Understanding Multiple Benefits of Managed Aquifer Recharge for the Resilience of California's Water Supply

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OBJECTIVES

The objective of this project is to identify the costs and benefits of below ground water storage in regions throughout California that are at the highest risk for water scarcity and flooding, and have the greatest capacity for using available storage space. To accomplish this, the project will:

1) Develop a framework to prioritize geographic regions in California that:
    a) are most vulnerable to water scarcity in the coming years due to climate and water availability projections
    b) are most likely to experience excess run-off available for storage in extreme weather events
    c) have the capacity to store water underground
2) Conduct a cost benefit analysis (CBA) on establishing water storage infrastructure in one or more of these areas (time dependent), taking into account:
    a) Potential risks to communities and ecosystems of using available storage space options
    b) Potential benefits to human and environmental stakeholders

SIGNIFICANCE

California has an increasingly scarce and unreliable surface water supply. Droughts are expected to become more frequent and intense, precipitation is expected to fall as rain rather than snow in shorter, more intense periods, and reliance on the Sierra snowpack for storage will become less tenable (1). This will result in runoff earlier in the season that is less suitable for irrigation applications, as well as increased risk of flooding. Strategically planning water storage, including

the protection and augmentation of groundwater resources, will help make farms, cities, and ecosystems more resilient to unpredictable future water availability (2).

Research has been done throughout the state to better understand the impacts of climate change projections on the water supply, the potential for water storage in underground aquifer space, and the management of storm water runoff during extreme weather events (3, 4, 5). However, these findings have yet to be synthesized into a comprehensive assessment of the feasibility of managing storm water runoff and addressing water scarcity concerns through the implementation of managed aquifer recharge projects in areas which are suitable at a statewide level. Some important work has been done in this realm, most notably by Sustainable Conservation's Groundwater Recharge Assessment Tool, which is focused on modeling aquifer recharge potential on agricultural lands in California's Central Valley. This project will work towards increasing the understanding of potential benefits from aquifer recharge on multiple land use types throughout California in order to enable water planning agencies to make informed and strategic management decisions for the future. By examining the high-level suitability of managed aquifer recharge on a variety of land use types across the state, and performing a cost benefit analysis of these options, there is the potential to determine areas where significant and multiple benefits can be gained through the development and implementation of aquifer recharge infrastructure.

BACKGROUND

Unsustainable use of groundwater resources is associated with numerous undesirable outcomes including: seawater intrusion, land subsidence, reduction in storage, surface water depletion, and degraded groundwater quality (6). The Sustainable Groundwater Management Act (SGMA) of California, passed in 2014, launched California on the path towards returning the state's groundwater basins into balanced levels of pumping and recharge (California DWR) (7). A crucial component of the basin management plans mandated by SGMA will be to investigate the potential for groundwater recharge, especially in heavily over drafted, high-priority basins.

California Department of Water Resources (DWR) has an ongoing effort to better understand the benefits and applicability of managed aquifer recharge (FLOODMAR) as a means of increasing the resilience and sustainability of California's water resources. This project would add to the work already being done in the state to gather information and understanding capable of informing changes in policy and action. Climate projections for the state of California include increasing dry periods and more intense droughts, coupled with more extreme rain events, and reduction in annual snowpack. All of these impacts imply the need for more robust and adaptive management plans for water resources throughout the state. Managed aquifer recharge represents an opportunity for basins throughout California to increase the resilience of their local water resources through the capture and storage of water during extreme precipitation events for future dry periods. Returning water to over drafted aquifers will also preserve the aquifer storage space, limit subsidence, prohibit seawater intrusion and reduce surface water depletion. Though these benefits are known, there is a lack of information and research on the areas in California that could benefit most from introducing managed aquifer recharge as part of their basin management plans.

AVAILABLE DATA

This project will make use of the following publicly available data sources:

California Water Sustainability Indicator Framework
Cal-Adapt California Climate Change Data
Groundwater basin descriptions and estimates of aquifer storage space - Bulletin 118
Case Studies on existing managed aquifer recharge projects in California
USGS Groundwater in California datasets
California State Groundwater models
California Statewide Groundwater Elevation Monitoring data
Soil Agricultural Groundwater Banking Index
Sustainable Conservation's Groundwater Recharge Assessment Tool (GRAT)

APPROACH

1) Perform a spatial analysis to determine regions of California that meet these criteria:
    a) Are most vulnerable to water scarcity in the coming years due to climate and water availability projections (vulnerability may encompass changes in runoff, streamflow, annual precipitation, overdraft, demand)
    b) Are most likely to experience excess run-off available for storage in extreme weather events
    c) Have the capacity to store water in underground aquifer space
2) Determine one or more areas of focus for multi-benefit CBA
3) Perform a multi-benefit CBA of managed aquifer recharge project implementation
    a) Consider ecosystem benefits, water supply and quality benefits, stakeholder and community member benefits
    b) Assess these benefits in the context of costs and risks to project implementation
    c) Consider required infrastructure associated with groundwater recharge and storage

DELIVERABLES

Final deliverables for the Bren School will include an oral presentation, poster, policy brief and written report. Final deliverables for the client will include:

1) Maps documenting areas in California where storage is available and feasible
2) Quantification framework for multiple benefits and risks, including potential mitigation strategies
3) Conceptual cost benefit analysis across different storage options

INTERNSHIP

The Environmental Defense Fund commits to host and mentor one paid intern at their San Francisco office during the summer of 2019.

SUPPLEMENTAL MATERIALS

REFERENCES

(1) Hanak, E. & Lund, J. R. (2011). Adapting California's Water Management to Climate Change. *Climatic Change*. 111: 17. https://doi.org/10.1007/s10584-011-0241-3

(2) Massoud, E.C., Purdy, A.J., Miro, M.E., & Famiglietti, J.S. (2018). Projecting Groundwater Storage Changes in California's Central Valley. *Scientific Reports.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6110742/

(3) Zhu, T., Jenkins, M.W., & Lund, J.R. (2005) Estimated Impacts of Climate Warming on California Water Availability Under Twelve Future Climate Scenarios. *Journal of the American Water Resources Association*. https://doi.org/10.1111/j.1752-1688.2005.tb03783.x

(4) Perrone, D., & Merri Rohde, M. (2016). Benefits and Economic Costs of Managed Aquifer Recharge in California. *San Francisco Estuary and Watershed Science*, 14(2). https://escholarship.org/uc/item/7sb7440w

(5) Gautam, M. R., Acharya, K. & Stone, M. (2010), Best Management Practices for Stormwater Management in the Desert Southwest. *Journal of Contemporary Water Research & Education*, 146: 39-49. doi:10.1111/j.1936-704X.2010.00390.x

(6) Babbitt, C., Gibson, K., Sellers, S., Brozović, N., Saracino, A., Hayden, A., Hall, M., & Zellmer, S. (2018). The Future of Groundwater in California: Lessons in Sustainable Management from Across the West. *The Environmental Defense Fund and Water for Food Daugherty Global Institute at the University of Nebraska.* https://www.edf.org/sites/default/files/groundwater-case-study.pdf

(7) California Department of Water Resources. (2014) *Sustainable Groundwater Management Act.* https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Files/2014-Sustainable-Groundwater-Management-Legislation-with-2015-amends-1-15-2016.pdf?la=en&hash=ADB3455047A2863D029146E9A820AC7DE16B5CB1

ADDITIONAL RESOURCES

California Statewide Groundwater Elevation Monitoring data
https://water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-Monitoring--CASGEM
Cal-Adapt Downloadable Datasets
http://cal-adapt.org/data/
Case Studies on existing managed aquifer recharge projects in California

https://www.americangeosciences.org/critical-issues/case-study/managed-aquifer-recharge-california
California Statewide Groundwater Elevation Monitoring data
https://water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-Monitoring--CASGEM
Groundwater models
https://gis.water.ca.gov/app/gicima/
Soil Agricultural Groundwater Banking Index
https://casoilresource.lawr.ucdavis.edu/sagbi/
Sustainable Conservation's Groundwater Recharge Assessment Tool (GRAT)
https://suscon.org/technical-resources/
U.C. Davis Water Sustainability Indicators Group
https://indicators.ucdavis.edu/water/indicators/goals
USGS Groundwater in California datasets
https://waterdata.usgs.gov/ca/nwis/gw/
https://groundwaterwatch.usgs.gov

BUDGET & JUSTIFICATION

It is not anticipated that the proposed project would require additional funding beyond the $1,300 contributed by the Bren School.

CLIENT LETTER OF SUPPORT

(see attached)

EDF
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January 22nd 2019

Group Project Committee
Bren School of Environmental Science and Management
University of California, Santa Barbara

Environmental Defense Fund's Western Water Program is pleased to support Claire Madden and Bridget Gibbon's proposal, "Understanding Multiple Benefits of Managed Aquifer Recharge on the Resilience of California's Water Supply."

As climate change continues to affect water supply reliability across California, EDF is seeking solutions to build economic, social, and ecological resilience. A critical component of year to year supply security is storage. While states across the Western U.S. have historically relied on dammed rivers to provide above-ground storage, water managers are increasingly recognizing the value of aquifer recharge as a pragmatic storage option. With strategic implementation, groundwater recharge projects can also benefit community health, groundwater-dependent ecosystems, and migratory species. EDF seeks to a support a Bren student group in exploring the opportunities for and barriers to multi-benefit groundwater storage across California.

EDF's extensive experience, well-developed relationships, and strong reputation among water managers, consultants, and public agency staff will allow us to support an effective and timely Bren group project.

As a recently graduated Bren MESM, I am particularly excited to support EDF's engagement on this joint project. Having first-hand experience on the student side of the process, I am confident that I can help to ensure a mutually beneficial project which provides EDF with tangible results to help forward our objectives and offers a meaningful learning experience for the Bren students.

Sincerely,

Anna Schiller

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