Conjunctive Water Management Resource Management Strategy

Draft Memorandum

CALIFORNIA WATER PLAN UPDATE 2023

April 2024

Conjunctive Water Management Resource Management Strategy

Draft Memorandum

CALIFORNIA WATER PLAN UPDATE 2023

Lead Authors:
Roy Hull (California Department of Water Resources)
Brett Wyckoff (California Department of Water Resources)
Saquib Najmus (Woodard & Curran)
Reza Namvar (Woodard & Curran)

Contributing Authors and Reviewers:
Jack Tung (California Department of Water Resources)
Paul Gosselin (California Department of Water Resources)
Tim Godwin (California Department of Water Resources)
Steven Springhorn (California Department of Water Resources)
Kamyar Guivetchi (California Department of Water Resources)
Mark Nordberg (California Department of Water Resources)
Abdul Kahn (California Department of Water Resources)
Frank Qian (Woodard & Curran)

Contents

Tables

Figures

Acronyms and Abbreviations

AEM	airborne electromagnetic
DEW	drier with extreme warming
DWR	California Department of Water Resources
FIRO	Forecast Informed Reservoir Operations
Flood-MAR	flood-managed aquifer recharge
GSA	groundwater sustainability agency
GSP	groundwater sustainability plan
MAR	managed aquifer recharge
R&DD Plan	Flood-MAR Research and Data Development Plan
SGMA	Sustainable Groundwater Management Act
State Water Board	State Water Resources Control Board
WAFR	Water Available for Replenishment
WMW	wetter with moderate warming

1. Introduction

Conjunctive water management, also referred to as conjunctive use, is broadly defined as the coordinated and planned use and management of the different sources of water in time and space. It is usually focused on surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives. It is a holistic approach to water resource management that can increase available water for beneficial uses, allow water agencies greater flexibility in scheduling deliveries, and improve drought resiliency (California Department of Water Resources 2003).

At its core, conjunctive management involves the efficient use of groundwater and surface water through the planned and managed operation of a groundwater basin and available surface water in the basin. Conjunctive management aims to optimize the use of surface water and groundwater to ensure sustainable and reliable water supplies. A common strategy involves allowing natural recharge or capturing excess surface water during wet periods and recharging it into the groundwater basin for later use. The recharge helps replenish the aquifer and provide a buffer against droughts. For example, recharging an aquifer can occur during years of above-average surface water supply or using available flood water, urban runoff, or recycled water. Recharge also occurs from precipitation, infiltration and seepage of irrigation water, conveyance systems, septic systems, and various surface water systems (e.g., streams, lakes, reservoirs).

Conjunctive management often requires an understanding of the connectivity between surface water and groundwater resources and the geologic constraints on surface water infiltration. Local managers must also understand that surface water and groundwater resources typically differ significantly in their timing, availability, quality, and management methods; and capital, development, and use costs.

Conjunctive management has been practiced by irrigation and water districts in California for more than 100 years. The California Department of Water Resources' (DWR's) *California's Groundwater Update 2013* (Statewide Chapter and Appendix D) includes an inventory and assessment of conjunctive management operations in California. DWR includes information on conjunctive management in *California's Groundwater Update 2020 (Bulletin 118)* , and will continue to report on the evolution and state of this practice as more and more water managers are utilizing it as a supply management tool.

In 2014, the Sustainable Groundwater Management Act (SGMA) was signed into California law. While all 515 groundwater basins in California are covered under the SGMA legislation, only the 94 basins designated by DWR as high- or medium-priority basins are required to be managed by groundwater sustainability agencies (GSAs), covered by groundwater sustainability plans (GSPs), and achieve groundwater sustainability by the 2040s. The law allows for the GSAs to locally manage their groundwater resources in a sustainable manner. Conjunctive use of surface and groundwater resources, at both a basin level and statewide, provides opportunities to improve the resiliency of the state's water resources and, in many instances, is a key management tool utilized by local agencies as part of their GSP implementation to achieve their sustainability goals. DWR anticipates that many GSAs will implement conjunctive water management and managed aquifer recharge (MAR) strategies as part of their projects and management actions. MAR strategies are already common in many parts of the state.

Conjunctive management can range in scale – from local to regional. As the areal coverage increases, so do the difficulties of, and benefits derived from, implementing conjunctive management projects. Locally planned conjunctive management projects are typically easier to design and implement and should be an integral part of water management portfolios of local agencies. At the larger geographic scale, conjunctive management with appropriate infrastructure and applied in a responsible manner has the potential to span multiple regions, achieve greater benefits, provide more operational flexibility, and be more resilient than individual, isolated projects.

In the long run, failure to integrate surface water and groundwater management will make it difficult to manage water for self-reliance, resilience, multiple benefits, and sustainable use including the ability to establish rights to use vacant aquifer space and banked water, reduce subsidence potential of aquifers, protect the environment, recognize and protect groundwater recharge and discharge areas, and safeguard natural resources under the public trust doctrine.

2. Current Use of Conjunctive Management in California

Many California communities are reliant on groundwater supplies during drought years, and maintaining groundwater supplies is a key strategy to long-term water reliability and resilience. The replenishment of depleted groundwater basins is becoming an essential part of California's long-term water resilience and drought mitigation efforts. Managed aquifer recharge strategies are long-term drought resilience projects and management actions to capture water when it is available and to store that water underground for use during drought periods. To successfully replenish groundwater basins, the State is committed to expediting groundwater recharge, which is a key element in the governor's *California's Water Supply Strategy: Adapting to a Hotter, Drier Future*, that was released in August 2022. The strategy outlines the necessary strategies to secure a more reliable water supply in the face of aridification and climate change. The report identifies expanding average annual groundwater recharge by at least 500,000 acre-feet.

Recent State Actions Supporting Groundwater Recharge

In alignment with the State's water strategy, DWR is providing local water districts with financial and technical assistance on projects, incentivizing local recharge, and streamlining regulatory pathways for project implementation. Governor Newsom has used his emergency authority in the face of drought and flood to facilitate groundwater recharge in an expedited manner. The State Water Resources Control Board (State Water Board) is taking actions to grant permits in an expedited manner.

Some key actions taken by the State to advance groundwater recharge are:

- Executive Order N-4-23: Governor Newsom set forth the conditions for water users to divert water for recharge without State permits. The executive order suspends certain regulatory requirements under conditions of imminent risk of flooding.
- On March 9, 2023, to capitalize on higher flows resulting from larger-than-average snowpack, the State Water Board approved a petition by the U.S. Bureau of Reclamation to divert more than 600,000 acre-feet of San Joaquin River floodwaters for wildlife refuges, recharge, and groundwater storage. This brings the total diversions the State Water Board has authorized for

groundwater recharge and other purposes to nearly 790,000 acre-feet since late December 2022.

- The State Water Board streamlined the permitting process for temporary groundwater storage permits to fast-track efforts to capture flood waters to recharge groundwater basins.
- In 2023, a State budget-related bill, Senate Bill (SB) 122, defined aquifers as "natural infrastructure." The enactment of this bill allows traditional infrastructure funding mechanisms to be utilized for aquifer operation and maintenance related to establishing or maintaining conjunctive management practices.
- The California Water Supply Solutions Act of 2023, also known as Senate Bill 659, was passed in October 2023 and is the latest legislative act aimed at supporting the implementation of SGMA and addressing California's water supply challenges. The act requires DWR to include in California Water Plan Update 2028, and every plan thereafter, actionable recommendations for increasing groundwater recharge throughout the state. The actionable recommendations include identifying opportunities for immediate and long-term solutions, with a priority for multi-benefit projects. The identification of these opportunities should include potential recharge locations, an estimate of the volume and source of water that can be recharged, legal and regulatory requirements, financial incentives, and how recharge activities would protect access to safe drinking water and provide water quality benefits. The act also requires the development of best practices to advance all benefits of groundwater recharge in the state. The best practices should define methods and processes to identify locations where groundwater recharge will be effective and protective of drinking water.

  The California Water Supply Solutions Act of 2023 directs and gives DWR authority to conduct several of the recommendations outlined in this resource management strategy. The passing of this legislation underscores the importance of identifying, utilizing, and protecting groundwater recharge areas in California and the need for this resource management strategy and its recommendations.

Flood-MAR Projects

Managed aquifer recharge (MAR) is the intentional recharge of surface water into an aquifer. It is often a critical tool for linking surface and groundwater resources under conjunctive management. Two of the most common MAR strategies consist of delivering surface water to spreading basins, where the water naturally percolates into the aquifer, or by directly injecting surface water down wells into the aquifer (i.e., aquifer storage and recovery). Some water managers also take advantage of an emerging strategy called flood-managed aquifer recharge (Flood-MAR) which is using flood water resulting from, or in anticipation of, rainfall or snow melt for MAR on agricultural lands and working landscapes, including but not limited to refuges, floodplains, and flood bypasses. DWR, in coordination with State and local agencies, landowners, Tribes, academia, private researchers, and non-governmental organizations, is conducting ongoing evaluations of Flood-MAR opportunities.

In 2019, DWR developed the *Flood-MAR Research and Data Development Plan* (R&DD Plan), presenting the work of the Flood-MAR Research Advisory Committee to support and expand the implementation of Flood-MAR projects in California. These projects offer numerous benefits such as improved water supply reliability, flood-risk reduction, aquifer replenishment, ecosystem enhancement, and more. The plan focuses on 13 critical research themes, including hydrology, water quality, land use planning, and economic analysis, among others.

The R&DD Plan seeks to facilitate and support strategic coordination among researchers, agencies, and funding entities for Flood-MAR efforts. The identified priority actions include convening experts, compiling existing information, and conducting new research studies. The plan emphasizes the importance of collaboration, partnerships, and engagement from all interested parties in the water management community to ensure successful implementation of Flood-MAR projects and the integration of surface and groundwater management for a sustainable water future in California.

To better understand the vulnerabilities associated with climate change related drought and flood impacts, DWR is conducting watershed climate studies for the Merced and Tuolumne rivers. DWR has also received funding to conduct these cutting-edge climate vulnerability assessments and adaptation strategy evaluations for the remaining tributary watersheds of the San Joaquin Basin (Calaveras, Stanislaus, and Upper and Lower San Joaquin watersheds), all of which can be integrated into a basin-wide assessment. The watershed studies indicate that at a watershed scale, Flood-MAR and related adaptation strategies, such as forecast informed reservoir operations (FIRO), can reduce vulnerabilities in the face of climate uncertainty. The studies predict it is possible to concurrently replenish aquifers, reduce flood risk, and improve ecosystems in the San Joaquin Basin with:

- Strong multi-sector partnerships to collaboratively plan, implement, and co-manage projects.
- Re-operation of local and federal flood protection and water supply reservoirs.
- Use of high flows for groundwater recharge on agricultural, working, and natural managed lands.
- Improved local conveyance infrastructure to move surface and alternative water supplies to groundwater recharge locations (farms, working landscapes, and natural managed lands).
- Better information about land use patterns, soils, and subsurface geology using airborne electromagnetic (AEM) technology.

In addition to the research, data development, and watershed-scale technical evaluations, DWR is also providing support in the form of local technical and financial assistance and communication and engagement. In July 2024, DWR will distribute $4.8 million in local assistance funding and provide technical assistance and guidance to implementing agencies. DWR will update ongoing communications and engagement plan, share guidance and information, and facilitate partnerships among local agencies.

Capturing Urban Runoff

Urban areas in California are beginning to see the value in capturing excess stormwater runoff, which can be diverted to recharge groundwater basins to augment local supplies. In 2018, Los Angeles County approved a local tax to fund capturing more stormwater before it is discharged to the ocean, cleaning it, and putting it to use in various ways including recharging local aquifers. The goal is to capture 300,000 acre-feet of runoff annually.

Data Collection by Airborne Electromagnetic Surveys to Support Conjunctive Use

DWR is conducting AEM surveys across the state to assist local water managers as they implement their GSPs to manage groundwater for long term sustainability. AEM surveys are a valuable tool in supporting conjunctive use strategies by providing critical information about subsurface hydrogeology and groundwater resources. The AEM project provides State and federal agencies, GSAs, other interested parties, and the public with basin-specific and cross-basin geophysical data, tools, and analyses.

The resulting information from the surveys will provide a standardized dataset that can be used to improve human understanding of aquifer structures and support development and refinement of groundwater models (California Department of Water Resources 2020a).

AEM surveys can also provide valuable support in various aspects of groundwater management. They can aid in the development or refinement of hydrogeologic conceptual models and groundwater models, as well as identify potential effective areas for groundwater recharge. This, in turn, improves the potential for successful development and implementation of GSPs.

Information developed as part of the AEM surveys can help support conjunctive management by improving the understanding of large-scale aquifer structure, such as the depth and thickness of aquifers. When combined with existing groundwater levels, this data help in informing the storage capacity. This information is essential for calculating the volume of water that can be stored and extracted during conjunctive use operations. Accurate estimation of storage capacity helps optimize the conjunctive use strategy and ensure sustainable water management. AEM data can also support analysis of potential recharge rates and pathways, from the land surface to groundwater aquifers. This information is useful to groundwater managers for identifying recharge pathways and strategically siting groundwater recharge facilities to optimally move and store excess surface water underground during wet periods for later use.

Future Projects and Water Available for Replenishment

For the wet water year 2023, DWR estimated that 4.1 million acre-feet of managed aquifer recharge was achieved in the state's 515 groundwater basins. DWR's analysis of the GSPs for the 21 critically overdrafted basins showed that they included approximately 200 projects related to conjunctive management. Across the Central Valley, there are more than 300 existing and planned recharge projects that have been implemented or proposed as future projects and management actions in GSPs. A significant number of these projects specifically address topics such as conjunctive use, recharge, and groundwater banking, highlighting their importance in sustainable groundwater management. These project statistics demonstrate the recognition and prioritization of conjunctive use as an important tool for managing water resources and ensuring long-term sustainability and resilience. The inclusion of such projects in the GSPs underscores the commitment of water management agencies and interested parties to harnessing the potential of conjunctive use to address groundwater challenges and adapt to changing climatic conditions.

Water Available for Replenishment

An understanding of the amount of surface water available for aquifer recharge projects is critical for local and regional agencies, permitting agencies, and policymakers in developing water management strategies. In 2018, DWR released the *Water Available for Replenishment* (WAFR) report, DWR's best estimate based on available information, of water available for replenishment of groundwater in the state. The WAFR report estimates 1.5 million acre-feet of surface water may be available statewide for recharging groundwater basins in an average year (California Department of Water Resources, 2018b). DWR's estimate of surface water available for recharge is based on a methodology that accounts for instream flows, outflows that can be diverted by the implementation of conceptual projects, and modeled outflows that account for water demands and hydrologic conditions. New projects and investments in infrastructure are required for recharging the full WAFR estimated available surface water (California Department of Water Resources, 2018b).

The WAFR report underscores the high variability in the amount of surface water potentially available for recharge in different hydrologic regions of the state (Figure 1). Five of the 10 hydrologic regions comprise 90 percent of the estimated water available for recharge. The Sacramento River Hydrologic Region comprises nearly 45 percent of the estimated water available for recharge in the state. The findings indicate that hydrologic regions with less surface water available for recharge may need to develop a more diversified portfolio of water supply alternatives.

Figure 1 DWR Estimate of Average Annual Surface Water Available for Recharge, by Hydrologic Region

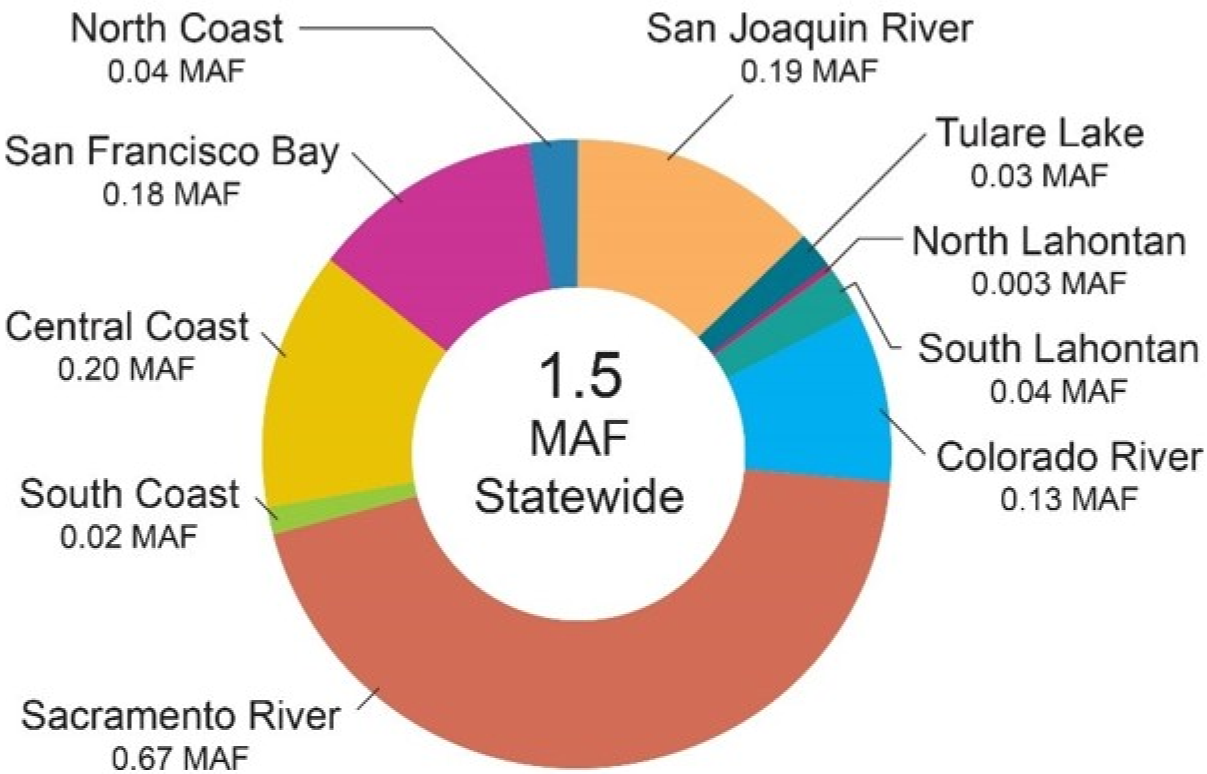

Figure 1 note: MAF = million acre-feet

In future conjunctive use projects, feasibility considerations will play a crucial role in determining the success and effectiveness of implementation. The five key project feasibility considerations of conjunctive management are hydrogeologic feasibility; available groundwater storage capacity; water source; conveyance, recharge, and extraction facilities; and pre- and post-treatment facilities (under certain circumstances). These considerations encompass the fundamental physical elements that are essential for conjunctive management to function optimally.

- **Hydrogeologic Feasibility**: Hydrogeologic feasibility is a critical factor in determining whether the geological conditions of an area are suitable for conjunctive use practices. Understanding the hydrogeological characteristics of the region, including the aquifer properties, groundwater flow patterns, and recharge potential, is necessary to ensure that the project can effectively capture, store, and manage water resources.
- **Storage Capacity**: Available groundwater storage capacity refers to the capacity of the aquifer to store and retain water. Assessing the storage

potential is essential to determine the viability of utilizing groundwater as a storage medium during times of surplus water availability. Adequate storage capacity allows for the storage of excess surface water, which can be extracted later during periods of water scarcity. Adequate storage must currently be present for storage projects. Projects that propose to create storage space by depleting the basin would violate the intent of SGMA. In particular, depleting a basin would likely trigger undesirable results for depletion of interconnected surface water, storage and groundwater elevations and could result in State Water Board intervention.

- **Water Source**: Identifying a reliable water source is another crucial consideration. Whether it is surface water, imported water, recycled water, or stormwater runoff, a consistent and sustainable water source is necessary for conjunctive use projects. The availability and quality of the water source directly affect the success of recharge and extraction operations.
- **Infrastructure**: Infrastructure is crucial for the successful implementation of conjunctive use projects. Conveyance, recharge, and extraction infrastructure collectively form the backbone of these projects, enabling the efficient movement, capture, and utilization of water resources. The conveyance system ensures smooth transportation of water to and from the recharge and extraction facilities, facilitating its distribution for storage or extraction purposes. Recharge infrastructure plays a key role in capturing and replenishing water into the groundwater system, while extraction infrastructure allows for the retrieval of water from the chosen source. By investing in and maintaining adequate infrastructure, water managers can optimize water resource management, enhance water availability, and support sustainable water use practices.
- **Treatment Facilities**: In certain circumstances, pre- and post-treatment facilities may be required to ensure the water quality meets the necessary standards. Depending on the source water and the intended use, treatment processes such as filtration, disinfection, or desalination may be necessary. Adequate treatment facilities ensure that the recharged or extracted water is of suitable quality for its intended purpose.

The presence and functionality of these physical elements are vital for conjunctive management to be practical and effective. Careful consideration and evaluation of these feasibility considerations are essential when planning and implementing future conjunctive use projects to ensure their long-term viability and success.

Groundwater Banking

Groundwater banking is essentially managed aquifer recharge and extraction by a managing entity. The managing entity facilitates in-lieu or direct recharge or extraction from a groundwater basin on behalf of other entities having rights over a specific volume of surface water. These “deposits” and “withdrawals” of surface water into the basin are accounted by the managing entity, typically the same entity who monitors groundwater conditions within the basin. In this way, surplus surface water, such as may be available in a wet year, can be “banked” by the owner, to be available, when it is needed, such as in a dry year. Banking projects cannot incorporate native groundwater and must be operated to protect native groundwater. Several groundwater banks have been established in California, especially in the San Joaquin Valley, where years of overdraft have created available aquifer space for storage of banked groundwater. Groundwater banking can only occur in areas where space in the basin has already been created. Unlike the San Joaquin Valley, most areas in the Sacramento Valley are not conducive for groundwater banks because of a lack of storage and interconnection to creeks and streams. The managing entity may, as a banking partner, receive a percentage of the banking entity’s deposit in exchange for the use of the aquifer storage space.

3. Benefits of Conjunctive Use

Conjunctive management projects may be implemented to meet many basin objectives including water supply reliability, drought resilience, sustainability, increasing flood protection, meeting environmental needs, improving groundwater quality, reducing land subsidence, and reducing groundwater overdraft. Preventing or reducing overdraft is especially important in that overdraft may cause land subsidence, wells to go dry, increased energy cost in pumping, and dewatering of critical environmental habitat.

Storing water in aquifers through conjunctive management offers several key advantages. Firstly, it helps prevent evaporation losses, as groundwater storage is typically less prone to evaporation compared to surface reservoirs. This becomes increasingly important in hotter climates, where evaporation rates are higher. Secondly, aquifer storage provides the opportunity to capture and store larger flood events that exceed surface reservoir capacities. During periods of intense rainfall and flooding, excess water can be intentionally diverted and stored underground, reducing the risk of flood damage while replenishing groundwater reserves. This approach not only enhances water supply reliability but also contributes to flood mitigation efforts. By maximizing water storage in aquifers, conjunctive management strategies can effectively address the challenges of evaporation losses and capitalize on larger flood events, helping to optimize reservoir operations, and ensuring greater resilience in water resource management, especially in the face of changing climatic conditions.

Being able to adapt to the changing climate requires maximizing the use of available water, which is highly dependent on effective conjunctive management of surface water and groundwater. Effective conjunctive management should optimize capturing of excess water when it is available so that enough water is stored to assist in meeting beneficial use needs while providing a sufficient reserve to get through extended dry periods. But the benefit derived from effective conjunctive management is limited by the combined, current surface water and groundwater production capacity of the management area.

Table 1 lists some of the many potential benefits of conjunctive management and it identifies potential constraints that can influence the usefulness and level of benefit that might be obtained.

Table 1 Benefits of Conjunctive Use with Examples and Major Constraints

Potential Benefit of Managed Groundwater Storage	Examples	Major Constraints
Improved local water supply reliability and resiliency	Imported surface water supplies and flood flows are recharged to local alluvial groundwater basin during wet years or seasons, increasing local water supply reliability	• There needs to be existing room in aquifer to accept this “extra” water. • Availability of surface water supplies. • Must protect native groundwater and groundwater uses. • Limited infrastructure availability and capacity to capture and recharge high-volume, short-duration flood flows. • Water quality concern of the recharged water and the effect on the aquifer.
Protection from saltwater intrusion	Recharge groundwater using captured flood flows, stormwater, or recycled water in the vicinity of saltwater interface to raise groundwater levels and prevent migration of saline water into freshwater production portions of the aquifer	• Availability of freshwater supply. • Considerable infrastructure requirements.
Improved flood control and groundwater storage	Flood-MAR (bypasses, agricultural fields, large scale basins)	Water rights issues

Potential Benefit of Managed Groundwater Storage	Examples	Major Constraints
Improved flood control and groundwater storage (urban/subdivisions)	Development of detention ponds at proposed residential subdivisions located in groundwater recharge protection areas can offset increased urban runoff caused by the development while maintaining natural groundwater recharge. New building requirements for on-site water retention	• Possible water quality problems at detention ponds requiring effective urban storm water management. • Requires adoption of local ordinance or legislation to support implementation.
Drought Resiliency	Banking water underground in wet years for withdrawal during a drought. Allows for more storage in the system through additional capacity in the aquifers and no evaporation losses	• Requires an adequate existing amount of storage space. • Must protect native groundwater. • Requires that it recovers by recharge during a wet year. • Requires that recharged water remains within the basin and does not flow downgradient in subsurface.
Water transfers	Utilize available surface water to meet demands with an emphasis on supplying underrepresented groups	• Incompatible with groundwater sustainability plans. • Must avoid stream depletion and in-stream flow requirements. • Requires cross-Delta transfer capacity.
Averted costs from depth to pumping	Rising groundwater levels will result in reduced pumping costs	
Averted costs of subsidence	Large scale: big infrastructure (canals, levees, railroads, utilities, sewer, runways) Small scale: damage to foundations and structures.	

Potential Benefit of Managed Groundwater Storage	Examples	Major Constraints
Averted costs of drilling	Could avoid need for drilling (replacing or deepening) dry wells every few years ($500,000 per new well).	
Flow in rivers	Conjunctive use allows better management of river loss and gain.	

Any conjunctive management strategy will produce changes to the water system. But a sustainable conjunctive management strategy should optimize the beneficial and efficient use of all water in the system while balancing the objectives of the basin. As a result, basin managers should consider performing extensive analysis for risk management and validate the potential opportunity costs in their conjunctive management planning because of the uncertainty or variability in water supplies and water demand resulting from population growth, land use changes, and climate change.

Diverse Water Portfolio

Conjunctive management of water resources is closely tied to the concept of having a diverse portfolio of options to meet water demands. By adopting a conjunctive management approach, water managers can optimize water supply by utilizing the most robust water portfolio available, whether it is surface water or groundwater. This means being able to switch between using surface water or tapping into the available groundwater reserves, depending on their availability and suitability.

Conjunctive management also allows for the effective utilization of previously untapped resources. For example, it enables the capture and use of flood pulses that were not previously harnessed. Additionally, FIRO can enhance conjunctive management by utilizing weather forecasting to optimize reservoir operations and make water available when needed.

Furthermore, conjunctive management allows for the possibility of becoming a source of surface water transfers, where water can be transferred between different regions or water districts to meet changing demands and balance water availability. Surface water transfers between different regions are predicated on the availability of surplus surface water and will not include native groundwater. But most basins subject to SGMA are in varying states of overdraft that must be addressed. The ability to conduct out-of-basin transfers will be limited until groundwater sustainability is reached within the basin and undesirable impacts to groundwater uses and users are avoided. Many groundwater sustainability agencies adopted policies that prohibit out of basin groundwater substitution transfers. For the near term, conjunctive management projects will primarily be focused locally within basins.

This opportunity in utilizing surface water and groundwater, along with the ability to leverage flood pulses, and FIRO, enhances the resilience and adaptability of water management systems, ensuring a more sustainable and reliable water supply for diverse needs.

Limits of Resource and Elasticity Capacity for Resource Use

Conjunctive management of water resources is not only about diversifying water sources but also about understanding the limits and capacity of these resources. It involves actively monitoring and gaining a better understanding of the characteristics of a water basin, such as the minimum sustainable groundwater level, the rate of recharge, and the elasticity of the aquifer. This knowledge allows for informed decision-making regarding the extraction of groundwater and the sustainable use of water resources.

By actively monitoring basin conditions, water managers can determine how low they can draw groundwater without causing negative impacts such as land subsidence or seawater intrusion and avoid impacts to all beneficial uses and users of surface water and groundwater. They can also assess how quickly the aquifer recharges, providing valuable information on the successful implementation of Flood-MAR projects and replenishment rate of the groundwater resource.

In groundwater basins that are being actively managed under SGMA, the long-term groundwater sustainability plans will provide operational guidance, through things such as sustainable management criteria, minimum thresholds, and monitoring programs.

Understanding the limits and flexibility of water resources enables water managers to establish sustainable extraction rates and develop management strategies that ensure long-term water availability. This active conjunctive use approach promotes responsible and efficient water use, preventing overexploitation, and facilitating the sustainable management of the basin's water resources.

Sustaining Environmental and Economic Resources

Conjunctive management of water resources plays a vital role in preventing the disconnection of river reaches and maintaining the flow of springs. By integrating surface water and groundwater management, this approach improves the ecological integrity of rivers and the availability of freshwater sources. Through sustainable pumping practices and sufficient and adequate monitoring, conjunctive management may prevent excessive groundwater extraction that could lead to dry river stretches and diminished spring flow. By recognizing the interconnectedness of surface water and groundwater systems, conjunctive management promotes the preservation of natural hydrological processes, safeguards river ecosystems, and sustains the vital habitats provided by springs.

4. Costs of Implementation

Costs for implementation of conjunctive management and groundwater storage may include expenses for a wide range of facilities and depend on the site-specific nature and existing infrastructure of the program. Accordingly, the cost for a unit increase in water supply or delivery is highly variable.

Some projects require relatively minor changes in operations or upgrades of existing infrastructure, such as increased sizing of pumps in existing wells or increased releases of water from existing conveyance canals. Other projects may require extensive new facilities such as canal turnout structures, new pipelines and pumps, injection or extraction wells, or construction of new recharge basins. The highly variable nature of implementation costs requires that the feasibility of new conjunctive management projects or programs be evaluated carefully on a case-by-case basis. Generalizations of implementation costs without site-specific information, such as available water supply and access to conveyance and groundwater storage, are rarely accurate.

The wide range of costs results from many factors including project complexity, regional differences in infrastructure construction and land costs, availability and quality of recharge supply, availability of infrastructure to capture, convey, recharge, and extract water, intended use of water, and treatment requirements. Additional issues that may also need to be addressed are who has ownership of the water, who compensates for disputes among neighbors, and impacts to or from third parties.

In 2021 and 2022, DWR awarded $68 million to 42 groundwater recharge projects that provide nearly 117,000 acre-feet of potential recharge capacity. DWR will award additional grants in 2023 based on available funding (Applications for this funding include 52 groundwater recharge projects costing a total of $211 million.). Since 2020, the State Water Board has provided a total of $1 billion to support 13 multi-benefit projects that will bring a total of 88,000 acre-feet per year to the state’s water supplies. Five of these projects are complete and adding 25,000 acre-feet per year, enough to supply 75,000 households annually (California Office of Gavin Newsom 2023).

5. Challenges to Implementation

There are a range of legal, technical, and managerial challenges that can act as barriers to successful implementation of conjunctive use, as shown in Table 2.

Table 2 Challenges to Implementation with Examples and Major Constraints

Challenges to Implementation	Examples	Major Constraints
Acquisition of water rights	Obtaining water rights to utilize flood flows for recharge requires specific permissions and regulatory compliance which can pose hurdles for project implementation.	• Costs associated with obtaining the necessary permits. • Rights to a given amount of water will need to be tracked from a source supplied to an aquifer for later extraction. • Integration of conjunctive use into existing water rights frameworks. • Uncertainty in surface water availability from state and federal water projects, such as the State Water Project and Central Valley Project can limit the effective management of water resources and the potential benefits of conjunctive management practices.
Physical capacities of existing storage and conveyance facilities	While surplus imported water supplies can be conveyed more readily during wetter months with lower water demand, this period also coincides with challenges in accomplishing in-lieu recharge and increased spreading of local runoff, limiting the recharge potential of other water sources.	• Physical capacities of existing storage and conveyance facilities often fall short in capturing surface water during wet years.

Challenges to Implementation	Examples	Major Constraints
Operational constraints	Insufficient coordination between infrastructure and operations hinder the realization of enhanced groundwater recharge from local runoff.	• Permitted export capacity, considerations for downstream users, and environmental considerations, restrict the movement of water for groundwater banking. • Need for increased capacities in surface water storage systems and Delta conveyance facilities is crucial because of stricter regulations and the anticipated impacts of climate change.
Matching infrastructure with soil conditions	Leaky basins or subterranean flow can result in recharged water moving beyond the zone of recovery, rather than being stored and available later.	• If the soils in a particular spreading basin are unsuitable for effective groundwater recharge, the infrastructure to transport surplus surface water becomes irrelevant. • Investments in infrastructure and careful site selection.

Challenges to Implementation	**Examples**	**Major Constraints**
Effects of land use changes	Urbanization and development have encroached upon natural recharge areas such as floodplains and wetlands, reducing their capacity to store and recharge groundwater.	• Protecting and preserving recharge areas through land use planning is crucial, but it may not always be a priority for local authorities, especially if the groundwater basin in question falls under a different jurisdiction. • Strengthening requirements and ordinances to mitigate the impacts of new developments on natural recharge and groundwater quality is important; basin-wide or watershed-scale approaches may offer cost-effective solutions.
Water quality considerations	There is a potential risk of lowering groundwater quality or contaminating aquifers if using water with high salt and nutrient loading or contaminated water for recharge, which necessitates careful water quality management and monitoring.	• Emerging contaminants, such as per- and polyfluoroalkyl substances (PFAS) and 1,2,3-Trichloropropane (TCP), and changes in allowable regulatory concentrations, can complicate things when a given volume of water is recharged to a basin, and later recovered.
Coordination with landowners, districts, and agricultural interests	Identifying suitable flood fields or recharge areas can be challenging; disagreements may arise over issues such as flood debris-laden water in ditches or the need for new channels.	• Logistical and managerial hurdles can impede the smooth execution of conjunctive use projects.

Challenges to Implementation	Examples	Major Constraints
Cultural and emotional hurdles	Lack of trust between interested parties, denial or refusal to conduct necessary analyses, and concerns about drawing attention to unfavorable conditions can hinder progress.	• Worries about the disproportionate burden falling on economically disadvantaged farmers or communities. • Socio-cultural dynamics require careful communication, engagement of interested parties, and addressing equity concerns to build consensus and overcome resistance to implementation.

The challenges to implementing conjunctive use are multi-faceted and involve legal complexities, technical requirements, and managerial considerations. Overcoming these barriers requires addressing water rights issues, matching infrastructure to soil conditions, managing water quality risks, navigating group dynamics, and fostering trust and collaboration among diverse parties. By actively addressing these challenges, the potential benefits of conjunctive use can be realized and contribute to sustainable water management.

6. Costs If Not Implemented

The potential costs of not implementing conjunctive use can be significant and wide-ranging. Failure to implement conjunctive use projects, as outlined in GSPs, can hinder the ability for basins to be sustainably managed. Without conjunctive use, basins may exhibit a range of negative impacts that can threaten their long-term viability and the communities reliant on them.

The consequences of not implementing or delaying the implementation of conjunctive use strategies can result in the depletion of groundwater resources. If any water source type is depleted, the beneficial uses and users in that area could be affected, potentially leading to small drinking water systems running dry; surface water users being adversely affected; loss of economic opportunities; and detrimental environmental impacts, particularly on fish populations and river ecosystems.

Moreover, the absence of conjunctive use can lead to increased costs associated with drawing water from deeper levels in areas showing signs of or already experiencing overdraft conditions. As groundwater levels decline, the need for deeper wells and more energy-intensive pumping systems arises, which adds financial burdens to water users. Additionally, the damage to aquifers, especially those containing silts and clays, can result in a permanent loss of their storage capacity and reduced ability to store water during wet periods. The lack of conjunctive use also undermines the resilience and flexibility of water management systems. By not integrating surface water and groundwater resources, water managers are left with limited options during droughts, floods, or other water supply challenges. This can increase the vulnerability of communities and ecosystems to water shortages, environmental degradation, and diminished water security.

Delaying the implementation of conjunctive use measures further compounds the costs. The longer the delay, the greater the likelihood of exacerbating existing problems and higher future costs of implementing necessary measures. Furthermore, such delays may result in public backlash and a damaged reputation for management agencies, raising questions about their ability to safeguard water resources and fulfill their responsibilities.

The costs of not implementing conjunctive use are extensive and multi-faceted. They encompass economic, environmental, and social dimensions, jeopardizing the sustainability of groundwater basins, compromising water availability for communities and ecosystems, and posing challenges for long-term water resource management. Timely and effective implementation of conjunctive use strategies is crucial to mitigate these costs and ensure a resilient and sustainable water future.

7. Climate Change Adaptation

Conjunctive use of water resources plays a vital role in climate change adaptation strategies. As climate change continues to affect water availability and intensify extreme weather events, the integration of surface water and groundwater management becomes essential for enhancing water resilience. Conjunctive use allows for the efficient utilization of surface water and groundwater resources, maximizing their combined benefits and mitigating the risks associated with climate variability.

Climate change has been extensively studied in recent years. The effects observed since the mid-20th century include declines in the average amount of snow and ice, rising sea levels, and rising average annual temperatures (Intergovernmental Panel on Climate Change 2014; Western Regional Climate Center 2019). By the end of the 21st century, California is projected to experience continued average maximum daily temperature increases of 5.6 °F to 8.8 °F, sea level rise from 1 foot to 10 feet, decline in springtime snowpack of 48 to 65 percent, and increasing heavy precipitation events, drought severity, and increasing areas burned by wildfire (Griggs et al. 2017; Bedsworth et al. 2018).

Because of climate change, reliance on historical hydrological patterns alone will no longer ensure successful management of California's water resources. California's latest water policy directive, the *2020 Water Resilience Portfolio*, outlines strategies and actions to improve California's capacity to prepare for disruptions, withstand and recover from climate-related effects, and adapt into the future. The specific character and magnitude of climate change impacts will differ according to the nature and makeup of water supplies, environmental conditions, user needs, and vulnerabilities that vary widely across the state.

California persistently fluctuates between wet and dry conditions on an interannual basis and on scales of decades or more. Groundwater basins operated at the margins of sustainable yield might build capacity to capture streamflow for managed recharge during wet periods in anticipation of persistent dry periods when demands on groundwater supplies are at their highest.

Based on Climate Change Technical Advisory Group recommendations, DWR has prepared two climate change scenarios, centered around future climate horizons of 2030 and 2070, for GSAs to use in GSP development (California Department of Water

Resources 2015, 2018). These scenarios consist of the drier with extreme warming (DEW) and wetter with moderate warming (WMW) scenarios which help water planners consider the range of potential climate shifts. DWR delivered three types of data to facilitate this analysis:

1. Climate variables of monthly temperature, precipitation, and evapotranspiration rates statewide.
2. Major stream inflows to the Central Valley and gridded hydrologic streamflow factors statewide.
3. Water operations data including Central Valley reservoir outflows and SWP and CVP water deliveries.

Statewide maps of the percent-change in average annual climatic water deficit (evaporative demand that exceeds available water) (Figure 2a) and recharge (net infiltration below the root zone) (Figure 2b) provide high-level information on the sensitivity of key hydrologic processes affecting groundwater as modeled under the 2070 DEW and WMW extreme climate projection scenarios. The percent-change for each metric is calculated using 1981–2010 as the modeled historical 30-year period and 2056–2085 as the future 30-year period. In the drier extreme, the 2070 DEW scenario indicates significant reductions in recharge derived from the Sierra Nevada because of declines in snowpack accumulation, earlier snowmelt, and less frequent atmospheric river conditions. In the wetter extreme, the 2070 WMW scenario indicates large-scale increases in recharge across the state associated with more frequent and intense atmospheric river conditions. The wetter extreme scenario suggests a significant increase in the potential for capture of winter, wet-season runoff and replenishment of groundwater basins.

One key aspect of conjunctive use in climate change adaptation is its ability to provide flexibility in water supply. By diversifying water sources and storage options, communities can better respond to changing precipitation patterns and periods of drought or intense rainfall. During dry spells, conjunctive use enables the utilization of stored groundwater reserves as a reliable water supply during shorter drought periods, reducing dependence on surface water sources that may be more vulnerable to climate-related fluctuations. But, during longer drought periods, the stored groundwater reserves may not be adequate and may result in overdraft conditions. Conversely, during periods of heavy rainfall and floods, a portion of available surface water can be captured and recharged into aquifers, on a space-available basis, serving as a valuable buffer for future water shortages.

Figure 2a Statewide Percent Change in Average Annual Climatic Water Deficit

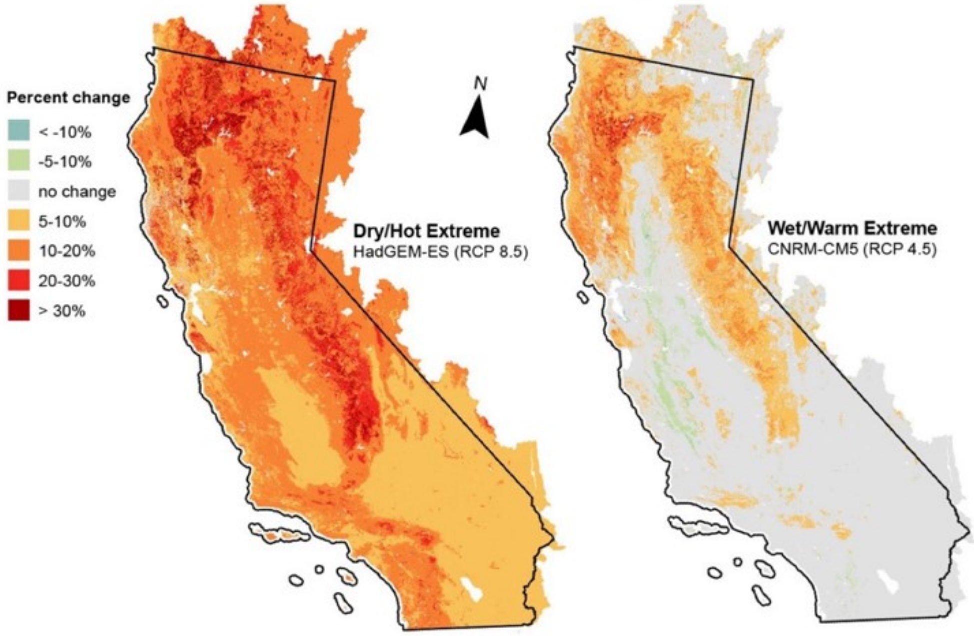

Figure 2a notes: HadGEM = Hadley Centre Global Environment Model, CNRM = National Centre for Meteorological Research model
Visual representation of drier with extreme warming scenario (left) and wetter with moderate warming scenario (right).

Figure 2b Statewide Percent Change in Average Annual Natural Recharge

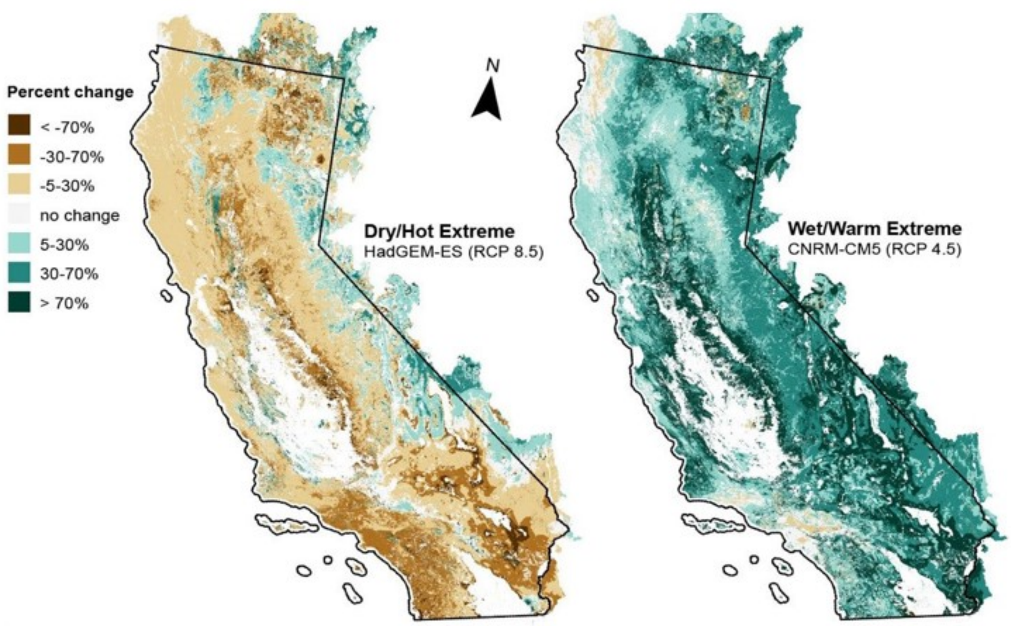

Figure 2b notes: HadGEM = Hadley Centre Global Environment Model, CNRM = National Centre for Meteorological Research model
Visual representation of drier with extreme warming scenario (left) and wetter with moderate warming scenario (right)

Furthermore, conjunctive use facilitates the management of climate-induced hydrological changes. With shifting rainfall patterns and altered runoff dynamics, conjunctive use practices allow for the optimization of water storage and distribution systems. By strategically coordinating the operation of reservoirs, groundwater pumping, and recharge activities, water managers can adapt to changing hydrological conditions and ensure the sustained availability of water resources. This integrated approach also helps minimize the potential environmental impacts of climate change by maintaining adequate baseflows in rivers, preserving ecosystems, and protecting aquatic habitats.

Overall, conjunctive use provides a holistic and adaptive approach to water resource management in the face of climate change. It enables the optimization of available water supplies, enhances resilience to water scarcity and extreme events, and promotes sustainable water-use practices. By integrating surface water and groundwater management, communities can better prepare for, and adapt to, the uncertainties and challenges brought about by a changing climate, improving long-term water security and resilience.

8. Climate Change Mitigation

While conjunctive use primarily focuses on climate change adaptation, it also has implications for climate change mitigation through its promotion of sustainable water use practices. By effectively managing water resources, it reduces the need for energy-intensive water supply alternatives, such as desalination or long-distance water transfers, which often have high energy requirements and associated greenhouse gas emissions. Additionally, optimizing water availability through conjunctive use can support agricultural practices that prioritize water-efficient irrigation techniques, leading to reduced energy consumption and lower carbon footprints in agricultural production.

Moreover, conjunctive use can indirectly contribute to climate change mitigation by supporting ecosystem health and resilience. By maintaining adequate baseflows in rivers and protecting aquatic habitats, conjunctive use helps preserve natural carbon sinks and biodiversity. Healthy ecosystems play a crucial role in sequestering carbon dioxide from the atmosphere, helping to mitigate climate change.

9. Conjunctive Use and the Governor's Water Resilience Portfolio

Governor Newsom signed an executive order on April 29, 2019, directing the California Natural Resources Agency, California Environmental Protection Agency, and California Department of Food and Agriculture to develop a comprehensive strategy to build a climate-resilient water system and ensure healthy waterways through the 21st century. These agencies solicited extensive public input to prepare the *Water Resilience Portfolio*, released by the governor on July 28, 2020. The portfolio includes 142 actions that encourage harnessing the best science, engineering, and innovation to support long-term water resilience and improve California's capacity to prepare for disruptions, withstand and recover from climate-related shocks, and adapt into the future (California Natural Resources Agency 2020).

The following are *Water Resilience Portfolio* actions connected to groundwater recharge and conjunctive use:

- Action 3.4: Explore ways to further streamline groundwater recharge and banking efforts that do not exacerbate water quality issues and provide technical assistance to facilitate the redirection of water during periods of extended high flows to allow water to sink into aquifers, including on agricultural land. Ensure diversions are protective of native fish and wildlife.
- Action 3.5: Make funding available for groundwater recharge and storage projects with multiple benefits.
- Action 3.7: Support use of aerial electromagnetic surveys, groundwater quality conditions, and well completion reports to identify optimal areas for enhanced recharge and critical connections in aquifer systems so that local governments may protect those lands from development and utilize for managed aquifer recharge.
- Action 3.8: Explore streamlined permitting for low-hazard dams that are not across a stream channel or watercourse and are used principally for agricultural and groundwater recharge purposes.
- Action 3.9: Help regions prevent contamination of groundwater basins, including through seawater intrusion, and remediate contaminated groundwater basins that will enable large-scale water recycling and conjunctive use.

10. Recommendations

California's Groundwater (also known as Bulletin 118) *Update 2020* (California Department of Water Resources 2021) published several recommendations in support of sustainable groundwater management that fall within four major categories: advance data-driven decisions; maintain momentum for sustainability; engage, communicate, and educate; and invest, innovate, and incentivize. Many of these recommendations are related to, or support, conjunctive management and recharge, including data collection, analysis, and dissemination. The State and the local agencies need to collaborate to implement these recommendations.

The following are recommendations from *California's Groundwater Update 2020* that support conjunctive management:

- Recommendation 1.2: Enhance existing groundwater level data collection programs to expand spatial coverage and increase the frequency of groundwater level measurements to quarterly, monthly, or more frequently to improve understanding of the seasonal variations and enable real-time decision-making.
- Recommendation 4.2: Identify optimal areas for enhanced recharge and critical connections in aquifer systems to enable local governments to maximize opportunities for managed aquifer recharge.
- Recommendation 6.1: Collaborate with State, federal, Tribal, local, and regional agencies to support and provide financial and non-financial incentives for a comprehensive approach to local and regional groundwater recharge and storage projects that would achieve multiple benefits.
- Recommendation 6.2: Promote streamlining and acceleration of managed aquifer recharge and groundwater banking permitting processes to support long-term proactive drought management strategies.
- Recommendation 7.1: Streamline groundwater substitution and water transfer permitting and approval processes by allowing consolidated basin-level environmental reviews to facilitate water market transactions.
- Recommendation 7.2: Facilitate the efficient, fair, and equitable development and implementation of water markets by creating an adaptable standardized framework for market structure, governance, and operations.

Additional Recommendations:

- California should continue to invest in characterizing and understanding its groundwater basins and associated aquifers and natural groundwater resources infrastructure, and identifying and establishing infrastructure needs so that surface water resource natural and built infrastructure can be integrated to optimally facilitate a true conjunctive management framework that improves water supply reliability and groundwater sustainability.
- While some of this information is available from GSPs and annual reports submitted for SGMA implementation within basins, California should work toward compiling a publicly available list of the locations, types, and volumes handled of all conjunctive management operations in the state. This information can be useful for water managers and for water accounting purposes.
- California should continue to investigate ways to capture excess stormwater and flood flows, especially during extreme atmospheric river events, and divert those flows for recharge in nearby aquifers to augment supply for later use. This management strategy will be important as the climate continues to change and there is less overall annual runoff and snowmelt contribution to spring runoff.
- Consistent with the *California's Water Supply Strategy: Adapting to a Hotter, Drier Future*, where economically feasible, California should encourage using recycled or desalinated water as a source supply for recharging local aquifers.

Related Resource Management Strategies

- Flood Management.
- Water Transfers.
- Recharge Area Identification, Utilization, and Protection.

11. References

California Department of Water Resources 2003; "Bulletin 118 Update 2003 California's Groundwater." Sacramento (CA): California Department of Water Resources. [Government Report.] Viewed online at: https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118. Accessed: 2020

California Department of Water Resources. 2016. "Conjunctive Management and Groundwater Storage. A Resource Management Strategy of the California Water Plan" [Government Report]. Viewed online at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/RMS/2016/08_ConjMgt_GW_Storage_July2016.pdf. Accessed: July 29, 2016

California Department of Water Resources. 2018a. "Flood-MAR Using Flood Water for Managed Aquifer Recharge to Support Sustainable Water Resources." [Government Report.] Viewed online at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-MAR/DWR_FloodMAR-White-Paper_a_y20.pdf. Accessed: JUNE 2018

California Department of Water Resources. 2018b. "Water Available for Replenishment." April 2018. Sacramento (CA). California Department of Water Resources. 60 pp [Government Report]. Available online at: https://cawaterlibrary.net/document/water-available-for-replenishment-2018/. Accessed: April 12th, 2018

California Department of Water Resources. 2019. "Flood-MAR Research and Data Development Plan Priority Actions to Expand Implementation of Effective and Efficient Flood-MAR Projects in California" [Report] Viewed Online at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-MAR/Flood-MAR-RDD-Plan_a_y_19.pdf. Accessed: October 2019

California Department of Water Resources. 2020a. "Conduct Airborne Electromagnetic Surveys.', Viewed online at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Prop68/P1-2020-AEM-Fact-Sheet.pdf. Accessed: 2020

California Department of Water Resources. 2020b. "Merced River Flood-MAR Reconnaissance Study' [Report]. Viewed online at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-MAR/Merced-River-Flood-MAR-Reconnaissance-Study.pdf. Accessed: 2020

California Department of Water Resources. 2021. "California's Groundwater Update 2020" [Government Report.] Viewed online at: https://data.cnra.ca.gov/dataset/calgw_update2020/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be. Accessed: November 17, 2021

California Department of Water Resources. 2022. "Watershed Climate Studies Demonstrate Vulnerability, Climate Adaptation and Multi-Sector Benefits" [Fact Sheet] Viewed online at: https://www.nbwatershed.org/wp-content/uploads/2022/04/OneWater-OneBay_SJV-Watershed-Studies-Factsheet-March-2022.pdf. Accessed: 2022

California Department of Water Resources. 2023. "California's Groundwater Conditions, Semi-Annual Update: March 2023" [Government Report.] Viewed online at: https://data.cnra.ca.gov/dataset/california-s-groundwater-semi-annual-conditions-updates/resource/72ed7f9c-36cb-4c0a-a3de-63b8f5a0a0ef. Accessed: March 15, 2023

California Natural Resources Agency. 2020. "Water Resilience Portfolio." California Natural Resources Agency. Sacramento (CA): California Natural Resources Agency. [Government Report.] Viewed online at: https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Water-Resilience/Final_California-Water-Resilience-Portfolio-2020_ADA3_v2_ay11-opt.pdf. Accessed: July 28, 2020

California office of Gavin Newsom. 2023 "Refilling California's Underground Reservoirs" [Fact Sheet]. Viewed online at: https://www.gov.ca.gov/wp-content/uploads/2023/03/Refilling-Californias-Underground-Reservoirs.pdf. Accessed: 2023

Griggs, G, Árvai, J, Cayan, D, DeConto, et al. 2017. “Rising Seas in California: An Update on Sea-Level Rise Science”, 71 pp. [Report.] Prepared for California Ocean Protection Council. Viewed online at: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf. Accessed: April 2017

Intergovernmental Panel on Climate Change. 2014. “Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change”. IPCC, Geneva, Switzerland, 151 pp. Viewed online at: https://www.ipcc.ch/report/ar5/syr/. Accessed: 2020

Western Regional Climate Center. 2019. California Climate Tracker. [Data.] Viewed online at: https://wrcc.dri.edu/Climate/Tracker/CA/. Accessed: 2020

13. Useful Web Links

2020 Water Resilience Portfolio
https://resources.ca.gov/Initiatives/Building-Water-Resilience/portfolio

California's Groundwater Update 2013
https://data.cnra.ca.gov/dataset/california-water-plan-groundwater-update-2013

California's Groundwater Update 2020
https://data.cnra.ca.gov/dataset/calgw_update2020

Sustainable Groundwater Management Act
https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management

California's Water Supply Strategy: Adapting to a Hotter, Drier Future
https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Water-Resilience/CA-Water-Supply-Strategy.pdf

California Water Supply Solutions Act of 2023
https://legiscan.com/CA/text/SB659/id/2844602

Flood-MAR Research and Data Development Plan
https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-MAR/Flood-MAR-RDD-Plan_a_y_19.pdf

Water Available for Replenishment
https://cawaterlibrary.net/document/water-available-for-replenishment-2018/

DEPARTMENT OF WATER RESOURCES • STATE OF CALIFORNIA