The Flood-MAR Research Advisory Committee

Flood-MAR Research and Data Development Plan

Priority Actions to Expand Implementation of Effective and Efficient Flood-MAR Projects in California

October 2019

Prepared by the California Department of Water Resources

The Flood-MAR Research Advisory Committee (RAC) is a multidisciplinary group of approximately 200 subject matter experts across 13 critical research areas, each of which is represented as a RAC subcommittee. The RAC is responsible for identifying the research, data, guidance, and tools necessary to support and expand the implementation of effective and efficient Flood-MAR projects. The work of the Flood-MAR RAC and this Research and Data Development Plan are an initial step to support sound science and information to ensure that local communities and decision-makers can better integrate recharge and flood management for long-term sustainability and resiliency.

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The Flood-MAR Research Advisory Committee thanks the following individuals, growers, organizations, companies, consultants, universities, laboratories, and local, State, and federal agencies for their time and effort in recognizing the importance of and contributing to the advancement of the Flood-MAR concept.

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California Chapter American Planning Association

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California Department of Fish and Wildlife

California Department of Food and Agriculture

California Department of Pesticide Regulation

California Department of Water Resources

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U.S. Geological Survey

U.S. Fish and Wildlife Service

Water Education for Latino Leaders

Western Regional Climate Center

Woodard and Curran

Yolo County Flood Control & Water Conservation District

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Acronyms and Abbreviations

CVFPP	Central Valley Flood Protection Plan
DWR	California Department of Water Resources
EO	executive order
FIRO	forecast-informed reservoir operations
GIS	geographic information system
GSA	groundwater sustainability agency
GSP	groundwater sustainability plan
IRWM	integrated regional water management
LiDAR	light detection and ranging
MAR	managed aquifer recharge
MOU	memorandum of understanding
NGO	nongovernmental organization
OPR	California Governor's Office of Planning and Research
R&DD Plan	research and data development plan
RAC	Research Advisory Committee
SBFA	California State Board of Food and Agriculture
SGMA	Sustainable Groundwater Management Act
SWAP	California State Wildlife Action Plan
SWRCB	State Water Resources Control Board
USGS	U.S. Geological Survey

Foreword

The Research Advisory Committee (RAC) is pleased to make this plan available to the growing network of farmers, researchers, planners, and water and land managers who want to expand our collective knowledge about using floodwaters for managed aquifer recharge (Flood-MAR). This plan outlines the priority information needed by those making management decisions about the where, when, and how of capturing available flood water to replenish California's depleted aquifers.

Developing this plan drew upon the interests and motivations of a broad cross-section of public and private subject experts who served on the Flood-MAR RAC; and the California Department of Water Resources (DWR) Flood-MAR Team supported the committee to conceive and draft the plan. As co-coordinators of this effort, we were encouraged by the level of participation by more than 200 subcommittee members and the many others who expressed interest.

Prioritizing the research, data, guidance, and tools needed to implement a complex integrated water management strategy like Flood-MAR is not a simple task, particularly when many of these components have not been formally studied. The RAC's 13 subcommittees identified more than 130 information needs and were asked to select those recommendations most important to inform and expedite Flood-MAR project implementation. We were pleased to see that many of the priority actions focus on compiling and providing access to existing data and knowledge as soon as possible. In addition, there was broad recognition that even the best research and data results need to be packaged in the form of tools and guidance to achieve widespread application.

Completion of this plan provides a starting point for the hard work of building a body of knowledge based on actionable science called for by the RAC. Implementation of the plan's recommended actions is essential for expanding and accelerating Flood-MAR project implementation to ensure more reliable water supplies, flood preparedness, and environmental enhancement within a changing climate. We intend that the RAC process, which brought together a community of Flood-MAR practitioners and researchers, continues as a network to drive the collaboration needed to implement the plan. We also believe this plan sets the priorities and identifies the needed funding for public and private investments in Flood-MAR.

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Executive Summary

This Flood-MAR Research and Data Development Plan (R&DD Plan) presents the work of the Flood-MAR Research Advisory Committee (RAC), a multidisciplinary group of subject matter experts across 13 research themes. The RAC was tasked to identify the research, data, guidance, and tools necessary to support and expand the implementation of Flood-MAR projects. Well-formulated Flood-MAR projects can benefit Californians and the environment through improved water supply reliability, flood-risk reduction, drought preparedness, aquifer replenishment, ecosystem enhancement, subsidence mitigation, water quality improvement, working landscape preservation and stewardship, climate change adaptation, recreation, and aesthetics.

The work of the Flood-MAR RAC and this R&DD Plan are an initial step to support sound science and information to ensure local communities and decision-makers can better integrate local water supplies and flood management for long-term sustainability and resiliency. The actions recommended in this R&DD Plan are foundational steps, and more work will be needed to respond to California's increasingly complex water management needs.

This R&DD Plan highlights the needed guidance, information, tools, and expert systems to support project implementers in 13 critical research areas.

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 13 themes comprehensively represent the knowledge areas needed to implement Flood-MAR projects. State and non-State co-chairs for each theme led theme-specific subcommittees that included academics, practitioners, nongovernmental organizations (NGOs), consultants, government agencies, Tribes, and professional associations. RAC meeting discussions focused not only on what State government can do to further Flood-MAR, but what all parties can do in partnership to leverage progress already made and fill existing knowledge and information gaps.

Between November 2018 and July 2019, the RAC held three meetings and one workshop to develop this plan. The RAC is building momentum within the research, data, analytical and water management communities to establish a network and develop the information and tools needed to scale up implementation of Flood-MAR projects. The resulting partnerships and knowledge will set the stage for collaboration as project implementation gets underway.

This Flood-MAR R&DD Plan intends to:

- Guide and support the work and investment of researchers, agencies, and funding entities.
- Guide strategic coordination and funding of Flood-MAR-related efforts.
- Compile information needed for decision-making, implementation, and management of multi-sector and multi-benefit Flood-MAR projects.

The priority actions identified in this plan can be implemented in the near-term and most of the priority actions could be completed within two years. Actions range from those that are relatively simple, such as convening experts and compiling existing information and making it readily available, to more complex, such as new research studies. The total estimated cost to complete all the priority actions is $147 million to support research, data and tool development, and provide guidance statewide. The needs of end users,

such as project planners, implementers and beneficiaries, must drive the implementation of the recommendations of this plan and ultimately the implementation of Flood-MAR projects.

All members of the water community (water managers, decision-makers, researchers, users, stakeholders) have a role in implementing this R&DD Plan. Implementation of research actions and pilot studies generally occurs through partnerships. It is vital that participants stay engaged, develop (and commit to) partnerships, and engage in creative (and perhaps at times difficult) discussions on needed solutions and tradeoffs.

Call to Action

Though at times contentious, water management in California is dynamic and critical for the health and wellness of all. There is significant opportunity to improve the integration of surface and groundwater management to create sustainable practices and provide benefits to meet local, regional, and state priorities. Implementation of integrated, multi-sector, and multiple benefit Flood-MAR projects can support a sustainable water future for California. However, better data, information, tools, and guidance are needed to ensure implemented projects are well formulated, support multiple needs, and promote broader participation by water management sectors and landowners. The RAC encourages all members of the water management community to stay engaged and support implementation of these priority actions that will concurrently support Flood-MAR projects, while creating more cooperative, informed, and aligned statewide water management.

Research Priorities – At a Glance

Below are the top three priority actions for each research theme. Appendix C provides a complete list of actions and descriptions identified by the Flood-MAR Research Advisory Committee (RAC) and its subcommittees.

Hydrology Observation and Prediction

- Improve comprehensive snowpack monitoring (Airborne Snow Observatory and in situ)
- Conduct inter-model comparison of surface hydrologic models with available historical precipitation products.
- Develop a spatially distributed soil moisture network for upper watersheds.

Reservoir Operations

- Develop improved statewide water accounting to support the kinds of agreements and incentives needed for using floodwaters for managed aquifer recharge (Flood-MAR), Sustainable Groundwater Management Act (SGMA)-related water plans, water markets, and enforcement of surface water rights.
- Extend forecast-informed reservoir operations (FIRO) to include operations for groundwater recharge, particularly for local and regional agricultural field and basin recharge opportunities.
- Analyze reservoir and broader water resources system to assess potential for shifting drought storage from surface water reservoirs to aquifers.

Infrastructure Conveyance and Hydraulics

- Build a standardized statewide geographic information system (GIS) conveyance database of conveyance networks that could be used for Flood-MAR projects.
- Research sediment transport impacts on conveyance networks and streams resulting from increased usage from Flood-MAR operations.
- Develop light detection and ranging (LiDAR), topography, and bathymetry data around potential Flood-MAR project areas that are

lacking this data in order to augment the GIS conveyance database.

Crop Systems Suitability

- Perform case studies on agricultural land-based Flood-MAR projects completed to date.
- Initiate and complete research on knowledge gaps of crop systems suitability for MAR in California.
- Develop decision support tool to determine crop suitability for Flood-MAR.

Soils, Geology, and Aquifer Characterization

- Improve subsurface geologic data and provide greater accessibility to useable and better-quality data.
- Improve subsurface hydrologic data and provide greater accessibility to useable and better-quality data.
- Synthesize hydrogeologic data to identify the best locations for recharge.

Land Use Planning and Management

- Document coordination and communication methods occurring between groundwater sustainability agencies (GSAs) and land use planning agencies to develop best practices.
- Identify sources of funding for integrated planning efforts and groundwater management.
- Develop protocols for data consistency for all planning documents.

Water Quality

- Develop a web-based platform to allow public access to a compilation of all existing knowledge identified by the Water Quality Subcommittee.
- Develop guidance and multi-criteria decision-making tools to address water quality issues in Flood-MAR projects.
- 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.

Recharge and Extraction Methods and Measurement

- Compile existing MAR projects and associated data.
- Compile pertinent information to determine the efficiency of MAR projects.
- Establish methods and considerations by which floodplains can be used as direct recharge sites and in conjunction with other recharge methods.

Environment – Terrestrial and Riparian/Aquatic

- Develop a tool to calculate groundwater recharge that occurs when floodplains are inundated.
- Develop a map that prioritizes Flood-MAR based on the additional habitat benefits that can be achieved at those sites.
- Map subsurface geology of floodplains to identify areas with the greatest potential for deep aquifer recharge.

People and Water

- Develop an ethical and just framework specifically focused on the Flood-MAR program.
- Develop an engagement best practices document for Flood-MAR.
- Document areas most feasible for recharge with disadvantaged communities that are groundwater dependent and would greatly benefit from Flood-MAR actions.

Economic Analysis

- Develop an economic analysis guidance document for groundwater recharge projects.
- Evaluate economic and other incentives for Flood-MAR implementation.
- Assess groundwater ownership rights and market issues associated with Flood-MAR.

Local, State, and Federal Policies and Legal Considerations

- Refine guidance and provide applicant assistance for beneficial use designations associated with recharge.
- Provide guidance and support for water availability analyses and associated determinations for processing of water rights applications.
- 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.

Tool and Application Development

- Conduct cost/benefit analysis, including multi-benefit.
- Identify policy linkages and governance structure.
- Create decision support tools to integrate Flood-MAR disciplines.

1.0 Introduction

California is known for its variable climate, notably its perennial oscillation between drought and flood events. Climate change is increasingly exacerbating this variability and consequent vulnerability, so water managers are eyeing a way to capitalize on the extremes by harnessing flood waters and redirecting them into parched aquifers. Using floodwaters for managed aquifer recharge (MAR), or Flood-MAR, is part of California's strategy to modernize its green and grey infrastructure and co-manage the state's entire water portfolio for multiple public and private benefits and water resiliency. The expansion of Flood-MAR project implementation is a recommendation in *California Water Plan Update 2018* (California Department of Water Resources 2018a). Further, Flood-MAR projects can support statewide water resilience as part of a portfolio of solutions required by Governor Newsom's Executive Order (EO) N-10-19.

The success and expansion of Flood-MAR implementation depends on water resource managers and policymakers:

- Recognizing aquifers as green infrastructure and environmental assets, and their replenishment as a public benefit.
- Engaging in strategic, integrated, and multi-disciplinary water management planning.
- Aligning water sectors, institutions, and regulations.
- Harnessing innovation, research, and data.
- Providing sufficient and stable funding.

This Flood-MAR Research and Data Development Plan (R&DD Plan) presents the input of subject matter experts, as part of the Flood-MAR Research Advisory Committee (RAC), on the research, data, guidance, and tools necessary to support the above considerations. This plan also recognizes, and strives to align with, other efforts to bring researchers, implementors, and policymakers together to promote Flood-MAR project implementation, including the 2017 Public Forum on Managed Groundwater Recharge (*Recharge Roundtable Call to Action*, a collaboration between the Groundwater Resources Association and UC Water [Dahlke et al., 2018]),

and the 2018 and 2019 Recharge and Land Use Symposium and Economic Summit.

Through the priority actions identified in this plan, a Flood-MAR network (described in detail below) will be established to support and expand the implementation of effective, efficient, and equitable Flood-MAR projects that achieve multiple benefits and support water resources sustainability for all uses.

1.1 Purpose of Flood-MAR Research and Data Development Plan

This R&DD Plan is the primary work product of the Flood-MAR Research Advisory Committee (RAC) and highlights the RAC's priority actions and provides a framework for implementing the priority actions in coordination and alignment with other efforts and potential sources of funding. Appendix A identifies all participants in the research theme subcommittees. Appendix B provides RAC meeting summaries. Appendix C includes a complete list of research and data gaps and needs identified by each of the RAC research theme subcommittees, as well as more detailed descriptions of the priority actions.

This Flood-MAR R&DD Plan intends to:

1. Guide and support the work and investment of researchers, agencies, and funding entities.
2. Guide strategic coordination and funding of Flood-MAR-related efforts.
3. Compile information needed for decision-making, implementation, and management of integrated, multi-sector, and multi-benefit Flood-MAR projects.

Through the implementation of the priority actions identified in this R&DD Plan, water managers, decision-makers, and landowners will have information:

- That is essential for decision-making, implementation, and management of integrated and multi-benefit Flood-MAR projects.
- To mitigate or overcome barriers and challenges to integrated, multi-sector, and multi-benefit Flood-MAR projects.

- To alleviate uncertainty about potential risks associated with Flood-MAR implementation to people, society, and the environment.
- To support both integration across research themes and water resources sectors for multi-benefit Flood-MAR project planning.

Beyond R&DD Plan development, the RAC is building the momentum within the research, data, analytical and water management communities to establish a network and develop the information and tools needed to scale up implementation of Flood-MAR projects. As a result, the development of partnerships and shared knowledge will facilitate collaboration as implementation gets underway.

2.0 Background

The section provides the context for why Flood-MAR is needed, what Flood-MAR means, and what barriers exist to Flood-MAR implementation.

2.1 A Snapshot of California's Water Management Setting

The California Department of Water Resources' (DWR's) Flood-MAR white paper describes California water as "a tale of extremes" — the familiar oscillation between the extremes of flood and drought. These extremes, and the usual annual variability in precipitation, have always made surface water planning challenging. Along with variable water supply, competing demands, and existing stressors, climate change impacts only exacerbate existing water challenges. Historically, groundwater has played a critical role in helping water managers support communities, the environment, and businesses adjust to a variable and uncertain surface water supply. Many have called groundwater a water "savings account" — water that is available in times of need, such as during the dry summer months and droughts. In many locations throughout the state, overdraft has caused the water savings account to become severely depleted resulting in land subsidence, water quality impairments, and adverse economic impacts. Replenishing our water savings account in times of plenty is imperative to being resilient in times of scarcity.

In 2014, several years into a major drought, Governor Jerry Brown signed a package of legislation called the Sustainable Groundwater Management Act (SGMA). SGMA provides a framework for achieving and ensuring groundwater sustainability. Generally, there are three primary actions water managers and users can take to support groundwater sustainability: (1) reduce groundwater demand, (2) increase water supplies, or (3) do both. Many have looked to increasing groundwater recharge as a way to decentralize water storage across California and increase local water supply (Perrone and Rohde 2016). But because surface water supply is already stretched thin, initiatives, such as Flood-MAR, are being considered as ways to more effectively use intermittent flood flows as a supply for managed aquifer recharge.

Sustainability is our shared goal as a society. Water management objectives and actions must align with societal goals and values and address a water system that is constantly changing. The current and future water management setting in California requires surface and groundwater managers and users to expand cooperation and integration to reduce the impacts of future floods and droughts and prepare for increased climate variability. Enhanced coordination and integration of surface water and groundwater management will help communities provide reliable, good quality water for people, the environment, and local economies that can respond and adapt to inter- and intra-annual water variability and extreme conditions.

The work of the Flood-MAR RAC and this R&DD Plan are an initial step to support sound science and information to help ensure local communities and decision-makers can better integrate local water supplies and flood management for sustainability and resiliency. RAC coordinators emphasize the importance of a holistic approach to the development of the R&DD Plan that will not only guide future Flood-MAR project implementation, but also support broader cooperation and integration among surface and groundwater managers and users. The actions of this R&DD Plan are foundational steps, but more work is needed to respond to California's increasingly complex water management needs. This R&DD Plan highlights the needed guidance, information, tools, and expert systems to support project implementers.

2.2 Flood-MAR Strategy

Flood-MAR is an integrated and voluntary resource management strategy that uses floodwater resulting from, or in anticipation of, rainfall or snowmelt for managed aquifer recharge (MAR) on agricultural lands, working landscapes, and managed natural landscapes, including refuges, floodplains, and flood bypasses. Flood-MAR can be implemented at multiple scales, from individual landowners diverting flood water with existing infrastructure, to using extensive detention/recharge areas and modernizing flood management infrastructure/operations. An example of a smaller scale Flood-MAR project is on-farm recharge or a single farmer applying available water on farmland (e.g., active farm land, fallowed fields, or designated recharge basins) in excess of crop needs. An example of a larger scale Flood-MAR

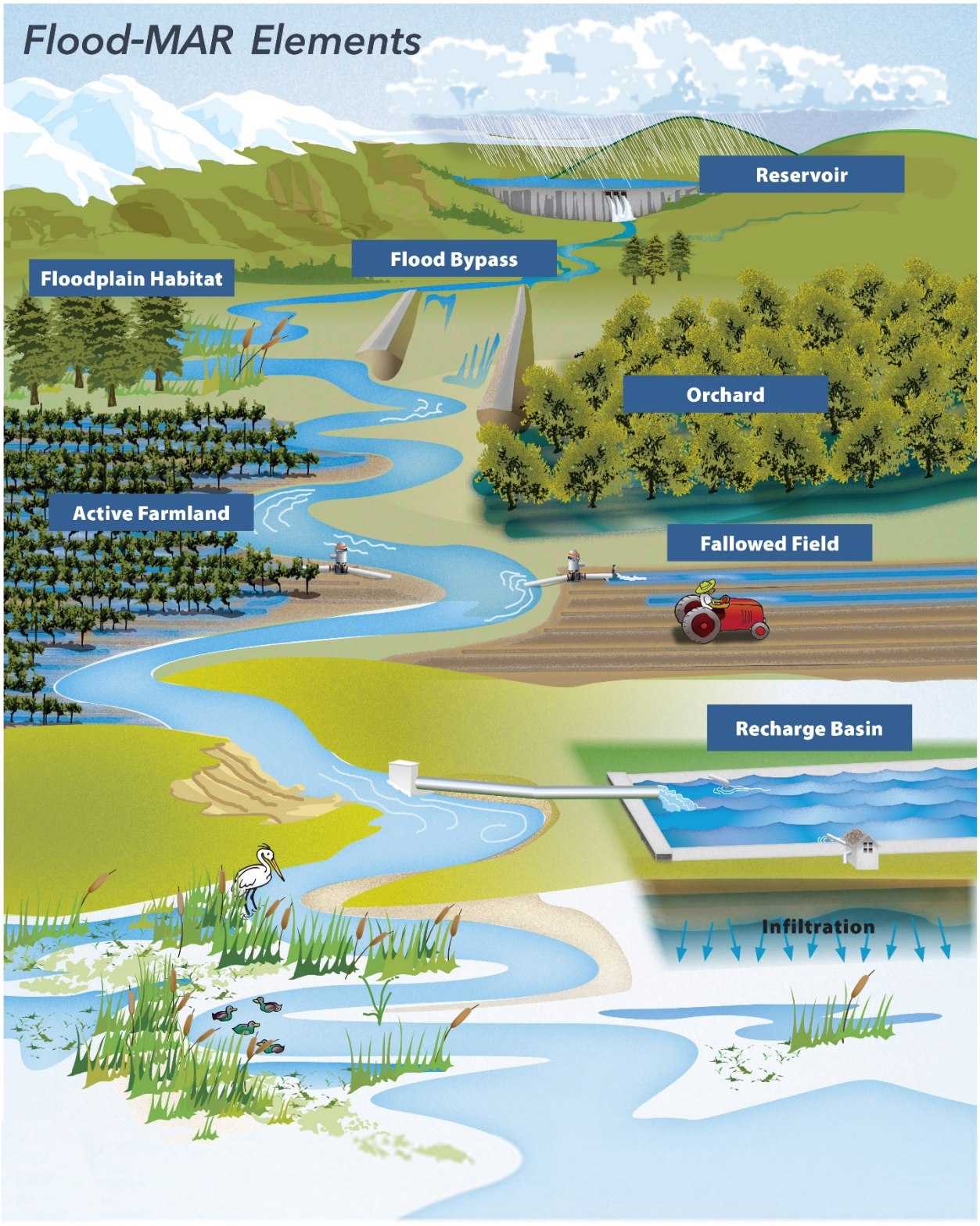
project is an extensive partnership of landowners, flood management agencies, water management agencies, and reservoir operators that coordinate operations to achieve flood-risk-reduction benefits and groundwater benefits through early evacuation of surface storage to large areas of land for infiltration into groundwater basins.

In general, the benefits of Flood-MAR increase with scale, partnerships, and resources. Well-formulated Flood-MAR projects can benefit Californians and the environment. Private, or non-public, benefits of Flood-MAR projects include improved water supply reliability for urban and agricultural water uses through direct supply or improved system flexibility. Potential public benefits include:

- Flood-risk reduction.
- Drought preparedness.
- Aquifer replenishment.
- Ecosystem enhancement.
- Subsidence mitigation.
- Water quality improvement.
- Working landscape preservation and stewardship.
- Climate change adaptation.
- Recreation and aesthetics.

The most recent cycle of drought and flood, and the passage of SGMA, make Flood-MAR an important part of California's portfolio of water resource management strategies, now and in the future, to improve water resources sustainability and climate resiliency.

Figure 1 Example of Physical Features of Flood-MAR Projects



2.3 Summary of Barriers and Challenges to Project Implementation

Complex technical, legal, and institutional barriers and challenges affect the planning and implementation of Flood-MAR projects. DWR's 2018 Flood-MAR white paper (California Department of Water Resources 2018b) categorized barriers and challenges by the following four themes:

1. Cooperation and governance.
2. Policy.
3. Legal, including water rights and regulations.
4. Implementation, including land use, recharge, recovery, conveyance, reservoir operations, economics, environmental considerations, and data and capacity building.

This plan identifies priority actions that can help implementers overcome barriers in all four areas.

Barriers and challenges were also identified during the November 2017 Public Forum on Managed Groundwater Recharge to Support Sustainable Water Management, and recommendations developed from the proceedings were submitted to the Brown Administration by the California State Board of Food and Agriculture (SBFA). The recommendations and key takeaways from the public forum encouraged using floodwater as a source for recharge (putting the "Flood" in Flood-MAR), while identifying the need for better data and information to evaluate recharge opportunities, developing better understanding of climate change vulnerabilities, and building partnerships around innovative, multiple-benefit solutions. Specifically, the SBFA letter recommended the following actions related to research and data:

- Establish a State Flood-MAR program that would establish and align a statewide system related to flood water recharge that develops local partnerships and studies opportunities to better integrate aquifer recharge projects on a statewide basis.
- Establish a Flood-MAR research and data development program to support studies and pilot projects conducted by State, regional, and local entities and academia to progress knowledge in keys areas; and convening a RAC. The RAC would identify priority research and data needs (this plan), a centralized repository for technical research and

data related to Flood-MAR, integrated training and education programs, and technical/scientific information and tools.

- Improve hydrology observation and prediction to advance California's ability to improve hydrological and hydraulic knowledge, forecasting abilities, and understanding of climate change effects on water supply reliability and public benefits of California's water system.
- Establish a centralized online resources site and database that includes best management practices and information on groundwater recharge benefits for growers and groundwater sustainability agencies (GSAs), including multiple benefits.

The Flood-MAR RAC broadly agreed with these recommendations. The priority actions in this plan support the SBFA's recommendations and provide a foundation to encourage greater investment for achieving these recommendations.

Additionally, DWR hosted a listening session in January 2019 with the agricultural community in Merced, California, that reaffirmed many of these barriers and challenges. During the listening session, as well as during RAC meetings, participants discussed agricultural community concerns related to:

- Funding and incentives, particularly funding for installation and operations of pumps and recharge credits for farmers.
- Site suitability and impact on crop yield.
- Availability and access to recharged water.
- Inclusion of Flood-MAR projects in groundwater sustainability plans (GSP).

The Flood-MAR RAC priority actions are intended to address and help overcome these concerns.

3.0 RAC Process and Priority Action Development

As stated in Subsection 2.3, research, data, guidance, and tools are essential to support effective and efficient Flood-MAR project implementation in California (California State Board of Food and Agriculture 2018). To help identify specific needs and gaps, as well as priority actions, DWR convened the Flood-MAR RAC in November 2018. The RAC includes State government and non-State-government representatives of 13 research themes identified in the *Draft Flood-MAR Research and Data Development Framework* (California Department of Water Resources 2019):

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 13 themes are intended to comprehensively represent all the knowledge areas that will be necessary to implement effective and efficient Flood-MAR projects. State and non-State co-chairs for each theme led theme-specific subcommittees that included academics, practitioners, nongovernmental organizations (NGOs), consultants, government agencies, tribes, and professional associations.

The research themes were identified based on implementation questions posed in DWR's Flood-MAR white paper (California Department of Water Resources 2018b):

- How will project needs be coordinated?
- How will the project be funded and landowners compensated?
- Where will the surface water come from?
- How will surface water get to the site?
- Where are good candidate sites for recharge?
- How will the water get into the ground?
- How will groundwater be recovered or otherwise used?
- Is the project technically, legally, politically, and economically feasible now and in the future?

Many of the conversations held by the RAC were organized around these questions to determine how to best support on-the-ground project implementation.

For each theme, subcommittees met to:

- Identify and compile existing research, data, guidance, and tools.
- Identify and compile current gaps or needs for research, data, guidance, and tool.
- Establish an action priority listing of needed research, data, guidance, and tools based on the gaps.
- Develop a general strategy for collectively addressing the prioritized research, data, guidance, and tool actions.

The RAC was charged with highlighting the essential and top priority research, data, guidance, and tool needs that will directly support decision-making, implementation, and management of integrated and multi-benefit Flood-MAR projects.

The subcommittee co-chairs were given flexibility in how they met with their subcommittee members, developed information, and made decisions. More detail on the subcommittee activities is provided in Appendix C. Generally,

the subcommittees and RAC members considered the following criteria when evaluating the priority of identified actions.

- Does the action answer questions that may arise during project formulation or implementation (i.e., implementation questions posed in 2018 white paper)?
- Does the action mitigate barriers or challenges to project implementation (such as cooperation and governance, policy, legal, and implementation challenges)?
- Does the action alleviate uncertainty about project implementation risks to people, society, and the environment?
- Does the action support integration across themes/water resources sectors and multi-benefit Flood-MAR project planning?

Between November 2018 and July 2019, the RAC held three meetings and one workshop to develop the R&DD Plan. RAC meetings were run by the RAC coordinators, with support from DWR staff and facilitation by the Sacramento State Consensus and Collaboration Program. The objectives of each RAC meeting are summarized below.

RAC Meeting 1, November 13, 2018

- Present and clarify information on process and plan for the Flood-MAR R&DD Plan development.
- Present, refine, and gain agreement on the RAC organization and charter.
- Identify development approaches and formats for the three outcome products (available information, gaps, prioritization).
- Identify next steps to engage the subcommittees.

RAC Meeting 2, February 26, 2019

- Review the priorities for research, data, guidance, and tools identified by the 13 subcommittees.
- Explore the interconnections and potential for integration among the different priorities.

Coordination and Implementation Workshop, June 27, 2019

- Review with participants the R&DD Plan priority actions supporting Flood-MAR project implementation.
- Learn from agencies and other entities that are advancing the identified priority actions.
- Identify opportunities for collaboration and co-benefits across existing and upcoming efforts.
- Inform the development of coordination principles and the framework for implementation of the R&DD Plan.
- Identify potential funding sources and opportunities to develop the research, data, guidance, and tools priority actions.

RAC meeting discussions focused not only on what State government should do to further Flood-MAR, but what all parties need to do in partnership to leverage progress already made and fill existing knowledge and information gaps.

4.0 Research, Data, Guidance, and Tools – Priority Actions

This section highlights the priority actions identified by the Flood-MAR RAC and each subcommittee and summarizes RAC meeting discussions. This section also includes a crosswalk that summarizes the priority actions by theme and the implementation questions.

4.1 Priority Actions by Theme

Subsections 4.3 through 4.15 present the top three priority actions identified by each research theme subcommittee. More information about the priority and other actions is provided in Appendix C.

4.2 Prerequisite Actions, Sequencing, and Integration of Priorities

RAC members discussed the importance of defining prerequisite actions (i.e., actions that may be required ahead of a priority action), action sequencing, integration for implementing the research priorities, and the development of project implementation guidance. During the second RAC meeting, co-chairs from each theme described their priorities and prioritization process and presented their top three actions.

RAC members were encouraged to identify and discuss opportunities for integration with other theme priorities. RAC members discussed integrating and aligning the priority actions using the implementation questions from DWR's 2018 Flood-MAR white paper but found the actions did not neatly fit into the implementation questions. RAC members also discussed a simplified organizational structure using three categories: (1) Economics and Political, (2) Legal and Regulatory, and (3) Technical. One RAC member noted that the three categories are clearly divided, but, in reality, there will much overlap between them. That overlap will require the RAC to operate with the understanding that these distinction lines between the categories are porous.

RAC members also discussed potential sequencing of the actions. For example, the three priority actions from the Crop Systems Suitability theme

build upon each other and would be most effectively completed in sequence. Most actions in the other 12 themes are independent. As one RAC member noted that the priority actions may not be easily sequenced and fit neatly into categories, meaning that the process may be an "everything at the same time" effort. Other RAC members indicated implementing "low-hanging fruit" projects will help fill some of the immediate research and data gaps and set direction and priorities. It was noted that the RAC must look at "what's happening on the ground" to determine need. Instead of framing a perfect program implementation strategy, trial and error may provide relevant information more quickly than well-planned and implemented plans and research. It will be valuable to monitor, learn from mistakes, and be adaptive.

4.3 Hydrology Observation and Prediction Priority Action Summary

Priority Action 1. Improve comprehensive snowpack monitoring (Airborne Snow Observatory and in situ)

Description. Develop measurement/monitoring strategies, including locations, best suited to provide forecast-supportive data for anticipating and characterizing rain-on-snow events, rainfall-runoff from snow events, and other snow-centered flood generation processes and conditions. Research and the needed monitoring capacities should focus on characterization of energy budgets (cold balances) and liquid-water conditions/budgets within snowpacks, rather than on the more traditional snowpack-total-water content focus.

Total Estimated Cost*	$3 million
Estimated Time to Complete	3 years
Potential Lead Entity(ies)	DWR, California Snow Survey Co-op

Priority Action 2. Conduct inter-model comparison of surface hydrologic models with available historical precipitation products.

Description. 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.

Total Estimated Cost*	$2 million ($1 million annual operations and maintenance)
Estimated Time to Complete	3 years
Potential Lead Entity(ies)	U.S. Geological Survey (USGS), DWR

Priority Action 3. Develop a spatially distributed soil moisture network for upper watersheds.

Description. Develop a high-resolution spatially distributed soil moisture network that would provide important information regarding antecedent conditions contributing runoff generation, drought monitoring, infiltration rates, and recharge potential. Initially, the network could be preferentially installed in regions identified as highly suitable for Flood-MAR projects and used to develop and calibrate integrated groundwater models to better understand processes driving gaining rivers under a variety of soil moisture conditions.

Total Estimated Cost*	$3 million
Estimated Time to Complete	3 years
Potential Lead Entity(ies)	USGS, DWR, local agencies

4.4 Reservoir Operations Priority Action Summary

Priority Action 1. 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.

Description. 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.

Total Estimated Cost*	$12.5 million
Estimated Time to Complete	5 years
Potential Lead Entity(ies)	DWR, local agencies

Priority Action 2. Extend forecast-informed reservoir operations (FIRO) to include operations for groundwater recharge, particularly for local and regional agricultural field and basin recharge opportunities.

Description. 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.

Total Estimated Cost*	$5–10 million
Estimated Time to Complete	2–5 years
Potential Lead Entity(ies)	Federal, state, and local agencies; academia

Priority Action 3. Analyze reservoir and broader water resources system to assess potential for shifting drought storage from surface water reservoirs to aquifers.

Description. 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. 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.

Total Estimated Cost*	$15 million
Estimated Time to Complete	2–5 years
Potential Lead Entity(ies)	DWR, regional and local agencies

4.5 Infrastructure Conveyance and Hydraulics Priority Action Summary

Priority Action 1. Build a geographic information system (GIS) conveyance database of conveyance networks that could be used for Flood-MAR projects.

Description. 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.

Total Estimated Cost*	$550,000
Estimated Time to Complete	1 year
Potential Lead Entity(ies)	DWR

Priority Action 2. Research sediment transport impacts on conveyance and streams caused by increased usage from Flood-MAR operations.

Description. 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.

Total Estimated Cost*	$120,000
Estimated Time to Complete	1 year
Potential Lead Entity(ies)	Academia, local agencies

Priority Action 3. Develop light detection and ranging (LiDAR), topography, and bathymetry data around potential Flood-MAR project areas that lack this data in order to augment the GIS conveyance database.

Description. Use the statewide GIS conveyance database recommended above to identify areas that have potential for Flood-MAR projects but lack sufficient conveyance. High-resolution LiDAR, topography, and bathymetry data could be used to enhance the statewide conveyance database, build hydraulic models, and information for Flood-MAR projects.

Total Estimated Cost*	$1 million
Estimated Time to Complete	1 year
Potential Lead Entity(ies)	Academia, local agencies

4.6 Crop Systems Suitability Priority Action Summary

Priority Action 1. Perform case studies on agricultural land-based Flood-MAR projects completed to date.

Description. 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, life span, yield, and disease/pests should be addressed among others.

Total Estimated Cost*	$300,000
Estimated Time to Complete	2 years
Potential Lead Entity(ies)	Academia, landowners, private sector

Priority Action 2. Initiate and complete research on knowledge gaps of crop systems suitability for MAR in California.

Description. 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.

Total Estimated Cost*	$15 million
Estimated Time to Complete	5+ years
Potential Lead Entity(ies)	Academia, landowners, NGOs, private sector, grower associations

Priority Action 3. Develop decision support tool to determine crop suitability for Flood-MAR.

Description. 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 recommendation.

Total Estimated Cost*	$2 million
Estimated Time to Complete	3 years
Potential Lead Entity(ies)	Land grant institution, agricultural consultant

4.7 Soil, Geology, and Aquifer Characterization Priority Action Summary

Priority Action 1. Improve subsurface geologic data and provide greater accessibility to useable and better-quality data.

Description. Organize and consolidate existing data to develop a better characterization of the subsurface geology and soils that define strategic recharge locations where one can achieve the high recharge rates needed to implement Flood-MAR. Key data types are drillers descriptive logs, borehole and surface (including airborne) geophysics, and core. Data should be ranked in terms of reliability.

Total Estimated Cost*	$20 million
Estimated Time to Complete	5+ years
Potential Lead Entity(ies)	DWR, academia

Priority Action 2. Improve subsurface hydrologic data and provide greater accessibility to useable and better-quality data.

Description. 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. The data on properties exist in the form of well testing and laboratory core analyses and need to be gathered into a database that will provide adequate accessibility for Flood-MAR and SGMA. The data on groundwater levels needs to be expanded to allow four-dimensional mapping of groundwater level data to determine the subsurface "space" available for recharge and the system response to recharge and pumping.

Total Estimated Cost*	$10 million
Estimated Time to Complete	10 years
Potential Lead Entity(is)	DWR, State Water Resources Control Board (SWRCB)

Priority Action 3. Synthesize hydrogeologic data to identify the best locations for recharge.

Description. Use soils and subsurface geologic and hydrologic data to (a) define the geologic history and framework, (b) characterize the architecture of aquifers and aquitards as well as estimates of their properties, (c) combine the subsurface hydrogeologic data with soils data to identify the best locations for recharge. The above will require new policy that establishes a subsurface characterization team within an agency with the mission of collecting, curating and hydrogeologically interpreting (mapping) the subsurface aquifer and non-aquifer sediments/rocks.

Total Estimated Cost*	$20 million
Estimated Time to Complete	10 years
Potential Lead Entity(ies)	DWR, SWRCB, California Governor's Office of Planning and Research (OPR), academia

4.8 Land Use Planning and Management Priority Action Summary

Priority Action 1. Document coordination and communication methods occurring between GSAs and land use planning agencies to develop best practices.

Description. Conduct surveys to understand how coordination and communication is occurring between GSAs and land use planning agencies and how GSAs are considering local general plans in their GSP process. Identify a transferable/scalable model for collaboration and lessons learned to determine how similar processes could be implemented elsewhere.

Total Estimated Cost*	$200,000
Estimated Time to Complete	8 months
Potential Lead Entity(ies)	DWR

Priority Action 2. Identify sources of funding for integrated planning efforts and groundwater management.

Description. 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 program or similar integrated planning efforts could be used to improve incorporation of Flood-MAR in land use planning.

Total Estimated Cost*	$50,000
Estimated Time to Complete	3 months
Potential Lead Entity(ies)	DWR, OPR

Priority Action 3. Develop protocol for data consistency.

Description. 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.

Total Estimated Cost*	$500,000
Estimated Time to Complete	8 months
Potential Lead Entity(ies)	OPR, SWRCB, DWR, academia, private sector, GSAs

4.9 Water Quality Priority Action Summary

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

Description. Compile all existing knowledge of research, data, guidance, and tools into an easily accessible database or web-based platform.

Total Estimated Cost*	$1 million
Estimated Time to Complete	1 year
Potential Lead Entity(ies)	DWR, academia

Priority Action 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.

Description. Implement research initiative to increase understanding of and develop tools to assess: water quality impacts associated with different water sources (streams with/without reservoirs, various watershed characteristics, stormwater runoff, turbidity) and conveyance systems (e.g., algicide accumulation in canals, turbidity increases with different conveyance systems based on soil type); potential land characteristics (land use, soils, land management practices, site grading) that enable receiving land to handle Flood-MAR for appropriate water quality (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 (ag landscape), toxic substances (urban stormwater landscape); 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 potential trade-offs between generation/mobilization of uranium, arsenic, manganese, and denitrification, geochemical evolution of the vadose zone and groundwater, and affected wells and streams; clarification of antidegradation policy within Flood-MAR context.

Total Estimated Cost*	$20 million
Estimated Time to Complete	10 years
Potential Lead Entity(ies)	Academia

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

Description. Develop guidance and a multi-criteria decision analysis matrix decision 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 also could be used to evaluate potential sites on a state-wide scale.

Total Estimated Cost*	$1 million
Estimated Time to Complete	2 years
Potential Lead Entity(ies)	DWR, SWRCB, CDFA, OPR, academia

4.10 Recharge and Extraction Methods and Measurement Priority Action Summary

Priority Action 1. Compile existing managed aquifer recharge projects and associated data.

Description. 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.

Total Estimated Cost*	$100,000
Estimated Time to Complete	6 months
Potential Lead Entity(ies)	Academia, DWR

Priority Action 2. Compile pertinent information to determine the efficiency of managed aquifer recharge projects.

Description. Compile (1) on-farm water-delivery measurement tools and methods, (2) methods of determining appropriate loss factors (e.g., ET), and (3) recommendations regarding appropriate groundwater monitoring to determine the efficiency of managed aquifer recharge projects.

Total Estimated Cost*	$200,000
Estimated Time to Complete.	1 year
Potential Lead Entity(ies)	Academia, DWR

Priority Action 3. Establish methods and considerations by which floodplains can be used as direct recharge sites and in conjunction with other recharge methods.

Description. 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.

Total Estimated Cost*	$200,000
Estimated Time to Complete	1 year
Potential Lead Entity(ies)	Academia, NGOs, DWR

4.11 Environment – Terrestrial and Riparian/Aquatic Priority Action Summary

Priority Action 1. Develop a tool to calculate groundwater recharge that occurs when floodplains are inundated.

Description. 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.

Total Estimated Cost*	$100,00
Estimated Time to Complete	6 months
Potential Lead Entity(ies)	Academia, NGO, private

Priority Action 2. Develop a map that prioritizes Flood-MAR based on the additional habitat benefits that can be achieved at those sites.

Description. Integrate SAGBI-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.

Total Estimated Cost*	$500,000
Estimated Time to Complete	1 year
Potential Lead Entity(ies)	Academia, NGO, private

Priority Action 3. Map subsurface geology of floodplains to identify areas with the greatest potential for deep aquifer recharge.

Description. Conduct similar studies to recent 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.

Total Estimated Cost*	$2,000,000
Estimated Time to Complete	5 years
Potential Lead Entity(ies)	Academia, NGO, private

4.12 People and Water Priority Action Summary

Priority Action 1. Develop an ethical and just framework specifically focused on the Flood-MAR program.

Description. 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.

Total Estimated Cost*	$1 million
Estimated Time to Complete	2 years
Potential Lead Entity(ies)	Academia, NGO

Priority Action 2. Develop an engagement best practices document for Flood-MAR.

Description. Summarize existing information from the existing 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.

Total Estimated Cost*	$1 million
Estimated Time to Complete	2 years
Potential Lead Entity(ies)	DWR

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

Description. Document areas that are groundwater dependent and face water shortages caused by neighboring community withdrawals or legacy groundwater contamination. A ranking of communities that are highly dependent on and could potentially benefit the most from Flood-MAR should be developed.

Total Estimated Cost*	$250,000
Estimated Time to Complete	1 year
Potential Lead Entity(ies)	DWR

4.13 Economic Analysis Priority Action Summary

Priority Action 1. Develop an economic analysis guidance document for groundwater recharge projects.

Description. 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.

Total Estimated Cost*	$250,000
Estimated Time to Complete	2 years
Potential Lead Entity(ies)	News task force

Priority Action 2. Evaluate economic and other incentives for Flood-MAR implementation.

Description. Identify and evaluate funding sources and incentives to establish landowner compensation programs and finance the implementation of Flood-MAR.

Total Estimated Cost*	$200,000
Estimated Time to Complete	2 years
Potential Lead Entity(ies)	Economic Analysis Subcommittee

Priority Action 3. Assess groundwater ownership rights and market issues associated with Flood-MAR.

Description. Develop a model of groundwater rights and surface and subsurface water transactions to better understand the benefits and costs of Flood-MAR projects.

Total Estimated Cost*	$200,000
Estimated Time to Complete	2 years
Potential Lead Entity(ies)	Economic Analysis Subcommittee

4.14 Local, State, and Federal Policies and Legal Considerations Priority Action Summary

Priority Action 1. Refine guidance and provide applicant assistance for beneficial use designations associated with recharge.

Description. Develop additional guidance for water right applicants requesting inclusion of "other" beneficial uses for non-extractive purposes of use, in the context of the SGMA. Conduct outreach, education, and provide project level assistance for applicants seeking to include non-extractive beneficial uses in their water right applications and change petitions. Refinement of guidance can be informed by tracking early case studies of applications and change petitions that propose to recharge surface water for a non-extractive purpose, drawing lessons learned from these and obtaining input from applicants.

Total Estimated Cost*	$600,000
Estimated Time to Complete	3 years
Potential Lead Entity(ies)	SWRCB, academia

Priority Action 2. Provide guidance and support for water availability analyses and associated determinations for processing of water rights applications.

Description. 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 development of water availability analysis. Evaluate protective flood flow metrics for conditioning in permits.

Total Estimated Cost*	$1,600,000
Estimated Time to Complete	3 years
Potential Lead Entity(ies)	SWRCB

Priority Action 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.

Description. 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 the primary laws, regulations and associated permitting processes at all scales (local, county, state, 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 programmatic 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.
- Provide a forum that facilitates interagency legal and policy issue resolution as issues are identified or arise in the implementation of Flood-MAR projects.

Total Estimated Cost*	$900,000
Estimated Time to Complete	3 years
Potential Lead Entity(ies)	SWRCB, CDFW, Policy Subcommittee, academia

4.15 Tool and Application Development Priority Action Summary

Priority Action 1. Conduct cost/benefit analysis, including multi-benefit.

Description. Identify and fill gaps related to quantifying the cost and benefits of implementing Flood-MAR strategies. Identify spatially explicit estimates on costs to implement (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 undesirable results stated in SGMA.

Total Estimated Cost*	$850,000
Estimated Time to Complete	18 months
Potential Lead Entity(ies)	Tools and Application Development Subcommittee

Priority Action 2. Identify policy linkages and governance structure.

Description. Identity 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 individuals landowners, irrigation districts, and multiple agencies (e.g., individual landowners versus group of landowners).

Total Estimated Cost*	$600,000
Estimated Time to Complete	18 months
Potential Lead Entity(ies)	Tools and Application Development Subcommittee

Priority Action 3. Create decision support tools to integrate Flood-MAR disciplines.

Description. 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.

Total Estimated Cost*	$950,000
Estimated Time to Complete	18 months
Potential Lead Entity(ies)	Tools and Application Development Subcommittee

Note for Subsections 4.3 through 4.15:
*Because work is assumed to be completed by graduate students or research assistants, salary costs are not loaded. Estimated costs may double, or even triple, if work is conducted by salaried professionals.

5.0 From Plan to Implementation

This section considers implementation of the priority actions and was developed using schedule and funding need estimates from the 13 theme subcommittees, as well as input received at the June 2019 RAC coordination and implementation workshop.

5.1 Coordination and Alignment with Other State Efforts

Many State programs and efforts influence the implementation of the priority actions. As appropriate, the timing, funding, and implementation of these other programs and efforts should be aligned with implementation of the priority actions to promote effectiveness and efficiencies. Current programs and efforts include:

Governor Newsom's EO N-10-19. In April 2019, Governor Gavin Newsom, by executive order, directed the California Natural Resources Agency, the California Environmental Protection Agency, and the California Department of Food and Agriculture to prepare a water resilience portfolio for California. The water resilience portfolio must prioritize multi-benefit approaches, utilize natural infrastructure, embrace innovation, encourage regional approaches, promote integration, and strengthen partnerships.

California Water Plan Implementation. Implementation and expansion of Flood-MAR projects is a recommendation of the *California Water Plan Update 2018* (California Department of Water Resources 2018a). DWR's Water Plan Team is exploring Flood-MAR opportunities in the Russian River Basin to support a water sustainability pilot project.

SGMA Implementation. SGMA requires GSAs of high- and medium-priority basins to complete GSPs by 2022 and reach basin sustainability by 2042 (critically overdrafted basins by 2020 and 2040, respectively). Many GSAs are currently characterizing their groundwater basins and formulating recharge projects.

Central Valley Flood Management Planning and Implementation. The Central Valley Flood Protection Plan (CVFPP) (California Department of Water Resources 2017) and Conservation Strategy provide a strategic blueprint to

improve flood risk management in the Central Valley by prioritizing the State's investment in flood management, promoting multi-benefit projects, and integrating and improving ecosystem functions associated with flood risk reduction projects. The 2022 update of the CVFPP will include an evaluation of Flood-MAR strategies that could support local objectives.

California State Wildlife Action Plan (SWAP). The SWAP (California Department of Fish and Wildlife 2015) examines the health of wildlife and prescribes actions to conserve wildlife and vital habitat. Groundwater is specifically recognized in the SWAP as a critical component of habitat connectivity and water quality, quantity, and availability goals for enhancing ecosystems.

Integrated Regional Water Management (IRWM). The IRWM program was initiated following the Regional Water Management Planning Act of 2002. The intent was to create a collaborative effort to identify and implement water management solutions on a regional scale that increase regional self-reliance, reduce conflict, and manage water to concurrently achieve social, environmental, and economic objectives. IRWM delivers higher value for investments by engaging all regional interests, providing multiple benefits, and working across jurisdictional boundaries. Cities, counties, water districts, community/environmental groups, Tribes, and others across the State have worked collaboratively to organize and establish 48 regional water management groups, covering more than 87 percent of the state's area and 99 percent of its population. Regional water management groups have significantly leveraged local and State investments. There is significant opportunity for IRWM regional water managements to better integrate and align with GSAs to improve regional water management planning and implementation.

Open and Transparent Water Data Act (Assembly Bill 1755) Implementation. Multiple State agencies, and stakeholders, are working together to create, operate, and maintain a statewide integrated water data platform, and to develop protocols for data sharing, documentation, quality control, public access, and promotion of open-source platforms and decision support tools related to water data.

5.2 Estimated Time and Funding Needed to Complete Priority Actions

The priority actions are intended to be implemented in the near-term, and include actions that are relatively simple, such as convening experts and compiling existing information and making it readily available, to more complex, such as new research studies. As indicated in Subsections 4.3 through 4.15, most of the priority actions can be completed within two years with a total estimated cost of $147 million.

5.3 Funding Sources

Some subcommittees expressed concern that funding sources were not yet secured to further Flood-MAR implementation. Secure funding is critical to successfully implement the plan. *California Water Plan Update 2018* describes current and potential new funding mechanisms that may be used to fund water management activities. Typically, State government has used the General Fund and general obligation bonds to fund State operations and local assistance programs, as well as grants received from federal programs. Potential future and novel funding sources explored in the California Water Plan include special designated funds, watershed assessments, new insurance programs, water markets, and others (California Department of Water Resources 2018c).

Local government activities are typically funded by local assessments, fees, taxes, and rates, as well as, money received through State and federal grant programs. Local governments usually cover the largest percentage of water management spending. Federal government activities are typically covered by federal agency operation, maintenance, and capital budgets. Academia, private researchers, and philanthropy generally rely on endowments, donations, and grants for funding.

The funding for the actions described in this plan likely will come from State general obligation bonds for State operations and grants and through non-State grants and private investment. Bond availability and non-State grant sources are described in greater detail below.

Bond Funding Availability

Current bond funds are available through Proposition 1, the Water Quality, Supply, and Infrastructure Improvement Act of 2014, and Proposition 68, the California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018. Bond-funded programs that could support Flood-MAR implementation include DWR's sustainable groundwater management grant programs and the Central Valley tributaries program. A new bond with funding for groundwater recharge projects likely will be put before voters within the next few years.

Non-State Source Grants

Many grants are available from private foundations and federal government programs that fund studies and projects related to Flood-MAR and actions described in this R&DD Plan. The following are a few examples:

- Gordon and Betty Moore Foundation
- National Science Foundation, Coupled Natural Human Systems Program
- U.S. Bureau of Reclamation Water SMART Program grants
- U.S. Department of Agriculture, National Institute of Food and Agriculture grants programs (e.g., Farm Bill)
- U.S. Department of Agriculture, Natural Resources Conservation Service Regional Conservation Partnership Program
- U.S. Environmental Protection Agency water research grants
- U.S. Geological Survey, National Institute for Water Resources grant programs

5.4 Roles and Responsibilities

All members of the water community (water managers, decision-makers, researchers, users, and stakeholders) have a role in implementing this R&DD Plan. It is vital that participants stay engaged, develop (and commit to) partnerships, and engage in creative (and perhaps at times difficult) discussions on needed solutions and tradeoffs. Implementation of research actions and pilot studies generally occurs through partnerships.

These partnerships may include:

- Local government/agencies (including GSAs and IRWM groups)
- State government/agencies
- Federal government/agencies
- Tribes
- Disadvantaged communities and community members
- Academia
- NGOs
- Private researchers
- Philanthropy
- Private landowners/businesses
- Farmers and agricultural interests

The above entities may also bring funding for implementing the R&DD Plan through government grants or operations, private investment, donations, or in-kind support. Government agencies and academia are excellent entities for compiling and disseminating local, regional, and statewide data, as well as providing guidance for their use, at the appropriate scales.

6.0 Establishing a Flood-MAR Network

In general, RAC members want an ongoing multi-stakeholder involvement process for coordinating, communicating, and carrying out the R&DD Plan actions. This could take any number of forms including informal information sharing, a network, or other collaborative platform.

Many RAC members recommend establishing a Flood-MAR network. The Flood-MAR network would be a collaborative that orchestrates the compilation of technical and financial assistance information to support Flood-MAR project research and implementation. The Flood-MAR network would also provide a clearinghouse and one-stop shop for interested parties seeking information and support for developing projects. The network would ensure that data collected through the priority actions is stored and archived centrally. Many of the sub-committees recommended developing decision support tools and these decision support tools should be connected or accessible through the network platform.

The RAC believes the network would best be administered by an entity with a budget and a specific function to support Flood-MAR that no other organization serves today. It could be a specific entity within DWR, the California State Water Resources Control Board, or the University of California.

The network could provide and allocate funding and other resources. For example, under the White House Regional Livability Program, multiple federal, state, and regional agencies requested a federal agency to take the lead under a memorandum of understanding. Thus, one federal agency brought the other relevant federal agencies together at the table on a dependable and consistent basis. Under this model, DWR or another agency could engage other State agencies to participate. Another way to use this model is to enhance and expand IRWM to support the Flood-MAR network with financing and management support within a designated lead agency.

Other RAC members thought this network should call for a funding platform, similar to the National Science Foundation model, that could receive funding from public or private grants, direct legislative action, or water bond

allocations for research in support of Flood-MAR. The R&DD Plan already documents the initial funding need and an advisory group, or the proposed network, could ensure that funding is directed towards the evolving actions as the R&DD Plan is implemented.

RAC members recommend that the network continue the work started with the development of this R&DD Plan. A first step of the network could be to further prioritize and refine the priority actions. This R&DD Plan presents 39 priority actions — three priorities actions for each the 13 RAC subcommittees. These actions are not an integrated prioritization of gaps across the themes. A next step for refining and guiding implementation of this plan may be to further consolidate and prioritize the 39 actions to address immediate needs and ensure efficient implementation of actions. In addition to these 39 priority actions, the 13 subcommittees identified hundreds of specific research, data, tools, and guidance (Appendix C) that would need to be pursued over the longer term in support of Flood-MAR implementation. These broader actions lay the foundation for a long-term action and engagement plan of a Flood-MAR Network. This prioritization and longer-term planning should consider the most pressing needs to support implementation of much needed recharge projects to support SGMA and long-term water management sustainability.

The Flood-MAR network would also require ongoing feedback between those implementing Flood-MAR and others engaged with the research, data, guidance, and tool development from all different perspectives. As an initial step, the network should share the R&DD Plan with an expanded stakeholder network inclusive of Tribes, GSAs, IRWM groups, landowners, water and flood managers, NGOs, and other implementing agencies, and community interest groups, including disadvantaged community groups, to ensure their needs and priorities are included when implementing this R&DD Plan. Their input is a primary consideration for further refining and prioritizing the actions identified in this plan.

The RAC recognized that implementation of early Flood-MAR pilot projects, completed in collaboration with network members, will inform and refine the prioritization of information needs. The needs of end users, such as project planners, implementers and beneficiaries, must drive the implementation of

the recommendations of this plan and ultimately the implementation of Flood-MAR projects.

Additionally, the network should add, update, revise, and remove priority actions in the R&DD Plan as Flood-MAR research, data, guidance, and tool development progresses and priority needs and gaps change. Continuous adaptation and learning will be required for implementing this R&DD Plan.

6.1 Call to Action

Though at times contentious, water management in California is dynamic and critical for the health and wellness of all. There is significant opportunity to improve the integration of surface and groundwater management to create sustainable practices and provide benefits to meet local, regional, and state needs. Implementation of integrated, multiple benefit Flood-MAR projects can support a sustainable water future for California, but better data, information, tools, and guidance are needed to ensure implemented projects are well formulated, support multiple needs, and promote broader participation by water management sectors and landowners. The RAC encourages all members of the water management community to stay engaged and support implementation of these priority actions that will not only support Flood-MAR projects, but also create more cooperative and informed statewide water management.

7.0 References and Resources

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California Department of Water Resources. 2019. *Flood-MAR Research and Data Development Framework*. Discussion Draft. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 26 pages. Viewed online at: https://water.ca.gov/-/media/DWR-Images/Flood/Flood-MAR/20180724_Flood-MAR-Development-Framework_Draft.pdf?la=en&hash=F78CD0A38244319FF6E89A189814F03E60E4134C. Accessed: Sept. 24, 2019.

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https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2018/Final/SupportingDocs/Funding-Mechanism-Inventory-and-Evaluation.pdf
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California State Board of Food and Agriculture. 2018. *Recommendations for Managed Aquifer Recharge to Support Sustainable Water Management*. Letter to the Governor's Office. May 15. 6 pages. Viewed online at: https://secure.cdfa.ca.gov/egov/groundwater/docs/Managed_Groundwater_Recharge_to_Support_Sustainable_Water_Management.pdf
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7.2 Additional Resources

Organizations and Program Webpages

Bachand & Associates Groundwater Recharge
https://www.bachandassociates.com/projects/groundwater-recharge

California Department of Water Resources Flood-MAR Webpage
https://water.ca.gov/Programs/All-Programs/Flood-MAR

California Department of Water Resources SGMA Program
https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management

California Economic Summit Webpage
https://www.caeconomy.org/

Groundwater Exchange
https://groundwaterexchange.org/

Public Forum on Managed Aquifer Recharge to Support Sustainable Water Management
https://secure.cdfa.ca.gov/egov/groundwater/

State Water Resources Control Board Groundwater Ambient Monitoring and Assessment Program
https://www.waterboards.ca.gov/water_issues/programs/gama/online_tools.html

Sustainable Conservation Groundwater Resources
https://suscon.org/technical-resources/

The Nature Conservancy Groundwater Resources Hub
https://groundwaterresourcehub.org/

University of California, Davis, Agricultural Groundwater Recharge and Banking
http://recharge.ucdavis.edu/

University of California, Davis, Groundwater Information and Educational Resources
http://groundwater.ucdavis.edu/

University of California, Davis, Dynamics of Water Supplies, Land-Use, and Disadvantaged Communities
https://waterclimatecommunities.ucdavis.edu/

UC Water Groundwater Recharge and Management Webpage
http://ucwater.org/recharge

Funding Opportunities and Grant Programs

California Department of Water Resources
https://water.ca.gov/Work-With-Us/Grants-And-Loans

Gordon and Betty Moore Foundation
https://www.moore.org/grants

National Science Foundation, Coupled Natural Human Systems Program
https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf19528

U.S. Bureau of Reclamation WaterSMART Program
https://www.usbr.gov/watersmart/

U.S. Department of Agriculture, National Institute of Food and Agriculture
https://nifa.usda.gov/page/search-grant

U.S. Department of Agriculture, Natural Resources Conservation Service, Regional Conservation Partnership Program
https://www.nrcs.usda.gov/wps/portal/nrcs/main/ca/programs/farmbill/rcpp/

U.S. Environmental Protection Agency Water Research Grants
https://www.epa.gov/research-grants/water-research-grants

U.S. Geological Survey, National Institute for Water Resources
https://water.usgs.gov/wrri/index.php

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