Flood-MAR

Research and Data Development Framework

Discussion Draft
June 2018

Discussion Draft – Research and Data Development Framework Reviewer's Guide

This Research and Data Development Framework on using flood water for managed aquifer recharge (Flood-MAR) to support sustainable water resources is presented as a discussion draft. Comments received on this draft by September 20, 2018, will be used to inform the final framework.

In August 2017, DWR released the Phase 3 report for the System Reoperation Study. A recommendation of this report was to "evaluate potential for using flood water for managed groundwater recharge on farmland and working landscapes for flood protection, drought preparedness, aquifer remediation, and ecosystem restoration. DWR will work with flood managers, land owners, and Groundwater Sustainability Agencies to determine opportunities to implement managed groundwater recharge projects that use excess flood flows as the source water."

Where to Find This Draft?

The discussion draft Research and Data Development Framework will be posted online in PDF format at: https://www.water.ca.gov/Programs/All-Programs/System-Reoperation-Program

How to Comment?

Send comments to: Romain.Maendly@water.ca.gov

Fax: 916-651-9274

Postal mail:
Attn: Romain Maendly

Statewide Infrastructure Investigations Branch
Division of Statewide Integrated Water Management
California Department of Water Resources

901 P Street, Room 213A
PO Box 942836
Sacramento, CA 94236-0001

What to Review?

Prior to the publication of the final version, this framework will be edited for grammar, punctuation, style, consistency, accuracy, or other issues relating to readability or quality.

Recommendations for what to focus on during your review:

- **Completeness of information:** In general, does the text say all it should say? Does the framework need additional research themes or sub-themes and is the information presented appropriately?
- **Organization of information:** Does any portion of the text cause readability issues because information is presented in a confusing sequence or because it is difficult to tell what section of text is a subsection of another?
- **Factual accuracy**. Is anything in the text incorrect? Do any research themes need further definition and development? Does any information need additional attribution to a specific source?
- **Logical consistency**. Does the narrative build in a logical way and effectively tell the right story?
- **Clarity/Comprehensibility**. Are there any holes/gaps in information that make the text difficult to understand? Are there ways to improve clarity and make the text more meaningful and effective?

Contents

Acronyms and Abbreviations

Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
Flood-MAR	flood water for managed aquifer recharge
SGMA	Sustainable Groundwater Management Act
SHA	safe harbor agreements
SWRCB	State Water Resources Control Board
RAC	research advisory committee
R&D Framework	Flood Water for Managed Aquifer Recharge Research and Data Development Framework

Flood-MAR Research and Data Development Framework

Introduction

This Flood Water for Managed Aquifer Recharge (Flood-MAR) Research and Data Development Framework (R&D Framework) identifies key research and data themes for advancement of the Flood-MAR resource management strategy that can be applied at any geographic scale whether that is local, regional, or statewide. The framework is intended to be a discussion draft to seek input and encourage discussion among stakeholders for developing, organizing, building, and maintaining statewide technical knowledge and expertise for the Flood-MAR resource management strategy. Each research theme has an introductory discussion to frame the research needs associated with that theme.

The purpose of the R&D Framework is to identify and categorize Flood-MAR relevant research themes, and coordinate ongoing and future research and pilot studies around a common research plan. The R&D Framework will identify gaps in data, information, and knowledge; and outline methods for developing, reviewing, and distributing information among stakeholders. It will also help inform the development of Flood-MAR reconnaissance studies. Conclusions and lessons learned from reconnaissance studies will be used to test, refine, and promote the long-term and continued research, development, and implementation of small- and large-scale Flood-MAR projects. This framework also recommends the development of a Flood-MAR decision support tool to incorporate all the technical findings of the Flood-MAR resource management strategy.

Description of Flood-MAR

Flood-MAR is an integrated and voluntary resource management strategy that uses flood water resulting from, or in anticipation of, rainfall or snowmelt for groundwater recharge on agricultural lands and working landscapes, including but not limited to refuges, floodplains, and flood bypasses. The ability to integrate flood and groundwater management by actively managing flood events to recharge aquifers could provide multiple benefits. As further discussed in the California Department of Water Resources' (DWR's) white paper, *Flood-MAR: Using Flood Water for Managed Aquifer Recharge to Support Sustainable Water Resources*, eight considerations for implementing this resource management strategy include:

- Site suitability.
- Source water availability.
- Conveyance.
- Recharge methods.
- Governance and coordination.
- Groundwater recovery and use.
- Funding and incentives.
- Feasibility analysis.

Problems, Needs, and Intended Outcomes

Current Flood-MAR efforts in California are often fragmented, with much of the existing implementation occurring through the efforts of local entities on a small scale. Many stakeholders within the state, such as

groundwater sustainability agencies, water agencies, flood managers, and others looking to implement the Flood-MAR resource management strategy, may simply not know where or how to start, what regulations apply, and what information is available to determine a project's feasibility. In addition, there are many complex technical, legal, and institutional barriers, challenges, and opportunities, that stakeholders may not be aware of, which may affect the implementation of the Flood-MAR resource management strategy. There is a clear need to coordinate and share Flood-MAR research needs and results, methodologies, best management practices, and existing technical information related to Flood-MAR.

The intended outcomes of this framework are:

- Develop a body of knowledge and a living inventory of technical research needs for the Flood-MAR resource strategy.
- Inventory, develop, and coordinate technical expertise related to research needs.
- Matrix technical expertise among participating groups and stakeholders to develop and communicate within the Flood-MAR interest communities a clear, concise, and consistent message.
- Ensure availability of research and technical expertise for all stakeholders.
- Promote long-term, and continued, research and development.
- Provide guidance to stakeholders to support implementation of the Flood-MAR projects.

Research and Data Development Strategy

Prioritizing research investments across a broad range of topics and disciplines will be critically important to building a sufficient technical understanding of Flood-MAR from a statewide perspective. This research and data development strategy is intended to leverage mutually beneficial and well-defined partnerships among academia, non-government organizations, government and tribal entities, and other stakeholders to adequately describe the eight fundamental factors for successfully implementing the Flood-MAR resource management strategy. These partnerships will be designed to provide the necessary interdisciplinary and interagency technical expertise and resources to support Flood-MAR in California.

Flood-MAR stakeholders will need to coordinate research and data development across multiple organizations, along with professional and technical areas. The inventory of research needs described below are categorized into themes supporting the eight fundamental factors. The themes can both overlap and support multiple fundamental factors. There is a need for a comprehensive, interdisciplinary, applicable, and integrated research initiative that combines an understanding of the Flood-MAR strategy with its implementation.

DWR, contingent on available funding, proposes to facilitate a stakeholder research advisory committee (RAC) that will coordinate the formulation, review, and distribution of the research themes and data needs of this framework, and to coordinate efforts for the development of reconnaissance studies and pilot projects that will demonstrate feasibility of potential projects. DWR will engage subject matter experts from various backgrounds to provide input to, and learn information from, reconnaissance studies to inform a larger Statewide Flood-MAR program. The RAC will help determine methods for filling in the data and information gaps, and distributing information publicly. The RAC, as a partnership of technical experts, will advance scientific information and implementation of the Flood-MAR resource management

strategy. For the RAC to succeed and flourish, guidelines of effective collaboration for the committee include:

- Identify and include stakeholders: There are many potential stakeholders. It is essential to identify and involve them to encourage the application of Flood-MAR research and use their experiences to develop future research needs.
- Choose a realistic strategy: The RAC will need to develop an achievable strategy that prioritizes the formulation, review, and distribution of the research themes and data needs for Flood-MAR and stakeholders.
- Establish a Flood-MAR mission statement: Collaborative partnerships must create and focus on a shared vision in order to best cooperate.
- Establish effective communication: The RAC will need to establish an effective communication process for internal and external collection and distribution of information.
- Set attainable goals: Setting specific, quantifiable, and attainable objectives and goals will be necessary to create momentum for future research.
- Institutional flexibility: RAC participants should be willing to incorporate partnership objectives into their own institutional mandates to keep the joint effort moving forward.

The activities of the RAC include, but are not limited to:

- Developing a repository and literature review for the body of knowledge and technical research related to the Flood-MAR resource management strategy. The repository would catalogue available information, data, and studies that would be shared with stakeholders.
- Facilitating the creation of an extensive network of collaborators and advisors, organized and led by DWR, to collect and disseminate the best available science and technical capacity. The network will be made up of members from government agencies, non-governmental organizations, and academia, along with private experts, extension advisors, firms, and stakeholders.
- Providing guidance to develop and support multi-agency technical and scientific activities, plans, and programs such as common standards, data-based information, modeling capabilities, testing, and documentation.
- Overseeing and providing independent, transparent, credible, and competent recommendations to technical and policy-informing studies. The intent would be to address controversies in a non-advocacy way.
- Fostering and providing independent technical reviews to better inform discussions of controversial topics.
- Leading and developing an integrated training and education program that provides scientific outreach and engagement for staff, stakeholders, industry leaders, regulators, planners, decision makers, and academic experts.

Analytical Tools and Modeling Support

Development and use of software models will be important in supporting decisions for the research themes in this report. There are a variety of existing computer models commonly used in water resources planning, including the HEC modeling suite, CALSIM, C2VSIM, WEAP, VIC, and others. These models will need to be cataloged along with a short description highlighting their advantages and limitations. If it is determined that existing models are inadequate for the development of the research themes described

here, then new models may need to be developed. In addition to models, identifying and utilizing technical expertise in the development, support, and use of these models will be critical.

- **Catalog existing water resources software models**: Identify and catalog hydraulic, hydrologic, groundwater, environmental, economic, and other Flood-MAR-related models. Identify technical experts that understand the models and can characterize their usefulness, limitations, and applicability.
- **Develop integrated and improved models**: For areas identified as suitable for recharge, integrated and improved models should be developed. These integrated models could be surface-groundwater interaction models that could capture the complexity and timing of surface water moving into a recharge area.
- **Develop modeling support, training, and expertise**: Identifying and developing models to use in the support of the Flood-MAR research themes may not be enough for some stakeholders. Those stakeholders that do not currently have the expertise or capacity may need to rely on the research advisory committee for training and modeling support to answer specific questions. A goal of the committee should be to help stakeholders develop their own expertise when feasible.
- **Develop a Flood-MAR Decision Support Tool**: A Flood-MAR decision support tool could provide a statewide standardized approach to expanding the strategy and methods developed during the research and reconnaissance study phases. This tool could be developed by DWR with input from the research advisory committee and supported with research and findings from stakeholder reconnaissance studies. The purpose of the tool would be to develop a matrix of performance measures that could integrate the research and data development with the reconnaissance study's findings and results. The tool could then help inform and adjust decisions on the Flood-MAR strategy as stakeholders move toward implementation of Flood-MAR projects and programs.

Research Themes and Data Needs

This section identifies general areas of research and data needs to improve understanding and advancement of Flood-MAR. Many of the research themes overlap with those needed for advancing sustainable water resource management and for informing a broader range of other strategies and relevant decisions. This framework and process will produce a living research inventory or literature review, managed by the RAC, that will expand with new information.

The research areas and activities discussed in this section were identified during public meetings, roundtables, workshops and forums, and in relevant scientific publications. Some of the sources used include:

- A forum on groundwater recharge held by the California Board of Food and Agriculture in November of 2017. It drew diverse stakeholder participation for a discussion of Flood-MAR research themes.
- Many forums held by the Groundwater Resources Association of California to discuss themes related to managed aquifer recharge.
- Researchers within the University of California (UC) system who have been active leaders in developing an understanding of Flood-MAR research themes.

There is a significant array of technical information that will be needed for the advancement of Flood-MAR. The research areas below are compiled by major themes. Some of the research themes may

already be under investigation and development, or will be required to be in the future (e.g., as part of the groundwater sustainability plans for SGMA). Research and data developed under other programs could be incorporated into this framework for use in Flood-MAR.

Research Theme 1: Hydrology Observation and Prediction

Improving hydrology observation and prediction will advance California's ability to manage water. Hydrology will dictate the ability to implement the Flood-MAR strategy in a specific watershed under a specific climate.

1.1 Develop Advanced Real-Time Hydrologic Models with Accurate Representation of the Water Cycle

New technologies are needed to allow continuous, precise measurements of data inventories and fluxes of water, including precipitation, groundwater, soil moisture, snow, evapotranspiration, and stream flow. An increase in accuracy from an advanced hydrologic model would provide better information than presently available to help make decisions for a range of possible flood peaks (volume, flow, and stage), determine water available, provide more time to efficiently operate infrastructure including reservoirs and canals, and develop better water accounting.

1.2 Improve Forecasting of Sub-Seasonal Hydrology

Sub-seasonal hydrology is defined in this document as the development of weather forecast that covers a time range between two-weeks and two-months into the future. Research into sub-seasonal hydrology is at a relatively early stage of development. The sub-seasonal time scale is important because it exists between the well-established and routine application of weather forecasts in diverse user sectors, and the increasing use of seasonal forecasts. Many management decisions, such as in agriculture, fall into the intervening two-week to two-month time scale. The development of more seamless weather-to-climate forecasts promises to be of significant societal value, and will augment the regions/situations where there is actionable forecast information.

1.3 Improved Projections of Changes in the Water Cycle at Regional and Seasonal Time Scales

Improved regional-scale projections of changes in precipitation, soil moisture, runoff, and groundwater availability on seasonal to multi-decadal time scales are needed to inform water management and planning decisions, especially decisions related to long-term infrastructure investments. Likewise, projections of changes in the frequency and intensity of severe storms, floods, and droughts are critical both for water management planning and for adapting the natural and human systems that depend on water resources. This will require new multiscale modeling approaches, such as nesting cloud-resolving climate models into regional weather models and then coupling these models to land-surface models that can simulate the hydrologic cycle, vegetation, multiple soil layers, groundwater, and stream flow. These models will also need to reliably project changes in storm paths and modes of regional climate variability.

Research Theme 2: Reservoir Operations

Using the Flood-MAR strategy will provide an opportunity to accomplish multiple goals by rethinking the way reservoirs are operated. Reservoir operations will play an important role in addressing water management challenges in a post-SGMA world which is being influenced by a changing climate with extreme variability in water years (flood and droughts). For example, one scenario could include reservoir re-operation to optimize conjunctive use between surface water and groundwater. Another potential scenario could increase the ability to retain flood water in reservoirs and use the extra surface water stored in-lieu of groundwater. The scenarios could also be combined to optimize the Flood-MAR strategy.

2.1 Evaluate Existing Reservoir Operating Rules under Changing Hydrology

An evaluation of the adequacy of existing flood operating rules to address water management challenges is needed. A significant portion of future adaptive water management strategies could involve changing existing reservoir rule curves, which are mostly static, to more dynamic rule curves with multiple objective and purposes including water supply, flood protection, hydropower, and ecological value.

2.2 Enhance Understanding of Forecast Informed Reservoir Operation Applicability

Forecast Informed Reservoir Operation is a water management strategy that uses improved watershed monitoring data, weather, and hydrologic forecasting to inform water managers about the risk associated with selectively retaining or releasing water from reservoirs in a flexible manner that more accurately reflects natural variability of meteorology and hydrology. The viability of this strategy is being assessed by the Sonoma County Water Agency on Lake Mendocino. It is also currently being evaluated by Orange County Water District on Prado Reservoir. Additional case studies are needed to expand the knowledge surrounding the associated operational risks, uncertainties, and potential feasibility.

2.3 Develop Optimized Conjunctive Use Methodology

Conjunctive use refers to the coordinated management of surface water and groundwater resources to regionally improve water supply availability and reliability, and to meet other water management objectives. While conjunctive use is not a new water management strategy, research is needed to optimize conjunctive use at a larger scale (e.g., U.S. Geological Survey defined basin or sub-region scale hydrologic unit code 6 or hydrologic unit code 4), to meet an expanded set of regional water management objectives. Also, research could be targeted at uncertainties, regulation requirements, coordinated management, and sustainability.

Research Theme 3: Infrastructure Conveyance and Hydraulics

An important consideration is how to move water from streams to recharge areas. Lands adjacent to rivers, channels, and irrigation canals may already have sufficient conveyance. Regions historically reliant on groundwater may have insufficient water conveyance capacity to support recharge.

The physical characteristics of existing water management facilities, such as conveyance capacity and operations, may limit the amount, or affect the timing of, water available at specific locations. Modified or new conveyance facilities, and the modification of operations at existing facilities may be necessary to increase managed aquifer recharge statewide.

3.1 Create a Database of Channel, Water Diversions, and Local Water Distribution

The width, depth, bed elevation, location, and operations of water diversions and water distribution is needed to better understand the available system capacity to convey water to recharge areas. The creation of a database detailing existing conveyance infrastructure, including system operation, would help with identifying the areas of greatest conveyance needs.

3.2 Develop Advance Understanding of Structure Erosion and Sediment Flow

Transporting flood flows using earthen channels could require better understanding of erosion and sediment transport. Increased flows could erode embankments, affect existing infrastructure including levees, channels, and bridges. It could also increase the cost of maintenance associated with an increase of sediment transported by flood flows. Impacts can reduce the capacity to convey water to groundwater basin recharge areas, increase the risk of damage, and increase the cost of repairing infrastructure.

Research Theme 4: Crop Suitability

The primary issue associated with using agricultural lands to recharge aquifers is understanding how waterlogged soils, including flooded/ponded/saturated soils affect the biological and chemical processes. This occurs through oxygen depletion, in both soils and crops, which may affect short- and long-term crop growth.

Compatibility with intermittent flooding must be evaluated and catalogued for specific crops; specifically, the ability of a crop's root zone to tolerate saturated conditions for various durations. This issue is particularly important for perennial crops and vines because of the risk of root damage, disease, and crop loss. Crop-type considerations are also important because of the different fertilizers and pesticides applied to various crops which may potentially contaminate the underlying aquifer if the field is used for Flood-MAR.

4.1 Creating a Database of Soil and Crop Response to Flooding

Various crops have different tolerances to flooding. Some crops perform extremely well under saturated soil conditions, rice being an obvious example, while other crops perform poorly. A database that catalogues crop tolerance to flooding could be created to inform growers. The database could cover a variety of soil saturation levels and seasons, including information describing the effects of flooding and growth stage of the plant.

4.2 Evaluate the Effects of Water Temperature/Water Quality on Crops

The water temperature of applied flood waters on crops is an important factor to consider and should be catalogued in the crop tolerance database. With abnormally warm water temperatures during the flooding period, the crop survival period may be reduced. Conversely, if water temperatures are cool, the survival of the submerged crop increases because the metabolic processes slow down. Cloudy conditions decrease solar radiation and keep soils and floodwaters cooler. But, prolonged, cold, wet weather favors disease development. Increase of water temperature induced by climate change could influence crop development.

4.3 Investigate Potential of Improving Crop Resilience to Prolonged Flooding

This information could inform research into plant breeding techniques using either conventional or genetic engineering. In turn, the research could help develop crops that successfully grow in waterlogged soils and improve groundwater levels. This would also require an advance understanding of flood consequences on crop diseases and pathogens.

Research Theme 5: Soil Suitability

The soil moisture content in the first few feet below the ground surface regulates land-surface energy and moisture exchanges with the atmosphere. It also plays a key role in flood and drought genesis and maintenance.

Understanding soil suitability for most direct recharge methods is imperative for a few reasons, the most important being nearly all agricultural land is privately owned and operated. Understanding the risks and best practices associated with Flood-MAR would help land owners understand the risks. Factors that determine the feasibility of groundwater recharge on agricultural land include deep percolation, root zone residence time, topography, chemical limitations, and soil surface conditions.

5.1 Develop a Statewide Soil Moisture Monitoring Network

The network would be an essential element to conduct successful research on understanding the physical, chemical, and biological processes in the soil layer. Long-term commitment for high-quality data are necessary for water resources analysis on climatic and regional scales. Modeling and observational studies have shown substantial soil moisture variability over a range of scales. The development of a monitoring plan/network for soil moisture based on both remotely sensed and on-site data is a requisite research endeavor that should account for such variability.

5.2 Create a Public Database of Soil Characteristics

The characteristics would include soil classification, hydraulic conductivity, porosity, and soil capacity. A map showing soil characteristics by location would help develop indices for extended use. This type of information can be found in the Soil Agricultural Groundwater Banking Index developed by UC Davis, or the Recharge Suitability Index developed by Land IQ and the Almond Board of California.

5.3 Understand the Dynamic Nature of Soil Structure and its Effects on Hydrology

There needs to be an understanding of the seasonal variations of soil hydraulic properties affected by tillage, compaction, cracking by repeated shrinking and swelling (on fallow fields or bare fields in winter). The same goes for soil sealing processes and how they affect infiltration rates. For example, subsidence is an important issue that affects a large portion of the state. Research is needed to understand the effects of subsidence on groundwater recharge and the movement of floodwater.

5.4 Understand the Effect of Flooding on Soil Chemistry and Microbial Communities

This is an important research need for agricultural practices. Farmers will need to use best practices in soil fertility and crop rotation management to sustain seasonal flooding on their fields.

Research Theme 6: Geologic and Aquifer Characterization

The characterization of groundwater basins has commonly been performed by surficial mapping of the soils and near-surface structural geology, coupled with discrete observations at individual borehole locations. To implement Flood-MAR successfully, extensive information regarding geology and aquifer characteristics will need to be developed and understood by local water managers.

6.1 Develop a Better Understanding of California's Hydrogeologic Systems

This is necessary to better understand the interconnections between surface water and groundwater. One technique which can be utilized is airborne electromagnetic (AEM) geophysical technique, which has been widely used in the oil industry to map the subsurface.

6.2 Develop Integrated Groundwater Models

Integrated surface water-refined groundwater models will help determine the potential recharge capacity of aquifers. These models could also help identify and prioritize recharge and extraction areas, as well as estimate determine localized aquifer responses to pumping. Future model updates could include subsidence and effects groundwater quality data.

6.3 Understand and Determine Location of Accretion and Depletion of Rivers caused by Groundwater Activities

This information is relevant to the management of groundwater levels (recharge and pumping rate) and understanding the potential effect on surface water supplies. This information is required to be addressed as one of the six undesirable results as part of the SGMA program. As groundwater sustainability agencies provide this information, it can be used to inform water management decisions.

6.4 Develop a Comprehensive Statewide Groundwater-Level Network and Database with Uniform Coverage of Major Aquifers

Currently, there is no standardized method of data collection, either spatially or temporally. The long-term viability of the data collection efforts is uncertain. Ideally, a comprehensive groundwater-level network is needed to assess groundwater-level changes. The data should provide access to real-time information.

Research Theme 7: Land Use Management

Land use management is integrated within many of the research themes including local land management, landscape management, climate change adaptability, ecosystem protection and restoration, water quality, and governmental/legal issues. Research topics discussed here relate specifically to land use management and are not meant to be a comprehensive research list for all Flood-MAR land use management issues. This theme could integrate with ongoing local and county planning efforts, and the Governor's Office of Planning and Research.

Generally, local land use decisions must vertically integrate with county land use plans. Each county and city must adopt a general plan with nine mandatory elements: land use, circulation, housing, conservation, open space, noise, safety, environmental justice, and air quality. Research and development within the Flood-MAR program can identify opportunities by working with county urban planners that develop cooperative extraterritorial county land use plans to manage groundwater at a regional scale. These opportunities may relate to land use, conservation, and open space planning to encourage landowner participation, identify means of adequate compensation, and for the protection of private rights (both land and water).

7.1 Investigate Headwater Management

Land use and water management begins with management of lands within the headwaters. Potential changes to headwater watersheds from the effects of fire and climate change will impact water supply. By restoring and developing healthy upstream watersheds which then integrates with water use and land management for the whole watershed through county planning.

7.2 Investigate the Development of a Statewide Mitigation Bank

There is a need to determine if a statewide mitigation bank can be developed. This could allow the use of offsets within the watershed for affected ecosystems and species.

7.3 Investigate Comprehensive Land Use Management within the State's Primary Watersheds

This would be focused within the major tributaries of California's rivers. There is a need to understand how overlying land uses and geology are connected within the watershed. A working knowledge of the watershed can assist with prioritizing aquifer recharge zones. Research has indicated historical riverbeds along major rivers may connect to deeper aquifers in downstream watersheds. Understanding where optimal recharge areas are in the upper watersheds, how they connect with downstream watersheds, and how they integrate with ongoing county planning efforts will help more effectively use limited resources.

Research Theme 8: Water Quality

Flood-MAR will require an assessment of recharge waters' potential effect on aquifer water quality. Different treatment standards will apply to different end uses of water; whether the recharged water will be used for municipal or agricultural use will determine the level of pre and/or post treatment of recharged water. Contaminants in a potential recharge area could be mobilized by recharge waters. A thorough program of aquifer, soil, and source water sampling, combined with geochemical modeling, may be needed to understand and predict the medium- and long-term chemical behavior of contaminants.

8.1 Research and Catalog the Components of Urban Stormwater and Determine if they can Affect Groundwater Quality

Understanding the composition of urban stormwater runoff water quality and using it for Flood-MAR could affect existing groundwater quality. This understanding will help to determine the suitability of urban stormwater runoff with Flood-MAR.

8.2 Understand Potential Removal Processes for Contaminants and Microbes

The use of reconnaissance studies can determine how changes in oxidation-reduction reactions influence the movement and reactions for inorganic and organic constituents. In addition, geochemical modeling can address potential changes in water quality with variable physical water conditions, as well as the influence of sequential aerobic and anaerobic conditions or alternating oxidizing and reducing conditions.

Research Theme 9: Recharge and Extraction Methods

An important consideration for the Flood-MAR strategy is to determine location-appropriate methods to recharge and extract water. Recharge methods include the inundation of spreading basins, recharge pits, ditches, and working lands. Existing or new wells will be needed to extract the groundwater. To choose the most practical and efficient techniques, many factors will need to be considered.

9.1 Investigate Characteristics and Implementation Potential of Various Groundwater Recharge Methods

Many methods exist for recharging groundwater; direct surface recharge, direct subsurface recharge, a combination of surface-subsurface methods, and indirect recharge. Flood-MAR is focused on the flooding existing lands without the construction of treatment or injection facilities. There are advantages and disadvantages to each method. The feasibility of implementing each of these methods should be investigated and then combined with factors such as location of the recharge basin, suitability of the soils and crops, source and conveyance of the flood water, operations and maintenance, and cost. The physical, chemical, and biological quality of recharge water also affects the feasibility and selection of recharge method. If suspended solids are present, surface application techniques tend to be more efficient than subsurface techniques where the solids can clog injection wells.

9.2 Investigate Methods and Technologies for Extracting Groundwater

Except in areas where groundwater naturally surfaces via springs, wells are needed to extract groundwater. Many of the same factors used to determine the best recharge methods will apply to determining the best types of wells and extraction techniques that could be used for groundwater extraction.

9.3 Develop a Map of Effective Recharge Areas with Respect to Current Aquifer use

These maps would indicate which aquifers could be further developed and which ones have already been over-developed. The map could also provide recharge information for various aquifers based on various recharge techniques.

9.4 Develop a Monitoring Network

To continue research and data collection, additional monitoring networks should be established. The data collected could demonstrate short-term, long-term, and seasonal trends in groundwater depth and quality as well as related surface conditions, and yield representative information about groundwater conditions.

Research Theme 10: Environment

Flood-MAR could provide ecosystem benefits by reconnecting and inundating floodplains, creating floodplain habitat (e.g., riparian), marsh, and wetlands, and supporting groundwater-dependent ecosystems. Diverting water from rivers could potentially impact sensitive species in the rivers. These potential benefits and impacts need to be understood with support from research and data collection.

10.1 Understand how Safe Harbor Agreements Would Work with Flood-MAR

Safe harbor agreements (SHAs) are voluntary agreements involving private or other non-federal property owners who participate in the recovery of species listed as threatened or endangered under the Endangered Species Act (ESA). There is a concern that ESA-listed species could be attracted to recharge areas in a Flood-MAR program, and that additional regulatory burdens would be placed on willing landowners if those species are present. One way to mitigate this concern is by creating an SHA, supported with research, that would include coordination and outreach with State and federal agencies to assess permitting issues associated with listed species and develop best management practices to mitigate potential effects.

10.2 Understand how Increases in Baseflow could Change Instream Flow Requirements and Other Permitting

Recharging groundwater may increase the annual river baseflow, affecting the upstream reservoir releases for environmental purposes. Currently, the State Water Resource Control Board (SWRCB) is evaluating unimpaired flow requirements for Sacramento-San Joaquin Delta (Delta) tributaries. An increase in the rivers baseflow could affect unimpaired flow requirements and water rights. Baseflow changes may necessitate a programmatic permitting process that can be implemented to capture these benefits.

10.3 Evaluate how Ecosystems Benefit from Flood-MAR

It will be necessary to understand and evaluate how groundwater-dependent ecosystems and additional environmental benefits associated with increased baseflow are affected. In concert with Theme 6, “Geologic and Aquifer Characterization,” the incremental benefit to fish and wildlife from additional baseflow would need to be modeled and quantified. While salmonids are the most frequently cited species that would benefit from additional baseflow, other species would benefit from baseflow as well, including vegetation that provides habitat and other ecosystem services.

10.4 Understand Potential Impacts on Land Uses to Achieve Benefits to Waterfowl and Other Species

Recharge projects which are also designed to maximize co-benefits to terrestrial species will need to understand habitat needs such as residence time and associated food web benefits in recharge areas, while balancing competing needs of current land uses. In other parts of the West, some agricultural operations have benefitted from rotating fields into wetlands. In concert with Theme 4, “Understanding Crop Suitability,” investigations should identify crops compatible with waterfowl and other species.

10.5 Evaluate Diversion Impact on Delta Outflow and Regulatory Instream Flow Requirements

Diversion of surface water flows for groundwater recharge projects could affect or require certain environmental flows. For example, bypass (pulse protection) flows would need to be maintained to avoid fish stranding. The SWRCB is in the process of recommending revised instream flow requirements for the San Joaquin River and Sacramento River watersheds for the protection of fish and wildlife. Additionally, there are salinity requirements in the southern Delta for the protection of agriculture, as well as other flow recommendations for Delta outflows and water project operations in the interior Delta. The new SWRCB recommendations may affect the amount and timing of flows that would be available for diversion of water for recharge.

Research Theme 11: Social Impacts

Flood-MAR will affect both flood and groundwater management activities, which could have both positive and negative effects on communities. For example, reduction in floodwater stage could lower water stages in the main channels during a flood event, reducing the risk of flooding and providing a socioeconomic benefit. Conversely, spreading of floodwater in areas better suited for groundwater recharge basins may require relocating people, animals, or temporary suspension of activities in recreational sites. There could be broad, and possibly difficult to quantify, social impacts from the implementation of Flood-MAR projects.

11.1 Identify Rural and Urban Communities that could be Impacted by Flood-MAR

Near any potential Flood-MAR project, rural and urban communities that could be affected should be identified. Examine how these communities would be affected by floodwater, groundwater, or both. Issues that could affect people and businesses could include economic changes such as cost and value of water and land, displacement of disadvantaged communities, and changes in agricultural development.

11.2 Examine the Effects of Multiple Research Themes on Communities

Flood-MAR projects may affect water quality and supply to groundwater dependent communities. These potential effects should be documented and understood. There is a need to research and evaluate alternative water resources management strategies for disadvantaged communities to increase resiliency and adaptive capacity to future environmental and economic change. For example, an examination of the interdependencies of poverty, land use, and environmental change in high- and medium-priority groundwater basins would be helpful for decision-making.

Research Theme 12: Economic Analysis

It will be important to develop an economic analysis of Flood-MAR projects. Demonstrating that Flood-MAR projects have an economic benefit will support implementation. An effective economic analysis for a Flood-MAR project would need to consider many economic topics such as costs of design and implementation, groundwater economic offsets and benefits, flood risk reductions benefits, economic impacts to water purveyors and users, and ecosystem benefit quantification.

12.1 Develop and Catalog Potential Project Costs

There are many variables which will affect the potential costs of implementing a Flood-MAR project. Items such as location, design and construction costs, land purchases and easements, fees and licenses, operations and maintenance costs, permitting issues, and many more. The research advisory committee can use its expertise to assist locals in developing a template that will help assess the costs and benefits of these cost estimates as part of their economic analyses.

12.2 Quantifying Benefits

There is a need to quantify urban and rural flood risk reduction benefits from reducing peak flows. There is also be a need to quantify crop losses caused by spreading floodwater on actively managed farmland. There is a need to determine which ecosystem models will be accepted by the regulating agencies when quantifying these benefits will assist in implementation, including how ecosystem valuations should be assessed.

12.3 Available Funding Sources and Funding Requirements

Sources and mechanisms need to be determined for the funding to implement Flood-MAR projects. The possibilities include proposing innovative funding methods for comprehensive watershed management. This could include potential public benefit funding strategies, including potential addition of public benefit types such as restoration of groundwater basins beyond minimum requirements for SGMA compliance. Another option is to investigate the concept of a California flood risk insurance program separate from federal programs.

Research Theme 13: Local, State, Federal Policies and other Legal Constraints

There needs to be an evaluation of how current and future local, State and federal policies would affect or influence the implementation of the Flood-MAR strategy. Because Flood-MAR is an integrated water management effort, a new law or regulation could create new barriers or challenges, which will require a clear understanding of their implication and remediation for a project implementation.

13.1 Integration with Statewide Programs

Flood-MAR planning should investigate how to integrate with the other statewide programs, including the Central Valley Flood Protection Plan and SGMA. In addition to integration and coordination, understanding how other statewide program requirements will inform Flood-MAR formulations, should be documented. Review how Flood-MAR can integrate with other California agencies, such as the Air Resources Board's Natural Working Lands Sector and other similar programs, where there may be a Flood-MAR nexus.

13.2 Investigate Land Owner Willingness through Surveys and Engagement

Counties and cities are responsible for planning oversight. Implementation of Flood-MAR will need to consider the effect on local tax receipts, and take into account how recharge zones will fit within existing planning and zoning efforts. Locals should manage resources within their jurisdictions while developing coherent resource management across regional boundaries. Linking Flood-MAR with the Williamson Act could increase landowner willingness to participate. If there are few willing local landowners, would the County have the ability through eminent domain to take and develop land for aquifer recharge?

13.3 Investigate how Surface Water Rights Holders could be Impacted

Modifications to the reservoir operations and additional stream diversions may affect the supply and reliability of existing surface-water-rights holders.

Next Steps

Engagement

As described in the Flood-MAR white paper, DWR will continue to work with stakeholders and other programs to pursue research and data collection, collect relevant existing literature, and assess available tools related to the themes presented in the framework. DWR, contingent on available funding, will work with Flood-MAR stakeholders to establish the RAC and begin formulation of a Flood-MAR research and data development plan. The RAC would implement the activities described in the research and data development strategy.

Development of Reconnaissance Studies and Pilot Projects

The purpose of reconnaissance studies and pilot projects is to test, refine, implement, and demonstrate the use of the tools, research, and data generated for Flood-MAR, with emphasis on highlighting the effectiveness of Flood-MAR. The scope of the studies and projects can vary from an experiment to test Flood-MAR theories and actions, to a larger scale and comprehensive feasibility study. The overall goals of the studies are to demonstrate, validate, and advance the concept and implementation of Flood-MAR.

It is encouraged that the development of reconnaissance studies and pilot projects should be coordinated with input from the RAC, local entities, and stakeholders so that all interested parties can benefit from lessons learned. The results of the studies could be presented in a study/project report that can be reviewed and commented on by the RAC and made available for interested parties through a common data and information exchange. These coordinated studies would help advance the Flood-MAR resource management strategy by providing information from actual Flood-MAR projects to fill in the data gaps.

DWR has begun studying Flood-MAR with a preliminary study on the Merced River and New Exchequer Dam to determine the potential to capture high-flow events for groundwater recharge. The goal of this preliminary study was to determine the volumes of potential water available to be diverted off the Merced River, which could provide multiple benefits, including flood protection, aquifer replenishment, and drought preparedness. This preliminary study will be expanded into a conceptual study that will refine the technical analysis that was preformed and begin touching upon some of the research themes of this framework.

Next, contingent on available funding, DWR will perform reconnaissance studies on multiple watersheds and reservoirs. These reconnaissance studies will incorporate strategies and research themes from this framework, and will explore in finer detail the types of analyses that could be accomplished and the benefits that could be attained by a Flood-MAR project.