Water Security, Drought and Climate Change: A California Perspective

(…and a Flood-MAR Example [Flood Managed Aquifer Recharge])

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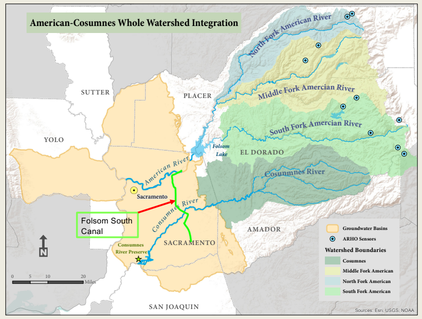
The Challenge

- Estimated California water overdraft = 1.1 to 2.4 MAF (1.4 – 3 km^3) due to groundwater exploitation
- Mediterranean climate: nearly all precipitation occurs during Nov.-March
- Hence water storage is paramount
- Key historical storage mechanisms:
  - Snowpack (~15 MAF [18.5 km^3] in Sierra Nevada)
  - Surface reservoirs (~42 MAF [51.8 km^3])
- During multi-year drought the surface storage provides only 2-3 yrs of water security
- Historically, bulk of the snowmelt runoff occurred during April-July, satisfying peak demand for cities, ecosystems and irrigated agriculture, which produces nearly half of the U.S.'s fruits, nuts & vegetables
- With climate warming more precipitation is falling as rain rather than snow, and the snow is melting sooner, greatly reducing stores of water in surface reservoirs
- Due to climate change, the increased likelihood of extreme drought and extreme flood events further exacerbate reliability of surface storage
- CA in 2014 passed the Sustainable Groundwater Management Act, requiring the elimination of groundwater overdraft

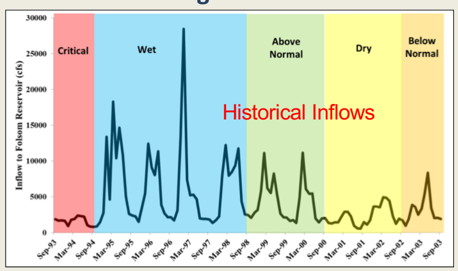
The Flood-MAR Opportunity

- Massive space for storage of *additional* water in the Central Valley aquifer system: ~142 MAF (175 km^3)
- Under climate change, possibly little change in mean annual precipitation, despite increasing extremes
- Under climate change, rivers flowing from the Sierra and traversing the Central Valley floor (above the aquifer system) will have more high-magnitude flows in winter
- In areas with the most space for increased groundwater storage, the rivers are losing
- Millions of acres of inactive (in winter) farmland with irrigation infrastructure for spreading water for recharge.

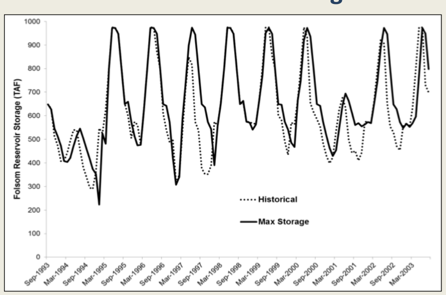
American-Cosumnes Basin Case Study



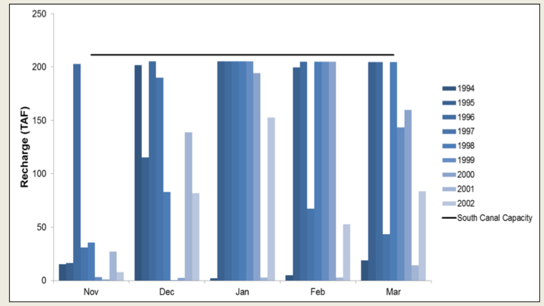
1. Strategy: Apply Flood-MAR Methods During 1993-2003…



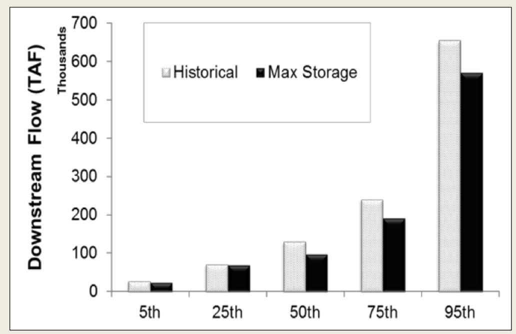
2. … Including Reoperation of Reservoir to Optimize for Hydropower, Res. Storage & Groundwater Recharge…



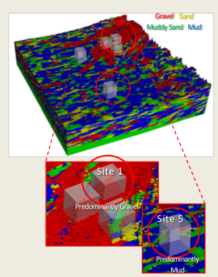
3. … Produces ~0.52 MAF/yr (0.64 km^3) *Water Available For Recharge (WAR)* …

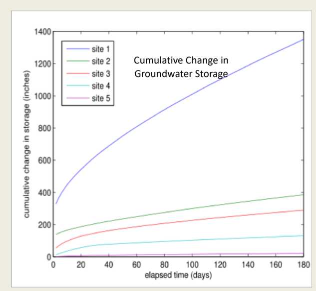


4. … While Maintaining Essential Env. Downstream Flows

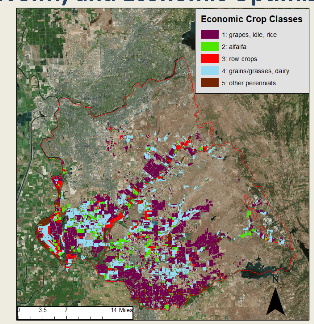


5. Hi-Resolution Aquifer Characterization Identifies Optimal Geologic Locations…

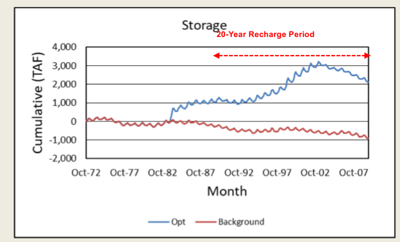




6. … Modeling of Groundwater System (w/ C2VSIM) and Economic Optimization…



7. … Predicts Water Recharged and Stored…



8. … Predicts Water Recharged and Stored Via Winter Farm Spreading…

36% WAR used
- Recharged: 3.9 MAF (4.8 km^3)
- Stored: 2.4 MAF (62%)
- Streams: 0.7 MAF (18%)
- Other Basins: 0.76 MAF (20%)

9. … and Via Both Farm Spreading *And* Exploitation of the Geology…

50% WAR used
- Recharged: 5.4 MAF (6.7 km^3)
- Stored: 3.7 MAF (68%)
- Streams: 0.87 MAF (16%)
- Other Basins: 0.89 MAF (16%)

REFERENCES keyed to numbered modules above

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1-4 Goharian, E., S. Sandoval, G. Fogg,. Estimating Available Flood Water for Managed Aquifer Recharge in American River Basin, California. In prep. 2019.

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