System-Wide Investigation of Central Valley Conjunctive Water Management Opportunities

U. S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Natural Heritage Institute

In Intensively Developed Water Systems

Old Paradigm:

Water for flow restoration vs. water for human uses = ZERO SUM GAME

New Paradigm:

- No new water development without a strong environmental restoration component
- Environmental flow restoration embedded within water augmentation

Mandates

- CVPIA

"develop and implement" a **"least-cost"** program to **supplement and replace** the CVP water dedicated to fish and wildlife restoration **through improvements in reservoir operations, water banking, and conjunctive use.** [§§3406(b)(3) and 3408(j)]

- CALFED Bay-Delta

"improve water supply reliability" for all sectors

- Environmental Water Account
- Other Critical Unmet Needs
  - Restore anadromous fishery of the San Joaquin River
  - CVP contract deliveries
  - AFRP program
  - Dilution water to improve water quality

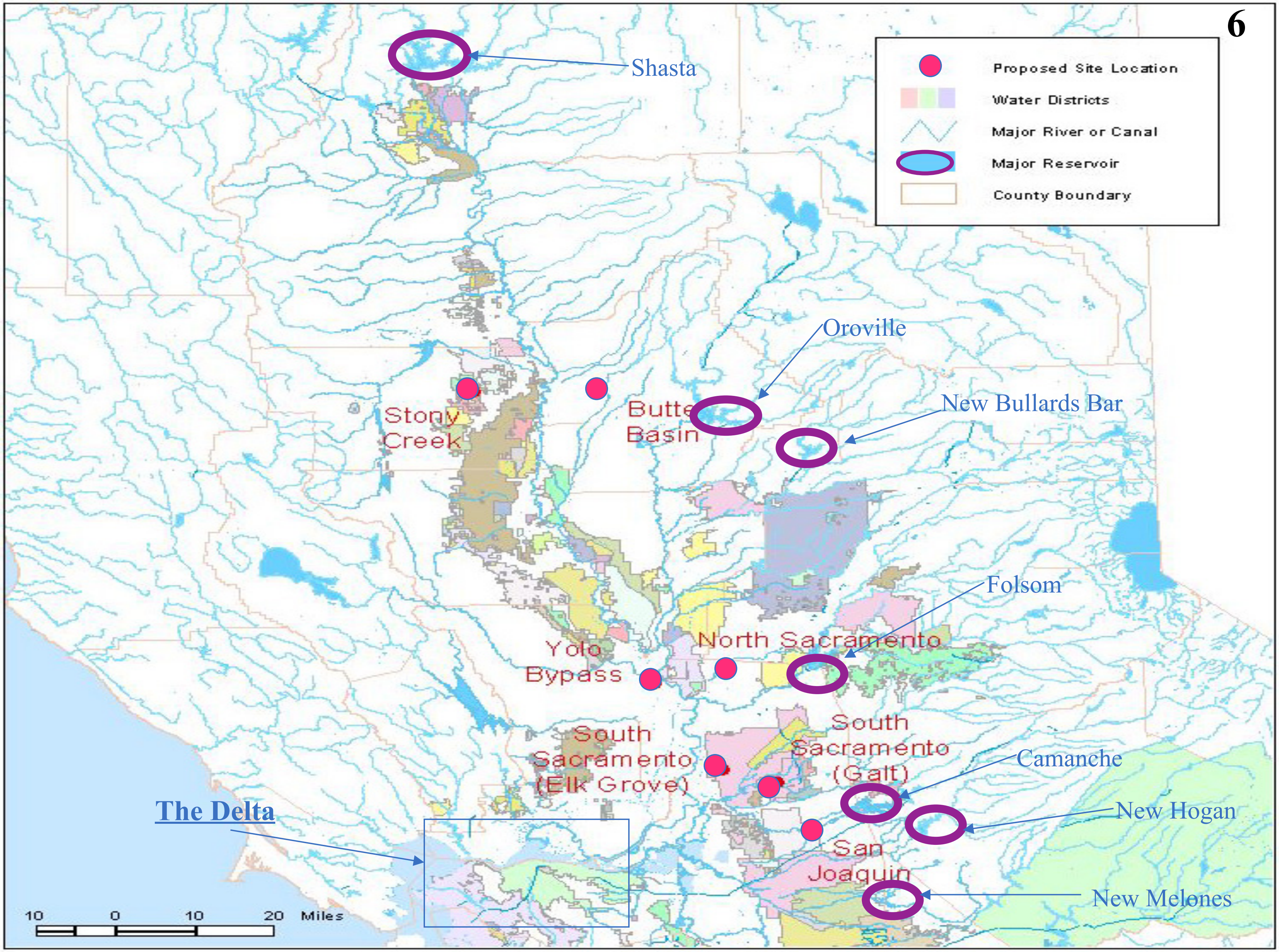
Characteristics of System-Wide Conjunctive Water Management

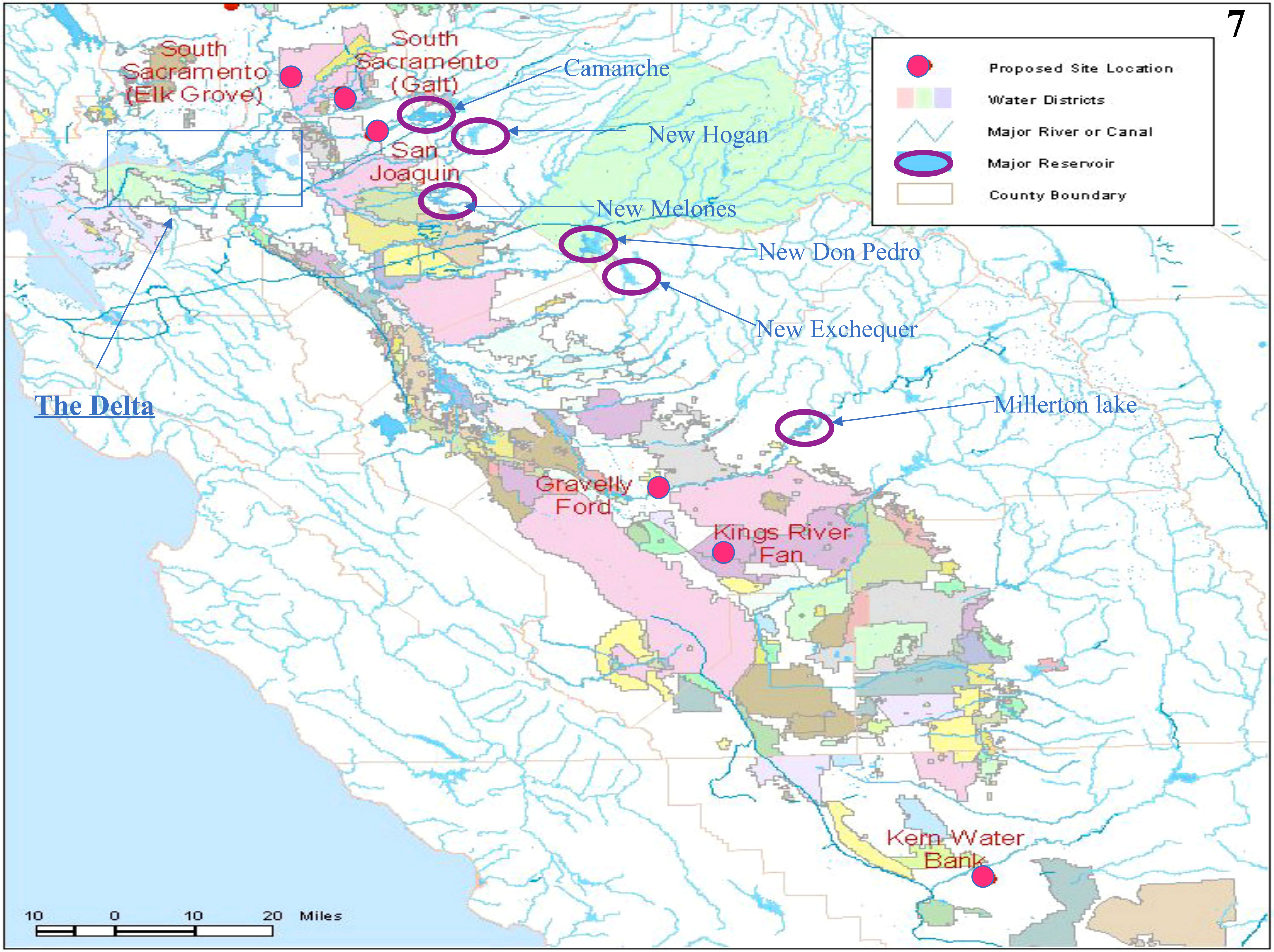
- Sources of Groundwater Recharge
  - Artificial recharge via water imported from a hydrologically disconnected source
- Sequence of Recharge and Recovery
  - Extraction ⟶ recharge
  - Recharge ⟶ recovery
  - "In lieu" recharge and recovery
- Destination Type
  - System-wide benefits

Components

- Reservoir operators would agree to re-operate the reservoir to generate source water* for banking for a fee
- Local interests controlling a groundwater basin would agree to temporarily “rent” unused aquifer storage space for a fee or share of the water
- Potential beneficiaries of the groundwater banking program would purchase a specified amount of the banked groundwater

* Water will be regarded as “new” water if it would otherwise have been released for flood control purposes and flowed out to sea


Shasta
Proposed Site Location
Water Districts
Major River or Canal
Major Reservoir
County Boundary
Oroville
New Bullards Bar
Stony Creek
Butte Basin
Folsom
North Sacramento
Yolo Bypass
South Sacramento (Elk Grove)
South Sacramento (Galt)
Camanche
New Hogan
The Delta
San Joaquin
New Melones
10 0 10 20 Miles



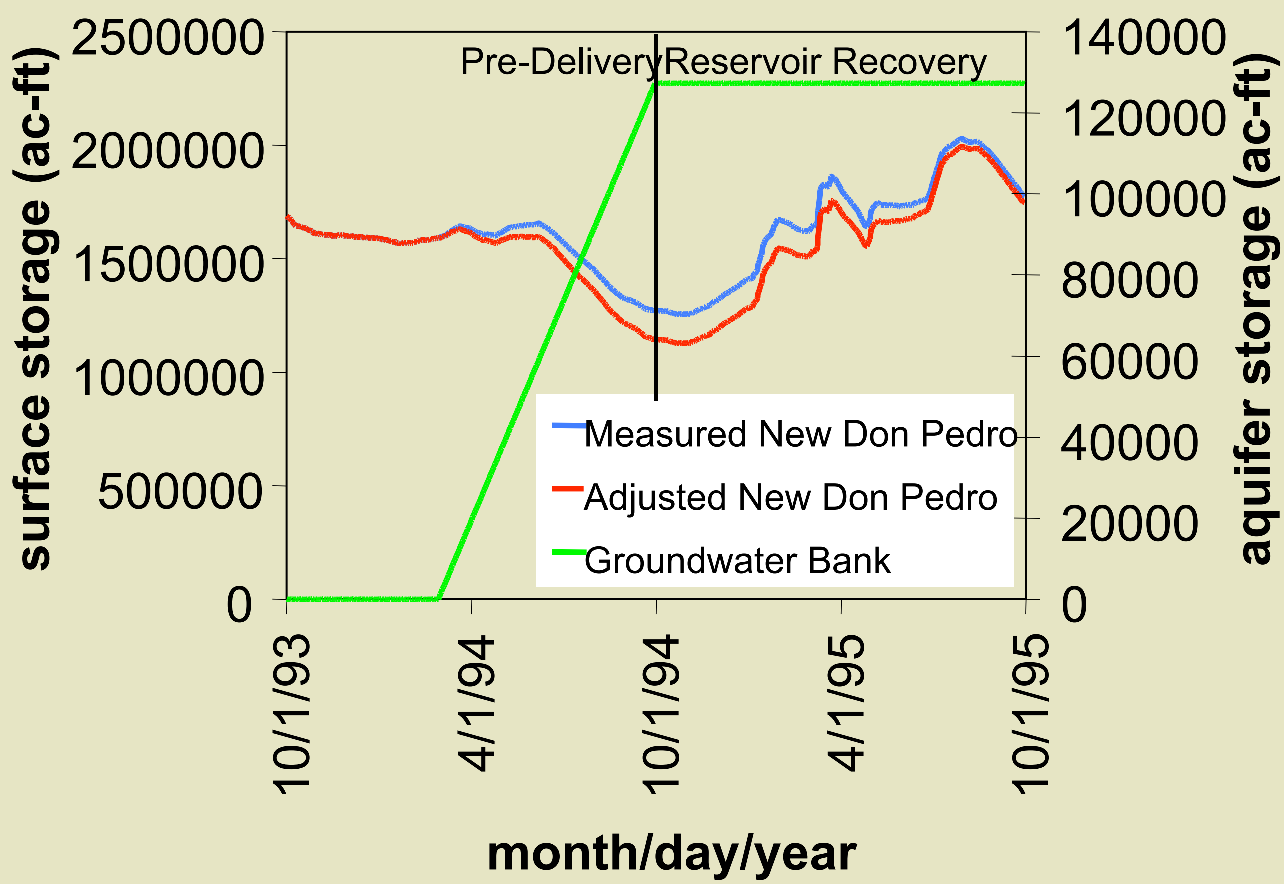
South Sacramento (Elk Grove)
South Sacramento (Galt)
Camanche
New Hogan
San Joaquin
New Melones
New Don Pedro
New Exchequer
The Delta
Millerton lake
Gravelly Ford
Kings River Fan
Kern Water Bank
Proposed Site Location
Water Districts
Major River or Canal
Major Reservoir
County Boundary
10 0 10 20 Miles

Reservoirs, Ownership, and Capacity

River	Reservoir/Dam	Operator	Storage (TAF)	Mean 1921-1983 Unimpaired Flow
Sacramento	Shasta	USBR/CVP	4,552	8,303
Feather	Oroville	DWR/SWP	3,538	4,441
Yuba	New Bullards Bar	YCWA	966	2,333
American	Folsom	USBR/CVP	974	2,660
Mokelumne	Camarache	EBMUD	417	730
Calaveras	New Hogan	COE	317	163
Stanislaus	New Melones	USBR/CVP	2,420	1,131
Tuolumne	New Don Pedro	MID/TID	2,030	1,841
Merced	New Exchequer	Merced ID	1,025	967
Kings River	Pine Flat	COE	1,000	1,745
Upper San Joaquin	Millerton Lake	USBR/CVP	520	1,740

Modes of Groundwater Banking

NHI Approach



Average Annual Yield Estimates for Eleven Regulated Tributaries of the Central Valley

River	Conjunctive Use Re-Operation (TAF)
Sacramento	196.8
Feather	126.9
Yuba	144.5
American	80.4
Mokelumne	69.4
Calaveras	25.4
Stanislaus	65
Tuolumne	77.9
Merced	108.1
Upper San Joaquin	100
Pine Flat Reservoir	108
TOTAL	1102.4

Factors Taken Into Account in Calculating Re-operation Yield

- Pre-existing rights & entitlements
- AFRP flows
- Temperature regulation

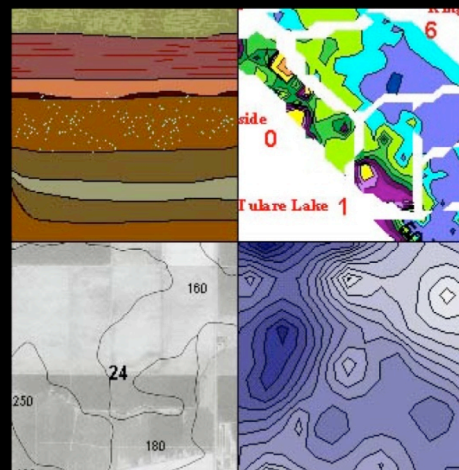
Next Steps

Reiterate reservoir yield analysis using CALSIM II

- Shasta (ongoing)
- Other 10 reservoirs (prospective)

SYSTEM-WIDE CONJUNCTIVE WATER MANAGEMENT

THE HYDROGEOLOGIC SUITABILITY OF POTENTIAL GROUNDWATER BANKING SITES IN THE CENTRAL VALLEY OF CALIFORNIA



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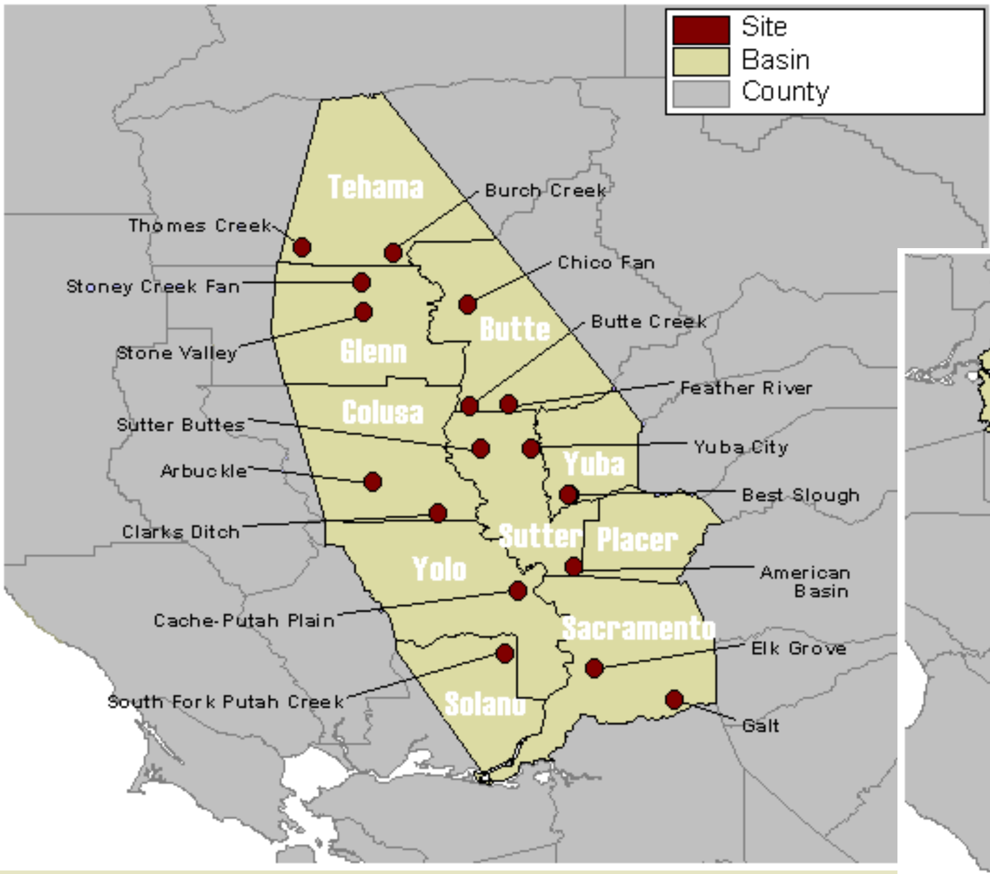
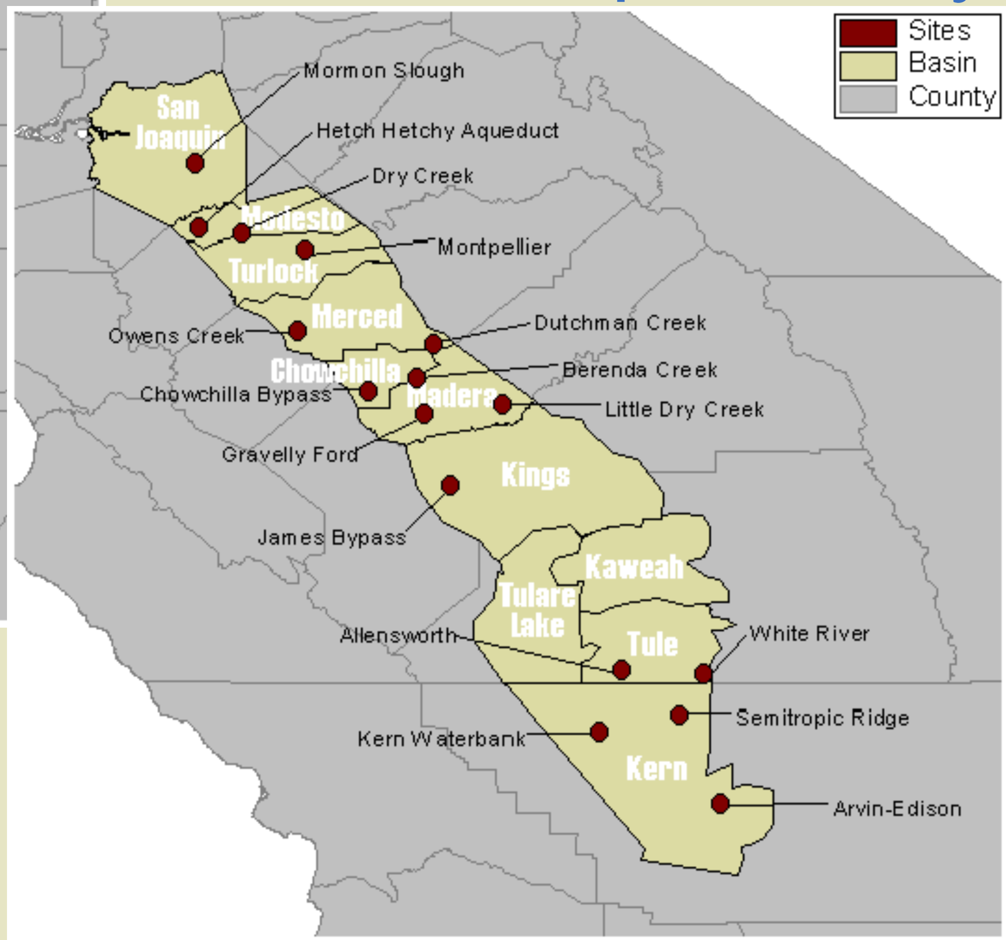
Potential Groundwater Banking Sites

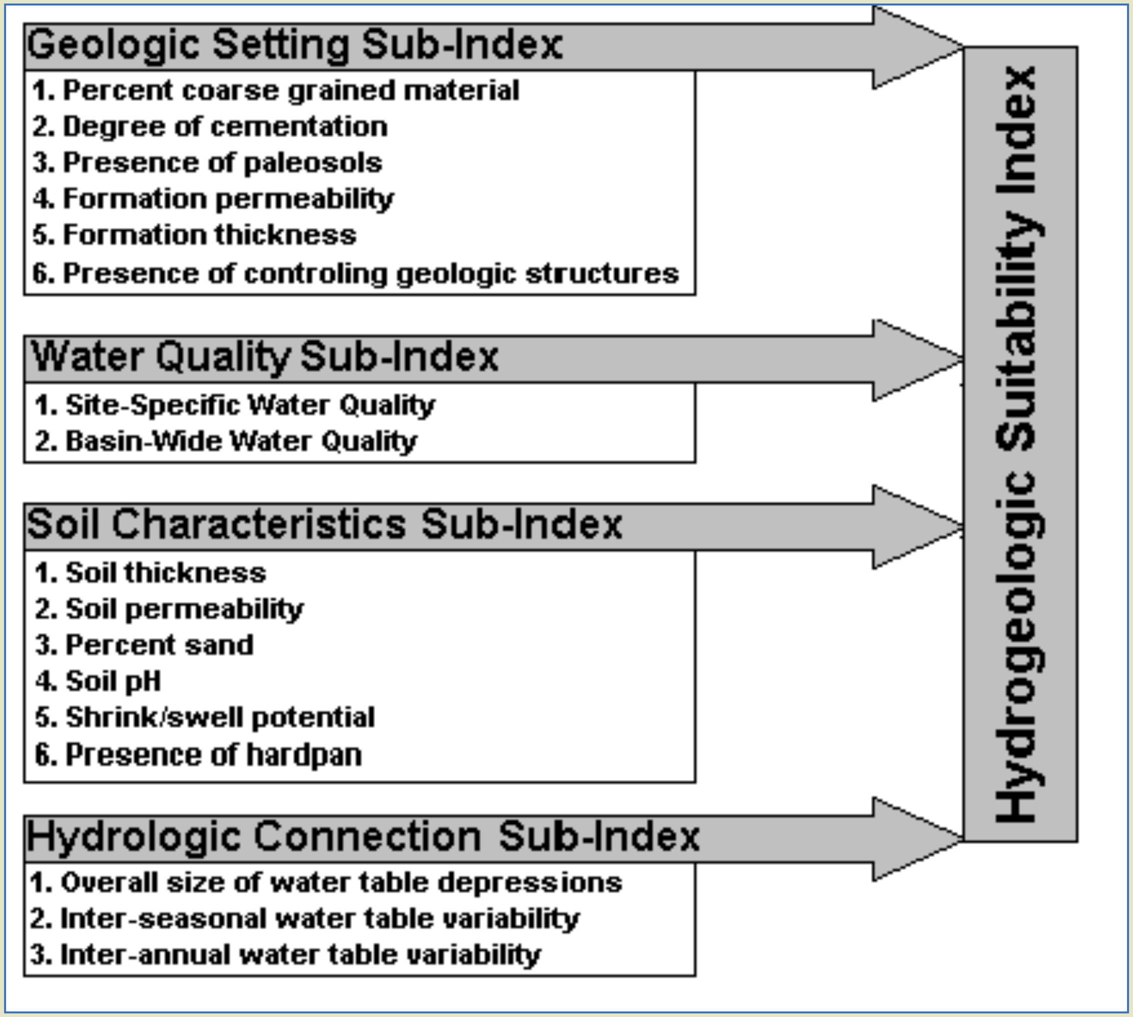


Sacramento Valley

San Joaquin Valley

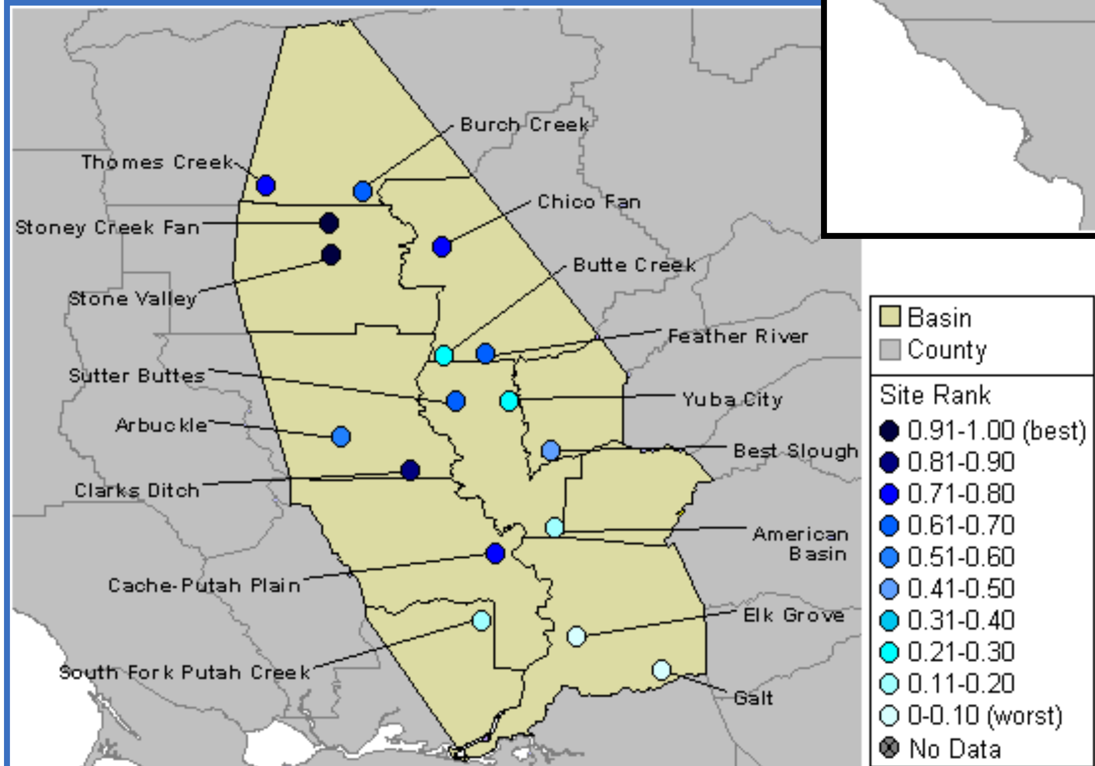


Hydrogeologic Suitability of Central Valley Sites for Groundwater Banking

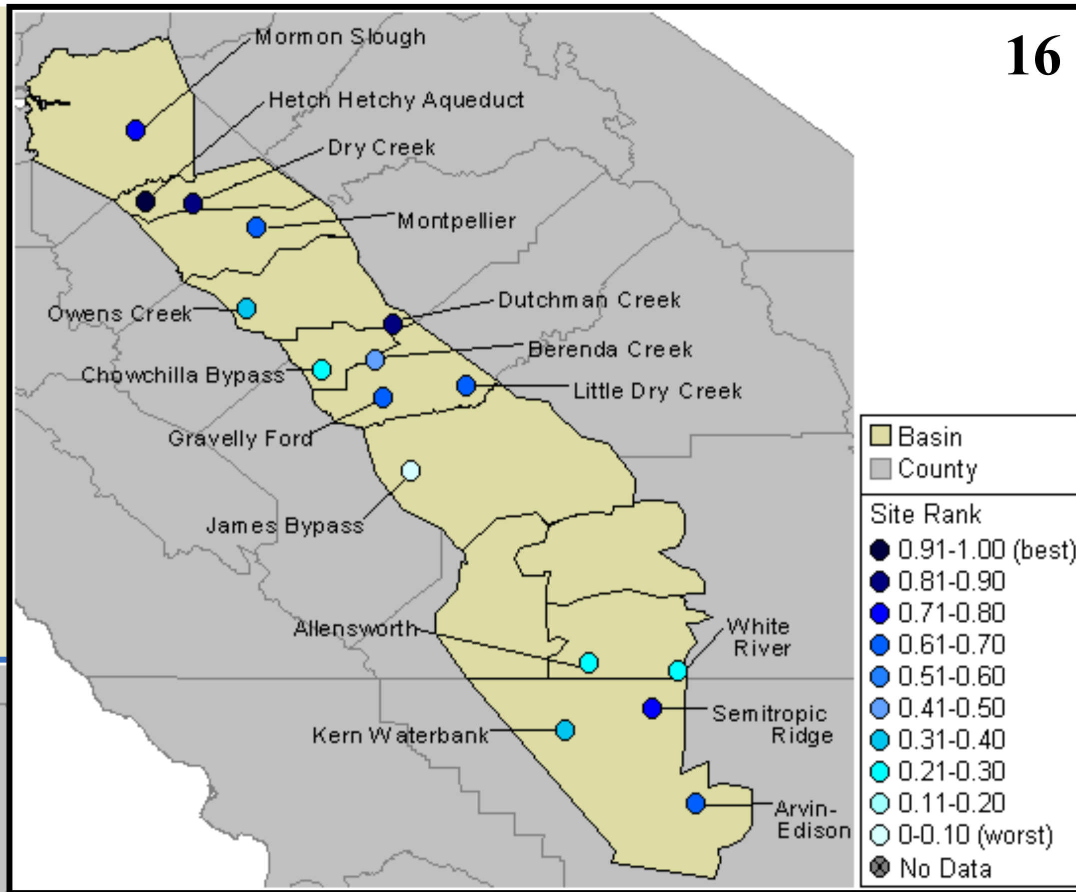


Hydrogeologic Suitability Sub-index

Sacramento Valley

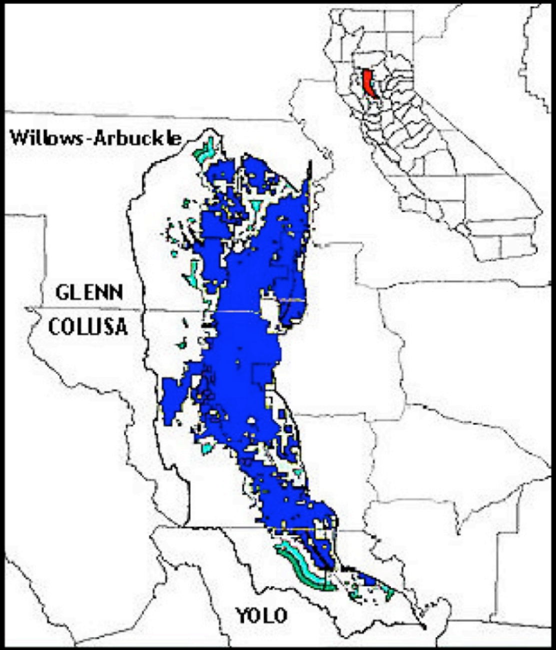


San Joaquin Valley



SYSTEM-WIDE CONJUNCTIVE WATER MANAGEMENT

ESTIMATING THE POTENTIAL FOR IN LIEU CONJUNCTIVE WATER MANAGEMENT IN THE CENTRAL VALLEY OF CALIFORNIA



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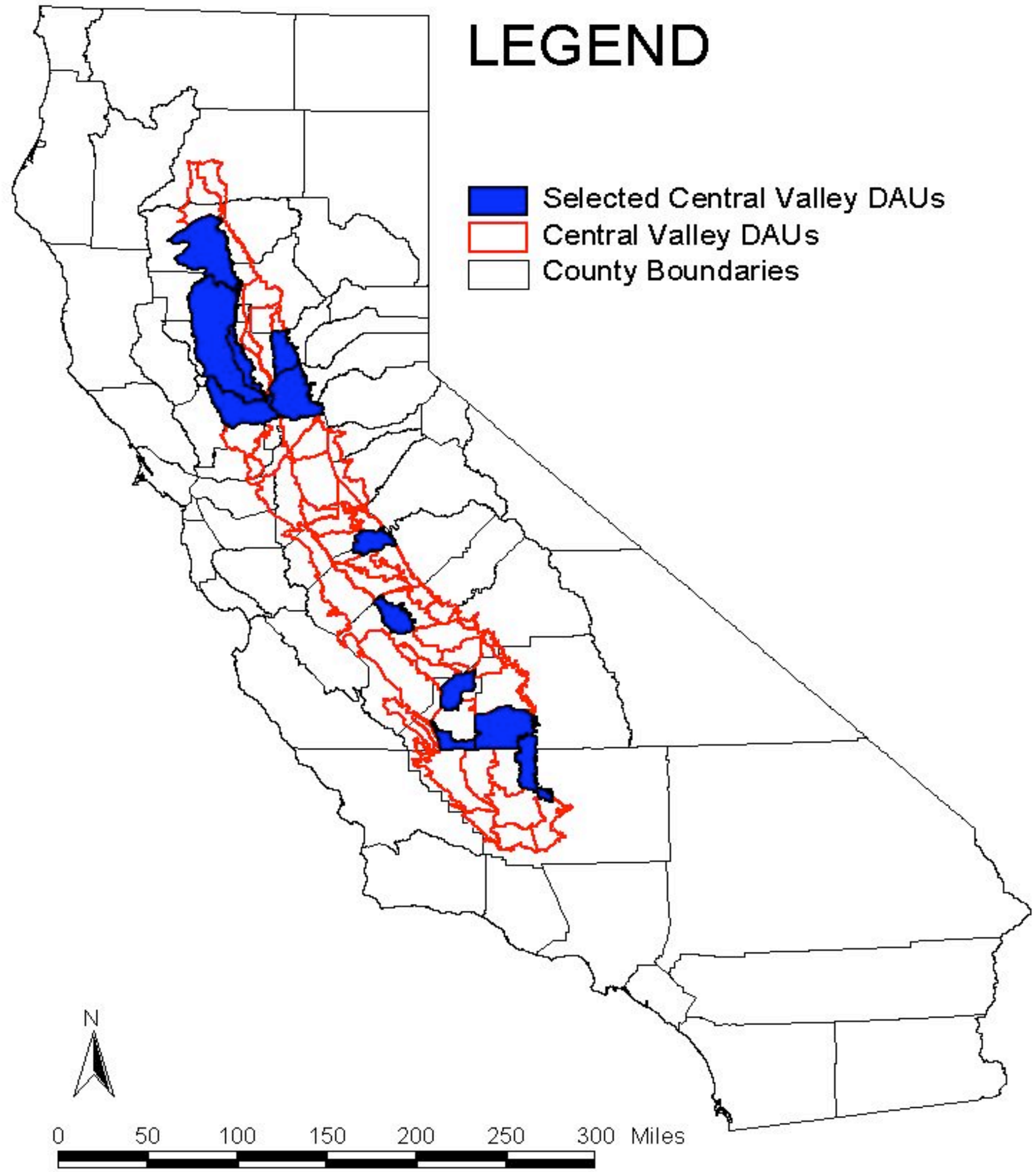
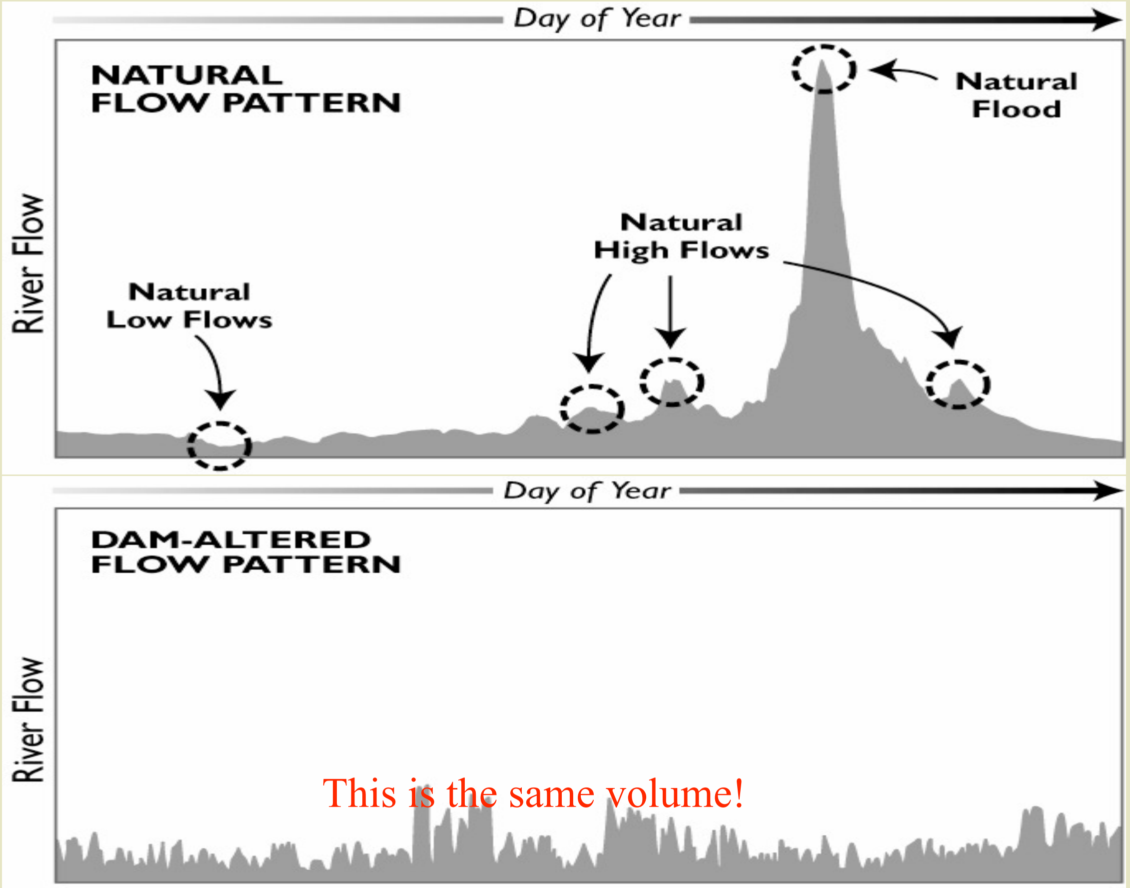
Evaluation Criteria

- Relative contribution of surface water & groundwater
- Proximity of groundwater-irrigated lands to surface water distribution networks
- Available aquifer storage space

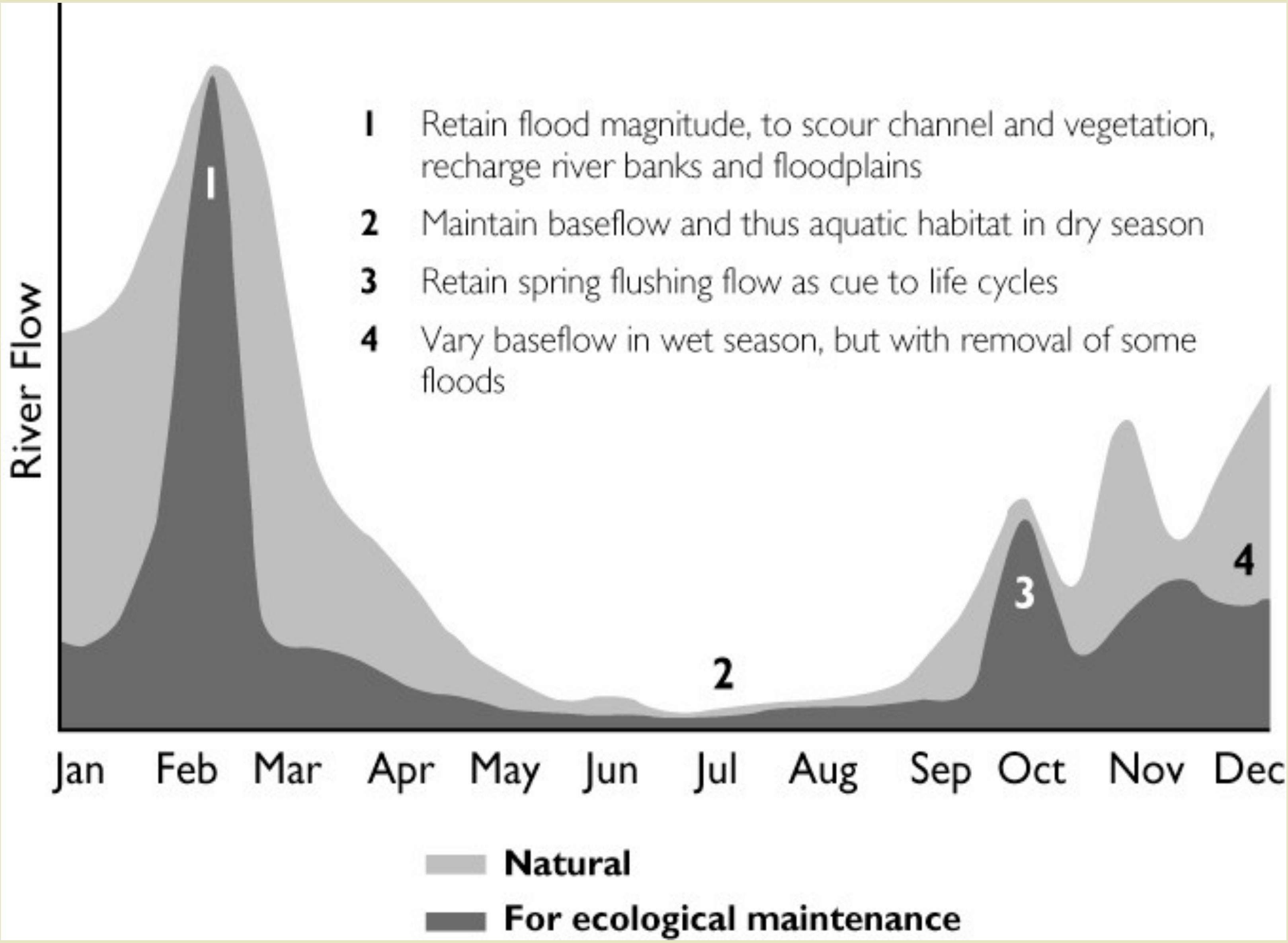
Promising Central Valley DAUs



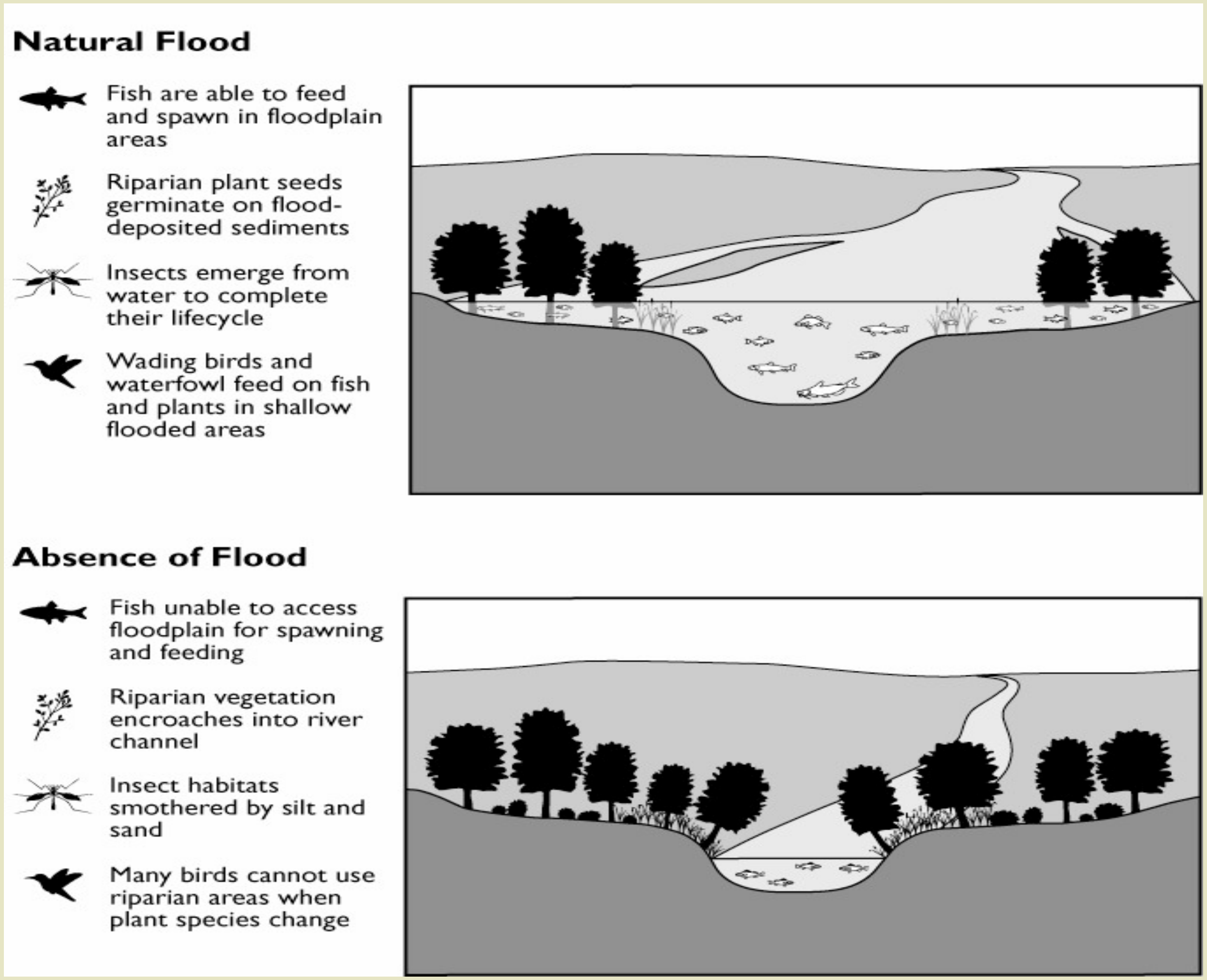
What is an Environmental Flow: moving from minimum flow to variable flow



It's not just a matter of water volume…


River Flow
1 Retain flood magnitude, to scour channel and vegetation, recharge river banks and floodplains
2 Maintain baseflow and thus aquatic habitat in dry season
3 Retain spring flushing flow as cue to life cycles
4 Vary baseflow in wet season, but with removal of some floods
1
2
3
4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Natural
For ecological maintenance

Making Rivers Function Like Rivers Again:
Impact of River Development on Floodplains



Fluvial Restoration Concept

Problem: Flow characteristics should be linked to biological benefits

Solution: Progressively develop applied biohydrology

- Link to CALFED Science Program
- Conduct adaptive management of flow experiments

Fluvial Restoration Concept

Problem: Shaving hydrologic peaks reduces natural variability

Solution: Convert from uncontrolled to controlled floods

Fluvial Restoration Concept

Problem: Capturing pulse flows is an engineering challenge

Solution: Coordinate & rotate reservoir operation for fluvial benefit

Next Steps

Floodplain / fluvial process investigation

- Determine the available water for environmental flows
- Define environmental flow requirements (magnitude, frequency, duration)
- Identify the floodplain constraints that limit the magnitude parameter
- Assess the sediment needs and availability for geomorphic restoration

Next Steps

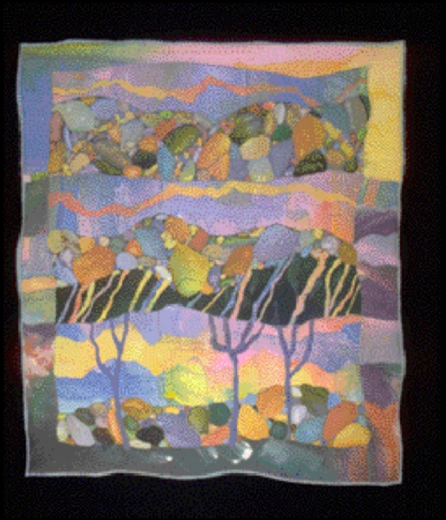
Regionalized and System-Wide Configurations

- What we know
  - How much water we have to “play with”
  - Locations of 2º storage sites
  - Ranking of tributaries by restoration potential
- What we need to learn
  - Feasibility of linking **particular reservoirs** to particular **2º storage sites** through **particular natural channels and artificial conveyance** and **reintegrating the supply** into the existing CV delivery system
- How to figure this out
  - System-wide “gaming” and whole-system modeling with CALSIM II

SYSTEM-WIDE CONJUNCTIVE WATER MANAGEMENT

DESIGNING SUCCESSFUL GROUNDWATER BANKING PROGRAMS IN THE CENTRAL VALLEY:

LESSONS FROM EXPERIENCE



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Nicholas A. Pinhey, University of Southern California
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and legal research by

Peter Kiel, Hastings College of the Law

The Local Control Imperative

Who?

What?

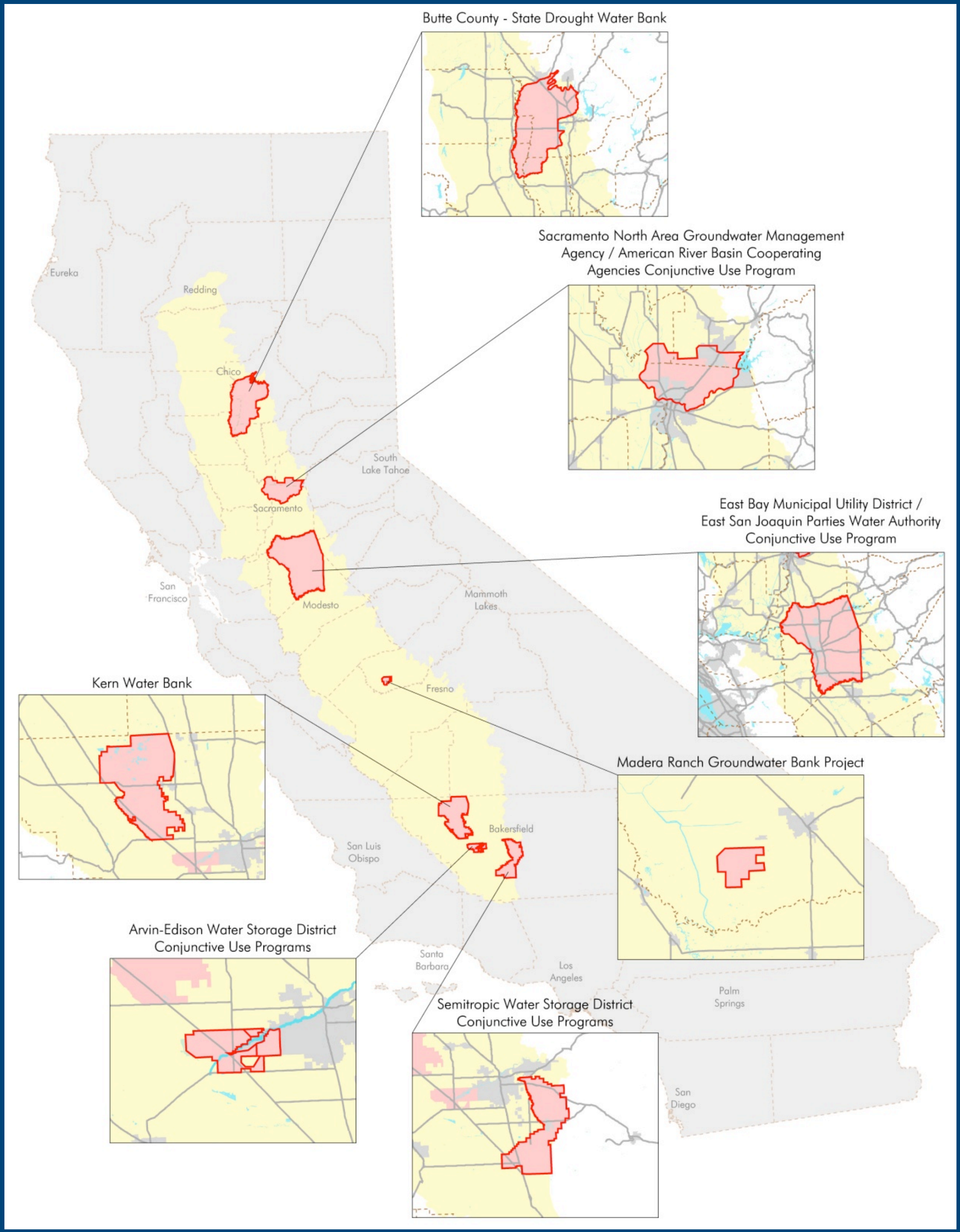
How?

Risk Factors Analyzed

- Hydrogeologic
  - "Leaky" aquifers
  - Adverse effects on other groundwater pumpers
  - Reduced natural infiltration
  - Groundwater invasion of crop root zones / wetlands regulations
- Water Quality
  - Degrading aquifer water
  - Leaching soil contaminants
- Financial
  - Delta pumping restrictions to delivery of banked water

Risk Factors Analyzed

- Legal
  - Injury to other groundwater users
  - Limiting the rights of current / future groundwater users
  - Legal action against other groundwater users
- Political
  - Adverse community reactions


Butte County - State Drought Water Bank
Sacramento North Area Groundwater Management Agency / American River Basin Cooperating Agencies Conjunctive Use Program
East Bay Municipal Utility District / East San Joaquin Parties Water Authority Conjunctive Use Program
Kern Water Bank
Madera Ranch Groundwater Bank Project
Arvin-Edison Water Storage District Conjunctive Use Programs
Semitropic Water Storage District Conjunctive Use Programs
Eureka
Redding
Chico
South Lake Tahoe
Sacramento
San Francisco
Modesto
Mammoth Lakes
Fresno
Bakersfield
San Luis Obispo
Santa Barbara
Los Angeles
Palm Springs
San Diego

Factors for Success

- Overall Project Design
  - Banked water imported
  - Facilities sited in existing water district service area or AB-3030 planning area
  - Operations performed by overlying water district / groundwater management authority
  - Local benefits obligated in enforceable contracts
  - For unincorporated areas, create local water management authority
  - Issues, alternatives, mitigations routinely analyzed in NEPA / CEQA with public participation

Constraints & Design Specifications for System-Wide Maximal Scale Conjunctive Use

- Groundwater banking projects will operate on the basis of voluntary, compensated contractual arrangements among reservoir owners, local groundwater management authorities, conveyance operators and end use beneficiaries.

- No changes in existing laws will be assumed, although the final report may identify legal reforms or measures to clarify existing laws that would facilitate the program.

Constraints & Design Specifications for System-Wide Maximal Scale Conjunctive Use

- Projects will cause no uncompensated adverse impacts on other groundwater or surface water rights holders.
- Projects will provide net environmental benefits.

Constraints & Design Specifications for System-Wide Maximal Scale Conjunctive Use

- Projects will be operated in an economically optimal fashion (i.e., the volumes of water and scale of operations will be limited by the marginal cost of substitute supplies).
- No new public subsidies will be assumed. That is to say, the project will be designed to be self-financing.

www.conjunctiveuse.org

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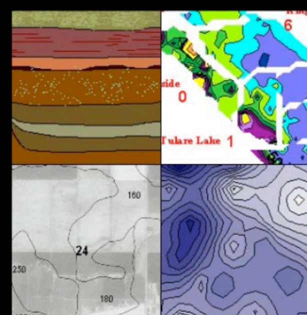

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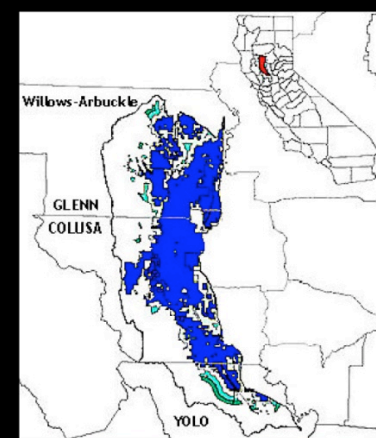

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Prospective Workplan

- Reassess "new water" yield potential of 11 reservoirs
- Analyze and rank tributary restoration potential
  - Define environmental flow prescriptions (with CALFED Science Program)
  - Identify floodplain constraints
  - Assess sediment needs and availability
- Implement system-wide modeling
- Identify optimal regional configurations
  - Analyze groundwater banking land use compatibility
- Formulate and implement pilot demonstration projects
- Conduct economic optimization analysis
- Prepare final report
- Conduct executive briefings