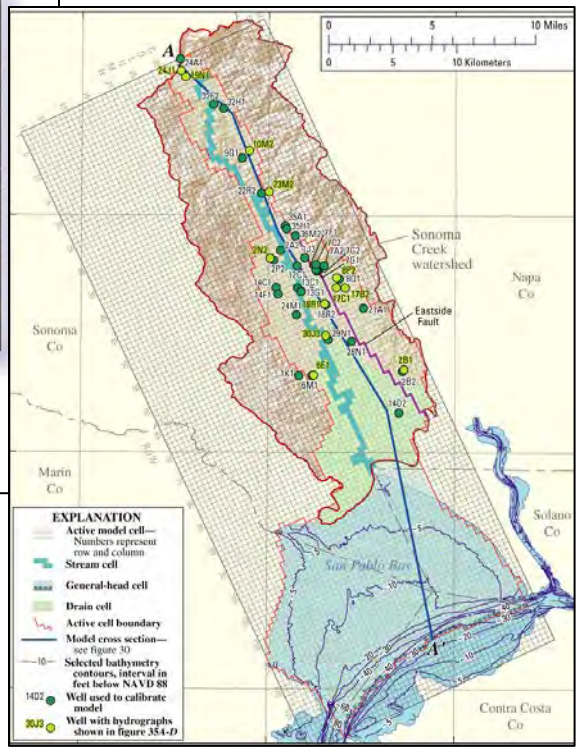
science for a changing world

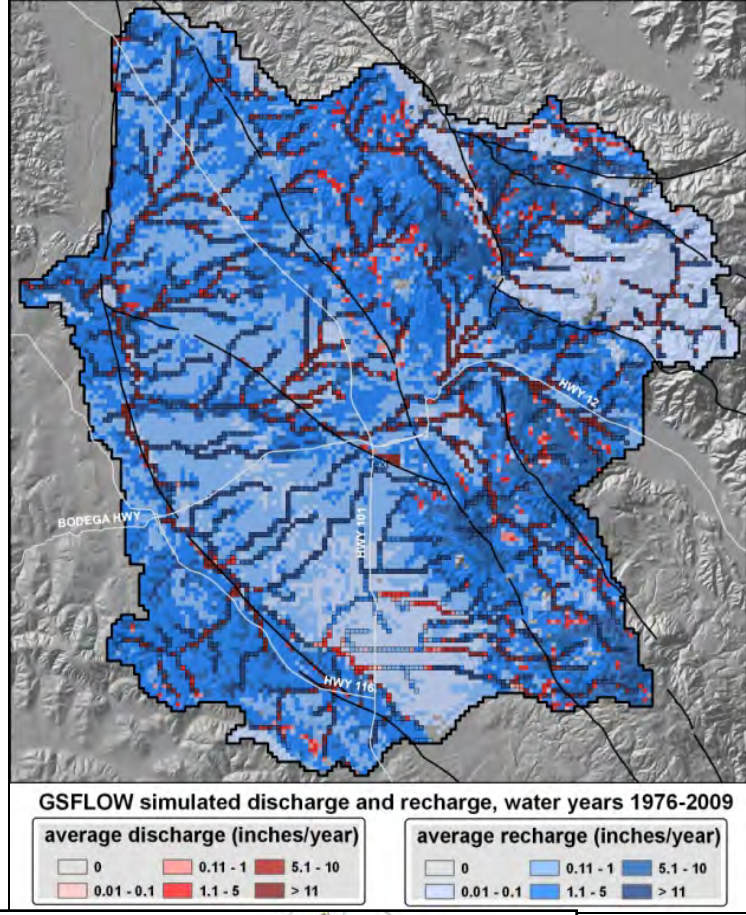
In cooperation with the
SONOMA COUNTY WATER AGENCY

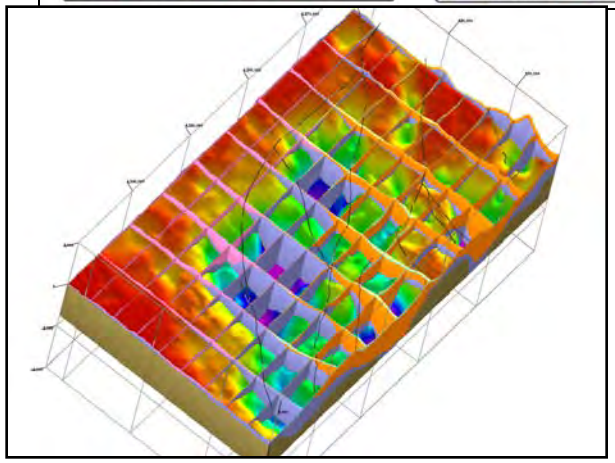
Geohydrological Characterization, Water-Chemistry, and Ground-Water Flow Simulation Model of the Sonoma Valley Area, Sonoma County, California

Scientific Investigations Report 2006-5092

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

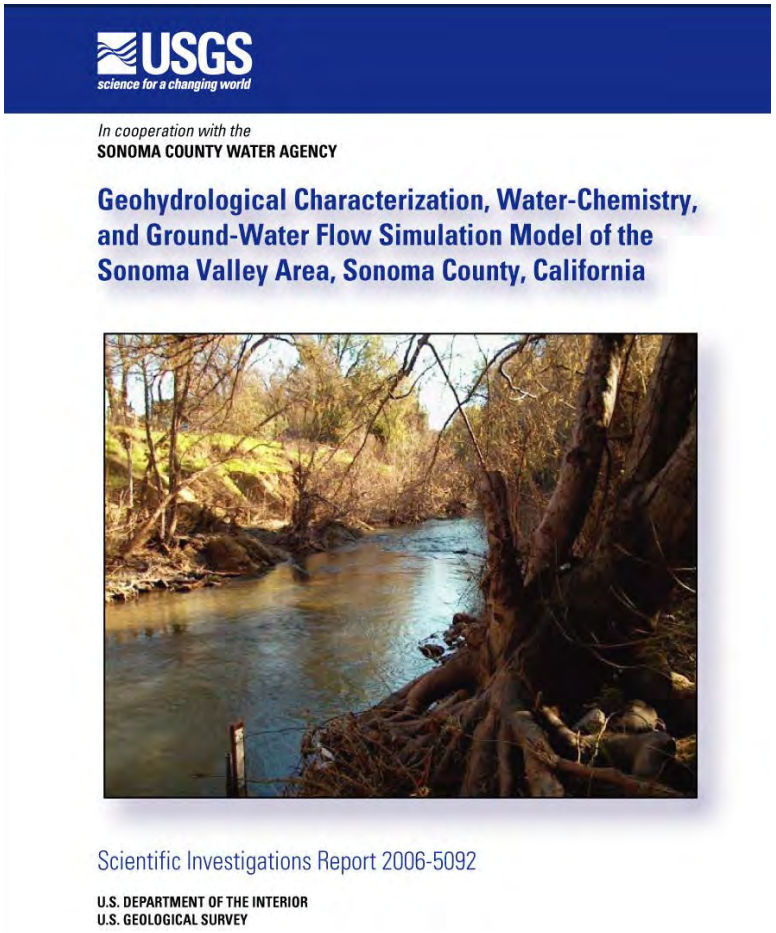


SONOMA COUNTY WATER AGENCY

# Agency/USGS Sonoma Valley Groundwater Study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Geohydrological Characterization, Water-Chemistry, and Ground-Water Flow Simulation Model of the Sonoma Valley Area, Sonoma County, California

Scientific Investigations Report 2006-5092

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

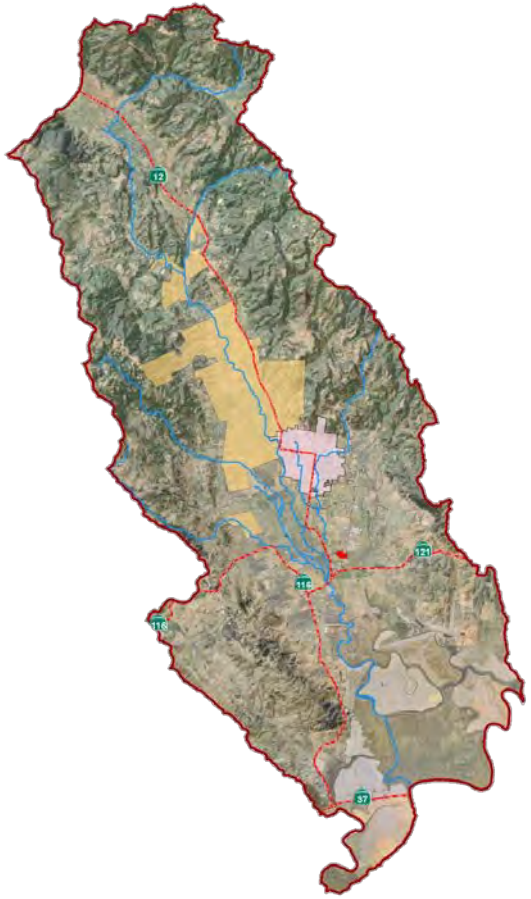
## Key Findings:

- Increased pumping between 1975-2000 (6,000 to 8,500 acre-ft/year)
- Localized decline of groundwater levels
- 17,000 acre-ft decline groundwater storage
- Salinity issues in southern part of Valley
- Numerical Model - Evaluate data gaps & simulate future conditions

# Overview of Sonoma Valley Groundwater Management Program

Sonoma Valley Groundwater Management Program

- **Convened Stakeholder Group in June 2006**
  - Agricultural alliances, environmental organizations, water purveyors, and residential groundwater users
- **Groundwater Management Plan Adopted in Late 2007**
  - Non-Regulatory and Collaborative Process
- **Fifth Year of Implementation**
- **Emphasizes:**
  - Local Control
  - Sustainability (Quantity and Quality)
  - Integration of Water Supplies
  - Prevention of Overdraft



# Scenario Modeling of Water Management Strategies Scenarios

- **CONSERVATION** of Urban, Non-Urban, & Agriculture
- **RECYCLED WATER** use to offset groundwater pumping
- **STORMWATER** to recharge of groundwater
- **BANKING** Russian River water to recharge groundwater basin

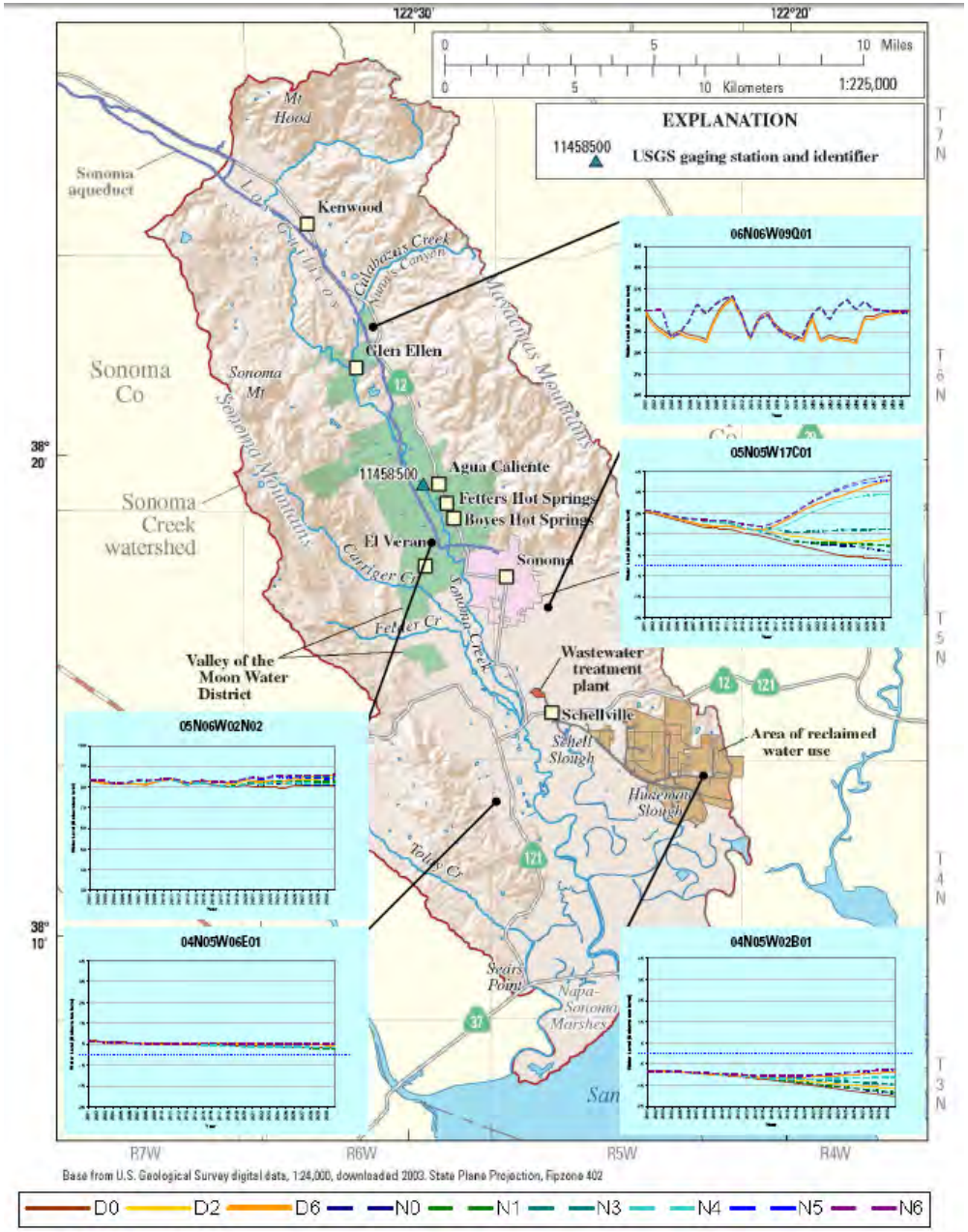
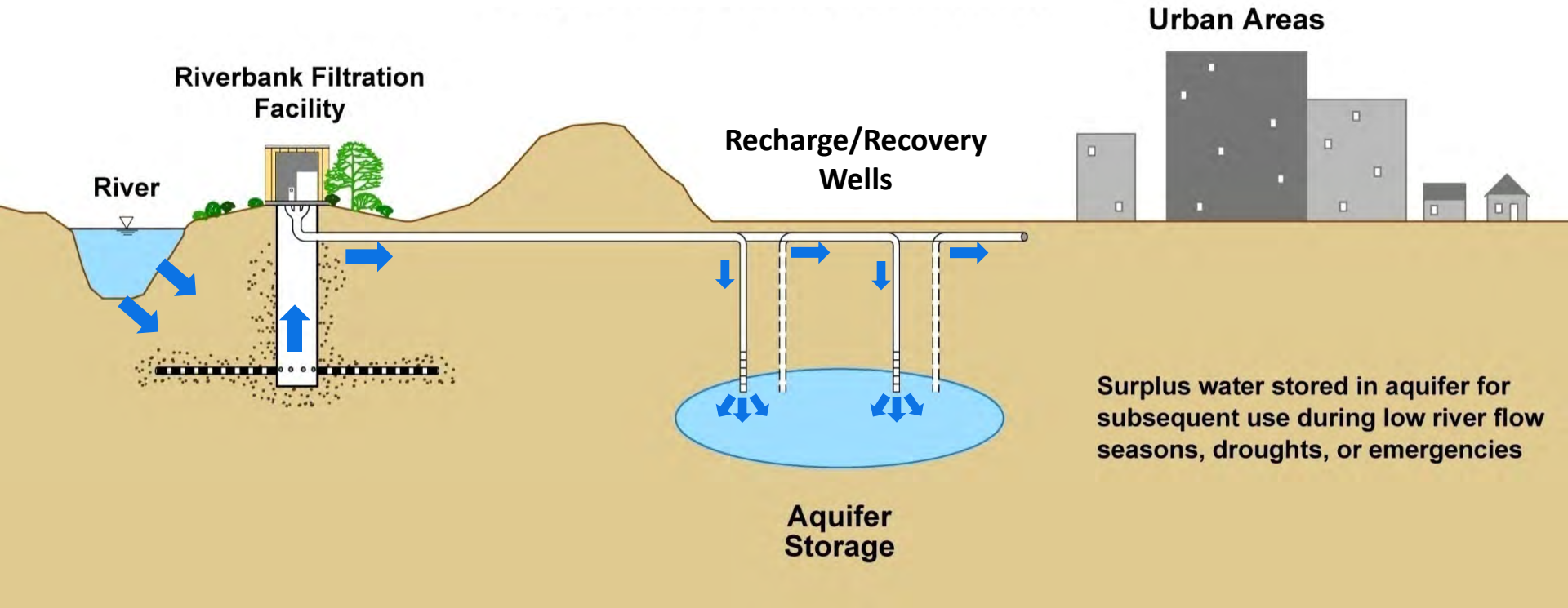



Figure 4-11 Simulated Water Levels In Selected Monitoring Wells For All Simulation Cases (Base map from USGS, 2006; locations of indicated monitoring wells approximate)

# Conceptual Aquifer Storage and Recovery Schematic

- Efficient conjunctive use of existing surface water and groundwater resources
- May allow for decreased summer flows in Dry Creek – protective of salmonids
- Increased drought and natural hazard reliability
- Decrease competition for local groundwater



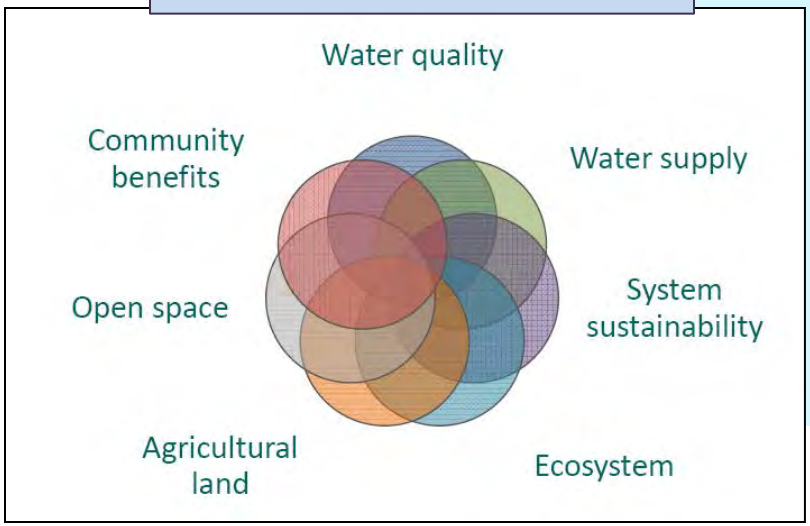
# Combining Stormwater Management & Groundwater Recharge – Watershed Studies

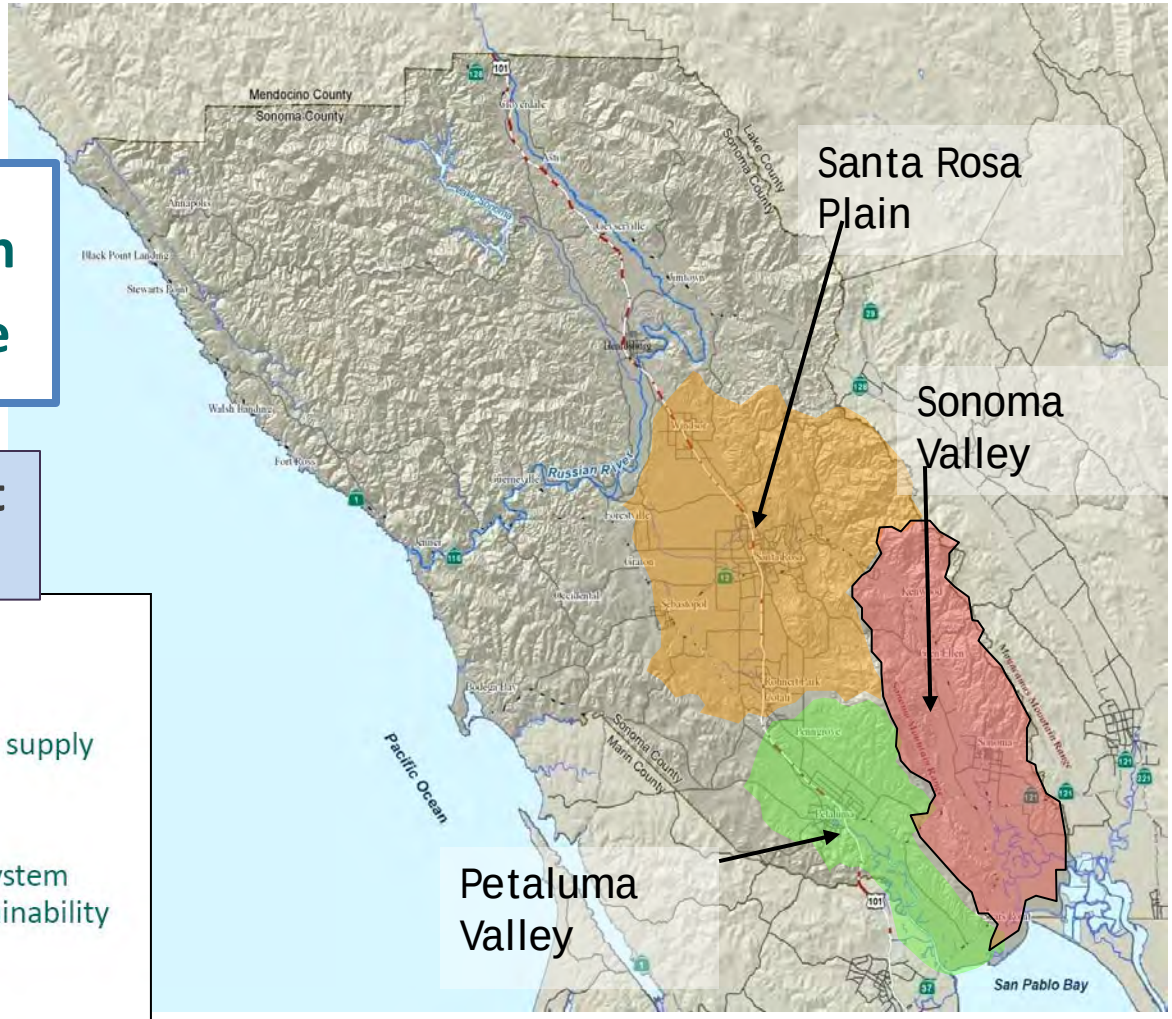
**Core Project Objectives**

**Flood hazard reduction**

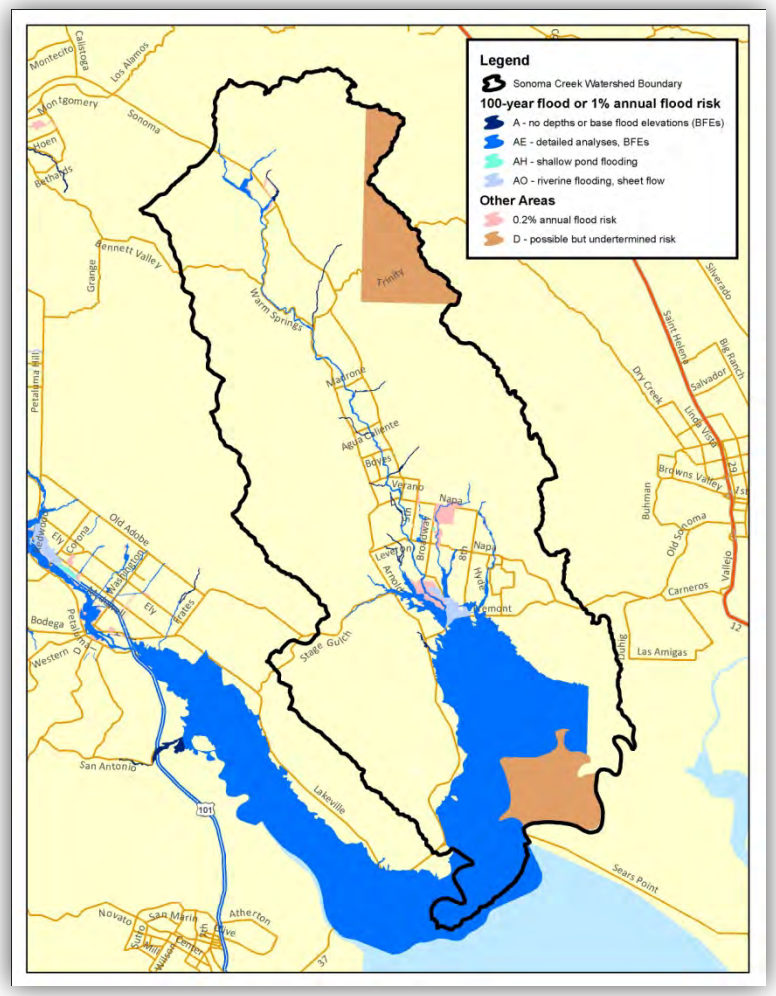
**Groundwater recharge**

**Supplemental Project Objectives**

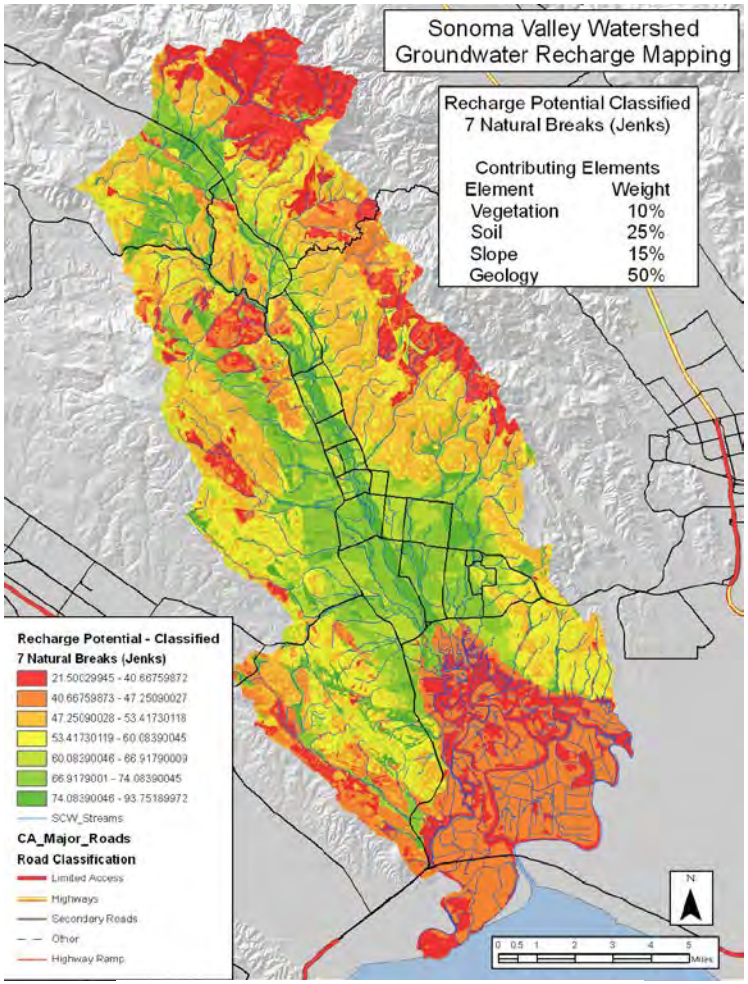


# Addressing Problems with Opportunities



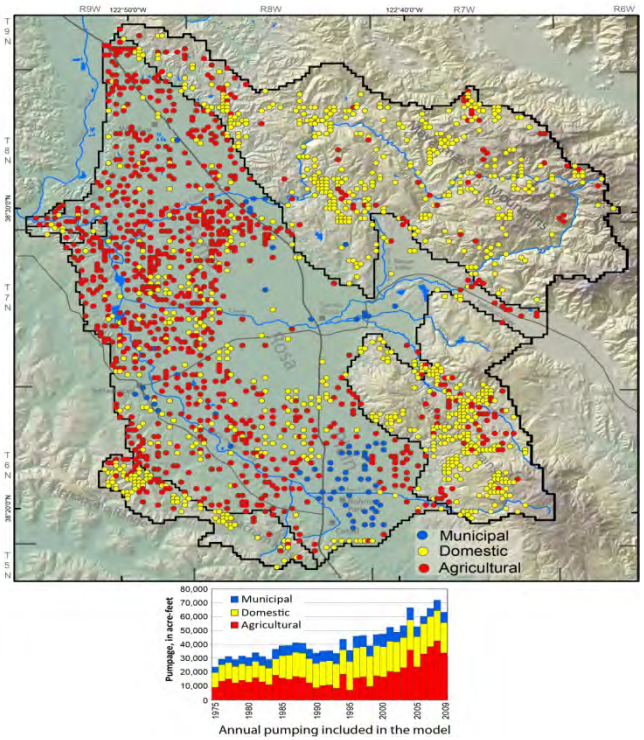

**Areas of Flooding**

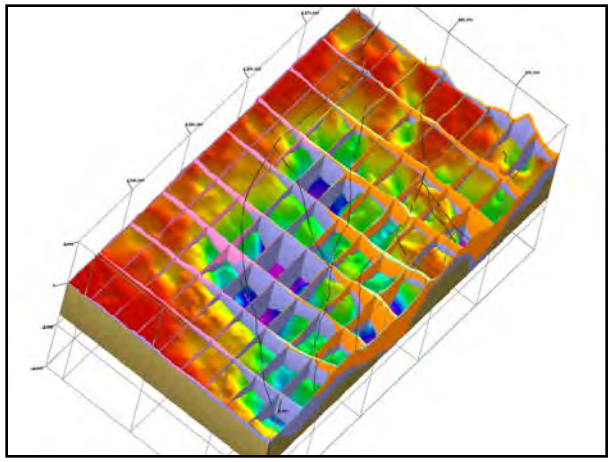



**Areas of Potential Recharge**

# Effective Groundwater Resource Planning

- **Strong Scientific Foundation**
- **Community-Based Stakeholder Involvement**
- **Collaborative Open Process**
- **Connecting People with Science**
- **Wide Array of Technical Tools**





***Presentations available at: http://water.usgs.gov/coop/***

***Follow-up email will be sent with contact information***

***Feedback welcome at: pahamilt@usgs.gov***