System-Wide Investigation of Central Valley Conjunctive Water Management Opportunities
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
### Reservoirs, Ownership, and Capacity

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

NHI Approach

- Pre-Delivery
- Reservoir Recovery

Graph showing surface storage and aquifer storage over time with different modes of groundwater banking.
## Average Annual Yield Estimates for Eleven Regulated Tributaries of the Central Valley

<table>
<thead>
<tr>
<th>River</th>
<th>Conjunctive Use Re-Operation (TAF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacramento</td>
<td>196.8</td>
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<tr>
<td>Feather</td>
<td>126.9</td>
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<td>Yuba</td>
<td>144.5</td>
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<td>American</td>
<td>80.4</td>
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<tr>
<td>Mokelumne</td>
<td>69.4</td>
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<td>Calaveras</td>
<td>25.4</td>
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<tr>
<td>Stanislaus</td>
<td>65</td>
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<tr>
<td>Tuolumne</td>
<td>77.9</td>
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<tr>
<td>Merced</td>
<td>108.1</td>
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<tr>
<td>Upper San Joaquin</td>
<td>100</td>
</tr>
<tr>
<td>Pine Flat Reservoir</td>
<td>108</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1102.4</strong></td>
</tr>
</tbody>
</table>
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

THE NATURAL HERITAGE INSTITUTE
David R. Purkey, Ph.D.
Gregory A. Thomas, J.D.

with research by:
Shannon Byrne
Ann M. Cheng
Nathan E. Harrison

September 2001
Potential Groundwater Banking Sites

Sacramento Valley

San Joaquin Valley

Sacramento Valley
Hydrogeologic Suitability of Central Valley Sites for Groundwater Banking

Geologic Setting Sub-Index
1. Percent coarse grained material
2. Degree of cementation
3. Presence of paleosols
4. Formation permeability
5. Formation thickness
6. Presence of controlling geologic structures

Water Quality Sub-Index
1. Site-Specific Water Quality
2. Basin-Wide Water Quality

Soil Characteristics Sub-Index
1. Soil thickness
2. Soil permeability
3. Percent sand
4. Soil pH
5. Shrink/swell potential
6. Presence of hardpan

Hydrologic Connection Sub-Index
1. Overall size of water table depressions
2. Inter-seasonal water table variability
3. Inter-annual water table variability
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

THE NATURAL HERITAGE INSTITUTE

David R. Purkey, Ph.D.
Elizabeth M. Mansfield

February 2002
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

This is the same volume!

It’s not just a matter of water volume...
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
Making Rivers Function Like Rivers Again: Impact of River Development on Floodplains

**Natural Flood**
- Fish are able to feed and spawn in floodplain areas
- Riparian plant seeds germinate on flood-deposited sediments
- Insects emerge from water to complete their lifecycle
- Wading birds and waterfowl feed on fish and plants in shallow flooded areas

**Absence of Flood**
- Fish unable to access floodplain for spawning and feeding
- Riparian vegetation encroaches into river channel
- Insect habitats smothered by silt and sand
- Many birds cannot use riparian areas when plant species change
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
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

Next Steps
SYSTEM-WIDE CONJUNCTIVE WATER MANAGEMENT

DESIGNING SUCCESSFUL GROUNDWATER BANKING PROGRAMS IN THE CENTRAL VALLEY:

LESSONS FROM EXPERIENCE

THE NATURAL HERITAGE INSTITUTE
Gregory A. Thomas

with case studies by:
David L. Brown, Ph.D., California State University, Chico
Nicholas A. Pinhey, University of Southern California
Jennifer L. Spalletta, Horum Crabtree & Brown LLP

and legal research by
Peter Kief, 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
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.
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