



Gary Bardini, PE

SAFCA 500-YEAR RESILIENCY PLAN

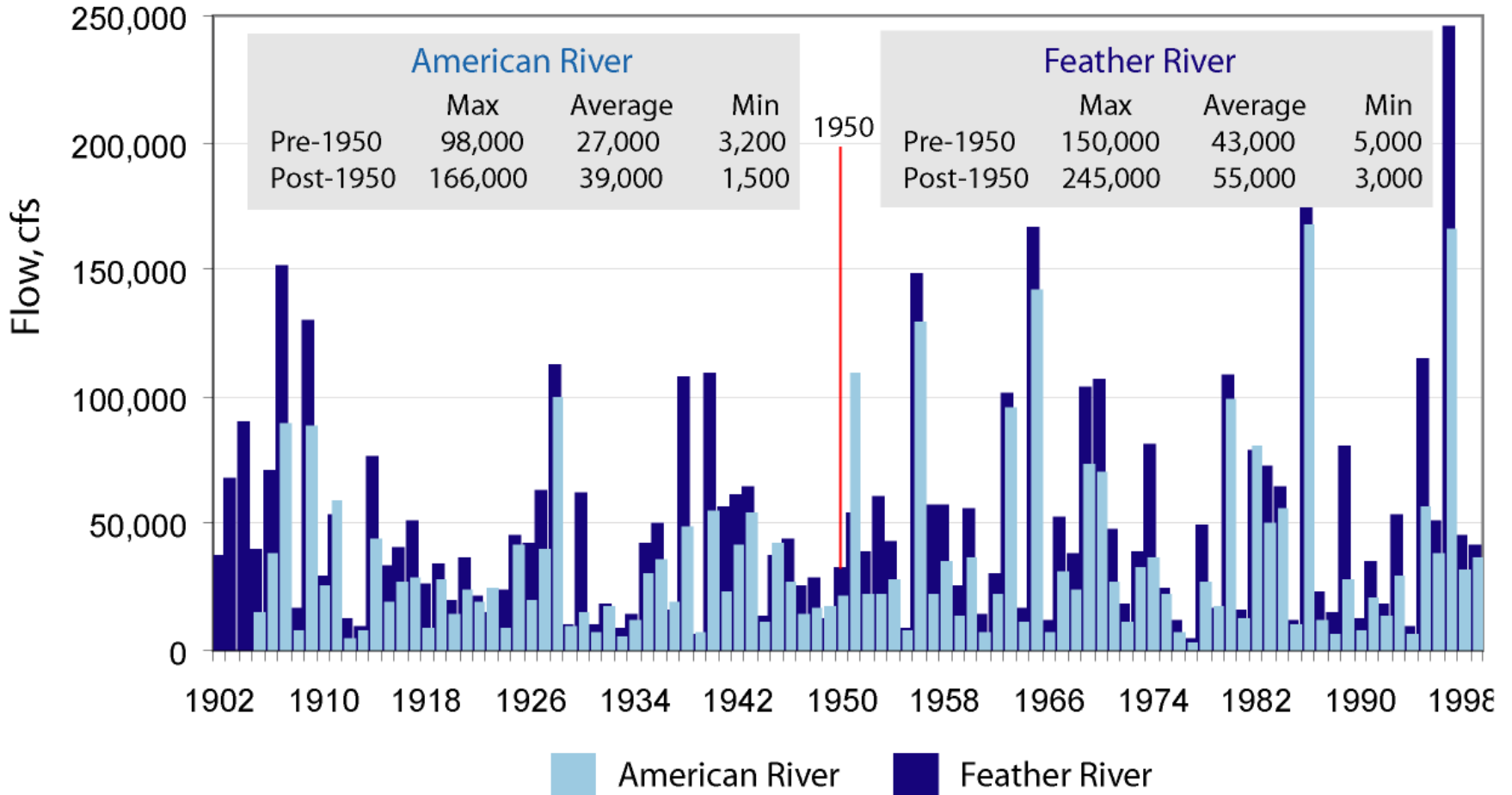
**Managing American River Flood Risks
and Regional Groundwater Levels
Together**

For many: the Pre-Katrina attitude to Flood Management

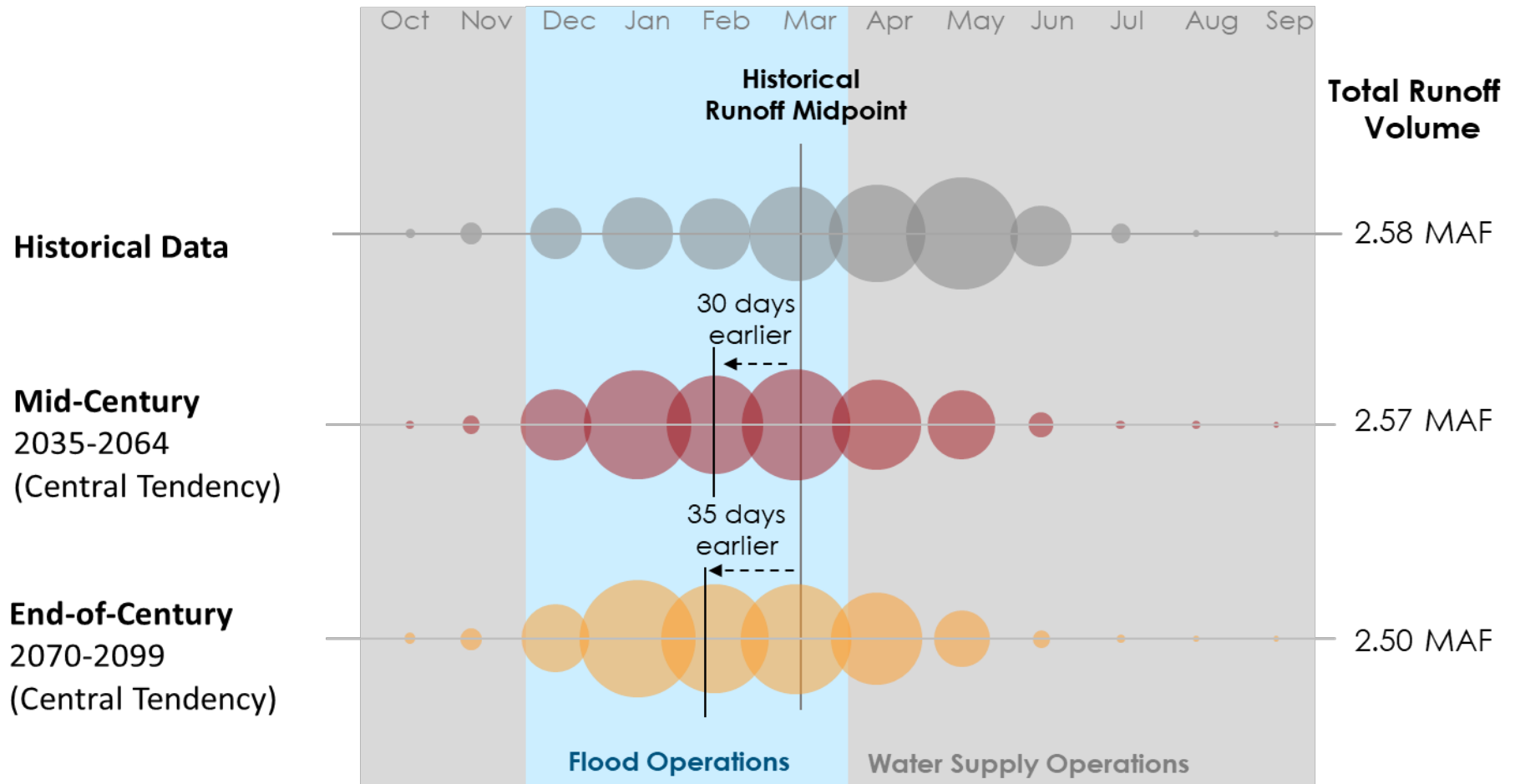


Recognition: Climate Change

20th Century Annual Peak 3-Day Flows without the Influence of Reservoirs



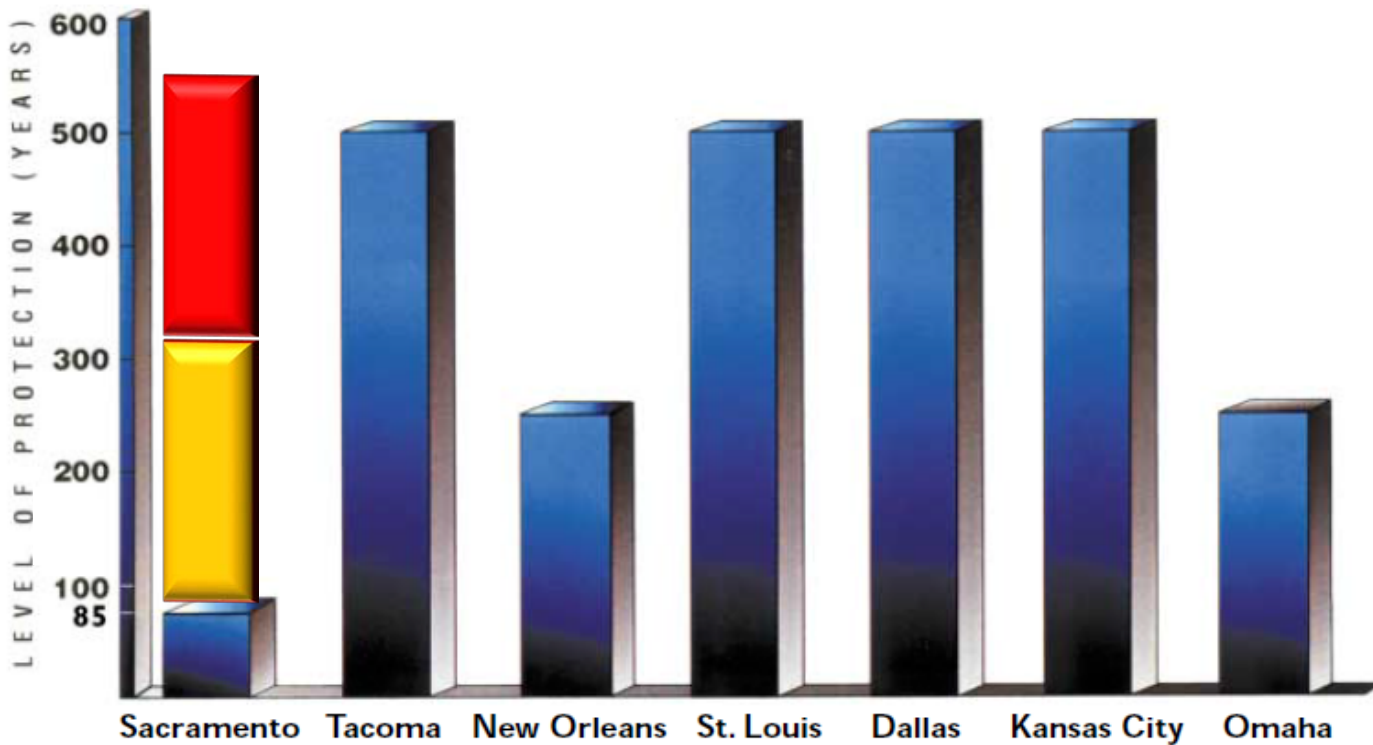
Projected Effects on Timing of Inflows to Folsom Reservoir with Future Climate Change Conditions



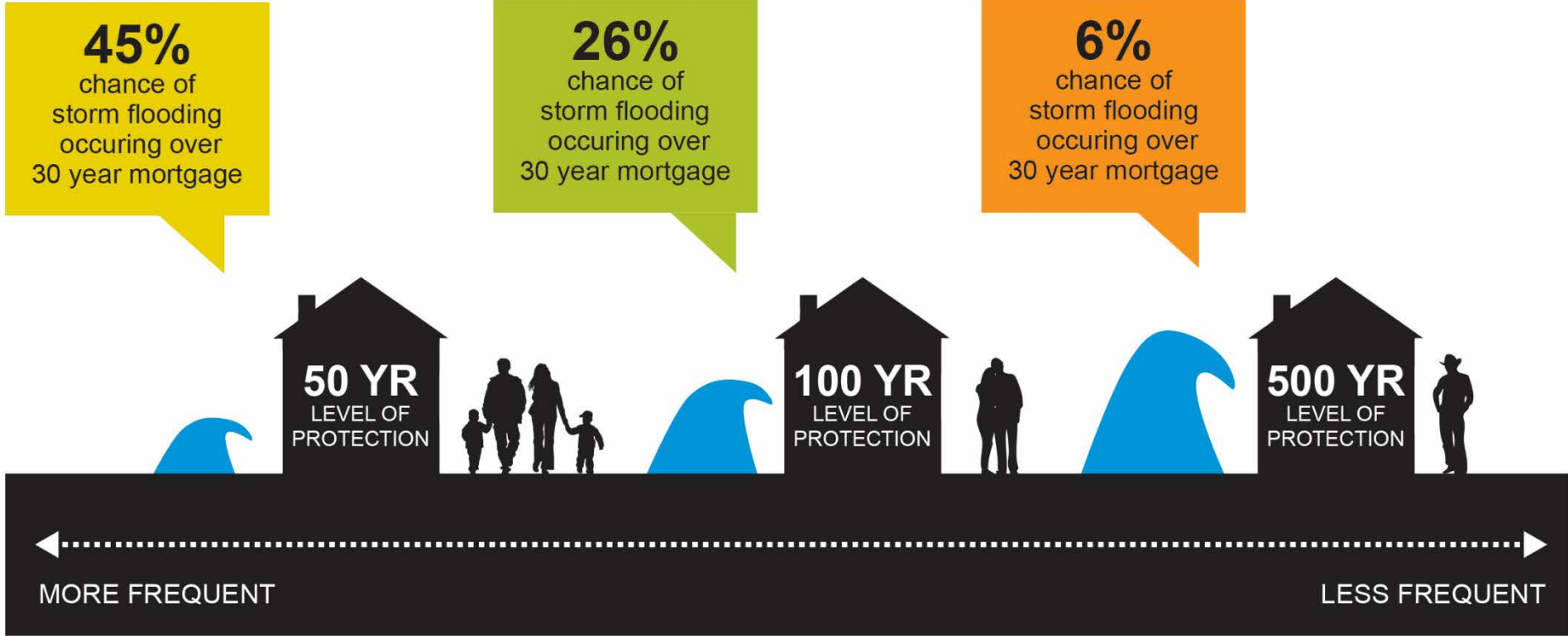
* American River Basin Study - DRAFT Technical Memorandum: Portfolio Evaluation

Achieving 500 Year Protection

Sacramento's Level of Flood Protection by Comparison to other River Cities



Protection Levels & Flood Risk



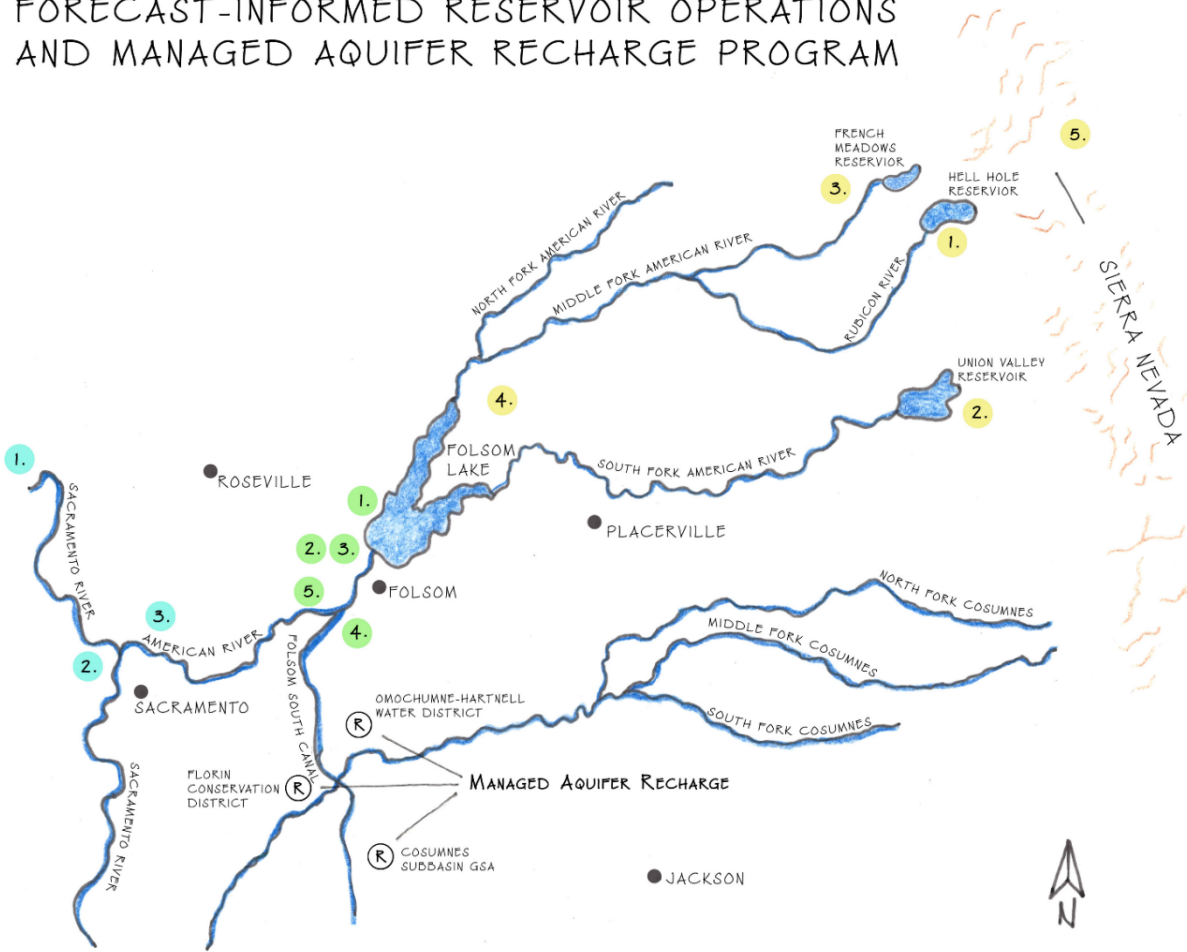
Chance of 50, 100, and 500 year flood events affecting a home over life of 30 year mortgage.

Ongoing Federal/State/SAFCA Flood Risk Reduction Projects

Project	Phase	Current Estimate
American River Watershed Common Features American River	Construction Complete/ Close-out	\$320,000,000
American River Watershed Common Features Natomas Basin	Construction Ongoing	\$1,200,000,000
American River Watershed Common Features 2016	Construction Ongoing	\$1,590,000,000
American River Watershed Folsom Dam Modifications Joint Federal Project	Construction Complete/ Closeout	\$850,000,000 (Corps Component)
American River Watershed Folsom Dam Raise and Bridge	Construction Ongoing	\$325,000,000
South Sacramento Streams Group	Construction Complete/ Close-out	\$110,000,000
TOTAL		\$4,395,000,000

Achieving 500-Year Flood Protection for the Greater Sacramento Region

AMERICAN RIVER UPSTREAM
FORECAST-INFORMED RESERVOIR OPERATIONS
AND MANAGED AQUIFER RECHARGE PROGRAM



UPSTREAM RESERVOIR MODIFICATION EFFORTS

1. HELL HOLE
2. UNION VALLEY
3. FRENCH MEADOS
4. FORECAST-INFORMED OPERATIONS
5. FOREST MANAGEMENT

RAISE & FOLSOM OPERATION

1. FOLSOM DAM 3.5-FOOT RAISE
2. UPDATED WATER CONTROL MANUAL
3. CONDITIONAL STORAGE OPERATION (FLOOD CONTROL DEVIATION)
4. GROUNDWATER CONJUNCTIVE OPERATIONS
5. ENVIRONMENTAL FLOWS AND TEMPERATURE MANAGEMENT

MANAGED AQUIFER RECHARGE

- DIRECT/ACTIVE RECHARGE
- AGRICULTURAL LAND RECHARGE
- INJECTION WELLS/DRY WELLS

SYSTEM OPERATION/BENEFITS

1. UPSTREAM RESERVOIRS
2. ENVIRONMENTAL FLOWS
3. FLOOD RISK REDUCTION

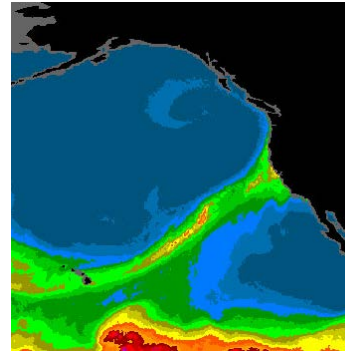
Major Ongoing Components for a Multi-benefit Project and Possible Public Financing

Upstream Facilities



- PCWA's Hell Hole Reservoir
- PCWA's French Meadows (deferred)
- SMUD's Union Valley Reservoir
- USACE prior study as a starting point only

Forecast Informed Reservoir Operations (FIRO)



- Improved forecast skills with 7-day ahead capacity, expanding to 10-day ahead capacity in the near future
- Storm events > 200-year storms for increased protection in the Sacramento region

Folsom Op



- Folsom Dam raise as a catalyst for additional storage use and water supply and ecosystem benefits
- USACE and Reclamation (emphasized) as key partners

Managed Aquifer Recharge (MAR)



- American River South Basin recharge opportunities for conjunctive use or banking operation in rural areas along the Folsom South Canal to the Cosumnes River
- Complementary to the Sacramento Area Water Bank, which focuses on urban core

FIRO on the American Basin



Primary Partners



Joint Federal Project with Water Control Manual Update

Non Federal Sponsor



Folsom Raise and Temperature Control Shutters Upgrade with Water Control Manual Update

Non Federal Sponsor



Upstream Reservoir Facility Modifications

Co Lead



FloodMAR with Groundwater Recharge

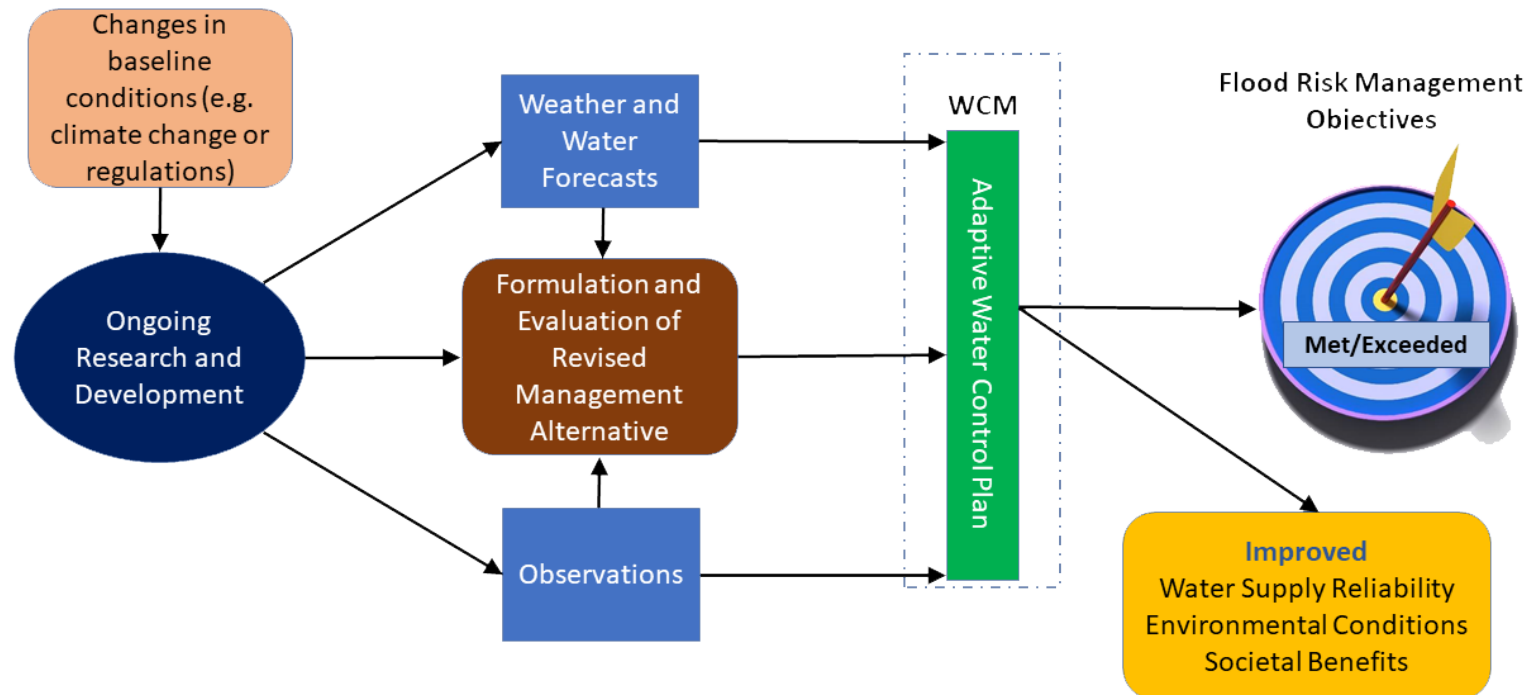
Facilitate (RWA, others Leading)



Forecast Informed Reservoir Operations (FIRO)

- The concept is not new, but the society is more ready for this application.
- The key is on the adaptive water control manual.

FIRO Model for Adaptive Water Control Manuals



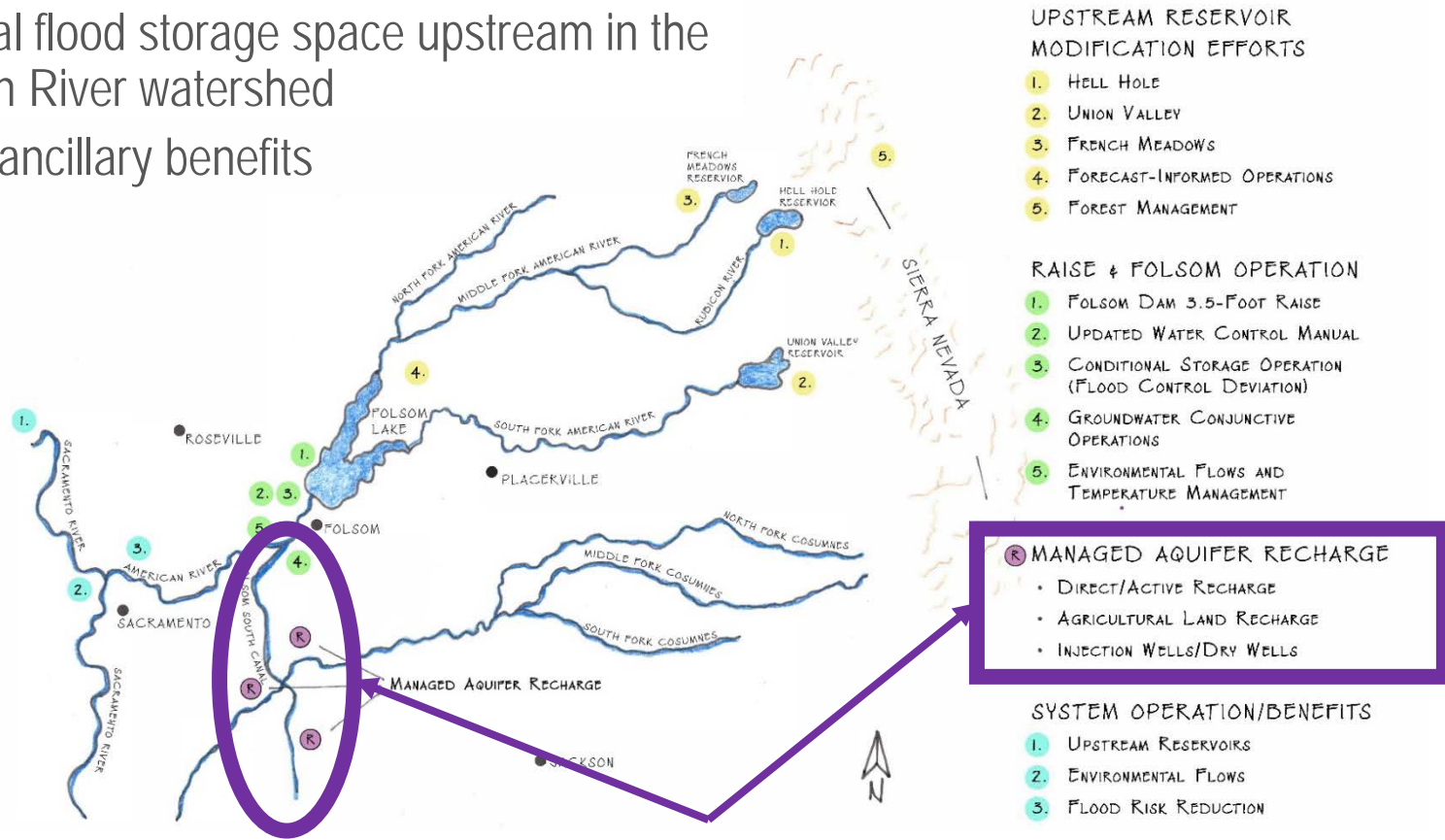
Summary of American River Flood Risk Benefits

Scenario	Forecast Operation	Level of Protection (1/ACE)
Scenario 1	<ul style="list-style-type: none">• Raise with 7-day forecast	350-370
Scenario 2	<ul style="list-style-type: none">• Raise and upstream operations with 7-day forecast and low-level release at Hell-Hole	420-440
Scenario 3	<ul style="list-style-type: none">• Raise and upstream operations with 7-day forecast and low-level release at Hell-Hole, Union Valley, and French Meadows	480-520



FIRO-MAR

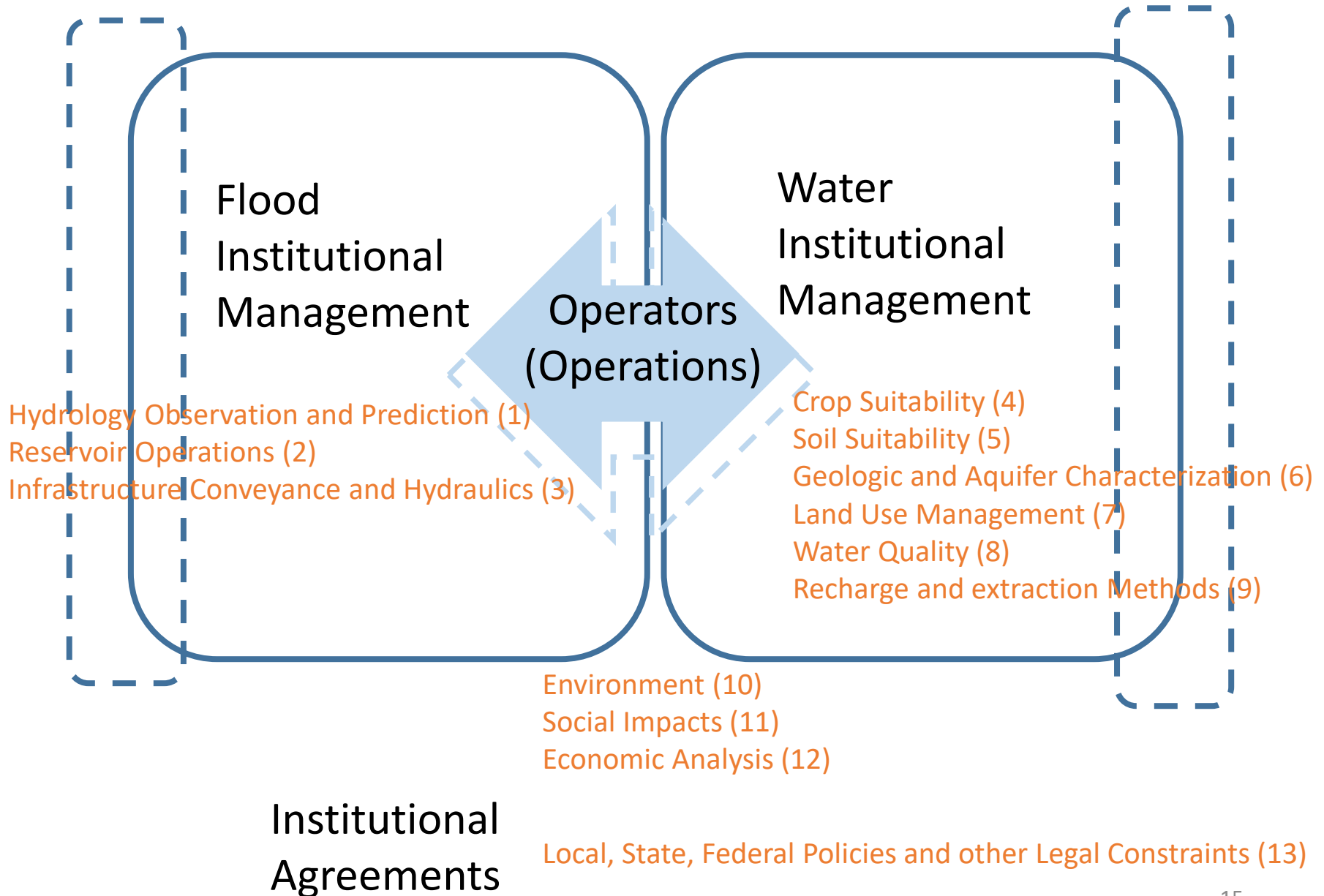
- Project features:
 - Weather forecasting used to operate Folsom Reservoir differently
 - Additional flood storage space upstream in the American River watershed
 - Creates ancillary benefits



Flood-MAR Research Themes

Flood-MAR Aspect	American Basin Flood-MAR Aspect
1. Hydrology Observation and Prediction	<ul style="list-style-type: none"> • 5- and 7-day rainfall runoff forecasts • Improved seasonal/snowpack runoff forecasts
2. Reservoir Operations	<ul style="list-style-type: none"> • Forecast-Informed Reservoir Operations (Folsom & Upstream) for flood control, water supply, and groundwater recharge operations
3. Infrastructure Conveyance & Hydraulics	<ul style="list-style-type: none"> • Lower American River levee armoring • Improved Lower American River high-flow coordination • Folsom South Canal diversion/routing
4. Crop Suitability	<ul style="list-style-type: none"> • Crops • Flooding
5. Soil Suitability	<ul style="list-style-type: none"> • Soil characteristics • Infiltration rates
6. Geologic and Aquifer Characterization	<ul style="list-style-type: none"> • Hydrogeologic systems --- Aquifer/stream interaction • Integrated groundwater models
7. Land Use Management	<ul style="list-style-type: none"> • Upper watershed / forest management • Recharge locations
8. Water Quality	<ul style="list-style-type: none"> • Stormwater quality • GW water quality management
9. Recharge & Extraction Methods	<ul style="list-style-type: none"> • Recharge/extraction methods • Monitoring
10. Environment	<ul style="list-style-type: none"> • American River fisheries management • Cosumnes River baseflow / Delta Outflow • Land use and other potential wetland/waterfowl impacts/benefits
11. Social Impacts	<ul style="list-style-type: none"> • Impacts/benefits to rural communities
12. Economic Analysis	<ul style="list-style-type: none"> • Funding sources • Project costs & benefit quantification
13. Local, State, Federal Policies & other legal constraints	<ul style="list-style-type: none"> • Integration with BoR operations • Local partnerships and agreements --- SGMA

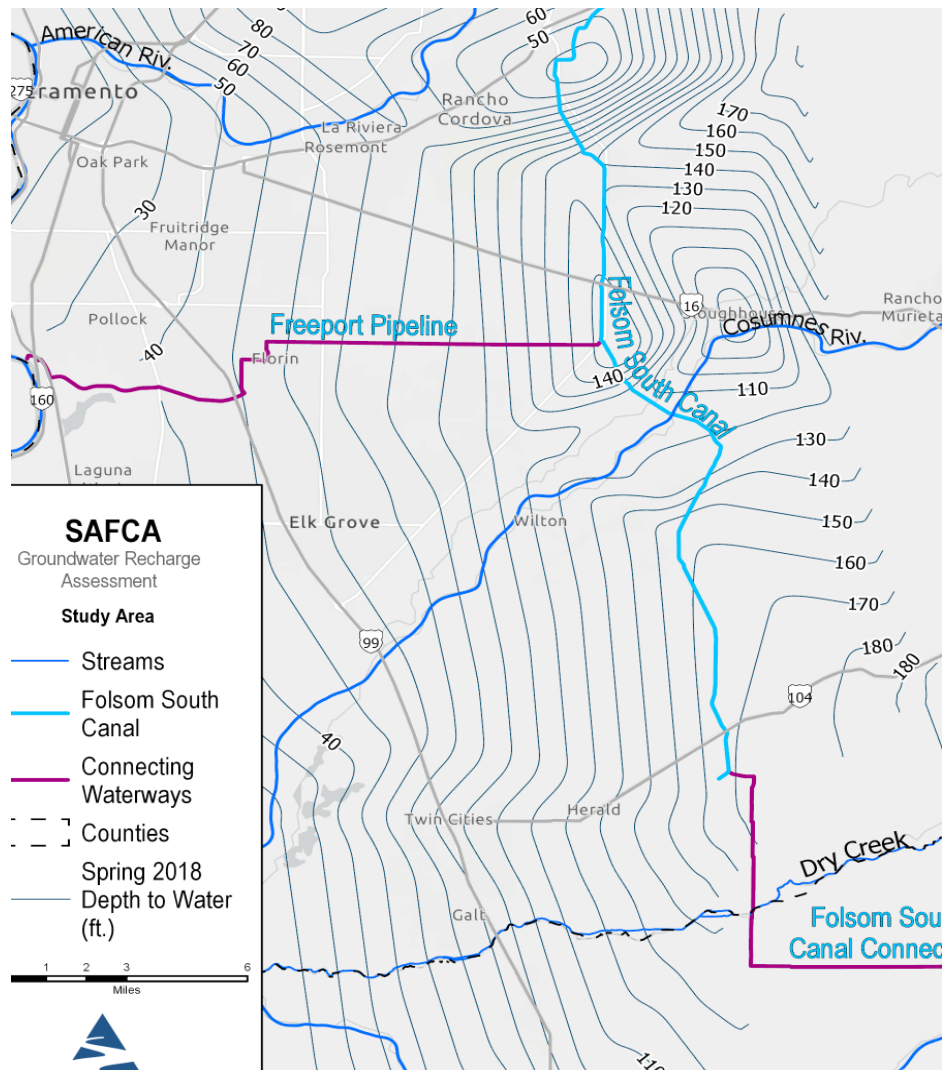
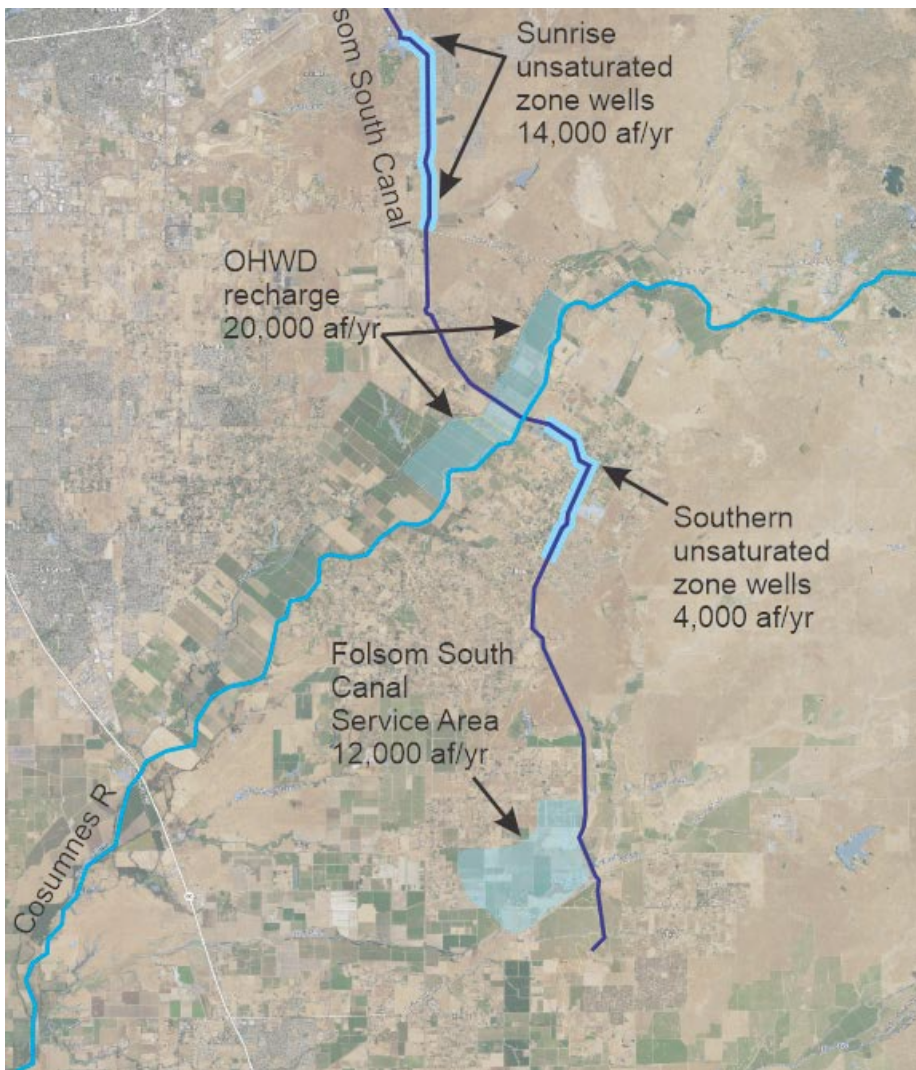
Implementing a Multi-Objective Project



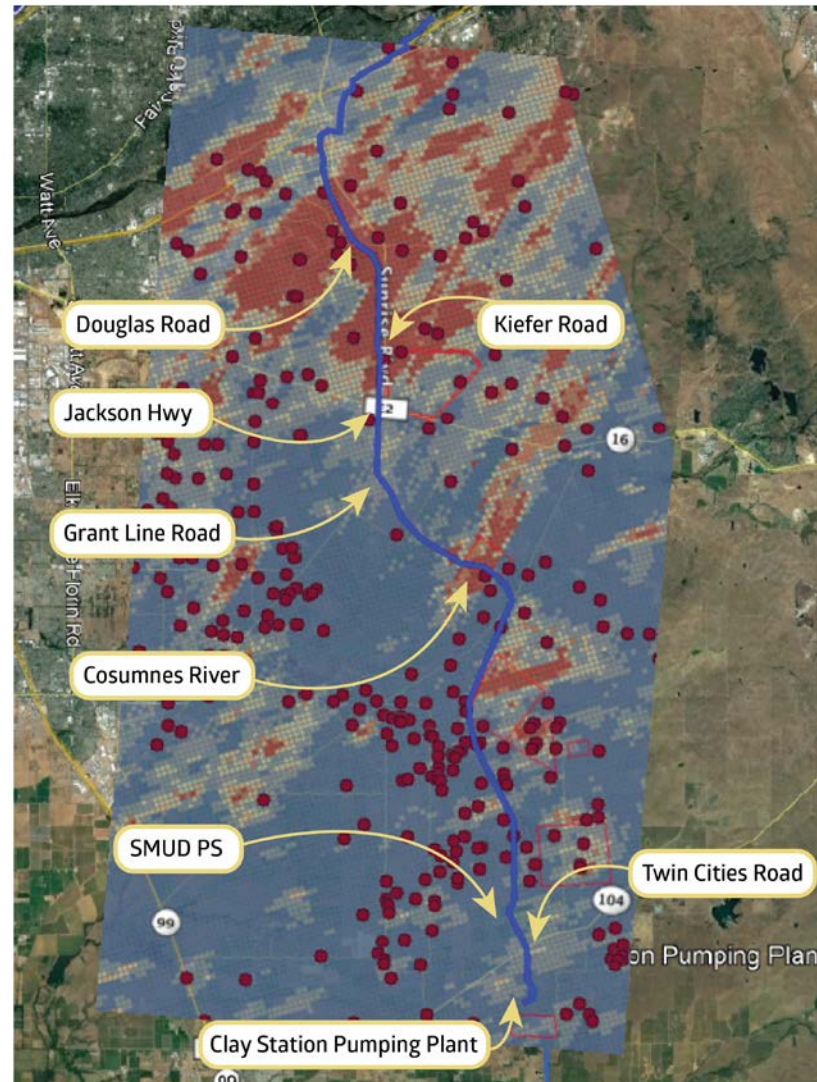
Groundwater Recharge Concepts

Hypothetical Project Components

Spring 2018 Depth to Water (ft)

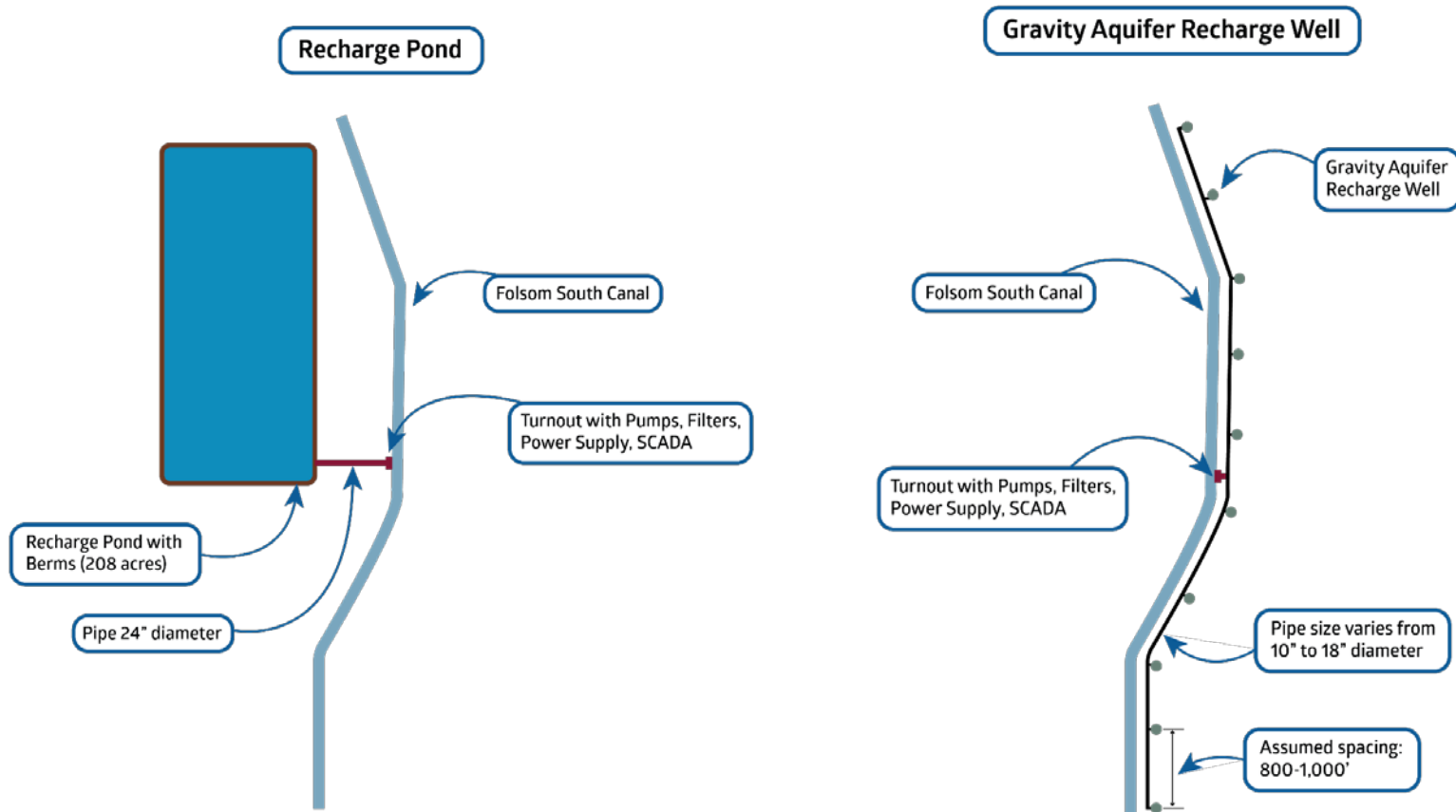


Recharge Potential



UC Davis Maples/Fogg study

Schematic Concepts of Recharge Ponds and Wellfields



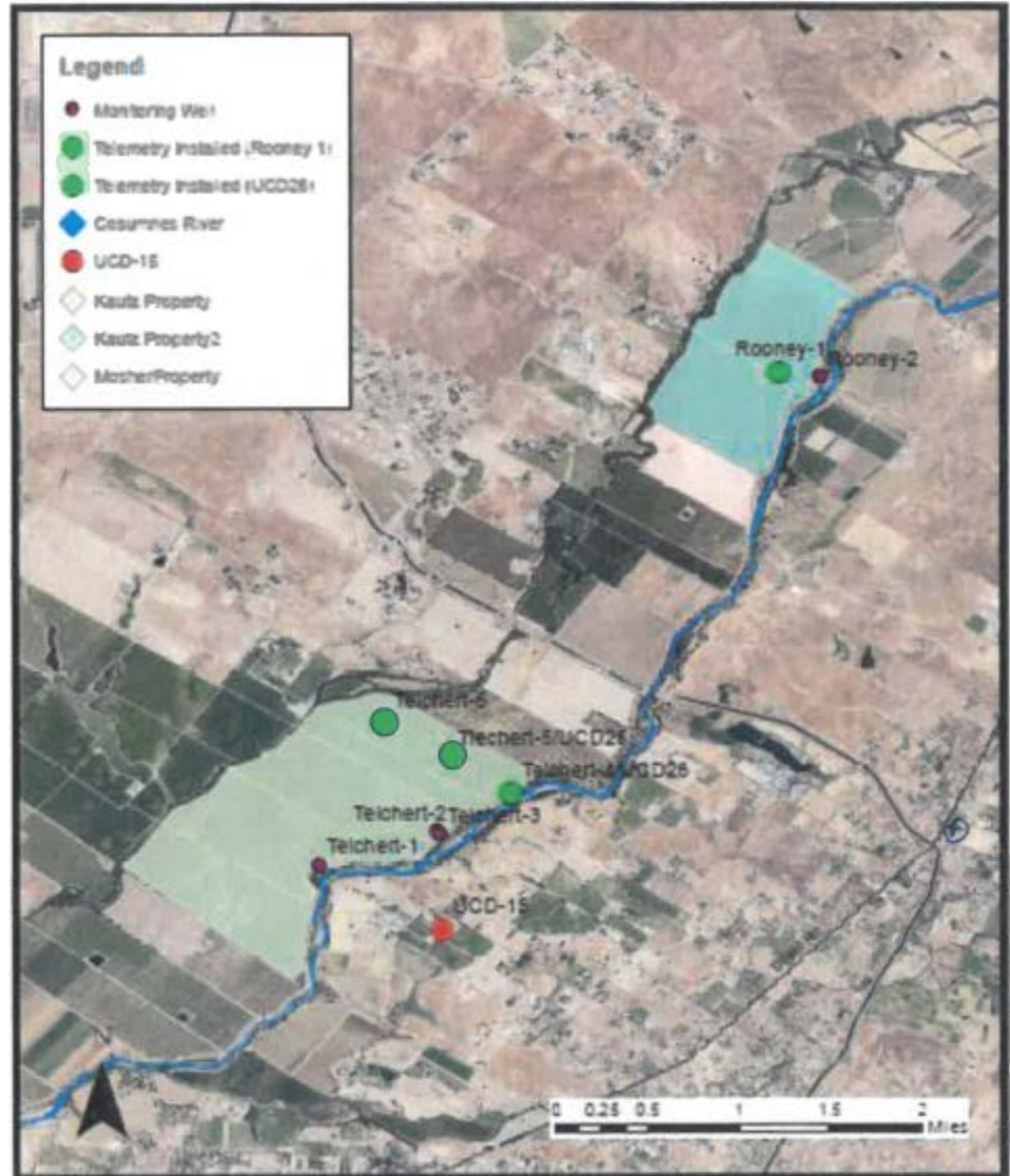
HYPOTHETICAL PROJECT

- An estimate of capital cost was developed for a hypothetical project with 120 TAF of annual recharge capacity and 100 TAF of annual recovery capacity.
- The project assumes that 60 TAF will be recharged via ponds and the other 60 TAF be recharged through gravity aquifer recharge wells.

Item	Per Unit Cost	Quantity	Total Cost
Recharge Pond	\$ 11M/ 10,000 AF	60,000 AF capacity	\$ 66 M
Gravity Aquifer Recharge Wells	\$ 10M/ 10,000 AF	60,000 AF capacity	\$ 60 M
Recovery Pipelines	\$ 1.5M/ Mile	3 miles of pipeline	\$ 4.5 M
Recovery Wells	\$ 150K/Well	124 wells; 1,000 GPM	\$ 19 M
Total Cost			\$ 150 M

OHWD Pilot Groundwater Recharge Project

- 10 Year Pilot Project
- 4,000 AF Annually Consumnes River Diversions
- Initial Study/Mitigated Negative Declaration (IS/MND) completed September 2018
- Rooney Site (376 acres of planted grapes)
- Teichart Site (785 acres of planted grapes)



The Water Bank can grow substantially through time



Sources of recharge

Municipal in-lieu

Municipal direct through ASR

Recycled in-lieu

Flood-MAR

Agricultural in-lieu