Flood-MAR FAQs

General

What is Flood-MAR?

Flood-MAR is a water resource management strategy that uses high flows resulting from, or in anticipation of, rainfall or snowmelt for managed aquifer recharge (MAR). Flood-MAR occurs on agricultural lands, working landscapes, and managed natural lands, including refuges, floodplains, and flood bypasses. Flood-MAR can be implemented at multiple scales, ranging from individual landowners diverting flood water using existing infrastructure, to using extensive detention/recharge areas and modernizing flood management infrastructure/operations.

How is Flood-MAR an important climate change adaptation strategy for California?

California will continue to experience more frequent extreme weather events intensified by climate change, that will exacerbate flood risks and lead to longer and more severe droughts. The effects of climate change will create new challenges for water supply reliability and necessitate wholesale changes in how water is managed across the state.

With less anticipated water storage from snowpack due to climate change, California needs to leverage both the current water system and new opportunities to provide sustainable alternatives that can simultaneously accommodate longer and deeper droughts, and more severe and frequent flooding events.

Recent cycles of drought and flood and Sustainable Groundwater Management Act requirements provide enhanced opportunities to modernize State policies related to flood management, land use, groundwater management, and ecosystem enhancement.

What are the potential benefits of Flood-MAR?

Flood-MAR can provide broad benefits for Californians and the state’s ecosystems, including:

- 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

Are there adverse impacts associated with Flood-MAR?

All water projects have the potential to change local, regional, or statewide economic, environmental, or water resources system conditions. These changes can be beneficial, as indicated above, or may be adverse, such as impacts to terrestrial habitat at a project site.

When considering a water project, changes should be quantified, and benefits should outweigh impacts. Quantifying changes requires estimating how physical conditions might change with a project compared to physical conditions without a project. Potential benefits and impacts would be project-specific and need to be carefully considered prior to project implementation. Robust tradeoff analyses are required to fully understand and evaluate project benefits and impacts.

For example, Flood-MAR projects have the potential to affect reservoir operations. Changes in reservoir operations can affect flood management, water supply, water quality, environmental flows, and the ability to meet contracted water deliveries. All impacted operators and interested parties need to be partners in a project and need to be consulted to develop operations strategies that limit or mitigate negative impacts.

I'm a flood manager. Why should I consider Flood-MAR?

Partnerships between flood and groundwater management communities help reduce the impacts of swings between high- and low-flow periods while helping to meet water supply and flood risk management objectives while also meeting other objectives, such as improving floodplain ecosystems, preserving working landscapes, and engaging California's agricultural community in needed solutions.

Aging infrastructure, deferred maintenance, and climate change have increased the flood risk to people and property. Flood-MAR can help reduce flood risk by decreasing river flow and stage with increased diversions to working landscapes, including floodplains and flood bypasses.

Reducing flow and stage also gives reservoir operators more flexibility to manage flood releases and increase flood storage in reservoirs. Together, Flood-MAR strategies, combined with reservoir reoperation and improved forecasting, can further reduce flood risk by allowing reservoir releases ahead of precipitation or snowmelt. Check out DWR's *Coordinating Flood & Groundwater Management: Considerations for Local Flood Managers* for more information.

How can flood and groundwater managers coordinate better?

Improved coordination can set everyone up for success. Consider the following:

- **Start early.** Begin coordinating before the flood season. Flood events can happen quickly, overwhelming local capacity to respond and hampering real-time coordination between flood and groundwater managers.
- **Identify diverters.** Identify landowners willing to divert water to their working lands ahead of or during high-flow events via the following steps.
  - Target or prioritize lands that contain soils with high recharge rates whenever possible.
  - Use the best available subsurface information, such as airborne electromagnetic (AEM) or towed transient electromagnetic (tTEM or TowTEM) surveys, to determine optimal recharges sites.
  - Maintain contact lists with diversion capacities, land area, land uses, total volume/depth landowner is willing to divert, and appropriate windows for diversion (i.e., when inundation would not risk crops and other land operations).
  - Coordinate with potential diverters. Local groundwater managers can work with diverters during high-flow events to support flood managers that are monitoring flood forecasts and responding to potential flood emergencies.
  - Start upstream. Maximize flood management benefits by first diverting water in more upstream portions of the watershed (i.e., coordinated management at the watershed or regional scale).
- **Identify thresholds.** Local and regional flood managers can identify thresholds on local creeks and streams that would trigger local flood response actions. They can also notify potential diverters to help take water off the system ahead of, or during, high-flow events.
- **Identify potential floodplain expansion.** Identify potential areas for floodplain expansion that can reduce flood risk and create groundwater recharge benefits. The DWR Flood-MAR webpage has information about ongoing pilot studies and toolsets that are available to support local decision making.
- **Collaborate on water rights.** Flood and groundwater managers should work together to navigate the streamlined water rights process for multi-benefit recharge projects. Local managers can also contact the California State Water Resources Control Board and the California Department of Fish and Wildlife for technical and regulatory assistance.

What do DWR’s watershed studies tell us about Flood-MAR opportunities?

DWR is working with local and federal agencies to conduct cutting-edge climate vulnerability assessments of watersheds in the San Joaquin Valley (known as the San Joaquin Watershed Studies) and to evaluate how flood protection and groundwater recharge strategies can be used to adapt to climate vulnerabilities.

The San Joaquin Watershed Studies developed integrated analytical toolsets that combine climate change, hydrologic (precipitation runoff), reservoir, recharge, and groundwater modeling.

DWR also anticipates integrating flood modeling in the near future. These studies and their findings will help inform water management decisions and identify strategies that can help improve conditions in the San Joaquin Valley. Studies are being conducted in the Calaveras, Merced, Stanislaus, Tuolumne, and Upper San Joaquin watersheds, and are estimated to be complete in 2025.

DWR has also completed the related *Merced River Watershed Flood-MAR Reconnaissance Study*. Key findings emphasize that:

- Due to rising temperatures, there's an 80 percent chance that Merced River's 100-year peak outflow will surpass the downstream flooding threshold by 2040.
- Increased reliance on groundwater from higher agricultural demands (driven by higher temperatures) and reduced surface water availability in dry years may result in a 98 percent probability of increased groundwater overdraft under projected 2040 climate conditions.
- Ecosystem species and habitats will be negatively impacted by declining groundwater levels and decreasing instream flows that support salmonid habitat.

The study also identifies key strategies to support a more climate-resilient watershed, such as:

- Using the existing water system and following current streamlined water rights guidance to divert flood waters for groundwater recharge to improve water supply.
- Partner with flood and ecosystem managers on projects that incorporate forecast-informed reservoir operations (FIRO) and recharge to significantly enhance flood protection, improve water supply, and benefit ecosystems.
- Improve infrastructure and select recharge sites to increase the efficiency of groundwater recharge and provide important benefits and outcomes for subsidence mitigation, groundwater-dependent ecosystems, shorebird and pollinator habitats, underserved communities, and groundwater basin retention.

- Develop Flood-MAR strategies that include changes in reservoir operations, such as FIRO, which are essential to achieving benefits across multiple water management sectors.

I’ve heard people talk about “FIRO-MAR.” What’s that?

Forecast-informed reservoir operations (FIRO) uses advanced weather forecasts and modeling tools to improve reservoir operations to better counter wet and dry periods. In California, most reservoirs were initially constructed for water supply reliability (e.g., storing winter runoff for summer use) or flood risk reduction. Today, these reservoirs support multiple purposes, and reservoir management is coordinated across watersheds by federal, State, and local agency operators. In many cases, reservoir operations are governed by federal manuals and rule curves that do not reflect today’s hydrology and multi-benefit priorities, and do not consider future climate-driven impacts.

The DWR San Joaquin Watershed Studies developed the FIRO-MAR concept, integrating FIRO with managed aquifer recharge (MAR) to demonstrate the benefits of working together across the flood, water supply, and ecosystem water sectors. These studies indicate that integrating reservoir reoperation and Flood-MAR can significantly reduce flood risk, improve water supply, and enhance conditions for aquatic and terrestrial species. More work is needed to better understand the risks, tradeoffs, and benefits of reservoir reoperation and support implementation.

Most FIRO studies performed to date have assessed flood management or water supply benefits from FIRO operations. These studies have been performed by the Center for Western Weather and Water Extremes, the U.S. Army Corps of Engineers, and the U.S. Bureau of Reclamation in coordination with local agencies, and have been conducted for Folsom Lake/Dam, Lake Mendocino and Lake Sonoma, Prado Dam (which includes Orange County’s existing recharge program) and the upstream Seven Oaks Dam area, and the Yuba-Feather River Watershed (at Lake Oroville and New Bullards Bar Reservoir).

Source Water Availability

Flood-MAR uses one challenge, flooding, to help overcome another: groundwater loss. Learn more here about how flood water can be used as a source of recharge.

Do I need a water right to conduct recharge?

A water right is needed whenever water is diverted from a surface water body for a beneficial use. Beneficial uses include domestic, irrigation, municipal, industrial, fish and wildlife preservation and enhancement, recreation, water quality, and others. However, California Water Code Section 1242.1 provides a pathway for reducing flood risk by diverting floodflows and for conducting groundwater recharge without a water right.

Further, water that is diverted to solely reduce a flood risk does not require a water right, as flood risk reduction is not considered a beneficial use of water, but rather an action to reduce a hazard. Flood operations alone do not require a water right; however, if they intend to provide multiple benefits, a flood operation may require a water right. For example, if intentional actions are taken to increase infiltration of floodwaters (such as ripping soils to increase infiltration) or recharged floodwaters will be put to beneficial use later, a water right may be needed.

While single-purpose flood risk reduction projects do not typically require a water right, these actions may still provide incidental recharge benefits. Flood diversions to unlined canals or those spread out over working landscapes can reduce pressure on leveed systems or reduce peak flows and flood risks downstream of diversions. These diversions can also result in substantial recharge and increased groundwater levels in a local area. The recharged floodwaters can later be allocated by groundwater sustainability agencies through their annual allocations process.

Flood and groundwater managers should also work together on multi-benefit projects that provide flood risk reduction, groundwater recharge, and other benefits. These partnerships allow project proponents to better use streamlined pathways for water rights applications that require an understanding of high-flow events and flood thresholds for local creeks and streams to estimate water available for recharge.

Technical and regulatory assistance is available on water rights applications by the California State Water Resources Control Board and the California Department of Fish and Wildlife.

How much water might be available for recharge?

The amount of water available for recharge is derived through complex analysis and varies based on location and many other factors. Hydrology, water storage and conveyance operations, environmental flow needs, and variable demands and water use make estimating both physical and legal water available in a watershed challenging. The following factors contribute to the complexity in understanding water availability:

- Season (e.g., irrigation vs. non-irrigation season)
- Variable demand based on water year type
- Start of season reservoir storage
- Incomplete or inaccurate data on actual water use
- System operations to meet other regulatory requirements

- Multiple water rights may service the same area
- Water reuse

"Water available" may be described by different entities in different ways. Some entities use "water available" to mean all water in a system at a given time, which includes appropriated and unappropriated water; they may also call this "physical water available." Other entities such as the State Water Resources Control Board, consider only unappropriated water "water available," and others may call this "legal water available."

How is water availability considered for water rights?

California Water Code and State Water Resources Control Board use the term "water available" to support water right application review and permitting. Every water right application submitted to the State Water Resources Control Board must include "sufficient information to demonstrate a reasonable likelihood that unappropriated water is available for appropriation (Water Code Section 1260(k))." This information includes an analysis to show no injury would occur to senior water right holders. Additionally, for a permit, the State Water Resources Control Board must find that there is "unappropriated water available to supply the applicant (Water Code Section 1375(d))." New water right permits are granted only where there is a reasonable likelihood that water is available in the given watershed.

Each water availability analysis is unique to an application based on local conditions and source water. The water availability analysis considers the water needs of both instream beneficial uses and senior right holders. Due to California's highly variable climate, the appropriative water rights system recognizes that water may not be available in all years (i.e., water may only be available in the wettest years for more junior rights and rights may be curtailed during dry years when the natural flow is not sufficient to meet all rights).

What methods are used to determine whether water is available for recharge?

There are several methods to quantify water available for a new water right. These methods are usually unique to the conditions and existing water rights within the source water watershed. However, to expedite and streamline water rights applications for projects that use high flows for recharge, the State Water Resources Control Board developed *Streamlined Processing for Standard Groundwater Recharge Water Rights*. This processing includes specific eligibility criteria designed to avoid injury to existing water users, the environment, and public trust resources. Additionally, there are two methods to quantify water available described in the State Water Resources Control Board's *Water Availability Analysis for Streamlined Recharge Permitting* guidance document. Method 1 is the

90th percentile/20 percent method (90/20 Method). The 90/20 Method may be used to demonstrate flow is available for diversion between December 1 and March 31 of each year. During this time period, diversions under the water right are limited to the lesser of:

- Actual flow measured at the gauge minus the 90th percentile flow for that day,
- A maximum of 20 percent of the total flow measured at the gauge, or
- The requested and approved rate of diversion in the temporary permit.

Method 2 is the presence or imminent threat of flood conditions (Flood Method). The Flood Method may be used to demonstrate flow is available for diversion when flows exceed thresholds adopted by a flood control agency that trigger flood control actions necessary to mitigate threats to human health or safety. The Flood Method can be used to extend a potential diversion window through May 31. This is particularly helpful in the San Joaquin River basin when high flows are typically experienced in springtime due to snowmelt.

California Water Code Section 1242.1 offers a pathway to divert water for recharge when floodflows exist in a system. Floodflows are defined in the Water Code, and diverters must meet additional requirements to divert under this pathway. The State Water Resources Control Board has developed *Technical Guidance Water Code 1242.1—Flood Diversions for Groundwater Recharge* to promote better understanding of these requirements.

When might water be available for recharge?

Source water for Flood-MAR projects is derived from high flows caused by precipitation or snow melt, which typically occur in the winter and spring. These high flows typically occur outside of the irrigation season when there is less demand from water users. For most watersheds, it is likely that unappropriated water is available mostly in wet years, and during exceptionally wet years water may be available in significant quantities (i.e., flood years). Exceptionally wet years have high flood risk, and climate change will increase this risk. These years will need to be managed for flood risk reduction first and foremost, minimizing flood risk associated with high flows while finding opportunities to maximize other benefits (e.g., recharge and ecosystem enhancement).

How might water availability change in the future?

The effects of climate change will continue to change both the quantity and timing of when water is available. Climate change is expected to continue to change snowpack, sea level, and river flows. Future projections illustrate higher peak flows earlier in the season as more precipitation falls as rain instead of snow, whereas historical runoff flows persisted later into the spring as snow melted. Climate change is also expected to result in more variable weather patterns throughout

California. This potential change in weather patterns will exacerbate flood risks and lead to longer and more severe droughts, adding to challenges for water supply reliability. To prepare for longer droughts and more severe flooding, California must engage in the strategic and integrated water management planning required to implement Flood-MAR.

How much storage space is available in aquifers?

Within the state’s 515 groundwater basins, there are an estimated 1,000 million acre-feet (maf) of storage capacity. Underground storage far surpasses the combined capacity of all surface reservoirs, which is about 40 maf. Airborne Electromagnetic (AEM) survey data and subsurface data compilation help us better understand the state’s aquifers and where water can be stored, how deep aquifers extend, and where recharge would be most effective. DWR has completed 16,000 miles of AEM surveys across 95 groundwater basins, and has digitized over 15,000 well completion reports that give a better understanding of the state’s aquifers. Physical limitations, poor water quality, and economic constraints may reduce the usability of the state’s vast groundwater storage.

When people talk about Flood-MAR, they sometimes say “high flows,” “floodwater,” or “floodflows.” Do these terms mean the same thing?

While these terms are often used synonymously, many use these terms intentionally to differentiate slightly different flow conditions.

“Floodflows” is defined in Water Code Section 1242.1 as follows:

> *(A) Where a waterbody is subject to a defined flood stage, flows in excess of flood stage where actions are necessary to avoid threats to human health and safety.*
>
> *(B)(i) Except as provided in clause (ii), where a waterbody is not subject to a defined flood stage, surface water escaped from or is likely to imminently escape from a channel or waterbody causing or threatening to cause inundation of residential or commercial structures, or roads needed for emergency response. Likely imminent escape from a channel or waterbody shall be demonstrated by measured flows in excess of the maximum design capacity of a flood control project, where such a project is present and the maximum design capacity is readily available information.*

(ii) *This subparagraph does not apply to flows that inundate wetlands, working lands, or floodplains, events that constitute a "design flood," groundwater seepage, or waters confined to a "designated floodway."*

(C) *Where flows would inundate ordinarily dry areas in the bed of a terminal lake to a depth that floods dairies and other ongoing agricultural activities, or areas with substantial residential, commercial, or industrial development.*

"High flows" and "floodwaters" are typically used more generally. "High flows" is typically used to describe flows that may be higher in volume or duration than average for that time of year. "Floodwater" is generally used to describe flows that inundate usually dry land, such as floodplains. "High flows" may or may not inundate usually dry land and therefore encompass the largest range of flows.

Some have used "floodwater" to describe inundation that has caused damage to structures and infrastructure, which is a narrower definition than typically used by DWR and flood management agencies. Because of this narrower definition used by some in the broader Flood-MAR community, the DWR Flood-MAR Program has shifted to use of "high flows" in the definition of Flood-MAR, since it encapsulates the largest potential range of flows to identify multi-benefit project opportunities.

Flood-MAR Related Policy and Guidance

California has water policy established over many decades that never envisioned Flood-MAR. Much work is underway to make policy changes needed to empower the use of Flood-MAR. Below are answers to questions about the current policy elements of Flood-MAR.

Why isn't recharge considered a beneficial use?

When applying for a water right, groundwater recharge is not considered a beneficial use of water. Recharge is a method of infiltrating water to underground storage. Recharged water may be extracted from an aquifer and put to beneficial use or recharged water may remain in an aquifer to achieve a beneficial use.

Common beneficial uses are domestic, fish and wildlife enhancement, irrigation, industrial, municipal, power generation, and recreation uses. An applicant must demonstrate that surface water is being put to a beneficial use to obtain a water rights permit or license. The State Water Resources Control Board's *Fact Sheet: Purposes of Use for Underground Storage Projects* contains guidance about defining beneficial-use types for recharge.

Is there guidance for streamlining and expediting water rights permitting?

Yes. The State Water Resources Control Board has released guidance on the streamlined water rights process which has specific requirements for local agencies and Groundwater Sustainability Agencies to divert high flows to underground storage. The streamlined process includes two options for conducting a simplified water availability analysis, based on either the 90/20 Method (a 90th percentile daily flow) or the Flood Method (threat of flood conditions). Refer to the FAQ about these methods for more information.

DWR and State Water Resources Control Board staff also provide project-specific technical support for local applicants who conduct water availability analyses and complete temporary water rights applications.

Can you help me understand Water Code Section 1242.1?

Added to the Water Code in 2023, Section 1242.1 provides a pathway to divert floodflows to reduce flood risk and conduct groundwater recharge without a water right. Section 1242.1 allows these diversions only if certain requirements are met, such as meeting the definition of floodflows, planning and reporting, public notification, and land restrictions for recharge. The State Water Resources Control Board receives reports and tracks diversions on their webpage. More detail can be found in the State Water Resources Control Board's *Technical Guidance Water Code 1242.1—Flood Diversions for Groundwater Recharge*. Water Code Section 1242.1 applies until January 1, 2029.

Water Code Section 1242.1 also requires local or regional agencies to adopt a local plan for flood control pursuant to Water Code Section 8201, or to consider flood risk as part of the most recently adopted general plan to divert floodflows for groundwater recharge. Many local and regional agencies are evaluating the need to update their general plans to make diversions. DWR currently provides technical and planning assistance to local agencies looking to define floodflows and update their general plans. Related mitigation planning guidance is also provided by California Office of Emergency Services and the Federal Emergency Management Agency.

How will the Central Valley Flood-MAR Dashboard support recharge efforts?

DWR has developed a Central Valley Flood-MAR Dashboard, which is currently online for beta testing by local agencies. The dashboard helps local water managers make diversions of floodflows for recharge under Water Code Section 1242.1.

How do I set up a district- or GSA-scale recharge program?

Developing robust groundwater recharge programs is a critical step to sustainable water management. DWR and Sustainable Conservation developed *District Recharge Program Guidance*, which is based on practical knowledge and field experience to help water districts, groundwater sustainability agencies (GSAs), and their technical consultants design recharge programs that not only replenish groundwater supplies, but also deliver additional benefits to their communities, ecosystems, and local economies. The guidance includes necessary considerations, publicly available tools, and examples to design and refine groundwater recharge programs that address the specific needs and priorities of all interested parties in their basins.

Is there guidance on the various recharge methods?

Yes. DWR's Sustainable Groundwater Management Grant Program developed a groundwater recharge methods best management practices and guidance documents to guide standard monitoring practices for a variety of recharge-related activities.

Recharge Site Selection and Suitability

Allowing water to spread over land so it can then sink into our aquifers requires careful study about the best places to invest in Flood-MAR. Below are answers about work underway to better understand where Flood-MAR will be most effective.

How do I know if my soils are suitable for recharge?

For most direct recharge methods, recharge volume is controlled by the rate at which water can infiltrate into the soil and the underlying geologic sediments. Infiltration rates will be faster for sandy soils, and much slower for soils with higher amounts of clay. Soil suitability indices can be used to help determine potential areas where groundwater recharge is feasible.

Currently, there are a few recharge suitability tools or indices for California that are publicly available:

- Soil Agricultural Groundwater Banking Index (SAGBI) at University of California (UC) Davis. SAGBI is a suitability index that uses five major indicators for evaluating soil suitability. SAGBI is fundamentally based on the Natural Resources Conservation Service's (NRCS') soil surveys, with additional assumptions governing its interpretation and use. UC Davis has identified 3.6 million acres of agricultural land in the state that have excellent or good potential for recharge.

- UC Davis Soil Properties SoilWeb App. A sand soil map layer is available from UC Davis. The map shows the percent sand over the soil interval depth from 0 to 60 centimeters. This layer was developed by the California Soil Resource Lab at UC Davis and UC Agriculture and Natural Resources in collaboration with the U.S. Department of Agriculture's NRCS.

Pro-tip: Both layers described above are on the SGMA Data Viewer.

What data are being collected about aquifer suitability and basin characterization?

DWR's Basin Characterization Program collects new data, reviews existing data, and integrates both in the SGMA Data Viewer, which is the most comprehensive, accessible repository for subsurface geologic data at the state level. DWR's Basin Characterization Program webpage also provides context for how to apply available data and identify areas for recharge.

Flood-MAR projects are optimized when the best recharge areas can be identified and used, and the outcome of recharge for supporting intended benefits can be realized. The most current and best available data and information about California's groundwater basins is needed to help local communities and project implementers better understand their aquifer systems and to support local and statewide groundwater management.

Additional basin characterization efforts have been completed and data are available in the SGMA Data Viewer's basin characterization category:

- Compiled, digitized, and performed a quality assurance/quality check of available lithologic and geophysical logs, and performed an analysis to evaluate the reliability of those lithologic and geophysical data.
- Installed approximately 150 new monitoring wells across the state for the purpose of filling data gaps.
- Installed telemetry in over 100 new or existing monitoring sites.
- Conducted Airborne Electromagnetic surveys for each high- and medium-priority groundwater basin in the state.
- Integrated available datasets to generate publicly accessible analysis tools, which can be used to create three-dimensional texture models, hydrostratigraphic models, and aquifer flow parameters.
- Conducted a pilot study in the Upper San Joaquin River to develop aquifer recharge potential maps, for different recharge methods. An outcome of the pilot is a vetted process for developing aquifer recharge potential maps that can then be applied in various geographies.

For more information about basin characterization and data integration, consider joining the Basin Characterization Exchange (BCX). BCX is open to federal, State, tribal, and local agencies, consultants, non-governmental organizations, academia, and interested parties who participate in Basin Characterization Program efforts.

What crops might be suitable in recharge areas?

Flood-MAR projects may include the temporary and seasonal inundation of agricultural lands as recharge areas. A crop's root zone must be able to tolerate wet conditions during off-season irrigation. This is particularly important for perennial crops and vines because of the risk of root damage, disease, and crop loss. Further, the timing of ground saturation for trees and vines (that is, before or after buds develop) affects the crop's tolerance to saturation. Areas planted with annual crops and fallowed land have less risk related to crop damage and disease, but timing of saturation is important for next season planting. It is also important to consider the types of fertilizers and pesticides that may be applied to a crop and the potential for those chemicals to enter the aquifer.

Many growers have been at the forefront of Flood-MAR implementation and are leading the way in identifying potential impacts of inundation for recharge on crops, including almonds, grapes (wine, table, and raisins), pistachios, and fallowed lands. Case studies have been performed and guidance materials have been developed, such as DWR and Sustainable Conservation's *District Recharge Program Guidance*.

The DWR Flood-MAR Program, in collaboration with partners such as Sustainable Conservation, developed a crop compatibility calendar that is available in the *Merced River Watershed Flood-MAR Reconnaissance Study*. The compatibility calendar identifies the total volume of water that can be applied to a given crop for recharge.

DWR's Integrated Water Flow Model Demand Calculator (IDC) and Sustainable Conservation's crop compatibility calendar have been used in DWR's San Joaquin Watershed Studies to better understand and model appropriate crops and timing for recharge applications.

Could there be an impact on water quality due to a Flood-MAR project?

Vadose zone and groundwater water quality are important concerns for recharging groundwater. Potential pollutants can include total dissolved solids, nitrate, lead, arsenic, boron, and organics, such as pesticides. These potential pollutants can come from human activities or can occur naturally in the environment.

Water quality must be considered for both groundwater in an aquifer and in surface water being used to recharge an aquifer. Recharging aquifers can have positive and negative impacts. For example, recharging groundwater can dilute an already contaminated aquifer and benefit groundwater quality. Conversely, recharged water can mobilize surface or near-surface nitrates or salinity into an aquifer, negatively impacting groundwater quality. Even so, there may be long-term improvements in groundwater quality because of recurring recharge with flood waters that are low in salts and nitrates. Short- and long-term groundwater water quality effects will be site-specific and an important factor in determining site suitability.

Sustainable Conservation developed *Protecting Groundwater Quality While Replenishing Aquifers: Nitrate Management Considerations for Implementing Recharge on Farmland* that summarizes research on potential mobilization of nitrates and salts under on-farm recharge practices and presents field- and regional-scale considerations for protecting water quality in communities. They also developed *Management Considerations for Protecting Groundwater Quality Under Agricultural Managed Aquifer Recharge*, a guidance document for growers.

What information is available on groundwater quality?

The best and most consistent dataset for groundwater quality is the State Water Resources Control Board's Groundwater Ambient Monitoring and Assessment Program, which is carried out in collaboration with the U.S. Geological Survey. The State Water Resources Control Board's Safe, Affordable Funding for Equity and Resilience (SAFER) platform also provides important water quality information.

What resources are available to support decision making on potential water quality or drinking water impacts?

DWR's Sustainable Groundwater Management Office developed *Guidance for Sustainable Groundwater Management Act Implementation: Considerations for Identifying and Addressing Drinking Water Well Impact*. This guidance also supports the identification of areas that could benefit most from Flood-MAR actions via implementation of groundwater sustainability plan projects and management actions.

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

Further research is needed to improve understanding around potential contaminants, and this important work is ongoing.

Does it matter where you conduct recharge to achieve desired benefits?

Yes! It does matter where you conduct recharge. Through careful planning and management and working with landowners, recharge practitioners can ensure that recharge activities are conducted at the appropriate times—and most importantly *in the right locations*—to maximize the number of associated benefits and minimize potential impacts. Recharge can then be targeted to fields that achieve a district's or groundwater sustainability agency’s desired outcomes. Often it is possible to target multiple outcomes from the same locations.

Strategic recharge programs can simultaneously benefit agriculture, communities, and ecosystems. *From Runoff to Recharge* gives an overview of siting recharge projects for multiple benefits. Additionally, the DWR San Joaquin Watershed Studies used the Groundwater Recharge Assessment Tool (GRAT) to target certain “recharge management areas” to achieve specific recharge outcomes, such as aquifer retention, subsidence mitigation, support of groundwater-dependent ecosystems, and support for disadvantaged communities. Documentation about the San Joaquin Watershed Studies is expected to be available later in 2025.

Recharge Accounting and Measurement

Groundwater management often requires understanding how much water is managed by different agencies or communities, including how much water is recharging a basin, how much water is extracted, and how water moves between basins or surface water bodies. This section explains what is being done to better measure and account for the amount of water that Flood-MAR is able to recharge.

What guidance and tools are available for measuring and accounting for groundwater recharge?

There are a range of guidance and tools available to help you measure and account for groundwater recharge. Thes tools and guidance are routinely updated as new data, information, and innovations are incorporated. Some of these resources include:

- **Water budget development.** *Draft Handbook for Water Budget Development: With or Without Models* provides the California water resources community with a resource for water budget development using hydrologic models or analytical methods. Specifically, the Draft Water Budget Handbook presents a comprehensive water budget framework, decision trees to guide water budget development, an accounting template, case studies, and a data resources directory.

- **Open-source groundwater accounting.** Groundwater Accounting Platform. The California Water Data Consortium developed the platform in partnership with DWR based on work completed by the Environmental Defense Fund. The Groundwater Accounting Platform was developed to provide an easy-to-use, cost-effective, and open-source option for groundwater accounting. It is a data-driven tool that enables water managers to track water availability and usage with user-friendly dashboards and workflows.
- **Modeling tools.** Check out DWR's Integrated Water Flow Model (IWFM), the California Central Valley Groundwater Surface Water Simulation Model (C2VSim), and the Sacramento Valley Simulation Model. For additional information about DWR's modeling tools, visit: https://www.water.ca.gov/Library/Modeling-and-Analysis.

What information is available about how much water has been recharged?

Groundwater sustainability agencies report detailed water accounting to DWR in their groundwater sustainability plan (GSP) annual reports. This accounting covers California groundwater basins subject to the Sustainable Groundwater Management Act (SGMA), including adjudicated basins and basins with alternative plans. A statewide roll-up of recharge information is available in the following:

- **SGMA portal.** DWR launched a Projects and Management Actions module in the SGMA portal in 2024. This module will be incorporated into existing data and will be regularly updated to demonstrate individual groundwater basins' and subbasins' progress toward SGMA implementation, including the benefits achieved from recharge projects.
- **Semi-Annual Update on California's Groundwater Conditions**. DWR compiled information about recharge projects that occurred from 2019 through 2024, based on GSP annual reporting.
- **California's Groundwater: Bulletin 118** *Update 2025* (currently in development). Bulletin 118 reports on a range of subjects, including recharge data as described in GSP annual reports, known recharge projects and methods, and State-enhanced recharge efforts.

I'm a landowner interested in doing a Flood-MAR project on my land. Do I get to pump out all the water I recharged?

If you obtain a water right for diversion of surface water and subsequent underground storage, then yes: you can pump recharged water out for your beneficial use.

Most people do not have the appropriate water rights for underground storage, so more likely, the amount of water you get to pump out needs to be negotiated with your groundwater sustainability agency (GSA). Your GSA may also have incentive programs offering financial or water supply benefits if you use your land for recharge.

Multi-benefit Flood-MAR Studies and Projects

Beyond improving flood risk reduction and groundwater recharge, we are working to understand how Flood-MAR can provide other benefits. These efforts are described below.

Can Flood-MAR projects provide ecosystem services?

DWR’s white paper *Flood-MAR: Using Flood Water for Managed Aquifer Recharge to Support Sustainable Water Resources* outlines ways that Flood-MAR can provide ecosystem benefits by:

- Reconnecting and inundating floodplains
- Creating floodplain habitat, marsh, and wetlands
- Supplementing base flows
- Supporting groundwater-dependent ecosystems through increased baseflow resulting from higher groundwater levels

Factors that contribute to ecosystem and habitat enhancement potential are land use, proximity and connectivity to the river, timing of recharge flows, and duration of flooding. Seasonal flooding of land can also boost food productivity to support aquatic and terrestrial species (e.g., insects, zooplankton). Recharging groundwater supplies also has the potential to provide ecosystem benefits by boosting instream baseflow or reducing surface water temperature through surface and groundwater interactions. Groundwater storage or banks may also be used to support environmental water accounts that use water stored in the ground during wetter periods to help increase instream flows during drier seasons or years via groundwater extraction or use in lieu of less-abundant surface water.

I’ve heard the term “EcoFIP” in relationship to DWR Flood-MAR efforts. What is that?

The Ecological Floodplain Inundation Potential (EcoFIP) tool identifies and analyzes restoration opportunities and benefits. DWR’s partner, cbec eco-engineering, developed EcoFIP to identify and analyze restoration opportunities and benefits.

EcoFIP came about as part of DWR’s multiple benefit floodplain restoration studies, which evaluate the benefits of increasing floodplain inundation for multiple benefits, including ecosystem enhancement, groundwater recharge, and flood risk reduction. EcoFIP comprehensively assesses physical opportunities for floodplain restoration and MAR at the parcel- or river mile-scale while providing conceptual design analysis at the project scale.

EcoFIP can evaluate any period of record, with the potential to consider future flow regimes due to climate change or alternative management scenarios. EcoFIP analysis focuses on identifying and developing potential floodplain restoration projects that provide high-quality salmonid rearing habitat and maximize recharge on floodplains.

EcoFIP also includes methods to calculate groundwater recharge that occurs from floodplain inundation, including high-level opportunity analyses based on hydrologic soil groups, electromagnetic surveys, and integration with existing groundwater models.

As part of DWR's multi-benefit floodplain restoration studies in the Cosumnes, Pajaro, and Upper San Joaquin river watersheds, and for the San Joaquin Watershed Studies, EcoFIP analysis was conducted at the reach scale to identify areas that could be inundated under certain flow conditions to improve habitat and increase recharge.

Funding and Incentives

Flood-MAR implementation requires changes in practice and policy, along with constructing new infrastructure and landowners who want to participate. Studies, planning, and implementation all have a cost. Learn more about funding and incentive programs that can support Flood-MAR here.

Are there State funding programs for implementing Flood-MAR projects?

Information and resources for open State funding opportunities will be available on the California grants portal, and DWR-specific programs will also be included on DWR's Grants and Loans webpage.

I'm a landowner interested in doing a Flood-MAR project on my land. Are there any funding programs or incentives for doing this?

Yes. Many local water districts and groundwater sustainability agencies (GSAs) provide incentives for participating in recharge programs. DWR recommends that you contact your local district or GSA and ask them about incentives.

If your district or GSA does not have an incentive program, you might consider sharing Central Valley Groundwater Recharge Incentives and Strategies, which is a guidance document developed by DWR and Sustainable Conservation, which outlines potential incentives for Flood-MAR.

Flood-MAR Network

The Flood-MAR Network is a collaboration among many individuals and organizations interested in promoting Flood-MAR implementation in California. These groups include:

- Federal, State, tribal, regional, and local entities
- Nonprofits and community-based organizations
- University and private researchers
- Private landowners
- Other interested parties

The Flood-MAR Network conducts workshops, webinars, and forums to share the latest information on statewide Flood-MAR efforts. The network also maintains information about its events and member activities on its website. More information about the network is below.

What is DWR's role in the Flood-MAR Network?

DWR is proud to be a founding member of the Flood-MAR Network, supporting its creation and formation. DWR staff from multiple divisions are part of the 600-member strong network, providing subject matter expertise and promoting State alignment.

Since the network's formation, DWR has provided consultant support through Sacramento State University as the Network Coordinator, which supports the network's administrative functions, facilitates gatherings and discussions, and convenes public forums about Flood-MAR.

How can I get more information or join the Flood-MAR Network?

Learn more about Flood-MAR Network activities and join the network through their Get Involved webpage.