Flood-MAR Research and Data Development Plan Evaluation

Evaluation of Progress Toward the 2019 Priority Actions to Expand Implementation of Effective and Efficient Flood-MAR Activities in California

April 2025

California Department of Water Resources

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Abbreviations and Acronyms

AEM	Airborne electromagnetic
DWR	California Department of Water Resources
DWR SJR watershed studies	California Department of Water Resources' San Joaquin River watershed studies
Eco-FIP	Ecological Floodplain Inundation Potential
FIRO	Forecast-informed reservoir operations
Flood-MAR	Flood-managed aquifer recharge
GIS	Geographic information system
GRAT	Groundwater Recharge Assessment Tool
GSA	Groundwater sustainability agency
GSP	Groundwater sustainability plan
InSAR	Interferometric synthetic aperture radar
LiDAR	Light detection and ranging
LCI	California Governor's Office of Land Use and Climate Innovation
MAR	Managed aquifer recharge
NGO	Non-governmental organization
RAC	Flood-MAR Research Advisory Committee
R&DD Plan	2019 Flood-MAR Research and Data Development Plan
SAFER	Safe, Affordable Funding for Equity and Resilience
SGMA	Sustainable Groundwater Management Act of 2014
State Water Board	California State Water Resources Control Board

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Executive Summary

Flood-managed aquifer recharge (Flood-MAR) has emerged as an important water resources management strategy in California to reduce flood risk while recharging depleted groundwater aquifers. In many cases, Flood-MAR provides other benefits including ecosystem enhancement, subsidence mitigation, drought preparedness, enhanced water supply reliability, and water quality improvement.

As a practice, Flood-MAR requires the close coordination and partnership of many entities and interests at state, federal, Tribal, regional, and local levels, on topics related to policy, legal matters (e.g., regulation and water rights), governance, and implementation, including environmental considerations, conveyance, land use, reservoir operations, economics, and data and tools. The complexity and interrelated nature of Flood-MAR necessitated early thought on how the various opportunities and challenges that were present would be integrated and solved by the broader research, planning, and implementation communities. Those explorations were documented in a Flood-MAR Research and Data Development Plan (R&DD Plan) in 2019 by a Research Advisory Committee (RAC), comprised of over 200 subject-matter experts across the state, representing academics, practitioners, nongovernmental organizations (NGOs), consultants, government agencies, Tribes, and professional associations. The R&DD Plan described 39 priority actions that the RAC concurred were needed to advance the use of Flood-MAR in California.

In the subsequent years since the R&DD Plan's development, much progress has been made toward advancing more widespread adoption of Flood-MAR. This evaluation details the results of a qualitative analysis that included engagement with people who had served as members of the RAC, other interested parties, and staff at state agencies, to better understand progress towards the 39 priority actions.

The conclusion reached is that roughly two thirds of the priority actions identified by the RAC have been completed or are underway.

Table ES-1. Status of R&DD Plan Priority Actions

Priority Action	Status
Hydrology Observation and Prediction	
Improve comprehensive snowpack monitoring (Airborne Snow Observatory and in situ)	In Progress
Research sediment transport impacts on conveyance and streams caused by increased usage from Flood-MAR operations.	In Progress
Develop a spatially distributed soil moisture network for upper watersheds.	In Progress
Reservoir Operations	
Develop improved statewide water accounting to support the kinds of agreements and incentives needed for Flood-MAR, SGMA-related water plans, water markets, and enforcement of surface water rights.	In Progress

Priority Action	Status
Extend FIRO to include operations for groundwater recharge, particularly for local and regional agricultural field and basin recharge opportunities.	In Progress
Analyze reservoir and broader water resources system to assess potential for shifting drought storage from surface water reservoirs to aquifers.	In Progress
Infrastructure Conveyance and Hydraulics	
Build a GIS conveyance database of conveyance networks that could be used for Flood-MAR projects.	Complete
Research sediment transport impacts on conveyance and streams caused by increased usage from Flood-MAR operations.	In Progress
Develop LiDAR, topography, and bathymetry data around potential Flood-MAR project areas that lack this data in order to augment the GIS conveyance database.	In Progress
Crop Systems Suitability	
Perform case studies on agricultural land-based Flood-MAR projects completed to date.	In Progress
Initiate and complete research on knowledge gaps of crop systems suitability for MAR in California.	In Progress
Develop decision support tool to determine crop suitability for Flood-MAR.	Complete
Soils, Geology, and Aquifer Characterization	
Improve subsurface geologic data and provide greater accessibility to useable and better-quality data.	In Progress
Improve subsurface hydrologic data and provide greater accessibility to useable and better-quality data.	In Progress
Synthesize hydrogeologic data to identify the best locations for recharge.	In Progress
Land Use Planning and Management	
Document coordination and communication methods occurring between GSAs and land use planning agencies to develop best practices.	In Progress
Identify sources of funding for integrated planning efforts and groundwater management.	In Progress
Develop protocol for data consistency.	Uncertain
Water Quality	
Develop a web-based platform to allow public access to a compilation of all existing knowledge identified by the Water Quality Subcommittee.	In Progress
Develop better knowledge of water quality issues (sources, conveyance, land use and land use history, naturally occurring contaminants) related to Flood-MAR design and implementation.	In Progress
Develop guidance and multi-criteria decision-making tools to address water quality issues in Flood-MAR projects.	In Progress
Recharge and Extraction Methods and Measurement	
Compile existing managed aquifer recharge projects and associated data.	In Progress
Compile pertinent information to determine the efficiency of managed aquifer recharge projects.	In Progress
Establish methods and considerations by which floodplains can be used as direct recharge sites and in conjunction with other recharge methods.	Complete
Environment – Terrestrial and Riparian/Aquatic	
Develop a tool to calculate groundwater recharge that occurs when floodplains are inundated.	Complete
Develop a map that prioritizes Flood-MAR based on the additional habitat benefits that can be achieved at certain sites.	Complete

Priority Action	Status
Map subsurface geology of floodplains to identify areas with the greatest potential for deep aquifer recharge.	In Progress
People and Water	
Develop an ethical and just framework specifically focused on the Flood-MAR program.	Not started
Develop an engagement best practices document for Flood-MAR.	Not started
Document areas most feasible for recharge with disadvantaged communities that are groundwater dependent and would greatly benefit from Flood-MAR actions.	In Progress
Economic Analysis	
Develop an economic analysis guidance document for groundwater recharge projects.	Not started
Evaluate economic and other incentives for Flood-MAR implementation.	In Progress
Assess groundwater ownership rights and market issues associated with Flood-MAR.	In Progress
Local, State, and Federal Policies and Legal Considerations	
Refine guidance and provide applicant assistance for beneficial use designations associated with recharge.	In Progress
Provide guidance and support for water availability analyses and associated determinations for processing of water rights applications.	Complete
Develop recommendations for environmental permitting refinements and permitting guidance for Flood-MAR project proponents and establish an interagency group to coordinate refined permit processes with entities seeking permits.	In Progress
Tool and Application Development	
Conduct cost/benefit analysis, including multi-benefit.	In Progress
Identify policy linkages and governance structure.	Uncertain
Create decision support tools to integrate Flood-MAR disciplines.	In Progress

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: FIRO = forecast-informed reservoir operations; GIS = geographic information system; GSA = groundwater sustainability agency; LiDAR = light detection and ranging; SGMA = Sustainable Groundwater Management Act

This evaluation summarizes the progress that has been made and offers additional considerations that were presented by the past RAC co-chairs during recent engagement. Also included are references to about 50 resources that have been developed by state and non-state entities to support the widespread adoption and implementation of Flood-MAR, the majority of which are accessible to the public. This evaluation did not include any revision or reprioritization of the 2019 R&DD Plan priorities nor make recommendations for future Flood-MAR related research or data development. This report demonstrates the excellent progress that has been made since 2019 to support implementation of Flood-MAR projects and provides practitioners references and links to best available information.

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1.0 Introduction

In the past decade, using flood waters for managed aquifer recharge (Flood-MAR) has emerged as a prominent water resources management strategy in California that can help the state better prepare for and respond to climate extremes like flood and drought. Early efforts to characterize the potential role of Flood-MAR as a creative climate adaptation in California culminated in a 2018 Flood-MAR White Paper by the California Department of Water Resources (DWR) that described the practice and explored its potential benefits, implementation factors, opportunities, and barriers or challenges.

Among other actions, the white paper called for the creation of a research and data development framework as a next step, to identify, categorize, and coordinate the research, data, guidance, and tools necessary to support and expand the implementation of effective and efficient Flood-MAR activities. The intended outcomes for the proposed framework included development of a body of knowledge and inventory of technical needs to guide and support the work and investment of researchers, agencies, and funding entities; exploration and matrixing of technical expertise among participating groups and interested parties to guide strategic coordination and funding of Flood-MAR efforts; and provision of guidance to support decision-making, implementation, and management of multisector, multibenefit Flood-MAR projects.

To facilitate the development of what would become the 2019 Flood-MAR Research and Data Development Plan (R&DD Plan), DWR convened a multidisciplinary group of approximately 200 subject-matter experts in the water community to form the Flood-MAR Research Advisory Committee (RAC). The RAC organized within 13 research-area Subcommittees:

1. Hydrology Observation and Prediction
2. Reservoir Operations
3. Infrastructure Conveyance and Hydraulics
4. Crop Systems Suitability
5. Soils, Geology, and Aquifer Characterization
6. Land Use Planning and Management
7. Water Quality
8. Recharge and Extraction Methods and Measurement
9. Environment – Terrestrial and Riparian/Aquatic

10. People and Water
11. Economic Analysis
12. Local, State, and Federal Policies and Legal Considerations
13. Tool and Application Development

The R&DD Plan was structured around these research areas, with three priority actions identified by each Subcommittee. State and non-state co-chairs, with support from DWR, led their topic-specific Subcommittees comprised of academics, practitioners, nongovernmental organizations, consultants, government agencies, Tribes, and professional association members. RAC meeting discussions focused on identifying the information and tools related to each Subcommittee's research area that would be needed to scale up implementation of Flood-MAR projects, including identifying potential roles and partnerships that could carry out those actions. At the time of the R&DD Plan's development, the RAC had estimated that most of the 39 priority actions could be completed in the near term (under five years) for approximately $147 million. Further details on the original R&DD Plan development methodology are provided in that document.

1.1 Evaluation Methodology

Although a Flood-MAR Network of practitioners emerged from the RAC's R&DD Plan development effort, no entity was charged with managing or tracking progress toward achieving the RAC's priority actions. In 2024, DWR retained a consultant, Stantec Consulting Services Inc., to conduct an evaluation and reconvene the people who had served as RAC co-chairs to document the accomplishments and activities underway toward achieving the priority actions.

To perform this evaluation, Stantec interviewed DWR staff who were originally engaged in supporting the RAC to prepare an initial evaluation of progress. Stantec then facilitated two workshops with the former RAC co-chairs in Fall 2024 to further the evaluation through reflection on successes, assessment of ongoing challenges, and recalibration of priorities for future Flood-MAR research and data development. Included with this evaluation are the resources and findings that DWR staff and former RAC co-chairs identified during evaluation engagement. Summary notes from the workshops are included in Appendix A.

Limits

This evaluation was limited in time and scope, and thus may not comprehensively document all the many accomplishments in the research and data-development space that have supported adoption of Flood-MAR practices in California. This evaluation

supports better understanding of what research and data development needs may still exist and to communicate the status of work that has already been accomplished.

1.2 Summary of Progress

This evaluation concludes that of the 39 actions that were prioritized by the RAC in 2019, seven have been completed, 22 are in progress but not yet complete, three have not been started, five contain a portion of elements that have not yet been undertaken, and two are of uncertain status.

Table 1-1. Status of Flood-Managed Aquifer Recharge R&DD Plan Priority Actions

Priority Action	Complete	In Progress	Not Started	Mixed Status (Multiple Components)	Uncertain
Hydrology Observation and Prediction					
Improve comprehensive snowpack monitoring (Airborne Snow Observatory and in situ)		X			
Research sediment transport impacts on conveyance and streams caused by increased usage from Flood-MAR operations.		X			
Develop a spatially distributed soil moisture network for upper watersheds.		X			
Reservoir Operations					
Develop improved statewide water accounting to support the kinds of agreements and incentives needed for Flood-MAR, SGMA-related water plans, water markets, and enforcement of surface water rights.		X			
Extend FIRO to include operations for groundwater recharge, particularly for local and regional agricultural field and basin recharge opportunities.		X			
Analyze reservoir and broader water resources system to assess potential for shifting drought storage from surface water reservoirs to aquifers.		X			
Infrastructure Conveyance and Hydraulics					
Build a GIS conveyance database of conveyance networks that could be used for Flood-MAR projects.	X				
Research sediment transport impacts on conveyance and streams caused by increased usage from Flood-MAR operations.		X			
Develop LiDAR, topography, and bathymetry data around potential Flood-MAR project areas that lack this data in order to augment the GIS conveyance database.		X			
Crop Systems Suitability					
Perform case studies on agricultural land-based Flood-MAR projects completed to date.		X			
Initiate and complete research on knowledge gaps of crop systems suitability for MAR in California.		X			

Priority Action	Complete	In Progress	Not Started	Mixed Status (Multiple Components)	Uncertain
Develop decision support tool to determine crop suitability for Flood-MAR.	X				
Soils, Geology, and Aquifer Characterization					
Improve subsurface geologic data and provide greater accessibility to useable and better-quality data.		X			
Improve subsurface hydrologic data and provide greater accessibility to useable and better-quality data.		X			
Synthesize hydrogeologic data to identify the best locations for recharge.		X			
Land Use Planning and Management					
Document coordination and communication methods occurring between GSAs and land use planning agencies to develop best practices.		X			
Identify sources of funding for integrated planning efforts and groundwater management.		X			
Develop protocol for data consistency.					X
Water Quality					
Develop a web-based platform to allow public access to a compilation of all existing knowledge identified by the Water Quality Subcommittee.		X			
Develop better knowledge of water quality issues (sources, conveyance, land use and land use history, naturally occurring contaminants) related to Flood-MAR design and implementation.				X	
Develop guidance and multi-criteria decision-making tools to address water quality issues in Flood-MAR projects.		X			
Recharge and Extraction Methods and Measurement					
Compile existing managed aquifer recharge projects and associated data.		X			
Compile pertinent information to determine the efficiency of managed aquifer recharge projects.		X			
Establish methods and considerations by which floodplains can be used as direct recharge sites and in conjunction with other recharge methods.	X				

Priority Action	Complete	In Progress	Not Started	Mixed Status (Multiple Components)	Uncertain
Environment – Terrestrial and Riparian/Aquatic					
Develop a tool to calculate groundwater recharge that occurs when floodplains are inundated.	X				
Develop a map that prioritizes Flood-MAR based on the additional habitat benefits that can be achieved at certain sites.	X				
Map subsurface geology of floodplains to identify areas with the greatest potential for deep aquifer recharge.		X			
People and Water					
Develop an ethical and just framework specifically focused on the Flood-MAR program.			X		
Develop an engagement best practices document for Flood-MAR.			X		
Document areas most feasible for recharge with disadvantaged communities that are groundwater dependent and would greatly benefit from Flood-MAR actions.				X	
Economic Analysis					
Develop an economic analysis guidance document for groundwater recharge projects.			X		
Evaluate economic and other incentives for Flood-MAR implementation.		X			
Assess groundwater ownership rights and market issues associated with Flood-MAR.				X	
Local, State, and Federal Policies and Legal Considerations					
Refine guidance and provide applicant assistance for beneficial use designations associated with recharge.				X	
Provide guidance and support for water availability analyses and associated determinations for processing of water rights applications.	X				
Develop recommendations for environmental permitting refinements and permitting guidance for Flood-MAR project proponents and establish an interagency group to coordinate refined permit processes with entities seeking permits.				X	
Tool and Application Development					
Conduct cost/benefit analysis, including multi-benefit.		X			

Priority Action	Complete	In Progress	Not Started	Mixed Status (Multiple Components)	Uncertain
Identify policy linkages and governance structure.					X
Create decision support tools to integrate Flood-MAR disciplines.		X			

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: FIRO = forecast-informed reservoir operations; GIS = geographic information system; GSA = groundwater sustainability agency; LiDAR = light detection and ranging; SGMA = Sustainable Groundwater Management Act

1.3 Document Organization

This evaluation document includes a section for each of the 13 research Subcommittees. Each section includes background information on why the topic was a priority for the development of further research and data in 2019; detailed tabular descriptions of the priority actions as defined in the original R&DD Plan; followed by an evaluation of progress toward each, with links to resources provided when available.

2.0 Hydrology Observation and Prediction

Adapting to climate change requires adjusting the way that weather and hydrologic conditions are observed and forecasted. Historical weather patterns and relationships between precipitation, snowpack, and streamflow—that have previously been used to anticipate how much water will run off for beneficial use—have already shown deviation from historical pattern. While DWR's observation and forecasting programs have a long history of working in partnership with the research community, to bring relevant research advances into program operation, the pace and scale of weather extremes necessitate acceleration of recent and ongoing advances, to ensure a forecasting framework that can adapt at the pace of a changing climate.

The Hydrology Observation and Prediction Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and eight subject-matter experts, representing state and federal agencies, academia, and technical consultants.

2.1 Summary of Priority Actions

The Hydrology Observation and Prediction RAC Subcommittee identified and defined three priority actions, as follows in Table 2-1.

Table 2-1. Hydrology Observation and Prediction Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Hydrology Observation and Prediction-1	Improve comprehensive snowpack monitoring (Airborne Snow Observatory and in situ).	• Develop measurement and monitoring strategies for (including locations best suited to) gathering forecast-supportive data to anticipate and characterize rain-on-snow events, rainfall-runoff from snow events, and other snow-centered flood generation processes and conditions. • Better characterize energy budgets (cold balances) and liquid-water conditions/budgets within snowpacks (rather than traditional total-water content focus).	$3 million	3 years	DWR and the California Snow Survey Cooperative
Hydrology Observation and Prediction-2	Conduct inter-model comparison of surface hydrologic models with available historical precipitation products.	• Compare surface hydrologic models to determine their relative strengths and weaknesses, including the ability to reproduce streamflow, snowpack, soil moisture, and other relevant hydrologic variables in the Sierra Nevada and across the Central Valley.	$2 million (plus $1 million annually for operations and maintenance)	3 years	USGS and DWR
Hydrology Observation and Prediction-3	Develop a spatially distributed soil moisture network for upper watersheds.	• Develop a high-resolution, spatially distributed (though with special attention to regions identified as highly suitable for Flood-MAR activities) soil moisture network to improve understanding of antecedent conditions that contribute to runoff generation, drought monitoring, infiltration rates, and recharge potential. • Use network to calibrate integrated groundwater models and better understand the processes that drive gaining rivers under a variety of soil moisture conditions.	$3 million	3 years	USGS, DWR, and local agencies

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: DWR = California Department of Water Resources; Flood-MAR = flood-managed aquifer recharge; USGS = United States Geological Survey

2.2 Evaluation of Progress

Hydrology Observation and Prediction-1: Improve comprehensive snowpack monitoring (Airborne Snow Observatory and in situ)

The evaluation concludes that this action is in progress, but not yet complete. DWR prepared a roadmap to a climate resilient forecasting framework in response to the surface water audit in 2021. Should funding be available, DWR's Hydrology and Flood Operations Office would implement the roadmap. More information is available on DWR's SnowTrax site.

Hydrology Observation and Prediction-2: Conduct inter-model comparison of surface hydrologic models with available historical precipitation products.

The evaluation concludes that this activity is in progress, but not yet complete. DWR is developing an assessment framework that would allow for inter-model comparison.

Hydrology Observation and Prediction-3: Develop a spatially distributed soil moisture network for upper watersheds

The evaluation concludes that this action is in progress, but not yet complete. DWR initiated this activity and has purchased the relevant equipment. The activity includes permit coordination with the U.S. Forest Service and formal Tribal consultation, which is underway. The data gathered from the network will be used to help calibrate the models that are currently being updated.

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3.0 Reservoir Operations

Reservoir operations govern water supply and downstream flow management in most of the state's watersheds. Most reservoirs were initially constructed for water supply reliability (e.g., storing winter runoff for summer use) or flood risk reduction. Today, these reservoirs support multiple purposes through their operations, and management of reservoirs is coordinated across watersheds by local, state, and federal agency operators. In many cases, the operations of reservoirs are governed by plans and rule curves that do not reflect today's hydrology and multibenefit priorities and do not consider future hydrology. There are numerous efforts to update reservoir operations, such as using forecasts to better counter wet and dry periods and support multipurpose water management including ecosystem releases or functional flow components. Recent studies support that integrating reservoir reoperation and Flood-MAR can significantly reduce flood risk, improve water supply through conjunctive use, and enhance conditions for aquatic and terrestrial species. More work is needed to better understand the risks, tradeoffs, and benefits of reservoir reoperation and support implementation.

The Reservoir Operations Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and seven subject-matter experts, representing state and federal agencies, local water districts, academia, and technical consultants.

3.1 Summary of Priority Actions

The Reservoir Operations RAC Subcommittee identified and defined three priority actions, as follows in Table 3-1.

Table 3-1. Reservoir Operations Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Reservoir Operations-1	Develop improved statewide water accounting to support the kind of agreements and incentives needed for Flood-MAR, SGMA-related water plans, water markets, and enforcement of surface water rights.	• Develop a common database set for modeling (e.g., water system, reservoir, groundwater). This database would include routine, systematic, and transparent procedures and responsibilities for updating these data sets and their documentation, including standards for reservoir, groundwater, and system models for use in Flood-MAR, SGMA, water rights, and water marketing agreements and plans.	$12.5 million	5 years	DWR and local agencies
Reservoir Operations-2	Extend FIRO to include operations for groundwater recharge, particularly for local and regional agricultural field and basin recharge opportunities.	• Conduct regional or local FIRO studies having more reservoir operations and conjunctive use in addition to hydrology forecasting to show benefits for both FIRO and non-FIRO operation strategies. Determine value, costs, and barriers, as well as policy implications and opportunities.	$5-10 million	2-5 years	Federal agencies, State agencies, local agencies, and academia
Reservoir Operations-3	Analyze reservoir and broader water resources system to assess potential for shifting drought storage from surface water reservoirs to aquifers.	• Conduct research to evaluate flood risk reduction benefits from lower drought storage levels in major reservoirs including an assessment of the relative likely flood and water supply benefits from systemic shift of drought storage to aquifers and storm capture from storm events.	$15 million	2-5 years	DWR along with regional and local agencies

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
		• Assess statewide, regional, and local opportunities for improvements and costs (e.g., recreation and hydropower) to water supply and flood management for current and warmer climate conditions. Identify impediments to making such shifts. • Estimate potential value of longer-term atmospheric river forecasts for reservoir operations to overcome the costs of false-positive forecasts.			

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: DWR = California Department of Water Resources; FIRO = forecast-informed reservoir operations; Flood-MAR = flood-managed aquifer recharge; SGMA = Sustainable Groundwater Management Act

3.2 Evaluation of Progress

Reservoir Operations-1: Develop improved statewide water accounting to support the kind of agreements and incentives needed for Flood-MAR, SGMA-related water plans, water markets, and enforcement of surface water rights.

The evaluation concludes that this action is in progress, but not yet complete. The initial phase of this action is in progress through improved local water accounting prepared and reported in groundwater sustainability plans (GSPs) and San Joaquin Flood-MAR Watershed Studies which model the fate of recharge in San Joaquin Basin quantifying water retained, flowing to adjacent subbasins, and returning to streams. Some examples of the initial efforts include the following:

- Detailed water accounting is provided to DWR in groundwater sustainability plan (GSP) annual reports for California groundwater basins subject to the Sustainable Groundwater Management Act (SGMA), including adjudicated basins and basins with alternative plans. Groundwater Sustainability Agencies (GSA) in California are also integrating various water models in their GSPs.

- The California Water Data Consortium developed an operational, publicly available Groundwater Accounting Platform in partnership with DWR, based on work completed by the Environmental Defense Fund.

- DWR's San Joaquin River basin watershed studies (referred to hereinafter as the "DWR SJR watershed studies") developed integrated analytical toolsets at the watershed scale that combine climate change, hydrologic (precipitation runoff), reservoir, recharge, and groundwater modeling. Ultimately, DWR anticipates integrating flood modeling as well.

Reservoir Operations-2 Extend FIRO to include operations for groundwater recharge, particularly for local and regional agricultural field and basin recharge opportunities.

The evaluation concludes that this action is in progress, but not yet complete. Most FIRO studies performed to date were developed to achieve flood management or water supply benefits from FIRO operations. San Joaquin Flood-MAR Watershed Studies developed the FIRO-MAR concept integrating FIRO with Managed Aquifer Recharge (MAR) operations to demonstrate the benefits within the flood, water supply, and ecosystem water sectors. More FIRO studies performed by the Center for Western Weather and Water Extremes, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation in coordination with local agencies are needed to explore the FIRO-MAR concept and to identify benefits, values, costs, and barriers to implementation. The initial work related to combining FIRO and recharge operations includes the following:

- Forecast-informed reservoir operation (FIRO) studies—led by the Center for Western Weather and Water Extremes, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation in coordination with local agencies—have been conducted for Folsom Lake/Dam, Lake Mendocino, Lake Sonoma, Prado Dam (which includes Orange County's existing recharge program) and the upstream Seven Oaks area, and the Yuba-Feather River Watershed (Oroville, New-Bollards Bar). Of these, Prado Dam has included an exploration of potential benefits from recharge whereas the other studies have evaluated other multibenefits. U.S. Bureau of Reclamation and U.S. Army Corps of Engineers are developing Water Control Manual Revisions for Folsom Lake to include FIRO.

- The DWR SJR watershed studies included an evaluation of FIRO-MAR benefits, values, and barriers to implementation, though costs were not estimated. See the Merced Watershed Study for details (and note that other watershed study reports will be published later in 2025 also look at FIRO-MAR strategies).

Reservoir Operations-3: Analyze reservoir and broader water resources system to assess potential for shifting drought storage from surface water reservoirs to aquifers.

The evaluation concludes that this action is in progress, but not yet complete. For example,

- The DWR SJR watershed studies included an evaluation of flood risk reduction and drought response benefits due to integrating reservoir and aquifer storage. The response of the watersheds, reservoirs, and aquifers to that integration varied across geographies (for example, flood risk reduction benefits were more significant in certain watersheds, as was aquifer response to recharge). The DWR SJR watershed studies are also assessing responses to warmer climate conditions and their effects to water supply, flood, and ecosystems. Conceptually, combining FIRO with recharge can help retain water supplies that are released from a reservoir and stored underground for later retrieval.

More specifically, a concept of shifting a portion of reservoir's conservation storage to groundwater aquifer was implemented in Merced Watershed Flood-MAR Study which showed some flood management and groundwater supply benefits but impacted the surface water supply. This concept was not included in the Stanislaus River Flood-MAR Watershed Study due to specific characteristics of New Melones reservoir (low flood risk) and higher groundwater levels in Stanislaus watershed. Groundwater modeling showed low retention of recharged water in the subbasins underlying Stanislaus watershed, high subsurface flow to neighboring subbasins, and high return of water to river. Tuolumne watershed showed similar results as far as groundwater characteristics, except flood risk is high for Don Pedro Reservoir (historically, flow in Tuolumne River near Modesto exceeded the operational channel capacity of 9,000 cfs). This does not

mean that this concept would not work for other watersheds. However, the impact to surface water supply reliability from shifting water from reservoirs to groundwater storage is high, but there are flood management and groundwater benefits. More work is needed to understand the benefits, values, and risks associated with such operations. Potentially, the evaluation needs to be performed on a watershed-to-watershed basis.

4.0 Infrastructure Conveyance and Hydraulics

Water conveyance facilities are necessary to get water to where it is needed, when it is needed. Conveyance facilities can include natural channels (e.g., rivers and creeks) or built infrastructure (e.g., canals, pipelines, ditches, and turnouts). For Flood-MAR projects, the ability to divert high flows (when available) and use conveyance features to move water to recharge areas is critical. Throughout the state, there are good recharge areas that are not accessible and that lack conveyance facilities. Also important for Flood-MAR projects is how sediment moves through the conveyance systems. Substantial winter flows are usually high in sediment, which can create issues for diversion and conveyance facilities.

The Infrastructure Conveyance and Hydraulics Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and six subject-matter experts, representing state and federal agencies, academia, and technical consultants.

4.1 Summary of Priority Actions

The Infrastructure Conveyance and Hydraulics RAC Subcommittee identified and defined three priority actions, as follows in Table 4-1.

Table 4-1. Infrastructure Conveyance and Hydraulics Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Infrastructure Conveyance and Hydraulics-1	Build a GIS database of conveyance networks that could be used for Flood-MAR projects.	• Develop a standardized statewide GIS database of conveyance networks (e.g., canals, pipelines, ditches, turnouts) and metadata that could be potentially used for Flood-MAR projects. • Initial development would prioritize locations with a high likelihood of Flood-MAR project implementation and include information to determine water available, soil and aquifer characteristics, land use, crop system suitability, water rights, maintenance schedules, and other criteria.	$550,000	Within 1 year	DWR
Infrastructure Conveyance and Hydraulics-2	Research sediment transport impacts on conveyance and streams caused by increased usage from Flood-MAR operations.	• Study the effect of sediment and debris in floodwaters on local conveyance networks to determine what kinds of impacts additional sediment could have on operations and maintenance and water quality. • Evaluate ways to remove the sediment and debris from the water before or during Flood-MAR operations, as it is important to understand the potential impacts towards maintenance schedule of irrigation conveyance.	$120,000	1 year	Academia and local agencies
Infrastructure Conveyance and Hydraulics-3	Develop LiDAR, topography, and bathymetry data around potential Flood-MAR project areas that lack this data in order to	• Use the statewide GIS conveyance database recommended above to identify areas that have high potential for Flood-MAR projects but lack sufficient conveyance.	$1 million	1 year	Academia and local agencies

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
	augment the GIS conveyance database.	• Use high-resolution LiDAR, topography, and bathymetry data to enhance the statewide conveyance database, build hydraulic models, and gather information for Flood-MAR projects.			

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: DWR = California Department of Water Resources; Flood-MAR = flood-managed aquifer recharge; GIS = geographic information system; LiDAR = light detection and ranging

4.2 Evaluation of Progress

Infrastructure Conveyance and Hydraulics-1: Build a GIS database of conveyance networks that could be used for Flood-MAR projects.

The evaluation concludes that this action is complete to its likely extent. Conveyance information and alignments for localized infrastructure are developed and maintained by local water agencies, and are, in most cases, not publicly available. A public, statewide geographic information system (GIS) database for conveyance infrastructure has not been developed, nor is it likely to be developed, given the sensitivity of that information for safety and security. GIS information for natural channels is well-documented and widely available. Examples of how local conveyance information has been used to inform Flood-MAR opportunities include:

- Understanding of conveyance networks for recharge projects (including Flood-MAR) has improved for many local water districts through tools such as the Groundwater Recharge Assessment Tool (GRAT) developed by Sustainable Conservation and Earth Genome. The GRAT tool can help local water managers determine where, when, and how much water can be used for recharge. Localized GRAT tools have been developed for several local areas, such as Madera County and Tulare Irrigation District.

- The DWR SJR watershed studies used GRAT to emphasize certain recharge management areas, to achieve the following recharge outcomes: aquifer retention, subsidence mitigation, support of groundwater dependent ecosystems, and support for disadvantaged communities. The studies included determination of available water, soil, and aquifer characteristics; land use; crop system suitability; maintenance schedules; and other criteria. Documentation on the watershed studies is expected to be available later in 2025.

Infrastructure Conveyance and Hydraulics-2: Research sediment transport impacts on conveyance and streams caused by increased usage from Flood-MAR operations.

The evaluation concludes that this action is in progress, but not yet complete.

- Local agencies, such as Yolo County and Tulare Irrigation District, are studying the effects of sediment transport on conveyance, but this knowledge does not exist statewide. Some agencies plan their diversions around avoiding sediment (e.g., Yolo County), whereas others build sediment management into their approach (e.g., Tulare Irrigation District).

- Other research resources include post-fire studies that include analysis of water quality challenges for reservoirs and waterbodies downstream of burned areas could help inform sediment management practices.

Infrastructure Conveyance and Hydraulics-3: Develop LiDAR, topography, and bathymetry data around potential Flood-MAR project areas that lack this data, in order to augment the GIS conveyance database.

The evaluation concludes that this action is in progress, but not yet complete. Although a statewide conveyance database has not been prepared, areas with high potential for Flood-MAR initiatives (including the San Joaquin Valley and Cosumnes River areas) have been identified and are being studied further through collection of new light detection and ranging (LiDAR) and bathymetric data.[1]

- LiDAR data was collected in the San Joaquin Valley in 2022, in a partnership between DWR and the U.S. Geological Survey 3D Elevation Program. That LiDAR data is not yet publicly available, but is anticipated to be released. Additionally, interferometric synthetic aperture radar (InSAR) data is collected monthly to track changes in topography, subsidence, and corresponding changes to flows. InSAR data is publicly available on the SGMA Data Viewer and Open Data portal.

- Local groundwater models, which are documented in GSPs for basins subject to SGMA, are likely the most comprehensive source of LiDAR, topography, and bathymetry data for a given basin. For example, DWR's consultant updated the Flood-MAR San Joaquin Groundwater-Surface Water Simulation Model ("FMSJSim") model that was used in the DWR SJR watershed studies with data from local models found in GSPs.

- The DWR Central Valley Floodplain Evaluation and Delineation ("CVFED") 2.0 model, which includes natural channels (i.e., rivers, streams, and creeks), is being updated with the most recent LiDAR data.

[1] Data collected to date is available upon request through DWR's Flood Emergency Response Information Exchange.

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5.0 Crop Systems Suitability

Flood-MAR projects may include the temporary and seasonal inundation of agricultural lands as recharge areas. Growers have increasingly expressed interest in implementing Flood-MAR projects on a variety of croplands. It is important to understand how the timing, duration, and frequency of inundation may impact crop production or agricultural management practices. Growers may implement Flood-MAR despite potential impacts on crop production or disruption to routine agricultural management practices, when they want to prioritize recharge as part of their operations.

The Crop Systems Suitability Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and 15 subject-matter experts, representing state agencies, growers, commodity groups, NGOs, academia, and technical consultants.

5.1 Summary of Priority Actions

The Crop Systems Suitability RAC Subcommittee identified and defined three priority actions, as follows in Table 5-1.

Table 5-1. Crop Systems Suitability Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Crop Systems Suitability-1	Perform case studies on agricultural land-based Flood-MAR projects completed to date.	• Conduct a summary and meta-analysis of studies that conclusively predict the suitability of a given crop or cropping system for Flood-MAR. • Hydrologic conditions, soil types, crop response, lifespan, yield, and diseases/ pests should be addressed (among others)	$300,000	2 years	Academia, landowners, and the private sector
Crop Systems Suitability-2	Initiate and complete research on knowledge gaps of crop systems suitability for MAR in California	• Conduct research to identify the most suitable cropping systems, identify the effects of MAR operations, and prioritize regions for MAR. • Establish a scientific committee to determine which crops, regions, and other variables to prioritize first in terms of future funding for research	$15 million	Over 5 years	Academia, landowners, NGOs, growers' associations, and the private sector
Crop Systems Suitability-3	Develop a decision support tool to determine crop suitability for Flood-MAR.	• Develop a decision support tool that summarizes the findings of the previous two actions. • The tool should exist as an online application that synthesizes grower response to key questions and delivers risk and management recommendations.	$2 million	3 years	Land grant institutions and agricultural consultants

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: Flood-MAR = flood-managed aquifer recharge

5.2 Evaluation of Progress

Crop Systems Suitability-1 Perform case studies on agricultural land-based Flood-MAR projects completed to date.

The evaluation concludes that this action is in progress. Many growers have been at the forefront of Flood-MAR implementation and are leading the way in identifying potential impacts of inundation for recharge on crops, including almonds, grapes (wine, table, and raisins), pistachios, and fallowed lands. Case studies have been performed and guidance materials have been developed, such as resources prepared by DWR and Sustainable Conservation. Case studies have been conducted on almond, wine grape, and raisin grape orchards. Case studies on pistachios are expected to be completed later in 2025.

During evaluation engagement, it was noted that growers remain particularly interested in understanding threshold amounts for applied water to ensure crop health during floodwater applications.

Crop Systems Suitability-2 Initiate and complete research on knowledge gaps of crop systems suitability for MAR in California.

The evaluation concludes that this action is in progress.

- Research, largely led by academics, has been conducted to identify the most suitable cropping systems, evaluate effects of MAR on agricultural operations, and prioritize regions for MAR, however there is still a gap in this scientific research field. This research has resulted in a list of publications that are shared on the Flood-MAR Hub website's Research tab.
- The DWR Flood-MAR program, in collaboration with partners such as Sustainable Conservation, through the different Flood-MAR studies developed a crop compatibility calendar, available in the Merced River Watershed Flood-MAR Reconnaissance Study, that identifies the total volume of water that can be applied to a given crop for recharge.
- Although the R&DD Plan called for the establishment of a scientific committee to prioritize data gaps on crop systems suitability for MAR, a group like this has not been convened, nor is it likely to be needed at this time as growers have been willing to pilot Flood-MAR projects on a variety of crops without this research.

Crop Systems Suitability-3: Develop a decision support tool to determine crop suitability for Flood-MAR.

The evaluation concludes that this action is complete.

- DWR's Integrated Water Flow Model Demand Calculator (IDC) and Sustainable Conservation's crop compatibility calendar may be considered decision support tools, as well as GRAT. The IDC is described in detail as part of the Merced Watershed Study.

- A UC Davis research lab, led by Professor Helen Dahlke, also developed a crop compatibility worksheet.

During evaluation engagement, it was noted that the need for a decision support tool has diminished, since growers are already actively implementing MAR projects and sharing best practices with one another.

6.0 Soil, Geology, and Aquifer Characterization

For recharge to happen, water must migrate through the soil surface and travel into and through the aquifer system. Therefore, underlying geology and depth to groundwater are important characteristics to assess for potential recharge areas. According to the 2018 Flood-MAR White Paper, an essential part of augmenting recharge will be the improved characterization of the subsurface, which dictates where, how, and how fast, groundwater exits and enters aquifer systems. Flood-MAR projects are optimized when the best recharge areas can be identified and used, and the outcome of recharge for supporting intended benefits can be realized. The most current and best available data and information about California's groundwater basins is needed to help local communities and project implementers better understand their aquifer systems and to support local and statewide groundwater management.

The Soil, Geology, and Aquifer Characterization Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and 20 subject-matter experts, representing state and federal agencies, NGOs, and academia.

6.1 Summary of Priority Actions

The Soil, Geology, and Aquifer Characterization RAC Subcommittee identified and defined three priority actions, as follows in Table 6-1.

Table 6-1. Soil, Geology, and Aquifer Characterization Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Soil, Geology, and Aquifer Characterization-1	Improve subsurface geologic data and provide greater accessibility to useable and better-quality data.	• Organize and consolidate existing data to better characterize subsurface geology and soils that define areas with high infiltration rates ideal for Flood-MAR recharge. • Use key data types such as drillers descriptive logs, borehole and surface (including airborne) geophysics, and core samples. • Rank data based on reliability.	$20 million	Over 5 years	DWR and academia
Soil, Geology, and Aquifer Characterization-2	Improve subsurface hydrologic data and provide greater accessibility to useable and better-quality data.	• Develop better characterization of subsurface hydrology data to define the spatial distribution of properties and groundwater levels needed to characterize anticipated rates of recharge and the local and regional consequences of recharge. • Gather well testing and laboratory core analyses data into an accessible database for Flood-MAR and SGMA. • Expand groundwater level data for four-dimensional mapping to determine the subsurface "space" available for recharge and the system's response to recharge and pumping.	$10 million	10 years	DWR and State Water Board
Soil, Geology, and Aquifer Characterization-3	Synthesize hydrogeologic data to identify the best locations for recharge.	• Use soils and subsurface geologic and hydrologic data to: – Define the geologic history and framework. – Characterize the architecture of aquifers and aquitards and estimate their properties.	$20 million	10 years	DWR, State Water Board, LCI, and academia

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
		– Identify the best locations for recharge by combining subsurface hydrogeologic data with soils data. • Establish a new policy to create a subsurface characterization team within an agency. This team will be responsible for collecting, curating, and hydrogeologically interpreting (mapping) subsurface aquifer and non-aquifer sediments/ rocks.			

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: DWR = California Department of Water Resources; Flood-MAR = flood-managed aquifer recharge; LCI = California Governor's Office of Land Use and Climate Innovation; SGMA = Sustainable Groundwater Management Act; State Water Board = State Water Resources Control Board

6.2 Evaluation of Progress

Soil, Geology, and Aquifer Characterization-1: Improve subsurface geologic data and provide greater accessibility to useable and better-quality data.

The evaluation concludes that this action is in progress.

- DWR has advanced this priority action through its Basin Characterization Program, including collection of new data, review of existing data, and integration of both in the SGMA Data Viewer, which is the most comprehensive, accessible repository for subsurface geologic data at the state level. DWR's Basin Characterization Program webpage also provides context for how to apply the available data to identify areas for recharge.

- DWR compiled, digitized, and performed a quality assurance/quality check of available lithologic and geophysical logs, performed an analysis to evaluate the reliability of those lithologic and geophysical data, and incorporated this information into the basin characterization category of the SGMA Data Viewer. DWR has also installed approximately 150 new monitoring wells across the state for the purpose of filling data gaps.

- DWR conducted airborne electromagnetic (AEM) surveys for each of the high- and medium-priority groundwater basins in the state and developed data viewers on the California Natural Resources Agency Open Data Portal.

- AEM and AEM surficial recharge maps—as well as geologic, lithologic, and geophysical data—are integrated into the basin characterization category of the SGMA Data Viewer. Greater synthesis of these data sources will be included in the ongoing Basin Characterization Program.

Soil, Geology, and Aquifer Characterization-2: Improve subsurface hydrologic data and provide greater accessibility to useable and better-quality data.

The evaluation concludes that this action is in progress, but not yet complete. Because geologic and hydrologic data are being tackled in tandem, many of the resources provided under the previous priority action apply here as well.

- Data accessibility has greatly improved through the SGMA Data Viewer and California Natural Resources Agency Open Data Portal (as described above under Soil, Geology, and Aquifer Characterization-1).

- Enhancements to the California Central Valley Groundwater-Surface Water Simulation ("C2VSim") model are in progress, using new subsurface information to provide more useful information related to recharge.

- DWR is working to integrate available datasets to generate publicly accessible analysis tools, which can be used to create 3-D texture models, hydrostratigraphic models, and aquifers flow parameters, which are all components of a groundwater flow model. This information can be used to estimate the space available for recharge.

- DWR's statewide monitoring network enhancement program is enhancing the state's data collection, management, and dissemination of groundwater level, land subsidence, and water quality data.

- In addition to DWR's technical support services, which have established 150 new monitoring wells, DWR's regional offices are working to install telemetry in over 100 new or existing monitoring sites.

Soil, Geology, and Aquifer Characterization-3: Synthesize hydrogeologic data to identify the best locations for recharge.

The evaluation concludes that this action is in progress, but not yet complete.

- DWR is leading basin characterization pilots in Pajaro and Upper San Joaquin to develop aquifer recharge potential maps, for different recharge methods. It is anticipated that an outcome of the pilots would be a vetted process for developing aquifer recharge potential maps, that can then be applied in various geographies.

California Water Code Section 12924 directs DWR to conduct groundwater basin characterization and is the basis for DWR's reestablishment of their Basin Characterization Program. A new policy, as indicated in the priority action, to create a subsurface characterization team within an agency is not needed.

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7.0 Land Use Planning and Management

Current or proposed land use is an important consideration for determining the suitability of potential recharge areas. Therefore, aligning land use planning with groundwater recharge is essential. Better connection with land use planning could ensure that selected recharge areas will remain available for recharge, rather than being converted to uses that discourage or reduce recharge opportunities. Recharge areas should also be protected to prevent pollutants from entering the groundwater. As there is local authority over land use planning, recharge activities need to be coordinated and consistent with local general planning and other local land using planning efforts. The 2018 Flood-MAR White Paper outlines the need for water and flood managers to work with local land use planners to protect watersheds and recharge areas. During evaluation engagement, attendees mentioned examples that illustrate the loss of high-value recharge areas to development (particularly in Sacramento County), underscoring the need for stronger planning protections.

The Land Use Planning and Management Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and 11 subject-matter experts, representing state and local agencies, associations, NGOs, and academia.

7.1 Summary of Priority Actions

The Land Use Planning and Management RAC Subcommittee identified and defined three priority actions, as follows in Table 7-1.

Table 7-1. Land Use Planning and Management Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Land Use Planning Management-1	Document coordination and communication methods occurring between GSAs and land use planning agencies to develop best practices.	• Conduct surveys to document current coordination methods between GSAs and land use agencies and how GSAs are considering local general plans in their GSP process. • Identify a transferable/ scalable a model for collaboration and lessons learned to determine how similar processes could be implemented elsewhere.	$200,000	8 months	DWR
Land Use Planning Management-2	Identify sources of funding for integrated planning efforts and groundwater management.	• Identify sources of funding for integrated planning efforts and determine application for incentivizing incorporation of Flood-MAR into general plans. • Determine the extent the integrated regional water management programs or similar integrated planning efforts could be used to improve incorporation of Flood-MAR in land use planning.	$50,000	3 months	DWR and LCI
Land Use Planning Management-3	Develop protocol for data consistency.	• Develop standard data sets and protocols for all planning documents to ensure that general plans, GSPs, and other planning efforts use consistent data in relation to Flood-MAR. • As data is collected, standards for data quality assurance/ quality control should be applied before the data is incorporated into plans.	$500,000	8 months	LCI, State Water Board, DWR, academia, private sector, GSAs

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: DWR = California Department of Water Resources; Flood-MAR = flood-managed aquifer recharge; GSA = groundwater sustainability agency; GSP = groundwater sustainability plan; LCI = California Governor's Office of Land Use and Climate Innovation; State Water Board = State Water Resources Control Board

7.2 Evaluation of Progress

Land Use Planning and Management-1: Document coordination and communication methods occurring between GSAs and land use planning agencies to develop best practices.

The evaluation concludes that this action is in progress, but not yet complete. To the knowledge of those engaged for this evaluation, documentation of best practices has not occurred; however, coordination and communication between GSAs and local land use planning agencies is happening to varying degrees across the state. Additionally, multiple proximate topics were shared during engagement, as described below.

- GSPs are publicly noticed for adoption and provided for review at the local level for consideration in city and county general plans. The degree of awareness varies by locality, as some municipalities work closely with the GSAs in their jurisdictions. A survey has not been conducted to evaluate the degree to which GSP considerations are being incorporated into general plans.

- The California Governor's Office of Land Use and Climate Innovation (LCI; formerly the California Governor's Office of Planning and Research) is developing revised guidance for general plans that will include information on the consideration of GSPs.

- The San Joaquin Valley Water Collaborative Action Program and organizations participating in the Water Blueprint for the San Joaquin Valley are considering strategies to best transition lands where groundwater overdraft far exceeds recharge potential in the San Joaquin Valley, where some land transition will be necessary to achieve groundwater sustainability.

- Added to California Water Code in 2023, Section 1242.1 requires local or regional agencies to adopt a local plan of flood control pursuant to Section 8201 or consider flood risk as part of the most recently adopted general plan in order to divert floodflows for groundwater recharge. Many local and regional agencies are evaluating the need to update their general plans to make diversions. This water code also describes other requirements for making diversions of floodflows for groundwater recharge without a water right. The State Water Board maintains information on 1242.1 diversions.

Land Use Planning and Management-2: Identify sources of funding for integrated planning efforts and groundwater management.

The evaluation concludes that this action is in progress, but not yet complete. Although funding programs that are either directly or indirectly relevant to Flood-MAR have been established, there is no clearinghouse or other resource that helps match prospective

project implementors with appropriate funding. Examples of existing funding programs are provided below.

- The Department of Conservation's Multibenefit Land Repurposing Program issues block grants that focus on increasing regional capacity to repurpose agricultural lands to reduce reliance on groundwater, while providing community and ecosystem benefits. The program relies on close coordination between GSAs and local planning agencies.

- DWR's Land*Flex* program issues block grants to GSAs in critically overdrafted basins with allocation plans in place, to partner with growers to reduce agricultural groundwater use.

Land Use Planning and Management-3: Develop protocol for data consistency.

The evaluation concludes that this action is in progress, but not yet complete. Activities include:

- DWR's Sustainable Groundwater Management grant programs developed a groundwater recharge methods document to guide standard monitoring practices for a variety of recharge-related activities. This document may be utilized as a point of reference for data consistency in land use planning documents.

- The Sustainable Groundwater Management Office developed protocols for planning documents as part of their responsibility to review and determine the adequacy of GSPs.

- In the GSP Regulations developed by the Sustainable Groundwater Management Office in May 2016 there are procedures for determining the adequacy of GSPs and the periodic evaluations of GSPs. The GSP Regulations require a description of the land use elements or topic categories of applicable general plans.

- The Sustainable Groundwater Management Office developed *A Guide to Annual Reports, Periodic Evaluation, and Plan Amendments* in October 2023 to provide guidance to GSAs preparing Annual Reports, Periodic Evaluations, and GSP Amendments for GSP implementation and compliance with SGMA and the GSP Regulations.

As stated above, California Water Code Section 1242.1 requires local or regional agencies to adopt a local plan of flood control pursuant to Section 8201 or consider flood risk as part of the most recently adopted general plan in order to divert floodflows for groundwater recharge. DWR is currently providing technical and planning assistance to local agencies. A component of this assistance will be a template and guidance for considering flood risk in general plans. Related mitigation planning guidance is also

provided by California Office of Emergency Services and the Federal Emergency Management Agency.

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8.0 Water Quality

Flooding recharge areas may mobilize surface or soil pollutants from current or past land uses, thus contaminating aquifers. Increasing recharge may also further spread groundwater contaminated plumes by altering the rate and direction of groundwater flows. It is anticipated that these potential adverse water quality changes would be short-term and localized, followed by longer-term benefits to the region as a result of diluting the contaminants. Work is still needed to better understand the impacts that managed recharge may have on groundwater quality.

The Water Quality Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and 28 subject-matter experts, representing local, state, and federal agencies, NGOs, academia, and technical consultants.

8.1 Summary of Priority Actions

The Water Quality RAC Subcommittee identified and defined three priority actions, as follows in Table 8-1.

Table 8-1. Water Quality Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Water Quality-1	Develop a web-based platform to allow public access to a compilation of all existing knowledge identified by the Water Quality Subcommittee.	• Compile all existing knowledge of research, data, guidance, and tools into an easily accessible database or web-based platform.	$1 million	1 year	DWR, Academia
Water Quality-2	Develop better knowledge of water quality issues (sources, conveyance, land use and land use history, naturally occurring contaminants) related to Flood-MAR design and implementation.	Implement research initiatives to increase understanding of and develop tools to assess: • Water quality impacts associated with: – Different water sources (e.g., streams with/ without reservoirs, various watershed characteristics, stormwater runoff and turbidity) – Conveyance systems (e.g., algicide accumulation in canals, turbidity increases with different conveyance systems based on soil type). • Potential land characteristics (e.g., land use, soils, land management practices, site grading) that enable receiving lands to handle Flood-MAR for appropriate water quality (e.g., turbidity, pathogens, chemicals). • Cost-benefit analyses of various practices. • Water quality issues related to past and current land practices in the recharge area including but not limited to: – crop selection, – past and current nutrient and pesticide management (in agricultural landscapes), – toxic substances (in urban stormwater landscapes).	$20 million	10 years	Academia

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
		• Potential water quality impacts to the vadose zone and receiving aquifer from legacy contaminants and naturally occurring contaminants. • Understanding of the relationship between healthy soils (carbon sequestration) and recharge water quality (e.g., denitrification). • Methods to assess areas that lack water quality and geochemistry data. • Better understanding of trade-offs between generation/ mobilization of uranium, arsenic, manganese, and denitrification, geochemical evolution of vadose zone and groundwater, and affected wells and streams. • Clarification of the State Water Board's antidegradation policy within the Flood-MAR context.			
Water Quality-3	Develop guidance and multi-criteria decision-making tools to address water quality issues in Flood-MAR projects.	• Develop guidance and a multi-criteria decision analysis matrix tool that includes weighting values for several important to critical factors related to water quality concerns for Flood-MAR projects. • The tool should allow users to conduct a site-specific suitability analysis of their location for Flood-MAR. • The tool could also be used to evaluate potential sites on a state-wide scale.	$1 million	2 years	DWR, State Water Board, CDFA, LCI, academia

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: CDFA = California Department of Food and Agriculture; DWR = California Department of Water Resources; Flood-MAR = flood-managed aquifer recharge; LCI = California Governor's Office of Land Use and Climate Innovation; Strate Water Board = State Water Resources Control Board

8.2 Evaluation of Progress

Water Quality-1: Develop a web-based platform to allow public access to a compilation of all existing knowledge identified by the Water Quality Subcommittee.

The evaluation concludes that this action is in progress, but not yet complete.

- During evaluation engagement, it was suggested that the best and most consistent dataset for groundwater quality is the State Water Resources Control Board's (State Water Board) Groundwater Ambient Monitoring and Assessment program, which is carried out in collaboration with the U.S. Geological Survey.
- Much academic research has been focused on water quality during managed recharge. Some resources have been uploaded to the Flood-MAR Network Hub's Resources tab; however, because it is a crowd-sourced site, it would be difficult to assess whether the repository is comprehensive.
- The State Water Board's Safe, Affordable Funding for Equity and Resilience (SAFER) platform may also meet this need, in part.

Water Quality-2: Develop better knowledge of water quality issues (sources, conveyance, land use and land use history, naturally occurring contaminants) related to Flood-MAR design and implementation.

The evaluation concludes that some elements of this activity are complete, while some elements have not been undertaken or were not able to be confirmed.

- Work is currently underway by DWR, the State Water Board's GAMA Program, LCI, and nonprofits to determine whether it is possible to assess risk to water quality from recharge using the current, publicly available data, using recharge that occurred in Water Year 2023 as a case study. If public data is not sufficient, this work will also determine what it would take to develop that functionality.
- Sustainable Conservation developed a white paper/literature review that summarizes research on potential mobilization of nitrate and salts under on-farm recharge practices and presents field-scale and regional-scale considerations to protect water quality for communities. They also developed a guidance document for growers on the topic of protecting groundwater quality during recharge, that focuses on nitrate management in connection to agricultural lands.
- The Flood-MAR Network's Water Quality Action Team is preparing a document that is anticipated to include discussion of potential water quality impacts from Flood-MAR, including Uranium, Arsenic, 1,2,3-TCP, biological, and other contaminants. That paper is also expected to include an outline of further

research that is needed to improve understanding around those potential contaminants.

- A Water Quality and Recharge Technical Advisory Committee (TAC) has been convened by DWR and partners to: 1) Outline what is known about the effects of recharge on drinking water quality and identify gaps in knowledge and data needed to fill those gaps; 2) Arrive at general agreement regarding which site level criteria affecting water quality risk can be used to inform MAR decision making, with consideration of the relative importance and interaction of the selected criteria; and 3) Identify the next steps needed for the development of a tool to make more informed managed aquifer recharge (MAR) decisions. The TAC will advise on the development of a white paper outlining the steps needed to create a geospatial tool that highlights where applied water is most likely to improve or maintain water quality and where recharge should be avoided.

- Work has been proposed to conduct additional research to better understand the relationship between healthy soils and recharge water quality (e.g., carbon sequestration, denitrification); develop guidance on the distance from undesirable sites that recharge should occur (e.g., Superfund sites, landfills); and improve groundwater quality monitoring in domestic wells.

- Research on water quality impacts associated with different water or conveyance sources and cost/benefit analyses of various Flood-MAR practices have either not occurred or are not known.

Water Quality-3: Develop guidance and multi-criteria decision-making tools to address water quality issues in Flood-MAR projects.

The evaluation concludes that this action is in progress, but not yet complete.

- Research to identify optimal locations for recharge in the state has been developed at UC Davis.

- The Flood-MAR Network Water Quality Action Team document (under development) may also include guidance considerations.

- As stated above, a Water Quality and Recharge TAC has been convened to identify the next steps needed for the development of a geospatial tool that highlights where applied water is most likely to improve or maintain water quality and where recharge should be avoided.

- Improved regional groundwater quality monitoring, as occurring in pilot studies and programs mentioned in Water Quality priority #2, could help with tracking the risks and/or benefits achieved by recharge and support multi-criteria decision-making.

During evaluation engagement, coordination with affected communities emerged as a critical component to incorporate into decision-making tools. Additionally, it was suggested that this action could be considered a prerequisite to the third People and Water priority action.

9.0 Recharge and Extraction Methods and Measurement

There are three primary methods for recharging groundwater: (1) active or intentional recharge using engineering practices through direct spreading or aquifer injection; (2) in-lieu recharge, which is generally accomplished by providing an alternative source of water to those who would otherwise use groundwater, thereby leaving that groundwater in place; and (3) passive or natural recharge where precipitation, surface water from rivers, streams, lakes, and wetlands, and runoff from rain events seeps into the ground and percolates down to the water table, replenishing aquifers. Flood-MAR typically leverages the capacity to directly spread water over large acreages of active agricultural land, fallowed land, working landscapes, managed natural lands, new or existing dedicated recharge basins, and open spaces. Groundwater is typically extracted from aquifers via groundwater extraction wells using pumps. There are numerous ways to measure both recharge and extraction. Accurate and comprehensive accounting of groundwater recharge and extraction (including the development of monitoring systems) is critical to track progress toward groundwater sustainability and build confidence in Flood-MAR as a management strategy.

The Recharge and Extraction Methods and Measurement Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and 14 subject-matter experts, representing local, state, and federal agencies, NGOs, and academia.

9.1 Summary of Priority Actions

The Recharge and Extraction Methods and Measurement RAC Subcommittee identified and defined three priority actions, as follows in Table 9-1.

Table 9-1. Recharge and Extraction Methods and Measurement Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Recharge and Extraction Methods and Measurement-1	Compile existing managed aquifer recharge projects and associated data.	• Develop a compilation of both the academic basics related to groundwater recharge (e.g., soil suitability) and the practical knowledge gained by those that have undertaken such projects.	$100,000	6 months	Academia, DWR
Recharge and Extraction Methods and Measurement-2	Compile pertinent information to determine the efficiency of managed aquifer recharge projects.	Compile: • On-farm water-delivery measurement tools and methods, • Methods of determining appropriate loss factors (e.g., evapotranspiration), and • Recommendations regarding appropriate groundwater monitoring to determine the efficiency of managed aquifer recharge projects.	1 year	$200,000	DWR, Academia
Recharge and Extraction Methods and Measurement-3	Establish methods and considerations by which floodplains can be used as direct recharge sites and in conjunction with other recharge methods.	• Compile available data and develop methods, analysis, and recommendations for practitioners to understand the site conditions that would make existing or potential floodplains ideal for groundwater recharge.	1 year	$200,000	Academia, NGOs, DWR

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: DWR = California Department of Water Resources

9.2 Evaluation of Progress

Recharge and Extraction Methods and Measurement-1: Compile existing managed aquifer recharge projects and associated data.

The evaluation concludes that this action is in progress.

- The Flood-MAR Network Hub's Projects tab includes a repository of self-reported MAR projects.
- DWR launched a Projects and Management Actions module in 2024 that will be incorporated into the existing SGMA portal and regularly updated to demonstrate individual groundwater basins and subbasins' progress toward SGMA implementation, including benefits achieved from recharge projects.
- DWR's Semi-Annual Update on California's Groundwater Conditions from Spring 2024 compiled information about recharge projects that occurred from 2019 through 2023, based on GSP annual reporting.
- Sustainable Conservation compiled a series of case studies into a practical manual of on-farm recharge methods.
- California Groundwater Bulletin 118 Update 2025 (currently in development) will report on recharge projects.

Recharge and Extraction Methods and Measurement-2: Compile pertinent information to determine the efficiency of managed aquifer recharge projects.

The evaluation concludes that this action is in progress, but not yet complete.

- During evaluation engagement, it was suggested that it will take time to demonstrate the effectiveness and efficiency of recharge projects; however, GSAs will be keen to demonstrate the success of these projects in annual reports and GSP periodic evaluations to show progress toward achieving GSP sustainability goals.
- A draft fact sheet is underway by the Flood-MAR Network Action Team on estimating recharge. It is anticipated that, once completed, this resource will be publicized on the Flood-MAR Hub website.

Recharge and Extraction Methods and Measurement-3: Establish methods and considerations by which floodplains can be used as direct recharge sites and in conjunction with other recharge methods.

The evaluation concludes that this action is complete.

- DWR has conducted Multiple Benefit Floodplain Restoration Studies to evaluate the benefits of increasing floodplain inundation for multiple benefits, including ecosystem enhancement, groundwater recharge, and flood risk reduction. To support these studies, DWR's consultant cbec eco-engineering developed the Ecological Floodplain Inundation Potential (Eco-FIP) tool to identify and analyze restoration opportunities and benefits, as well as develop project concepts and designs for specific sites.

10.0 Environment – Terrestrial and Riparian/Aquatic

The 2018 Flood-MAR White Paper outlines ways that Flood-MAR can provide ecosystem benefits by reconnecting and inundating floodplains, creating floodplain habitat (e.g., riparian), marsh, and wetlands; supplementing baseflows; and supporting groundwater dependent ecosystems through increased baseflow resulting from higher groundwater levels. Factors that contribute to ecosystem and habitat enhancement potential are land use, proximity and connectivity to the river, timing of recharge flows, and duration of flooding. Seasonal flooding of land can also boost food productivity to support aquatic and terrestrial species (e.g., insects, zooplankton). Recharging groundwater supplies also has the potential to provide ecosystem benefits by boosting instream baseflow or reducing surface water temperature through surface and groundwater interactions. Groundwater may also be used to support environmental water accounts that use water stored in the ground during wetter periods to help increase instream flows during drier seasons or years (via groundwater extraction or in-lieu use).

The Environment – Terrestrial and Riparian/Aquatic Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and 45 subject-matter experts, representing local, state, and federal agencies, NGOs, academia, water district associations, and consultants.

10.1 Summary of Priority Actions

The Environment – Terrestrial and Riparian/Aquatic RAC Subcommittee identified and defined three priority actions, as follows in Table 10-1.

Table 10-1. Environment – Terrestrial and Riparian/Aquatic Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Environment – Terrestrial and Riparian/ Aquatic-1	Develop a tool to calculate groundwater recharge that occurs when floodplains are inundated	• Develop a tool to calculate groundwater recharge that occurs when floodplains are inundated. • This tool could be used to quantify the groundwater benefit of flooding that provides habitat for fish and wildlife.	$100,000	6 months	Academia, NGOs, private sector
Environment – Terrestrial and Riparian/ Aquatic-2	Develop a map that prioritizes Flood-MAR based on the additional habitat benefits that can be achieved at certain sites.	• Integrate Soil Agricultural Groundwater Banking Index-type tools with maps of habitat potential, groundwater dependent ecosystems, and other environmental information to identify opportunities for implementing Flood-MAR and achieving other environmental outcomes.	$500,000	1 year	Academia, NGOs, private sector
Environment – Terrestrial & Riparian/ Aquatic-3	Map subsurface geology of floodplains to identify areas with the greatest potential for deep aquifer recharge.	• Conduct studies similar to work from Stanford's Center for Groundwater Evaluation and Management to map below-ground reservoirs to support groundwater sustainability planning for the Tulare Irrigation District. Similar mapping would be valuable across the entire floodplain of the San Joaquin River to identify the magnitude of groundwater deficit supporting baseflows during dry years.	5 years	$2 million	Academia, NGOs, private sector

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: Flood-MAR = flood-managed aquifer recharge

10.2 Evaluation of Progress

Environment – Terrestrial and Riparian/Aquatic-1: Develop a tool to calculate groundwater recharge that occurs when floodplains are inundated

The evaluation concludes that this action is complete.

- The Eco-FIP tool includes methods to calculate groundwater recharge that occurs from floodplain inundation, including high level opportunity analyses based on hydrologic soil groups, electromagnetic surveys, and integration with existing groundwater models. Those methods were piloted in DWR's Multibenefit Floodplain Restoration Studies.

Environment – Terrestrial and Riparian/Aquatic-2: Develop a map that prioritizes Flood-MAR based on the additional habitat benefits that can be achieved at certain sites.

The evaluation concludes that this action is complete for select pilot study locations.

- As part of DWR's multibenefit floodplain restoration studies, a Tier 1 Eco-FIP analysis can be conducted at the reach-scale to identify areas that could be inundated under certain flow conditions to improve habitat and increase recharge. The studies included an investigation of salmonid rearing and riparian habitats, where the Eco-FIP toolset could be modified with additional information about different habitat benefits. Tier 1 maps are available for each study location.

Environment – Terrestrial and Riparian/Aquatic-3: Map subsurface geology of floodplains to identify areas with the greatest potential for deep aquifer recharge.

The evaluation concludes that this action is in progress, but not yet complete.

- AEM surveys have been conducted along all major waterways in the state.

DWR is leading basin characterization pilots in the Pajaro and Upper San Joaquin watersheds to develop aquifer recharge potential maps for different recharge methods. It is anticipated that an outcome of the pilots would be a vetted process for developing aquifer recharge-potential maps that can then be applied in various geographies. Survey information and recharge mapping should be available in 2025.

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11.0 People and Water

Much of California's Central Valley, where Flood-MAR is expected to play a significant role in flood protection and water supply reliability, is characterized by small, rural, and often disadvantaged communities. The People and Water Subcommittee adopted a perspective that the effort to increase the use of Flood-MAR would have impacts on communities. Following the principles of environmental justice, the Subcommittee prioritized actions that would increase opportunities for people living in Flood-MAR practice areas to have roles in decisions about research, investigations, and ultimately, project implementation.

The People and Water Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and nine subject-matter experts, representing state agencies, NGOs, academia, and consultants.

11.1 Summary of Priority Actions

The People and Water RAC Subcommittee identified and defined three priority actions, as follows in Table 11-1.

Table 11-1. People and Water Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
People and Water-1	Develop an ethical and just framework specifically focused on the Flood-MAR program.	• Incorporate the principles of a Water Ethics Framework and Research Justice into all aspects of Flood-MAR research and implementation strategies to ensure Flood-MAR projects do not have unjust conditions and impacts across all social communities.	$1 million	2 Years	Academia, NGO
People and Water-2	Develop an engagement best practices document for Flood-MAR.	• Summarize existing information from the Tribal policy-advisor and disadvantaged communities involvement programs, and those identified in local, regional, state, and federal planning processes, for engaging community members in Flood-MAR actions. • Create a best practices document that summarizes the specific, actionable tools currently being used.	$1 million	2 years	DWR
People and Water-3	Document areas most feasible for recharge with disadvantaged communities that are groundwater dependent and would greatly benefit from Flood-MAR actions.	• Document areas that are groundwater dependent and face water shortages caused by neighboring community withdrawals or legacy groundwater contamination. • Develop a ranking of communities that are highly dependent on and could potentially benefit the most from Flood-MAR.	$250,000	1 year	DWR

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: DWR = California Department of Water Resources; Flood-MAR = flood-managed aquifer recharge

11.2 Evaluation of Progress

People and Water-1: Develop an ethical and just framework specifically focused on the Flood-MAR program.

The evaluation concludes that this activity has not been started. During engagement, it was shared that this action was predicated on supporting extensive research initiatives (National Science Foundation-funded) that had been proposed by academic partners within the RAC, which to-date has not been undertaken.

People and water-2: Develop an engagement best practices document for Flood-MAR.

The evaluation concludes that this activity has not been started. Although a Flood-MAR-specific engagement document has not been developed, analogous engagement tools have been prepared by DWR in the context of SGMA (Guidance on Engaging and Communicating with Underrepresented Groundwater Users and Communication and Engagement Toolkit).

People and water-3: Document areas most feasible for recharge with disadvantaged communities that are groundwater dependent and would greatly benefit from Flood-MAR actions.

The evaluation concludes that some elements of this action are complete, while some elements have not been undertaken. For example, communities that are highly dependent on groundwater and could potentially benefit most from Flood-MAR have not been ranked. Complete activities include:

- DWR's Sustainable Groundwater Management Office developed a guidance document with considerations for identifying and addressing drinking-water well impacts, to support the implementation of GSP projects and management actions that could be used to identify areas that would most benefit from Flood-MAR actions.
- DWR's Water Shortage Vulnerability Evaluation tool (developed to support Senate Bill 552 implementation) evaluates an area's vulnerability to water shortage and is useful for drought resilience planning at the county level.
- The SGMA Data Viewer includes a layer for viewing reported dry wells, which could be an indication that a community is groundwater dependent and at risk for water shortages.
- The State Water Board's Drinking Water Needs Assessment may also provide insights on communities most at risk to water shortage.

- Sustainable Conservation has developed information about disadvantaged communities located near recharge areas that could be used to create a guidance document or decision-support tool with the capability to identify areas that are ill-suited for recharge and what precautions are needed for infiltration of runoff from particular land-use types. (e.g., located near landfills, Superfund sites).

During evaluation engagement, it was noted that some advocates and community members feel this priority action did not adequately address concerns related to groundwater quality. In the intervening years, there have been worries expressed that additional recharge could either contribute to, or mobilize existing groundwater contaminants, potentially leading to unsafe groundwater resources for communities. A reframing of this action that acknowledges ongoing water quality injustices and explores how recharge can be implemented safely—possibly in concert with wellhead treatment—may be necessary.

12.0 Economic Analysis

Economic analysis is integral to the successful implementation of Flood-MAR because it enables decision-makers, project proponents, and community stakeholders to navigate the financial, institutional, and social complexities of groundwater recharge initiatives. By identifying, quantifying, and comparing the full range of both direct and indirect costs and benefits, economic analysis provides a solid foundation for informed policy and investment decisions. These costs and benefits include upfront capital expenses for infrastructure, ongoing operations and maintenance, and the broader economic gains derived from reliable groundwater supplies, increased water storage, reduced land subsidence, and enhanced ecosystem services.

By conducting rigorous economic evaluations, practitioners can quantify the monetary value of public benefits—such as flood protection, improved water quality, and habitat restoration—while also estimating cost savings from avoided damage due to subsidence or flooding. These evaluations help determine fair compensation mechanisms for landowners who engage in recharge projects and guide the development of sustainable funding strategies (e.g., grants, incentives, or market-based programs). Such strategies encourage partnerships among diverse stakeholders, including State and federal agencies, nongovernmental organizations, private landowners, and local communities.

Beyond enumerating benefits and costs, economic analysis clarifies how Flood-MAR projects interact with California's complex water rights system. By examining legal, institutional, and market factors, analysts can identify potential barriers and propose solutions that ensure Flood-MAR is both economically viable and equitable. When combined with environmental and social assessments, economic analysis becomes a powerful tool for shaping policy, guiding strategic decisions, and fostering more resilient groundwater management practices across the State.

To ensure Flood-MAR is implemented at the pace and scale necessary for meaningful impact, pilot projects and feasibility studies must be employed to test and demonstrate both the benefits and potential impacts on local economies, ecosystems, and communities. A thorough understanding of the economic, environmental, institutional, and operational dimensions of Flood-MAR projects is essential for cultivating productive partnerships and securing multiple funding sources. In particular, a rigorous economic analysis framework is especially vital for:

- Evaluating the economic and financial benefits and costs of Flood-MAR projects.
- Determining the economic value of public benefits and avoided costs.
- Identifying landowner compensation mechanisms.

- Developing State incentive programs.
- Establishing consistent standards for economic evaluation, including how recharge is accounted for in economic returns.

The Economic Analysis RAC Subcommittee—composed of two co-chairs, a coordinator, and 10 subject-matter experts from State and federal agencies, nongovernmental organizations, academia, and consulting firms—developed key priority actions for implementing Flood-MAR as part of the R&DD Plan. The three key priority actions to address the financial, institutional, and legal hurdles associated with implementing Flood-MAR projects across California. These actions focus on developing standardized economic guidelines, establishing incentives, and clarifying groundwater rights and market considerations. By building robust, equitable, and transparent economic decision-making frameworks, stakeholders can more effectively evaluate the costs and benefits of Flood-MAR, encourage widespread participation through financial and policy incentives, and navigate the complex legal structures of California's water rights system.

12.1 Summary of Priority Actions

The Economic Analysis RAC Subcommittee identified and defined three priority actions, as follows in Table 12-1.

Table 12-1. Economic Analysis Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Economic Analysis-1	Develop an economic analysis guidance document for groundwater recharge projects.	• Develop an economic analysis guidance document to provide practitioners, decision-makers, analysts, and other stakeholders a set of guidelines, standard procedures, and methods for conducting financial and socioeconomic analyses. • This guidance document should have statewide, regional, and local application.	$250,000	2 years	New Task Force
Economic Analysis-2	Evaluate economic and other incentives for Flood-MAR implementation.	• Identify and evaluate funding sources and incentives to establish landowner compensation programs and finance the implementation of Flood-MAR.	$200,000	2 years	Economic Analysis Subcommittee
Economic Analysis-3	Assess groundwater ownership rights and market issues associated with Flood-MAR.	• Develop a model of groundwater rights and surface/ subsurface water transactions to better understand the benefits and costs of Flood-MAR projects.	$200,000	2 years	Economic Analysis Subcommittee

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: Flood-MAR = flood-managed aquifer recharge

12.2 Evaluation of Progress

Economic Analysis-1: Develop an economic analysis guidance document for groundwater recharge projects.

The evaluation concludes that this activity has not yet been initiated. However, several ongoing or completed studies may provide useful starting points:

- DWR conducted benefit-cost analyses for Flood-MAR projects in the DWR SJR watershed studies and Multiple Benefit Floodplain Restoration Studies.
- Existing economic analysis guidance documents offer an array of economic analysis tools and methodologies that can inform watershed management and multi-benefit water resource projects, including managed aquifer recharge. By presenting innovative approaches and case studies, they address integrated water management and infrastructure solutions that may be relevant to Flood-MAR in terms of effectiveness, efficiency and equity. These guidance documents include:
  - The Technical Reference document prepared for the California Water Commission's Proposition 1 Water Storage Investment Program.
  - DWR's Handbook for Assessing Value of State Flood Management Investments.
  - The draft Economic Analysis Guidebook for Watershed Management and Multi-benefit Planning (in development at DWR).
- During the plan evaluation and engagement with the co-chairs, two major concerns emerged:
- Existing economic guidance may not be sufficiently aligned with current Flood-MAR contexts, particularly given evolving climate realities, emerging equity considerations, and the rapid development of recharge technologies.
- Co-chairs shared the need for updating benefit-cost analyses and additional funding to undertake thorough economic studies. Without adequate financial resources, it is difficult to produce or maintain robust, evidence-based guidance that resonates with today's hydrologic, regulatory, and market conditions.
- Moving forward, the creation of a dedicated, updated guidance document remains a priority for the co-chairs to effectively evaluate and optimize Flood-MAR investments across California. Drawing on lessons from prior studies and existing frameworks can help ensure that new guidance is both technically sound and responsive to the latest challenges in groundwater management.

Economic Analysis-2: Evaluate economic and other incentives for Flood-MAR implementation.

The evaluation concludes that this action is in progress, but remains incomplete. Several initiatives underscore ongoing efforts:

- DWR and Sustainable Conservation jointly developed a document outlining potential incentives for Flood-MAR.
- A Flood-MAR Network Incentives Action Team convenes regularly to explore and refine incentive structures, financing models, and funding sources that can support Flood-MAR projects across California.

While these activities represent important strides, co-chairs indicated that further action is needed to fully realize Flood-MAR's multi-benefit potential. In particular, opportunities for further action include:

- Develop comprehensive methodologies to quantify economic, social, and environmental benefits of Flood-MAR. By clearly articulating these benefits, the case for robust incentive mechanisms —such as landowner compensation programs—can be strengthened, helping to secure additional funding for broader implementation.
- Utilize the insights from detailed benefit assessments to design tailored incentives that reflect the full spectrum of Flood-MAR benefits. This includes exploring market-based instruments, grants, and other financial mechanisms that can drive stakeholder participation and project success.
- Foster stronger collaboration among policymakers, funding agencies, and local communities. By integrating feedback from diverse stakeholders, the development of incentive structures can be more responsive to on-the-ground needs and aligned with the broader goals of groundwater sustainability.

By advancing these further actions, policymakers and project proponents will be better equipped to design, prioritize, and advocate for Flood-MAR initiatives. Such efforts will not only promote groundwater sustainability but also deliver a range of additional public benefits, reinforcing the overall value and impact of Flood-MAR projects in California.

Economic Analysis-3: Assess groundwater ownership rights and market issues associated with Flood-MAR.

The evaluation concludes that progress is underway: while existing water rights considerations are being integrated into analyses, a comprehensive review of market-related issues remains outstanding. Key points include:

- The DWR SJR watershed studies have incorporated existing water rights into their analyses of Flood-MAR opportunities. This integration is critical for understanding the legal and institutional context that influences project feasibility, resource allocation, and long-term sustainability.

- Market-related issues have not yet been thoroughly examined. Co-chairs indicated the need for robust analyses of trading mechanisms, valuation strategies, and potential barriers to market participation to fully harness the benefits of Flood-MAR. During plan evaluation engagement, it was suggested that the Environmental Defense Fund may have the latest information on market issues associated with Flood-MAR, offering a potential resource to guide further assessment.

In response to feedback received during the plan evaluation, it is recommended to rephrase this priority action by removing the reference to “ownership.” Under California law, water rights holders have a license or permit to put water to beneficial use, rather than owning the water outright. An updated phrasing might focus on “groundwater rights and market considerations” or “groundwater use permits and market issues.”

- To strengthen this priority action, co-chairs indicated that future efforts should include:

- Conduct comprehensive studies on trading mechanisms, water banking, credit trading, and long-term transfer options to understand the economic potential and challenges of Flood-MAR.

- Engage with regulatory agencies (e.g., the State Water Resources Control Board), local groundwater sustainability agencies, market experts, and organizations like the Environmental Defense Fund to integrate legal and market perspectives into Flood-MAR.

- Update guidelines to clearly define how Flood-MAR fits within California’s water rights structure, ensuring that legal frameworks are aligned with the evolving needs of groundwater management.

- Undertake a targeted literature review of groundwater rights and market issues associated with Flood-MAR, specifically tailored to California’s unique legal, regulatory, institutional, and market framework. This review should identify existing gaps, benchmark best practices, and provide a foundation for future policy and economic analysis.

By expanding market assessments and updating terminology to reflect California’s legal context, stakeholders can better leverage both water rights and market opportunities to advance Flood-MAR, ensuring that projects remain equitable, sustainable and legally sound.

13.0 Local, State, and Federal Policies and Legal Considerations

The passage of SGMA in 2014 provided an opportunity to modernize state policies related to the nexus between flood management, land use, groundwater management, and ecosystem enhancement. However, policy and legal challenges remain for local agencies looking to implement Flood-MAR projects. These challenges are described in the 2018 Flood-MAR White Paper.

The Local, State, and Federal Policies and Legal Considerations Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and 7 subject-matter experts, representing state agencies, NGOs, academia, and consultants.

13.1 Summary of Priority Actions

The Local, State, and Federal Policies and Legal Considerations RAC Subcommittee identified and defined three priority actions, as follows in Table 13-1.

Table 13-1. Local, State, and Federal Policies and Legal Considerations Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Local, State, and Federal Policies and Legal Considerations-1	Refine guidance and provide applicant assistance for beneficial use designations associated with recharge.	• Develop additional guidance for water right applicants requesting inclusion of "other" beneficial uses for non-extractive purposes of use, in the context of SGMA. • Conduct outreach and education and provide project-level assistance for applicants seeking to include non-extractive beneficial uses in their water right applications and change petitions. • Track early case studies of applications and change petitions that propose surface water recharge for non-extractive purposes and use lessons learned (plus input directly from applicants) to improve guidance over time.	$600,000	3 years	State Water Board, academia
Local, State, and Federal Policies and Legal Considerations-2	Provide guidance and support for water availability analyses and associated determinations for processing of water rights applications.	• Conduct education and outreach to water right applicants on the information needs to support a finding of unappropriated water available to supply a permit. • Provide project-specific support to applicants and their engineering consultants during the development of water availability analyses. • Evaluate protective flood flow metrics for inclusion in permit conditions.	$1.6 million	3 years	State Water Board

Local, State, and Federal Policies and Legal Considerations-3	Develop recommendations for environmental permitting refinements and permitting guidance for Flood-MAR project proponents and establish an interagency group (part of the Flood-MAR Network) to coordinate refined permit processes with entities seeking permits.	To clarify how project proponents should approach environmental permitting in Flood-MAR projects and support projects in obtaining permits, the following actions are recommended: • Convene an interagency subgroup of the Flood-MAR Network consisting of agencies with regulatory and decision-making authority over projects focused specifically on permitting. • Working from existing information, prepare a comprehensive list of primary laws, regulations, and associated permitting processes at all scales (local, county, state, and federal) that may apply to Flood-MAR projects in California, prioritizing the permits and specific issues the group will work on initially. • Examine the jurisdictional authorities and management capacities of the types of agencies that have formed GSAs and how those authorities and capacities would or would not support holding a programmatic permit for Flood-MAR. For areas where GSAs are not appropriate permit holders, identify what other agencies might be. • Analyze how federal, state, and local environmental permitting could be coordinated to facilitate implementation of Flood-MAR. • Develop recommendations geared to key decision-makers.	$900,000	3 years	State Water Board, CDFW, Policy Subcommittee, academia

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
		• Provide a forum that facilitates interagency legal and policy issue resolution as issues are identified or arise in the implementation of Flood-MAR projects.			

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: CDFW = California Department of Fish and Wildlife; Flood-MAR = flood-managed aquifer recharge; GSA = groundwater sustainability agency; SGMA = Sustainable Groundwater Management Act; State Water Board = State Water Resources Control Board

13.2 Evaluation of Progress

Local, State, and Federal Policies and Legal Considerations-1: Refine guidance and provide applicant assistance for beneficial use designations associated with recharge.

The evaluation concludes that some elements of this action are complete, while some elements have not been undertaken.

- The State Water Board developed a fact sheet with guidance on defining beneficial-use types for recharge.

- While most guidance has been for extractive uses, the State Water Board did approve a temporary change petition from the U.S. Bureau of Reclamation in 2023 that allowed flood flows released from the Friant Dam to be used to "improve the condition of groundwater basins within the Central Valley Project," which could be considered precedent setting for non-extractive uses. Further review of that change petition could be expanded to a case study.

The evaluation concludes that outreach, education, and project-level assistance for non-extractive beneficial uses has not been conducted.

Local, State, and Federal Policies and Legal Considerations-2: Provide guidance and support for water availability analyses and associated determinations for processing of water rights' applications.

The evaluation concludes that this action is complete.

- The State Water Board released guidance on streamlined processing for groundwater recharge water rights. The process includes two options for conducting simplified water availability analyses, based on either a 90th-percentile daily flow or threat of flood conditions. DWR and State Water Board staff have provided project-specific technical support to local applicants to conduct water availability analyses and complete temporary water rights' applications.[2] At least two workshops have been conducted by the State Water Board with water rights' applicants. Additionally, one-on-one technical assistance support has been provided numerous times.

- DWR has developed a San Joaquin Valley Flood-MAR Dashboard, which is currently online for beta testing by local agencies. The tool assists local water

[2] DWR and State Water Board staff supported with the preparation of two temporary water rights applications in Winter 2023 and eight in Winter 2024.

managers in making diversions of floodflows for recharge under California Water Code Section 1242.1.

Local, State, and Federal Policies and Legal Considerations-3: Develop recommendations for environmental permitting refinements and permitting guidance for Flood-MAR project proponents and establish an interagency group to coordinate refined permit processes with entities seeking permits.

The evaluation concludes that some elements of this activity are complete, while some elements have not been undertaken.

- Environmental Science Associates prepared a comprehensive list of all laws, regulations, and permitting processes associated with implementing Flood-MAR projects.[3]

- The Governor's Executive Order N-4-23 temporarily suspended certain regulations to allow expedited recharge to occur.

The evaluation concludes that the following activities have not been started: formation of an interagency subgroup, examination of agency jurisdictional authority or management capacity, analysis of potential permit coordination, development of recommendations geared to decision-makers, and convening of a forum to facilitate interagency dialogue.

[3] This resource is available upon request from DWR.

14.0 Tool and Application Development

Reliable and relevant tools and applications are needed to provide useful information to Flood-MAR project planners and implementers to ensure they have the resources to make sufficient data-driven decisions. The ability to simulate, estimate, or predict the effectiveness of a given intervention—whether it be an agricultural, hydrologic/hydrogeologic, or environmental process that connects to water quality, policy, or partnering community considerations—is a necessary step toward quantifying costs and multibenefits. Developing more comprehensive tools and applications (particularly expanding the spatial and temporal coverage of existing resources) and leveraging those resources to develop decision-support tools will be useful for most of, if not all, the other research and data development topics.

The Tool and Application Development Subcommittee that developed the priority actions in the R&DD Plan consisted of two co-chairs, a coordinator, and 19 subject-matter experts, representing state and federal agencies, NGOs, academia, and consultants.

14.1 Summary of Priority Actions

The Tool and Application Development RAC Subcommittee identified and defined three priority actions, as follows in Table 14-1.

Table 14-1. Tool and Application Development Priority Actions from the R&DD Plan

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Tool and Application Development-1	Conduct cost/benefit analysis, including multi-benefit.	• Identify and fill gaps related to quantifying the costs and benefits of implementing Flood-MAR strategies. • Identify spatially explicit estimates on costs to implement (i.e., capital expenditures, plus any ongoing operating costs) across all Flood-MAR strategies and improve methods to estimate the benefit and impacts of actions along financial/ economic terms, including non-monetary considerations such as impacts on local communities, environmental/ ecological benefit, and other hydrological/ geological benefits consistent with avoiding the undesirables results stated in SGMA.	$850,000 – not inclusive of salaries for graduate students or research assistants	18 months	Tool and Application Development Subcommittee

Code	Priority Action	Description	Total Estimated Cost	Estimated Time to Complete	Potential Lead Entity(ies)
Tool and Application Development-2	Identify policy linkages and governance structure.	Identify gaps related to: • Defining the legal (e.g., California Water Code) and regulatory framework (e.g., water right permits) of Flood-MAR, • Its linkages with other regulations and policies (e.g., SGMA), and • The ability to simulate different policy (e.g., state incentives) and regulatory scenarios to define Flood-MAR governance structures for funding, implementation, operation, and coordination among individual landowners, irrigation districts, and multiple agencies (e.g., individual landowners versus groups of landowners), and alignment with California Water Code and water right permits.	$600,000 – not inclusive of salaries for graduate students or research assistants	18 months	Tool and Application Development Subcommittee
Tool and Application Development-3	Create decision support tools to integrate Flood-MAR disciplines.	• Link data inputs and outputs between tools, at comparable spatial/ temporal scale, so that independent tools and models that represent different functional aspects involved in a typical Flood-MAR project can be seamlessly integrated. • Create an integrated model to fully represent the system and to effectively share technical results in a manner that is accessible to decision-makers.	$950,000 – not inclusive of salaries for graduate students or research assistants	18 months	Tool and Application Development Subcommittee

Source: Adapted from 2019 Flood-MAR Research and Data Development Plan

Key: Flood-MAR = flood-managed aquifer recharge; SGMA = Sustainable Groundwater Management Act

14.2 Evaluation of Progress

Tool and application Development-1: Conduct cost/benefit analysis, including multibenefit.

The evaluation concludes that this action is in progress, but not yet complete. The following resources or entities may have conducted some amount of cost/benefit analysis related to Flood-MAR activities:

- GRAT
- Local agencies
- DWR SJR watershed studies
- Eco-FIP tool

During evaluation engagement, it was noted that many GSAs have included Flood-MAR in their GSPs. An analysis of GSP implementation actions could provide valuable insight into the progress being made in this area.

Tool and application Development-2: Identify policy linkages and governance structure.

The evaluation was not able to determine the status of this action. The following actions may be relevant:

- Executive Order N-4-23.
- A related policy framework was initiated under Senate Bill 122 in 2023.
- The State Water Board has developed a streamlined permitting process for recharge.

Tool and application Development-3: Create decision support tools to integrate Flood-MAR disciplines.

The evaluation concludes that this action is in progress, but not yet complete. During evaluation engagement, it was noted that DWR has made significant strides in developing integrated tools for decision support. These integrated decision support tools have been deployed in the Merced River Watershed Flood-MAR Reconnaissance Study and the DWR SJR watershed studies.

15.0 References

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APPENDIX A

Summary Notes from Meetings with Flood-MAR Research Advisory Committee Co-Chairs

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Flood-MAR Research and Data Development Plan Evaluation
Meeting #1 with Research Advisory Committee Co-Chairs
September 23, 2024, 11 AM – 1 PM

This meeting with former Co-Chairs of the Flood-Managed Aquifer Recharge (Flood-MAR) Research Advisory Committee (RAC) evaluated progress toward achieving the priority actions in the 2019 Research and Data Development (R&DD) Plan, which the Co-Chairs had developed to guide research, funding, and the strategic implementation of Flood-MAR projects across California. The discussion reviewed initial findings of an assessment underway to document the accomplishments and progress made over the past five years, identify ongoing activities. Discussion also revisited priority areas to determine if they are still relevant or need adjustment due to changing circumstances. This document summarizes the discussion at a high level. A roster of meeting attendees is provided on the last page.

Historical Context and Development of the 2019 R&DD Plan, provided by Romain Maendly

- Flood-MAR is based on the concept of leveraging floodwaters to replenish groundwater through managed aquifer recharge.
- Historical constraints such as levee development in the mid-1800s have altered river connectivity, reducing natural recharge opportunities.
- Past water management practices led to a heavy reliance on groundwater during drought, prompting the emergence of the Sustainable Groundwater Management Act (SGMA) around a decade ago to address groundwater sustainability.

Assessment of Priority Actions, provided by Marisa Perez-Reyes

- The initial R&DD Plan identified 13 research themes, ranging from technical to holistic approaches, each led by co-chairs from various sectors (state, local, academic). The plan advanced a diversified water portfolio through research and collaborative efforts, with an emphasis on multi-benefit projects integrating flood management and water supply enhancement.
- Of the 39 priority actions identified in the R&DD Plan, 29 have seen some level of implementation (i.e., were either complete, underway, or partially underway) and the rest either not started or of uncertain status.

Implementation Challenges and Research Needs:

- Implementing Flood-MAR on a larger scale has proven more complex even than initially imagined, necessitating more data and research. Meeting participants indicated that project implementation timelines could range from 10 to 20 years.

- Significant efforts have been made to integrate land use planning, but local adoption varies widely, and there is no statewide legislative framework to enforce the connection between land use and floodplain management.

Economic Feasibility and Incentives:

- The economic viability of Flood-MAR was a major focus, with discussions highlighting the need for updated economic analyses that factor in current regulations, costs, and benefits of using existing infrastructure.

- Participants emphasized that economic guidance should include incentive programs to encourage farmers and local agencies to participate.

Engagement and Stakeholder Perspectives:

- The meeting highlighted the broadening interest from various sectors, including members of disadvantaged communities, environmental groups, and local agencies.

- Building trust and showcasing tangible benefits have been critical in shifting stakeholder perceptions.

Future Directions and Adjustments:

- The changing climate and recent wet years have shifted some priorities, with more attention now on streamlining institutional frameworks and developing tools, notably ones that assist growers in navigating permitting and operational logistics for Flood-MAR projects.

- There is a recognized need to sustain and enhance the Flood-MAR Network, which was a key recommendation from the RAC.

Recommendations:

- **Integration of Land Use and Water Management:** Local land use policies need to be better aligned with water management goals in both flood management and recharge domains. More robust state-level guidance or legislation could strengthen the connection.

- **Economic Analysis and Incentives:** Updated economic tools and frameworks are needed to make the case for Flood-MAR investments, particularly in light of recent cost escalations and regulatory changes.

- **Data and Monitoring:** Accurate and comprehensive monitoring systems for groundwater recharge and quality are essential to track progress and build confidence in Flood-MAR as a viable sustainability strategy.

- **Stakeholder Engagement:** Ongoing outreach and education are needed to bring more diverse groups into the fold, especially in regions facing significant groundwater challenges.

Meeting Attendees	Organization, Role
Ajay Goyal	DWR, Branch Manager
Aleksander Vdovichenko	DWR, 2019 Support Lead for Reservoir Operations
Amrith Gunasekara	California Farm Bureau Federation, 2019 State Chair for Crop Systems Suitability
Daniel Mountjoy	Sustainable Conservation, Research Advisory Committee (RAC) Co-Coordinator
David Arrate	DWR, 2019 Support Lead for Infrastructure Conveyance and Hydraulics
Ellizabeth Patterson	Mayor of City of Benicia, 2019 State Chair for Land Use Planning and Management
Emmanuel Asinas	DWR, 2019 State Chair for Economic Analysis
Francisco “Paco” Flores Lopez	DWR, 2019 Support Lead for Tool and Application Development, Recharge and Extraction Methods and Measurement, Soil, Geology, and Aquifer Characterization, and Crop Systems Suitability
Glen Low	Earth Genome, 2019 Non-State Co-Chair for Tool and Application Development
Graham Fogg	UC Davis, 2019 Non-State Chair Soil, Geology, and Aquifer Characterization
Jon Parker	Kern Water Bank Authority, 2019 Non-State Chair
Jenny Marr	DWR, 2019 Support Lead for Economic Analysis
Jim Wieking	DWR, 2019 Support Lead for Policies and Legal Considerations
Josué Medellin-Azuara	UC Merced, 2019 Non-State Chair for Economic Analysis
Kamyar Guivetchi	DWR, Executive Advisor, Water Innovation and Technology
Mark Nordberg	DWR, 2019 State Chair for Recharge and Extraction Methods and Measurement
Michael Anderson	DWR, 2019 State Chair for Hydrology Observation and Prediction
Mike Antos	Stantec, 2019 Non-State Chair for People and Water and Principal Consultant for 2024 R&DD Plan Evaluation
Nat Seavy	National Audubon Society, 2019 Non-State Co-Chair for Environment - Terrestrial and Riparian/Aquatic
Rich Juricich	Retired from Colorado River Board (formerly DWR), Woodard and Curran, 2019 State Chair for Tool and Application Development
Romain Maendly	DWR, RAC Co-Coordinator
Sam Sandoval	UC Davis, 2019 Non-State Co-Chair for Tool and Application Development
Shyamal Chowdhury	US Army Corp of Engineers, 2019 Non-State Chair for Infrastructure Conveyance and Hydraulics
Thomas Harter	UC Davis, 2019 Non-State Chair for Water Quality
Tim Godwin	DWR, 2019 State Chair for Soil, Geology, and Aquifer Characterization

Meeting Attendees	Organization, Role
Wyatt Arnold	DWR, 2019 Support Lead for Hydrology Observation and Prediction
Marisa Perez-Reyes	Stantec, Technical Lead for 2024 R&DD Plan Evaluation
Robyn Finley	Stantec, Support for 2024 R&DD Plan Evaluation

Flood-MAR Research and Data Development Plan Evaluation
Meeting #2 with Research Advisory Committee Co-Chairs
October 30, 2024, 1 – 3 PM

This second convening of former Co-Chairs of the Flood-Managed Aquifer Recharge (Flood-MAR) Research Advisory Committee (RAC) was to reflect on the successes achieved since the RAC's initial efforts in 2019, asses ongoing challenges, and identify priorities for the next five years. Discussion topics ranged from the institutional and economic barriers to growing acceptance among growers and Groundwater Sustainability Agencies (GSAs). Participants also emphasized the importance of leveraging recent data, such as insights from 2023's extreme weather events, to refine tools, policies, and strategies for implementing Flood-MAR. This document provides a high-level summary of the discussion. A roster of meeting attendees is provided on the last page.

Expanded and Improved Implementation:

- The transition of Flood-MAR as a concept to an implemented practice has gained significant traction in recent years, with many participants envisioning larger-scale projects within the next five years.
- Participants emphasized the need for enhanced tools and frameworks to guide project planning, cost assessments, and evaluations of multi-benefit outcomes.

Data and Research Opportunities:

- Participants identified the 2023 snowpack and runoff events as critical data points for advancing Flood-MAR research. The Co-Chairs highlighted the value of analyzing these events to identify best practices, refine models, and address institutional challenges.

Institutional Challenges:

- Institutional and regulatory barriers were frequently identified as impediments to scaling up Flood-MAR. Suggestions included simplifying permitting processes, increasing interagency coordination, and adapting water rights frameworks to align with changing hydrology.

Economic Considerations:

- While Flood-MAR is generally viewed as cost-effective, the high costs of certain implementation controls (e.g., fish screens and diversion infrastructure) remain a concern.
- Participants advocated for policy incentives and financial frameworks to support landowner participation and inclusion of Flood-MAR in sustainability plans.

Growing Community and Stakeholder Engagement:

- Participants emphasized the importance of building trust with disadvantaged communities and environmental groups.
- Multi-benefit projects that address flood risk, water supply, and ecological health were highlighted as key priorities for broadening stakeholder support.

Vision for the Future:

When prompted to share their vision for a successful future, Co-Chairs identified the following goals:

- Widespread adoption of Flood-MAR as a standard practice.
- Creation of integrated tools for planning and assessment.
- Greater alignment between state policies and local needs.
- Demonstrable reductions in flood risk through reservoir reoperation and managed aquifer recharge.
- Broader stakeholder participation, including leadership from GSAs, growers, and disadvantaged communities.

Meeting Attendees	Organization, Role
Abdul Khan	DWR, 2019 State Co-Chair Tool and Application Development
Aleksander Vdovichenko	DWR, 2019 Support Lead for Reservoir Operations
Daniel Mountjoy	Sustainable Conservation, Research Advisory Committee (RAC) Co-Coordinator
David Arrate	DWR, 2019 Support Lead for Infrastructure Conveyance and Hydraulics
Emmanuel Asinas	DWR, 2019 State Chair for Economic Analysis
Francisco “Paco” Flores Lopez	DWR, 2019 Support Lead for Tool and Application Development, Recharge and Extraction Methods and Measurement, Soil, Geology, and Aquifer Characterization, and Crop Systems Suitability

Meeting Attendees	Organization, Role
Glen Low	Earth Genome, 2019 Non-State Co-Chair for Tool and Application Development
Jenny Marr	DWR, 2019 Support Lead for Economic Analysis
Jim Wieking	DWR, 2019 Support Lead for Policies and Legal Considerations
Josué Medellin-Azuara	UC Merced, 2019 Non-State Chair for Economic Analysis
Kamyar Guivetchi	DWR, Executive Advisor, Water Innovation and Technology
Mark Nordberg	DWR, 2019 State Chair for Recharge and Extraction Methods and Measurement
Meagan Wylie	College of Continuing Education, Sacramento State, Flood-MAR Network Coordinator
Michael Anderson	DWR, 2019 State Chair for Hydrology Observation and Prediction
Mike Antos	Stantec, 2019 Non-State Chair for People and Water and Principal Consultant for 2024 R&DD Plan Evaluation
Nat Seavy	National Audubon Society, 2019 Non-State Co-Chair for Environment - Terrestrial and Riparian/Aquatic
Rich Juricich	Retired from Colorado River Board (formerly DWR), Woodard and Curran, 2019 State Chair for Tool and Application Development
Sam Sandoval	UC Davis, 2019 Non-State Co-Chair for Tool and Application Development
Sean Sou	DWR, 2019 Support Lead Environment-Terrestrial and Riparian/Aquatic
Shem Stygar	DWR, 2019 Support Lead for Water Quality
Thomas Harter	UC Davis, 2019 Non-State Chair for Water Quality
Tim Godwin	DWR, 2019 State Chair for Soil, Geology, and Aquifer Characterization
Wyatt Arnold	DWR, 2019 Support Lead for Hydrology Observation and Prediction
Lisa Beutler	Stantec, Technical Support for 2024 R&DD Plan Evaluation
Robyn Finley	Stantec, Support for 2024 R&DD Plan Evaluation