

*... in Civilizations . . .*

# “Demography is Destiny”

*French philosopher Auguste Comte*

...but for California's historical development...

## “Geography is Destiny”

Theme: California's unique geography has played a fundamental role in shaping the state's development, and natural resource management challenges.

## Presentation Topics

- Hydrology geography
- Historical water supply development and use
  - Surface water supplies
  - Groundwater supplies
  - Alternative supplies
- Overview of major law affecting supplies and use
- Summary water quality and flood control

## Geography:

- Location of resources shaped California's development:
  - Gold
  - Arable land
  - Early irrigation systems
  - Natural harbors
  - Film industry (locations and weather)
  - WWII industrialization – economic geography

AND, WATER – distribution and demand has shaped development and its impact on natural environment

The story of  
California is  
the story of  
water . . .

. . . And it is  
a pretty  
interesting  
story





The Gold Rush was the start of a philosophy of putting California's water to work







# Hydraulic Mining

**1853** - Used powerful jets of water to blast away hillsides

**Malakoff Diggins** (South Yuba River) - mined 100,000 tons of gravel per day and used **16 billion gallons** (32,000 acre-feet) of water per year.

11 million ounces of gold (**worth \$9.7 billion**) by the mid-1880s.





Arteries of Commerce



# Acre Foot

- An acre-foot covers 1 acre of ground – the size of a football field – 1 foot deep.
- Typically, 1 acre-foot can meet the annual needs of two average urban households, and has been shrinking due to conservation actions.



# Watersheds

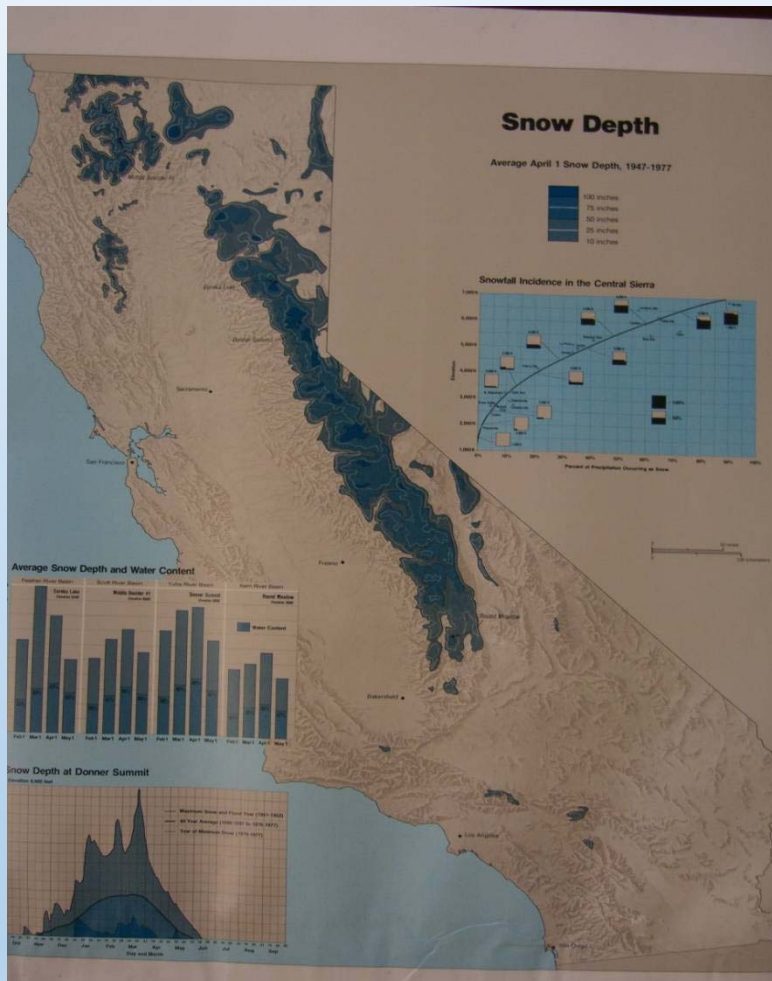
A watershed is the land through which runoff – snowmelt and rain – drains into lakes, streams and rivers.



# CALIFORNIA IS ONE OF ONLY 5 MEDITERRANEAN CLIMATE ZONES ON THIS PLANET

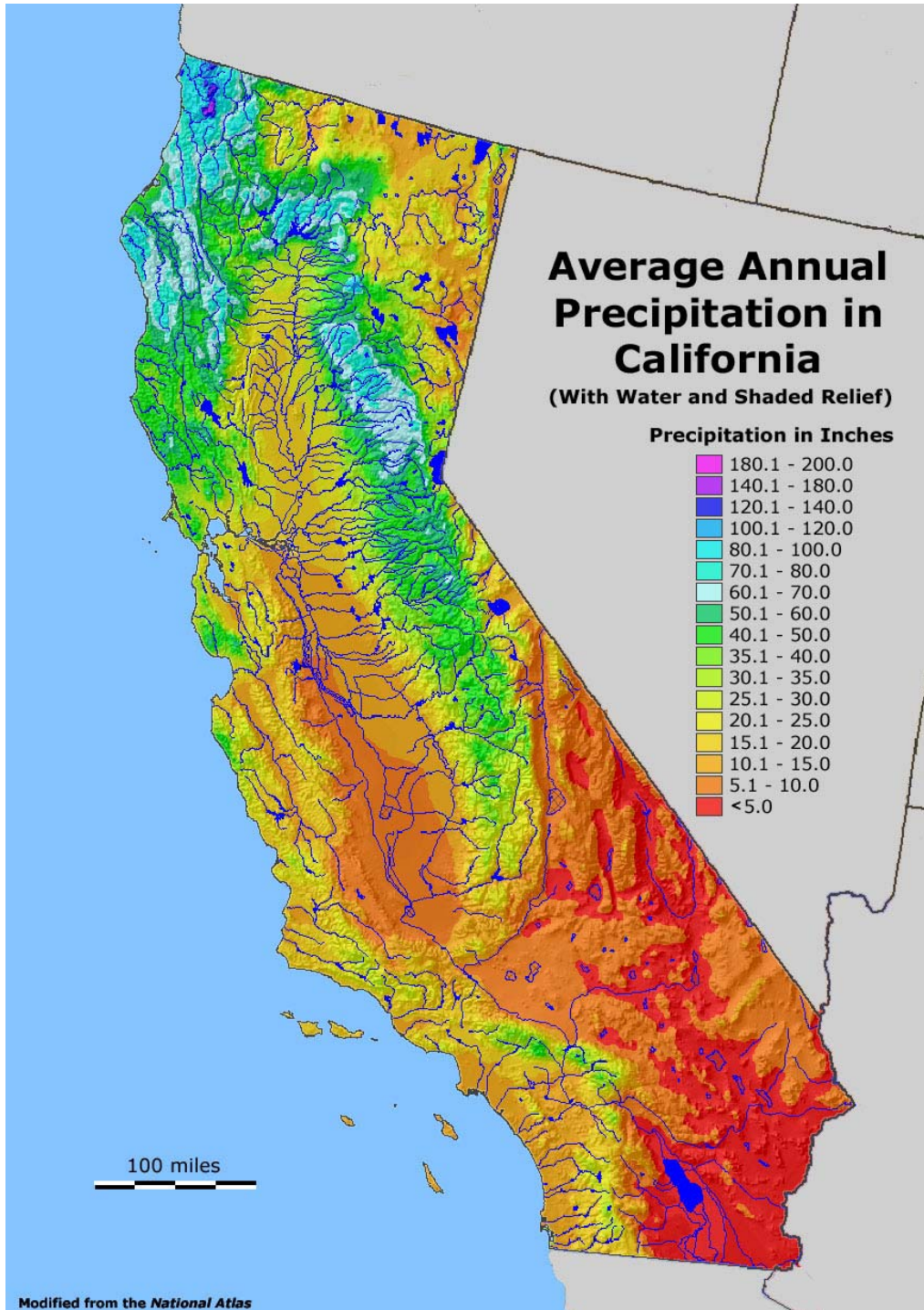


# California Hydrology – geography of natural supply and use



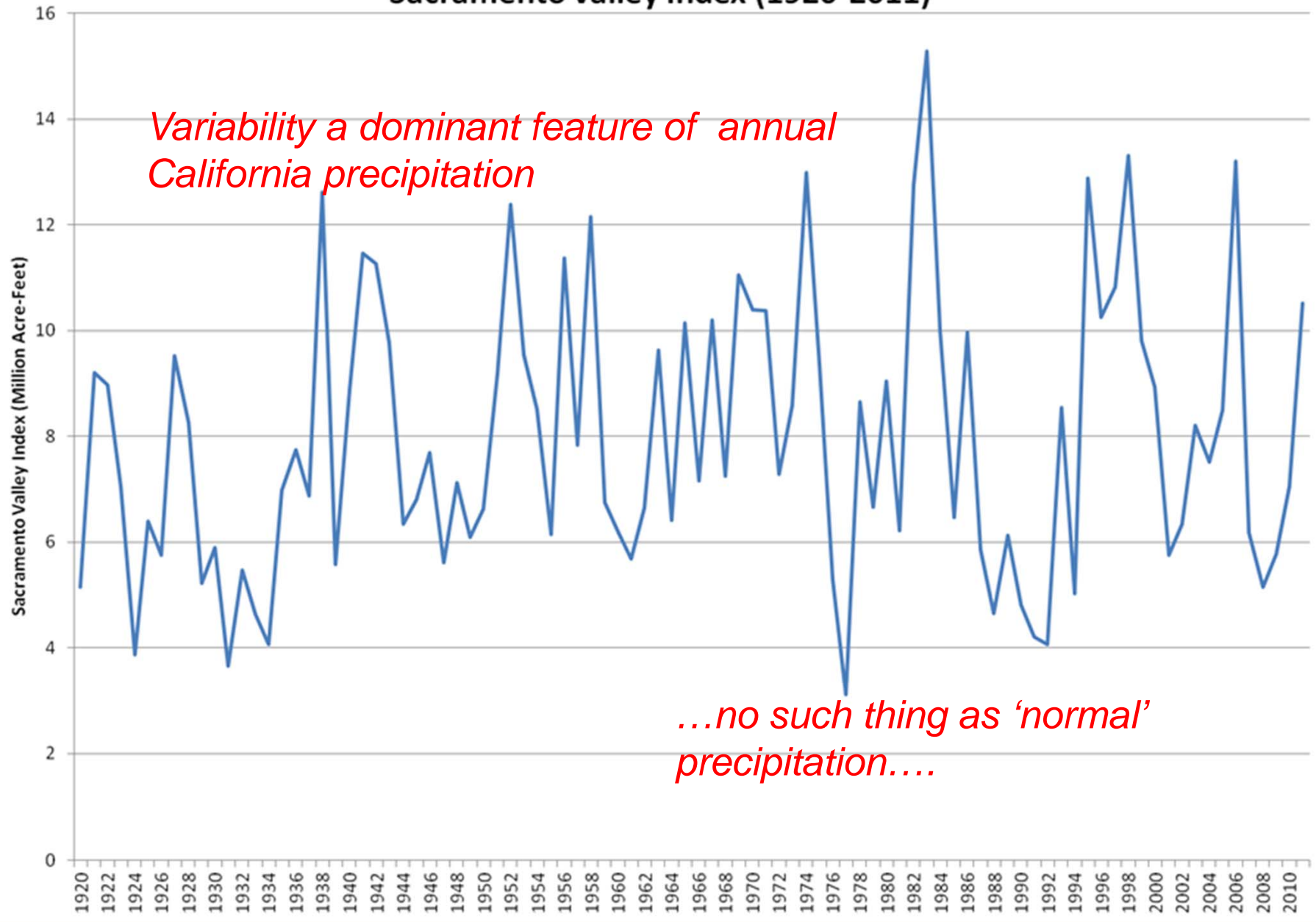
- 💧 Mediterranean climate – dry summers, mild winters
- 💧 In average year, 82 million acre-feet of water used:
  - 💧 Urban – 9 MAF
  - 💧 Agriculture – 34 MAF
  - 💧 Environment – 39 MAF

# California Hydrology



- Wet in north
- Dry in south
- Greatest population in south

### Sacramento Valley Index (1920-2011)



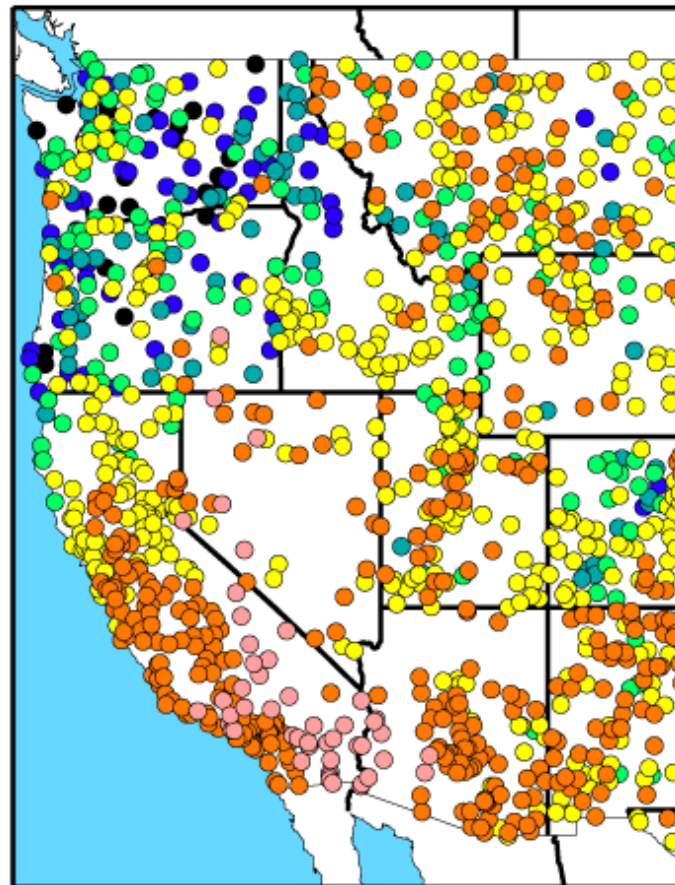
*Variability a dominant feature of annual California precipitation*

*...no such thing as 'normal' precipitation....*

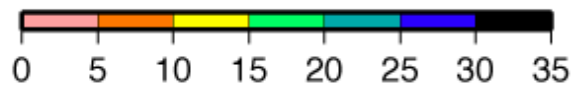


# Just a few storms each year are the core of California's water supplies

c) AVERAGE NUMBER OF DAYS/YR TO OBTAIN HALF OF TOTAL PRECIPITATION, WY 1951-2008

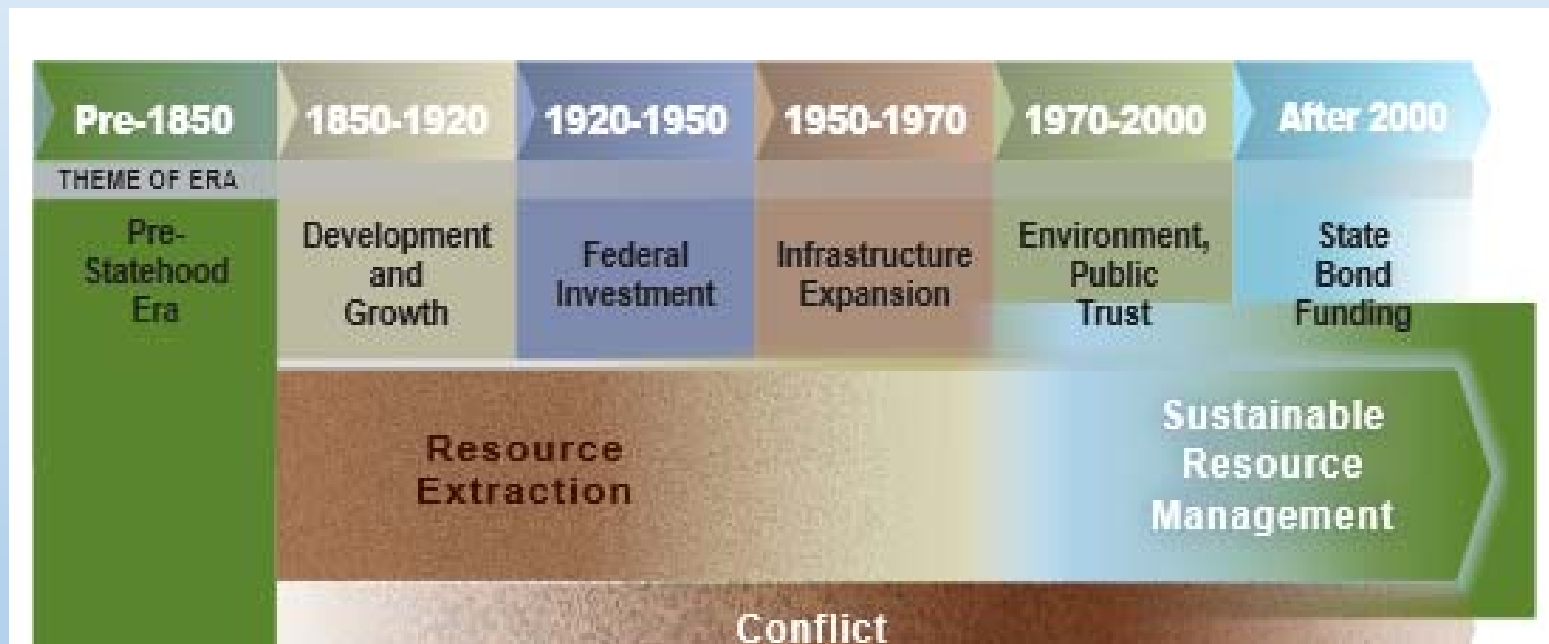


days/year



Source: Dettinger et al (2011)

# History of Resource Development Philosophy in the 21st Century



## 1850-1900: Economic Activity was Near a Water Source



In the 19<sup>th</sup> Century, Water for  
Economic Activity Was  
From:

- A Local Stream or
- Groundwater Basin

The Invention of the  
Centrifugal Groundwater  
Pump Spurred the Economy

But, A growing California  
Economy Needed New  
Sources of Supply



# California Water Development



**Hetch Hetchy System**

**San Francisco PUC**

**1913 - Raker Act**

**Los Angeles Aqueduct**

**Los Angeles DWP**

**1913**

**Mokelumne River Aqueduct**

**East Bay MUD**

**1929**

**Central Valley project**

**U.S. Bureau of Reclamation**

**1940 (C.C. Canal first)**

**Colorado River Aqueduct**

**MWD of So. Cal.**

**1941**

**State Water Project**

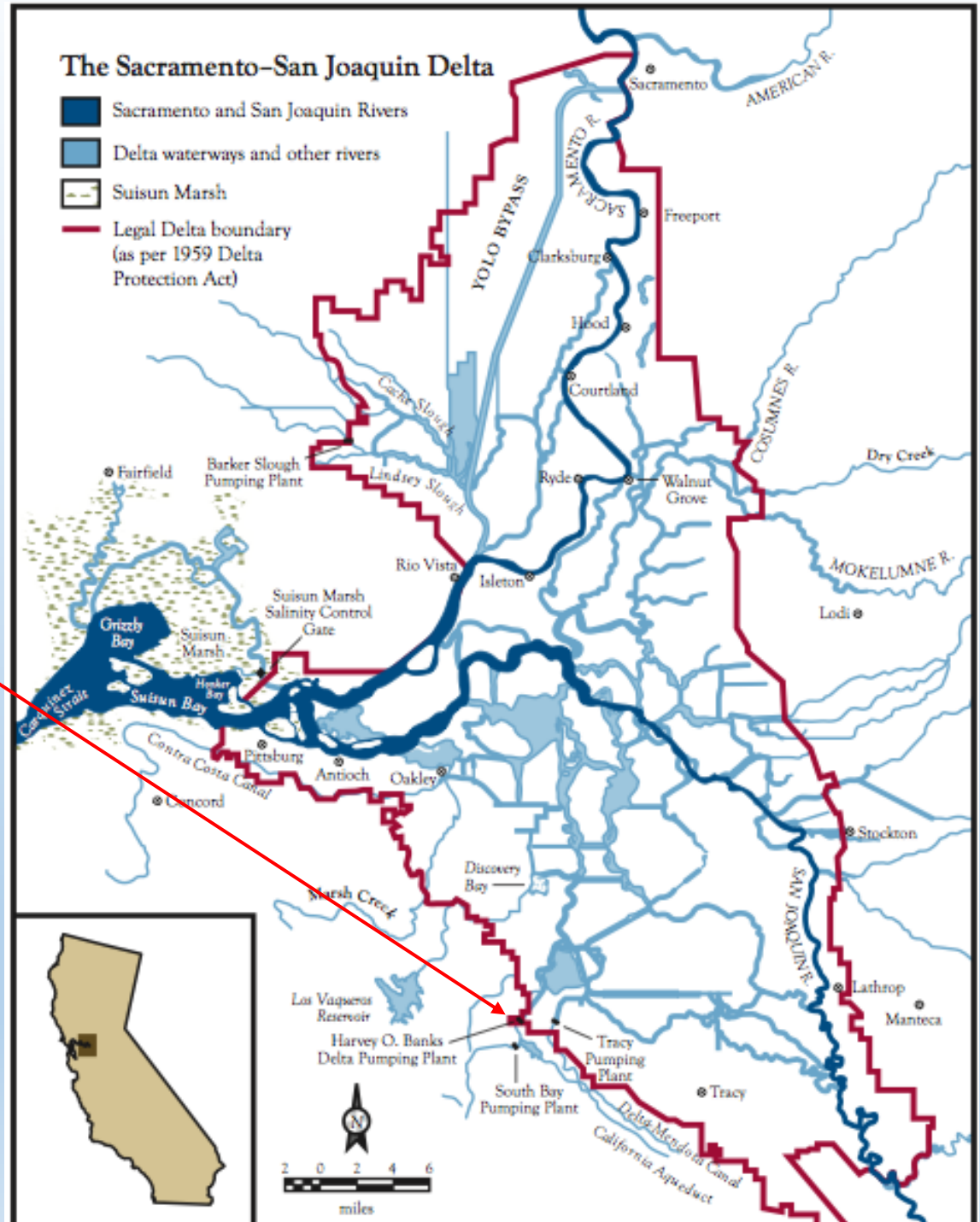
**California DWR**

**1960 - Burns Porter Act**

# The Sacramento-San Joaquin Delta

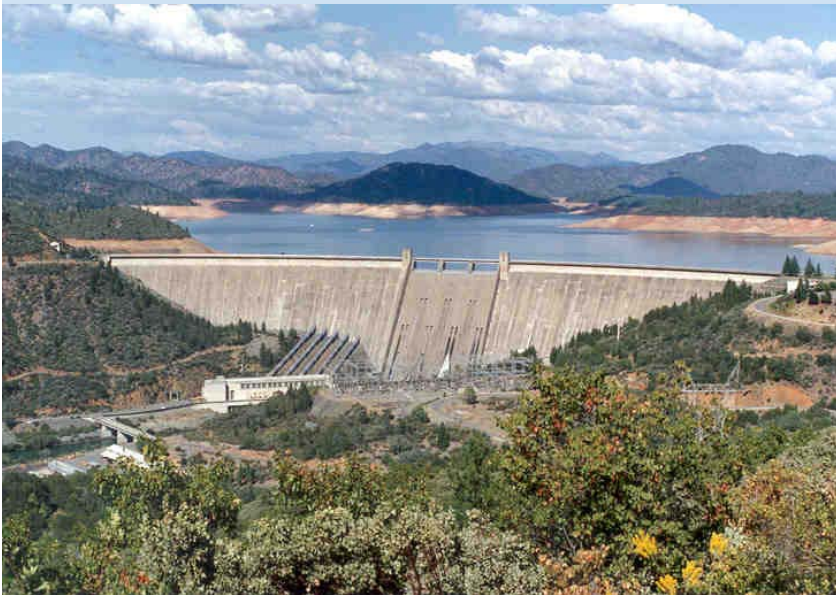
The hub of California's water transfer system

*Location of SWP and SWP Pumping Plants*



## Federally Funded Projects

- 💧 35 federally funded dams, reservoirs and canals. Built by U.S. Army Corps of Engineers and U.S. Bureau of Reclamation



Shasta Dam

- 💧 Central Valley Project (CVP), begins on the Sacramento River at Shasta Dam and ends near Bakersfield.

## Federally Funded Projects - CVP



- 💧 90% used to irrigate farms in Central Valley
- 💧 Some water to urban residents in the Bay Area

## Financing

- 💧 1902: Reclamation Act – 160 acre service limitation
- 💧 1982: Act increased service limitation to 960 acres
- 💧 1992: CVPIA added environment as specific purpose created water account for environment

## State-Funded Projects - SWP

1961 – construction begins

Facilities were built from north to south – Oroville Dam to Southern California.

The State Water Project is the largest state-financed water project ever built.



*Gov. Pat Brown at Oroville Dam*



# Burns-Porter Act – State Water Project



1959 - The state Legislature authorized construction of the State Water Project through the California Water Resources Development Bond Act, also known as the Burns-Porter Act

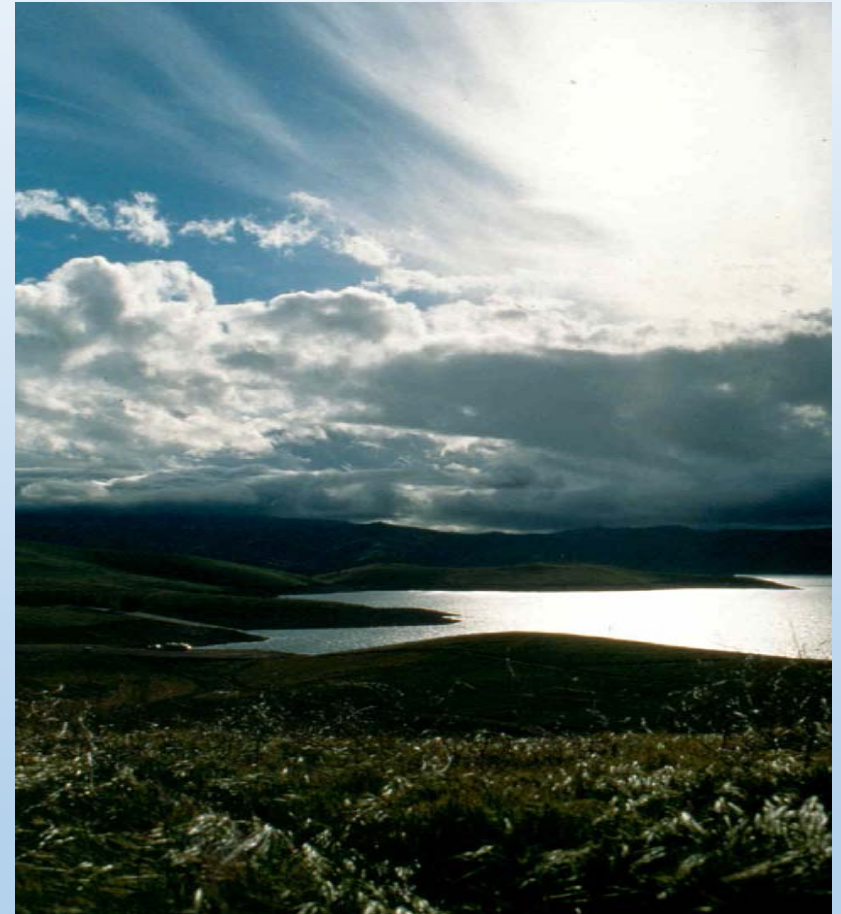
# State Water Project



- 💧 SWP includes 34 storage facilities; 20 pumping plants; 4 pumping-generating plants; 5 hydroelectric power plants; and about 700 miles of open canals and pipelines.
- 💧 Planned to deliver 4.2 MAF/year; currently delivers less than 3.0 MAF/year – reliability diminished due to lack of construction of some planned facilities and new regulatory requirements.
- 💧 About 30% of deliveries to agriculture in the San Joaquin Valley and 70% to urban Southern California, Bay Area and Central Coast.

# Financing the SWP

- 💧 1960 - \$1.75 billion bond
- 💧 29 contractors pay all costs, including bond interest, energy and transmission charges per Water Supply Contracts
- 💧 No acreage limitations



San Luis Reservoir

# Who Pays for California's Water?

- **Californians Spend \$33 Billion Annually**
  - **\$28b by Local Agencies – 85%**
  - **\$4b by State Government – 12%**
  - **\$1b by Federal Government – 3%**
- **Spending by Category**
  - **\$18b for Water Supply – 55%**
  - **\$11b for Water Quality – 33%**
  - **\$4b for Flood/Other – 12%**



Source: Public Policy Institute of California

# Water and Energy

- 💧 20% of state's electricity is used to bring water to consumers and send it away for sewage treatment.
- 💧 SWP is single-largest power consumer in California
- 💧 SWP is the fourth-largest power generator in California, generating about two-thirds of electricity to run its facilities.



Hyatt Powerplant below Lake Oroville is in a cavern the size of two football fields.

## Joint Operation of the CVP/SWP

- Upstream reservoirs capture water during wet season and snow runoff
- Stored water released to meet regulatory requirements and water deliveries to SWP and CVP customers
- Coordinated Operations Agreement
  - Joint responsibilities for Delta Water Quality Management
  - Sharing of access to unregulated surplus flows in Delta.

# Operation of the CVP/SWP

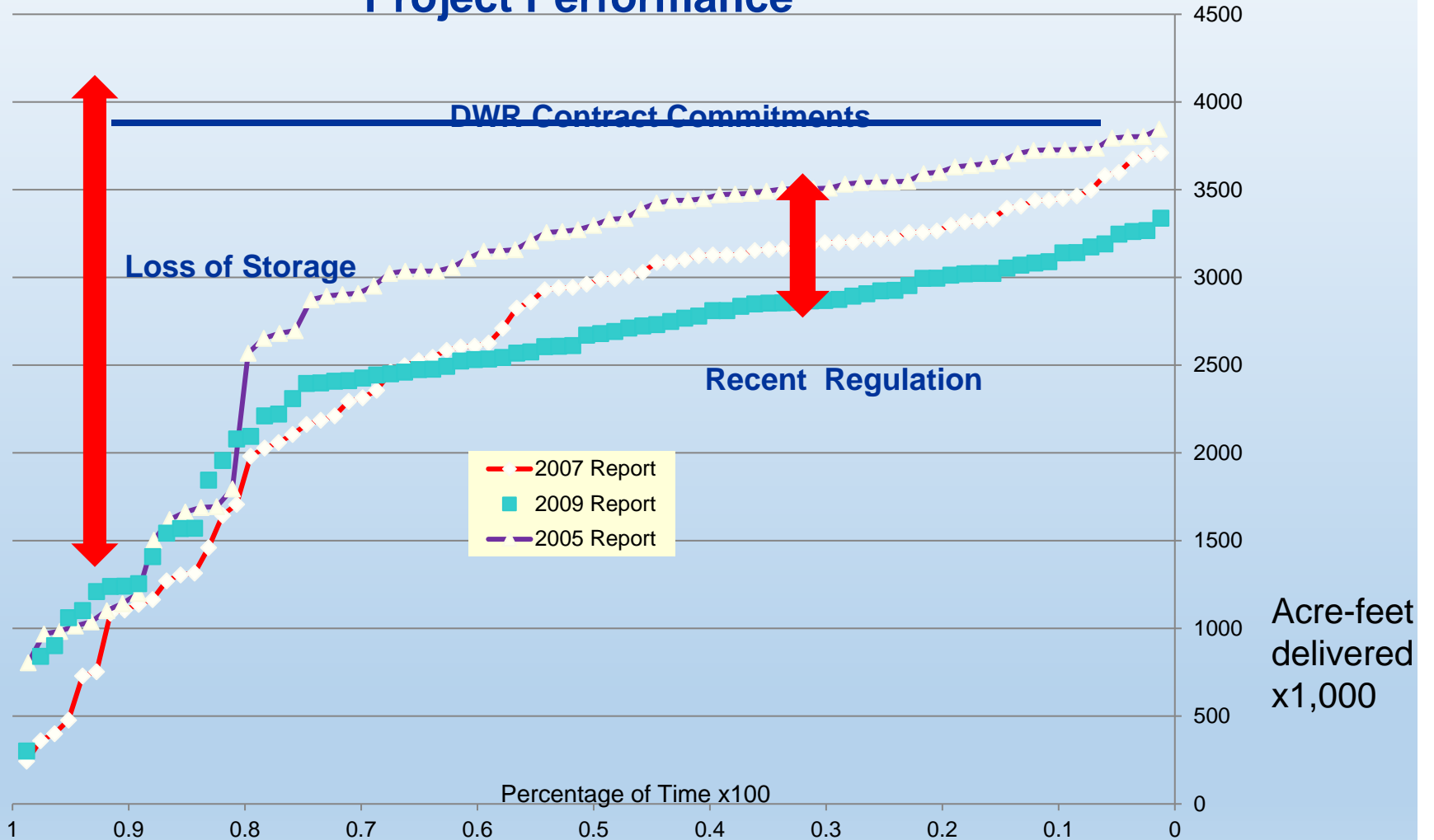
- Water delivered to service areas by contract, subject to agreements with *senior* rights holders
  - *Sacramento River Settlement Contractors (CVP)*
  - *San Joaquin River Exchange Contractors*
  - *North Delta Water agency (SWP)*
  - *City of Sacramento*
  - Project contractors:
    - Tehama Colusa Canal, Sacramento area contractors, Contra Costa WD,
    - Export service: San Luis Delta Mendota Water Authority, Santa Clara Valley WD, EBMUD
- Reservoir storage, natural river conditions and regulatory requirements determine water available for export

## Operation of the CVP/SWP

- Export supply determined by:
  - Snowpack
  - Reservoir storage
  - Instream flow requirements
  - Delta flow/water quality/fish protection regulations
  - Export pumping capacity
- If demand or available storage capacity exists and there is pumping capacity within requirements, water can be pumped.
- Over past decades, shift from demand limited system to regulatory constrained system.



# Regulatory Changes Have Dramatically Affected Project Performance

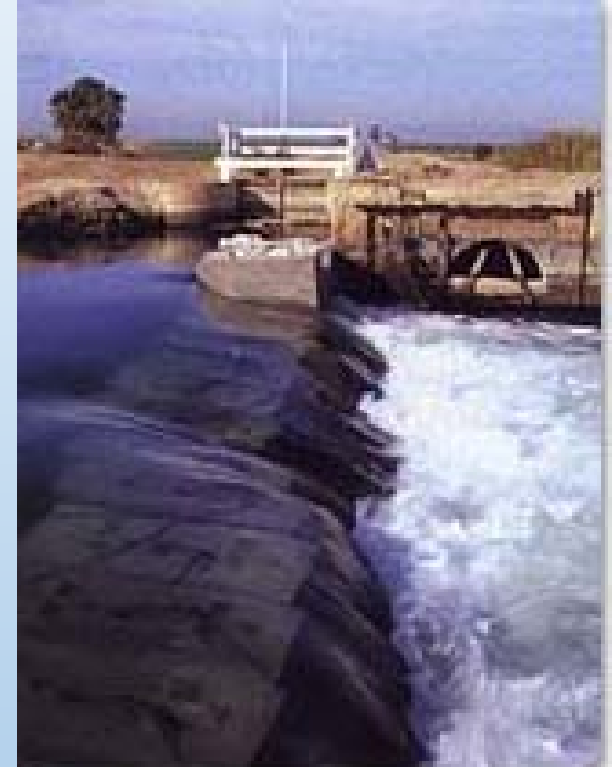


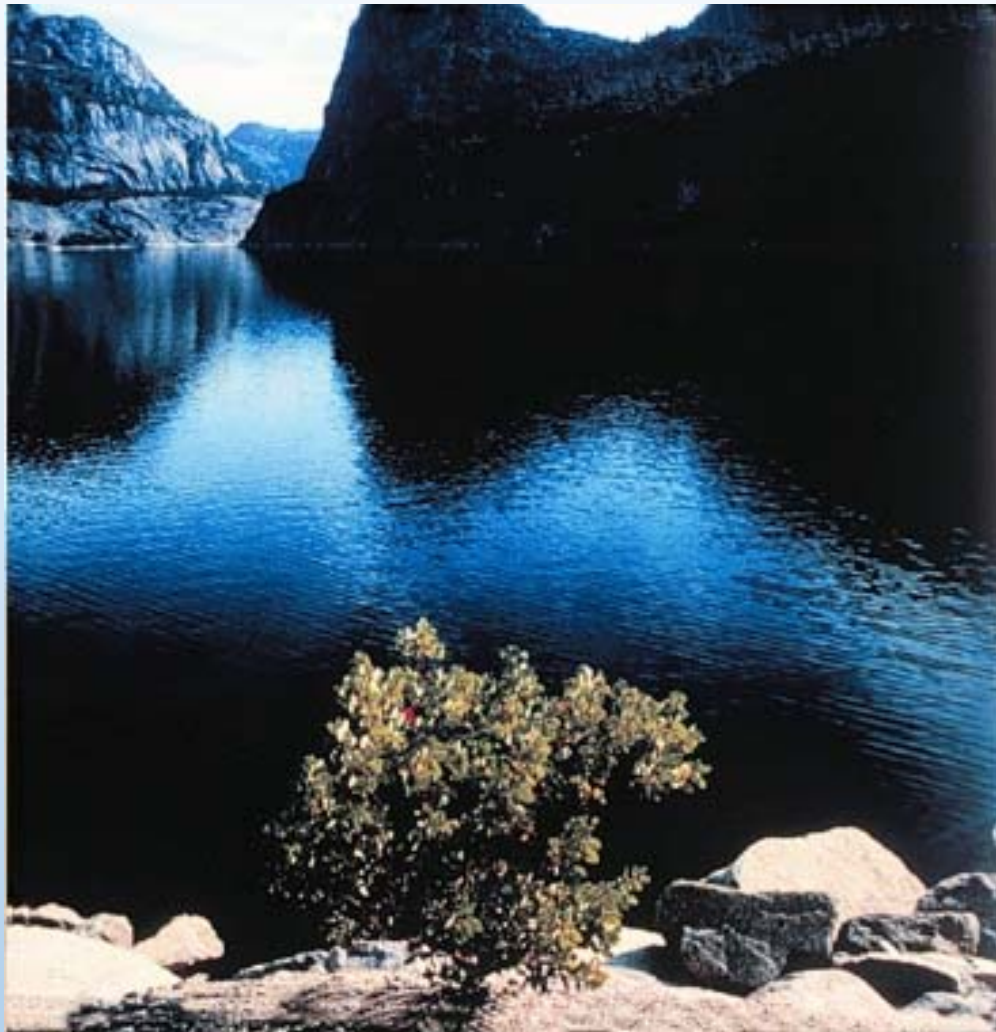
# Locally Funded Projects

600 cities and local agencies provide water through local projects and imported supplies.

Local systems:

- 💧 San Francisco's Hetch Hetchy Project
- 💧 East Bay Municipal Utility District's Pardee and Camanche Reservoirs and Aqueducts
- 💧 Los Angeles' Owens Valley and Los Angeles Aqueduct
- 💧 Metropolitan's Colorado River Aqueduct & Diamond Valley Lake





# Hetch Hetchy

## **Raker Act (1913)**

- Federal lands in the Sierra Nevada Mountains, including Hetch Hetchy Valley in Yosemite, used to build the water system
- The Bay Area Water Supply and Conservation Agency (BAWSCA)
- 1.7 million citizens and businesses

# More Local Systems

💧 Metropolitan Water District of Southern California - largest local district  
- operates Colorado River Aqueduct.

💧 Other local projects serve farmers, such as Glenn-Colusa Canal in the Sacramento Valley.



Diamond Valley Lake (MWD photo)



# Major Water Projects



# Environmental Protection Law



American River

- 💧 1972 State Wild and Scenic Rivers Act - no dams or diversion facilities on the Smith River and parts of Klamath, Trinity, Van Duzen, Scott, Eel, Salmon, Feather and American
- 💧 In 1980, some rivers added to the Federal Wild and Scenic Rivers System
- 💧 Today parts of other rivers included

# Environmental Protection Law

- Federal and State Endangered Species Acts
- Federal Energy Regulatory Commission
- Clean Water Act
- Porter Cologne water quality act
- Fish and Game code
- California Environmental Quality Act



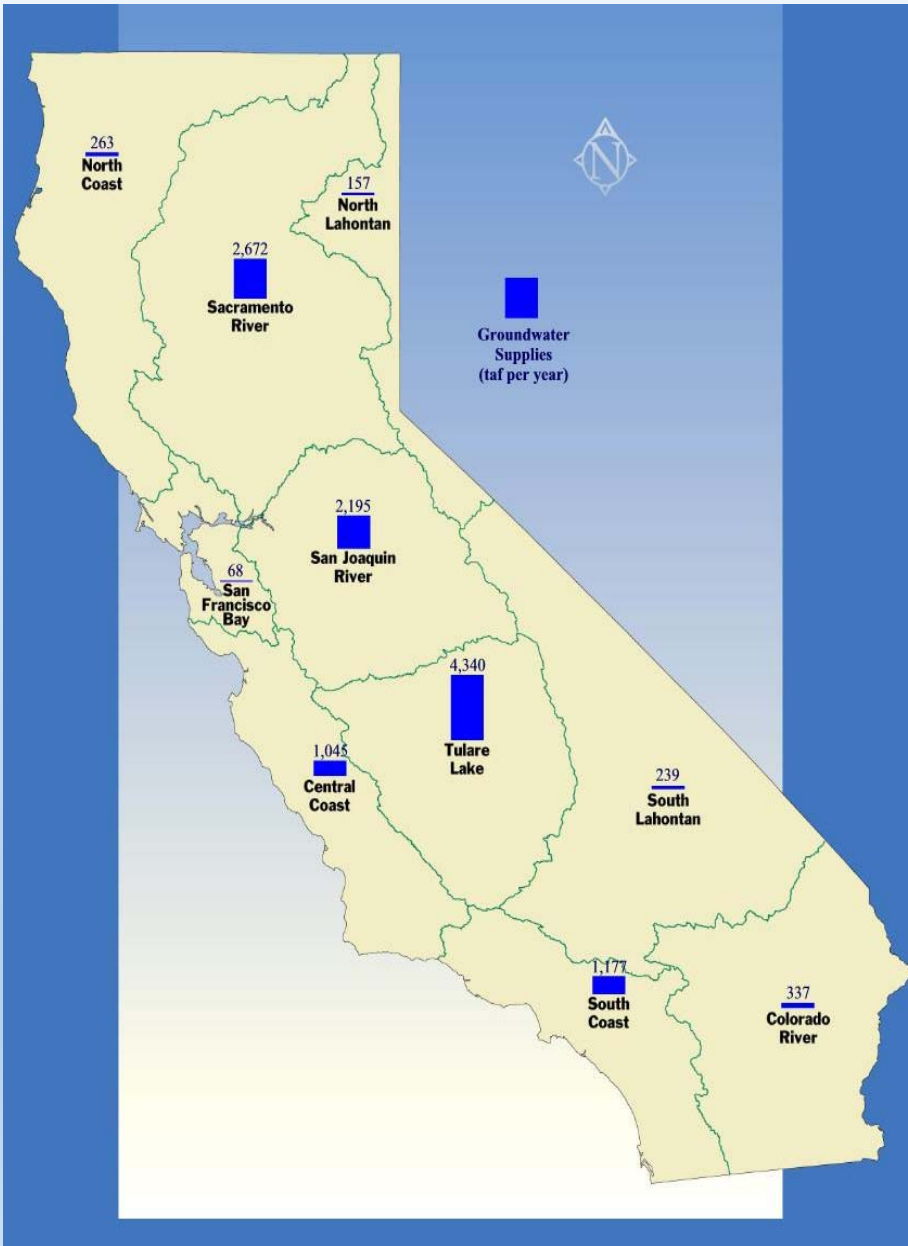
# Groundwater

Groundwater exists in aquifers – water bearing permeable rock or unconsolidated gravel, sand or silt

- 💧 About 30% of state's ag and urban water supply comes from groundwater in normal years; more in dry years.
- 💧 California uses more groundwater than any other state – about 40% of population gets drinking water from groundwater
- 💧 Groundwater that is “conjunctively managed” with surface water is an important source of agricultural supply



# Groundwater Supplies



Where is the groundwater?

More than 400 groundwater basins hold about 850 MAF of water. Only a fraction of that total minority that is economically usable.

**Bulletin 118 Groundwater Basins Subject to  
Critical Conditions of Overdraft – Update based on  
2018 Final Basin Boundary Modifications**



## Groundwater Overdraft in CA

- **Overdraft From Pumping More than Natural and Artificial Replenishment**
- **Central Valley Overdraft > 2 MAF Annually**
- **Results in Substantial Subsidence, Water Quality Concerns, and, in Some Cases, Severe Shortages**
- **SGMA Passed in 2014 to Address these Challenges**

# Groundwater Management

- 💧 In Southern California, many groundwater basins have been adjudicated, with courts establishing the pumping rights of many parties.
- 💧 Historic regulation of groundwater – 2014 Sustainable Groundwater Management Act (SGMA) provides local authority and responsibility to manage groundwater.

# Groundwater Pollution

Pollution is a serious threat. All the state's groundwater basins are contaminated to some degree.

- 💧 Trichloroethylene (TCE) - Used in adhesives, lubricants, paint products, pesticides, adhesives, rug-cleaners
- 💧 Perchlorate - Primary ingredient of solid rocket propellant
- 💧 Methyl tertiary butyl ether (MTBE) - added to gasoline to reduce air pollution in 1990s
- 💧 Groundwater overdraft can mobilize polluted groundwater



# Flood Management

## 💧 Floodplain Management

- In next 25 years population increase of about 14 million. Development will impact floodplains

## 💧 Levee Repairs

- Nearly 250 levee repair sites identified and work progressing

## 💧 Climate Change

- Warming ocean water and melting ice = sea level increase by 1.6 feet by 2050 along coastlines. By 2100 sea rise could be more than 3 feet. Recent warming running ahead of predictions and estimates may be low



# Flood Management: Levees

## 2005 – Hurricane Katrina

## 2006 – California Reacts to Flood Risk

Gov. Schwarzenegger declares a State of Emergency for California's levee system

- Flood Bonds passed

## 2012 – Central Valley Plan

Strategic Plan for improving flood management in Central Valley

## 2013 – Statewide Plan

Strategic Plan for improving flood management statewide



# Diversifying Water Supply

- California's Water Plan founded on "all of the above" approach to improving water supply reliability
- State guidelines for Integrated Regional Water Management Plans require analysis of:
  - Ocean Desalination
  - Wastewater Recycling
  - Water Conservation
  - Stormwater Capture
  - Water Transfers



## Ocean Desalination

- Popularly viewed as ‘ultimate’ solution
- Process is reliable but expensive
- Energy/Greenhouse Gas considerations
- Limited application
  - For additional baseload supply where imported water is expensive and unreliable
  - For isolated coastal urban locations
- Uneconomic for agriculture or urban irrigation
- Expect more, but limited application in future

## Wastewater Recycling

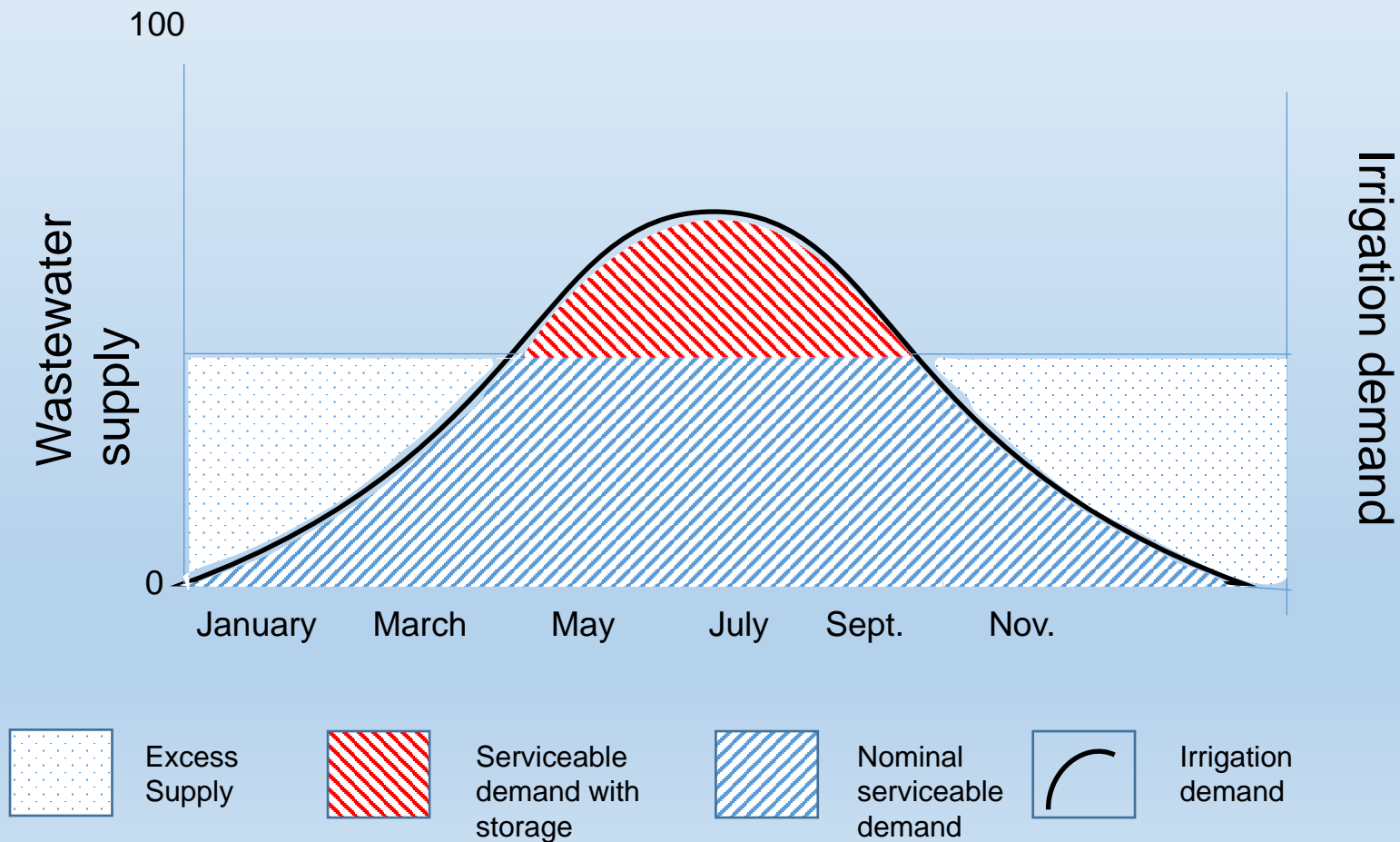
Process of recycling treated sewage for non-potable and potable uses

- Requires separate plumbing system for non-potable applications
- Economic justification includes consideration of reliability and offset in treated wastewater disposal costs
- Expect more in future, particularly with incentive of state and federal cost shares

## Wastewater Recycling

- Wastewater recycling for potable use
  - Potential use that could justify storage
  - Effectively being used in Orange County
  - Pioneering efforts in San Diego – indirect potable reuse project
    - DHS regulation of drinking water

# Conceptual Recycled Water Potential Typical Urban Location – Opportunities and Limitations



## Water Conservation

- Reduction in use/demand management
- Role in water supply reliability planning – long term efforts
- Role in drought response – temporary use reductions
- Long term efforts cause ‘demand hardening’, limiting easy drought response
- Historic drought fueled movement for “Making conservation a California Way of Life”

# Stormwater Capture

- Generally focused on urban areas
- Receiving re-look as other sources less available, costs rise
- Very site specific: capture opportunities, storage opportunities, treatment issues
- Link to sustainability planning – limiting hardscape, local water retention, infiltration strategies

## Water Transfers

- Where one entity with excess supply transfers to another in need
- Common inter and intra-district strategy in agriculture
- Increasingly a way to shore up urban supplies
- Transfers using CVP/SWP infrastructure
  - Temporary land fallowing
  - Transfers from water storage
- Complicated due to legal and physical constraints

## Water Transfers

- Legal issues:
  - Real water test
  - Source of water and water rights:
    - location, pre-'14 water right no SWRCB jurisdiction, lead agency under CEQA is transferring agency; one-year exemption
    - If a post-'14 water right SWRCB lead agency and exempt from CEQA for one year transfer 'SWRCB equivalent process'
- Physical issues: *can you move it through the Delta?*



## Summary

- California's historical development and its supporting water development was shaped by unique geography
- Development and management of water supply in California involves a complex mix of Federal, State, Local and private interests operating under an increasingly complicated regulatory regime seeking balancing of water demands with natural resource protection
- Water supply planning has evolved from “gap analysis” to “risk analysis” and an integrated water management approach that values diverse portfolios to maintain supply reliability
- A growing population, competing demands, and climate change effects will make water resources management an ongoing challenge