

August 22, 2023

MEETING NOTICE

WATER CONSERVATION AND DEMAND MANAGEMENT COMMITTEE

Members of the Water Conservation and Demand Management Committee:

Director Nai Hsueh, Committee Chair

Director Barbara F. Keegan

Director Rebecca Eisenberg, Committee Vice Chair

Staff Support of the Water Conservation and Demand Management Committee:

Rick L. Callender, Esq., Chief Executive Officer

Melanie Richardson, Assistant Chief Executive Officer

Bhavani Yerrapotu, Acting Assistant Chief Executive Officer

Aaron Baker, Chief Operating Officer, Water Utility

Rachael Gibson, Chief of External Affairs

J. Carlos Orellana, District Counsel

Joseph Aranda, Assistant District Counsel

Sam Bogale, Deputy Operating Officer, Treated Water Division

Vincent Gin, Deputy Operating Officer, Water Supply Division

Gregory Williams, Deputy Operating Officer, Raw Water Division

Bart Broome, Assistant Officer, Office of Government Relations

Marta Lugo, Deputy Administrative Officer, Office of Government Relations

Kirsten Struve, Assistant Officer, Water Supply Division

Antonio Alfaro, Government Relations Advocate, Office of Government Relations

Vanessa De La Piedra, Groundwater Management Manager, Groundwater Monitoring and Analysis Unit

Metra Richert, Unit Manager of the Water Supply Planning and Conservation Unit

Samantha Greene, Senior Water Resources Specialist, Water Supply Planning & Conservation Unit

Jing Wu, Senior Water Resources Specialist, Water Supply Planning & Conservation Unit

Justin Burks, Senior Water Conservation Specialist, Water Supply Planning & Conservation Unit

The regular meeting of the Water Conservation and Demand Management Committee is scheduled to be held on **Monday, August 28, 2023, at 11:00 a.m., in the Headquarters Building Boardroom, 5700 Almaden Expressway, San Jose, CA 95118.**

The meeting agenda and corresponding materials are located on our website:

<https://www.valleywater.org/how-we-operate/committees/board-advisory-committees>



Water Conservation and Demand Management Committee Meeting

Public and non-presenting staff Join Zoom Meeting
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Meeting ID: 925 9734 0524



Santa Clara Valley Water District Water Conservation and Demand Management Committee Meeting

**Headquarters Building Boardroom
5700 Almaden Expressway
San Jose CA 95118**

REGULAR MEETING AGENDA

**Monday, August 28, 2023
11:00 AM**

District Mission: Provide Silicon Valley safe, clean water for a healthy life, environment and economy.

Water Conservation and Demand
Management Committee
Director Rebecca Eisenberg, (District
7, Committee Vice Chair)
Director Nai Hsueh (District 5,
Committee Chair)
Director Barbara F. Keegan (District
2)

All public records relating to an item on this agenda, which are not exempt from disclosure pursuant to the California Public Records Act, that are distributed to a majority of the legislative body will be available for public inspection at the Office of the Clerk of the Board at the Santa Clara Valley Water District Headquarters Building, 5700 Almaden Expressway, San Jose, CA 95118, at the same time that the public records are distributed or made available to the legislative body. Santa Clara Valley Water District will make reasonable efforts to accommodate persons with disabilities wishing to attend Board of Directors' meeting. Please advise the Clerk of the Board Office of any special needs by calling (408) 265-2600.

Vincent Gin
Kirsten Struve
(Staff Liaisons)

Glenna Brambill, (COB
Liaison)
Management Analyst II
gbrambill@valleywater.org
1-408-630-2408

Note: The finalized Board Agenda, exception items and supplemental items will be posted prior to the meeting in accordance with the Brown Act.

Santa Clara Valley Water District
Water Conservation and Demand Management Committee
REGULAR MEETING
AGENDA

Monday, August 28, 2023

11:00 AM

Headquarters Building Boardroom
5700 Almaden Expressway
San Jose CA 95118

*****IMPORTANT NOTICES AND PARTICIPATION INSTRUCTIONS*****

Santa Clara Valley Water District (Valley Water) Board of Directors/Board Committee meetings are held as a “hybrid” meetings, conducted in-person as well as by telecommunication, and is compliant with the provisions of the Ralph M. Brown Act.

To maximize public safety while still maintaining transparency and public access, members of the public have an option to participate by teleconference/video conference or attend in-person. To observe and participate in the meeting by teleconference/video conference, please see the meeting link located at the top of the agenda. If attending in-person, you are required to comply with Ordinance 22-03 - AN ORDINANCE OF THE SANTA CLARA VALLEY WATER DISTRICT SPECIFYING RULES OF DECORUM FOR PARTICIPATION IN BOARD AND COMMITTEE MEETINGS located at <https://s3.us-west-2.amazonaws.com/valleywater.org.if-us-west-2/f2-live/s3fs-public/Ord.pdf>

In accordance with the requirements of Gov. Code Section 54954.3(a), members of the public wishing to address the Board/Committee during public comment or on any item listed on the agenda, may do so by filling out a Speaker Card and submitting it to the Clerk or using the “Raise Hand” tool located in the Zoom meeting application to identify yourself in order to speak, at the time the item is called. Speakers will be acknowledged by the Board/Committee Chair in the order requests are received and granted speaking access to address the Board/Committee.

- Members of the Public may test their connection to Zoom Meetings at: <https://zoom.us/test>
- Members of the Public are encouraged to review our overview on joining Valley Water Board Meetings at: <https://www.youtube.com/watch?v=TojJpYCxXm0>

Valley Water, in complying with the Americans with Disabilities Act (ADA), requests individuals who require special accommodations to access and/or participate in Valley Water Board of Directors/Board Committee meetings to please contact the Clerk of the Board’s office at (408) 630-2711, at least 3 business days before the scheduled meeting to ensure that Valley Water may assist you.

This agenda has been prepared as required by the applicable laws of the State of California, including but not limited to, Government Code Sections 54950 et. seq. and has

not been prepared with a view to informing an investment decision in any of Valley Water's bonds, notes or other obligations. Any projections, plans or other forward-looking statements included in the information in this agenda are subject to a variety of uncertainties that could cause any actual plans or results to differ materially from any such statement. The information herein is not intended to be used by investors or potential investors in considering the purchase or sale of Valley Water's bonds, notes or other obligations and investors and potential investors should rely only on information filed by Valley Water on the Municipal Securities Rulemaking Board's Electronic Municipal Market Access System for municipal securities disclosures and Valley Water's Investor Relations website, maintained on the World Wide Web at <https://emma.msrb.org/> and <https://www.valleywater.org/how-we-operate/financebudget/investor-relations>, respectively.

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<https://valleywater.zoom.us/j/92597340524>

Meeting ID: 925 9734 0524

Join by Phone:

1 (669) 900-9128, 925 9734 0524#

1. CALL TO ORDER:

1.1. Roll Call.

- 2. TIME OPEN FOR PUBLIC COMMENT ON ANY ITEM NOT ON THE AGENDA.** *Notice to the public: Members of the public who wish to address the Board/Committee on any item not listed on the agenda may do so by filling out a Speaker Card and submitting it to the Clerk or using the "Raise Hand" tool located in the Zoom meeting application to identify yourself to speak. Speakers will be acknowledged by the Board/Committee Chair in the order requests are received and granted speaking access to address the Board/Committee. Speakers' comments should be limited to two minutes or as set by the Chair. The law does not permit Board/Committee action on, or extended discussion of, any item not on the agenda except under special circumstances. If Board/Committee action is requested, the matter may be placed on a future agenda. All comments that require a response will be referred to staff for a reply in writing. The Board/Committee may take action on any item of business appearing on the posted agenda.*

3. APPROVAL OF MINUTES:

3.1. Approval of Minutes.

[23-0804](#)

Recommendation: Approve the June 26, 2023, Meeting Minutes.

Manager: Candice Kwok-Smith, 408-630-3193

Attachments: [Attachment 1: 06262023 WCaDMC DRAFT Mins](#)

Est. Staff Time: 5 Minutes

4. REGULAR AGENDA:

4.1. Safe Clean Water Conservation Program - Project A2: Water Conservation Rebates and Programs Update.

[23-0805](#)

Recommendation: Receive an update on the Safe Clean Water funded conservation programs. This is a discussion item, and no action is required.

Manager: Kirsten Struve, 408-630-3138

Attachments: [Attachment 1: PowerPoint Presentation](#)

Est. Staff Time: 15 Minutes

4.2. Flood-Managed Aquifer Recharge Preliminary Feasibility Study for Santa Clara County.

[23-0807](#)

Recommendation: Receive and discuss the Pre-Feasibility Study for a Flood-MAR Program in the Santa Clara Valley Water District Service Area, Santa Clara County, CA.

Manager: Kirsten Struve, 408-630-3138

Attachments: [Attachment 1: FloodMAR Report](#)
[Attachment 2: PowerPoint Presentation](#)

Est. Staff Time: 15 Minutes

4.3. Water Supply Master Plan 2040 Conservation and Stormwater Capture Project Update - "No Regrets" Package Implementation.

[23-0808](#)

Recommendation: Receive information on the "No Regrets" package implementation. This is a discussion item, and no action is required.

Manager: Kirsten Struve, 408-630-3138

Attachments: [Attachment 1: PowerPoint Presentation](#)
[Attachment 2: Flyer](#)

Est. Staff Time: 15 Minutes

4.4. Valley Water Demand Model and Forecast.

[23-0806](#)

Recommendation: Receive and discuss Valley Water demand model and forecast.

Manager: Kirsten Struve, 408-630-3138

Attachments: [Attachment 1: TM3 Model Approach and Devel](#)
[Attachment 2: PowerPoint Presentation](#)

Est. Staff Time: 15 Minutes

4.5. Review the Water Conservation and Demand Management Committee (WCaDMC) Work Plan, the Outcomes of Board Action of Committee Requests; and the Committee's Next Meeting Agenda.

[23-0809](#)

Recommendation: Review the Committee work plan to guide the committee's discussions regarding policy alternatives and implications for Board deliberation.

Manager: Candice Kwok-Smith, 408-630-3193

Attachments: [Attachment 1: WCaDMC 2023 Work Plan](#)

Est. Staff Time: 5 Minutes

5. CLERK REVIEW AND CLARIFICATION OF COMMITTEE REQUESTS.

This is an opportunity for the Clerk to review and obtain clarification on any formally moved, seconded, and approved requests and recommendations made by the Committee during the meeting.

6. ADJOURN:

6.1. Adjourn to Regular Meeting at 11:00 a.m., on Monday, September 25, 2023.



Santa Clara Valley Water District

File No.: 23-0804

Agenda Date: 8/28/2023

Item No.: 3.1.

COMMITTEE AGENDA MEMORANDUM **Water Conservation and Demand Management Committee**

Government Code § 84308 Applies: Yes ☐ No ☒
(If "YES" Complete Attachment A - Gov. Code § 84308)

SUBJECT:

Approval of Minutes.

RECOMMENDATION:

Approve the June 26, 2023, Meeting Minutes.

SUMMARY:

A summary of Committee discussions, and details of all actions taken by the Committee, during all open and public Committee meetings, is transcribed and submitted for review and approval.

Upon Committee approval, minutes transcripts are finalized and entered into the District's historical records archives and serve as historical records of the Committee's meetings.

ENVIRONMENTAL JUSTICE IMPACT:

There are no environmental Justice impacts associated with this item.

ATTACHMENTS:

Attachment 1: 06262023, WCaDMC Draft Meeting Mins.

UNCLASSIFIED MANAGER:

Candice Kwok-Smith, 408-630-3193



WATER CONSERVATION AND DEMAND MANAGEMENT COMMITTEE MEETING

DRAFT MINUTES

MONDAY, JUNE 26, 2023

A regular meeting of the Water Conservation and Demand Management Committee was held on June 26, 2023, at Santa Clara Valley Water District, Headquarters Building Boardroom, 5700 Almaden Expressway, in San Jose, California.

1. CALL TO ORDER

Committee Chair Director Nai Hsueh called the meeting to order at 11:02 a.m.

1.1. ROLL CALL

Committee Board Members in attendance were: Committee Chair, Director Nai Hsueh (District 5), Director Barbara F. Keegan (District 2), establishing a quorum, and Committee Vice Chair, Eisenberg (District 7-arrived at 11:15 a.m.).

Valley Water Staff in attendance were: Gina Adriano, Joseph Aranda, Meghan Azralon, Aaron Baker, Roseryn Bhudsabourg, Neeta Bijoor, Sam Bogale, Glenna Brambill, Justin Burks, Phil Dolan, Anthony Fulcher, Samantha Greene, Andy Gschwind, Jason Gurdak, Linh Hoang, Matt Keller, Jessica Lovering, Michael Martin, Metra Richert, Don Rocha, Clarissa Sangalang, Ashley Shannon, Nicholas Simard, Kirsten Struve, Cindy Torres, Gregory Williams, and Jing Wu.

Public in attendance were: Brian Boyer (Cinnabar Hills Golf Club), Sarah Dominick (Hazen and Sawyer), Katja Irvin (Sierra Club-Loma Prieta Chapter), Julia Nussbaum, and Bill Tuttle (San Jose Water Company-SJWC).

2. TIME OPEN FOR PUBLIC COMMENT ON ANY ITEM NOT ON AGENDA

There was no one present who wished to speak.

3. APPROVAL OF MINUTES

3.1 APPROVAL OF MINUTES APRIL 24, 2023

Committee Chair Director Nai Hsueh reviewed the materials as outlined in the agenda items. It was moved by Director Barbara F. Keegan, seconded by Committee Chair Director Nai Hsueh, and unanimously approved, the minutes of the May 22, 2023, Water Conservation and Demand Management Committee regular meeting as presented.

4. REGULAR AGENDA ITEMS

4.1 DROUGHT RESPONSE PLAN

Michael Martin reviewed the materials as outlined in the agenda item and answered questions as needed.

The Water Conservation and Demand Management Committee discussed the following: great presentation, graphics of the triggers explained, recycled/purified water, direct/indirect potable water, Board's engagement, and alignment with the State's mandated Water Shortage Contingency Plan.

Kirsten Struve and Samantha Greene were available to answer questions.

Public Comment:

Brian Boyer (Cinnabar Hills Golf Club) had questions on the DSCI slides.

Water Conservation and Demand Management Committee took no action.

Committee Chair Director Nai Hsueh moved to Agenda Item 3.2.

3. APPROVAL OF MINUTES

3.2 APPROVAL OF MINUTES JUNE 5, 2023

Committee Chair Director Nai Hsueh reviewed the materials as outlined in the agenda items. It was moved by Committee Vice Chair Director Rebecca Eisenberg seconded by Committee Chair Director Nai Hsueh, and with majority approved, the minutes of the June 5, 2023, Water Conservation and Demand Management Committee special meeting as presented. Director Barbara F. Keegan abstained.

Committee Chair Director Nai Hsueh moved to Agenda Item 4.2.

4. REGULAR AGENDA ITEMS

4.2 REVIEW AND APPROVED PROPOSED WATER CONSERVATION AND DEMAND MANAGEMENT COMMITTEE WORK PLAN, THE OUTCOMES OF BOARD ACTION OF COMMITTEE REQUESTS; AND THE COMMITTEE'S NEXT MEETING AGENDA

Committee Chair Director Nai Hsueh and Kirsten Struve reviewed the materials as outlined in the agenda items.

August agenda items:

-  SCW Funding,
-  Demand Model and Water Use Data
-  Collaboration with UC Water on Flood Managed Aquifer Recharge (Flood MAR)

The next meeting will be August 28, 2023, 11:00 a.m.

The Water Conservation and Demand Management Committee took no action.

5. CLERK REVIEW AND CLARIFICATION OF COMMITTEE'S REQUESTS

Glenna Brambill stated there were no formal action items for Board consideration, however, the committee had made suggestions for staff consideration on the drought response plan.

6. ADJOURNMENT

Committee Chair Director Nai Hsueh adjourned at 11:53 a.m.

Glenna Brambill
Board Committee Liaison
Office of the Clerk of the Board

Approved:



Santa Clara Valley Water District

File No.: 23-0805

Agenda Date: 8/28/2023

Item No.: 4.1.

COMMITTEE AGENDA MEMORANDUM **Water Conservation and Demand Management Committee**

Government Code § 84308 Applies: Yes ☐ No ☒
(If "YES" Complete Attachment A - Gov. Code § 84308)

SUBJECT:

Safe Clean Water Conservation Program - Project A2: Water Conservation Rebates and Programs Update.

RECOMMENDATION:

Receive an update on the Safe Clean Water funded conservation programs. This is a discussion item, and no action is required.

SUMMARY:

Through the 2020 voter-approved Measure S, a renewal of Santa Clara Valley Water District's (Valley Water) Safe, Clean Water and Natural Flood Protection Program (SCW), up to \$1 million per year is for water conservation program activities, including rebates, technical assistance, and public education, within the first seven (7) years of the SCW. SCW funding not only helps Valley Water meet its countywide long-term water conservation goal of 110,000 acre-feet of water per year by 2040, but these water conservation programs also increase water supply reliability, help reduce greenhouse gases, and irrigation runoff pollution to the Bay. In Fiscal Year 2022 (FY22), SCW provided an opportunity to enhance and create the following programs:

- Landscape Rebate Program
- Lawn Busters Program
- Conservation Webinar Series
- 2022 and 2023 Landscape Summit
- Qualified Water Efficient Landscaper Training
- Train-the-Trainer Home-Scale Permaculture Program
- Irrigation Scheduler Web Application Development

Landscape Conversion Program Enhancements

To increase participation in Valley Water's conservation program, SCW funding was utilized to

increase the Landscape Conversion Rebate rate from \$1 per square foot (sf) to \$2 per sf and was also utilized to increase payment to local non-profit Our City Forest for the Lawn Busters Program from \$2 per sq ft to \$4 per sq ft. The Lawn Busters Program is offered to low-income community members, United States veterans, and other disadvantaged community members. FY23 resulted in 18,000 square feet (sq. ft.) of lawns converted through the Lawn Busters program across 21 projects. The increased funding for the Landscape Rebate Program, combined with increased awareness of the program due to the drought, led to the conversion of over 2 million sq ft of lawn, 700,000 sq ft of which was eligible for SCW funding.

Technical Assistance and Public Education

The SCW program allowed Valley Water to pilot new programs and create new resources to help the public better conserve water. In addition to the increased rate for the Lawn Busters Program, SCW funding also allowed for the creation of a hands-on Do-it-Yourself (DIY) Lawn Busters workshops, taught by Our City Forest, in which participants learned about plant selection and design and were able to participate in removing turf lawn and replacing with low-water using plants and mulch.

To further educate the public about outdoor water efficiency, Valley Water also piloted a webinar series taught by local professionals. The series topics ranged from graywater and rainwater collection to irrigation controller programming. Especially notable was the opportunity to pilot live language interpretation services to extend access to non-English speakers, specifically in Spanish, Vietnamese, and Mandarin.

Valley Water was also able to contract with California Water Efficiency Partnership (CalWEP) to host our annual 2023 Landscape Summit for landscape professionals as a hybrid in-person/virtual event. Nearly 190 people attended the event, with over 115 of those attending virtually. Topics included Integrating Advanced Graywater Systems, Increased Irrigation Efficiency, and Green Storm Water Infrastructure. The 2023 agenda and video are available on our website at <https://www.valleywater.org/saving-water/outdoor-conservation/workshops-events>.

Enhanced training for landscape professionals was also made possible by SCW funding, with securing a contractor, CalWEP, to administer the EPA WaterSense certified Qualified Water Efficient Landscaper (QWEL) training for landscape professionals who live or work within Santa Clara County. The QWEL training, offered in both Spanish and English, equips our local landscapers, contractors, and designers with the tools they need to provide water-efficient landscaping to the residents of Santa Clara County. A Train-the-Trainer Home-Scale Permaculture Program was also piloted to help participants gain an understanding of the impact of home-scale permaculture water management strategies ("slow it, spread it, sink it"), as well as the skills to design, implement and maintain these systems, including presentations, energy-water nexus, soil and plant relationships. Training like QWEL and the Permaculture pilot provide landscape professionals with the knowledge and tools they need to design and implement sustainable landscapes appropriate for California's climate.

Lastly, the development of a powerful online Irrigation Scheduler web application through SCW provides the public with tools needed to correctly program their landscape irrigation. Created by an irrigation expert, the free online Irrigation Scheduler utilizes local weather data to create site-specific

irrigation schedules. It also provides videos to support the online irrigation scheduling tool. The tool is available on our website at www.valleywaterscheduler.com <<https://www.valleywaterscheduler.com>>.

The Webinar Series, QWEL training, and Permaculture Pilot were highly successful and as a result, Valley Water is pursuing extensions and expansions of these programs to continue offering to the public.

ENVIRONMENTAL JUSTICE IMPACT:

There are no Environmental Justice impacts associated with this item.

ATTACHMENTS:

Attachment 1: SCW A2 Presentation

UNCLASSIFIED MANAGER:

Kirsten Struve, 408-630-3138



Safe Clean Water – A2: Conservation Programs Update

Water Conservation and Demand Management Committee, August 28, 2023

Ashley Shannon, Sr. Water Conservation Specialist



Safe Clean Water- Conservation Program Update

- Measure S, Safe Clean Water and Natural Flood Protection
- \$1 Million per year for Water Conservation activities
- Opportunity to enhance and create Water Conservation programs and resources



Safe, Clean Water
and Natural Flood Protection

Priority A: Ensure a safe, reliable water supply

Safe Clean Water- Conservation Program Update

Meet long-term water conservation goal, 110,000 AFY by 2040

FY23 Programs:

- Landscape Rebate Program
- Lawn Busters Program
- Conservation Webinar Series
- 2022 and 2023 Landscape Summit
- Qualified Water Efficient Landscaper Training
- Train-the-Trainer Home-Scale Permaculture Program
- Irrigation Scheduler Web Application Development

Landscape Conversion Program Enhancements

Landscape Rebate Program

- Increase rate from \$1/sq ft to \$2/sq ft
- Over 2 Million sq ft converted in FY23

Lawn Busters

- Partnership with Our City Forest
- Increase funding from \$2/sq ft to \$4/sq ft
- Low-income community members, United States veterans, and other disadvantaged community members
- 18,000 sq ft, 21 projects



Technical Assistance and Public Education

Lawn Busters Workshops

- Virtual and hands-on
- Landscape design and transformation

Webinar Series

- Outdoor water use efficiency topics
- Live translation in Spanish, Chinese, and Vietnamese

2023 Landscape Summit

- Over 190 attendees
- Landscape professionals



Technical Assistance and Public Education

Qualified Water Efficient Landscaper (QWEL)

- EPA WaterSense Certified Program
- Offered in English and Spanish

Train-the-Trainer Home-Scale Permaculture Program 2023 Landscape Summit




Technical Assistance and Public Education

Irrigation Scheduler web application

- Fee online tool
- Increase irrigation efficiency

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Irrigation Scheduler**


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Provided by Santa Clara Valley Water District
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5700 Almaden Expressway
San Jose, CA 95123
Days per week allowed: Any days
Schedule type: Normal
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Choose new zone number *Required

Description *Required






Plant Material Choose one

 Low Water Use  Moderate Water Use  High Water Use  Warm Turf Grass  Cool Turf Grass

Exposure Choose one

 Shade  Part Sun  Full Sun

Soil Choose one [Need soil help?](#)

 Clay  Clay Loam  Loam  Sandy Loam  Sand

Slope Choose one



Santa Clara Valley Water District

File No.: 23-0807

Agenda Date: 8/28/2023

Item No.: 4.2.

COMMITTEE AGENDA MEMORANDUM **Water Conservation and Demand Management Committee**

Government Code § 84308 Applies: Yes ☐ No ☒
(If "YES" Complete Attachment A - Gov. Code § 84308)

SUBJECT:

Flood-Managed Aquifer Recharge Preliminary Feasibility Study for Santa Clara County.

RECOMMENDATION:

Receive and discuss the Pre-Feasibility Study for a Flood-MAR Program in the Santa Clara Valley Water District Service Area, Santa Clara County, CA.

SUMMARY:

For decades, the Santa Clara Valley Water District (Valley Water) has been implementing managed aquifer recharge (MAR) using imported surface water supplies from the Bay-Delta watershed and local surface water supplies captured in 10 surface water reservoirs. Between 2000 and 2019, Valley Water MAR averaged almost 90,000 acre-feet of water per year countywide. Given future uncertainties with climate change and regulations related to local and imported surface water supplies, the Water Supply Master Plan 2040 (Master Plan) recommends evaluating approaches for mitigating the potential loss of supplies. The Master Plan has a suite of conservation and stormwater capture projects, referred to as the "no regrets package," that the Valley Water Board of Directors (Board) approved for further planning and evaluation. One of the "no regrets" projects is Flood-MAR, which uses flow and/or infrastructure modifications to capture and infiltrate high-magnitude or excess surface water flows on open space, such as agricultural or other working lands.

Valley Water is interested in whether Flood-MAR can enhance water supply while also providing co-benefits related to watershed stewardship. Valley Water has contracted with UC Water, a team of researchers from across the University of California system, to conduct a pre-feasibility study (study) on Flood-MAR implementation in Valley Water's service area (Attachment 1). The study has two interrelated tasks: Task 1 evaluates economic, management, legal, and policy issues related to implementing Flood-MAR, whereas task 2 develops a mapping tool to preliminarily screen potentially suitable Flood-MAR sites for further evaluation.

Pilot Flood-MAR projects in California have primarily been single projects conducted by smaller

agencies and private landowners. Since Valley Water may not have direct control of lands that present good recharge opportunities, a Flood-MAR program could support effective implementation of projects on non-Valley Water property through incentive structures, project development, and oversight to ensure expected benefits are attained. Given Valley Water's size and range of responsibilities, the program would require careful planning and implementation to ensure incentives are properly developed and implemented, regulations are followed, program staffing and coordination is efficient, and water supply benefits are accurately tracked.

The study identified three types of Flood-MAR projects that are being piloted in other parts of California and their potential viability in Valley Water's service area:

- 1) Active diversion of high magnitude streamflow: diverts unappropriated flows onto agricultural fields or other open space.
- 2) Floodplain restoration: reclaims large floodplains without harming adjacent public or private interests
- 3) Hillslope runoff capture: captures hillslope runoff downstream of existing reservoirs or in unregulated watersheds and infiltrates the runoff on adjacent agricultural fields or other open space.

Given the geography and hydrology in Valley Water's service area, hillslope runoff capture projects will likely be the most feasible for Valley Water. Unlike other areas of California, where large Flood-MAR projects may have a significant water supply benefit (thousands of acre-feet per year), individual hillside runoff projects are expected to provide lower volumes of recharge (e.g., tens to hundreds of acre-feet per year). Therefore, Flood-MAR would likely provide a relatively small recharge benefit compared to Valley Water's existing MAR program. Other benefits of well-placed hillslope runoff Flood-MAR could also include diversifying surface water supplies, improving surface water quality, maintaining or improving groundwater quality, and/or improving habitat quality.

Key findings related to potential Flood-MAR program development include:

- A third-party entity that supports landowner outreach, project-level water accounting, and monetary incentive calculations could improve stakeholder communication and maintain trust between Valley Water and landowners.
- Recharge Net Metering (ReNeM) is a rebate-based incentive structure currently being piloted in the Pajaro Valley. However, institutional differences may affect ReNeM's viability in Valley Water's service area. For example, groundwater pumping fees for agricultural water users are almost an order of magnitude higher in the Pajaro Valley (~\$263 per AF) than in Valley Water's service area (~\$37 per AF), reducing the potential motivational power of a rebate on pumping fees. In addition, Valley Water would need to evaluate whether such a rebate is consistent with legal requirements such as the District Act and Proposition 26.
- Given that Valley Water manages the groundwater and has extensive experience managing surface water rights, and because the landowner will not have rights to the recharged water, when water rights are necessary, Valley Water should consider being the water rights applicant and manager for individual Flood-MAR projects.

The study also analyzed spatial data from Valley Water's service area using a mapping tool to identify

locations having multiple favorable conditions that could indicate Flood-MAR suitability. The preliminary suitability map is based on surface and subsurface conditions that affect runoff, infiltration, and recharge. The current tool does not account for land cover type or source water availability, which are also important considerations for overall Flood-MAR suitability. The suitability map is a dynamic, living tool that will continue to be updated as new data become available, including land cover and hydrology data.

The preliminary suitability map indicates there may be land areas within the Santa Clara and Llagas subbasins that have physical conditions potentially favorable for Flood-MAR (Attachment 1). Potentially favorable locations will require further evaluation using the mapping tool to examine water source availability and landcover suitability. Further, the suitability map is based on regional data and therefore, potential Flood-MAR implementation at individual sites would depend on additional feasibility considerations, such as a field survey confirming recharge capability and evaluating soil contaminant load, design and construction costs, permitting, source water, participation incentives, and landowner interest.

Next Steps

The results of the pre-feasibility study indicate a Flood-MAR program may be viable for Valley Water, though it will provide a relatively small water supply benefit and will need to navigate key uncertainties regarding permitting, water rights, water supply benefit, and incentive structure. To begin addressing those uncertainties, staff will begin developing a pilot Flood-MAR program structure at Valley Water. Developing a Flood-MAR program includes activities such as developing eligibility criteria, incentives, and water supply benefit accounting. In addition, staff will add a hydrology component to the mapping tool to refine the identification of suitable areas for hillslope runoff capture. An enhanced mapping tool coupled with a pilot program will enable Valley Water to identify potential locations and partners for a pilot project. The costs and benefits associated with individual projects, along with the county-wide cost and benefit potential, will be a key consideration in determining whether to recommend converting the pilot program into an official Valley Water program. Based on projects completed in the Pajaro Valley Water Management Agency service area, each project site implementation could cost hundreds of thousands of dollars.

Valley Water is actively pursuing grant funding to support the pilot program. In early 2023, Valley Water received a \$350,000 from the Pajaro River Watershed Integrated Regional Water Management Group Proposition 1 grant funds. Valley Water will use this grant funding to develop the pilot Flood-MAR program. Valley Water expects Flood-MAR implementation projects may be competitive in future State grant solicitations since Governor Newsom's California Water Plan identified Flood-MAR as an important tool for securing California's water future.

Staff will provide regular updates on the Flood-MAR pilot program development to the Agricultural Water Advisory Committee, Water Conservation and Demand Management Committee, and the Environmental and Water Resources Committee.

ENVIRONMENTAL JUSTICE IMPACT:

There are no Environmental Justice impacts associated with this item.

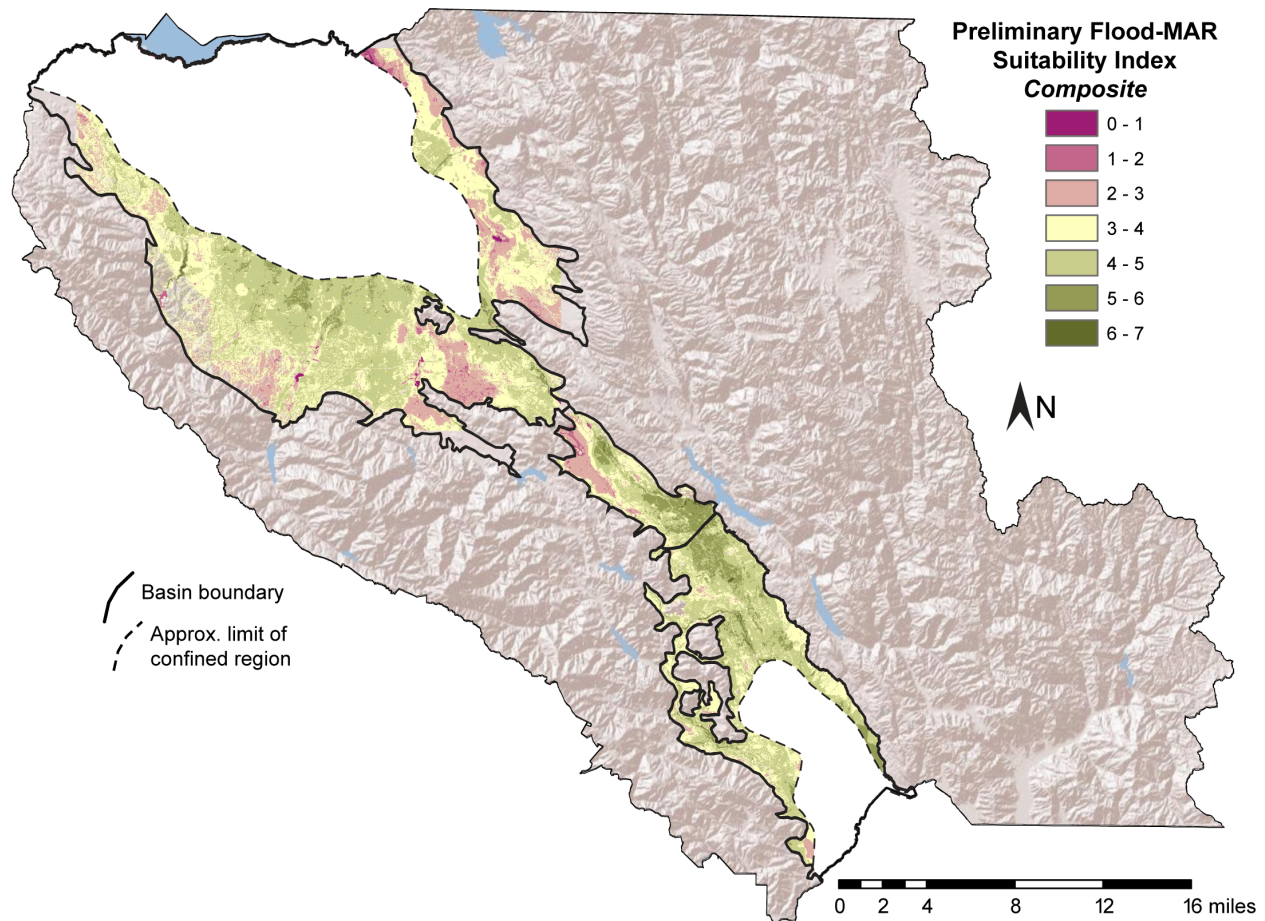
ATTACHMENTS:

Attachment 1: Flood-MAR study report
Attachment 2: PowerPoint Presentation

UNCLASSIFIED MANAGER:

Kirsten Struve, 408-630-3138

Pre-Feasibility Study for a Flood-MAR Program in the Santa Clara Valley Water District Service Area, Santa Clara County, CA



Water Resource Innovation Partnership (WRIP)

Award A4412X to the University of California (UC Water)

Final: 17 July 2023

A. T. Fisher¹, N. Green Nylen², J. Pensky¹, M. Bruce², M. Kiparsky², V. Bautista¹,
E. Kam¹, N. Santos³, J. Viers³, A. Rallings³, G. Fogg⁴

¹ Earth and Planetary Sciences Department, University of California, Santa Cruz, CA 95064

² Center for Law, Energy & the Environment, University of California, Berkeley CA 94720

³ School of Engineering, University of California, Merced, CA, 95343

⁴ Department of Land, Air, and Water Resources, University of California, Davis, CA, 95616

Executive Summary

Flood-managed aquifer recharge (Flood-MAR) collects and infiltrates high-magnitude or excess surface water flows on agricultural lands or other working or open landscapes. UC Water has partnered with Santa Clara Valley Water District (Valley Water) to explore the potential for implementing Flood-MAR in Valley Water's service area to support the augmentation of water supplies in Valley Water groundwater recharge zones.

This report provides both a high-level evaluation of options and considerations for Flood-MAR in Valley Water's service area and a mapping tool to support preliminary evaluation of potential Flood-MAR locations. The evaluation of options and considerations suggests that small, distributed recharge projects which collect and infiltrate local hillslope runoff from heavy rain events may be the most feasible types of Flood-MAR projects for Valley Water to focus on initially. Individually, these projects would contribute small water supply benefits relative to Valley Water's existing managed aquifer recharge (MAR) program. However, they could also help diversify Santa Clara County's water supplies, slow and infiltrate stormwater runoff, maintain or improve groundwater quality, and provide ecosystem benefits.

The report articulates key questions Valley Water will want to assess to determine whether Flood-MAR is legally, administratively, institutionally, and technically viable; identifies potential pathways for answering those questions; and provides recommendations for next steps for exploring Flood-MAR implementation in Valley Water's service area.

Options and considerations for a Flood-MAR program

We evaluated the potential for a programmatic approach to Flood-MAR, as compared to developing Flood-MAR through a series of one-off projects. A Flood-MAR program would support short- and long-term planning, information gathering, and evaluation and enable ongoing adjustment of both individual projects and Valley Water's Flood-MAR strategy. Because Valley Water may not have direct control of lands that present the best opportunities for Flood-MAR, a program could support effective implementation of projects on non-Valley Water property, including by providing appropriate incentive structures and oversight to ensure that Flood-MAR projects individually and collectively meet expectations. A programmatic structure would also support internal collaboration within Valley Water, foster economies of scale, leverage dispersed institutional expertise, and house institutional memory relevant to Flood-MAR.

Building an agency-scale Flood-MAR program at a large and complex agency like Valley Water would be a novel and ambitious approach. **Table ES-1** summarizes considerations for developing a Flood-MAR program within Valley Water and related questions, grouped into three main categories: (1) program goals and objectives, (2) internal program support, and (3) program functions. Some considerations are likely shared with other Valley Water programs, enabling Valley Water to straightforwardly leverage existing expertise in the Flood-MAR context, whereas other considerations will require innovation.

We examined three types of Flood-MAR projects and their potential viability in Valley Water's service area:

- 1) Flooding agricultural fields or other open space with high-magnitude streamflows,
- 2) Floodplain restoration, and

- 3) Distributed recharge projects that collect and infiltrate local hillslope runoff resulting from heavy precipitation events.

Given the geography, hydrology, and existing utilization of other types of MAR in Valley Water's service area, distributed recharge projects that collect and infiltrate hillslope runoff are likely the most promising type of Flood-MAR for Valley Water to focus on initially, allowing relatively rapid progress and implementation. Individual hillslope runoff projects are expected to provide lower volumes of recharge (tens to hundreds of acre-feet per year) than the large Flood-MAR projects (providing water supply benefits of thousands of acre-feet per year) that may be more feasible in other parts of California. Therefore, Flood-MAR would likely provide a relatively small additional water supply benefit compared to Valley Water's existing MAR program. However, Flood-MAR projects that collect and infiltrate hillslope runoff could also benefit Santa Clara County by diversifying water supplies, slowing and infiltrating stormwater runoff during major rain events, maintaining or improving groundwater quality, and supporting groundwater dependent ecosystems (including by increasing baseflow to rivers and streams).

Additional key points and findings include the following:

- Valley Water's existing MAR facilities already occupy many of the best recharge sites in Santa Clara County (County), and their recharge capacity exceeds the volume of water available for recharge from Valley Water's traditional sources in many years. However, the mapping tool discussed below indicates there may be areas suitable for Flood-MAR, pending further evaluation.
- If Valley Water pursues distributed Flood-MAR projects that collect and infiltrate local hillslope runoff, organizing Flood-MAR efforts at a programmatic level will likely be more efficient and effective than pursuing individual projects with less coordination.
- Valley Water could partner with other landowners and managers to develop Flood-MAR projects, a process it could facilitate with incentives.
- One potential model for providing incentives for Flood-MAR implementation is Recharge Net Metering (ReNeM), a rebate-based incentive structure developed through a collaborative effort in nearby Pajaro Valley. However, differences in the physical and institutional contexts of the two areas may affect the potential viability of a ReNeM-like incentive structure for Flood-MAR in Valley Water's service area. For example, groundwater production charges for agricultural water users are more than seven times higher in the Pajaro Valley (~\$282 per AF) than in Valley Water's service area (~\$37 per AF), reducing the potential motivational power of a rebate on those charges.
- Most permitting needs for Flood-MAR projects, summarized in **Table ES-2**, will likely be familiar to Valley Water because of its extensive experience with MAR implementation. However, Valley Water would need to decide how to address permitting needs for small Flood-MAR projects that are distributed across its service area on non-Valley Water property. Valley Water may be best positioned to pursue most permits and other regulatory approvals for such projects.
- It may make sense for Valley Water, rather than individual landowners, to apply for any necessary water right permits for Flood-MAR projects, including those on private land.

These institutional findings support, and are supported by, a Flood-MAR suitability mapping tool and related analysis.

Pre-feasibility analysis of surface and subsurface suitability for Flood-MAR

To support Valley Water in identifying the potential for Flood-MAR within its service area, UC Water also developed a mapping tool to identify areas that may be suitable for Flood-MAR, pending further evaluation. The mapping tool uses multi-criteria decision analysis (MCDA) with spatial data from the Valley Water service area to identify locations with multiple favorable conditions that could justify Flood-MAR development. MCDA is a decision-making approach that evaluates several factors (criteria) together to aid consideration of alternatives.

The mapping tool is based mainly on five data coverages (**Figure ES-1A**):

- Three data sets showing surface conditions throughout Santa Clara County: soil infiltration capacity, land use/land cover, and shallow geology; and
- Two data sets showing subsurface conditions within three groundwater management areas: vadose zone thickness (the depth of the unsaturated zone that extends from the land surface down to the groundwater table) and climate sensitivity of groundwater levels.

Other datasets incorporated as part of the mapping tool include surface slope, aquifer properties (as applied in regional groundwater models), water quality, locations of operating managed recharge systems, and areas designated as "open space." These and other datasets can be used to filter results from an initial screening (for example, removing sites that are too steep for infiltration for Flood-MAR) or can help prioritize potential project sites for field investigation.

Sites with the highest Flood-MAR suitability tend to be located where multiple criteria are satisfied: on old stream channels, on or near active (although often ephemeral) stream channels, and on other coarse Quaternary fluvial and alluvial deposits; where land is undeveloped, has low-intensity development, or is used for agricultural activities; where there is a vadose (unsaturated) zone 20-100 ft thick; and where there have been large differences in groundwater levels during dry climate periods compared to wet periods. Areas with potentially favorable Flood-MAR conditions are found throughout the project region, suggesting that some distribution of benefits may be possible, depending on additional considerations including design and construction costs, permitting, available water supplies, incentives for participation, and landowner interest.

The areas with the most favorable conditions for Flood-MAR, based on this pre-feasibility assessment, include (**Figure ES-1B**):

- Santa Clara Plain - along the western and southern margins of the basin, around and outside of the region generally dominated by confined conditions.
- Coyote Valley - along the southern and eastern half of the basin, particularly along active and old stream channels and other stream deposits.
- Llagas Subbasin - in the northern half and along the western margin of the subbasin, particularly where fluvial deposits cut across areas having finer soils.

This pre-feasibility assessment is designed to be used by Valley Water as a screening tool and guide, not as an absolute assessment upon which final decisions are based. There are multiple steps that Valley Water may find useful in advancing Flood-MAR efforts in this region, several of which could be advanced simultaneously or in close succession:

- Assess drainage areas and runoff generation to identify sites that may produce adequate hillslope runoff to support Flood-MAR projects that collect and infiltrated local hillslope runoff resulting from heavy precipitation events.
- Extend the MCDA by incorporating more existing datasets and/or by updating existing coverages or adding new coverages.
- Use the existing MCDA to identify potential field sites, advancing the effort towards quantitative feasibility assessment of specific project options.
- For potential Flood-MAR sites that pass a desktop analysis, conduct a field assessment to identify areas that prove to be more favorable based on observed, local conditions. Field assessment can include one or more of these approaches:
 - Conduct geophysical surveys using electrical, radar, and/or seismic methods and/or exploratory drilling to collect geotechnical data and/or continuous cores.
 - Monitor rainfall on site and in areas contributing to drainage, and potentially measure runoff if channelized flow occurs, to better understand local patterns and magnitudes, with comparison to historic records.
 - Sample local wells, with relatively high temporal and spatial resolution, to understand local groundwater quality and variability of quality.
 - Test local infiltration conditions at a plot to field scale.
 - Estimate project cost based on expected size, method to be used for collection/retention, and other engineering and institutional considerations.

A path forward

There is statewide consensus that enhancing recharge could benefit many parts of California, and there are working examples of successful Flood-MAR projects. This study looked at the preliminary feasibility of Flood-MAR within Santa Clara County for expanding the County's recharge capacity. Flood-MAR could be a useful complement to the variety of tools and methods Valley Water currently uses to manage resources for its large and heterogeneous service area. Advancing a Flood-MAR program could help Valley Water stay at the forefront of innovation and stewardship, contribute to resource resilience, and address future water management challenges. Valley Water's existing MAR systems provide an average of 90,000 acre-feet of recharge per year, and related pond sets have capacity to recharge 1,500 to 7,700 acre-feet per year. Flood-MAR projects that collect hillslope runoff in other parts of California generate <1,000 acre-feet per year of annual recharge per site; while smaller in magnitude, such projects could augment Valley Water's existing MAR program. Flood-MAR remains developmental in many ways, requiring creativity, care, and persistence to implement successfully.

In summary, our findings suggest both that a Flood-MAR program may be institutionally viable for Valley Water and that physical potential for Flood-MAR may exist within Valley Water's service area. We present a set of tools Valley Water can use and suggest other actions it can take to further investigate Flood-MAR feasibility. Positive indications of institutional viability and Flood-MAR suitability will be necessary at each stage to justify Valley Water's continued exploration of Flood-MAR. We find both at this pre-feasibility stage.

Table ES-1. Preliminary assessment of considerations for implementing a Flood-MAR program in Santa Clara County, assuming an initial focus on distributed recharge projects that collect hillslope runoff.

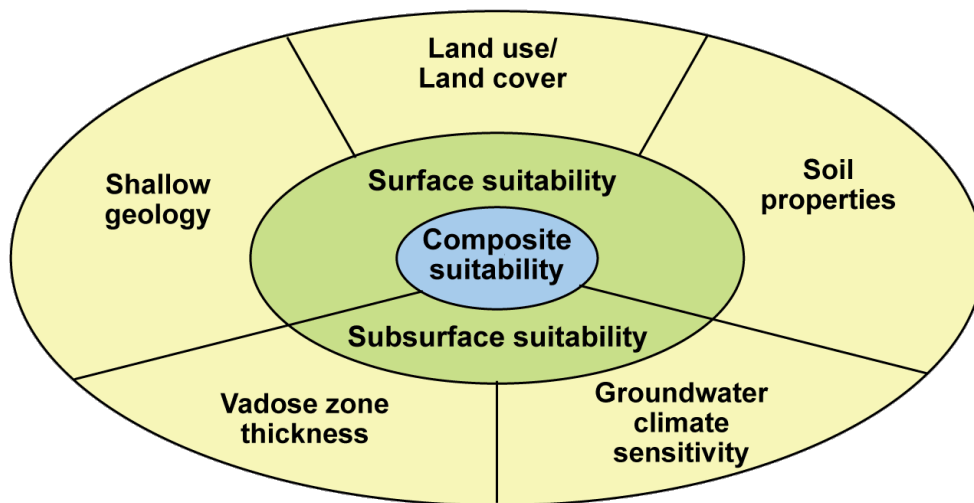
PROGRAM GOALS AND OBJECTIVES	
What primary benefits are sought?	Enhancing water supply, advancing stakeholder engagement, and supporting climate change adaptation and resilience
What incidental benefits / co-benefits are sought, or would be desirable?	Reducing flood risk, preserving working landscapes, enhancing riparian habitat, maintaining / improving groundwater quality, and minimizing land subsidence potential
What negative impacts must be avoided?	Harm to fish/ecosystems, flooding, and property / infrastructure damage
What specific objectives would the program work towards in the short (and longer) term?	Developing appropriate incentive structures, legal / regulatory compliance support, and oversight for distributed projects
INTERNAL PROGRAM SUPPORT	
Where could the program reside in Valley Water?	Water Supply Planning and Conservation Unit (lead)
Who else would be involved internally?	Likely: staff from Groundwater Management Unit; Raw Water Operations Unit; Raw Water Field Operations & Pipeline Maintenance Unit; Hydrology, Hydraulics, and Geomorphology Unit; Watershed Policy and Planning Unit; Environmental Planning Unit; Financial Planning and Revenue Unit; Communications Unit; Treasury-Debt Management Unit; Office of the District Counsel; and related capital program design and implementation units
How would the program be funded?	Likely revenue from water charges, grant funding, and other appropriate Valley Water sources
PROGRAM FUNCTIONS	
1. Assessing source water options and availability	
When/where do high-magnitude flows occur in Valley Water's service area, and how are they expected to change in the future?	Hillslope runoff during heavy precipitation events, downstream of existing reservoirs and in unregulated watersheds (expected to increase in the future)
What flow / other requirements may affect the viability of potential source waters?	Valley Water's Fish and Aquatic Habitat Collaborative Effort (FAHCE) Program, Lake and Streambed Alteration Agreements (LSAAs), downstream water rights, fully appropriated stream system (FASS) designations, etc.
What storage / conveyance infrastructure would be needed to move potential source waters to potential recharge locations?	Ditches and culverts for collecting and conveying hillslope runoff to dedicated infiltration basins or lands, stream diversions for diverting flood water to off-stream lands
What legal permissions would be needed to access potential water sources?	Likely water right permits for capturing hillslope runoff, LSAAs and water rights for stream diversions, and related agreements with participating landowners / managers
2. Assessing areas suitable for recharge and recharge options	
What areas have moderate-to-high surface and subsurface suitability for Flood-MAR?	Areas with Flood-MAR Suitability Index ≥ 4 in the site-suitability tool (confirm through field investigation)

Which of these areas have compatible current land uses?	See site-suitability tool land use/land cover data set, other data to assess risks/benefits related to flooding, habitat, water quality
What are the water quality implications of recharging water in these areas?	Assess by comparing quality / contaminant profile data for potential source waters, soil / vadose zone, and groundwater
Which types of Flood-MAR projects, using which potential water sources, would be useful and feasible in these areas?	Initially, focus on distributed recharge projects that collect hillslope runoff and infiltrate it in dedicated recharge basins; but assess potential for other types of projects / water sources
3. External coordination and engagement needs	
Who owns and manages the land in potential recharge areas?	Private parties, especially growers, and other public agencies
Who holds or might be involved in acquiring water rights to potential water sources?	Valley Water may be best positioned to apply for water right permits from the State Water Resources Control Board (with landowner cooperation), especially to collect hillslope runoff
Who might be involved in acquiring other necessary permits and approvals?	Likely Valley Water (with cooperation from landowners, land managers, consultants, construction contractors, and others)
Who else might be interested in or be affected by Flood-MAR implementation?	Nearby landowners / tenants, downstream surface water users, domestic well users/groups, non-government organizations (NGOs), wildlife/other agencies
What partnerships, coordination, and other outreach/engagement will be needed to effectively implement / fund the program?	Potentially: private landowners/tenants, Santa Clara Valley Open Space Authority (OSA), Peninsula Open Space Trust (POST), Guadalupe-Coyote Resource Conservation District (GCRCD)
4. Incentives for Flood-MAR implementation on non-Valley Water property	
For what purposes might incentives be helpful or necessary?	To encourage recharge projects on non-Valley Water property.
What forms could incentives take?	Multiple options could be considered: direct payment, rebate, funding construction / land rental, and support for maintenance
What size / type of incentive may be needed to encourage sufficient participation?	Not clear; will require evaluation of interest, motivation, and other factors for potential program participants
How would incentives be administered?	Valley Water or a third-party certifier could administer incentives
5. Legal and regulatory compliance	
How would the program support / coordinate / fund permitting for Flood-MAR projects?	Valley Water may be better positioned to apply for water rights and other permits than individual landowners.
What level of environmental review would be required to support projects?	Projects may be eligible for CEQA suspension under Executive Order B-39-17 or Executive Order N-7-22.
What water rights would be needed to access potential water sources?	Temporary permits (180-day, 5-year) to support pilot efforts, standard permits for long-term operations.
What water quality permits / other approvals would projects need?	Potentially: NPDES Construction General Permit + Stormwater Pollution Prevention Plan, Section 404 permit, Section 401 Water Quality Certification
What species and ecosystem protections would affect projects?	Potentially: FAHCE, Lake and Streambed Alteration Agreements (LSAAs), CESA Incidental Take Permits, ESA Section 7 compliance
What cultural resources might be affected?	Depends on site (National Historic Preservation Act Section 106)

What other local, state, or federal permits or requirements might apply?	Santa Clara County Grading Permit, Valley Water District Act requirements
How would the program affect Valley Water's ability to meet its own statutory responsibilities and other legal obligations?	TBD — Would help meet SGMA requirements for sustainable groundwater management; projects could be selected to help meet FAHCE Settlement Agreement obligations
What funding sources are legally appropriate for Flood-MAR projects?	TBD — Would need to discuss with District Counsel's office and Finance
6. Tracking, oversight, evaluation, and adjustment	
How would the program provide effective oversight of Flood-MAR projects?	TBD — Would need to track project level recharge/infiltration effectiveness, water quality impacts, other benefits and risks
How would the program track its overall progress and effectiveness?	TBD — Would need to track program-level recharge/infiltration effectiveness, water quality impacts, other benefits and risks
What would happen if / when a project does not meet expectations?	TBD — Would need to require corrective measures when recharge is ineffective or the project creates substantial risks
How would the program learn / adjust?	TBD — Would need clear mechanisms for adaptive management

Table ES-2. Potential permitting and regulatory compliance needs for Flood-MAR projects

Category	Permit or approval	Agency	Applicability
Environmental review	CEQA compliance <i>Initial Study → (Mitigated) Negative Declaration or Environmental Impact Report</i>	Lead Agency	The project has the potential to affect the environment.
Water rights	Temporary water right permit –180-day or 5-year	State Water Resources Control Board: Division of Water Rights	The project involves temporary diversion and beneficial use of surface water (e.g., for pilot or while standard permit is pending).
	Standard water right permit	State Water Resources Control Board: Division of Water Rights	The project involves long-term diversion and beneficial use of surface water.
Water quality	CWA Section 401 Water Quality Certification	State Water Resource Control Board / Regional Water Quality Control Board	The project involves a federal permit or license for an activity that may result in a discharge of dredged or fill material into waters of the United States.
	CWA Section 404 Permit	U.S. Army Corps of Engineers	The project involves discharge of dredged or fill material into waters of the United States
	NPDES Construction General Permit + Storm Water Pollution Prevention Plan	State Water Resource Control Board / Regional Water Quality Control Board	The project disturbs one (1) or more acres of soil.
Species / ecosystems	Section 1602 Lake and Streambed Alteration Agreement (LSAA)	California Department of Fish and Wildlife	The project involves streambed alteration.
	CESA Section 2081 Incidental Take Permit	California Department of Fish and Wildlife	The project may affect state-listed species.
	ESA Section 7 compliance	U.S. Fish and Wildlife Service / National Marine Fisheries Service	The project involves a federal permit or license for an activity that may affect federally listed species.
Historic preservation	National Historic Preservation Act Section 106 compliance	State Office of Historic Preservation	The project involves construction near cultural resources.
Grading	Grading Permit	Santa Clara County	The project involves grading.



Assessment of suitability for Flood-MAR using stormwater

A

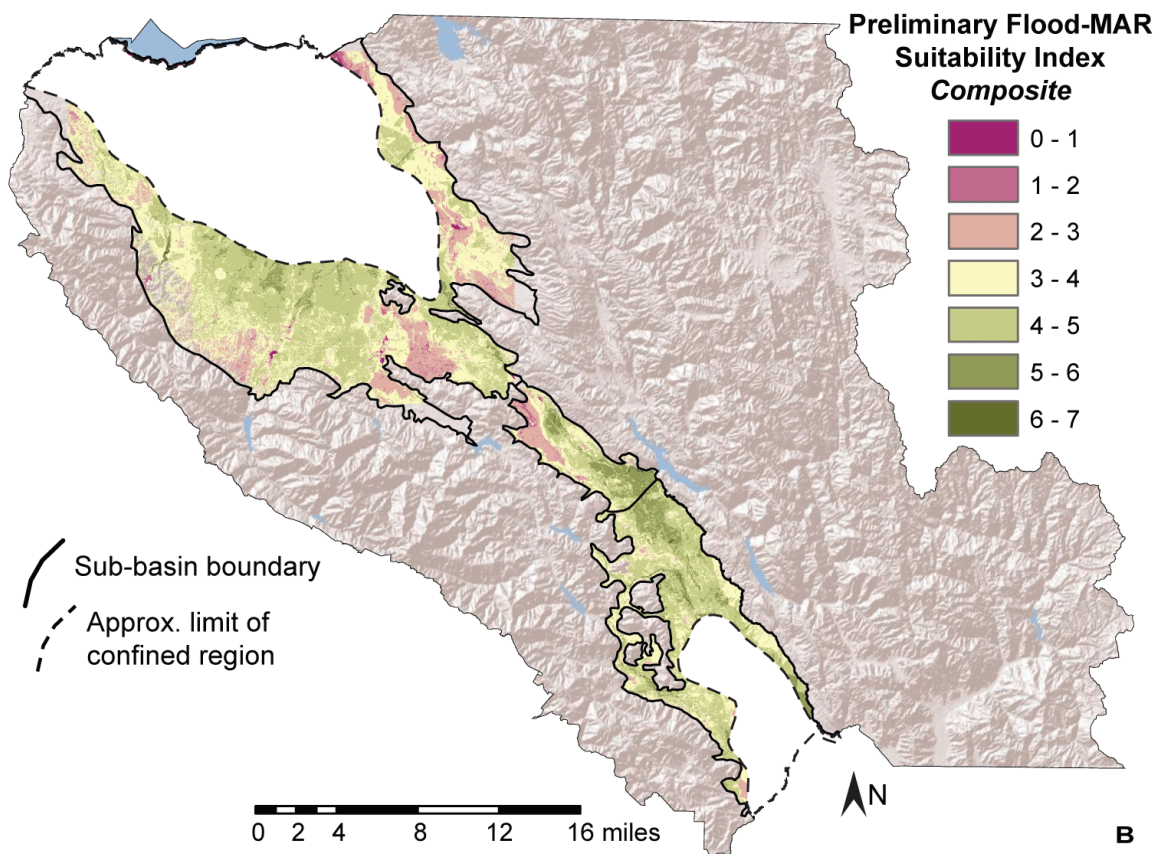


Figure ES-1. A. Overview of approach taken to combine factors for evaluation of suitability for Flood-MAR projects in Santa Clara County, using a geographic information system. The primary analysis used five factors, each weighted 20%. An alternative analysis added subsurface properties as used in regional groundwater models. **B.** Preliminary Flood-MAR suitability based on surface and subsurface factors, with values ≥ 4 indicating moderate to high suitability. White polygons with dashed boundaries denote areas having confined groundwater conditions.

Acknowledgements

This work was completed as part of the Water Resource Innovation Partnership (WRIP) between the University of California (UC) and Valley Water. UC participants are grateful to the many Valley Water personnel who contributed to this effort, including regular meetings and administrative oversight, review and preparation of datasets that were subsequently incorporated into the GIS, and Valley Water-UC workshops to exchange information, ideas, and opinions. The following individuals contributed to this effort, but UC personnel take responsibility for errors in fact or interpretation that may be found. We are especially grateful to S. Greene and J. Gurdak, who were primary technical and administrative leads, meeting with UC personnel on a regular basis, coordinating data delivery, explaining how Valley Water operates and introducing us to colleagues, discussing issues and interpretations in detail, and providing editorial guidance. K. Struve, A. Fulcher, B. Kassab, and E. Olson of Valley Water provided valuable technical and editorial feedback. V. de la Piedra helped to develop the WRIP and participated in numerous discussions, and C. Abuye and N. Murphy provided important data and editorial suggestions, and R. Harmon gave advice on data processing. Additionally, UC colleagues and Pajaro Valley Water Management Agency (PV Water) personnel shared insights and experiences that informed the report's findings. This work was supported by Valley Water (Contract #A4412X), the Gordon and Betty Moore Foundation (Award #9956), USDA/NIFA (Award #2021-67019-33595) and The Recharge Initiative (www.rechargeinitiative.org).

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I. Introduction

A. Background and motivation

Groundwater resources in California are increasingly stressed by rising demand, a changing climate, and shifting land use. Groundwater basins in central California are particularly vulnerable to growing groundwater demand and decreasing supply. Climate change is increasing both drought frequency and rainfall intensity. Urbanization and agricultural development tend to route water quickly off the landscape, limiting opportunities for infiltration and recharge, and long-term agricultural, industrial, and municipal needs are growing.

To help address these challenges, California's 2014 Sustainable Groundwater Management Act (SGMA) requires priority groundwater basins across the state to form groundwater sustainability agencies (GSAs), develop groundwater sustainability plans (GSPs), and implement practices to help maintain the supply and quality of water resources for coming generations. Santa Clara Valley Water District (Valley Water) is the GSA for the groundwater subbasins in Santa Clara County, which include the Santa Clara and Llagas subbasins. Both subbasins are listed as high priority by the Department of Water Resources (DWR). Valley Water has conjunctively managed groundwater and surface water in these basins for many decades.

The primary goal of this project is to explore the potential for implementation of flood-managed aquifer recharge (Flood-MAR) in Valley Water's service area to augment water supplies and provide additional benefits. In this report, we provide both a high-level evaluation of options and considerations for Flood-MAR in Valley Water's service area and a mapping tool to support preliminary evaluation of potentially suitable locations for Flood-MAR implementation. The report articulates key questions Valley Water will want to assess to determine whether a Flood-MAR program is legally, administratively, institutionally, and technically viable; identifies potential pathways for answering those questions; and provides recommended next steps for exploring Flood-MAR implementation in Valley Water's service area.

B. What is Flood-MAR?

Boosting groundwater recharge can help California communities make the most of increasingly variable precipitation and surface water resources.¹ Managed aquifer recharge (**MAR**) is a strategy that can improve both the supply and quality of groundwater² by routing excess surface water into aquifers using a variety of techniques. MAR intentionally replenishes aquifers for later recovery and use or to achieve other benefits.³ Today, MAR is playing a growing role in maintaining groundwater as an effective drought reserve and in slowing or reversing the effects of years of unsustainable groundwater pumping.⁴ However, as climate change stretches the limits of California's surface water storage and conveyance systems, making MAR even more imperative, finding suitable sources of water for recharge can be challenging.

Therefore, water managers are increasingly looking for underutilized water sources to support recharge. High-magnitude surface water flows that result from heavy precipitation events, mostly during the wet season, are expected to increase with continued climate change.⁵ In many stream systems, these flows remain unappropriated (not already spoken for under existing water rights). They have historically been considered a nuisance or hazard, rather than a potentially

useful water source. Therefore, most existing water infrastructure was not designed to retain these flows. They occur less frequently, sometimes with little warning, and capturing and storing sudden large volumes of water in surface reservoirs can be difficult and risky.

Flood-MAR aims to prepare for—and capitalize on—opportunities to collect and infiltrate high-magnitude surface water flows. **Box 1** explains how the State of California defines Flood-MAR. Essentially, Flood-MAR is multi-benefit MAR that can aid in flood-risk reduction and involves agricultural lands or other working landscapes. This broad definition encompasses a wide range of recharge-related activities, including flooding agricultural fields with high-magnitude streamflows during the wet season, floodplain restoration, and distributed recharge projects that collect and infiltrate hillslope runoff during heavy rainfall events.

Box 1. Flood-MAR defined

The California Department of Water Resources (DWR) defines Flood-MAR as “an integrated and voluntary resource management strategy that uses flood water resulting from, or in anticipation of, rainfall or snow melt for managed aquifer recharge...on agricultural lands and working landscapes.”⁶ DWR described the contours of Flood-MAR more fully in a 2018 white paper,⁷ including the following key details:

- **Flood-MAR uses “flood water”** — DWR’s conception of “flood water” includes both (1) “high flows resulting from the largest annual precipitation...or snowmelt events typically during the winter and spring” and (2) “flows released from flood control reservoirs ahead of rain or snowmelt to evacuate additional flood control space” when those flows are “above regulatory instream flow requirements.” “Flood water” is a broad category that potentially encompasses non-urban stormwater. In fact, DWR describes Flood-MAR as “similar in concept to [urban] stormwater capture and reuse programs currently employed in many areas across the State.”
- **Flood-MAR involves agricultural lands or working landscapes** — “Flood-MAR focuses on the ability to use direct spreading on large acreages of active agricultural land, fallowed land, working landscapes, dedicated recharge basins (new or existing), or open space. For active farmland, recharge water is anticipated to be applied during the non-irrigation season, using existing or additional irrigation equipment or conveyance facilities.” DWR notes that working landscapes that may be suitable for Flood-MAR include, but are not limited to, “refuges, floodplains, and flood bypasses.”
- **Flood-MAR can be implemented at multiple scales** — “Flood-MAR can be implemented at multiple scales, from individual landowners diverting flood water with existing infrastructure, to using extensive detention/recharge areas and modernizing flood protection infrastructure/operations.”
- **Flood-MAR is an integrated, multi-benefit adaptation strategy** — Flood-MAR involves “better integration of flood and groundwater management” and is inherently “multi-benefit—providing flood risk reduction, drought preparedness, aquifer replenishment, ecosystem enhancement, and other potential benefits.” As a result, Flood-MAR is a promising adaptation strategy that can “help address two of the most challenging elements of future climate changes: more flashy/intense flood flows, and longer/deeper droughts.” To fulfill this promise, DWR emphasizes the importance of proactive, strategic, and integrated planning across scales and jurisdictions to ensure that “California’s water systems... are resilient to changing conditions and able to adapt nimbly and dynamically to stressors.”

Flood-MAR can be designed and implemented to achieve a range of desirable benefits like enhancing water supply, reducing flood risk, preserving working landscapes, improving water quality, and mitigating land subsidence.⁸ The actual benefits achieved will differ from project to project and will depend on the Flood-MAR approach employed, as well as a host of other site- and project-specific factors.

C. Valley Water's setting and interest in exploring Flood-MAR

Valley Water is responsible for providing clean water, flood protection, and stewardship of streams for more than 2 million residents of Santa Clara County (**Figure I-1**). Water supplies in Valley Water's service area include groundwater, local and imported surface water, and recycled water. Groundwater pumping accounts for about 40% of water use, and groundwater levels are managed through a MAR program that recharges local and imported surface water supplies. Hydrologic conditions, water resource needs, and considerations for developing projects to enhance water supplies and other resources vary across the service area.

Although Valley Water already has an extensive MAR program, it is interested in understanding the potential for Flood-MAR to enhance water supply and water-supply resilience in Santa Clara County. Valley Water maintains 102 groundwater recharge ponds comprising 285 acres and 98 miles of controlled instream recharge (**Figure I-2**).⁹ These recharge facilities have a total potential recharge capacity of about 143,500 acre-feet per year (AFY), although the actual amount recharged rarely approaches this maximum.¹⁰ Valley Water's service area includes three groundwater management areas. In the northern part of Santa Clara County, the Santa Clara Subbasin consists of the Santa Clara Plain and Coyote Valley groundwater management areas; to the south lies the Llagas Subbasin, another groundwater management area (**Figure I-1**). This report refers to the three groundwater management areas as: the Santa Clara Plain, Coyote Valley, and Llagas Subbasin. Between 2010 and 2019, Valley Water's MAR program recharged an average of 88,500 AFY of imported and local surface water, including 53,000 AFY in the Santa Clara Plain principal aquifer, 13,500 AFY in the Coyote Valley, and 22,000 AFY in the Llagas subbasin.¹¹

Valley Water defines four primary benefit zones (**Figure I-1B**): designated regions where the agency replenishes groundwater, monitors conditions, and protects groundwater from pollutants. Valley Water collects a groundwater production charge from owners and operators of groundwater wells in the benefit zones to fund agency activities that protect and replenish groundwater supplies.¹² The charge is based on the amount of groundwater pumped and the purpose of use (agricultural or non-agricultural). For fiscal year 2022–2023, agricultural groundwater production charges are \$36.85 per AF in all benefit zones, whereas non-agricultural groundwater production charges, depending on the groundwater charge zone, range from \$368.50 to \$1,724.00 per AF.¹³

Despite a long history of major investments in improving water supply reliability, Valley Water faces water supply challenges during extended droughts, which are expected to become more frequent and intense with continued climate change.¹⁴ Both imported and local surface water supplies are becoming less reliable as increasing precipitation extremes—wet and dry—test the limits of existing surface water storage and conveyance systems. Meanwhile, rising temperatures and a thirstier atmosphere are increasing the amount of water necessary to meet the

same evapotranspiration needs and increasing reservoir evaporation, exacerbating short- and long-term imbalances between water supply and water demand.

To help meet these challenges, Valley Water has commenced planning efforts to pursue a “no regrets” package of water conservation and local stormwater collection and recharge projects it hopes will reduce county-wide water demand by ~10,000 AFY while increasing available water supplies by ~1,000 AFY by 2040.¹⁵ This package could include Flood-MAR. Indeed, among the potential projects discussed in Valley Water’s Water Supply Master Plan are “[f]looding or recharge on South County agricultural parcels during the winter months” targeted to increase supply by approximately 1,000 AFY.¹⁶

Flood-MAR projects on non-Valley Water land could expand recharge, enhancing water supply in Santa Clara County. Valley Water’s existing MAR projects already occupy most of the best recharge sites on Valley Water property, and their recharge capacity generally exceeds the volume of water available for recharge from Valley Water’s traditional sources during most years. However, there may be areas under private ownership, or under other public agencies’ management jurisdictions, that may be suitable for recharge to take advantage of surface supplies from storms during all year types that are not currently accessible.

Flood-MAR also has the potential to help Valley Water meet other important responsibilities and goals. Depending on the type of project and sites selected, potential incidental or co-benefits of Flood-MAR may include:

- Supporting climate change adaptation,
- Increasing meaningful stakeholder engagement,
- Reducing flood risk,
- Maintaining or improving groundwater quality (especially where nitrate/ salts are a concern),
- Preserving working landscapes,
- Strengthening surface water-groundwater connections by raising groundwater levels in the vicinity of streams (and therefore baseflow),
- Enhancing groundwater dependent ecosystems, potentially including riparian habitat, and
- Minimizing the potential for resumed land subsidence in the Santa Clara Plain.

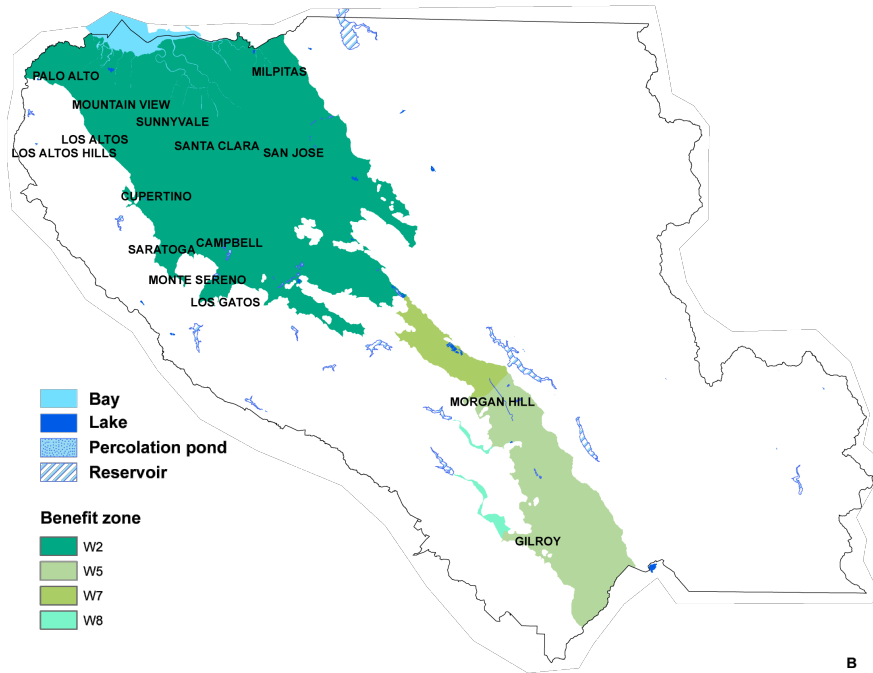
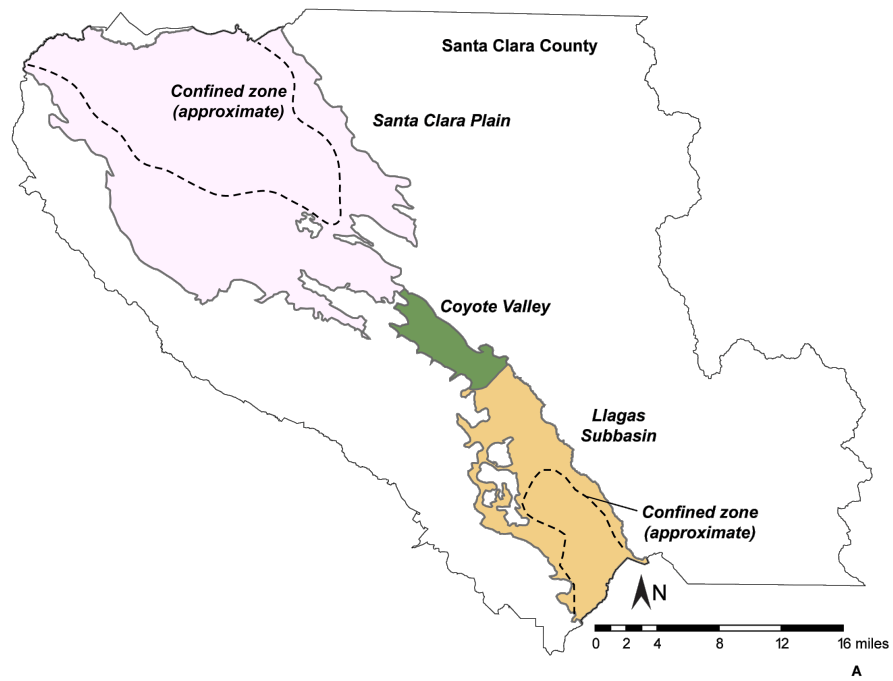


Figure I-1

Figure I-1. Regional map, project area, basins, benefit zones, subregions and features.

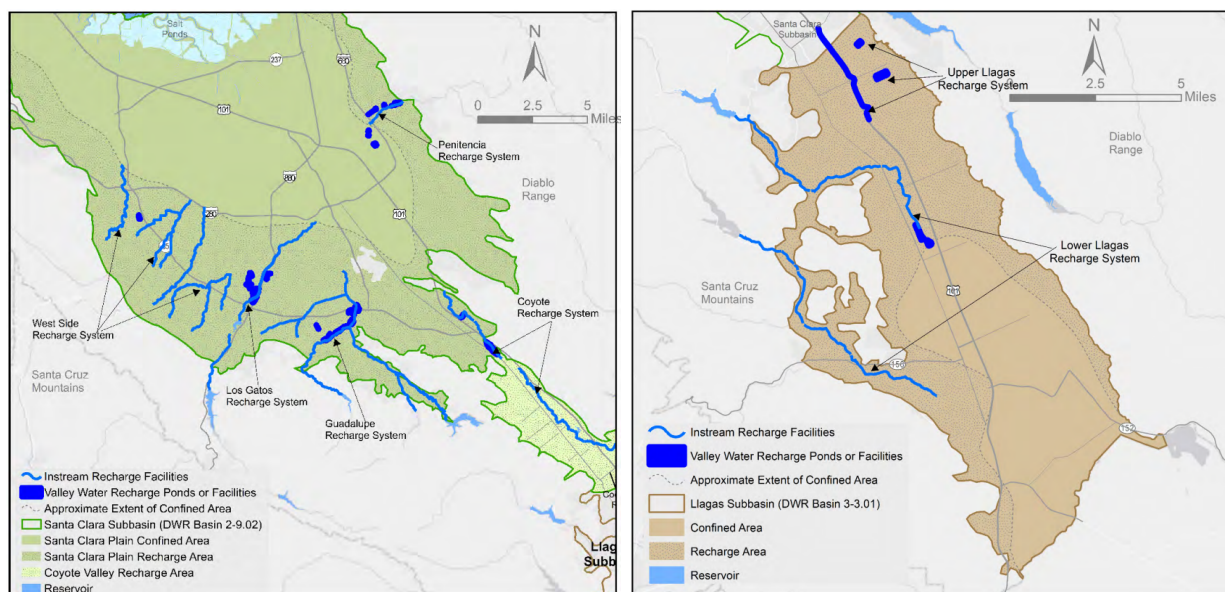


Figure I-2. Existing MAR facilities in the Santa Clara Subbasin, including the Coyote Valley, on the left, and the Llagas Subbasin, on the right.¹⁷

D. Project components and general approach

The Water Resource Innovation Partnership (WRIP) between Valley Water and a team of water researchers from the University of California (UC Water) has completed a pre-feasibility assessment of opportunities to develop a Flood-MAR program to help augment and diversify Valley Water’s managed recharge program while generating additional benefits for the region.

The WRIP included two tasks. Task 1 was a high-level analysis of institutional, economic, management, legal, and policy considerations for a potential Flood-MAR program in Valley Water’s service area. Part II of this report describes the results of that high-level analysis. Task 2 comprised spatial data compilation, interpretation, and analysis to assess where Flood-MAR objectives might be accomplished. The results of this work are summarized in Part III of this report. In addition to this report, our deliverables include a functional geographic information system (GIS) -based tool that can help Valley Water identify promising Flood-MAR sites for further evaluation and support the next stages in feasibility assessment, including evaluating costs, permitting, and other factors related to developing and operating a new program.

Valley Water is rich in data, knowledge, and expertise in groundwater management, including MAR. The WRIP is intended to supplement Valley Water's many capabilities by building capacity and stimulating innovative thinking that can help Valley Water continue to secure and sustain water resources for Santa Clara County into the future.

II. Options and considerations for a Potential Flood-MAR Program

A. Utility of a Flood-MAR program

A Flood-MAR program could be designed to strategically and adaptively steer Flood-MAR efforts in Santa Clara County. Identifying and prioritizing the best opportunities for Flood-MAR will require coordinated consideration of Flood-MAR options, potential collaborators, funding possibilities, and incentives.

For the purposes of this report, we make a distinction between *programs* and *projects*. We define a project as an individual MAR installation such as a defined infiltration basin, along with the defined set of actions that are necessary to successfully implement such an installation, such as planning, design, and permitting. In contrast, we define a program as the institutional umbrella under which a range of related projects could be carried out.

A Flood-MAR program could support short- and long-term planning, information gathering, evaluation, and adjustment. It could guide a modular or phased approach to Flood-MAR implementation that, for example, initially prioritizes certain project types or co-benefits. Because Valley Water may not have direct control of lands that present the best opportunities for Flood-MAR, a program could support effective implementation of projects on non-Valley Water property, including by providing appropriate incentive structures, outreach, and oversight to ensure that Flood-MAR projects individually and collectively meet expectations. A programmatic structure would also support internal collaboration within Valley Water, facilitate outreach and other forms of public engagement around Flood-MAR, foster economies of scale, leverage dispersed institutional expertise, and house institutional memory relevant to Flood-MAR.

To inform potential development of a Flood-MAR program at Valley Water, we use the remainder of Part II to outline three different approaches to Flood-MAR, discuss considerations for developing a Flood-MAR program, and summarize key takeaways regarding options and considerations for Flood-MAR.

B. Three approaches considered for Flood-MAR

We examined three types of Flood-MAR projects and their potential viability in Valley Water's service area:

- 1) Flooding agricultural fields or other open space with high-magnitude streamflows,
- 2) Floodplain restoration, and
- 3) Distributed recharge projects that collect and infiltrate local hillslope runoff resulting from heavy precipitation events.

1. Flooding agricultural fields

Flooding agricultural fields with high-magnitude streamflows, either local or imported, may be the most widely known approach to Flood-MAR. This approach is a subset of agricultural

managed aquifer recharge (Ag-MAR)— "intentionally flooding fallow, dormant, or active cropland when excess surface water is available."¹⁸ Ag-MAR is the focus of significant ongoing research¹⁹ and is seen as a key tool for addressing unsustainable overdraft in some parts of California, particularly the Central Valley.

Risks to groundwater quality are generally higher for Ag-MAR than for other types of MAR. Ag-MAR has the potential to leach in-use and legacy contaminants (nitrogen, salts, etc.) from current agricultural practices and past agricultural use,²⁰ in addition to geogenic contaminants such as arsenic,²¹ into the underlying groundwater. However, strategic Ag-MAR implementation can reduce water quality risks and even improve groundwater quality. For example, Ag-MAR implementation can prioritize sites where crops had low nitrogen needs, there is low to medium historical nitrogen loading, growers are currently using best practices for managing salts and applying fertilizers and other chemicals, and it is possible to recharge large volumes of relatively clean, high-magnitude flood flows.²² Where groundwater quality is poor, high-volume Ag-MAR has the potential to actively improve groundwater quality through dilution. Care should be taken to meaningfully include those who could be affected by Ag-MAR in decision making processes. This includes communities that rely on shallow drinking water wells that could benefit from higher groundwater levels or experience negative impacts, such as short- or long-term water quality degradation.²³

Whether this type of Flood-MAR would be feasible or cost effective in Santa Clara County is unclear. It would rely on diverting high flows from streams and moving that water to appropriate agricultural fields. However, the State currently considers many of the streams in Santa Clara County to be “fully appropriated” (see **Box 2**), which could make establishing new water rights to divert high flows from those streams challenging. Furthermore, Valley Water already has surface storage reservoirs and MAR facilities associated with the County’s most productive watersheds that may be able to accept some high flows.

To better understand the potential utility of this Flood-MAR approach in its service area, Valley Water could explore how often and where unappropriated high streamflows occur within its service area. Depending on the location of a potential Ag-MAR site relative to the source of high streamflows and existing conveyance infrastructure, new permanent or temporary infrastructure may be needed to convey water to it.²⁴ Existing infrastructure that could, in theory, be used to support Ag-MAR may have limited capacity to carry flood flows, since such infrastructure was generally designed to move and distribute water under more moderate flow conditions to meet irrigation demands. On the other hand, due to the intermittent nature of water availability, it may be cost-effective for some Ag-MAR implementers whose property is close to a source of high flows to rely in part on temporary infrastructure and rented equipment.

Example: Terranova Ranch and the larger McMullin On-Farm Flood Capture Expansion Project (McMullin) increase conveyance capacity from the Kings River to farmland, grazing land, and fallow land in an effort to grapple with flooding during times of excess water, augment groundwater recharge and in-lieu recharge across the region, and address the impacts of climate change.²⁵ Terranova and McMullin target both private and public properties where economic productivity won’t be negatively impacted by temporary flood conditions.²⁶ As a pilot study, Terranova diverted roughly 14 AF per day to 1,000 acres of farmland growing tomatoes, wine grapes, alfalfa, pistachios, olives, walnuts, and almonds, though McMullin plans to expand the program’s capacity to divert roughly 1,000 AF per day to more than 15,000 acres.²⁷ Terranova’s estimated costs for the pilot were \$36 per AF.²⁸

2. Floodplain restoration

Another approach to Flood-MAR is floodplain restoration. Whereas the other two approaches we discuss here involve actively diverting high flows, floodplain restoration projects take a different tack. When portions of artificial levees—constructed to keep flood water out of the floodplain—are removed or set back, high flows can once again access these areas, bringing sediment, nutrients, and water that help to rebuild lost ecosystem function.

Floodplain restoration projects can have a broad suite of potential benefits, including for riparian ecosystems and habitat, and may help reduce downstream flooding. Due to the relatively unconstrained nature of water flow into areas where levees have been removed, it may not be possible to measure the volume of water spread or infiltrated. However, measurements of groundwater levels in nearby wells can be used to derive estimates and demonstrate benefits.

A key consideration for this approach for Valley Water is that much of Santa Clara County is densely populated, so there may be limited areas in which this approach could be used. Valley Water could explore whether there are areas in the County where levees currently exist, levee breaches or setbacks would likely have recharge benefits, and floodplain restoration efforts would be unlikely to exacerbate local flood impacts.

Example: The Lower Cosumnes River Floodplain Restoration Project in the eastern Sacramento-San Joaquin Delta alters or removes levees to reintroduce natural flooding regimes and promote habitat restoration and enhancement, though the program previously used active management measures like wetland construction and hand-planting of native plant species.²⁹ Although recharge is not its primary goal, the 50,000-acre, landscape-scale public-private partnership (initiated by The Nature Conservancy in 1985) slows and detains floodwaters, allowing them to infiltrate and augment groundwater.³⁰

3. Distributed recharge projects that collect hillslope runoff

A third approach to Flood-MAR is developing an array of relatively small (~100–1,000 AFY) recharge projects, each collecting drainage from 100s to 1,000s of acres, that collect and infiltrate local stormwater in locations that are especially well suited for recharge. Targeted incentives may be especially important for this Flood-MAR approach. For example, a program in the Pajaro Valley incentivizes individual landowners and Pajaro Valley Water Management Agency (PV Water) to support projects that collect some of the hillslope runoff from significant precipitation events and route it through ditches, culverts, and a sediment detention basin before the runoff flows into a dedicated infiltration basin.

Given the geography, hydrology, and existing utilization of other types of MAR in Valley Water's service area, distributed recharge projects that collect hillslope runoff are likely the most promising type of Flood-MAR for Valley Water to focus on initially. This approach would complement Valley Water's existing MAR program by tapping a currently underutilized water source and expanding recharge efforts on lands owned and managed by others. Routing hillslope runoff from heavy precipitation events into local, dedicated infiltration basins would enable site-appropriate design and the ability to incorporate soil amendments tailored to best protect or enhance groundwater quality. As we note in **Part III.D**, Valley Water could assess potential water supplies for this Flood-MAR approach by assessing drainage areas and estimating runoff to identify especially promising areas for implementation within its service area.

Example: PV Water operates a recharge net metering (ReNeM) program that uses performance-based financial incentives to encourage groundwater recharge at individual project sites, typically on private property. Specifically, the program uses ditches and canals to divert hillslope runoff generated by heavy precipitation events to infiltration basins where the collected runoff can help recharge groundwater.³¹ PV Water initiated its ReNeM program as a pilot study in 2016 and made the program permanent in 2021.³² The agency aims to scale the program to eventually infiltrate approximately 1,000 AFY; together, the three currently deployed projects collectively infiltrate about one-third of this volume. **Figure II-1** shows the infiltration basin for one of these projects.



Figure II-1. Hillslope-runoff collection and infiltration project at Bokariza-Drobac Ranch, showing the 4.3 acre infiltration basin during dry conditions (top) and wet conditions (bottom). Photo credit: A. Fisher (UCSC).

C. Considerations for developing a Flood-MAR program

If Valley Water decides to pursue Flood-MAR, establishing a Flood-MAR program would be helpful for coordinating, prioritizing, and ensuring effective implementation of Flood-MAR projects regardless of the type, scale, or number of projects envisioned. A Flood-MAR program could be especially critical for providing the incentive structure and oversight necessary to support the Flood-MAR approach we have identified as most promising for early implementation in Valley Water's service area: distributed recharge projects that collect hillslope runoff.

Below, we discuss considerations for developing a Flood-MAR program within Valley Water and related questions, grouped into three main categories:

- 1) program goals and objectives,
- 2) internal program support, and
- 3) program functions.

Note that many considerations overlap with or influence one another. Additionally, some considerations are likely shared with other Valley Water programs, enabling Valley Water to straightforwardly leverage that existing expertise in the Flood-MAR context. Other considerations may be largely uncharted territory, creating the opportunity for state-level leadership and innovation by Valley Water.

1. Program goals and objectives

A Flood-MAR program's goals inform all other aspects of the program, including what types of projects, scales of recharge, recharge locations, partnerships, and incentive structures are likely to be necessary or helpful. Goals should be based on the benefits sought, or that would be desirable, as well as the negative impacts it needs to avoid. In addition to broad goals, a Flood-MAR program needs specific objectives. For example, initial objectives for Valley Water might include identifying program design features and functions that would support an early focus on distributed recharge projects that collect hillslope runoff. We summarize key questions associated with program goals and objectives—and our preliminary assessment of answers for Valley Water—in **Table II-1**.

Table II-1. Preliminary assessment of considerations related to goals and objectives for a potential Flood-MAR program in Santa Clara County, assuming an initial focus on distributed recharge projects that collect hillslope runoff.

PROGRAM GOALS AND OBJECTIVES	
What primary benefits are sought?	Enhancing water supply, advancing stakeholder engagement, and supporting climate change adaptation and resilience
What incidental benefits / co-benefits are sought, or would be desirable?	Reducing flood risk, preserving working landscapes, enhancing riparian habitat, maintaining / improving groundwater quality, and minimizing land subsidence potential
What negative impacts must be avoided?	Harm to fish/ecosystems, flooding, and property / infrastructure damage
What specific objectives would the program work towards in the short (and longer) term?	Developing appropriate incentive structures, legal / regulatory compliance support, and oversight for distributed projects

2. Internal program support

Developing and operating a Flood-MAR program requires sufficient internal program support. We summarize key considerations related to internal program support in **Table II-2**, noting our preliminary assessment of these considerations for Valley Water.

Where a Flood-MAR program is housed within an agency will influence the program's goals, functions, and design. This will be especially true in large agencies whose subcomponents are compartmentalized, with relatively distinct, well-defined functions, funding streams, and boundaries. Valley Water is such an agency. Based on discussions with staff, a Flood-MAR program would likely be spearheaded by the Water Supply Planning and Conservation Unit, within the Water Supply Division of its Water Utility business area. This placement reflects Flood-MAR's potential to enhance water supply. Other units would likely provide support, as summarized in **Table II-2**.

The program could be funded with revenue from water charges, supplemented by grants from agencies such as California's Department of Water Resources and the U.S. Department of Agriculture's Natural Resources Conservation Service. If a Flood-MAR program proves feasible from a water supply lens, Valley Water might consider prioritizing projects likely to generate multiple benefits. For example, some Flood-MAR projects could also help meet Watersheds goals and responsibilities by enhancing habitat. Multi-benefit projects might make program operations, program decision making, and project permitting more complex, but it could also enhance opportunities to secure external funding.

Table II-2. Preliminary assessment of considerations related to internal program support for a potential Flood-MAR program in Santa Clara County, assuming an initial focus on distributed recharge projects that collect hillslope runoff.

INTERNAL PROGRAM SUPPORT	
Where could the program reside in Valley Water?	Water Supply Planning and Conservation Unit (lead)
Who else would be involved internally?	Likely: staff from Groundwater Management Unit; Raw Water Operations Unit; Raw Water Field Operations & Pipeline Maintenance Unit; Hydrology, Hydraulics, and Geomorphology Unit; Watershed Policy and Planning Unit; Environmental Planning Unit; Financial Planning and Revenue Unit; Communications Unit; Treasury-Debt Management Unit; Office of the District Counsel; and related capital program design and implementation units
How would the program be funded?	Likely revenue from water charges, grant funding, and other appropriate Valley Water sources

3. Program functions

A Flood-MAR program needs to perform a range of functions to enable coordinated and effective project implementation. In **Table II-3**, we summarize key considerations related to program functions and our preliminary assessment of these considerations for Valley Water, organized into 6 main categories: (1) assessing source water options and availability, (2) assessing areas suitable for recharge and recharge options, (3) external coordination and engagement needs, (4) incentives for Flood-MAR implementation on land not owned by Valley

Water, (5) legal and regulatory compliance, and (6) tracking, oversight, evaluation, and adjustment. We highlight several considerations in more depth below.

Table II-3. Preliminary assessment of considerations related to program functions for a potential Flood-MAR program in Santa Clara County, assuming an initial focus on distributed recharge projects that collect hillslope runoff.

PROGRAM FUNCTIONS	
1. Assessing source water options and availability	
When/where do high-magnitude flows occur in Valley Water's service area, and how are they expected to change in the future?	Hillslope runoff during heavy precipitation events, downstream of existing reservoirs and in unregulated watersheds (expected to increase in the future)
What flow / other requirements may affect the viability of potential source waters?	Valley Water's Fish and Aquatic Habitat Collaborative Effort (FAHCE) Program, Lake and Streambed Alteration Agreements (LSAAs), downstream water rights, fully appropriated stream system (FASS) designations, etc.
What storage / conveyance infrastructure would be needed to move potential source waters to potential recharge locations?	Ditches and culverts for collecting and conveying hillslope runoff to dedicated infiltration basins or lands, stream diversions for diverting flood water to off-stream lands
What legal permissions would be needed to access potential water sources?	Likely water right permits for capturing hillslope runoff, LSAAs and water rights for stream diversions, and related agreements with participating landowners / managers
2. Assessing areas suitable for recharge and recharge options	
What areas have moderate-to-high surface and subsurface suitability for Flood-MAR?	Areas with Flood-MAR Suitability Index ≥ 4 in the site-suitability tool (confirm through field investigation)
Which of these areas have compatible current land uses?	See site-suitability tool land use/land cover data set, other data to assess risks/benefits related to flooding, habitat, water quality
What are the water quality implications of recharging water in these areas?	Assess by comparing quality / contaminant profile data for potential source waters, soil / vadose zone, and groundwater
Which types of Flood-MAR projects, using which potential water sources, would be useful and feasible in these areas?	Initially, focus on distributed recharge projects that collect hillslope runoff and infiltrate it in dedicated recharge basins; but assess potential for other types of projects / water sources
3. External coordination and engagement needs	
Who owns and manages the land in potential recharge areas?	Private parties, especially growers, and other public agencies
Who holds or might be involved in acquiring water rights to potential water sources?	Valley Water may be best positioned to apply for water right permits from the State Water Resources Control Board (with landowner cooperation), especially to collect hillslope runoff
Who might be involved in acquiring other necessary permits and approvals?	Likely Valley Water (with cooperation from landowners, land managers, consultants, construction contractors, and others)
Who else might be interested in or be affected by Flood-MAR implementation?	Nearby landowners / tenants, downstream surface water users, domestic well users/groups, non-government organizations (NGOs), wildlife/other agencies

What partnerships, coordination, and other outreach/engagement will be needed to effectively implement / fund the program?	Potentially: private landowners/tenants, Santa Clara Valley Open Space Authority (OSA), Peninsula Open Space Trust (POST), Guadalupe-Coyote Resource Conservation District (GCRCD)
4. Incentives for Flood-MAR implementation on non-Valley Water property	
For what purposes might incentives be helpful or necessary?	To encourage recharge projects on non-Valley Water property.
What forms could incentives take?	Multiple options could be considered: direct payment, rebate, funding construction / land rental, and support for maintenance
What size / type of incentive may be needed to encourage sufficient participation?	Not clear; will require evaluation of interest, motivation, and other factors for potential program participants
How would incentives be administered?	Valley Water or a third-party certifier could administer incentives
5. Legal and regulatory compliance	
How would the program support / coordinate / fund permitting for Flood-MAR projects?	Valley Water may be better positioned to apply for water rights and other permits than individual landowners.
What level of environmental review would be required to support projects?	Projects may be eligible for CEQA suspension under Executive Order B-39-17 or Executive Order N-7-22.
What water rights would be needed to access potential water sources?	Temporary permits (180-day, 5-year) to support pilot efforts, standard permits for long-term operations.
What water quality permits / other approvals would projects need?	Potentially: NPDES Construction General Permit + Stormwater Pollution Prevention Plan, Section 404 permit, Section 401 Water Quality Certification
What species and ecosystem protections would affect projects?	Potentially: FAHCE, Lake and Streambed Alteration Agreements (LSAAs), CESA Incidental Take Permits, ESA Section 7 compliance
What cultural resources might be affected?	Depends on site (National Historic Preservation Act Section 106)
What other local, state, or federal permits or requirements might apply?	Santa Clara County Grading Permit, Valley Water District Act requirements
How would the program affect Valley Water's ability to meet its own statutory responsibilities and other legal obligations?	TBD — Would help meet SGMA requirements for sustainable groundwater management; projects could be selected to help meet FAHCE Settlement Agreement obligations
What funding sources are legally appropriate for Flood-MAR projects?	TBD — Would need to discuss with District Counsel's office and Finance
6. Tracking, oversight, evaluation, and adjustment	
How would the program provide effective oversight of Flood-MAR projects?	TBD — Would need to track project level recharge/infiltration effectiveness, water quality impacts, other benefits and risks
How would the program track its overall progress and effectiveness?	TBD — Would need to track program-level recharge/infiltration effectiveness, water quality impacts, other benefits and risks
What would happen if / when a project does not meet expectations?	TBD — Would need to require corrective measures when recharge is ineffective or the project creates substantial risks
How would the program learn / adjust?	TBD — Would need clear mechanisms for adaptive management

a. Considerations related to water rights for recharge

One important function of a Flood-MAR program would be to identify the legal clearances, such as a water right permit, needed to divert a potential water source and how best to approach obtaining those clearances for individual projects.

Acquiring a water right permit to divert and use high-magnitude stream flows (or hillslope runoff) for groundwater recharge is not necessarily easy or straightforward. First, the State Water Resources Control Board (State Water Board) simply has less experience considering permit applications that seek to divert sporadic flood flows or to recharge any source of water in order to serve non-extractive beneficial uses, such as reducing the development of “undesirable results” under SGMA³³ (like significant and unreasonable land subsidence, seawater intrusion, degradation of water quality, or depletion of interconnected surface waters). Likewise, GSAs and other local water management agencies across the state have little experience to date applying for water right permits like these. Additionally, the regulatory landscape is changing in real time as the Governor directs the State Water Board and other agencies to expedite permitting of recharge projects to “maximize the extent to which winter precipitation recharges underground aquifers.”³⁴

The California Legislature and the State Water Board have both taken steps in recent years to try to better support water right permitting for these types of projects. In 2019, the Legislature added a five-year temporary permit option (in addition to the existing 180-day temporary permit option)³⁵ as a bridge to a standard permit, and the State Water Board developed a streamlined administrative process for those pursuing a standard permit to divert water for recharge during “high flow conditions” or “imminent threat” of flooding,³⁶ summarized in **Table II-4**.³⁷ Both options are open only to groundwater sustainability agencies or other “local agencies” under SGMA, and each defines slimmed down requirements for water availability analysis (used to demonstrate that water is available to be appropriated; see also **Box 2** regarding fully appropriated stream systems) that are nonetheless intended to provide adequate protection for fish and other wildlife and other water users. To help potential MAR proponents understand permitting options and requirements associated with water rights for recharge, the State Water Board created several webpages,³⁸ including one that lists all applications for temporary permits for underground storage received since 2016,³⁹ and fact sheets. One fact sheet discusses the distinctions between flood-control projects that result in incidental recharge—which do not require a water right—and other recharge activities—which do.⁴⁰ A second fact sheet explains what California’s requirement for “beneficial use” means in the context of water rights for recharge and provides guidance on demonstrating / accounting for different beneficial uses of recharged water.⁴¹

Despite these efforts, important issues related to water right permitting for recharge projects remain unclear, creating stumbling blocks for those trying to implement certain types of recharge projects. To date, only two applications have been submitted for 5-year temporary permits.⁴² Both identify extractive beneficial uses (agricultural irrigation). One, submitted on August 24, 2022, was approved on January 11, 2023,⁴³ while the other application, submitted on November 16, 2022, is still pending as of February 21, 2023.⁴⁴ Because, to date, few entities have sought to include non-extractive uses in their water right applications (or to pursue entirely non-extractive beneficial uses), it is not clear how an applicant might demonstrate that the beneficial use is accruing or what level of proof the State Water Board will expect an applicant to provide.

Similarly, to date, there are no examples of applications to support a small recharge project that collects and infiltrates hillslope runoff, including those in the Pajaro Valley. Therefore, it is unclear what the State Water Board will require of successful applicants for such projects and whether there might be circumstances under which a water right would not be needed to implement this type of project.

We expect greater clarity to emerge as more Flood-MAR project proponents submit, and the State Water Board responds to, water right permit applications that address a wider range of water source characteristics and post-recharge purposes of use.

Table II-4. Comparison of traditional permit options and newer permit options (outlined with a heavy black line) tailored to support groundwater recharge projects under SGMA.⁴⁵

	Temporary Permits		Standard Permits	
Permit pathway	Temporary Permit (urgent need)	Temporary Permit for Diversion to Underground Storage	Streamlined Permit for Groundwater Recharge	Standard Permit
Authority	Water Code §§ 1425–1431	Water Code §§ 1433–1433.6	Administrative adjustment to standard permit process	Water Code §§ 1375–1410.2
Duration	Up to 180 days <i>(revocable; no priority)</i>	Up to 5 years <i>(revocable; no priority)</i>	Permanent authorization <i>(secures a priority date)</i>	Permanent authorization <i>(secures a priority date)</i>
Eligibility	“Any person” demonstrating “an urgent need to divert and use [surface] water” for beneficial use	A GSA (or other “local agency” under SGMA) proposing “diversion of surface water to underground storage for beneficial use that advances the sustainability goal of a groundwater basin”	A GSA (or other “local agency” under SGMA) proposing diversions of high flows between Dec. 1 and Mar. 31 to underground storage for beneficial use	“Any person” proposing to divert and use surface water for beneficial use
Water availability analysis	Simplified	Simplified <i>(simplified analysis OK if diversion would occur only when flow exceeds flood stage)</i>	Streamlined <i>(availability assumed when defined “high flow conditions” or “imminent threat of flood conditions” exist)</i>	Standard <i>(must demonstrate reasonable likelihood water is available to appropriate)</i>
CEQA review	Required <i>(unless suspended by executive order)</i>	Must be completed before applying	Must be completed before applying	Required
Required findings	<ul style="list-style-type: none"> • No injury to other legal water users • No unreasonable effects on fish/wildlife • In the public interest • <u>Urgent need</u> 	<ul style="list-style-type: none"> • No injury to other legal water users • No unreasonable effects on fish/wildlife • In the public interest • <u>Consistent with GSP, if applicable</u> 	<ul style="list-style-type: none"> • No injury to other legal water users • No unreasonable effects on fish/wildlife • In the public interest 	<ul style="list-style-type: none"> • No injury to other legal water users • No unreasonable effects on fish/wildlife • In the public interest
Guidance on “Best Use”	For pilot projects <i>or when applicants need to get a diversion authorized quickly</i>	As a bridge to get a recharge project up and running while a streamlined / standard application is in process	For qualifying recharge projects seeking permanent authorization	For permanent recharge projects that don’t qualify under the streamlined pathway

Box 2. Fully appropriated stream systems and new water right permits

Another set of challenges arises if the proposed water source is part of a fully appropriated stream system (FASS). Stream systems that have been designated as fully appropriated year round are generally off limits for new water rights.⁴⁶ Additionally, an application won't be accepted if it proposes to divert water from a seasonally fully appropriated stream during the season it is deemed fully appropriated. A water right applicant can request the State Water Board to revise its FASS determination through a petition process that requires an additional \$10,000 fee and can take several years to complete before a related permit application can be processed.⁴⁷ In Santa Clara County, the portion of Uvas Creek upstream of Uvas Dam, Moody Gulch, and Alamitos Creek have been declared fully appropriated year round, while Casey Gulch Creek, Coyote River, Guadalupe Creek, and the remainder of Uvas Creek have been declared fully appropriated seasonally.⁴⁸

We anticipate that Valley Water, rather than individual landowners, is better positioned to apply for water right permits that may be necessary for Flood-MAR projects on non-Valley Water property. First, Valley Water has extensive experience applying for and managing water rights and the expertise and resources needed to do so efficiently. Second, the water right permitting options that are tailored to MAR are only available to GSAs or other local water agencies under SGMA. Third, CEQA is currently suspended for local or state agencies seeking certain temporary permits for capturing water from high-runoff events for local recharge. Finally, having Valley Water apply for the permit helps to assure that project goals remain aligned with the overall Flood-MAR program and priorities.⁴⁹

b. Considerations related to Recharge Net Metering incentives

Valley Water could support Flood-MAR implementation in its service area by directly constructing and maintaining Flood-MAR projects on land it owns or acquires, collaborating on projects sited on other agencies' lands, and/or creating incentives for others to implement Flood-MAR projects on non-Valley Water land.

Recharge net metering (ReNeM) is an incentive structure that encourages distributed groundwater recharge at individual project sites located on private or public land by compensating rechargers for project performance—the net increase in infiltration associated with the project's operation.⁵⁰ This compensation is intended to offset the operation, maintenance, and opportunity costs rechargers incur as a result of maintaining hillslope runoff collection systems and infiltration basins on their properties. Under PV Water's ReNeM program, incentives are structured as partial rebates against groundwater production charges (known as groundwater augmentation charges) based on the volume of water infiltrated on an annual basis. At present, all recharge projects operated through ReNeM were developed for resource benefit (non-regulatory) purposes.

For a ReNeM program to successfully support a cooperative partnership between parties, it is crucial that the parties share a mutual understanding of the incentive structure and agreement. This includes establishing a mutually-agreed upon manner for determining the incentive payment⁵¹—in the case of ReNeM, an agreed-upon valuation of the water that is infiltrated. Valley Water could support this mutual understanding in several ways. A contract between participants or similar tool can establish a list of expectations and understandings that support a

trustworthy and reliable partnership. Ideally, this tool would also detail the understood method for arbitrating requested changes to the program or program disputes. This tool should also clarify the method for establishing the incentive amount—in the case of ReNeM, a means of establishing the amount of water infiltrated in order to calculate the payment amount.

One avenue for building trust in a ReNeM program is by incorporating a third-party certifier (TPC) who is delegated key responsibilities in order to minimize conflict and demonstrate the trustworthiness of the program. In the case of ReNeM, the TPC could be responsible for (or contribute to) ensuring the reliability of the measurements upon which payments to rechargers are predicated, overseeing incentive payments to rechargers, evaluating program performance, preparing reports, and determining when adjustments are needed. To ensure the TPC builds trust into the program, the TPC entity must have both the expertise and the capacity necessary to carry out the responsibilities it has been delegated.

Though incentivizing private participation in Flood-MAR seems promising in concept, it is not without challenges that Valley Water would need to navigate successfully. For example, differences in the physical and institutional contexts of PV Water and Valley Water may affect the potential viability of a ReNeM-like incentive structure for Flood-MAR in Valley Water's service area. Most importantly, groundwater production charges for agricultural water users are more than seven times higher in the Pajaro Valley (\$282 per AF⁵²) than in Valley Water's service area (~\$37 per AF⁵³), reducing the potential motivational power of a rebate on those charges. Another useful comparison is the cost of incentive compared to the next potential water source.

c. Considerations related to legal and regulatory compliance for small, distributed recharge projects

To be effective, a Flood-MAR program would likely need to support and coordinate permitting for individual Flood-MAR projects. Most Flood-MAR projects will require permits or other approvals from multiple local, state, and/or federal agencies. **Table II-3** summarizes many of these permitting and approval requirements, and **Table II-5** provides additional information about when they might come into play.

This support and coordination role would be especially important for smaller, distributed projects that collect hillslope runoff, since individual rechargers may lack the resources and bandwidth to identify and address all regulatory requirements on their own. In particular, Valley Water has—and would further build—essential institutional knowledge that could both aid individual project development and contribute to economies of scale. Therefore, Valley Water may be better positioned than individual landowners to apply for the regulatory approvals needed for particular projects. Additionally, Valley Water can explore possibilities for addressing some regulatory requirements (such as environmental review) on a programmatic-level for similar projects (such as distributed stormwater recharge projects implemented under a ReNeM-like incentive structure).

Table II-5. Potential permitting and regulatory compliance needs for Flood-MAR projects.

Category	Permit or approval	Agency	Applicability
Environmental review	CEQA compliance <i>Initial Study → (Mitigated) Negative Declaration or Environmental Impact Report</i>	Lead Agency	The project has the potential to affect the environment.
Water rights	Temporary water right permit –180-day or 5-year	State Water Resources Control Board: Division of Water Rights	The project involves temporary diversion and beneficial use of surface water (e.g., for pilot or while standard permit is pending.
	Standard water right permit	State Water Resources Control Board: Division of Water Rights	The project involves long-term diversion and beneficial use of surface water.
Water quality	CWA Section 401 Water Quality Certification	State Water Resource Control Board / Regional Water Quality Control Board	The project involves a federal permit or license for an activity that may result in a discharge of dredged or fill material into waters of the United States.
	CWA Section 404 Permit	U.S. Army Corps of Engineers	The project involves discharge of dredged or fill material into waters of the United States
	NPDES Construction General Permit + Storm Water Pollution Prevention Plan	State Water Resource Control Board / Regional Water Quality Control Board	The project disturbs 1 or more acres of soil.
Species / ecosystems	Section 1602 Lake and Streambed Alteration Agreement (LSAA)	California Department of Fish and Wildlife	The project involves streambed alteration.
	CESA Section 2081 Incidental Take Permit	California Department of Fish and Wildlife	The project may affect state-listed species.
	ESA Section 7 compliance	U.S. Fish and Wildlife Service / National Marine Fisheries Service	The project involves a federal permit or license for an activity that may affect federally listed species.
Historic preservation	National Historic Preservation Act Section 106 compliance	State Office of Historic Preservation	The project involves construction near cultural resources.
Grading	Grading Permit	Santa Clara County	Project involves grading

D. Key takeaways regarding options and considerations

In Part II, we discussed the utility of a Flood-MAR program, described three approaches to Flood-MAR, and summarized considerations for developing a Flood-MAR program, which we have distilled into **Tables II-1, II-2, and II-3**. Below, we highlight key takeaways for Valley Water.

- Valley Water’s existing MAR facilities already occupy many of the best recharge sites in Santa Clara County (County), and their recharge capacity exceeds the volume of water available for recharge from Valley Water’s traditional sources in many years. However, the mapping tool discussed below indicates there may be areas suitable for Flood-MAR, pending further evaluation.
- If Valley Water pursues distributed Flood-MAR projects that collect and infiltrate local hillslope runoff, organizing Flood-MAR efforts at a programmatic level will likely be more efficient and effective than pursuing individual projects with less coordination.
- Valley Water could partner with other landowners and managers to develop Flood-MAR projects, a process it could facilitate with incentives.
- One potential model for providing incentives for Flood-MAR implementation is Recharge Net Metering (ReNeM), a rebate-based incentive structure developed through a collaborative effort in nearby Pajaro Valley. However, differences in the physical and institutional contexts of the two areas may affect the potential viability of a ReNeM-like incentive structure for Flood-MAR in Valley Water’s service area. For example, groundwater production charges for agricultural water users are more than seven times higher in the Pajaro Valley (~\$282 per AF) than in Valley Water’s service area (~\$37 per AF), reducing the potential motivational power of a rebate on those charges.
- Most permitting needs for Flood-MAR projects, summarized in **Table ES-2**, will likely be familiar to Valley Water because of its extensive experience with MAR implementation. However, Valley Water would need to decide how to address permitting needs for small Flood-MAR projects that are distributed across its service area on non-Valley Water property. Valley Water may be best positioned to pursue most permits and other regulatory approvals for such projects.
- It may make sense for Valley Water, rather than individual landowners, to apply for any necessary water right permits for Flood-MAR projects, including those on private land.

Considerable work is still needed to develop and implement a successful Flood-MAR program at Valley Water. Flood-MAR remains developmental in many ways, and Valley Water could continue to evaluate whether a Flood-MAR program could help increase water resilience in its service area, in part supported by the Flood-MAR suitability mapping tool discussed in the next section of this report.

III. Pre-feasibility Analysis of Surface and Subsurface Suitability for Flood-MAR

A primary goal of this project is to assess sites where there may be good opportunities to improve groundwater resources using Flood-MAR in Santa Clara County, particularly distributed locations that could host recharge systems supplied by local stormwater collection. The methods used in this study have been applied in other regions,⁵⁴ but this report presents results of the first regional effort to map suitability for Flood-MAR in Santa Clara County. Results of this work have direct implications for this region, and may serve as a template for other parts of the state and country, where planning and implementation of new groundwater projects are expected to be increasingly common and important in coming years.

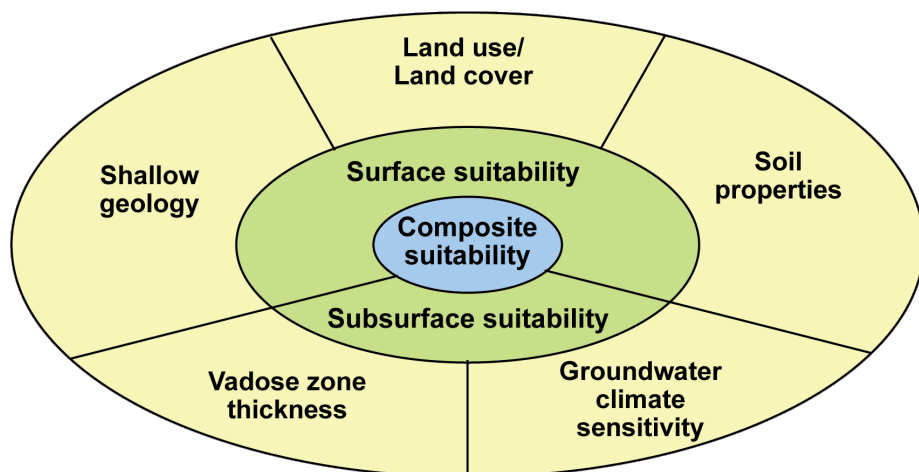
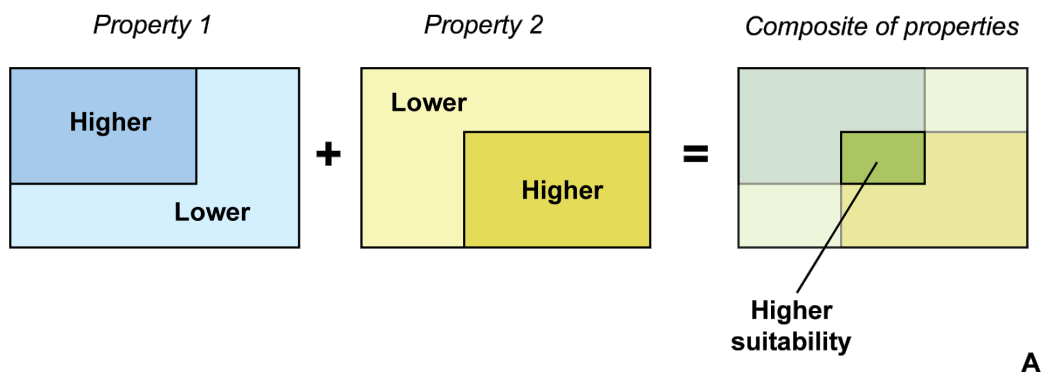
A. Data and Methods

1. Multicriteria decision analysis (MCDA) for Flood-MAR suitability

A Geographic Information System (GIS) is a computer-based mapping and analysis system, combining a geospatial database that uses a variety of data types and formats, visualization tools for displaying datasets, and scripting tools for modifying and combining datasets to generate new data coverages. The use of a GIS for spatial assessment of Flood-MAR suitability through multicriteria decision analysis (MCDA) is well established in the technical literature (**Fig. III-1**).⁵⁵ Individual datasets are acquired and imported into the GIS in digital format, with adjustments made as needed to the geographic projection, resolution, data gaps or errors, and/or units of measurement and display. Each dataset used as part of the formal analysis is called a "**factor**." Each factor includes spatial data in either real-world units (e.g., ft/day for infiltration capacity) or categories (e.g., row crops or moderate urban development for land use/land cover). An assessment is made as to how each factor varies across the study region, and a classification scale is developed for simplified representation of the data, known as a "**rating**." Once all the factors of interest are rated, multiple factors are combined according to their importance ("**weight**") to generate a spatial suitability "**index**," helping to identify locations where there is alignment of properties that are the most favorable for the processes or activities of interest (**Fig. III-1A**). Note that factors could be developed that are either positive or negative with respect to feasibility, using a particular method, and some could be used to filter potential project regions or focus on specific subregions. These issues are discussed later when data are presented.

For the current project to assess suitability for Flood-MAR, we divided the assessment into two general classes of coverages: *surface* and *subsurface* (**Fig. III-1B**). Surface coverages included parameters the soil infiltration capacity, land use/land cover, and the nature of shallow geologic units, found at the surface or below soils. These datasets are available for the full study region, although, as described later, considerable processing was required to put them in suitable formats. Subsurface coverages included hydrogeologic parameters such as geometry (lateral extent, thickness) of aquifers and confining layers, vadose zone thickness (distance from the ground surface to top of groundwater) and the climate sensitivity of groundwater levels to inter-annual variations. We also explored use of transmissive and storage properties within uppermost aquifer units (as applied in groundwater models), but as described later, these were not

incorporated into the MCDA as delivered. Subsurface factor coverages were available mainly within spatially defined groundwater management areas.



Assessment of suitability for Flood-MAR using stormwater

B

Figure III-1. Selected concepts applied for this study. **A.** Overview of general approach taken using a geographic information system (GIS), with independent factors rated on the basis of perceived suitability for Flood-MAR, then combined to identify areas with a higher or lower suitability index. **B.** Cartoon illustrating primary factors and weights as applied for this study. Individual surface and subsurface factors were weighted equally in primary analysis, although additional factors and weights were also tested, as discussed in text. Weights can be adjusted as desired using the GIS project to recalculate suitability indices.

This project uses existing GIS data coverages to efficiently develop new datasets, maps, interpretations, and recommendations. Many GIS datasets were available when this project began, so we focused first on evaluation of these coverages, identifying gaps or other problems, and determining what additional work can be justified in support of improving the Flood-MAR suitability assessment, rather than investing extensive effort before potential benefits are clear. We revisit this issue later in this report.

In order to combine disparate data types for classifying Flood-MAR suitability with MCDA, we used the following workflow:

- Factor datasets, polygons delineating spatial regions, and point data were acquired and documented, then imported into a draft (working) GIS project for evaluation. Data that were selected for use with the main GIS project were reprojected and/or regridded, if needed, to assure consistency with project standards and to align values with those from other factor datasets. For this project, a 1/9-arc-second digital elevation model (DEM) with ~10 ft x 10 ft resolution was selected as the spatial template; all subsequent datasets were reprojected and/or regridded so that values would align with pixels comprising the DEM.
- Some data incorporated into the main project were in vector form, comprising shapes or factor values at individual points, although most of the data subjected to quantitative assessment through MCDA were applied as raster data. Shapes were used mainly to define project subareas or to focus investigation and interpretation, e.g., parcel maps indicating open space or otherwise accessible properties.
- Factors used quantitatively as part of MCDA for Flood-MAR suitability were rated on an integer scale with eight levels: 0 to 7, where 0 indicates *poor suitability* and 7 indicates *excellent suitability*. Ratings were assigned independently for each factor, based on consideration of the nature of the data (quantitative or categorical) and the distribution of values/categories in a spatial sense and within a probability density function (PDF, aka, *histogram*). In general, we sought to have intermediate values on each rating scale (3 to 4) apply for conditions that were "acceptable" or "satisfactory" for Flood-MAR, with higher values (5 to 7) being *good to excellent* and lower values (0 to 2) being *poor to fair*. Ratings were also assigned with an eye towards showing the diversity of conditions. Criteria used to assign ratings are specific to each factor, as discussed later in this report, and maps and histograms of assigned factor ratings are shown.
- Factors were analyzed initially as part of separate surface and subsurface assessments, with factor weights (fractional values, $0 < W_f < 1$) assigned based on the inferred importance of each factor and confidence in data accuracy (**Figure III-1B**). For assessment of Flood-MAR suitability based on surface factors, we used ratings for soil infiltration capacity, shallow geology, and land use/land cover, with each factor weighted equally ($W_{f\text{-surface}} = 0.33$ for each). For assessment of Flood-MAR suitability based on subsurface factors, we assigned equal weights to vadose zone thickness and climate sensitivity of groundwater levels ($W_{f\text{-subsurface}} = 0.50$). We also tested incorporation of transmissivity and storage values from shallow aquifer layers (as applied in groundwater models) weighting these at half the value of other subsurface factors. Independent consideration of surface and subsurface data resulted in generation of two Flood-MAR suitability index maps: surface and subsurface.
- Surface and subsurface Flood-MAR suitability indices were combined to create a map of composite Flood-MAR suitability, with each of five total factors weighted evenly ($W_{f\text{-composite}} = 0.20$) (**Figure III-1A**). As discussed in more detail below, there is no standard or rigorous basis for assigning relative weights to different factors, so as an initial analysis, we chose equal weighting, reasoning that the initial set of five factors were all fundamentally important for siting Flood-MAR projects. That said, relative weighting can be adjusted in the future and used to generate new maps, and variations in weighting of factors or indices could be applied to different sites based on local conditions, preferred

mode of MAR (infiltration basin, flood plain inundation, etc.). The working GIS project can be updated and/or augmented to include or exclude data as desired, based on what makes sense for particular goals and subareas of the Valley Water service area.

- The map of Flood-MAR suitability using surface data was updated prior to combining with the subsurface assessment to exclude areas with slopes that exceed some reasonable threshold (as discussed later), based on the understanding that the first Flood-MAR projects that might be considered during future work may involve a dedicated infiltration basin supplied with excess stormwater runoff from nearby hillslopes (the Flood-MAR approach identified as initially most promising in **Part II**). The engineering challenges of building a Flood-MAR infiltration basin on a steep slope are likely to outweigh any perceived advantages offered by good surface or subsurface conditions. It makes sense to focus first on areas where construction and operation is easier and cheaper. The use of slope as a factor to exclude parts of the study area is an example of application of a *filter*, independent of the rated factors used to calculate Flood-MAR suitability indices. Later in this report we discuss how additional filters could be applied to help focus site evaluation.
- Additional maps were generated to highlight subregions of the project area and additional factors that could be of particular interest, including open space, the spatial extent of Valley Water's groundwater benefit zones, and water quality data. As discussed below, these factors were not used in the quantitative calculation of Flood-MAR suitability indices because these could be considered to be positive or negative characteristics, depending on the nature of project scope, type, funding, and other characteristics. It may be preferred to view these factors as *overlays* on maps showing a Flood-MAR suitability index, as a means to highlight or exclude specific project options. And as with application of filters, additional overlays could be added to the digital GIS project in the future, as new data become available or additional issues are found to be useful for this purpose.

2. GIS development, data sources, and datasets

a. Creation and structure of a Flood-MAR suitability GIS

Geographic information system work for this project was completed using *ArcGIS*, Version 10.7 (released December 2018), commercial software that is widely used for environmental resource assessment, run on the *Windows 10* operating system. A copy of the project was saved in version 10.4 format for distribution, to assure compatibility with systems and software in current use by Valley Water. The GIS created for this project uses a geographic coordinate system (GCS) based on the North American Datum, 1983, California Zone 3. Incoming data that used a different GCS were regrided and/or reprojected to be compatible with the standard GCS. Data are plotted in State Plane Coordinates in units of feet.

In the context of the discussion in this section, a "GIS project" comprises an ArcGIS file ending with the .mxd extension that, when opened, displays one or more data layers linked to a geodatabase. When this project was completed, it was transferred to Valley Water as a Map Package, a self-contained and compressed folder and file structure with a .mpk extension. This GIS project contains symbology, a map layout, organized and nested data layers, and other components as needed to make the project self-contained and usable on a computer system other

than the one on which it was created. To facilitate this, the GIS project developed and delivered for this Flood-MAR suitability assessment (VWMAR104.mpk) was set up so that (a) folder and file locations are specified relative to the main project file (rather than with absolute file paths), and (b) the project uses a single geodatabase that travels with the rest of the files and data in a dedicated folder (VW.gdb). Of course, the computer on which the project is opened must have a suitable version of *ArcGIS* installed, with compatible *ArcGIS* settings, have associated *Windows 10* files installed, etc.

The project team compiled and reviewed a large number of documents that were available on the Valley Water website or made available by Valley Water collaborators, then created an initial listing of potentially useful data. Some of data coverages were immediately available on the Valley Water website or other websites organized and maintained by federal, state, or regional agencies or other groups; we started work with these data and coverages. Metadata concerning incoming data was collected in a *GoogleSheet* (*WRIP-GIS_IncomingArchive_Metadata*), to aid in tracking file status and potential utility:

https://docs.google.com/spreadsheets/d/1JIMUDHgKZLWLiAWLkIJ59SMlikV_qDnoYvfQCYK9pAA/edit#gid=0

All incoming datasets were placed initially in a dedicated *IncomingArchive* folder on the UCSC Hydrogeology data server (a redundant RAID 1+0, with data mirroring and striping), secured behind a firewall and backed up regularly. These incoming data were preserved without editing, so that we could reopen them later to check status and verify earlier decisions.

Any of these files that required additional steps for assessment (e.g., reprojection, clipping, and/or numerical manipulation) were subsequently copied to a working folder (*ScratchShared*), which contains numerous files, subfolders, and informal projects. Neither this working folder nor the *IncomingArchive* folder are considered to be part of the main project, which is located in a separate folder (*VW_MAR_Proj*) on the UCSC server.

As GIS data were acquired, they were imported into one or more temporary (working) GIS projects for assessment in informal "scratch" GIS projects. Simply importing a GIS data coverage can result in generation of new files, so we were careful to do this outside the *IncomingArchive* folder. If data were considered to be useful for the main project, they were exported from the working project into a dedicated folder/file structure for the main project, including renaming as needed (using *ArcCatalog*) so that folders and files would be readily identifiable and named in a consistent way. Files subsequently imported into the main project are listed on a dedicated *GoogleSheet* of metadata, *WRIP-GIS_MainProject_Metadata*,

<https://docs.google.com/spreadsheets/d/1vjHjco1cknS8gmZcEhFzcMVLbTc3dD0csiXQ2kFebKk/edit#gid=1052823668>

Individual datasets in the main project are nested in a series of folders and subfolders by category, including short and descriptive names that are also used in naming data layers in the project itself, e.g., 01_ProjAreas, 05_DEM, 10_Soils, etc. Each of these folders contains either a single set of *ArcGIS* files needed to comprise a data layer, or (more often) a series of files and subfolders that are needed in support of one or more data layers, each with one or more datasets. The metadata *GoogleSheet* contains two tabs, one each for *Data Folders* and *Data Files*, including details concerning sources and formats. An overview of data categories and types used in the main GIS project is presented in **Table III-1**.

Table III-1. Main data types and sources used for this project.

Surface	Data Source ^a
Soil infiltration capacity	SSURGO
Land use/Land cover	NLCD
Geology	USGS
Subsurface	
Vadose zone thickness	Valley Water
Aquifer transmissivity	Valley Water
Aquifer storage	Valley Water
Sensitivity of water levels to climate	Valley Water
Filter	
Slope	USGS
Applications	
Selected open space areas	SCV-OSA, Valley Water
Groundwater benefit zones	Valley Water
Water quality (TDS and nutrients)	Valley Water

^a SSURGO = Soil Survey Geographic Database, USDA/NRCS
 NLCD = National Land Cover Database
 USGS = United States Geological Survey
 SCV-OSA = Santa Clara Valley, Open Space Authority
 Additional metadata for data sources available here:
<https://docs.google.com/spreadsheets/d/1vjHjco1cknS8gmZcEhFzcMVLbTc3dD0csiXQ2kFebKk/e/dit#gid=0>

b. Datasets used in project

i. Project Area polygons and features

The full project area is Santa Clara County, but most groundwater resources are found in the Santa Clara Plain, Coyote Valley, and Llagas Subbasin (**Figure I-1**). The Santa Clara Plain is more urbanized, although there are population centers in Coyote Valley and the Llagas Subbasin as well. In general, Coyote Valley and the Llagas Subbasin have considerable land areas in agricultural production and designated as undeveloped. Groundwater flow directions are generally from the NNW to SSE in the Llagas Subbasin, and from SSE to NNW in Coyote Valley and the Santa Clara Plain; of course there are local gradients and flow patterns in association with variations in stratigraphy, recharge, and pumping.

Valley Water defines a series of groundwater “benefit zones” that roughly correspond to the following groundwater management areas: W2 (Santa Clara Plain), W7 (Coyote Valley), and W5 and W8 (Llagas Subbasin) (**Figure I-1**). Valley Water has identified regions in the Santa Clara Plain and Llagas Subbasin where groundwater conditions are generally confined, meaning that there are fine-grained layers forming the top of important aquifer units, limiting local recharge into underlying, principal aquifers. The limits of confined conditions were mapped decades ago and appear on numerous Valley Water documents, as well as figures shown in this report. Other important hydrologic features included in the main GIS project created as part of this study

include water bodies and channels, particularly losing stream reaches and the locations of operating percolation basins.

ii. Land surface elevation (DEMs)

We used a USGS digital elevation model (DEM) as the basis for the full project, with pixel dimensions and locations forming a template for incorporation of all additional raster data (**Figure III-2**). The selected DEM uses the NAD83 datum, has resolution of 1/9-arc-second, equivalent in the project area to ~10 ft x 10 ft, and has complete coverage across Santa Clara County. This resolution is fine enough to allow relatively detailed assessment, without creating excessive computational or visualization burdens. We also incorporated a 1/3-arc-second DEM in the project, which can be useful for displays of the full project area because it renders more quickly than the finer DEM.

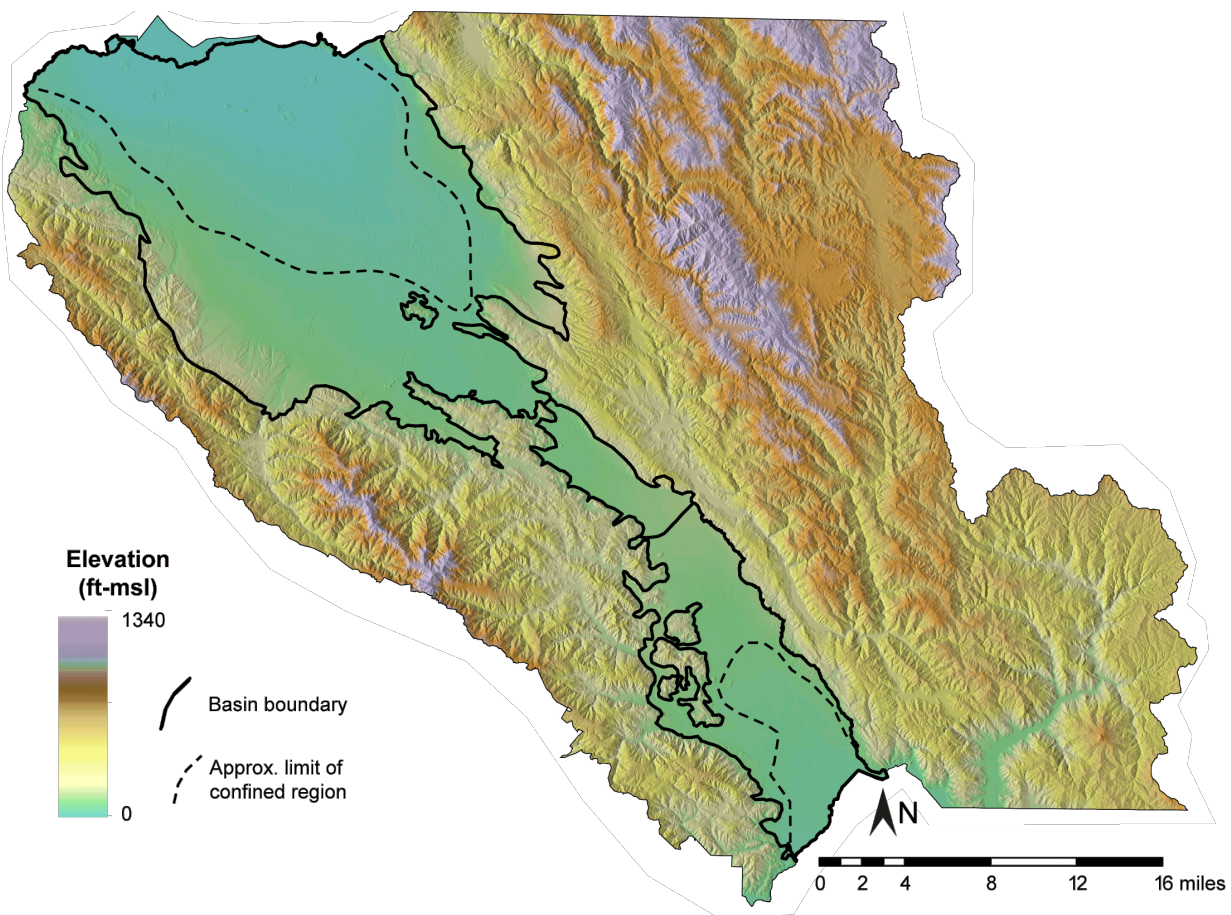


Figure III-2. Hill-shade digital elevation model of full project area (Santa Clara County), showing groundwater subbasins and approximate limits of confined regions.

A hill-shade DEM illustrates variations in slopes in Santa Clara County, emphasizing that primary aquifers that are the focus of this study are located mainly below valley floors and define the Santa Clara Plain, Coyote Valley, and Llagas Subbasin (**Figure III-2**). That said, there local areas with steep slopes, especially near basin edges and where stratigraphically deeper geological units penetrate through the valley fill deposits.

iii. Infiltration capacity

Soil information was extracted from the NRCS SSURGO database⁵⁶ and processed for plotting (**Figure III-3**). Infiltration capacity is not provided as a simple spatial coverage in the SSURGO database. Instead, polygons are defined for a wide variety of map unit symbol codes (MUSYM), and for each code there is information on the thickness of individual soil layers and their typical properties, including each layers' saturated hydraulic conductivity. The latter usually appears as a range of values, often extending across 1–2 orders of magnitude. Thus considerable manipulation of SSURGO data was required to generate a map of soil infiltration capacity for use in Flood-MAR suitability analysis.

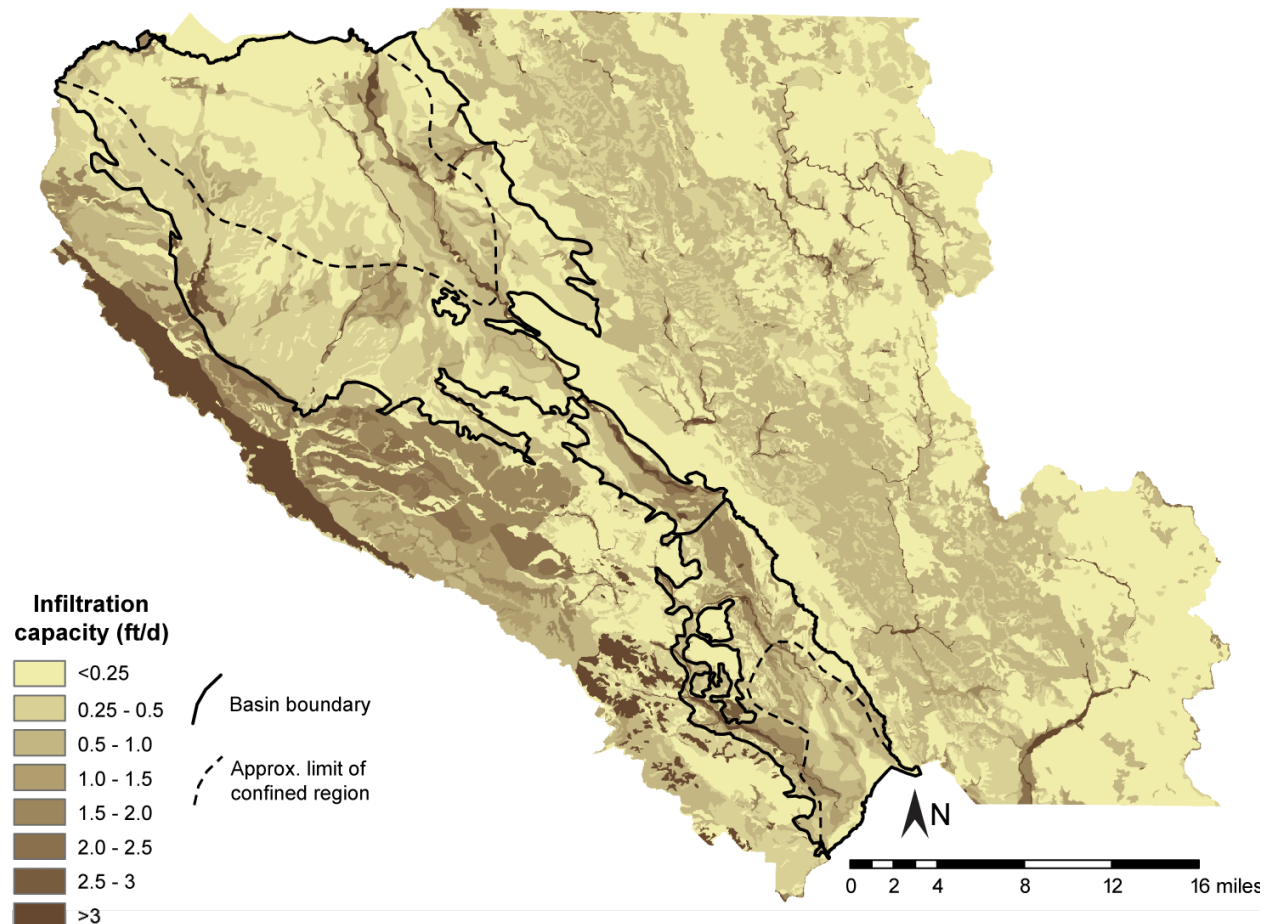


Figure III-3. Infiltration capacity of soils in study area, binned to highlight areas with most favorable properties for Flood-MAR. In general, Flood-MAR project sites should be identified in areas where infiltration rates are ≥ 0.5 ft/day. Higher rates are better for increasing water supply.

We extracted data for each soil type represented in Santa Clara County and linked these to soil polygons. For each soil type, we took the arithmetic mean of saturated conductivity listed for each soil horizon, then calculated the harmonic mean of layer values, accounting for both differences in properties and the thickness reported for each soil layer:

$$IC_E = \frac{\sum_{i=1}^n d_i}{\sum_{i=1}^n \left(\frac{d_i}{\overline{K}_i} \right)} \quad (1)$$

where IC_E = soil infiltration capacity (ft/day), d_i = layer thickness (ft), and \overline{K}_i = arithmetic mean of the range of conductivity values reported for individual layers (ft/day). This approach allowed for a wide range of soil properties to be represented, while giving more importance for vertical infiltration to layers having the lowest (limiting) infiltration capacity. This approach also recognizes that, within each soil polygon, more infiltration is likely to occur where conditions are most favorable. Soil IC_E values were converted to units noted above during compilation and processing, then rasterized. The resulting map is interpreted as representing the infiltration capacity of shallow soils, and is available for the full project region (**Figure III-3**).

iv. Land use/land cover

We considered numerous datasets that define land use/land cover (LULC) across the project region, and decided to work mainly with the 2019 National Land Cover Dataset (NLCD, <https://www.mrlc.gov/data/nlcd-2019-land-cover-conus>) (**Figure III-4**). This dataset offers several advantages compared to other options. First, this is a well-established data product generated for the full continental United States by the U.S. Geological Survey in collaboration with regional partners, applying standardized methods and incorporating data from 2001-19. The NLCD includes the full project region, rather than leaving gaps that would require patching (with a different classification scheme), has the same resolution as the DEM used as the raster template for GIS work (after regriding to align pixels), and uses a self-consistent set of LULC designations with sufficient granularity for the present application. For example, the NLCD includes four designations for "developed" land, ranging from high intensity to open space, distinguishes between deciduous, evergreen, and mixed forests, and has distinct classifications for cultivated crops and hay/pasture. Areas designated as cultivated crops could be updated with an overlay that includes classifications based on crop type or land practices, if desired, but we did not attempt this for the initial suitability analysis for several reasons.

Some earlier studies using MCDA for recharge suitability analysis have favored specific crops on the basis of associated soils types, perceived economic value, or application of fertilizers or nutrients.⁵⁷ However, cropping datasets have incomplete coverage for the project area (which covers all of Santa Clara County). The accuracy of various data products is a concern, but coarser classification means that LULC designations are more likely to be correct than for more detailed assignment of practices. In addition, cropping data is not necessarily indicative of farming practices, e.g., distinguishing between conventional, organic, or dry-farming techniques. We have a separate data coverage for soil properties, so linking crops to infiltration would involve "double-counting" soil properties (e.g., rice is grown frequently where soils are hydrophobic). In some areas, crops are rotated annually or more frequently, so no single snapshot will be indicative of "typical" conditions during some designated time period, and the extent and reliability of available data is highly variable across the region. Indeed, many more detailed cropping datasets are not well documented, so the sources and reliability of data are unknown.

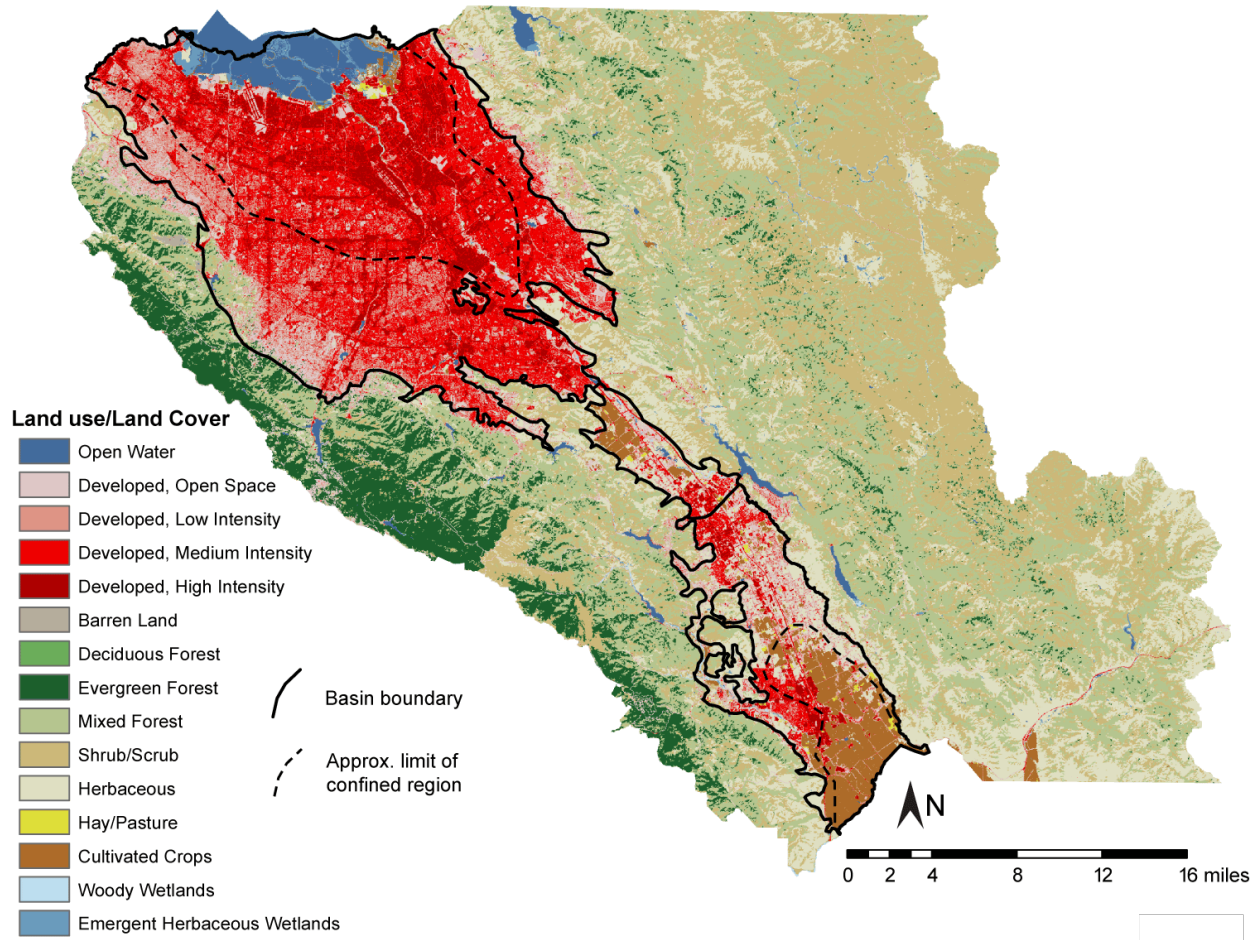


Figure III-4. Land use/land cover in the study area, based on categories in the National Land Cover Dataset.

As discussed later in the section on rating of datasets, we did not wish to apply a rating system that would favor particular crops, for reasons noted above and because how one rates individual crops depends on a series of potentially useful but ultimately arbitrary classifications. For example, one could consider some perennial vine or tree crops to be either favorable or contraindicated for Flood-MAR projects, because the plants will or will not tolerate inundation (depends on MAR operations as well as soils and crop species). Similarly, one could decide that a lower value crop is more favorable for Flood-MAR because a grower removing that land from production in favor of MAR might seem more likely, but in practice these are decisions made by individuals and companies on the basis of many considerations. We note that a more granular cropping coverage could be overlain as a replacement for selected NLCD designations (e.g., cultivated crops could be divided into a finer classification), if desired.

v. Geology

Regional geology maps for the study region were combined to develop a composite coverage, using a geodatabase downloaded from the USGS. In the context of this study, *Geology* refers to 72 formations or other lithologic units or designations identified with specific codes (**Figure III-5**). For Quaternary deposits that are found near the surface in most of the designated groundwater basin areas, we used a compilation of datasets created by *Whitter et al.* (2006)⁵⁸ and digitized by

Wentworth et al. (2006),⁵⁹ defining 55 "type names." For areas with older geological units, data was obtained from the USGS State Geologic Map Compilation (SGMC) geodatabase,⁶⁰ including 13 formations ranging in age from Eocene to Mesozoic, and four Quaternary units. Where the latter was also represented by Quaternary deposits in the *Wentworth et al.* (2006) compilation, the latter designations superseded those from the statewide compilation.

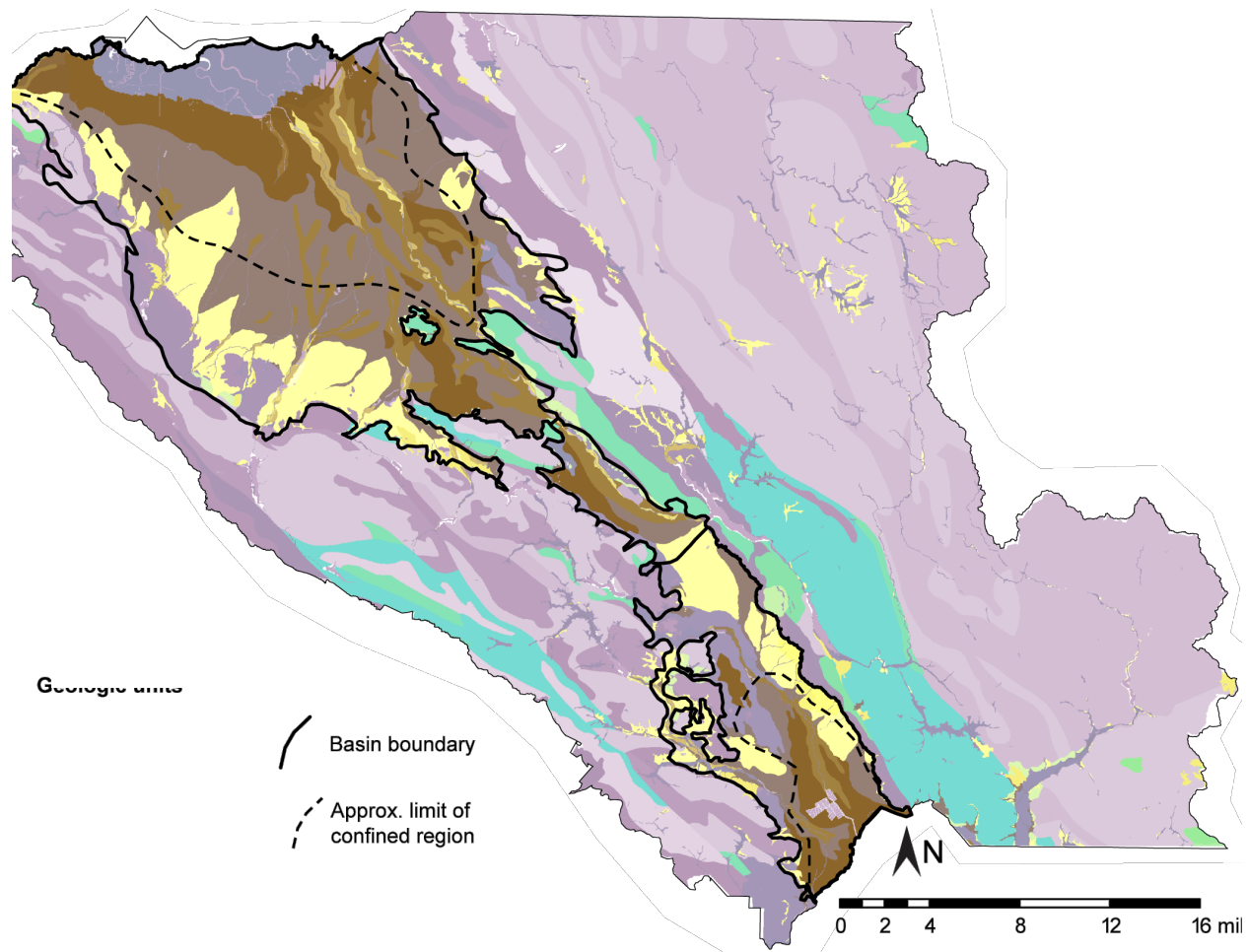


Figure III-5. Geologic units mapped across study area, including 72 distinct lithologies and other classifications. A full listing is included in metadata, but in general, areas with lithologies most conducive to Flood-MAR activities are coarse Quaternary deposits, including areas colored buff-tan to brown to dark lavender.

In general, Quaternary deposits comprise the primary aquifer units in the three groundwater management areas, but particularly at basin edges, older units may be interlayered with younger deposits and therefore could be important for Flood-MAR suitability assessment. Basin edges, where alluvial and fluvial units may pinch out against bedrock deposits, are often locations of "mountain front" recharge because primary aquifer units are sometimes exposed ("daylighted") in these areas. In contrast, areas closer to valley centers often contain wetland or estuarine deposits that are fine grained and can result in development of confined conditions in underlying aquifers. Thus the lateral edges of the groundwater basins are of particular interest for assessing Flood-MAR suitability.

In addition, rural agricultural and residential activities may be supported by individual wells or small well networks in some areas, and the inclusion of older deposits from regional maps is helpful for assuring that there is analysis of surface datasets for the full project area, allowing identification of potential project sites that, while not accessing one of the main groundwater basins, could be useful for local pumpers, streams systems, and/or wetlands. As discussed in greater detail in the section on rating of geological units, many of the Quaternary units have similar descriptions that make interpretation difficult (for example: Qha = Holocene alluvial deposits, undifferentiated; Qhay = Latest Holocene alluvial deposits, undifferentiated). This is true particularly where designated units comprise a wide range of sediment/rock textures (e.g., gravel, sand, silt, clay), and where the dominant texture of deposits is expected to vary at a small spatial scale. Accurate representation of the influence of these deposits on potential Flood-MAR projects will require careful and site-specific field investigation, but the suitability analysis should nevertheless be useful in initial (desktop) screening of options.

vi. Hydrogeology – water levels

Several datasets were made available by Valley Water containing groundwater level data, expressed as depth below ground surface (aka, depth to water, DTW), and used for multiple calculations and data coverages: (a) median water levels in groundwater wells during 2010-19, (b) maximum depth to water during a recent drought, 2014-15, and (c) minimum depth to water during a long time period that includes multiple periods with relatively wet conditions, 1978-2019, with the majority of data being post-1994, and ~25% of minimum depth observations from 2005-06. These maps were provided as raster coverages created by Valley Water using measurements from monitoring and production wells. All of these subsurface datasets, and those for additional coverage discussed in this section of the report, extend close to the limits of groundwater basin extent, a subset of the total project area (Santa Clara County).

We examined additional maps of water levels around the groundwater management areas, including maps going back the early 1990s, but many of these were either PDF scans of hand-contoured maps or maps generated using *AutoCAD* software or *ArcGIS* "package files" with labeled contours rather than raster data. None of these maps could be used in the present application because Flood-MAR suitability index calculations require a gridded (raster) representation. In principle, contour lines could have been digitized and converted to point values, then these data could be gridded to generate a water level raster, but this would be twice removed from data values used to generate the original contours.

In application to the Flood-MAR suitability index, median water level was interpreted to be equivalent to vadose zone thickness, the depth from the ground surface to groundwater level in a producing aquifer (**Figure III-6A**). The coverages for maximum depth to water (under dry conditions, DTW_{dry}) and minimum depth to water (wet conditions, DTW_{wet}) were used to calculate a climate sensitivity factor, $C_s = DTW_{dry} - DTW_{wet}$, resulting in higher values at locations where there were the greatest differences in water levels between dry and wet conditions (**Figure III-6B**). We interpret larger values of C_s to be a positive indicator of Flood-MAR suitability, identifying locations where infiltrated surface water may have a good opportunity to reach a pumped aquifer where there is available storage space. We also note that higher groundwater levels under wet conditions and lower water levels under dry conditions could result from differences in pumping. Thus the phrase "climate sensitivity" represents a hybrid of hydrologic and human (behavioral) influences.

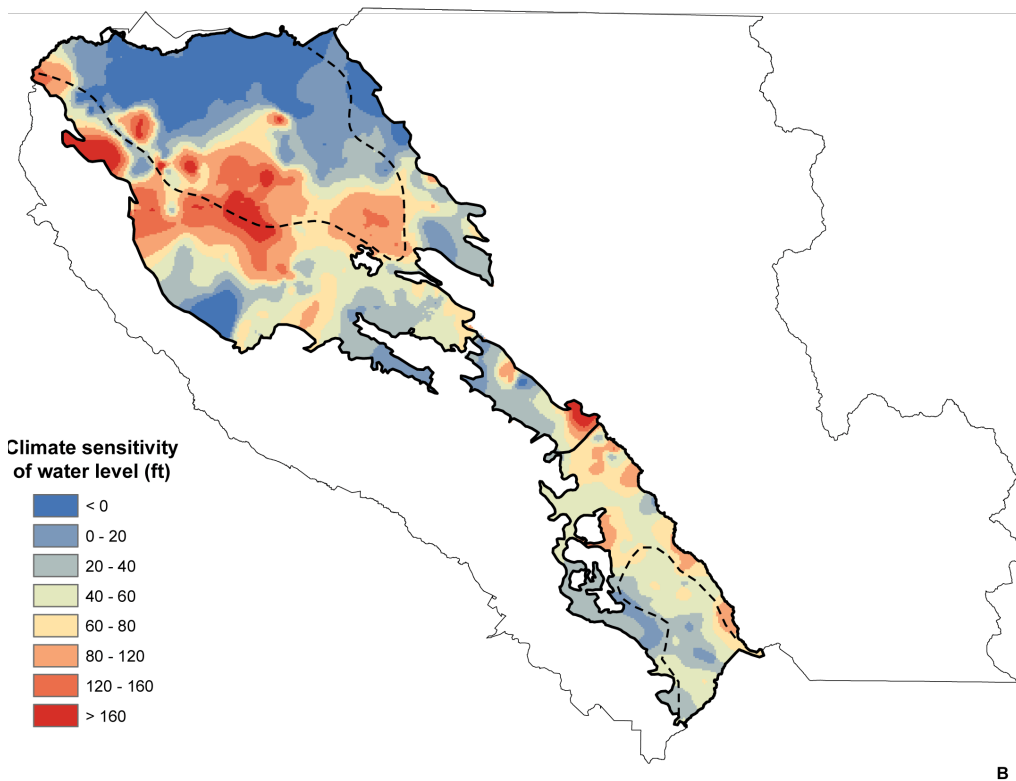
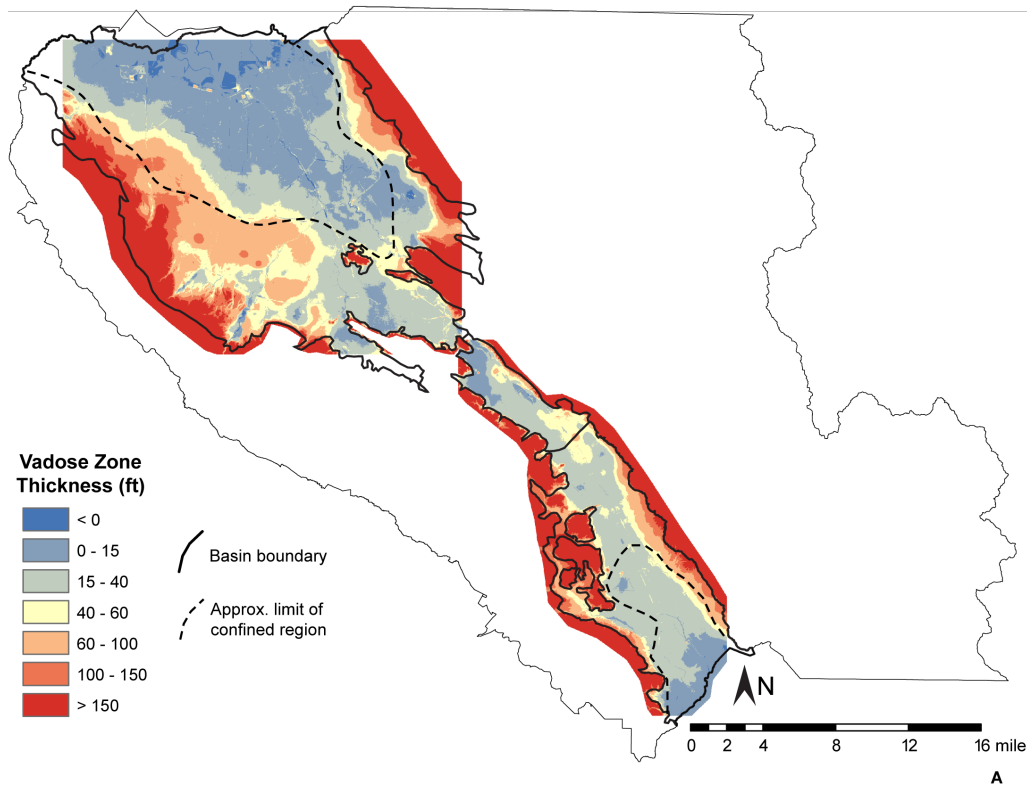


Figure III-6. A. Vadose zone thickness based on median depth to water (DTW) during 2010-19. **B.** Climate sensitivity of DTW defined as DTW_{dry} (2014-15) – DTW_{wet} (1978-2019, minimum). White spaces within the subbasins in panel A indicate areas where vadose zone thickness is not interpolated because of limited depth-to-water data.

The vadose zone tends to be thinnest near the basin centers, particular at the north end of the Santa Clara Plain and the southern end of the Llagas Subbasin, where confined conditions are dominant, and on the northern side of Coyote Valley. The vadose zone tends to be thickest where there are local topographic highs, including locations where bedrock formations are surrounded by valley fill deposits, and on the edges of the groundwater basins as they slope upward into surrounding mountain ranges (**Figure III-6A**). The climate sensitivity of water levels is highly variable around the project region, and is notably high in the central and western sides of the Santa Clara Plain (near large well fields and percolation basins), at the southeastern end of Coyote Valley, and along the margins of Llagas Basin (**Figure III-6B**).

vii. Hydrogeology – Transmissivity and Storage

Multiple data coverages were used to assemble maps of aquifer properties, as applied for groundwater models currently in use by Valley Water, including updated versions of simulations developed for the Santa Clara Plain, Coyote Valley, and the Llagas Subbasins (**Figure III-7**). Acquisition and development of these data coverages for use in the current project varied by management area and model, as summarized in this section. Transmissivity is defined as the product of horizontal hydraulic conductivity multiplied by aquifer thickness for a tabular, horizontal aquifer layer or layers. Thus for unconfined conditions, transmissivity varies with water level. The storage factor calculated for the present application is the product of specific yield (S_y) and aquifer layer thickness, indicating space available for storage of supplemental surface water. Data used for this analysis was provided by Valley Water personnel and subject to evaluation and discussion to determine how it might be applied.

For the model of groundwater flow in the Santa Clara Plain, data were evaluated for the top three model layers (1, 2, 3), for which lateral grid resolution was typically 1,000 to 6,000 ft. Layers 1 and 2 exist for this model only where the principal aquifer is confined, representing the upper unconfined and confining layers, respectively. Where Layer 1 exists, in the confined region, its thickness is ~80 to 100 ft. Where Layers 1 and 2 are absent (outside the confined region), Layer 3 is the uppermost active model layer and is ~100 to 500 ft thick. For transmissivity calculations for this model, we multiplied horizontal conductivity (K_h) by layer thickness for Layer 1 in confined areas, or by Layer 3 where the main aquifer is unconfined and model Layers 1 and 2 are inactive. This approach accounts for there being limited (but often non-zero) transmissivity above confined parts of the Santa Clara Plain, but generally results in greater transmissivity where there are unconfined conditions that correspond to thicker aquifer layers. Layer 1 values of horizontal conductivity were constant in the model, $K_h = 70$ ft/day, whereas Layer 3 values varied, $K_h = 5$ to 333 ft/day.

A similar approach was applied for storage from the Santa Clara Plain model, using Layer 1 where it was active above a confining layer, and Layer 3 where conditions were unconfined. In each case, we multiplied the value of S_y by layer thickness in the same cell location. Specific yield in the Layers 1 and 3 of this model varied with location, $S_y = 0.02$ to 0.21.

For input data used with groundwater models for Coyote Valley and the Llagas Subbasin, we worked only with the uppermost layer, Layer 1. For the Coyote Valley model, Layer 1 has spatial resolution of 250 by 250 ft. Although K_x and K_y are specified separately (with a range of 35 to 650 ft/day), they are assigned the same values ($K_x = K_y$) in individual cells. In addition, $S_y = 0.08$ in this model throughout the domain, so differences in storage calculations as applied in

this study depend entirely on cell thickness. Cells in Layer 1 of the Coyote Valley model are assigned thicknesses of 13 to 376 ft.

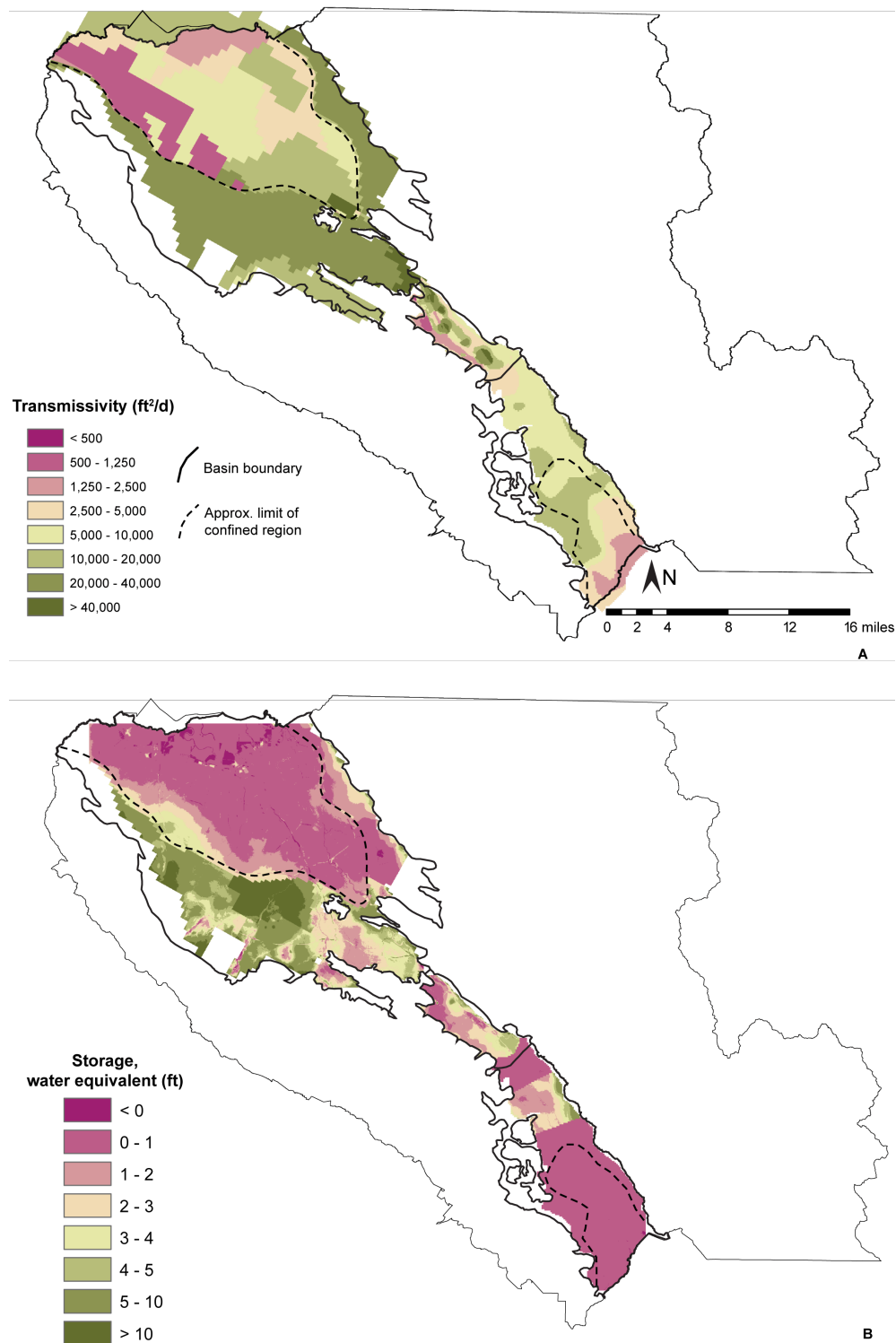


Figure III-7. Aquifer properties from MODFLOW property files. **A.** Transmissivity from upper layers. **B.** Storage from upper layers, defined as specific yield x thickness of vadose zone.

For the Llagas Subbasin model, calculations were made for Layer 1, which has a spatial resolution of 500 x 500 ft. As with the Coyote Valley model, K_x and K_y are specified separately (with a range of 14 to 134 ft/day), but are assigned same values ($K_x = K_y$) within individual cells. Specific yield is much lower in the Llagas Subbasin model than in the other two models, with values of $S_y = 0.005$ to 0.06 , and cell thicknesses are 150 to 295 ft.

Resulting values of transmissivity vary from <500 ft²/day to $>40,000$ ft²/day, with the highest values calculated from model input data in the unconfined part of the Santa Clara Plain (**Figure III-7A**). There are some elevated values apparent along the center of Coyote Valley, and transmissivity is lower along valley edges, especially on the southwest side. Transmissivity values tend to be lower overall in Llagas Subbasin, with the lowest values in the confined area along the southeastern side of the basin. The overall coarse granularity of model cells is apparent in the calculated transmissivity values, as the model resolution is several orders of magnitude coarser than the $\sim 10 \times 10$ ft pixel size applied in this study, but there is "structure" in the variability that seems to be broadly consistent with the nature of basin fill deposits.

The distribution of storage factor values suffers in comparison, with large areas in which there is little variability. In the Santa Clara Plain, there appears to be considerable storage associated with the unconfined area along the southwestern side of the basin. There are much smaller parts of Coyote Valley and Llagas Subbasin with elevated storage potential, and large sections of Llagas Subbasin, in particular, with little available storage based on values used in the groundwater models (**Figure III-7B**). As discussed later in the report, after an initial analysis using transmissivity and storage ratings and discussion with Valley Water personnel, we elected to not use transmissivity and storage values in the suitability analysis.

c. Filters and constraints for application of Flood-MAR

Remaining factors applied in this pre-feasibility assessment of Flood-MAR suitability for the Valley Water service area were not applied directly as part of suitability index calculations, but were used instead as either (a) *filters* to limit the extent of the analysis to a subset of the total project region, or (b) *constraints* that help to focus investigation of specific subregions. Each of these approaches is explained in this section. These should be considered as examples of a filter and/or constraint approach, for which numerous additional datasets could be applied, as discussed later.

We apply DEM slope as a filter to suitability index calculations, removing areas having a ground surface slope $\geq 10\%$, reasoning that these areas are less desirable based on challenges in collection of hillslope runoff under steep conditions (**Figure III-8**). Some areas with slopes $>10\%$ might still be viable for projects, but the most feasible sites are likely to be in or close to the main groundwater basins that occupy valleys. That said, we don't include slope as a numerical factor as part of suitability index calculations because we don't consider there to be a continuous, monotonic relation between slope and project feasibility. Instead, we suggest that this factor is suitable for binary categorization, separating areas that are too steep from other areas that could be viable. Setting a limit at 10% slope is admittedly arbitrary, but we include the map of slope values as part of the working GIS project, and an alternative slope filter could be created and applied if desired.

Other potential filters that were discussed as this project was developed included (a) proximity to a known channel (perhaps gaining channels or channels with groundwater dependent

ecosystems, GDEs) and (b) the mapped extent of confined areas. We did not include the first of these factors as a filter because how it would be applied depends on several additional considerations, and could vary depending on potential project goals and methods used for MAR. For example, if a project were conceived entirely as a means to enhance groundwater storage for subsequent recovery by pumping, then closer proximity to a stream (especially a gaining stream) might be considered to be a negative factor. Alternatively, if the stream channel were known to contain a GDE or other important species, proximity of a Flood-MAR project could be considered to be a positive factor. If any of these considerations were to apply, one would also need to decide how to design the filter, what distance limit might be appropriate (1000 ft, 5000 ft, etc.). Similar considerations could apply depending on whether the primary approach to be taken is infiltration in a dedicated basin, with an area of perhaps 1-10 acres, or if flood-plain inundation across a larger area were possible. We don't argue against adding these or other constraints, but for this pre-feasibility analysis, we elected to filter locations based only on slope.

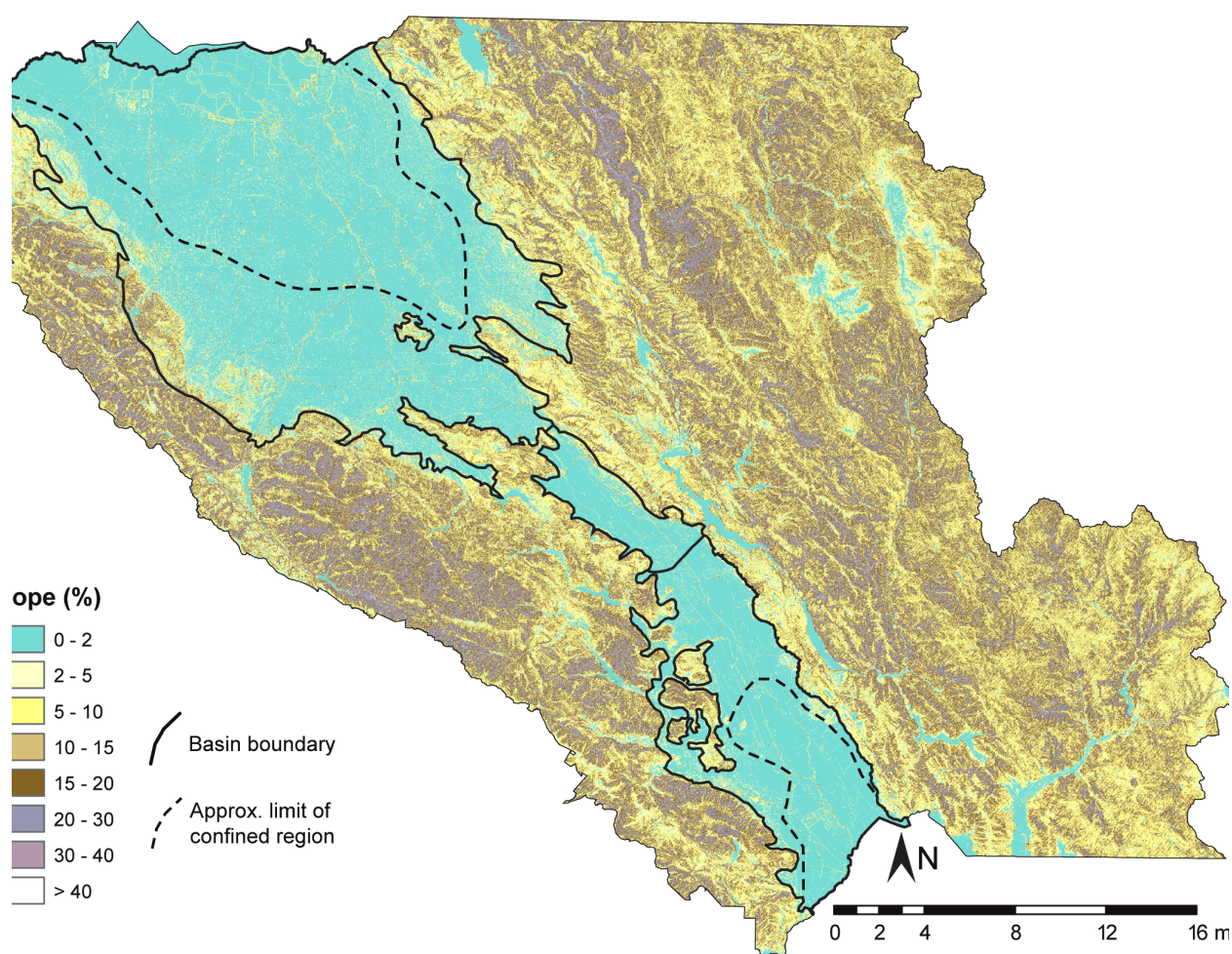


Figure III-8. Values of slope from the digital elevation model, used as a filter for Flood-MAR suitability maps (areas with slopes $\geq 10\%$ removed from consideration).

Considerations for placement of a Flood-MAR project could include identification of parcels designated as open space, for which restoration goals might be consistent with enhanced infiltration for Flood-MAR (**Figure III-9**). Open space parcels could be additionally categorized based on ownership; flood zone designation; or presence of endangered, threatened, or endemic

species. Additional considerations could include the boundaries of Valley Water benefit zones (**Figure I-1**), or the presence of disadvantaged communities. We also added data to the project showing the distribution of water quality indicators (**Figure III-10**). Whether these or other factors were considered to be positive or negative with respect to placement of a Flood-MAR project depends on numerous additional considerations, and it will often be useful to simply render maps of a Flood-MAR suitability index with an overlay of polygons representing additional information. Addition of these coverages also helps to illustrate the benefit of working directly with the GIS project, rather than as single-display maps, so that additional features can be added and symbology to clarify spatial variations.

d. Suitability ratings

Ratings for each factor used in the calculation of a suitability index were applied on a scale from 0 to 7, where lower ratings indicate less suitability for Flood-MAR and higher ratings indicate more suitability. The establishment of a rating scale for each factor is discussed in the next section. Once surface and subsurface factors were assigned spatially, three Flood-MAR suitability indices were calculated for the project region: surface suitability, subsurface suitability, and composite suitability. Each suitability index calculation was based on rated and weighted factors, using the following formulas:

$$SI_{\text{surface}} = (0.33 \times IC_r) + (0.33 \times LULC_r) + (0.33 \times Geol_r) \quad (2a)$$

$$SI_{\text{subsurface}} = (0.50 \times VZ_r) + (0.50 \times CS_r) \quad (2b)$$

$$SI_{\text{composite}} = (0.6 \times SI_{\text{surface}}) + (0.4 \times SI_{\text{subsurface}}) \quad (2c)$$

with the last equation being equivalent to:

$$SI_{\text{composite}} = (0.2 \times IC_r) + (0.2 \times LULC_r) + (0.2 \times Geol_r) + (0.2 \times VZ_r) + (0.2 \times CS_r)$$

The use of equal weights for the five main factors considered is broadly consistent with other analyses of MAR suitability (e.g., Sallwey et al., 2018). These formulae could be modified in the future on the basis of new information or to assess the sensitivity of associated calculations.

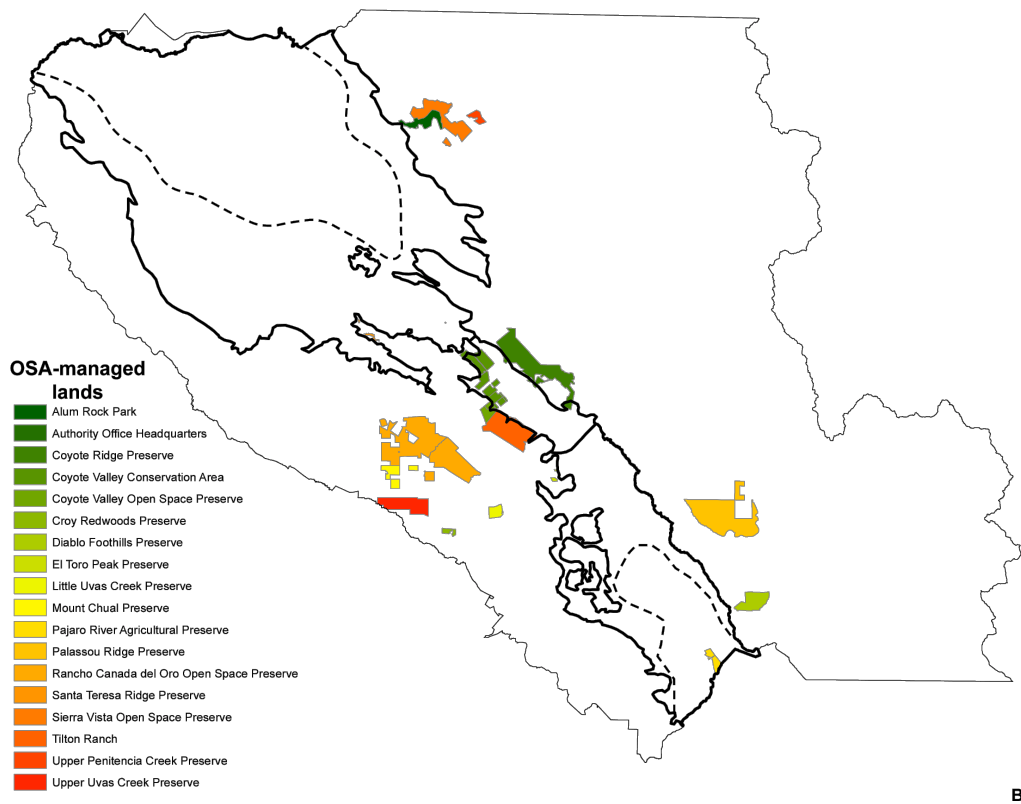
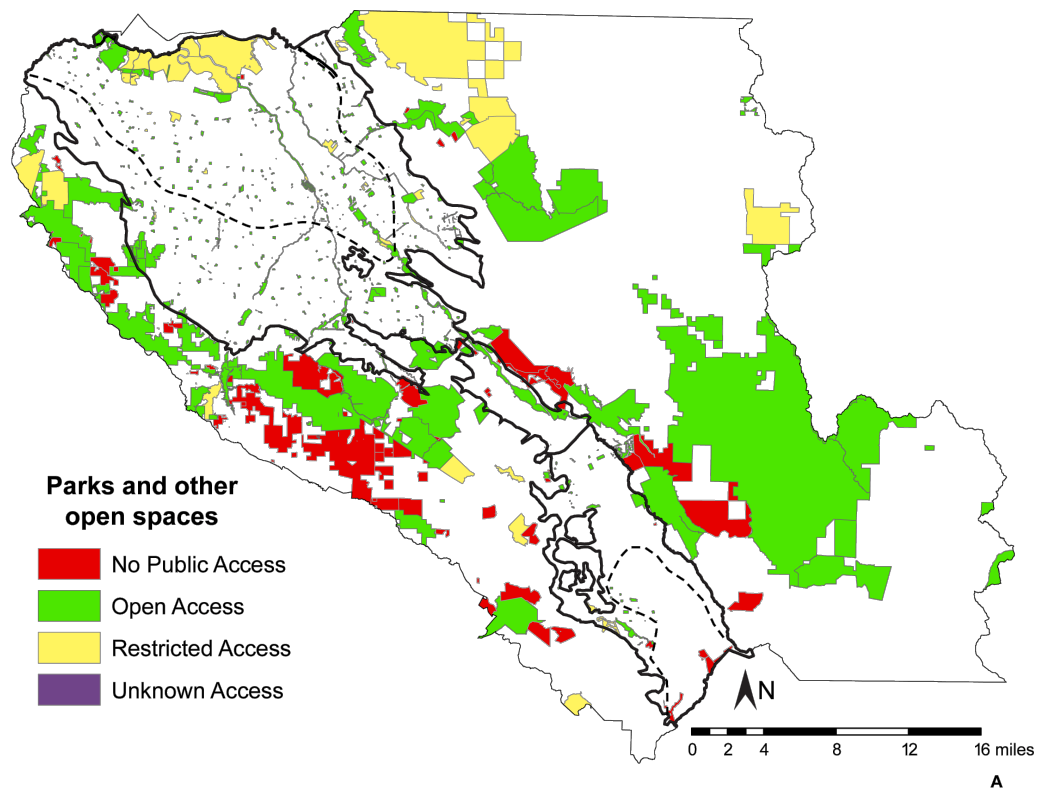


Figure III-9. Selected categories of open space, which could be used to focus application of suitability maps. **A.** Regional parks and related spaces. **B.** Properties managed by the Open Space Authority of Santa Clara County.

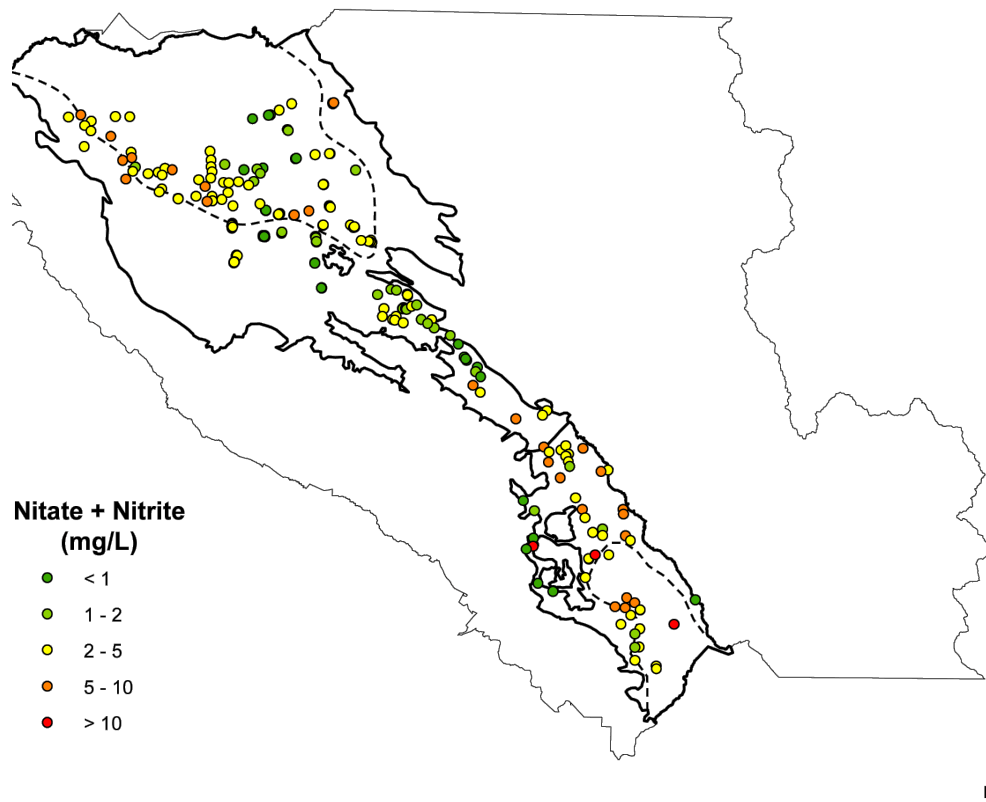
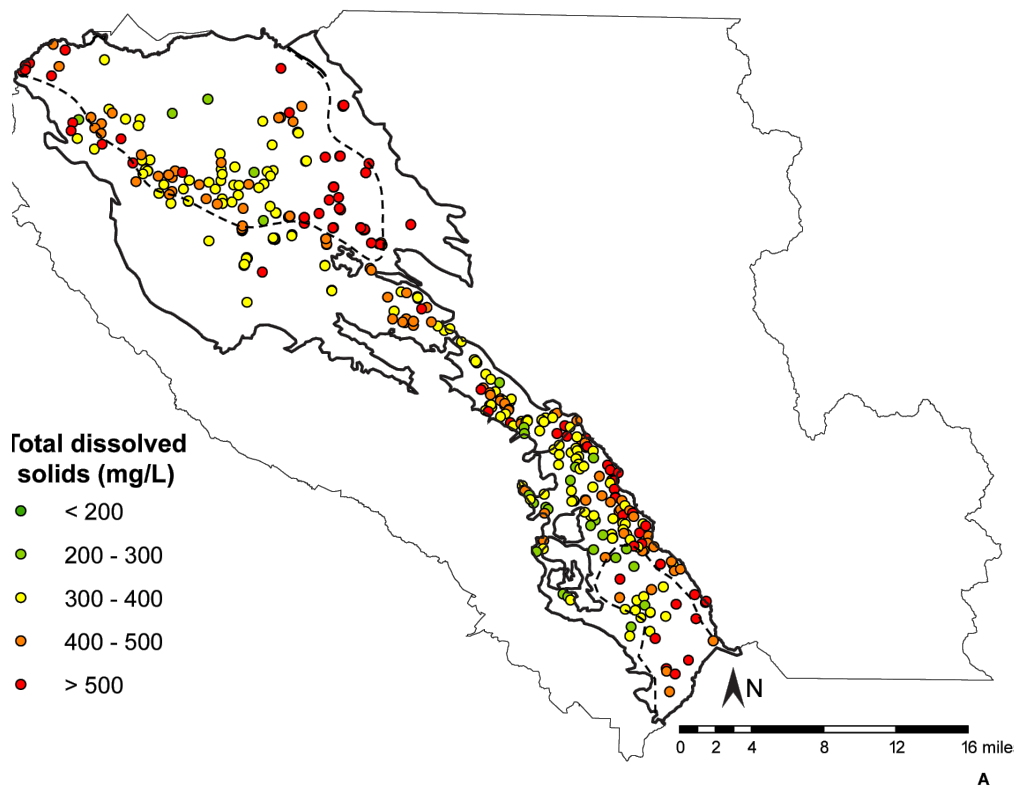


Figure III-10. Water quality indicator examples, which could be used to focus application of Flood-MAR projects. **A.** Total dissolved solids. **B.** Concentrations of nitrate+nitrite.

B. MAR Suitability Analyses

1. Surface factor ratings and suitability index

a. Infiltration capacity

The rating scale was set so that IC values that are moderately favorable for a Flood-MAR project would be rated $IC_r = 3$ to 4 on a scale of 0 to 7, representing values of $IC = 1$ to 2 ft/day (**Table III-2**). Areas with the highest infiltration capacity rating are located mainly in association with current streams, previous channels, and sandstone units in the Santa Cruz Mountains (**Figure III-11**). Active stream channels (either perennial or ephemeral) are not likely to be used for creation of new Flood-MAR projects, but near-stream areas could prove useful for this purpose if there is a suitable water supply available.

Overall, soils in Santa Clara County tend to be unfavorable for infiltration for recharge, with $IC \leq 1$ ft/day ($IC_r \leq 2$) mainly because many of the valley fill and wetland units are a complex mixture of textures and depositional facies, including common fine units. About 10% of the study region has moderately to highly favorable soils based on IC , comprising ~90,000 acres (**Table III-2**). Within the groundwater management areas, favorable soils tend to occur in clusters, particularly at the southern end of Coyote Valley, the northern and southwestern side of Llagas Basin, and around the edges of the limit of confined aquifer conditions in the Santa Clara Plain (**Figure III-11**). In many cases, these are active, ephemeral, or paleo-stream channels or associated deposits, as identified in earlier studies.⁶¹

Table III-2. Summary of ratings for infiltration capacity.

Suitability Rating	Infiltration Capacity (ft/day)	Area (acres) ^a	% Land Area ^a
0	< 0.25	328,200	39.3
1	0.25 - 0.5	173,900	20.8
2	0.5 - 1.0	210,800	25.2
3	1.0 - 1.5	33,700	4.0
4	1.5 - 2.0	42,600	5.1
5	2.0 - 2.5	13,800	1.6
6	2.5 - 3.0	1,800	0.2
7	> 3.0	30,400	3.6

^a Area rounded to nearest 100 acres. Percent land area calculated based on the total area represented in Santa Clara County.

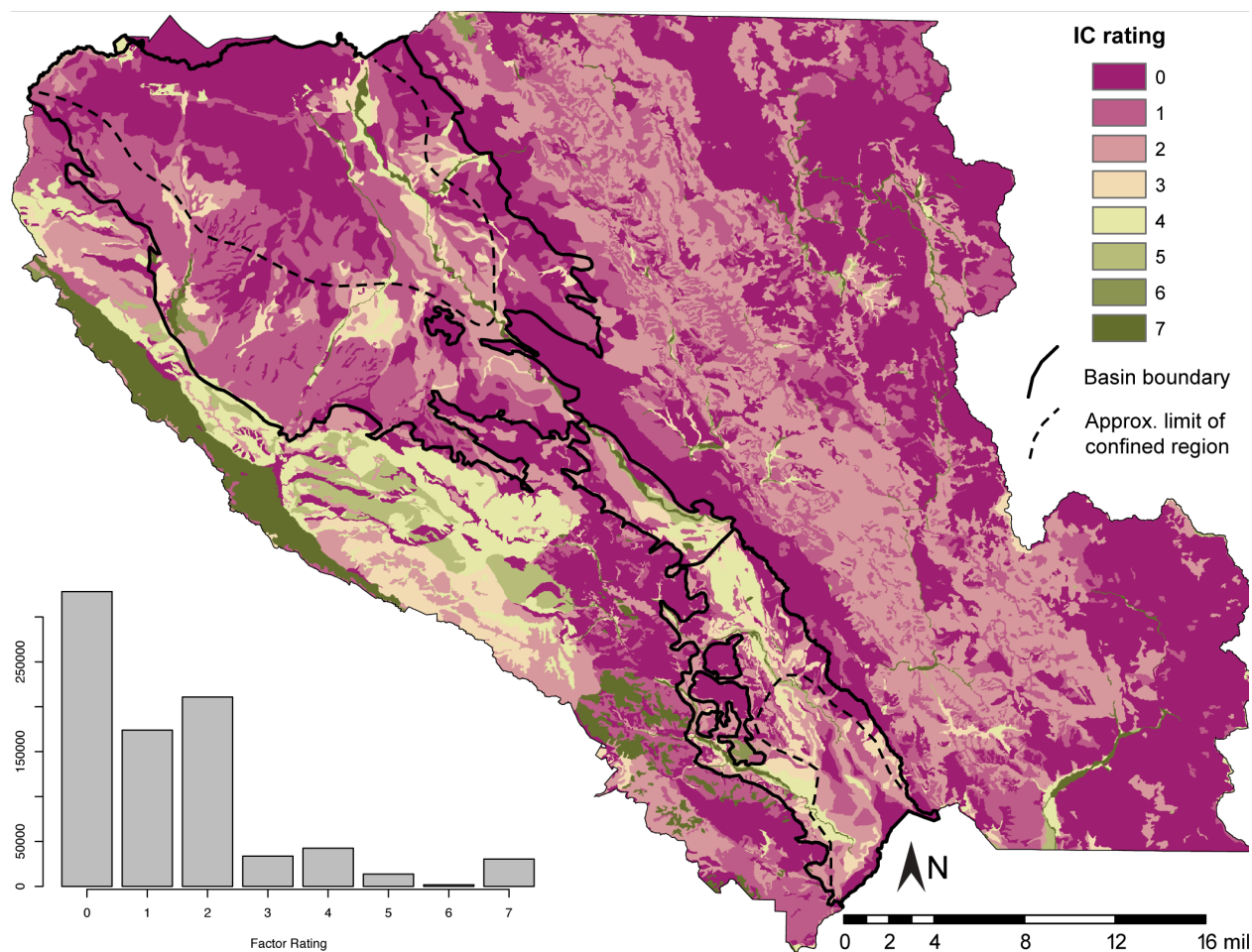


Figure III-11. Infiltration capacity ratings. Rating values defined in **Table III-2** and discussed in text.

b. Land use/land cover

Much of the project area appears to be favorable for Flood-MAR on the basis of land use/land cover (LULC) (**Figure III-12**). However, the regions with the most continuous favorable LULC ratings are outside the groundwater management areas, particularly outside the Santa Clara Plain. The rating system used for LULC extends across the full range of 0 to 7, but we elected to use a somewhat less granular categorization scheme, with six rating values (0, 1, 3, 5, 6, 7). $LULC_r = 0$ was assigned mainly for open water and wetlands (which often have hydrophobic soils), whereas $LULC_r = 1$ was assigned only for high-intensity development (urban areas) (**Table III-3**). Medium- and low-intensity development was rated 3 and 5, respectively, reasoning that the latter could prove suitable for Flood-MAR if there were sufficient open spaces capable of hosting a project. This could be compatible with developed land use if a parcel were zoned as a park or for environmental benefit.

Areas with *LULC* categories indicating extensive vegetation, other than wetland, were rated $LULC_r = 5, 6$, or 7 (**Table III-3**). Scrub/shrub and herbaceous landscapes were rated $LULC_r = 5$ and 6, respectively, and all forests, cultivated crops, and hay/pasture were rated $LULC_r = 7$. The latter rating deserves particular justification. Unlike other studies that favored particular crop types,⁶² we are more neutral with regard to using this factor to indicate suitability, for several reasons. As noted previously, the presence of specific crops is likely to be a weak indicator of

Flood-MAR suitability on its own because (a) cropping changes over time, (b) within individual crops there can be large differences in landscape management, (c) and it is possible that a grower may wish to set aside some land for Flood-MAR, even if that land is productive. Alternatively, there could be incentives for land fallowing, or limitations in access to water for that makes land less valuable for agriculture.

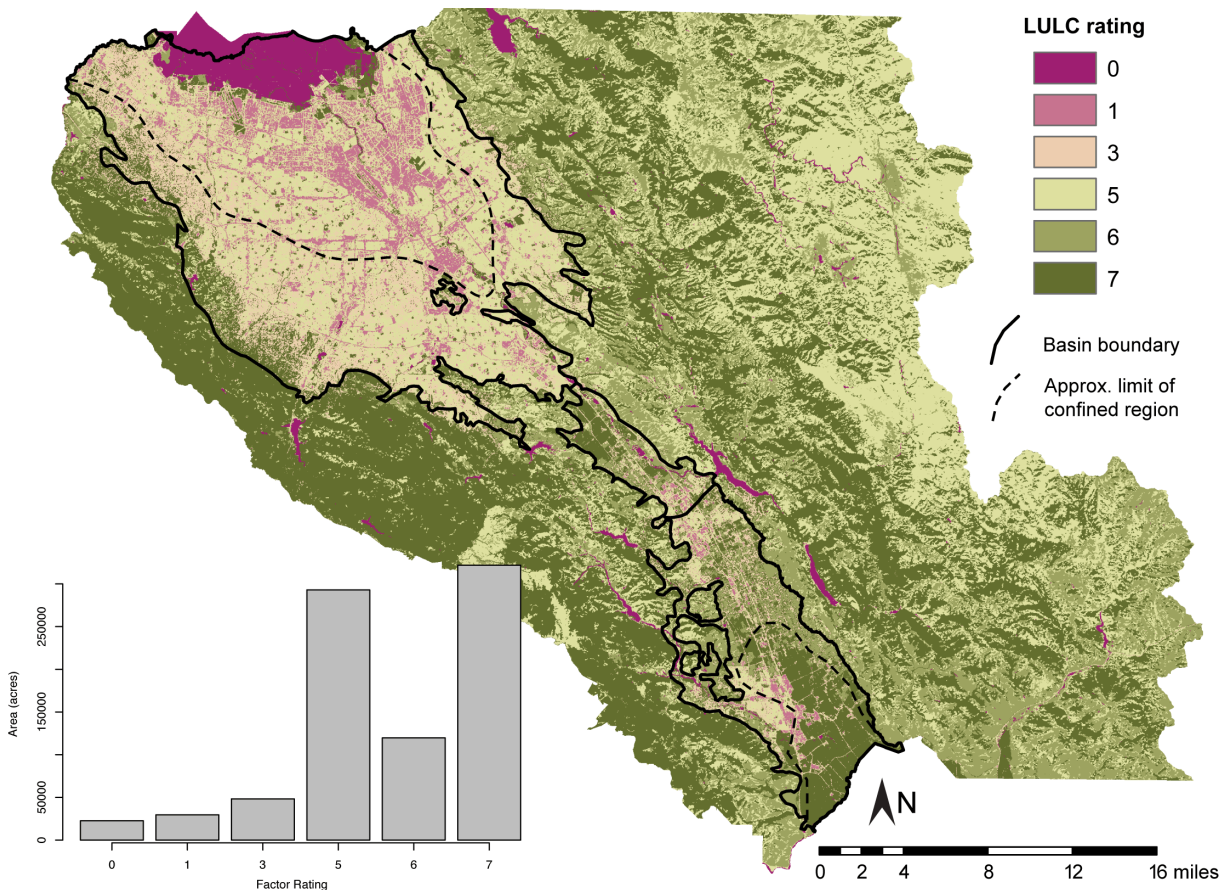


Figure III-12. Land use/land cover ratings. Rating values defined in **Table III-3** and discussed in text.

Table III-3. Summary of ratings for land use/land cover.

Suitability Rating	Land Use	Area (acres)	% Land Area ^a
0	Open Water, Woody Wetlands, Emergent Herbaceous Wetlands	22,600	2.7
1	Developed-High Intensity	29,600	3.5
3	Developed-Medium Intensity	48,300	5.8
5	Developed-Low Intensity, Shrub/Scrub	293,000	35.1
6	Herbaceous	119,700	14.3
7	Developed-Open Space, Barren Land, Deciduous Forest, Evergreen Forest, Mixed Forest, Hay/Pasture, Cultivated Crops	321,900	38.5

^a Area rounded to nearest 100 acres, percent is relative to all of Santa Clara County.

There are exceptions to this approach that may be worth considering, for example areas planted in perennial crops that do not tolerate frequent or long-term inundation (e.g., stone fruit trees); but even in those areas, an infiltration basin with an area of 1 to 5 ac might be accommodated, particularly if that part of a parcel were not especially productive and had favorable characteristics for MAR. There also could be specific agricultural land uses that are contraindicators for Flood-MAR, e.g., dairy operations that tend to generate animal waste, and thus elevated TDS and nitrate values in runoff. The current framework allows for more specificity that could include lower $LULC_r$ for particular land uses, but we have not attempted this in the initial set of calculations.

c. Geology

Geology and landscape type categories were rated for 72 specific substrate types (**Figure III-13**). Quaternary units that include former stream channels have the highest geology ratings $Geol_r = 6$ or 7 (**Table III-4**), and tend to be found close to current/active channels. Other Quaternary valley fill and fluvial units generally have high ratings as well $Geol_r = 4$ or 5, but some units were largely undifferentiated (gravel to sand to silt to clay) or were identified as generally being older and more lithified, resulting in classification of $Geol_r = 3$. $Geol_r \leq 3$ were generally assigned to units that were Plio-Pleistocene or older, including crystalline rocks in the Santa Cruz Mountains.

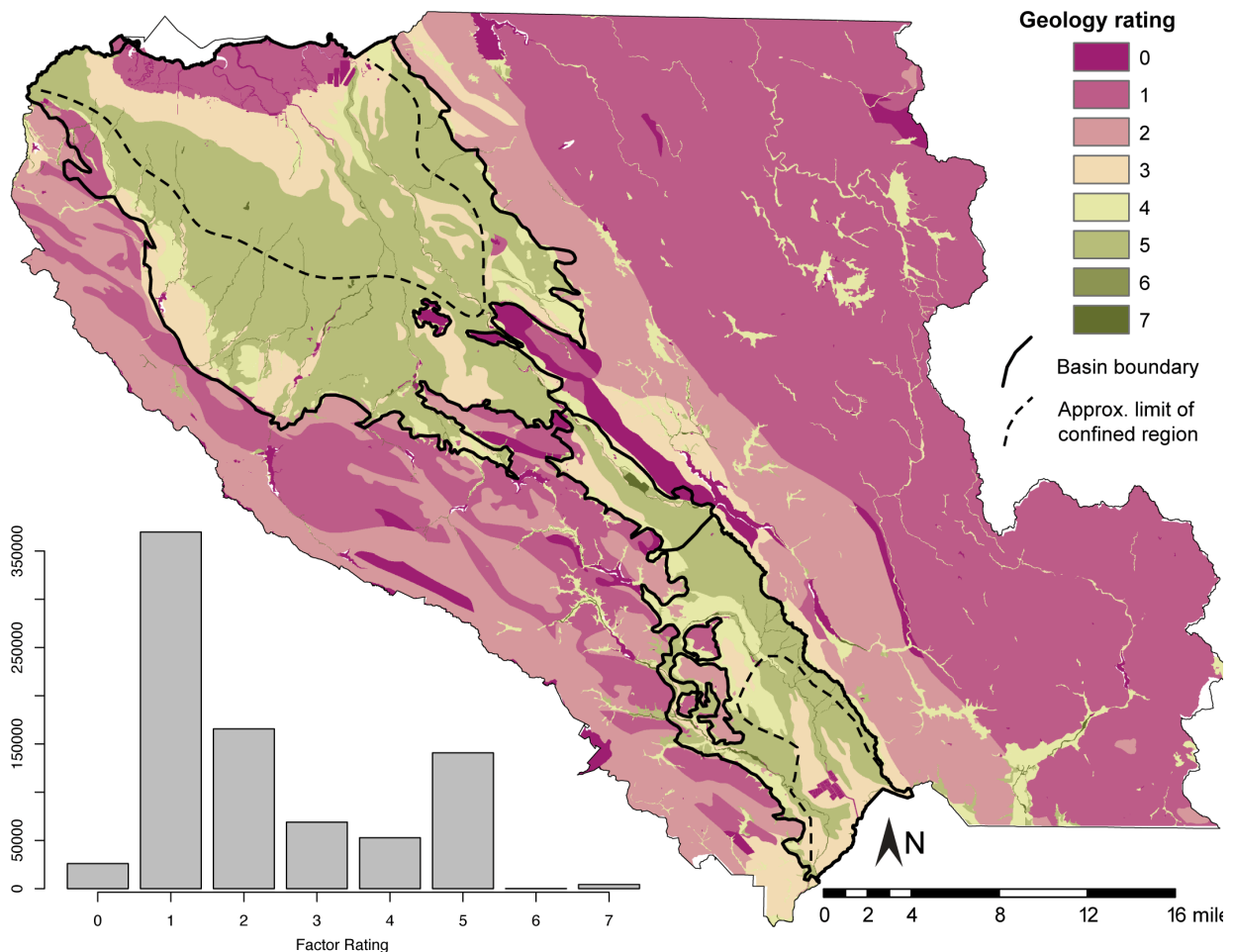


Figure III-13. Regional geology ratings. Rating values defined in **Table III-4** and discussed in text.

In general, the groundwater basins have more favorable geology for Flood-MAR, and there is considerable variability and structure (**Figure III-13**). More than 7% of the land area in Santa Clara County has geology characterized as $Geol_r \geq 5$, comprising nearly 60,000 acres, most of which is located in the groundwater management areas.

Table III-4. Summary of ratings for geology.

Suitability Rating	Lithology ^a	Area (acres)	% Land Area ^b
0	Ultramafic rocks, chiefly Mesozoic, unit 3 (Coast Ranges and Western Klamath Mountains), H2O, nm	26,000	3.1
1	Franciscan mélangé/Franciscan Complex, unit 1 (Coast Ranges)/Tertiary intrusive rocks (hypabyssal), unit 2 (Quien Sabe Volcanic Field)/Qhbm/adf/Qhb/Qhf	370,000	44.6
2	Mesozoic volcanic rocks, unit 1 (Coast Ranges)/Cretaceous marine rocks (in part nonmarine), unit 1 (Coast Ranges)/Eocene marine rocks/Miocene marine rocks	166,000	20.0
3	Plio-Pleistocene and Pliocene loosely consolidated deposits/Pliocene marine rocks/Qhff/Qt/Qhfe/Qht/Qhty/Qhcb/Qot/Qpt/Qht1/Qht2/Qt1/Qt2	69,000	8.3
4	Older Quaternary alluvium and marine deposits/Quaternary alluvium and marine deposits/Qha/Qa/Qpa/Qf/Qhfy/Qoa/Qhly-Qhty/Qhf-Qhff	52,700	6.4
5	Qhl1/Qpf/Qhly/Qhf1/Qhl/Qhf2/Qhf/Qof/Qhf-Qpf/Qhf-Qhl/Qhl-Qpf/Qof2/Qof1	141,000	17.0
6	Qhc-Qhly	65	0.01
7	Qhc/gq	4,300	0.5

^a Lithologic units as identified on USGS geological maps. Full definitions available for all units in metadata on suitability rating factors, https://docs.google.com/spreadsheets/d/1qTI0mknAR5wT8NDZxh9YfkHwd_g0RzeQ6uQ0Umtm9KA/edit?usp=sharing

^b Percent land area was calculated based on the total area of Santa Clara County.

d. Surface suitability index

The three surface factors were weighted equally to derive a Flood-MAR Suitability Index (**Figure III-14**). Because the three surface factors applied are mostly independent (perhaps with limited correlation between IC_r and $Geol_r$), the resulting map is highly granular and shows considerable variability and complexity across the project region. We also filtered out all pixels having slopes $\geq 10\%$, which removed mountainous areas to the west and east of the groundwater basins. More than 7% of the land area has Flood-MAR Suitability based on surface data characterized as $SI_{\text{surface}} = 4$ to 7, comprising ~60,000 acres, most of which is located in the groundwater management areas, and particularly Coyote Valley and the Llagas Subbasin. If we consider areas with $SI_{\text{surface}} = 3$ -4, the center of the range calculated, this comprises another ~19% of land area, an additional ~150,000 acres that is (once again) mostly in the groundwater management areas.

On the one hand, this is a promising result, suggesting that there may be many opportunities around the Valley Water service area to accomplish Flood-MAR goals. On the other hand, one application for this GIS project is to set priorities for specific regions, so having too much of an area rated highly could make screening difficult. The addition of subsurface data helps to narrow the spatial focus of potential Flood-MAR project sites.

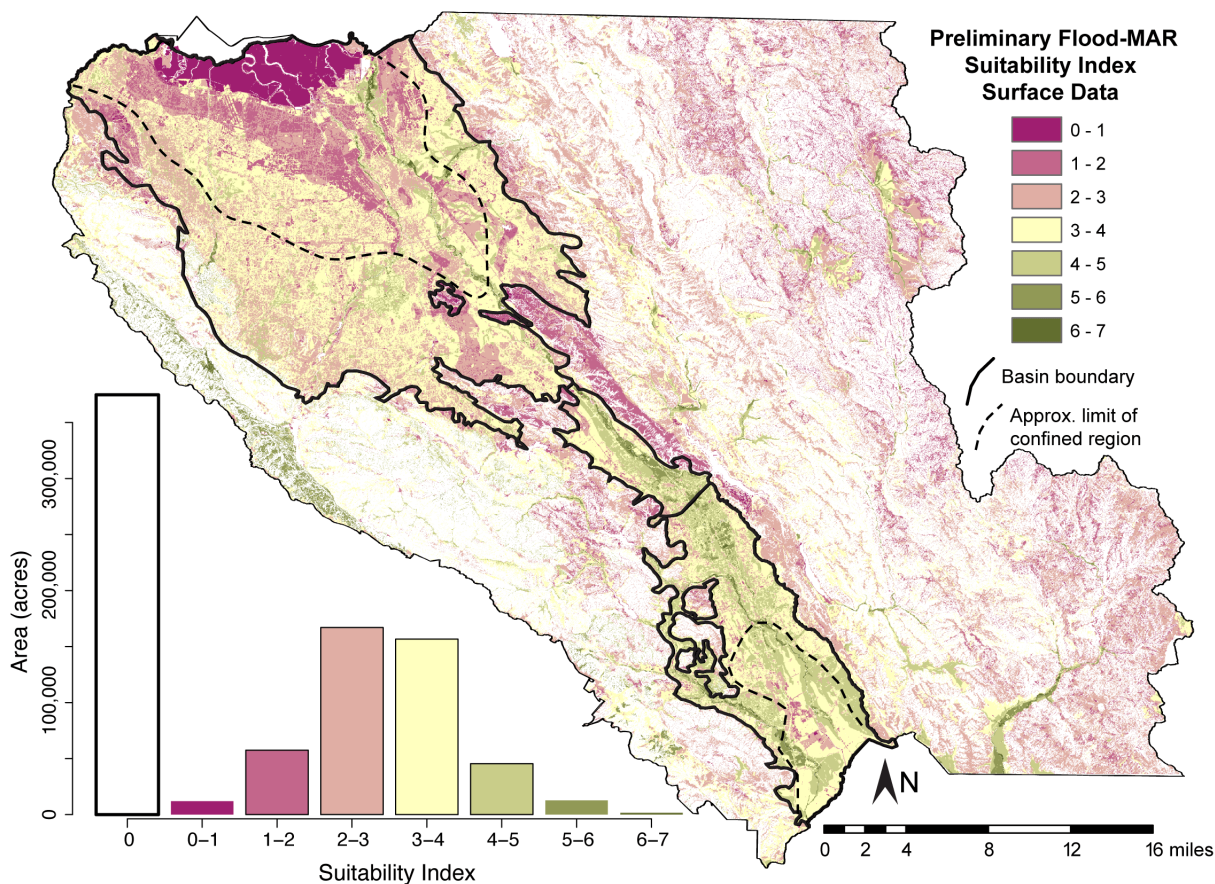


Figure III-14. Preliminary Flood-MAR suitability index for full project area based on surface datasets, filtered to remove areas with slopes $\geq 10\%$ (resulting in suitability index = 0). Factors used for this analysis include: infiltration capacity, geology, and land use/land cover, filtered using the digital elevation model. Areas with each index are listed in **Table III-5**.

Table III-5. Summary of Flood-MAR suitability based on surface datasets.

Suitability Rating	Area (acres) ^a	% Land Area ^a
0 ^b	374,800	45.3
0 - 1	11,900	1.4
1 - 2	57,500	6.9
2 - 3	167,000	20.2
3 - 4	156,600	18.9
4 - 5	45,500	5.5
5 - 6	12,700	1.5
6 - 7	1,600	0.2

^a Area rounded to nearest 100 acres, percent is relative to all of Santa Clara County.

^b Includes land filtered by slope >10%.

2. Subsurface suitability ratings and index

a. Vadose zone thickness

Ratings for vadose zone thickness have the most complex (and arguably, the most subjective) categorization system. At the limits, a high water table with $DTW < 10$ ft is considered too shallow for Flood-MAR; mounding and saturation of shallow soils are likely to occur ($VZ_r = 0$ in this analysis). A somewhat thicker vadose zone, 10-20 ft, was assigned $VZ_r = 1$. At the other extreme, a vadose zone >200 ft thick indicates that groundwater is so deep that surface infiltration seems likely to be perched rather than reach a depth from which groundwater pumping is common ($VZ_r = 2$). VZ values between 20 and 200 ft were assigned intermediate VZ_r values, with the peak in thickness assigned for $VZ_r = 7$ when $DTW = 20$ -60 ft (**Table III-6**).

Table III-6. Summary of ratings for vadose zone thickness.

Suitability Rating	Vadose Zone Thickness (ft)	Area (acres) ^a	% Land Area ^a
0	< 10	44,000	15.7
1	10 - 20	34,300	12.2
7	20 - 60	91,400	32.6
5	60 - 100	31,300	11.2
3	100 - 200	27,400	9.8
2	> 200	51,500	18.4

^a Area rounded to nearest 100 acres, percent is relative to extent of the vadose zone thickness coverage.

Much of the project area (groundwater basins for this and other subsurface datasets) has relatively high vadose zone ratings ($VZ_r = 5$ to 7, 44% of the basin areas), particularly unconfined

areas in the Santa Clara Plain and Llagas Basins, and the southern and eastern sides of Coyote Valley (**Figure III-15**). We used a limited rating scale, omitting values of 4 and 6, mainly because there was not enough confidence in finer granularity in classification (e.g., it was not clear if $DTW = 120$ ft is really much better than $DTW = 175$ ft).

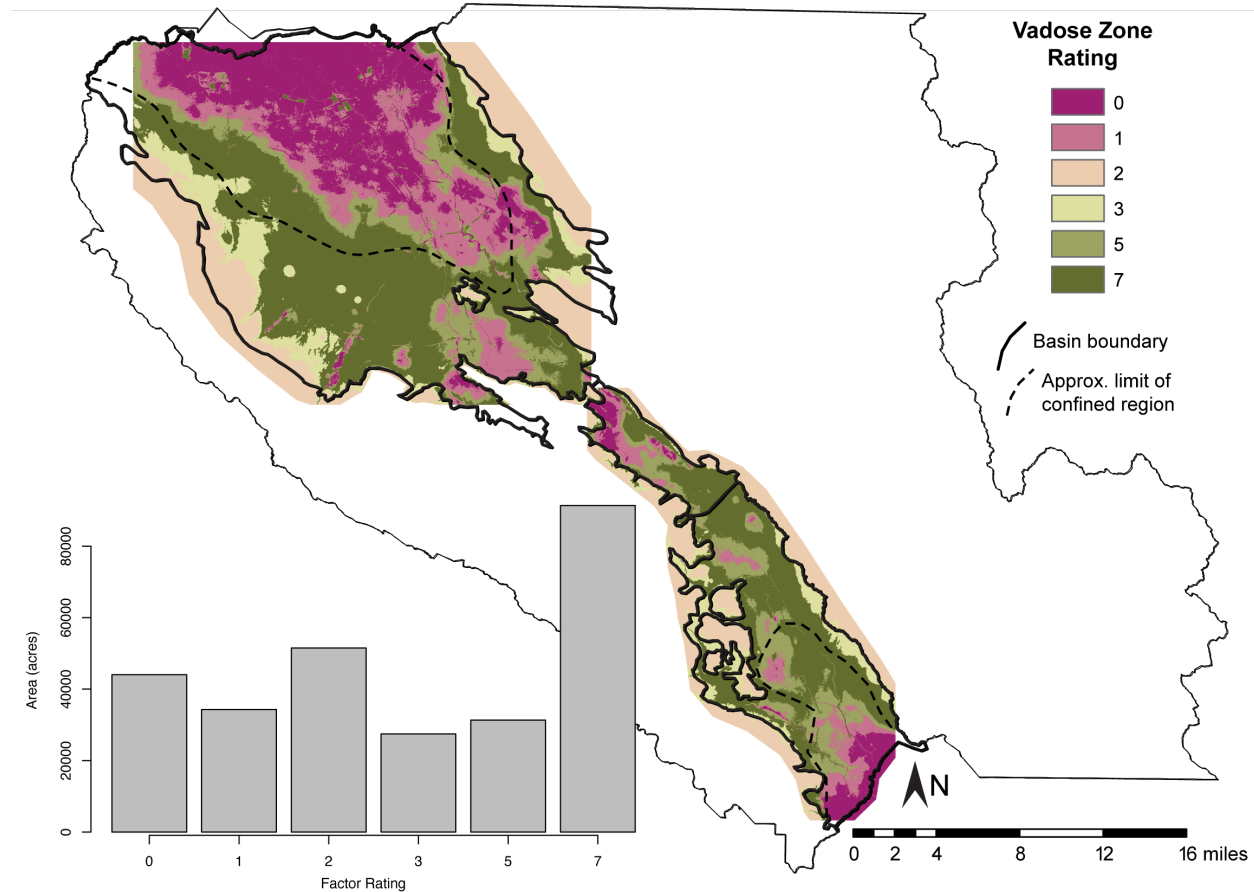


Figure III-15. Vadose zone thickness ratings. Rating values defined in **Table III-6** and discussed in text.

b. Climate sensitivity of groundwater levels

Climate sensitivity of groundwater levels is more variable across the project region, with scattered patches having elevating ratings (**Figure III-16**). This factor is based on the difference in water levels during dry and wet periods; it is intended to indicate which areas appear to be capable of receiving recharge or being highly susceptible to differences in pumping rates or patterns. Large areas of elevated CS_r (5 to 7) are found in the Santa Clara Plain, but there are also patches in Coyote Valley and the Llagas Subbasin, particularly along the eastern basin edges. These areas comprise >20% of the groundwater management areas, covering >50,000 acres (**Table III-7**).

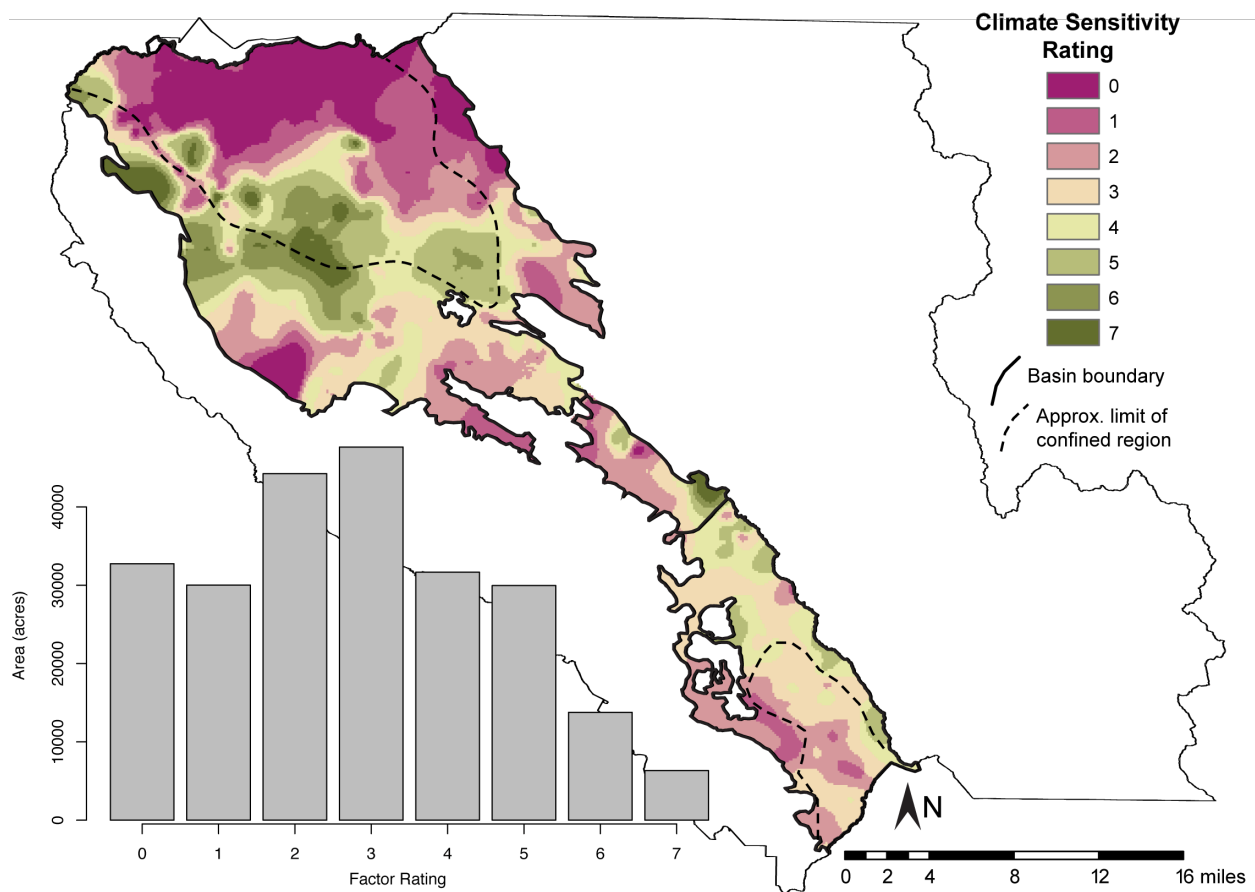


Figure III-16. Ratings of climate sensitivity of groundwater levels. Rating values defined in Table III-7 and discussed in text.

Table III-7. Summary of ratings for climate sensitivity of groundwater water levels.

Suitability Rating	Difference in depth to water, $DTW_{dry} - DTW_{wet}$ (ft)	Area (acres) ^a	% Land Area ^a
0	< 0	32,700	13.9
1	0 - 20	30,000	12.7
2	20 - 40	44,300	18.7
3	40 - 60	47,600	20.2
4	60 - 80	31,700	13.4
5	80 - 120	30,000	12.7
6	120 - 160	13,800	5.8
7	> 160	6,300	2.7

^a Area rounded to nearest 100 acres, percent is relative to extent of the climate sensitivity coverage.

c. Transmissivity

Transmissivity ratings ($T_r = 6$ to 7) are highest in unconfined areas where there are thick and conductive surface layers, with the highest values in southern Santa Clara Plain and central Coyote Valley. Moderate ratings ($T_r = 4$ to 5) are common in clusters throughout the project region, including much of Llagas Subbasin (**Figure III-17**). Because the Santa Clara Plain groundwater model incorporates no variation in horizontal conductivity in the confined area, variations in T_r result entirely from variations in cell thickness. Somewhat greater granularity is apparent in Coyote Valley and the Llagas Subbasin (**Figure III-17**). The majority of the management areas have shallow transmissivity on the upper 50% of the rating scale (**Table III-8**). As noted previously, ratings for transmissivity are not included in the final suitability analysis.

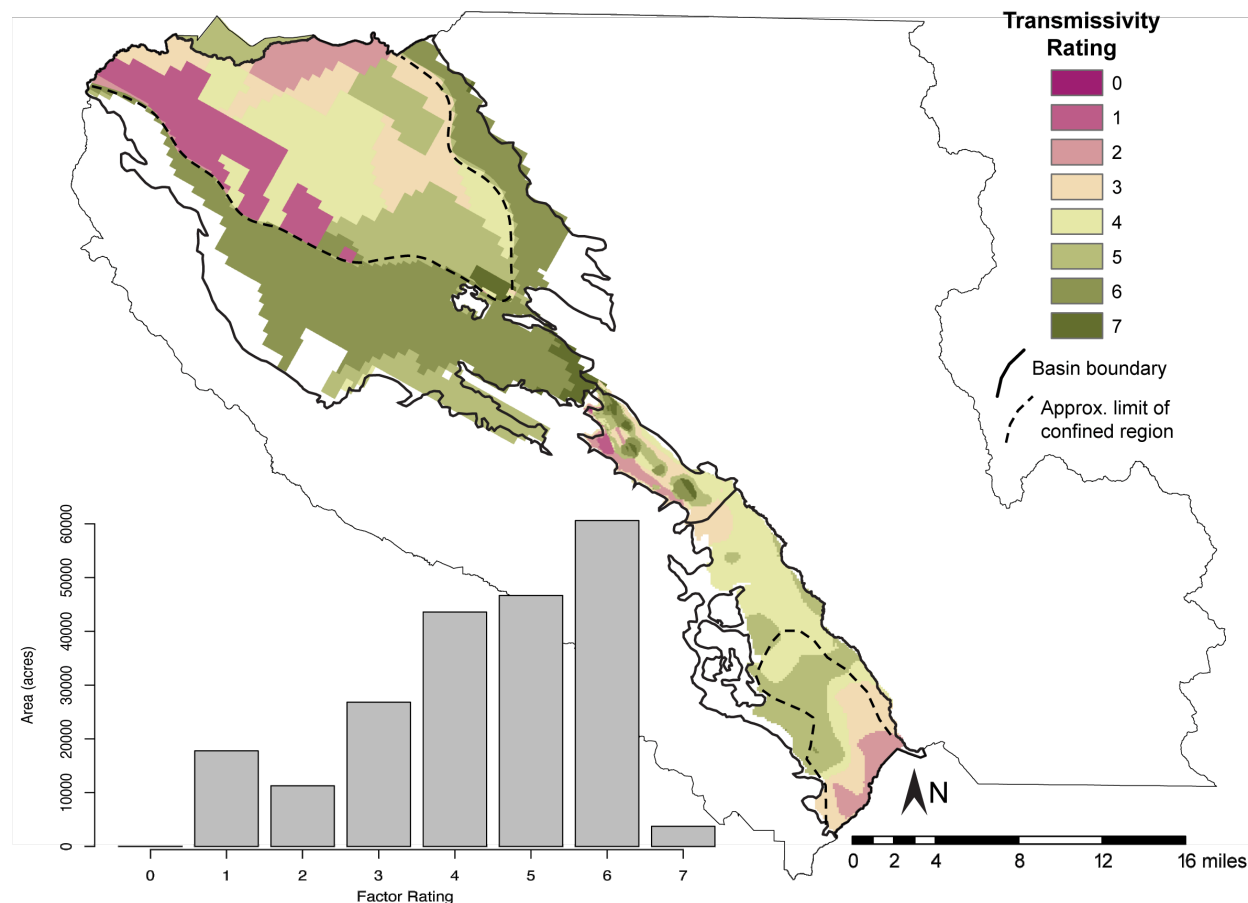


Figure III-17. Ratings of transmissivity from groundwater model datasets. Rating values defined in **Table III-8** and discussed in text.

Table III-8. Summary of ratings for transmissivity.

Suitability Rating	Transmissivity (ft ² /day)	Area (acres) ^a	% Land Area ^a
0	0 - 500	0	0
1	500 – 1,250	17,800	8.4
2	1,250 – 2,500	11,300	5.4
3	2,500 – 5,000	26,800	12.7
4	5,000 – 10,000	43,600	20.7
5	10000 – 20,000	46,700	22.2
6	20,000 – 40,000	60,600	28.8
7	> 40,000	3,700	1.8

^a Area rounded to nearest 100 acres, percent is relative to the total extent of the transmissivity coverage.

d. Available storage

The distribution of rated storage factors (S_r) is similar in some ways to that for shallow transmissivity, with the lowest values in confined areas (**Figure III-18**). The overall range is low, with 85% of the study areas apparently having <5 ft of available storage ($S_r \leq 5$, product of vadose zone thickness and specific yield). There is reason to suspect that values of aquifer thickness and/or specific yield might be underrepresented in computer models. Particularly in the Llagas Subbasin, the majority of the study region is rated as having essentially no available storage, mainly on the basis of low S_y values. Given the distribution of values derived from the regional computer models, there would be little benefit to expanding the storage rating scale to boost intermediate values ($S_r = 3$ to 5), but this analysis suggests that it may be worth considering a more holistic assessment of basin stratigraphy that incorporates detailed information available from groundwater well logs and other data.⁶³ Still, >25% of the study region has moderate to high S_r values (**Table III-9**). As noted previously, ratings for available storage are not included in the final suitability analysis.

e. Subsurface suitability index

Subsurface datasets were combined to generate a Flood-MAR suitability index based on these data coverages alone (**Figure III-19, Table III-10**). Given limitations in transmissivity and storage data as represented in regional groundwater models, and following discussion with Valley Water personnel, we eliminated use of these factors and focused instead on vadose zone thickness and climate sensitivity of water levels (**Figure III-1**). The areas with the highest suitability index for Flood-MAR based on subsurface data are in unconfined regions of the three groundwater management areas where water levels are moderately deep, allowing for reasonable transit times for infiltration to reach the water table and demonstrating considerable variability between wet and dry climate periods. There is a relatively uniform distribution of $SI_{\text{subsurface}}$ ratings, and ~50% of the study region has moderate to high suitability based on subsurface data, $SI_{\text{subsurface}} = 4$ to 7 (**Table III-10**). During an earlier analysis, when transmissivity and storage data originating from groundwater models was applied to subsurface suitability assessment, the

mapped pattern was much the same, although average values were lower overall and there was less area with higher ratings, mainly because storage ratings tend to be low (compare **Figure III-19** to **Figure III-18**).

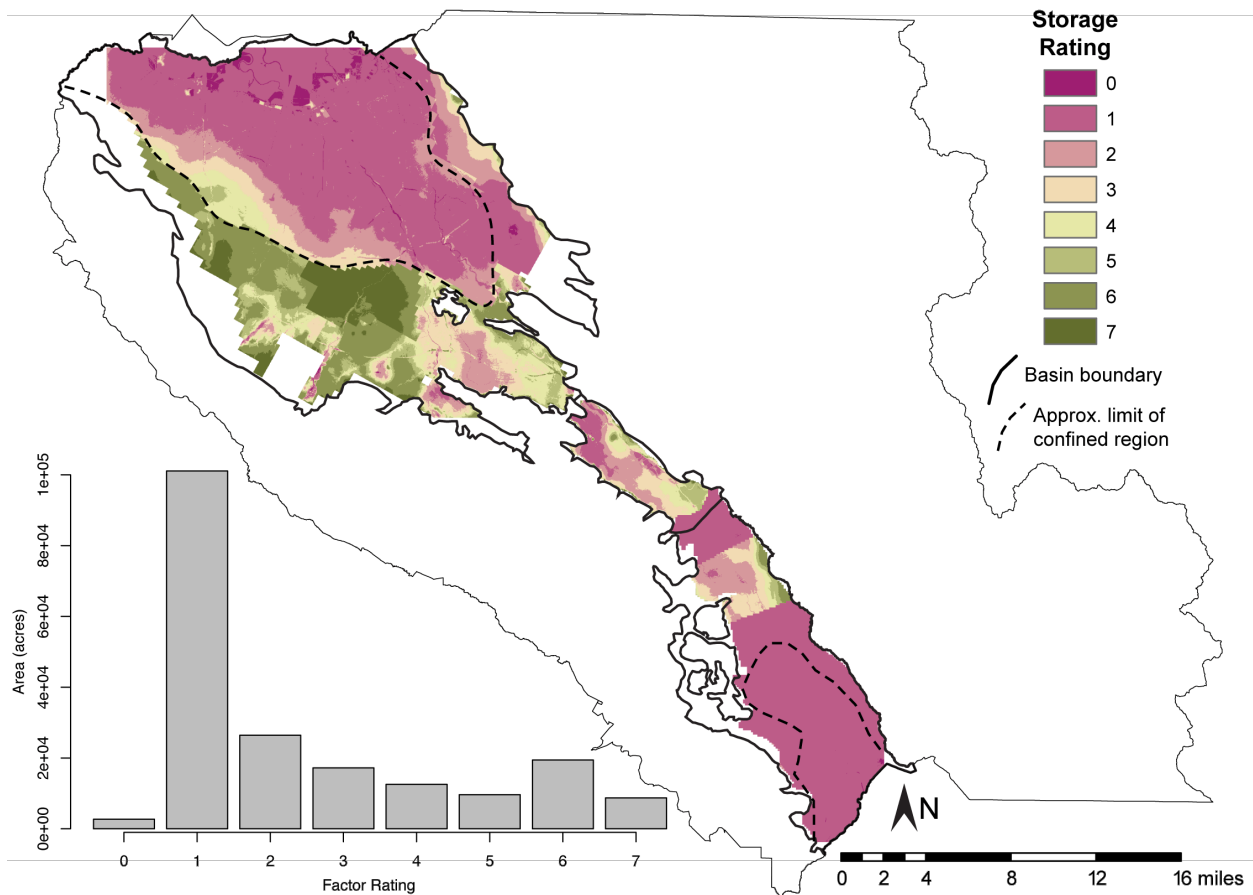


Figure III-18. Ratings of available storage. Rating values defined in **Table III-8** and discussed in text.

Table III-9. Summary of ratings for available storage.

Suitability Rating	Storage (ft)	Area (acres) ^a	% Land Area ^a
0	0	2,700	1.4
1	0 - 1	101,100	51.1
2	1 - 2	26,400	13.4
3	2 - 3	17,200	8.7
4	3 - 4	12,600	6.4
5	4 - 5	9,600	4.9
6	5 - 10	19,400	9.8
7	> 10	8,700	4.4

^a Area rounded to nearest 100 acres, percent is relative to extent of the storage coverage.

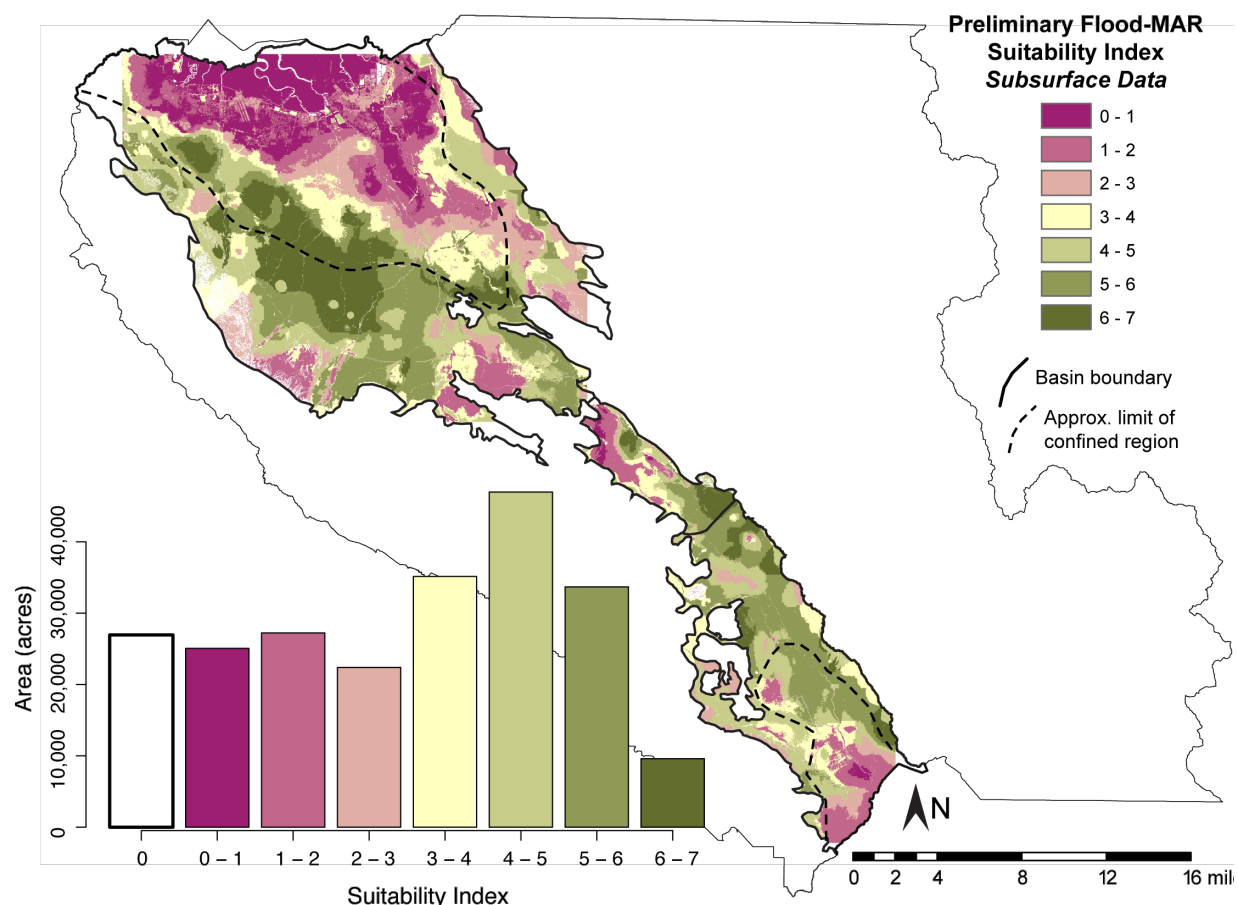


Figure III-19. Preliminary Flood-MAR suitability index for groundwater basins based on subsurface datasets. Factors used for this analysis were vadose zone thickness and climate sensitivity of groundwater levels. Shallow aquifer properties as represented in groundwater models were applied initially, but not used in the (final) analysis shown above because of coarse resolution and concerns about reliability based on model calibration. Areas with each index are listed in **Table III-10**. White spaces within the subbasins in panel A indicate areas where vadose zone thickness is not interpolated because of limited depth-to-water data.

Table III-10. Preliminary Flood-MAR suitability based on subsurface datasets.

Suitability Rating	Area (acres) ^a	% Land Area ^a
0	26,900	11.9
0 - 1	25,100	11.0
1 - 2	27,200	12.0
2 - 3	22,400	9.9
3 - 4	35,100	15.5
4 - 5	47,000	20.7
5 - 6	33,700	14.8
6 - 7	9,600	4.2

^a Area rounded to nearest 100 acres, percent is relative to extent of the subsurface rating coverage.

3. Composite suitability index

A composite Flood-MAR suitability index map, based on all surface and subsurface factors that were rated and weighted, shows considerable spatial variability (**Figure III-20**). This is largely a consequence of the granularity and resolution of surface datasets. More than 35% of the study region for which all datasets exist (i.e., within the groundwater subbasins) has $SI_{\text{composite}}$ values of 4 to 7, comprising ~79,000 acres (**Table III-11**). Importantly, patches with elevated $SI_{\text{composite}}$ values are found throughout the basins.

Three additional displays illustrate ways in which preliminary Flood-MAR SI maps can be helpful in planning and screening project activities. **Figure III-21** shows $SI_{\text{composite}}$ with Valley Water's existing managed recharge operations, including in-stream recharge and groundwater recharge ponds, which are located outside the confined areas within the groundwater subbasins. The location of the mapped boundary between the confined and unconfined aquifer conditions is based on long-standing geologic interpretations, going back decades. While this boundary is considered approximate due to geologic uncertainty and aquifer heterogeneity, it continues to be supported by substantial geologic and hydrogeologic data. Flood-MAR projects would likely be prioritized outside the confined areas in the recharge zones and in locations that complement the spatial coverage of existing managed recharge operations.

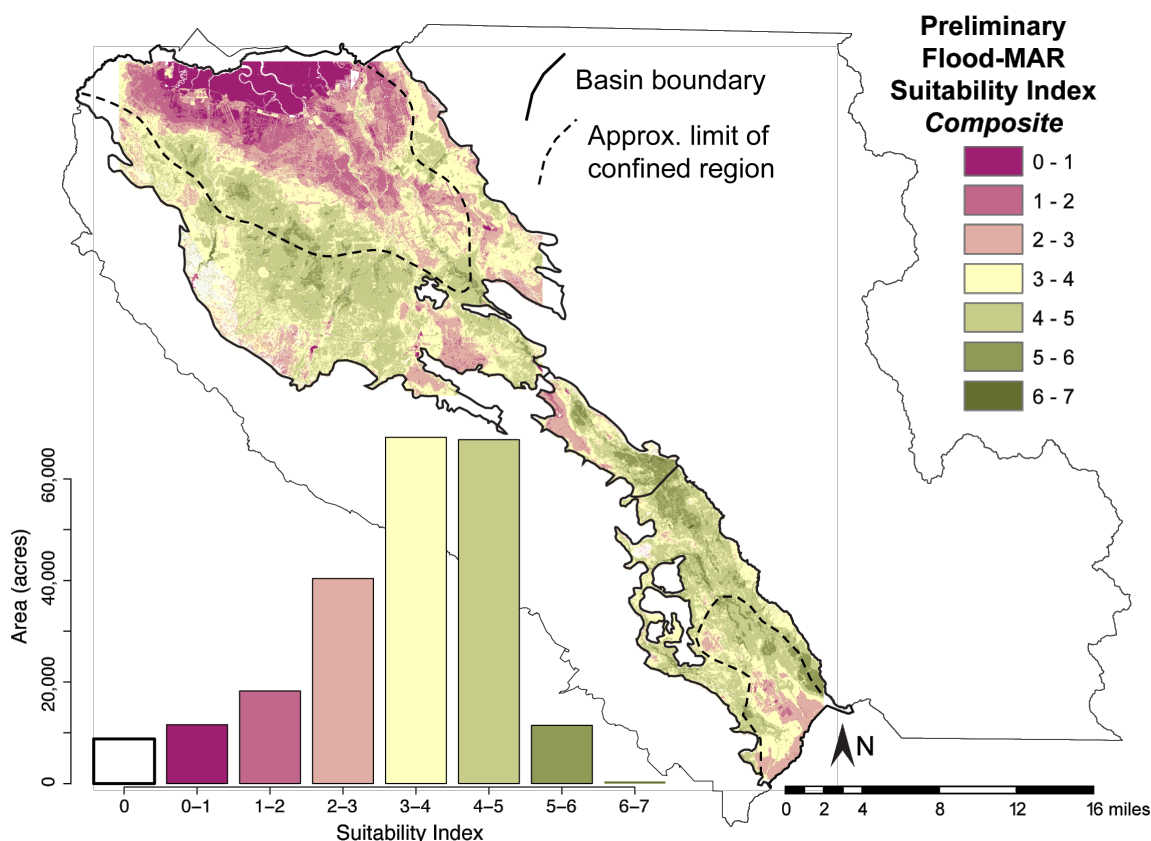


Figure III-20. Preliminary Flood-MAR suitability index for groundwater basins based on composite of surface and subsurface datasets, filtered to remove areas with slopes $\geq 10\%$. Combined surface and subsurface factors were weighted evenly (**Figure III-1A**). Areas with each index are listed in **Table III-11**. White spaces within the subbasins in panel A indicate areas where vadose zone thickness is not interpolated because of limited depth-to-water data.

Table III-11. Preliminary Flood-MAR suitability based on composite analysis.

Suitability Rating	Area (acres) ^a	% Land Area ^a
0	8,800	3.9
0 - 1	11,600	5.1
1 - 2	18,200	8.0
2 - 3	40,400	17.8
3 - 4	68,200	30.1
4 - 5	67,700	29.9
5 - 6	11,500	5.1
6 - 7	400	0.2

^a Area rounded to nearest 100 acres, percent is relative to extent of the composite rating coverage.

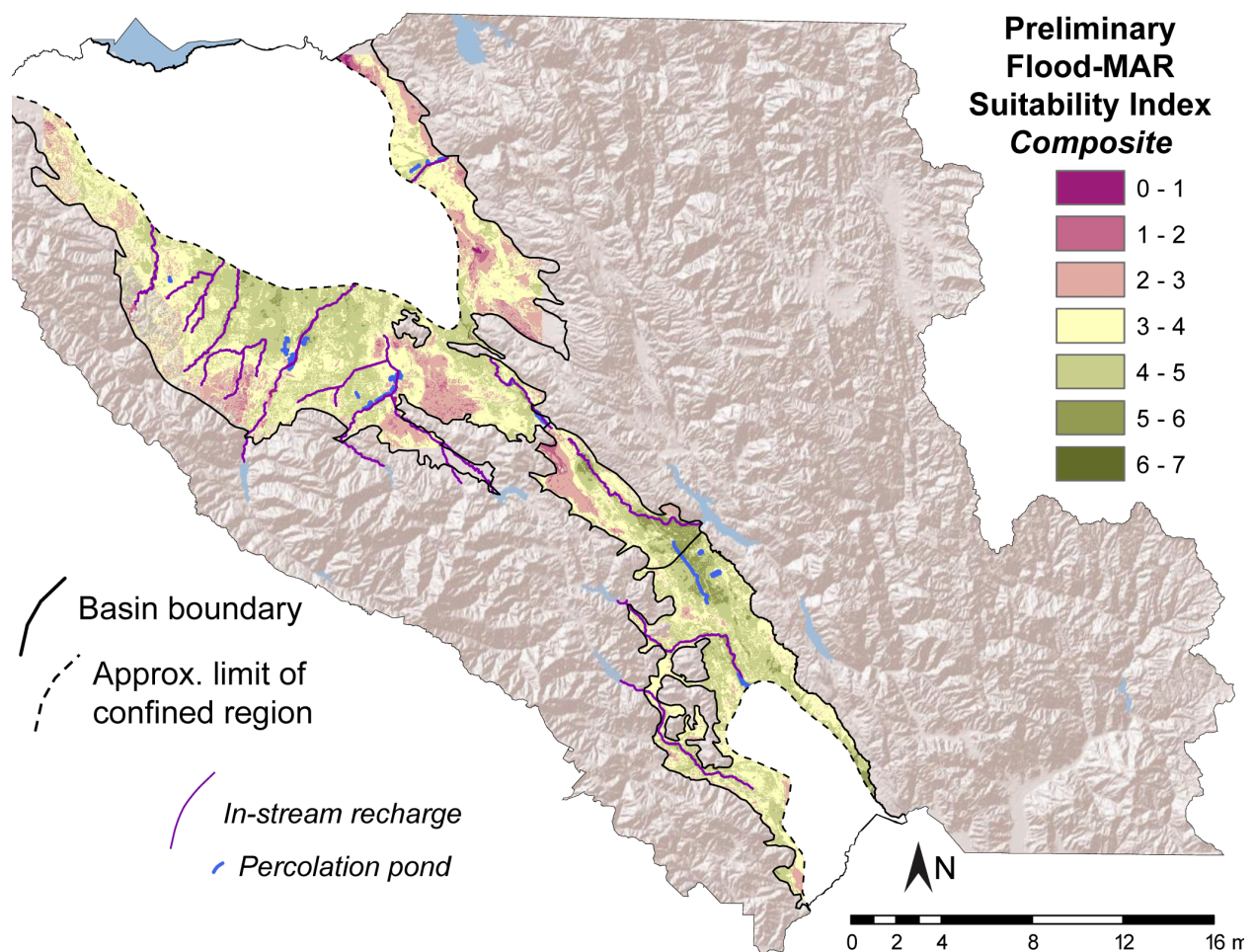


Figure III-21. Valley Water's existing managed recharge operations and losing streams overlaid on the preliminary Flood-MAR suitability index map. Comparison of these data allows identification of potential Flood-MAR project sites that complement existing activities and conditions. Areas having confined conditions are denoted with white polygons having dashed boundaries.

A plot of water quality (represented by TDS concentration) on top of $SI_{\text{composite}}$ helps to show where areas with elevated suitability have more or less salt in ambient groundwater (**Figure III-22A**). Depending on project goals, Flood-MAR projects could be prioritized where water quality is better or worse, implying consequent application of recovered water having higher quality or likely dilution where groundwater is impaired, respectively. A map showing parks and related open spaces over $SI_{\text{composite}}$ (**Figure III-22B**) could help with identification of potential project sites that could help to generate multiple ancillary benefits, including improved habitat, where there are fewer concerns about food safety compared to areas that are developed for agriculture. These maps are shown as examples; one benefit of generating a working GIS project is that this allows for new factors to be considered, analyses to be revised, and new maps generated as program and project ideas develop. The working GIS also allows for higher-resolution assessment of potential site locations than is apparent on printed pages or image files with a fixed raster format.

C. Discussion of Results, Limitations, and Next Steps

1. Use and limitations of work to date

This GIS project should prove useful to Valley Water and their stakeholders, contractors, and collaborators in exploring options for developing a Flood-MAR program in the Valley Water service area. Resulting SI maps (**Figures III-14, III-19, and III-20**) suggest that there could be opportunities, but also indicate important limitations to this approach. First, mapping of Flood-MAR suitability should be considered as useful mainly as a screening tool, particularly in the early stages of program and site assessment. It can also be useful for explaining why a site that "seems good" to a stakeholder or based on initial inspection may not be suitable because subsurface conditions are often not well correlated to those seen at the surface.

Even within this context and use case, the SI maps are fundamentally limited by the accuracy and resolution of available data. For surface coverages like *LULC*, these can change over short time periods, and factor coverages derived over multiple years (or even decades) could result in inconsistent merging of data periods. For subsurface coverages like transmissivity or available storage, there are limitations based on model resolution and the direct measurements that provided the basis for calibrating groundwater models. Groundwater models have been calibrated multiple times over a period of years, beginning when there was much less available data and the development of a three-dimensional stratigraphic model was more difficult than it would be today, and the resolution of these models is relatively coarse.

We encourage considering the datasets used in this study to be a useful snapshot of the state of available knowledge, a foundation upon which Valley Water can build greater understanding and aid in systematic decision making about if, how, and where to create a Flood-MAR program and develop initial projects. Because the main product of this work is a dynamic GIS project, not a small series of static maps, the potential for expansion and application of this work can grow over time. The dynamic nature of the GIS also allows for a sensitivity study to assess how robust the SI maps may be to different choices in the MCDA process.

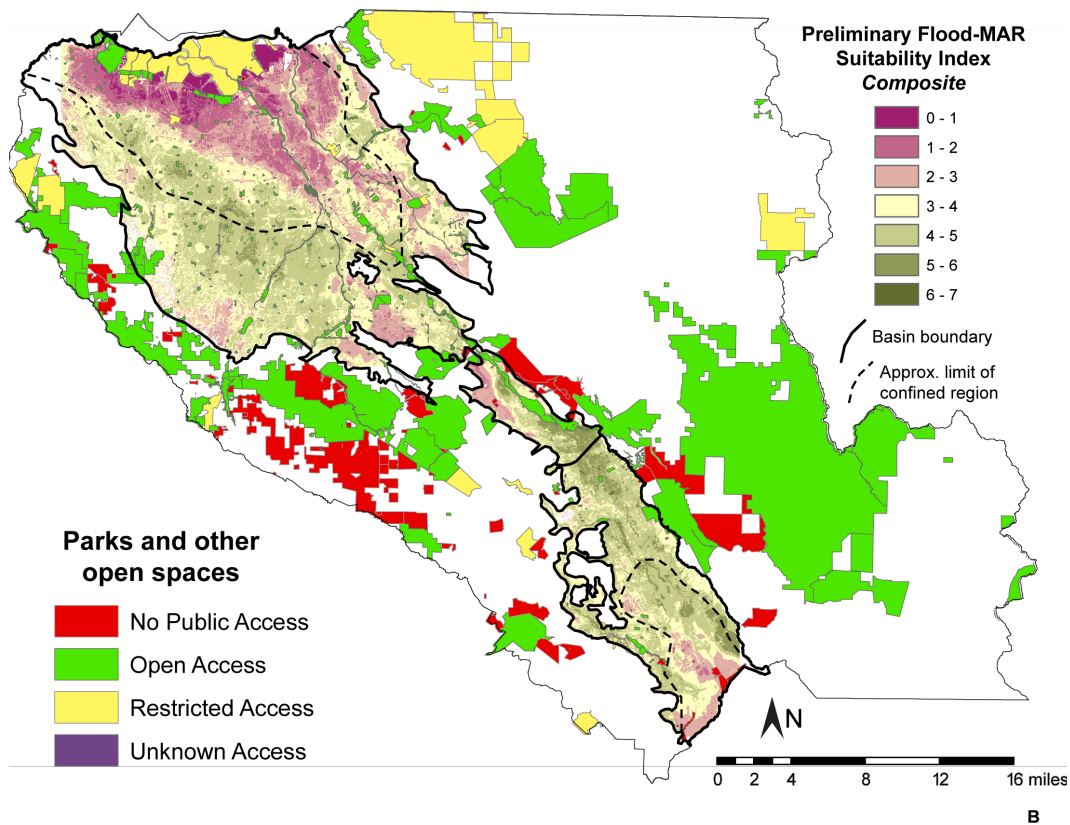
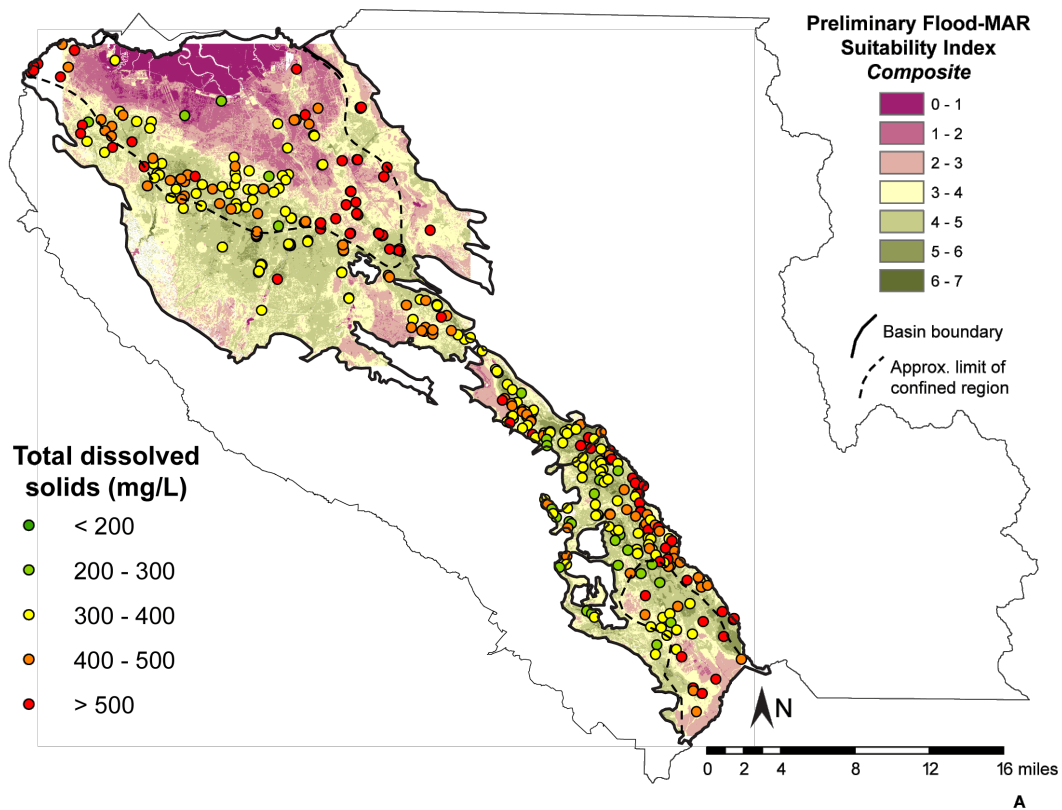


Figure III-22. Examples of data overlays that could be used to focus on specific areas for potential Flood-MAR projects, with composite suitability index used as base map. **A.** Water quality indicator (total dissolved solids). **B.** Open space.

2. Additional filters and constraints that could be applied

Numerous additional considerations were not included in this pre-feasibility assessment. Perhaps the most important of these is an evaluation of available water supplies. In the Pajaro Valley, a similar GIS-based assessment of Flood-MAR suitability was augmented by hydrologic runoff analyses, using a catalog of climate responses under different land-use scenarios, to quantify how much stormwater runoff could be generated at potential project sites.⁶⁴ Deterministic simulations of this kind are certainly useful, but they require compilation and manipulation of dozens of high-resolution datasets, then running numerical models and performing a complex calibration process. It may be that some form of statistical assessment could provide useful indications of opportunities for stormwater collection in non-urban areas within the Valley Water service area. Other potential water sources in support of Flood-MAR could, in principle, include storm flows in creeks and streams, advanced purified water, or imported water. However, Valley Water presently has sufficient managed recharge facilities to recharge its available local and imported water. In addition, there are infrastructure limitations that would pose challenges for delivering advanced purified water to a decentralized system of Flood-MAR basins. Some assessment of water supply options is provided in Part II.

Given options for water supplies, as well as methods for accomplishing Flood-MAR objectives, water cost and value considerations could be incorporated into the MCDA process for assessing site suitability. Valley Water could also take into account the presence of disadvantaged communities or other social factors, and potential benefits of Flood-MAR efforts for baseflow and aquatic systems. As previously noted, this project is being delivered as a working GIS that can be updated, revised, or modified to incorporate priorities and values as desired and as conditions and interests shift over time.

3. Implications and Next Steps

Maps of Flood-MAR suitability can be used to focus (a) incorporation of additional datasets that currently exist, (b) generation of new datasets that could be useful for improving the *SI* analyses, and (c) screening or targeting specific locations for potential Flood-MAR projects. These next steps could be managed in series or parallel.

SI maps indicate that there could be many good opportunities to accomplish Flood-MAR objectives in the Valley Water service area. In general, the Flood-MAR opportunities appear to be most common (as a percentage of groundwater management areas) in the Coyote Valley and Llagas Subbasin. Areas with the highest suitability include old stream channels and other features that have relatively coarse surface and near-surface lithologies, as well as room in the subsurface to receive and transmit excess surface water.

Part III of this report and the associated GIS project should be considered in the context of the findings in **Part II**, which focuses on institutional, incentive, legal, and policy issues. In particular, cost and access considerations could be important filters that help to focus attention on specific physical locations. If institutional and suitability indicators are positive, initial field visits and exploration of water supply options may be justified. It may also be worth considering larger-scale efforts in data collection and generation of datasets that could be added to the existing GIS. Most MAR suitability studies have focused on surface data coverages, but the complexity of the hydrogeologic framework in Valley Water's groundwater basins could help to justify updating the three-dimensional stratigraphic understanding of one or more of these

systems, perhaps in concert with efforts to add resolution to representation of groundwater flow processes simulated with numerical models. The latter could aid in testing of Flood-MAR scenarios. The effort needed to revise the subsurface stratigraphic framework would be significant. For comparison, analysis of ~1,000 groundwater well logs in the Pajaro Valley to define the complex layering and variability of subsurface deposits was a multi-year effort, with a large USGS and agency team, as part of development of a new, regional groundwater model.⁶⁵

D. Summary of Findings and Recommendations

Multicriteria decision analysis of spatial data from the Valley Water service area, using a GIS, suggests that there are numerous locations where surface and subsurface conditions are favorable for Flood-MAR. Within the three primary groundwater management areas, preliminary Flood-MAR suitability based on a composite MCDA using surface and subsurface data is relatively high across ~79,000 acres, equivalent to >35% of the land area. Sites with the highest suitability for Flood-MAR tend to be located where many of these criteria are satisfied: on old stream channels, on and near active (although often ephemeral) stream channels, and on other coarse Quaternary fluvial and alluvial deposits; where land is undeveloped, has low-intensity development, or is used for agricultural activities; where there is a vadose zone 20-100 ft thick; where there have been large differences in groundwater levels during dry climate periods compared to wet periods; and where shallow aquifer properties include high transmissivity and/or high potential for storage of supplemental recharge.

Conditions in the Santa Clara Plain appear to be most favorable for Flood-MAR along the western and southern margins, around and outside of the region dominated by confined conditions. Areas that are unfavorable for Flood-MAR include those underlain by fine-grained bay, wetland, and estuarine deposits. Groundwater levels are relatively high and space for augmenting storage is limited within the urbanized core of this management area, where Valley Water efforts in MAR have operated successfully for decades, but other areas could be considered if suitable water sources were found.

Conditions in the Coyote Valley appear to be most favorable for Flood-MAR along the southern and eastern half of the basin, particularly along active and old stream channels and other fluvial deposits. The northwestern part of Coyote Valley is part of the Laguna Seca wetland complex that has a shallow water table and hydrophobic soils, making it unfavorable for Flood-MAR activities.

Conditions in the Llagas Subbasin appear to be most favorable for Flood-MAR in the northern half and along western margin of the basin, particularly where fluvial deposits cut across areas having finer soils. The southern part of this basin is mapped as being mostly confined, and the regional groundwater flow direction is to the south-southeast and out of the basin, so focusing on northern areas may be most beneficial in terms of improving resource conditions.

There are multiple steps that Valley Water may find useful in advancing Flood-MAR efforts in its service area; these are not mutually exclusive, and it will likely accelerate the pace of progress to undertake more than one at a time.

- The MCDA was completed using a stand-alone GIS with a limited suite of available data coverages. More datasets could be added if it were decided that standard rating

scales could be applied. For example, a dataset showing proximity to losing stream reaches could be added if this were considered to be desirable as a means to enhance aquatic ecosystems, or water quality data could be gridded and added based on whether it would be preferred to adding recharge to areas with higher or lower water quality indicators.

- The existing MCDA can be used to start identifying potential field sites, allowing for a quantitative feasibility assessment of specific project options like site access, permitting, and available water supplies. For the latter variable, an assessment of drainage areas and runoff potential could help to identify sites that meet some threshold criteria (e.g., 200 AFY of available runoff at a single project during a median water year, based on historical or project hydrologic conditions).
- Existing MCDA datasets can be updated to generate new data coverages that will provide additional benefit to Valley Water operations. As one possible example, knowledge of subsurface aquifer properties is currently limited by the resolution and accuracy of existing groundwater models. It is likely that hundreds of well logs that were not available when these models were initially developed could be used to generate a higher-resolution representation of subsurface geological conditions, and this information could be used to assess likely transmission and storage properties. This would be a major effort and is probably not justified on the basis only of improving the MCDA for Flood-MAR; but if an improved stratigraphic representation were helpful for updating groundwater models, it could provide co-benefits for Flood-MAR assessment.
- Potential Flood-MAR sites identified by Valley Water personnel or service area constituents that pass a desktop assessment (including consideration of water supplies, access, and other factors) could be prioritized for nested and increasingly detailed field investigations, to help screen out areas that are not likely to result in a successful project. A typical field assessment might include one or more of these steps:
 - Systematic geophysical surveys using electrical, radar, and/or seismic methods, to determine the site-specific layering and nature of subsurface materials in the upper 75-150 ft-below ground surface.
 - Exploratory drilling using a relatively efficient approach like direct push to collect geotechnical data and/or continuous cores, to assess soil texture, available carbon, shallow groundwater levels, and other characteristics.
 - Monitoring of rainfall on site and in areas contributing to drainage, and potentially measuring (and sampling) runoff if channelized flow occurs, to better understand local patterns and magnitudes relative to those available from long-term meteorological stations.
 - Sampling of local production wells, or monitoring wells if available, with repeat visits on a monthly or quarterly schedule. Standard water quality panels can be run to improve understanding of local groundwater quality and variability.
 - Sites that look favorable following one or more of the criteria noted above could be tested directly for infiltration conditions, at a scale of tens of ft² to acres, if there were access to a suitable water supply for multi-day testing.

Designing, creating, and operating Flood-MAR projects remains at the forefront of technical and institutional innovation. Each region and every potential site is different, and while there are many practices that have proven successful in other areas, a staged and thoughtful approach is important, as is the recognition that one goal of testing and evaluation is to eliminate sites that are not likely to work for Flood-MAR. Evaluating five or ten sites may be required in order to find one or two that have a high probability of success. Screening of projects and sites that would not work for Flood-MAR is an essential part of building a successful Flood-MAR program.

Additional considerations for developing a Flood-MAR program are listed and discussed in Part II of this report. In aggregate, these analyses should help Valley Water to develop a plan for advancing Flood-MAR, helping to distribute a variety of benefits across their service area, and strengthening the resilience and sustainability of essential water resources.

Endnotes

¹ See Mahesh L. Maskey Mustafa S. Dogan, Angel Santiago Fernandez-Bou, Liying Li, Alexander Guzman, Wyatt Arnold, Erfan Goharian, Jay R. Lund, and Josue Medellin-Azuara, *Managing Aquifer Recharge to Overcome Overdraft in the Lower American River, California, USA*, 14 WATER 966 (2022), available at <https://doi.org/10.3390/w14060966>; see also *Climate Change Basics*, CALIFORNIA DEPARTMENT OF WATER RESOURCES, <https://water.ca.gov/Water-Basics/Climate-Change-Basics> (last visited July 27, 2022); California Department of Water Resources, News Release: State Agencies Fast-track Groundwater Recharge Pilot Project to Capture Flood Waters for Underground Storage (Jan. 13, 2021), available at <https://water.ca.gov/News/News-Releases/2023/Jan-23/State-Agencies-Fast-track-Groundwater-Recharge-Pilot-Project>.

² Herman Bouwer, *Artificial recharge of groundwater: hydrogeology and engineering*, 10 HYDROGEOLOGY JOURNAL 121–142 (2002), available at <https://doi.org/10.1007/s10040-001-0182-4>.

³ P. Dillon, S. Toze, D. Page, J. Vanderzalm, E. Bekele, J. Sidhu, and S. Rinck-Pfeiffer, *Managed aquifer recharge: rediscovering nature as a leading edge technology*, 62 WATER SCIENCE & TECHNOLOGY 2338–2345 (2010).

⁴ See, e.g., Janny Choy and Geoff McGhee, *Groundwater: Ignore It, and It Might Go Away*, WATER IN THE WEST (July 31, 2014), <https://waterinthewest.stanford.edu/groundwater/overview/>.

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⁸ See 2018 Flood-MAR White Paper, *supra* note 7, at 23–28.

⁹ Santa Clara Valley Water District, Groundwater Management Plan for the Santa Clara and Llagas Subbasins at 1-7 (2021) (“2021 Groundwater Management Plan”), available at <https://www.valleywater.org/your-water/where-your-water-comes/groundwater/sustainable>; see also *id.* Appendix I, with modifications based on personal communication with Valley Water staff (J. Gurdak, B. Kassab, 5/31/23).

¹⁰ 2021 Groundwater Management Plan, *supra* note 9, at 4-4, 4-6, fig. 4-4.

¹¹ 2021 Groundwater Management Plan, *supra* note 9, at 4-4, 4-14 to 4-19.

¹² See *Current Water Charges*, VALLEY WATER, <https://www.valleywater.org/your-water/current-water-charges> (last visited Feb. 21, 2023); see also *2022–23 Groundwater Production Charge-Setting Process*, VALLEY WATER, <https://www.valleywater.org/your-water/current-water-charges/groundwater-production-charge-setting-process-2022-23> (last visited Feb. 21, 2023).

¹³ *Current Water Charges*, *supra* note 12.

¹⁴ Santa Clara Valley Water District, Water Supply Master Plan 2040 at 13–16 (2019) (“Master Plan”), available at https://www.valleywater.org/sites/default/files/Water%20Supply%20Master%20Plan%202040_11.01.2019_v2.pdf.

¹⁵ Master Plan, *supra* note 14, at Appendix G (Board Agenda Memorandum for January 14, 2019).

¹⁶ Master Plan, *supra* note 14, at Appendix H (Project List as of February 2019).

¹⁷ 2021 Groundwater Management Plan, *supra* note 9, figures 4-2, 4-3.

¹⁸ Hannah Waterhouse, Taylor Broadhead, Aysha Massell, Helen Dahlke, Thomas Harter, and Daniel Mountjoy., *Management considerations for protecting groundwater quality under agricultural managed aquifer recharge*, at 3 (2021), available at <https://suscon.org/wp-content/uploads/2021/06/Management-Considerations-for-Protecting-Groundwater-Quality-Under-AgMAR.pdf>.

¹⁹ Levintal et al. (2022), *supra* note 5.

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²¹ See Sarah Fakhreddine et al., *Mobilization of Arsenic and Other Naturally Occurring Contaminants during Managed Aquifer Recharge: A Critical Review*, 55 ENVIRONMENTAL SCIENCE & TECHNOLOGY 2208–2223 (2021), available at <https://dx.doi.org/10.1021/acs.est.0c07492>.

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²³ Waterhouse et al. (2021), *supra* note 18, at 10, 17; Levintal et al. (2022), *supra* note 5.

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²⁵ Mehdi Ghasemizade, Kwabena O. Asante, Christian Petersen, Tiffany Kocis, Helen E. Dahlke, and Thomas Harter, *An integrated approach toward sustainability via groundwater banking in the southern Central Valley, California*, 55 WATER RESOURCES RESEARCH 2742–2759 (2019), <https://doi.org/10.1029/2018WR024069>; Don Cameron, *Can Flooding Planted Fields Save California Farms?* AMERICAN VEGETABLE GROWER, January 2020, available at <https://www.terranovaranch.com/sustainability/sustainability-water-recharge/can-flooding-planted-fields-save-california-farms/>.

²⁶ Philip Bachand, Sujoy B. Roy, Nicole Stern, Joseph Choperena, Don Cameron, and William R. Horwath, *On-farm flood capture could reduce groundwater overdraft in Kings River Basin*, 70 CALIFORNIA AGRICULTURE 200–207 (2016), available at <https://escholarship.org/uc/item/1vd7b35c>.

²⁷ Bachand et al. (2016), *supra* note 26; McMullin Area Groundwater Sustainability Agency, McMullin On-Farm Flood Capture Expansion Project, Project Brief (2022), available at https://www.mcmullinarea.org/wp-content/uploads/2022/04/20220324-MAGSA-Expansion-Project-Brief_FINAL.pdf; Kings Basin Water Authority, Project Information Form: On-Farm Flood Capture Expansion Project (2015), available at http://www.kingsbasinauthority.org/documents/IRWMP_Project_List/Project_Info_Forms/144_Terranova.pdf.

²⁸ Bachand et al. (2016), *supra* note 26.

²⁹ Ramona O. Swenson, Keith Whitener, and Mike Eaton, *Restoring Floods to Floodplains: Riparian and Floodplain Restoration at the Cosumnes River Preserve, California riparian systems: processes and floodplains management, ecology, and restoration*, at 224–229 in P.M. Faber, editor California Riparian Systems: Processes and Floodplains Management, Ecology, and Restoration. 2001 Riparian Habitat and Floodplains Conference Proceedings. Riparian Habitat Joint Venture. Riparian Habitat Joint Venture, Sacramento, CA. (2003), available at http://www.sjrdotmdl.org/concept_model/phys-chem_model/documents/300001823.pdf.

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³¹ S. Beganskas and A.T. Fisher, *Coupling distributed stormwater collection and managed aquifer recharge: Field application and implications*, 200 JOURNAL OF ENVIRONMENTAL MANAGEMENT 366–379 (2017), <https://doi.org/10.1016/j.jenvman.2017.05.058>.

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³³ See State Water Resources Control Board, Fact Sheet: Purposes of Use for Underground Storage Projects, https://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/docs/purposes_of_use_fact_sheet_final.pdf (last updated June 2020).

³⁴ See, e.g., Governor Gavin Newsom, Executive Order N-3-23, Feb. 13, 2023, available at <https://www.gov.ca.gov/wp-content/uploads/2023/02/Feb-13-2023-Executive-Order.pdf?emrc=63f5cc8b93d44>.

³⁵ See *Temporary Permits for Groundwater Recharge*, STATE WATER RESOURCES CONTROL BOARD, https://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/groundwater_recharge/temporary_permits.html (last visited Feb. 21, 2023); see also CAL. WATER CODE §§ 1425–1431 (governing 180-day temporary permits); CAL. WATER CODE §§ 1433–1433.6 (governing 5-year temporary permits); State Water Resources Control Board, Water Rights Fiscal Year 2022–2023 Fee Schedule Summary, available at https://www.waterboards.ca.gov/resources/fees/water_rights/docs/FY-22-23-Fee-Schedule-Summary-Final.pdf. It is important to note that temporary permits are simply conditional, temporary approvals to divert and use available water. A temporary permit is not a water right, and applying for one does not get the applicant a spot in line in California’s first-in-time, first-in-right system of appropriative water rights. See **Figure II-4**.

³⁶ See *Streamlined Processing for Standard Groundwater Recharge Water Rights*, STATE WATER RESOURCES CONTROL BOARD, https://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/groundwater_recharge/streamlined_permits.html (last visited Feb. 21, 2023).

³⁷ See also Kate Fritz and Nell Green Nylen, *Water right permitting options for groundwater recharge: Avoiding unintended consequences*, LEGAL PLANET (July 27, 2020), <https://legal-planet.org/2020/07/27/water-right-permitting-options-for-groundwater-recharge-avoiding-unintended-consequences/>.

³⁸ See *Permits for Groundwater Recharge*, STATE WATER RESOURCES CONTROL BOARD, https://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/groundwater_recharge/ (last visited Feb. 21, 2023); see also web pages linked from this page.

³⁹ See *Pending Temporary Permits for Underground Storage consistent with Governor Executive Orders*, STATE WATER RESOURCES CONTROL BOARD, (hereinafter “Pending Temporary Permits”), https://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/groundwater_recharge/pending_applications.html (last visited Feb. 21, 2023) (listing temporary permit applications and explaining how to look up application documents in the State Water Board’s eWRIMS database).

⁴⁰ See State Water Resources Control Board, Fact Sheet: Flood Control, Groundwater Recharge, and Water Rights, available at https://www.waterboards.ca.gov/publications_forms/publications/factsheets/docs/flood_control_factsheet.pdf (last updated July 2020); see also Kate Fritz and Nell Green Nylen, *When does a groundwater recharge project NOT need a water right?*, LEGAL PLANET (August 3, 2020), <https://legal-planet.org/2020/08/03/when-does-a-groundwater-recharge-project-not-need-a-water-right/>.

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⁴² See Pending Temporary Permits, *supra* note 39.

⁴³ Application T033322 by Omochumne-Hartnell Water District and the approved Temporary Permit to Divert and Use Water are both available at <https://ciwqs.waterboards.ca.gov/ciwqs/ewrims/DocumentRetriever.jsp?appNum=T033322&wrType=Temporary%20Permit&docType=DOCS>.

⁴⁴ Application T033287 by Central California Irrigation District is available at <https://ciwqs.waterboards.ca.gov/ciwqs/ewrims/DocumentRetriever.jsp?appNum=T033287&wrType=Temporary%20Permit>.

⁴⁵ Table is from Fritz & Green Nylen (July 27, 2020), *supra* note 37.

⁴⁶ See State Water Resources Control Board, Order WR 98-08 Revising Declaration of Fully Appropriated Stream Systems (Nov. 19, 1988), *available at* https://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/orders/1998/wro98-08.pdf.

⁴⁷ See *Groundwater Recharge Permitting - Frequently Asked Questions*, STATE WATER RESOURCES CONTROL BOARD, https://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/groundwater_recharge/faqs.html (last visited Feb. 21, 2023); State Water Resources Control Board, Water Rights Fiscal Year 2022–2023 Fee Schedule Summary, *available at* https://www.waterboards.ca.gov/resources/fees/water_rights/docs/FY-22-23-Fee-Schedule-Summary-Final.pdf.

⁴⁸ See *Fully Appropriated Stream Systems*, STATE WATER RESOURCES CONTROL BOARD, https://www.waterboards.ca.gov/waterrights/water_issues/programs/fully_appropriated_streams/ (last visited Feb. 21, 2023) (displaying FASS on an interactive map); see also State Water Resources Control Board, Map: Declaration of Fully Appropriated Stream Systems, Santa Clara County (August 22, 1991), *available at* https://www.waterboards.ca.gov/waterrights/water_issues/programs/fully_appropriated_streams/docs/fas_maps/santa_clara.pdf.

⁴⁹ Miller et al. (2018), *supra* note 41.

⁵⁰ Miller, Fisher, and Kiparsky (2021), *supra* note 32.

⁵¹ See Christina Babbitt, Kate Gibson, Scott Sellers, Nicholas Brozović, Anthony Saracino, Ann Hayden, Maurice Hall, and Sandra Zellmer, *The Future of Groundwater in California: Lessons in Sustainable Management from Across the West* (2018), *available at* <https://www.edf.org/sites/default/files/groundwater-case-study.pdf>.

⁵² See *Rates*, PV WATER, <https://www.pvwater.org/rates> (last visited Feb. 21, 2023). PV Water collects “groundwater augmentation charges” from those who pump groundwater in its service area and does not distinguish between agricultural and non-agricultural users. For the period from December 2022 through November 2023, the augmentation charge for metered users pumping groundwater outside the delivered water zone is \$282 per AF. *Id.*; see also Pajaro Valley Water Management Agency, Ordinance No. 2021–02, April 21, 2021, *available at* https://www.pvwater.org/images/board-and-committees/board_of_directors_assets/ordinances/Ord.2021-02_Augmentation.Charge.Increase.in.Rates_web.pdf (adjusting groundwater augmentation charges).

⁵³ *Current Water Charges*, *supra* note 12. For 2022–2023, agricultural groundwater production charges are \$36.85 per AF in all benefit zones, while non-agricultural groundwater production charges range from \$368.50 to \$1,724.00 per AF. *Id.* Valley Water’s District Act caps groundwater charges for “agricultural water” at “one-fourth of the rate for all water other than agricultural water.” Santa Clara Valley Water District Act, § 26.7(a)(3)(D), codified at CAL. WATER CODE § 60-26.7(a)(3)(D). Valley Water’s Board of Directors has further restricted charges for agricultural water users through its pricing policies. It adopted Resolution 99-21 in 1999, establishing an “open space credit” that limits groundwater production charges for agricultural water to “one-tenth of the rate for all water other than agricultural water.” LAFCO of Santa Clara County, 2011 Countywide Water Service Review: Chapter 3. Santa Clara Valley Water District at 77 (2011), *available at* https://santaclaralafco.org/sites/default/files/service_reviews/Santa%20Clara%20Valley%20Water%20District.pdf.

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⁵⁵ See, e.g., Ismail Chenini, I., Abdallah Ben Mammou, and Moufida El May, *Groundwater recharge zone mapping using GIS-based multi-criteria analysis: a case study in central Tunisia (Maknassy Basin)*, 24 WATER RESOURCES MANAGEMENT 921–939, (2010), <https://doi.org/10.1007/s11269-009-9479-1>; A.S. Jasrotia, R. Kumar, and A. K. Saraf, *Delineation of groundwater recharge sites using integrated remote sensing and GIS in Jammu District, India*, 28 INTERNATIONAL JOURNAL OF REMOTE SENSING 5019–5036 (2007), <https://doi.org/10.1080/01431160701264276>; A.T. O’Geen, T., M. B. B. Saal, H. Dahlke, D. Doll, R. Elkins, A. Fulton, G. Fogg, T. Harter, J. W. Hopmans, C. Ingels, F. Niederholzer, S. S. Solis, P. Verdegaa, and M. Walkinshaw, *Soil suitability index identifies potential areas for groundwater banking on agricultural lands*, 69 CALIFORNIA AGRICULTURE 75–84 (2015), <https://doi.org/10.3733/ca.v069n02p75>; Russo, Fisher, and Lockwood (2014), *supra* note 54; J. Sallwey, J. P.

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⁵⁷ See, e.g., Marwaha et al. (2021), *supra* note 54; O’Geen et al. (2015), *supra* note 55.

⁵⁸ R.C. Whitter, K. L. Knudson, J. M. Sowers, C. M. Wentworth, K. D. Koehler, and C. E. Randolph, Maps of Quaternary Deposits and Liquefaction Susceptibility in the Central San Francisco Bay Region, California, (2006), U. S. Geological Survey Open-File Report 2006-1037, v. 1.1, Reston, VA, *available at* <https://pubs.usgs.gov/of/2006/1037/>.

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⁶⁵ R.T. Hanson, Geohydrologic framework of recharge and seawater intrusion in the Pajaro Valley, Santa Cruz and Monterey Counties, California (2003), U. S. Geological Survey Water Resources Investigations Report 03-4096, Sacramento CA, *available at* <https://pubs.usgs.gov/wri/wri034096/>; R.T. Hanson, W. Schmid, C. C. Faunt, J. Lear, and B. Lockwood, Integrated Hydrologic Model of Pajaro Valley, Santa Cruz and Monterey Counties, California (2014), U. S. Geological Survey Scientific Investigations Report 2014-5111, Menlo Park, CA, *available at* <https://pubs.usgs.gov/sir/2014/5111/>.



Flood-Managed Aquifer Recharge Pre-feasibility Study in Santa Clara County

Samantha Greene, Ph.D. and Jason Gurdak, Ph.D., Senior Water Resources Specialists

Andrew Fisher, Ph.D., Professor, UC Santa Cruz

Michael Kiparsky, Ph.D., Nell Green Nysten, Ph.D., J.D., and Molly Bruce, J.D., M.E.M., UC Berkeley
Water Conservation and Demand Management Committee, August 28, 2023

Photo courtesy of the Santa Clara Valley Open Space Authority

Water Supply “Ensure Sustainability” Strategy



Secure
existing
supplies and
infrastructure



Expand
conservation
and reuse

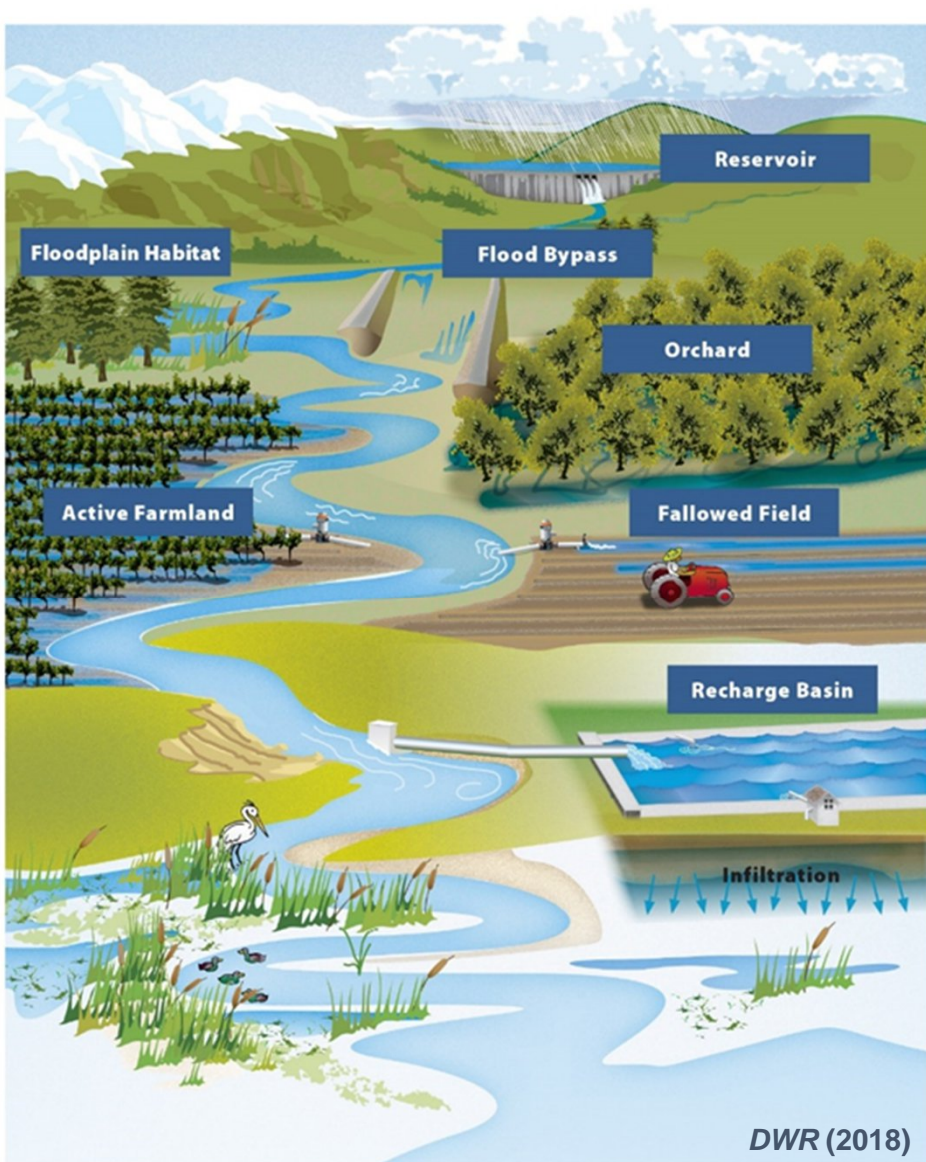


Optimize
the system

- “No Regrets” Package of conservation and stormwater capture projects
 - Includes Flood-Managed Aquifer Recharge (Flood-MAR) on open lands
- Flood-MAR smaller in magnitude than existing Valley Water MAR (tens to hundreds AFY versus ~90,000 AFY)

Flood-MAR

- Physical improvements to captures high flows for aquifer recharge on open space.
- Example Components:
 - Site selection
 - Stormwater collection/routing/infiltration
 - Regulatory requirements
 - Participation incentives
 - Water accounting
- Example considerations:
 - Recharge effectiveness
 - Water quality
 - Implementation costs (scale: hundreds of thousands of dollars per project)



Roadmap for Flood-MAR Study in Santa Clara County

- Step 1: Preliminary feasibility study with UC Water (Water Resources Innovation Partnership)
- Step 2: Pilot Flood-MAR program development, including refining site suitability identification
- Step 3: Pilot Flood-MAR project implementation
- Step 4: Implement Flood-MAR program full scale

Moving to each subsequent step requires positive results from previous steps

Valley Water is currently completing Step 1

Step 1: Water Resources Innovation Partnership

(Jan 2021 to June 2023)

- Partnership Goal: complete a preliminary feasibility study on Flood-MAR implementation in Santa Clara County
 - Evaluate potential program features (e.g., incentives, staffing, permitting, etc.)
 - Develop mapping tool to determine the potential availability of Flood-MAR sites
- Key preliminary feasibility questions:
 - 1) Does Valley Water have the tools and information to develop a pilot program?
 - 2) Does the mapping tool indicate sufficient potential site availability to support pilot program development?



A Flood-MAR program could provide a framework for:

- Project implementation on non-Valley Water land
- Regulatory and engineering management
- Water recharge tracking
- Incentive calculation



Photos: Flood-MAR site
in the Pajaro Valley
(courtesy of Dr. Andrew
Fisher)



Programmatic considerations

- Hillslope capture and infiltration most viable approach
- Creek flow diversions potentially feasible, but most surface water is captured by upstream reservoir
- Third-party entity could support
 - Landowner partnerships
 - Water recharge tracking
 - Incentive calculation
- Valley Water may oversee permitting and water rights applications and tracking/reporting

Costs and Incentives Ideas

- Water rates and grants:
 - Infrastructure costs
 - Program management costs
 - Incentive reimbursement
- Incentives like “Recharge Net Metering”
 - Water rate-based reimbursement may not have motivational power in Santa Clara County
 - Need to evaluate if rebates are consistent with District Act and Proposition 26



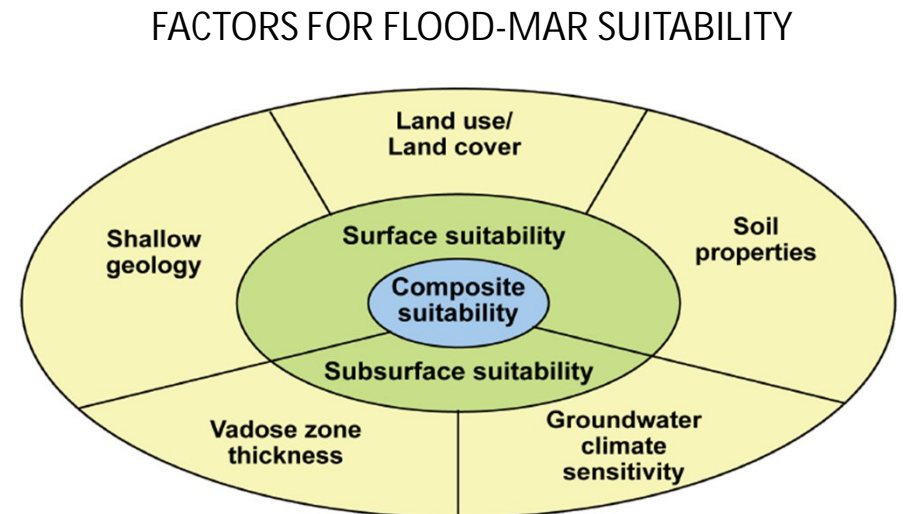
Pumping – **Rebate** = Recharge Net Metering

Source: law.berkeley.edu/ReNeM

Mapping Tool Development

General goal: Identify areas where factors beneficial to Flood-MAR overlap – indicates increased potential for Flood-MAR success in that region.

- Selected datasets incorporated into mapping tool
- Combine datasets into a composite suitability index
- Regional tool → not site-specific

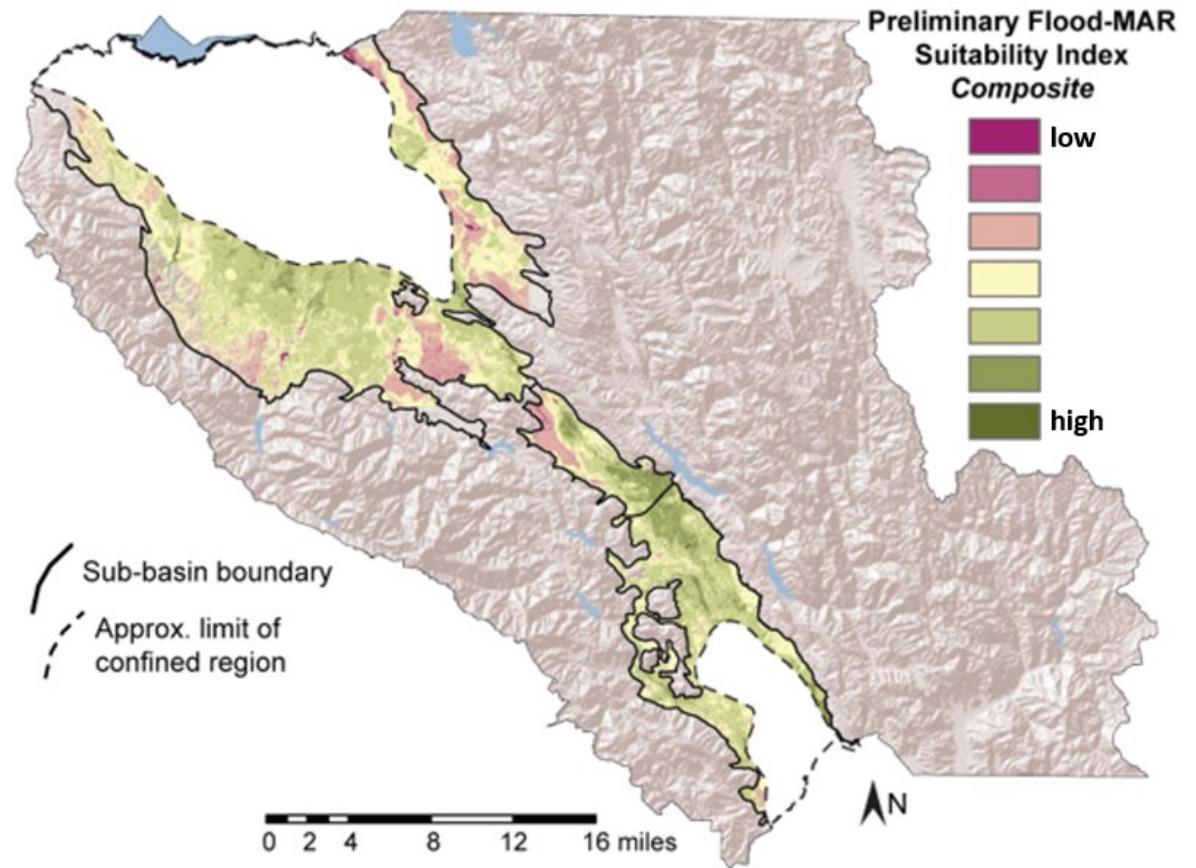


Preliminary Screening

Developed with large-scale datasets

Mapping tool will be refined using additional criteria like water source and land slope.

Field analysis to confirm site suitability will be required at potential project sites



Next Steps

- Pilot program development
 - Design eligibility criteria, permitting approach, and incentive structure
 - Develop third-party partnerships and internal staffing needs
 - Determine project (site level) implementation needs
- Add surface water runoff to mapping tool
- Apply for grant funding as available

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Santa Clara Valley Water District

File No.: 23-0808

Agenda Date: 8/28/2023

Item No.: 4.3.

COMMITTEE AGENDA MEMORANDUM **Water Conservation and Demand Management Committee**

Government Code § 84308 Applies: Yes ☐ No ☒
(If "YES" Complete Attachment A - Gov. Code § 84308)

SUBJECT:

Water Supply Master Plan 2040 Conservation and Stormwater Capture Project Update - "No Regrets" Package Implementation.

RECOMMENDATION:

Receive information on the "No Regrets" package implementation. This is a discussion item, and no action is required.

SUMMARY:

As part of the Water Supply Master Plan 2040 development, Santa Clara Valley Water District's (Valley Water) Board of Directors (Board) approved a "No Regrets" package for implementation in September 2017. The "No Regrets" package of conservation and stormwater capture projects and programs is broadly supported by stakeholders, relatively low cost, and can be implemented independently of other projects and programs in the Water Supply Master Plan 2040. These projects and programs include:

- 1) Advanced Metering Infrastructure
- 2) Leak Repair Incentives
- 3) Graywater Rebate Program Expansion
- 4) Model Water Efficiency New Development Ordinance
- 5) Stormwater Capture

This memo provides an update on the efforts and progress to date on the implementation of the "No Regrets" package. Valley Water is currently in the process of updating the Water Supply Master Plan. The "No Regrets" package will remain part of the updated plan for continued implementation as Staff develops and improves programs to increase savings rates required to meet the long-term water conservation savings targets of 99,000 acre-feet per year by 2030 and 110,000 acre-feet per year by 2040.

ADVANCED METERING INFRASTRUCTURE (AMI)

Advanced Metering Infrastructure (AMI) in concert with a proposed customer-side leak repair incentive program are critical elements to have in place by 2040. AMI facilitates customer engagement with their water usage and enables water retailers to track water usage remotely and frequently.

In 2019, Valley Water partnered with the Bay Area Water Supply and Conservation Agency (BAWSCA) on a study to identify each water retailer's metering and related system, data gaps, and potential for collaborative procurement for AMI as an option for the region. This study, performed by Manage Water Consulting, Inc. and Don Schlenger and Associates, was completed in June 2019. BAWSCA and Valley Water held a joint meeting to review the findings of the study with water retailers from the BAWSCA and Valley Water service areas. The meeting included presentations from project leads of several pilot studies funded by Valley Water's Water Conservation Research Grant Program (funding through Safe, Clean Water), including San Jose Water Company, City of Mountain View and Purissima Hills Water District.

Based on this research and stakeholder engagement, Staff developed AMI Program Guidelines in 2020 to encourage the installation of AMI meters, and to maximize their savings potential by pairing the meters with software that will give near real-time water data on an accessible online database, leak alerts, and water use reports. These guidelines were updated in a stakeholder review process concluding in May 2023 with input from water retailers currently or potentially interested in participating in the AMI Program. The guidelines were presented to the Retailer Water Conservation Subcommittee prior to finalizing.

As of July 2023, Valley Water has cost-sharing agreements providing four million in AMI funding in the following service areas:

- City of Morgan Hill (approx. 17,000 AMI meters funded),
- City of Milpitas (approx. 16,700 AMI meters funded), and
- City of Palo Alto (approx. 21,000 AMI meters funded in June 2023).

Additionally, Purissima Hills Water District has received funding for approximately 1,000 AMI meters through the Safe, Clean Water Program, while the City of Gilroy has funded approximately 14,400 AMI meters through an Integrated Resources Water Management Proposition 1 grant applied for with Valley Water support. While AMI implementation progress across service areas varies, an estimated 48,000 AMI meters have been installed to date in the county through a combination of Valley Water cost-share agreement funding, Valley Water grant funding, and Valley Water support for external grant funding.

Valley Water's goal is to collaborate with retailers and cities throughout our service area to implement AMI through incentives, grants, and support letters (i.e., IRWM, California Public Utilities Commission, etc.). The conservation budget includes dedicated funding to assist in the implementation of this program.

LEAK REPAIR INCENTIVES

Though customers are alerted of possible leaks much more quickly with AMI, a trained workforce is required to fix leaks expeditiously. Valley Water and BAWSCA determined the need for a leak certification (i.e., establishing a licensing program) or certificate program to provide professionals with the necessary skills to identify and repair leaks. After completing this proposed training program, professionals will be placed on a reliable, objective resource list for landlords and homeowners to address leaks.

To conduct comprehensive research and offer training framework recommendations, Valley Water and BAWSCA collaborated on a contract in 2021 with the California Water Efficiency Partnership (CalWEP), a non-profit organization aiming to maximize urban water efficiency and conservation throughout California. The research and deliverables from this partnership will be utilized by Staff to determine logistical aspects of the future training program as well as to develop an RFP to procure a vendor responsible for managing and operating the future program. Phase 1 is complete and encompassed surveying agencies from multiple regions, interviewing and facilitating focus groups with industry experts, and conducting extensive online research. This process highlighted the interest and need across California for an affordable, relevant, and accessible leak detection and repair training program that highlights the importance of water conservation. Phase 2 will be completed later in Summer 2023.

Additionally, Valley Water is conducting two pilots focused on low-income, disadvantaged, or underrepresented communities:

Leak Assessment and Repair Pilot

This vendor-supported pilot is leveraging an existing program between Richard Heath and Associates, Inc. (RHA) and Pacific Gas and Electric's (PG&E's) Energy Savings Assistance (ESA) Program. The program retrofit leaking fixtures and sprinklers, in addition to performing a meter-check for leaks and providing water conservation resources.

Toilet Repair and Retrofit Pilot

This pilot is being performed concurrently with the Leak Assessment and Repair Pilot. This pilot project replaces 1.6 or greater gallon per flush (gpf) toilets with high-efficiency, WaterSense-certified 0.8 gpf toilets. To date, 43 toilet retrofits have taken place and an additional 25 are expected to take place for the month of July.

A total of 211 households have been served through both pilots. The pilots are expected to wrap up in mid-August. Staff will then evaluate water savings and resource requirements to determine whether evolving pilots into a full program is cost-effective in meeting the long-term water conservation savings targets.

GRAYWATER REBATE PROGRAM EXPANSION

In partnership with the non-profit Ecology Action between June 2019 and June 2020, the Graywater Direct Installation Program completed 307 site assessments and installed 71 laundry-to-landscape

graywater systems. 64% of low-income participants chose the no-cost, self-installation option. Ecology Action provided construction assistance to all 36 self-installations throughout the installation process.

These graywater systems replaced potable water irrigation on nearly 31,700 square feet of landscaped area, resulting in a project water savings of 522,386 gallons/year, or 32.1 acre-feet over a 20-year project life. The average 2020 value in water utility bill savings for each participating household was \$48/year. This pilot also trained 20 landscape professionals including 3 licensed contractors who performed work as subcontractors under Ecology Action.

Though at the time the pilot occurred, it was not deemed cost-effective to continue as a standalone program, Valley Water is considering including comparable installation services under its planned procurement to replace the current Lawn Busters Program with Our City Forest. The Outdoor Conservation Direct Install Program Request for Proposal update was discussed at the November 2022 Water Conservation and Demand Management Committee.

Valley Water has continued to develop its Graywater Laundry to Landscape Rebate Program by partnering with cost-sharing retailers to double the overall rebate from \$200 to \$400 in those service areas. In addition to the direct install pilot, Valley Water has issued an additional 42 rebates, for a total of 113 Graywater Laundry to Landscape systems installed in Santa Clara County. While Valley Water does not currently plan to rebate for more advanced Graywater systems, we have provided additional graywater system resources including guides, evaluation tools, virtual workshops and webinars, informational and instructional videos, and a list of local graywater installers available at www.watersavings.org <<http://www.watersavings.org>>.

MODEL WATER EFFICIENCY NEW DEVELOPMENT ORDINANCE

The Model Water Efficiency New Development Ordinance (MWENDO), developed in 2015 by the Santa Clara County Water Efficient New Development Task Force, composed of representatives from Santa Clara County, several cities, Valley Water, Sustainable Silicon Valley, and Joint Venture Silicon Valley, is intended to be adopted by jurisdictions in Santa Clara County to ensure water use efficient in new development. The ordinance, which has received support from the local Sierra Club chapter, is designed to be customizable depending on cities' needs and includes a variety of water efficiency measures for new developments such as:

- Single-Family Residential
- Multi-Family Residential and Nonresidential Projects
- Commercial Facilities

Valley Water continues to monitor actions related to the adoption of MWENDO and provide staff support to municipalities as part of ongoing efforts to support cities' and the County's interests in expanding water efficiency measures. To assist jurisdictions with MWENDO adoption, Valley Water has developed a template staff/Council agenda report, a cost-effectiveness study, and instructions for filing with the California Building Standards Commission (CBSC) and California Energy Commission (CEC). So far, Valley Water has reached out to every jurisdiction in the county at the City Manager or

City Council level for their consideration and adoption of the MWENDO. At this time, no cities in Santa Clara County have yet officially adopted MWENDO, however, some cities already have many of these measures as part of their existing municipal code and may consider additional measures to be included as part of the upcoming 2025 building code adoption cycle.

While the 2022 version of California's Title 24 building code update was effective January 1, 2023, jurisdictions can adopt additional reach codes like MWENDO at any time. Currently, Valley Water is finalizing updates to the ordinance to reflect the latest Title 24 updates and water conservation reach code best practices. The revised MWENDO will include a supplemental provision to encourage cities and the County to prohibit irrigation of decorative, non-functional turf with potable water on CII sites within their jurisdictions.

STORMWATER CAPTURE

Stormwater capture can have water quality, water supply, flood management, environmental, and community (e.g., aesthetics, recreation, and education) benefits. The "No Regrets" package proposed evaluating stormwater capture projects to develop at least 1,000 acre-feet per year (AFY) on average of stormwater water supply (which brings the 2040 target from 109,000 to 110,000 acre-feet saved per year). To this end, Valley Water is evaluating, and in part implementing, two different scales of stormwater capture projects - "centralized" and "decentralized":

"Centralized" projects are those that capture water from multiple parcels and/or are municipal projects, including "green streets" projects and stormwater recharge on open space (e.g., Flood-Managed Aquifer Recharge). "Decentralized" projects focus primarily on keeping stormwater onsite and/or private citizen projects. Valley Water has implemented two decentralized programs - rain barrel/cistern rebates and rain garden rebates.

Centralized Projects

To support the evaluation of centralized projects, Valley Water led the development of the Storm Water Resources Plans (SWRP) for the northern part of Santa Clara County flowing to the Bay and for the South County area flowing towards Pájaro Watershed. The SWRPs develop, prioritize, and plan "centralized" stormwater projects in Santa Clara County that are typically located on public lands. Valley Water will continue to track city and County efforts, develop partnerships where there may be complementary project interests; and seek grant funding for partnership projects.

In addition to the SWRPs, staff are also investigating the potential to use open space for stormwater recharge. An example of this type of project is in the Central Valley where floodwaters are diverted onto some orchards to recharge the aquifer. The planned flooding for groundwater recharge is referred to as flood-managed aquifer recharge (Flood-MAR). Staff are monitoring the pilot projects to determine impacts and benefits to crops, water quality, and water supply. As noted by the California Department of Water Resources (DWR), "complex technical, legal, and institutional barriers and challenges affect the planning and implementation of Flood-MAR projects" including water rights, permitting, and environmental considerations. However, recognizing the broad potential benefits of Flood-MAR, DWR is leading the statewide efforts to evaluate these issues with stakeholders with the

goal of expanding Flood-MAR on agricultural lands and working with landscapes throughout California. Staff are engaging in these statewide efforts. In addition, Valley Water recently completed a preliminary feasibility analysis on Flood-MAR in Santa Clara County. The study indicates there may be sites that could support stormwater recharge, but site level analyses would need to be done to determine project feasibility. The preliminary feasibility study will be presented to the WCADM and EWRC in August.

Decentralized Projects

Regarding “decentralized” projects, Valley Water launched Rainwater Capture rebates under its Landscape Rebate Program on January 1, 2019. This program, which encourages customers to participate in decentralized stormwater capture, includes rebates for rain barrels, cisterns, and rain gardens.

The program rebate amounts are as follows: \$35 per qualifying rain barrel installed to collect rainwater from existing downspouts; \$0.50 per gallon for diverting existing downspouts to qualifying cisterns; and \$1 per square foot of roof area diverted (up to \$300 per site) into an installed rain garden to collect roof water runoff. Cities of Cupertino, Milpitas, Morgan Hill, and Santa Clara as well as San José Municipal Water Services have or currently cost share with Valley Water to increase Rainwater Capture rebate amounts. Since 2019, 56 cisterns (50,345 gallons), 657 rain barrels, and 90 rain garden (from ~61,000 sq ft of roof surface) rebates have been issued. Additional details are available at <https://valleywater.dropletportal.com/overview/>.

ENVIRONMENTAL JUSTICE IMPACT:

There are no Environmental Justice impacts associated with this item.

ATTACHMENTS:

Attachment 1: PowerPoint Presentation

Attachment 2: Water Conservation Flyer

UNCLASSIFIED MANAGER:

Kirsten Struve, 408-630-3138



No Regrets Package

Presented by: Metra Richert, Water Supply Planning & Conservation Manager
Water Conservation and Demand Management Committee, August 28, 2023



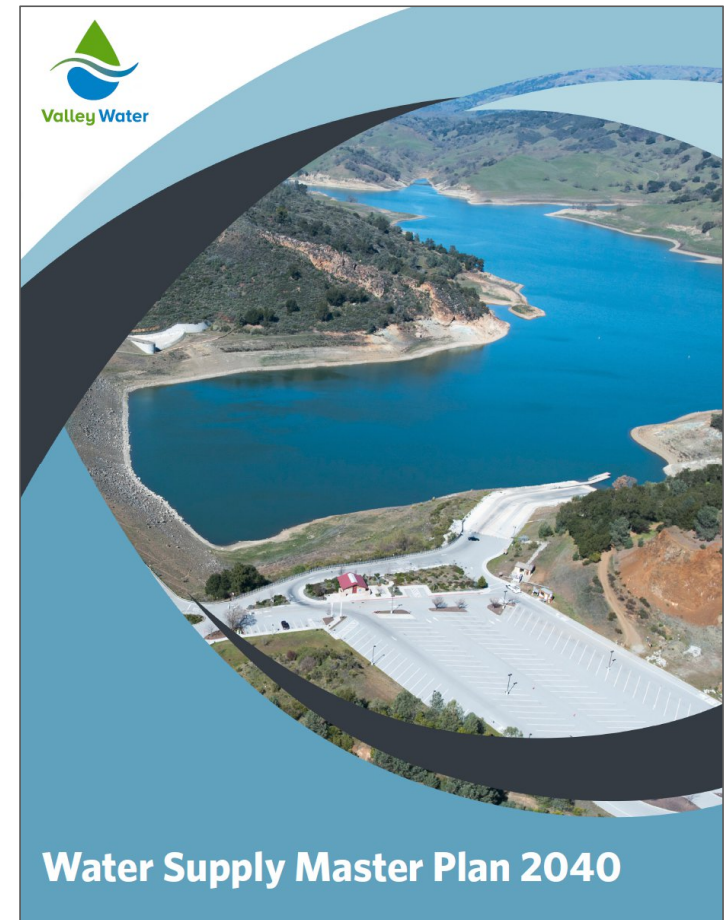
Water Supply Master Plan

Guiding document for long-term water supply investments

Major update every five years

“No-regret” package part of Water Supply Master Plan 2040

Approved by the Board in 2017



No Regrets Package

An investment of \$100 million to provide 11,000 acre-feet of water supply savings at a unit cost of about \$400 acre-foot

Menu of conservation and stormwater capture projects

1. Advanced Metering Infrastructure
2. Leak Repair Incentives
3. Graywater Rebate Program Expansion
4. Model Water Efficiency New Development Ordinance
5. Stormwater Capture

AMI and Home Water Use Reports

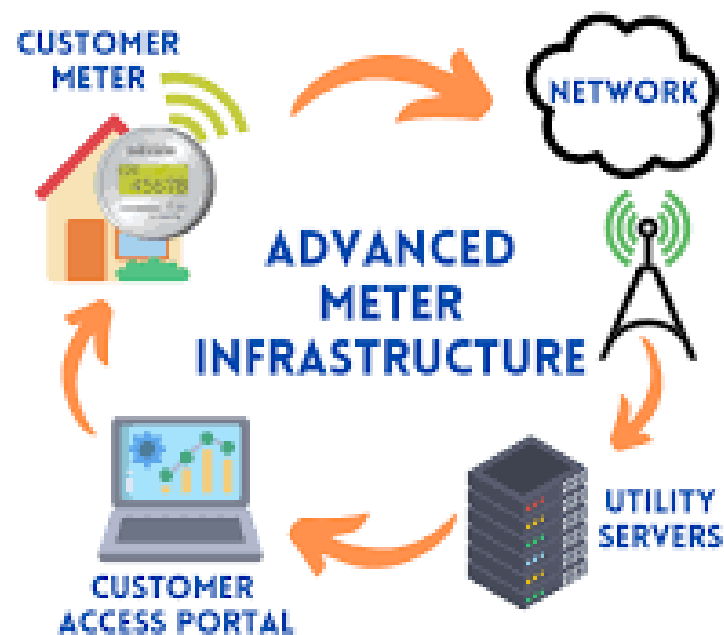
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Joint study with BAWSCA – 2019

Develop AMI program cost-share guidelines – 2020

Updated AMI program cost-share guidelines - 2023

HOW DOES AMI WORK?



valleywater.org

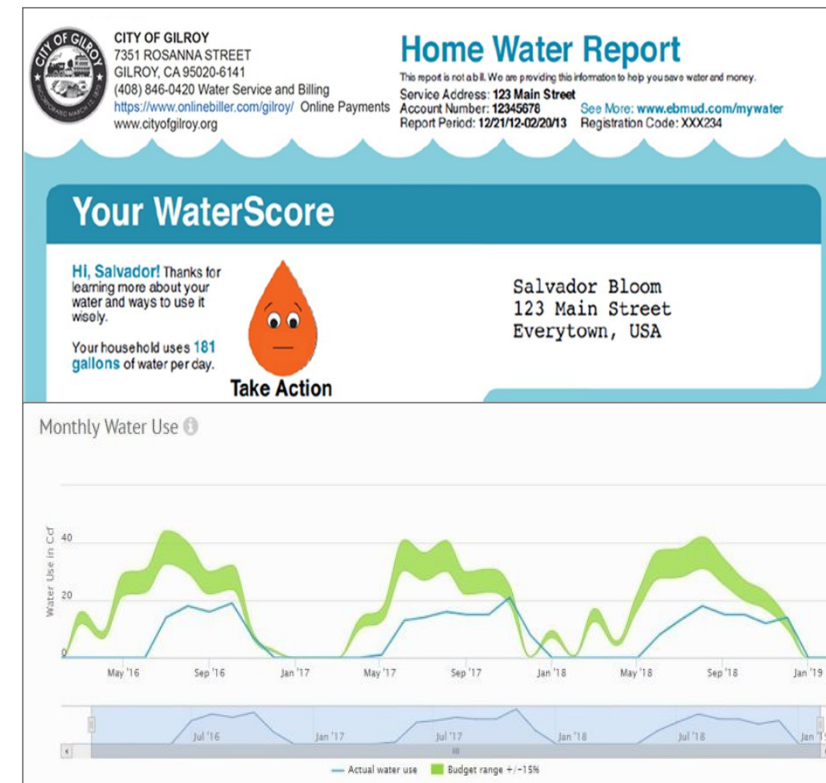
AMI and Home Water Use Reports

Advance Metering Infrastructure (AMI)

- Milpitas, Morgan Hill, Gilroy, Palo Alto, San Jose Water Company

Home Water Use Reports

- Gilroy, Santa Clara, Milpitas, Morgan Hill, San Jose Muni



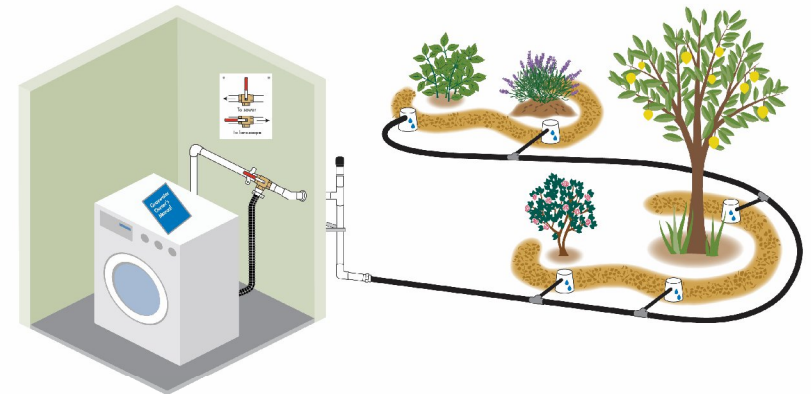
Leak Repair Incentives

- Research showed the need for a leak certification or certificate program to provide professionals with the necessary skills to identify and repair leaks
- Conducting comprehensive research to establish a training framework
- Next steps include developing a request for a proposal
- 211 households have been served under two pilots
 1. Leak Assessment and Repair Pilot
 2. Toilet Repair and Retrofit Pilot

Graywater Rebate Program Expansion

- Completed a Graywater Installation Program
 - Trained a contractor workforce to install code-compliant graywater systems
 - Using the trained contractors, over 75 low-income/underserved Santa Clara County residents had graywater laundry-to-landscape systems installed
- Issued a total of 113 rebates

Laundry to Landscape: Graywater System Example 



This diagram is not drawn to scale and is provided for reference purposes only. It is your responsibility to properly design, install, maintain, and use your laundry-to-landscape graywater system (graywater system). If you are unsure of the intricacies of your plumbing system or how to properly design or install a graywater system, please consult with a professional. Valley Water does not accept any liability and responsibility for any direct, special, indirect or consequential loss or damage whatsoever arising out of or in connection with providing you with access to this diagram.

Model Water Efficiency New Development Ordinance (MWENDO)

8

- Developed in 2015 through a collaboration of various Santa Clara County organizations
- Intended to ensure water use efficiency in new developments
- Designed to be customizable depending on cities' needs
- Every jurisdiction in the county has been approached
- Finalizing updates to the ordinance to reflect the latest Title 24 updates, water conservation reach code best practices, and Valley Water ordinance.

Stormwater Capture

Focusing on decentralized capture:

- Rain barrels
- Cisterns
- Rain gardens
- Flood-Managed Aquifer Recharge (Flood-MAR)

Support centralized and decentralized projects from Stormwater Resources Plans



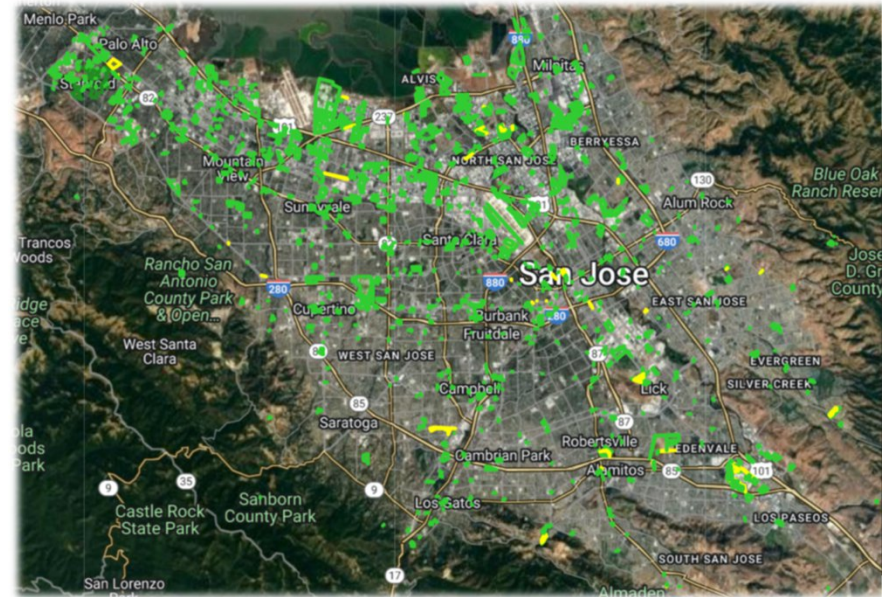
Stormwater Capture

- Cisterns: 56 installed; 50,345 gallons
- Rain Barrels: 657 installed
- Rain gardens: 90 rebates from ~61,000 sq ft of roof surface
- Flood-MAR: Completing preliminary study summer 2023
- Stanford Urban Runoff Purification: Initial water quality study is completed
- Butterfield Basin: Preliminary assessment completed - groundwater too high
- Martial Cottle Stormwater: Indication of high groundwater, further assessment needed

Santa Clara County Stormwater Plans

Santa Clara Basin (North County) and South Santa Clara County Stormwater Resources Plans

- Valley Water led the development of GSI-focused plans using B2 funds
- Collaborative effort with other agencies, non-profits
- Map opportunity areas, prioritize projects
- Required for State funding of stormwater projects
- Compliance with municipal stormwater permit



GSI projects from the Santa Clara Basin Plan. Green areas are GSI sites, yellow areas are green streets.



Valley Water

Clean Water • Healthy Environment • Flood Protection

Water Conservation Rebates and Programs



Say YES to Saving Water!

Valley Water's water conservation rebates and programs are designed to make water conservation easier, helping you say YES to saving water. Learn more about all of our conservation programs and resources by visiting watersavings.org.

Online Shopping Cart

Valley Water offers free water conservation devices that can help you save water. You can request free water efficient devices and free resources to evaluate your water use efficiency. Visit cloud.valleywater.org/shopping-cart to order your FREE gear and literature today!

Landscape Rebate Program

The Landscape Rebate Program can help you create beautiful drought resilient landscapes. Get started by finding more information at valleywater.dropletportal.com. Make sure you submit an online application for approval and schedule a pre-inspection **before beginning any work** on your project.

■ Rebate Caps

The following landscape rebate site caps apply to the combined program components, including Landscape Conversion, Large Landscape Lawn to Mulch, Irrigation Equipment Upgrade and Rainwater Catchment.

- \$3,000 for single-family or multi-family residential properties (4 or fewer units)
- \$100,000 for all commercial, industrial, institutional properties or multi-family residential properties (5 or more units)

Rebate rates and caps may be higher in some areas.
Other programs are capped separately.

■ Landscape Conversion

Any property with qualifying high-water using landscapes (i.e., lawn or functional swimming pools) can receive a rebate of at least \$2 per square foot (sq. ft.) for converting to a drought resilient landscape.

■ Large Landscape Lawn to Mulch

Any commercial, industrial, institutional properties or multi-family residential properties can receive a rebate of at least \$1 per sq. ft. for converting a qualifying lawn to a minimum of 3 inches of mulch (minimum 15,000 sq. ft. lawn area). The irrigation system watering any trees in the converted lawn area needs to be converted to a low-flow irrigation system. Golf course options are offered.



A converted low-water use garden featuring California poppies in bloom.

■ Irrigation Equipment Upgrade

Rebates are offered for replacing old, inefficient irrigation equipment with new, qualifying high-efficiency equipment, including:

- High-efficiency nozzles (up to \$5 each)
- Rotor sprinklers or spray bodies with pressure regulation and or check valves (up to \$20 each)
- Rain Sensors (up to \$50)
- Flow sensors, hydrometers, and dedicated landscape meters (up to \$1,000)
- Smart irrigation controllers (up to \$300-\$2,000 each)
- Sprinkler to In-Line Drip Conversion (\$0.25 per sq. ft.)

■ Rainwater Capture

Rainwater capture or diversion projects collecting rainwater from existing downspouts can receive rebates for the following:

- Rain barrels up to 199 gallons (up to \$35 per barrel)
- Cisterns 200 gallons or more (\$0.50 per gallon)
- Rain gardens (\$1 per sq. ft. of roof area diverted, up to \$300)

Graywater Rebate Program

Receive at least \$200 per home for transforming your clothes washer into a graywater system. Plants don't need drinking water to thrive: reuse graywater in your yard! Apply online and find how-to videos at watersavings.org. No pre-inspection is required but **wait for approval before beginning any work**.

Landscape Surveys

Request to have your landscape and irrigation system surveyed by a trained irrigation professional for FREE. Following the survey, the specialist will provide you with a customized report, outlining any apparent leaks or inefficiencies, suggestions for irrigation scheduling, and recommendations for money-saving landscape rebates. Whether your landscape is small or large, we have a program to fit your needs.

Water Wise Outdoor Survey Program

A Water Wise Outdoor Survey is for landscapes at single-family, small commercial, industrial, institutional properties or multi-family residential sites up to half an acre. To get started, have a recent copy of your water bill on hand and submit a request at valleywater.org/outdoor-survey.

Call **408-630-2000** or email waterwise@valleywater.org with questions. If you are a customer of San Jose Water Company, please contact them directly to schedule a CATCH survey at **408-279-7900** or customer.service@sjwater.com.

Large Landscape Program

A Large Landscape Survey is for landscapes at commercial, industrial, institutional properties or multi-family residential common areas with over half an acre. Also, free landscape water budgets are available for some properties, which compare your actual irrigation use to a property specific budget. Visit waterfluence.com to see if your property already receives this free benefit. Request a survey at watersavings.org.

Commercial and Facility Rebates

Receive up to \$100,000 for replacing or updating equipment with water-efficient technology that results in measurable water savings. This custom rebate based on the measured amount of water saved is available to qualifying facilities including facilities like businesses, schools, hospitals and government buildings. The rebate is \$4 per 100 cubic ft. of water saved per year, or 100% of the project cost (excluding labor and taxes), whichever is less.

Fixture Replacement Program

Replace old qualifying fixtures for FREE! Inefficient fixtures can be replaced for free by licensed plumbers at qualifying commercial, industrial, institutional properties or multi-family residential properties. Inefficient fixtures that qualify include toilets, urinals, showerheads, faucet aerators, and pre-rinse spray valves. Sign up at blusinc.com, call **800-597-2835**, or customerservice@blusinc.com.

Submeter Rebate Program

Submeters can save 10-30% of water used! Received at least \$150 per installed water submeter by upgrading from a single meter. Accessory dwelling units (ADUs or granny units), mobile home parks, apartments, and condominium complexes can qualify. There is no rebate cap when all eligibility requirements are met.

Report Water Waste

Help local residents and businesses preserve our shared water supply by confidentially reporting water waste and violations of outdoor water-use restrictions. Any specific notes like location, date and time, or frequency will help our inspectors follow up. To report water waste, you may do one of the following:

- Use our Access Valley Water app (by downloading or using the QR code)
- Email waterwise@valleywater.org
- Call **408-630-2000**



CONTACT US

To find out the latest information on Valley Water projects or to submit questions or comments, use our **Access Valley Water** customer request system at access.valleywater.org.



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scvwd



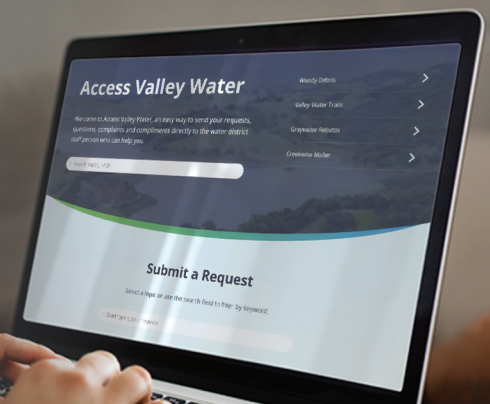
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Santa Clara Valley Water District

File No.: 23-0806

Agenda Date: 8/28/2023

Item No.: 4.4.

COMMITTEE AGENDA MEMORANDUM Water Conservation and Demand Management Committee

Government Code § 84308 Applies: Yes ☐ No ☒
(If "YES" Complete Attachment A - Gov. Code § 84308)

SUBJECT:

Valley Water Demand Model and Forecast.

RECOMMENDATION:

Receive and discuss Valley Water demand model and forecast.

SUMMARY:

As part of the Water Supply Planning program, Valley Water developed and maintains an econometric-based demand model. A reliable water demand forecast is needed to determine the level of investment necessary to meet Santa Clara County's future water supply needs. This memorandum summarizes Valley Water's demand modeling approach and provides the demand forecasts Valley Water proposes to use in its Water Supply Master Plan 2050.

Demand Model Approach

Valley Water's demand modeling integrates the understanding of historic water use trends, housing and economic growth, climate change, and post-drought water use rebound. The model was developed, calibrated, and validated using historic datasets, including sectoral water use provided by the retailers (e.g., residential, commercial, etc.), independent well owner pumping, weather, economic parameters, and housing information (Attachment 1).

The demand model is segmented by billing group (e.g., individual retailers, independent pumpers grouped by groundwater management zone, and agricultural users grouped by management zone). Each retailer is then further segmented into single family, multi-family, and commercial, industrial, and institution (CII) sectors. An econometric equation developed using historic datasets was created for each model segment. The model combines the segment-level equations with projected growth, climate, economic, and drought rebound parameters to forecast Santa Clara County demands. Given the uncertainty in each of the projected parameters, Valley Water is proposing to use a demand range for its Water Supply Master Plan 2050 analyses.

Forecasted Water Use

Valley Water used forecast information on housing and economic growth from the Association of Bay Area Governments (ABAG) Plan Bay Area 2040 and city general plans. Water rate forecasts were provided by the Valley Water Protection and Augmentation of Water Supplies (PAWS) analyses. Climate change data from global climate models were downscaled for Santa Clara County. Valley Water also included a drought rebound assumption that considered the muted rebound seen during the 2012-2016 drought and the Board of Directors (Board) June 2023 resolution to make water conservation a way of life.

Forecasted county-wide 2050 demands for Valley Water range from approximately 330,000-425,000 acre-feet per year (AFY) if Valley Water does not achieve its long-term water conservation goal of 110,000 AFY by 2040. If Valley Water achieves its conservation goal by 2040, then forecasted demands range from approximately 330,000 AFY-390,000 AFY. The lower bound, which is the same with and without conservation forecasts, assumes demands stay constant at 2025 levels through 2050, in part owing to the success in making water conservation a way of life and mitigating the impacts of growth on water use. From a historical perspective, water use dropped 25% in the last 5 years (from 148 gallons per person per day in 2017 to 111 gallons per person per day in 2022). In addition, the county population increased by 25% over the past 30 years, while water demand has decreased by about 8% in that time (1990-2020). The higher bound demand is significantly impacted by severe climate change and growth. As part of the Water Supply Master Plan update, Valley Water is developing a 2050 conservation target and will bring it to the committee for review when ready; thus, no conservation is accounted for between 2040-2050 in the reported forecasts.

Next Steps

Valley Water will continue to track growth, economic, and climatic factors that can impact demands and update forecasts as needed. Valley Water plans to use the demand forecast data in water supply modeling that will inform Water Supply Master Plan 2050 investment recommendations.

ENVIRONMENTAL JUSTICE IMPACT:

There are no Environmental Justice impacts associated with this item.

ATTACHMENTS:

Attachment 1: Demand Model Development
Attachment 2: PowerPoint Presentation

UNCLASSIFIED MANAGER:

Kirsten Struve, 408-630-3138

March 2, 2020

To: Samantha Greene, Ph.D.

From: Luke Wang
Jack Kiefer
Kinsey Hoffman
Leah Benschung

cc: Jing Wu, Metra Richert, Jessica Lovering

Technical Memorandum 3

Modeling Approach and Development

Introduction

Santa Clara Valley Water District (Valley Water) has developed a new model to forecast total water demand in Santa Clara County. Demand projections from the model will be used to support several planning initiatives and documents including:

- The 2021 Urban Water Management Plan (UWMP);
- Monitoring of and updates to the Water Supply Master Plan;
- Inputs to Valley Water's water supply planning model; and
- Evaluation of conservation programs and capital projects.

Valley Water manages a diverse portfolio of water supplies to provide water to Santa Clara County's 13 water supply retailers and non-retailer groundwater pumpers.¹ The majority of water users in Santa Clara County are customers of the water supply retailers. As a result, each retailer typically develops their own water demand forecasts. These forecasts are useful and have been used to inform Valley Water's prior UWMPs. However, Valley Water is responsible for County-wide water resource planning activities (e.g., groundwater management, treated water production, potable reuse development, surface water infrastructure management and development, and active conservation program implementation); collectively, these activities are better served by a consistent modeling approach and planning assumptions across the service area.

The purpose of this Technical Memorandum (TM 3) is to document the modeling approach selected to develop Valley Water's updated demand model. Major characteristics of the modeling approach include a statistical/econometric analytical framework, differentiation of rates of water use from drivers of growth, and model segmentation based on geography (e.g., retail agency), time of year, and water use sector. TM 3 also includes a summary of the statistical model fits and performance compared to historical

¹ Non-retail groundwater pumpers include private well owners that are outside of retailers' service areas.

observations of water consumption. Discussions of model fits and performance are organized based on water use sector segmentation and includes the following sectors:

- Single family;
- Multifamily;
- Commercial, Industrial, and Institutional (CII); and
- Non-retailer groundwater pumpers.

The model sectors are designed to establish baseline demand projections without considering additional future water conservation. Projections of future conservation savings are generated separately by Valley Water's water conservation model and then deducted from the baseline projections generated for the model sectors described herein.

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1. Modeling Approach

Valley Water’s demand model is organized following the demand forecasting typology identified in TM 1.² This section provides a general overview of this approach to establish context for detailed discussions on model development in Sections 2 – 5 of this TM.

1.1 Model Segmentation

The demand model was segmented based on type of provider, i.e., retail agency or non-retail groundwater pumper. Within each provider type, the model was further segmented by geography, sector/billing classification, and time of year. For retail provided water, model geographies were based on each retail agency’s service area within Santa Clara County. Billing classifications often differed among retail agencies necessitating standardization of billing classifications into common sectors (e.g., single family, multifamily, commercial, industrial, and institutional). Appendix A provides a detailed summary of the billing classifications for each retail agency, and the standardized sectors used for modeling; Valley Water directly solicited the retail agencies for input in standardizing billing classifications, particularly for classes that have the potential to span across multiple water use sectors (e.g., landscape irrigation and recycled water). Non-retail groundwater pumpers were organized geographically by groundwater basin charge zone, including W2 (representing the Santa Clara Plain sub-basin management area) and W5 (representing the Llagas sub-basin and Coyote Valley sub-basin management area). Water use classifications for non-retail groundwater pumpers are consistent across each charge zone and include agricultural, municipal, and domestic water use types. These water use classifications were ultimately organized into two model sectors, Municipal and Industrial (M&I) and Agricultural (Ag).

The retail agency demands were modeled using a monthly timestep, and non-retail groundwater pumper demands were modeled using an annual timestep. Non-retail groundwater pumper annual demands were then post-processed to monthly demands using a monthly distribution. Figure 1-1 further details the hierarchical structure of model segmentation.

² Technical Memorandum 1: Benchmark Analysis of Regional Demand Projection Models.

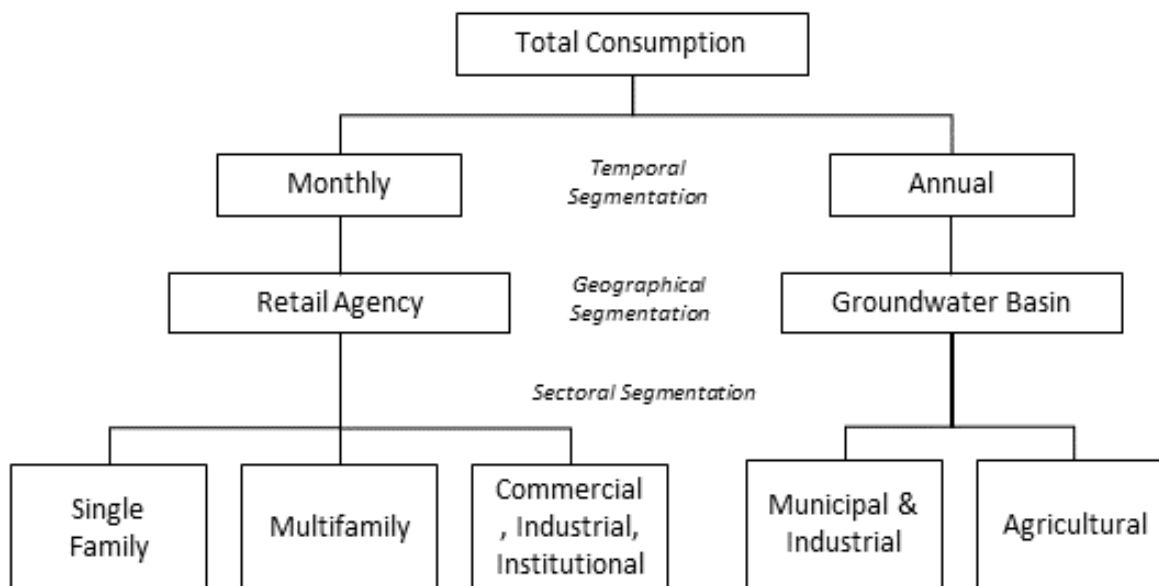


Figure 1-1: Hierarchy of Model Segmentation

1.2 Rate of Use Differentiation

Rate of use differentiation (i.e., characterizing consumption to reflect water using intensity) was applied in developing the retailer models. Rates of use were calculated given Equation (1) below, where for any given model sector Q reflects volumetric consumption, N is the count of driver units, and q is the rate of water use per driver unit.

$$Q \equiv N * \frac{Q}{N} \equiv N * q \quad (1)$$

Rate of use differentiation requires a reliable and consistent historical driver unit dataset for model development and a corresponding future dataset representing projected driver unit counts. Consistent and reliable driver unit datasets for the retailer models were developed using data from the California Department of Finance (CADO; historical data) and the Association of Bay Area Governments (ABAG; future projected data).³ Corresponding driver units were not available for the non-retailer groundwater pumpers, so models were developed on a volumetric basis. Table 1-1 documents the driver units and corresponding rate of use for each retail model sector.

Table 1-1: Driver Units and Rate of Use for Each Retail Model Sector

Model Sector	Driver Unit (N)	Corresponding Rate of Use (q)
Single Family	Housing units	Consumption per housing unit
Multifamily		
CII	Employees	Consumption per employee
CII (Stanford)	Population	Consumption per capita

³ Refer to Technical Memorandum 2: Data Collection and Review (TM 2).

1.3 Method / Statistical Approach

Valley Water collected historical consumption data from its retail agencies,³ which generally spanned the period 2000-2018.⁴ This dataset was sufficient from temporal, geographical, and sectoral perspectives (following sectoral standardization) to explore fitting customized statistical / econometric models identified in TM 1.² Development of historical econometric models provide a strong analytical benefit in forecasting demand, as they allow for the estimation of cause-effect relationships between weather, price, socioeconomic, and other factors that lead to variability in water demand. Quantifying these causal relationships allows for analysis of “what-if” scenarios that are uncertain, but important to consider for planning (e.g., climate change, development patterns, drought recovery).

Development of statistical / econometric models is an iterative process. Figure 1-2 and Table 1-2 outline the process used to fit the econometric models.

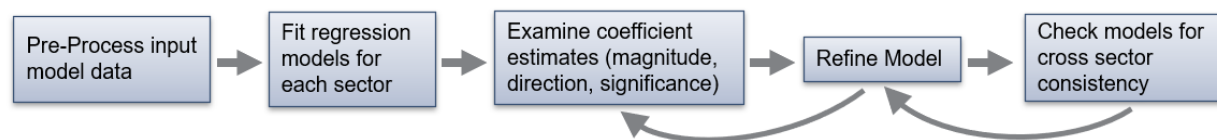


Figure 1-2: Process for Developing Statistical / Econometric Models

Table 1-2: Description of Model Fitting Procedures

Model Fitting Procedure	Description
Pre-process model input data ^(a)	Conduct necessary pre-processing calculations prior to model fitting, e.g.: <ul style="list-style-type: none"> • Geographical processing of driver units. • Calculate per-unit use. • Calculate natural logarithms of per-unit use and appropriate predictors. • Calculate departures from normal conditions for appropriate predictors (i.e., economic trend and weather). • Calculate any index, “dummy”, or interacted parameters (e.g., seasonal cycle, geography, drought severity). • Smoothing monthly and bimonthly data to adjust for irregular billing cycles.
Fit regression models for each sector	Use statistical estimation software (e.g., R, SAS, EViews) to fit linear regression equations to per unit use with the initially selected predictor variables.
Examine coefficient estimates and measure of fit	Check measures of fit (e.g., R ²) and coefficient estimates for reasonable magnitude, direction/sign, and significance.
Refine model to improve measures of fit and coefficient estimates	If the model fit is poor or if coefficient estimates are illogical or insignificant, several actions can be taken, including but not limited to: <ul style="list-style-type: none"> • Identifying and removing outlier data points that have significant leverage on coefficient estimates. • Remove predictors with insignificant or illogical coefficient estimates from the regression equation. • Testing alternate specifications of predictor variables.
Check models for cross-sector consistency	Model fits and predictors are compared across sectors to judge estimates relative to prior expectations; e.g., testing if the relative effects of price and socioeconomic variables vary by sector in a logical way based on past experience.
^(a) Model data pre-processing is detailed in TM 2.	

⁴ Retail agencies submitted historical billing records of varying lengths. Sufficient retailers submitted records from 2000-2018 to establish model fits over the time period.

1.4 Summary of Model Predictors

Several model predictors were used to develop Valley Water’s demand model. To be considered for use, potential predictors needed to pass the following conceptual criteria:

- Logical connection to explaining changes in water consumption;
- Historical record consistent with the time series of observed water consumption; and
- Availability of future projections consistent with the desired forecast horizon (i.e., 2020-2045) or a reasonable basis for assuming or generating projected values.

Initial selection of model predictors is discussed in detail in TM 2. However, during the model fitting process, derivatives of initial variables were also developed and included in subsequent model equations. One example is time lags on weather variables; supplementary variables were created from the temperature and precipitation time series at one to three-month lags. These lagged weather variables aimed to capture a delayed or persistent response in water use. A second example is an extended drought effect variable. The initial drought variables were directly calculated from historic water use restrictions. A supplemental drought variable was created that extended the last historic occurrence of mandatory water restrictions (2017) through the end of the historic dataset (2019); this “extended drought effect” variable was considered to represent inertia in behavioral changes in water use after the water use restrictions were no longer in place (i.e., delayed drought rebound). Table 1-3 details the predictors used to develop the demand models and identifies the expected sign and magnitude of the coefficient estimates resulting from the linear regression.

Table 1-3: Description of Demand Model Predictors

Predictor Variable	Log Transformed?	Expectations about Coefficient Estimates	Description
Departure from normal temperature ^(a)	Yes	Positive sign	Represents difference from long-term temperature. Higher than normal temperatures are associated with higher demands.
Departure from normal precipitation ^(a)	Yes	Negative sign	Represents difference from long-term precipitation. Higher than normal rainfall is associated with lower demands.
Seasonal index	No	Larger absolute magnitudes for agencies with greater seasonal peaking	Reflects the cyclical pattern in water use where demands are generally higher in the summer and lower in the winter. Represented in the model as a sine / cosine pair of variables. ^(b)
Price	Yes	Negative sign with absolute value between 0 and 1	Economic theory suggests negative correlation with demand.
Economic index	Yes	Positive sign	Several economic indices were explored as potential predictors ^(c) with the detrended Economic Cycles Research Institute (ECRI) selected as the index that produced the most reasonable coefficient estimates across model sectors. Water demand is positively correlated with economic fluctuations of the business cycle. The index is modeled in form of departures from long-term trend.
Housing density	Yes	Negative sign (commonly with absolute value between 0 and 1)	Housing density is negatively correlated with demand; on average, residences with more units per acre (or smaller parcel sizes) tend to use less water on outdoor uses.
Median income	Yes	Positive sign (commonly with absolute value between 0 and 1)	Economic theory suggests positive correlation of income with demand; generally geographical areas with higher median incomes tend to use more water.
Persons per household	Yes	Positive sign (commonly with absolute value between 0 and 1)	Positively correlated with demand; generally, residences with more people tend to use larger amounts of water.
Mix of Industries / economic activity ^(d)	Yes	N/A	The representation of industries / economic activity with a geographical area is related to the amount of water used within the CII sector. Fitted parameters for these variables are generally unique by utility, thus there is no generally accepted range of coefficient estimates.
Drought Severity	No	Negative sign	Reflects the effect of drought restrictions from the most recent drought (2014-2017, with extended restrictions through 2019) on water demand. ^(e) Defined as the presence of drought restrictions (represented as a binary) multiplied by the requested cutback (e.g. 0-30%).

^(a) Lagged values of temperature and precipitation were also evaluated and included as model predictors as the influence of weather on water demand can persist several months.

^(b) Most sectors have a single sine/cosine pair representing the seasonal cycle, except for Stanford. Stanford has two sine/cosine pairs to capture seasonal effects associated with the academic calendar. See Section 4.3 for additional discussion.

^(c) Other economic indices explored as potential predictors are documented in TM 3.

^(d) Detail on the derivation of specific predictors representing mix of industries / economic activity is documented in TM 3.

^(e) A unique prediction variable was also evaluated for the 2008-2011 drought but was dropped during the model development process as the coefficient estimate was not statistically significant. The 2008-2011 drought overlapped with the severe economic downturn of the Great Recession which likely mutes its statistical significance.

2. Single Family Regression Development

This section reviews the development of the statistical regression for the single family residential sector.

2.1 Model Predictors and Fitted Coefficients

The fit for the final single family regression is presented in Table 2-1. Coefficient estimates are within the expected range for all explanatory variables.

Table 2-1: Single-Family Regression Predictors and Coefficients

Variable	Coefficient	Standard Error	t-Statistic	Probability
Intercept	3.821	0.324	11.776	<0.05
Seasonal index 1 ^(a)	-0.283 (avg) -0.045 to -0.185	0.013 (avg) 0.008 to 0.026	-24.086 (avg) -7.379 to -24.086	<0.05
Seasonal index 2 ^(a)	-0.262 (avg) -0.616 to -0.064	0.013 (avg) 0.008 to 0.026	-23.026 (avg) -44.960 to -3.786	<0.05
Departure from normal temperature	1.008	0.135	7.464	<0.05
Departure from normal temperature, 1-month lag	0.824	0.137	5.997	<0.05
Departure from normal temperature, 2-month lag	0.354	0.137	2.583	<0.05
Departure from normal temperature, 3-month lag	0.306	0.127	2.413	<0.05
Departure from normal precipitation	-0.008	0.003	-3.01	<0.05
Departure from normal precipitation, 1-month lag	-0.009	0.003	-3.649	<0.05
Departure from normal precipitation, 2-month lag	-0.004	0.003	-1.582	0.114
Price	-0.085	0.009	-9.942	<0.05
Economic index	0.945	0.101	9.316	<0.05
Housing density	-0.406	0.007	-60.745	<0.05
Median income	0.195	0.025	7.778	<0.05
Persons per household	0.473	0.04	11.907	<0.05
Drought severity, extended	-1.506	0.048	-31.109	<0.05
^(a) Seasonal indices are unique to each retail agency.				

Variables with an increasing effect on water use (i.e., a positive coefficient) included temperature, economic index, median income, and persons per household. Variables with a decreasing effect on water use (i.e., a negative coefficient) included precipitation, price, housing density, and the extended drought effect.

2.2 Historical Model Performance

Figure 2-1 shows the observed and predicted per-unit use for the single family sector in gallons per unit per day (gpud) calculated as a unit-weighted average across all retail agencies. Performance of the single family regression is summarized in Table 2-2 which shows performance metrics for unit-weighted average County-wide demand. Visual inspection of the time series plot and review of the model fit parameters showed good performance at the County-wide level, including strong agreement with the observed seasonal cycle and ability to reproduce declining consumption during the Great Recession, recovery between the Great Recession and the recent drought, and the sharp decline and muted recovery following the most recent drought.

Historical performance of the single family regression was also strong at the retail agency-level. Model fit statistics calculated at the retail agency-level generally mirrored County-wide performance. Model fit statistics and time series plots for each retailer are presented in Appendix B.

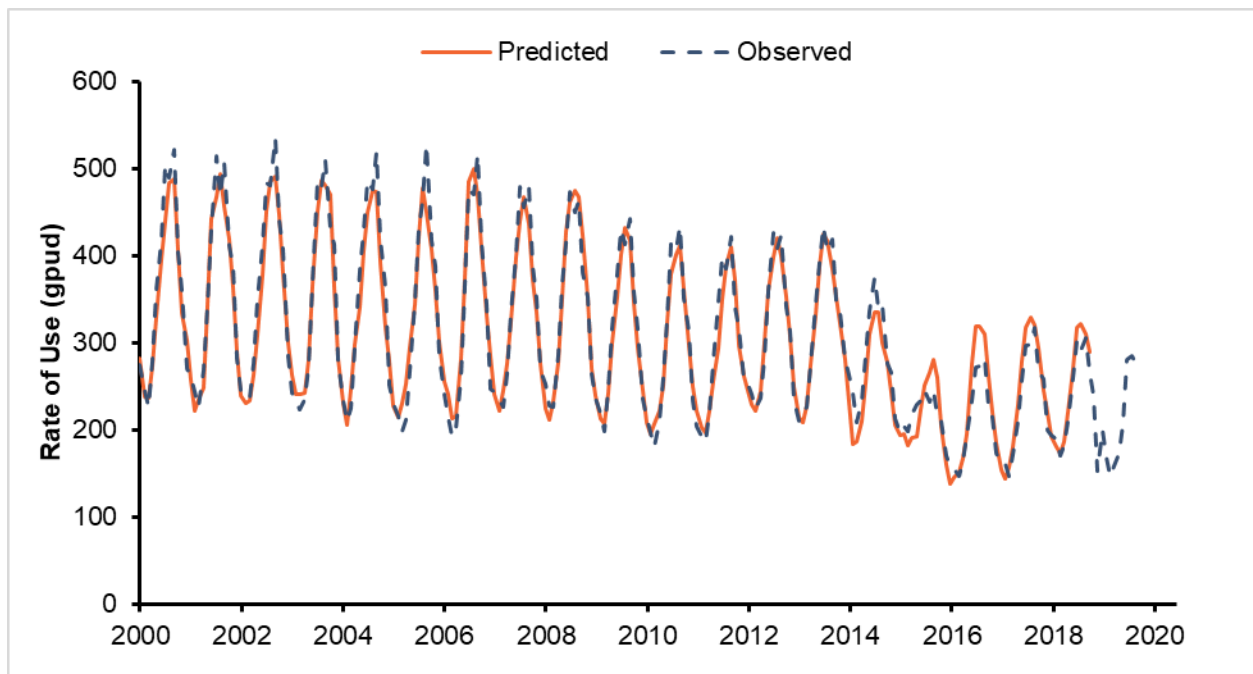


Figure 2-1: County-Wide Single-Family Observed and Predicted Per Unit Rate of Use

Table 2-2: County-Wide Single-Family Regression Performance Metrics

Regression Statistic ^(a)	Value
R-squared	0.95
Average Observed Value (gpud)	305.71
Mean Absolute Percentage Error	5.82%
Mean Bias	-1.13%
^(a) Statistics calculated using County-wide unit-weighted average observations and predicted values from the regression fits.	

3. Multifamily Regression Development

This section reviews the development of the statistical regression model for the multifamily residential sector.

3.1 Model Predictors and Fitted Coefficients

The fit for the final multifamily regression is presented in Table 3-1. Though most predictors are the same as the single family sector, several predictors (e.g., median income and 2-month lagged departure from precipitation) were dropped and certain predictors (e.g., the intercept term and drought severity) were allowed to vary by retail agency. These modifications to the model design resulted in stronger measures of fit and more reasonable coefficient estimates. Final coefficient estimates presented in Table 3-1 are within the expected range for all explanatory variables.

Table 3-1: Multifamily Regression Predictors and Coefficients

Variable	Coefficient	Standard Error	t-Statistic	Probability
Intercept	5.209	0.074	70.141	<0.05
Agency-specific intercepts ^(a)	-0.223 (avg) -0.719 to 0.280	0.013 (avg) 0.007 to 0.023	-31.555 (avg) -104.09 to 15.203	<0.05
Seasonal index 1 ^(b)	-0.161 (avg) -0.372 to -0.056	0.012 (avg) 0.006 to 0.031	-16.311 (avg) -35.651 to -3.872	<0.05
Seasonal index 2 ^(b)	-0.138 (avg) -0.255 to -0.056	0.012 (avg) 0.006 to	-13.943 (avg) -29.588 to -13.943	<0.05
Departure from normal temperature	0.488	0.098	4.974	<0.05
Departure from normal temperature, 1-month lag	0.514	0.100	5.155	<0.05
Departure from normal temperature, 2-month lag	0.397	0.094	4.226	<0.05
Departure from normal temperature, 3-month lag	0.194	0.092	2.101	<0.05
Departure from normal precipitation	-0.002	0.002	-1.127	0.260
Departure from normal precipitation, 1-month lag	-0.006	0.002	-2.954	<0.05
Price	-0.055	0.013	-4.347	<0.05
Economic index	1.568	0.091	17.226	<0.05
Housing density	-0.205	0.011	-18.105	<0.05
Persons per household	0.900	0.057	15.788	<0.05
Drought severity, extended ^(c)	-0.718	0.044	-16.294	<0.05
^(a) Several agencies including San Jose Water Company, San Jose Municipal Water, Great Oaks Water Company, City of Gilroy, California Water Service, and the City of Sunnyvale were fitted with agency-specific intercept terms in order to optimize historical model performance. ^(b) Seasonal indices are unique to each retail agency. ^(c) Recorded drought severity coefficient estimate is for all agencies except San Jose Water Company, which was fitted an agency-specific drought severity coefficient.				

Variables with an increasing effect on water use (i.e., a positive coefficient) included temperature, economic index, and persons per household. Variables with a decreasing effect on water use (i.e., a negative coefficient) included precipitation, price, housing density, and the extended drought effect.

3.2 Historical Model Performance

Figure 3-1 shows the observed and predicted per-unit use for the multifamily sector in gpud calculated as a unit-weighted average across all retail agencies.⁵ Performance of the multifamily regression is summarized in Table 3-2 which shows performance metrics for unit-weighted average County-wide demand. Visual inspection of the time series plot and review of the model fit parameters showed good model performance at the County-wide level, including strong agreement with the observed seasonal cycle and ability to reproduce declining consumption during the Great Recession, recovery between the Great Recession and the recent drought, and the sharp decline and muted recovery following the most recent drought.

Historical performance of the multifamily regression was also strong at the retail agency-level. Model fit statistics calculated at the retail agency-level generally mirrored County-wide performance. Model fit statistics and time series plots for each retailer are presented in Appendix C.

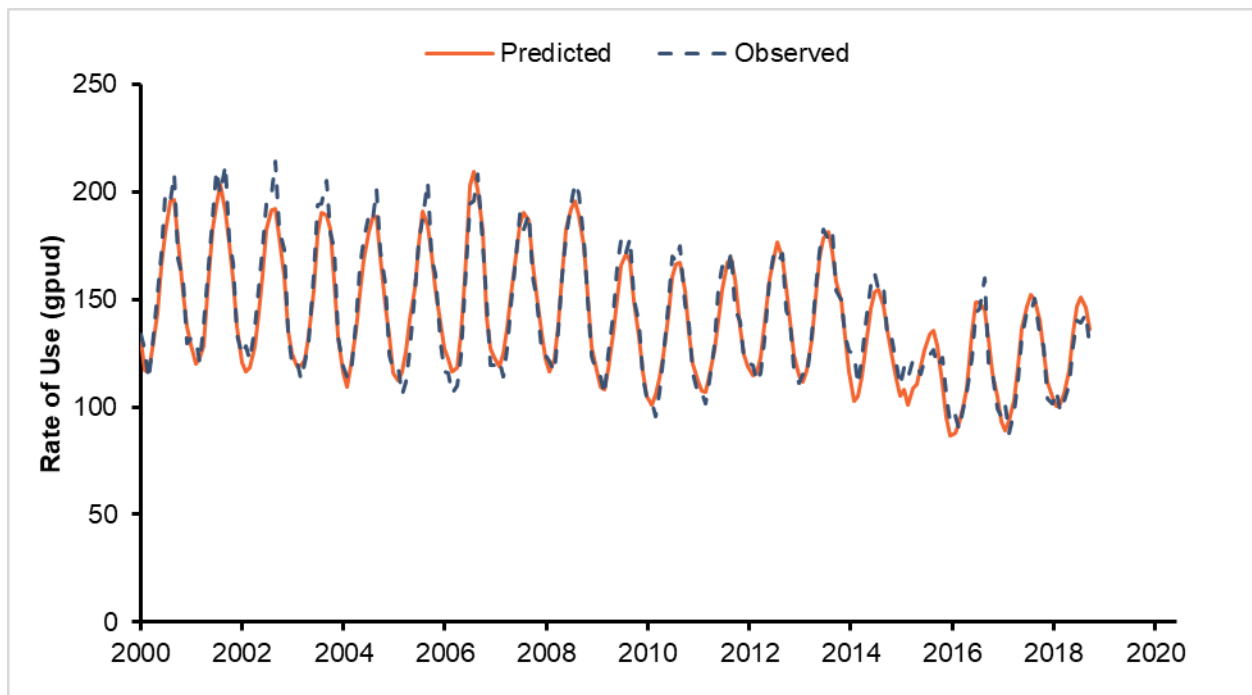


Figure 3-1: County-Wide Multifamily Observed and Predicted Per Unit Rate of Use

⁵ Figure 3-1 excludes an outlier monthly observed datapoint for a single retail agency.

Table 3-2: County-Wide Multifamily Regression Performance Metrics

Regression Statistic^(a)	Value
R-squared	0.94
Average Observed Value (gpud)	142.26
Mean Absolute Percentage Error	4.53%
Mean Bias	-0.87%
^(a) Statistics calculated using County-wide unit-weighted average observations and predicted values from the regression fits.	

4. CII Regression Development

This section reviews the development of the statistical regression for the CII sector. Distinct regressions representing the commercial, industrial, and institutional water use sectors⁶ were initially considered. However, different billing classification schemes among retail agencies introduced definitional uncertainty in sectoral water use and driver units. For example, certain agencies lacked a distinct industrial billing classification while others combined commercial and institutional categories. Additional verification of water use at the account-level was not possible given the data constraints for this project.⁷ In response to these constraints and uncertainties, total use within the commercial, industrial, and institutional sectors was consolidated into a single composite CII regression. The benefit of combining these sectors is a more parsimonious representation with respect to number of sectors, while providing a means to use the mix of industries to explain CII water use variability across retail agencies.

4.1 Model Predictors and Fitted Coefficients

Model predictors for the final CII regression equation along with their statistics are in Table 4-1. Note that understanding/quantifying the types of economic activity occurring within the County are important to understanding changes in CII consumption over time. Since individual regressions for the commercial, industrial, and institutional sectors were not developed, predictor variables representing the relative proportion of employment among different industry groupings was used in the CII regression. Proportional employment based on industry grouping is meant to reflect the relative mix of industries / economic activity within each retail agencies' service area. Most CII model predictors are similar to those used for the single family and multifamily sectors, however certain variables (e.g., 3-month lagged departure from normal temperature) were excluded during the regression refinement process. Final coefficient estimates presented in Table 4-1 are within the expected range for all explanatory variables.

⁶ Refer to Appendix A for a summary of standardized sectors by retail agency.

⁷ The finest spatial resolution of all consumption data was at the retail agency-level.

Table 4-1: CII Regression Predictors and Coefficients

Variable	Coefficient	Standard Error	t-Statistic	Probability
Intercept	-0.186	0.268	-0.695	0.49
Seasonal index 1 ^(a)	-0.29 (avg) -0.41 to -0.17	0.02 (avg) 0.01 to 0.03	-20.79 (avg) -33.3 to -9.2	<0.05
Seasonal index 2 ^(a)	-0.34 (avg) -0.53 to -0.10	0.02 (avg) 0.01 to 0.03	-23.34 (avg) -39.2 to -3.5	<0.05
Departure from normal temperature	1.037	0.158	6.580	<0.05
Departure from normal temperature, 1-month lag	0.912	0.161	5.657	<0.05
Departure from normal temperature, 2-month lag	0.370	0.158	2.340	<0.05
Departure from normal precipitation	-0.003	0.003	-0.997	0.32
Departure from normal precipitation, 1-month lag	-0.007	0.003	-2.312	<0.05
Departure from normal precipitation, 2-month lag	-0.002	0.003	-0.692	0.49
Price	-0.062	0.025	-2.453	<0.05
Economic index	0.963	0.140	6.881	<0.05
Proportion of total Employment (Retail)	0.142	0.032	4.430	<0.05
Proportion of total Employment (Professional Services)	0.499	0.031	16.065	<0.05
Proportion of total Employment (Information, Government, and Construction)	0.093	0.026	3.508	<0.05
Proportion of total Employment (Industrial)	0.351	0.026	13.249	<0.05
Proportion of total Employment (Health Education, and Recreational Services)	0.466	0.059	7.923	<0.05
Drought severity, extended	-1.424	0.070	-20.232	<0.05
^(a) Coefficients vary by retailer.				

Variables with an increasing effect on water use (i.e., a positive coefficient) included temperature, economic index, and the mix of industries/economic activity ratios. Variables with a decreasing effect on water use (i.e., a negative coefficient) included precipitation, price, and the extended drought effect.

4.2 Historical Model Performance

Figure 4-1 shows the observed and predicted per-unit use for the CII sector in gallons per employee per day (gped) calculated as a unit-weighted average for across all retail agencies. Performance of the CII model is summarized in Table 4-2 which shows regression performance metrics for county wide demand. Visual inspection and performance metrics showed good model performance including the same seasonal cycle and quantities. The CII regression was also able to reproduce declining consumption during the Great Recession, recovery between the Great Recession and the recent drought, and the sharp decline and muted recovery following the most recent drought.

Historical performance of the CII regression was also strong at the retail agency-level. Model fit statistics calculated at the retail agency-level generally mirrored County-wide performance. Model fit statistics and time series plots for each retailer are presented in Appendix D.

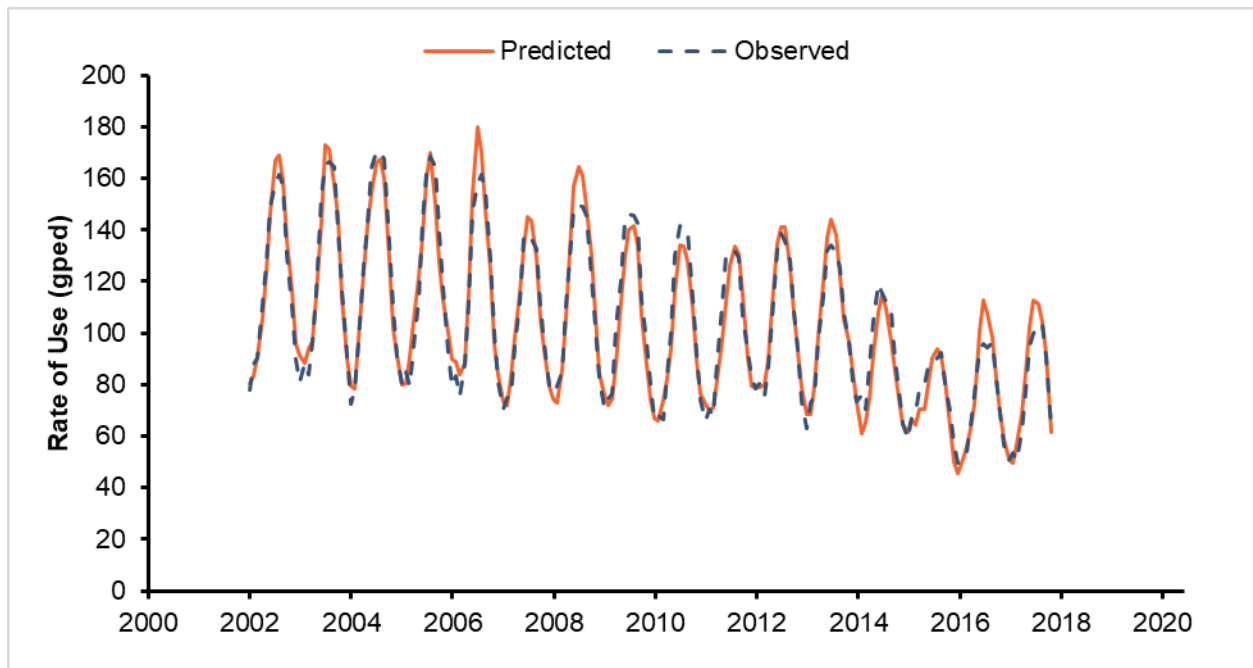


Figure 4-1: CII Observed and Predicted Rate of Use

Table 4-2: County-Wide CII Regression Performance Metrics

Regression Statistic ^(a)	Value
R-squared	0.96
Average Observed Value (gped)	103.89
Mean Absolute Percentage Error	5.08%
Mean Bias	-0.06%

^(a) Statistics calculated using County-wide unit-weighted average observations and predicted values from the regression fits.

4.3 Stanford University Regression Development

As an academic institution, Stanford University (Stanford) is considered part of the CII sector. However, an independent regression for Stanford was developed given its unique characteristics among retailers. Unlike other retail agencies, Stanford does not have accounts in the traditional sense as individual users are not billed. Additionally, employee water use as the sole driver unit (consistent with the CII sector for other retailers) is not appropriate for Stanford as students account for a significant portion of water use. This distinction informed the decision to use population (understood to be total faculty, staff, and students) as the driver unit for Stanford. Since the driver unit for the Stanford CII model was population, rather than jobs like the rest of the retailers' CII use, rate of use must be modeled separately. It is expected that the significant variables and/or magnitudes of coefficients would be different for Stanford than the other retailers' CII sectors due to the difference in driver units. A discussion of Stanford's regression predictors and fitted coefficients is presented in Appendix E. A summary of the Stanford's historical model performance is included in Appendix D.

5. Non-Retail Groundwater Pumper Regression Development

Historic water use for non-retail groundwater pumpers includes groundwater use by private well owners that are outside of retailers' service areas. Historic groundwater use was reported by groundwater basin and billing classification. The groundwater basins include Santa Clara Plain (referred to as charge zone "W2") as well as Coyote Valley sub-basin management area and the Llagas sub-basin and (referred to as charge zone "W5"). Water use was classified as either agricultural or municipal/industrial (M&I). M&I can include residential domestic water use.

Historical regression fits for non-retail groundwater pumpers were performed on annual water use. Agricultural water use was typically reported annually or semi-annually. M&I use was reported monthly or semi-annually. As a result, a monthly resolution for model fitting was not possible.

Further, historical model fits for non-retail groundwater pumpers were performed on a volumetric basis. Typical driver units for groundwater use, such as number of wells, did not support the "rate of use times driver" approach that was used for single family, multifamily, and CII model development.

Fitted models were only finalized for the M&I sector for the two groundwater basins. Agricultural use was often reported semi-annually (in January and July) and was estimated by a "table of averages" approach based on crop type, resulting in a lack of variability that could be modeled by predictor variables. Initial exploration of statistical/econometric model development showed that agricultural water use has been generally constant over the last twenty years and was not well-characterized by typical predictor variables.

5.1 Model Predictors and Fitted Coefficients

Model predictors for the non-retail groundwater pumpers M&I regression models along with their statistics are in Table 5-1. The two groundwater zones were modeled separately; a combined regression provided no improvement in the statistical significance of coefficients.

Table 5-1: Predictors for Non-Retail Groundwater Pumpers M&I Regression.

Basin	Variable	Coefficient	Std. Error	t-Statistic	Prob.
W2	Intercept	-0.59	4.08	-0.14	0.89
	Drought	-0.70	0.20	-3.54	<0.05
	Price	-0.81	0.06	-13.31	<0.05
	Temperature ^(a)	1.83	0.93	1.98	0.07
W5	Intercept	1.43	0.47	3.04	<0.05
	Number of Wells	0.19	0.04	5.56	<0.05
	Drought	-0.31	0.15	-2.09	0.06
	Price	-0.12	0.05	-2.41	<0.05
	Precipitation ^(a)	-0.09	0.02	-3.62	<0.05
^(a) Temperature and precipitation for non-retail groundwater pumper models were in absolute terms, not departures from normal.					

Variables with an increasing effect on water use (i.e., positive coefficient) included maximum temperature (used in the W2 model only) and number of wells (used in the W5 model only). Variables with a decreasing effect on water use (i.e., negative coefficient) included the extended drought effect,

price, and precipitation (used in the W5 model only). Economic indices, density, and median income were not found to be statistically significant for the groundwater M&I regressions. Note that temperature was found to be statistically significant for the W2 charge zone but not for the W5 charge zone regression, while precipitation was found to be statistically significant for W5 but not W2.

5.2 Historical Model Performance

Performance of the groundwater M&I regressions is summarized in Table 5-2. Figure 5-1 and Figure 5-2 show the observed and predicted demand for the M&I sector for groundwater charge zone W2 and W5, respectively. The M&I W5 regression had a lower correlation coefficient than all other model fits described in this TM, likely due to the relatively constant annual average water use over the available period.

Table 5-2: Regression Performance Metrics for Groundwater M&I Models

Regression Performance Metric	M&I, W2	M&I, W5
R-squared	0.96	0.81
Average Observed Value (mgd)	7.81	7.68
Mean Absolute Percent Error	4.32%	3.54%
Mean Bias	-0.22%	-0.09%

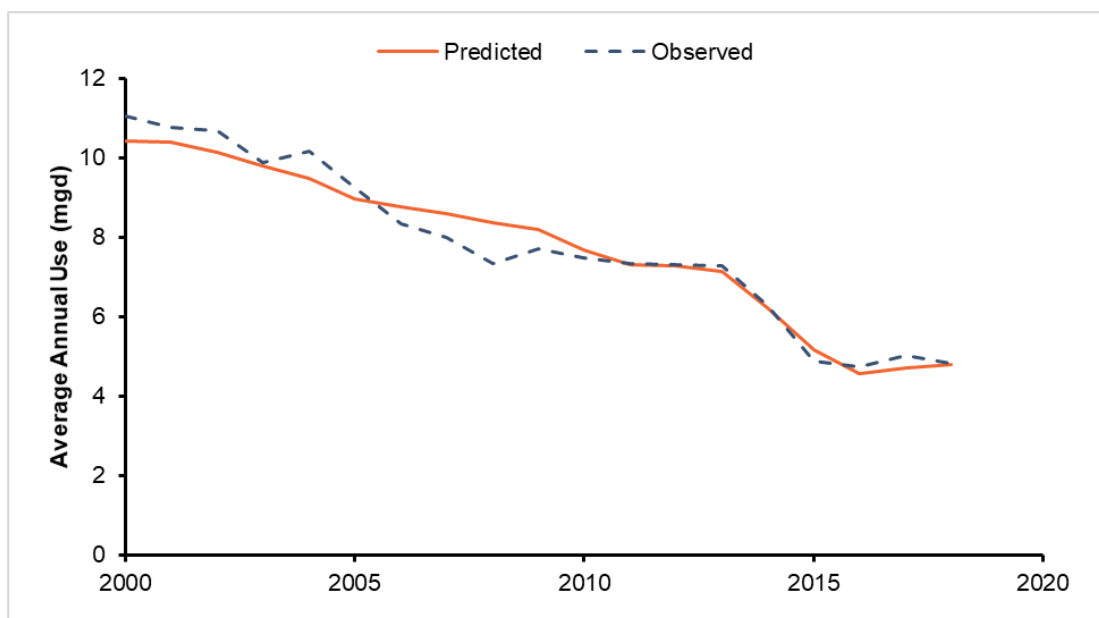


Figure 5-1: Observed and Predicted M&I Demand for Groundwater Basin W2

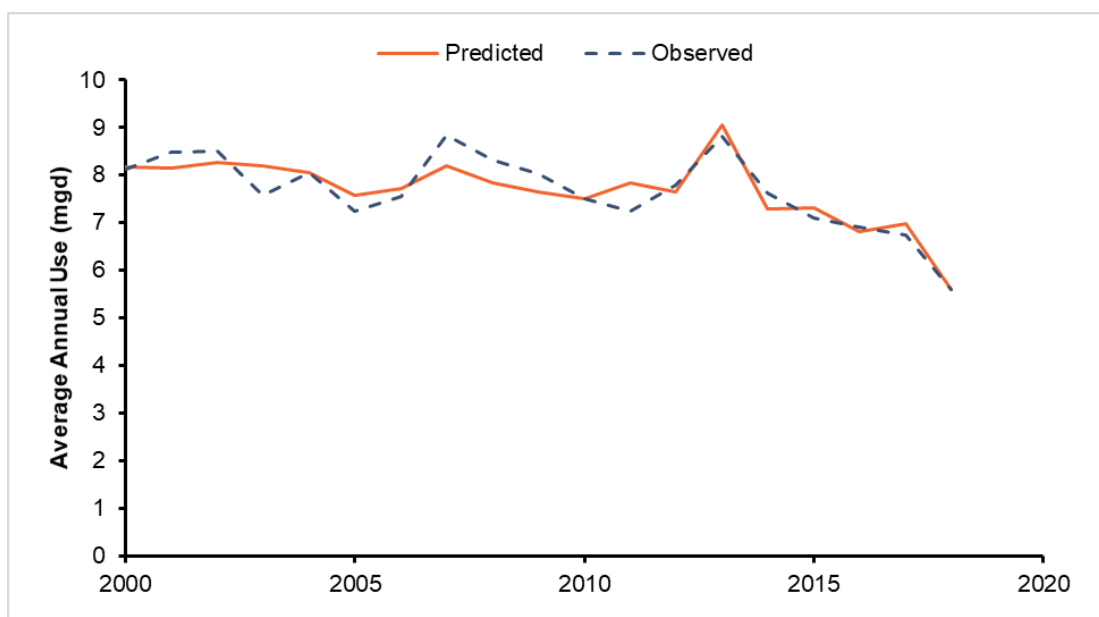


Figure 5-2: Observed and Predicted M&I Demand for Groundwater Basin W5

Figure 5-3 shows historic agricultural water use for the W2 and W5 charge zones. Agricultural water use in the W2 charge zone is less than 1 mgd and has been slightly declining over the last twenty years. Agricultural water use in the W5 charge zone has been generally constant over the last twenty years at approximately 23 mgd. Initial exploration of statistical/econometric model development showed that agricultural water use was not well-characterized by typical predictor variables. Agricultural water use in both charge zones would be well-represented by an average water use from a historical reference period that is then held constant into the future.

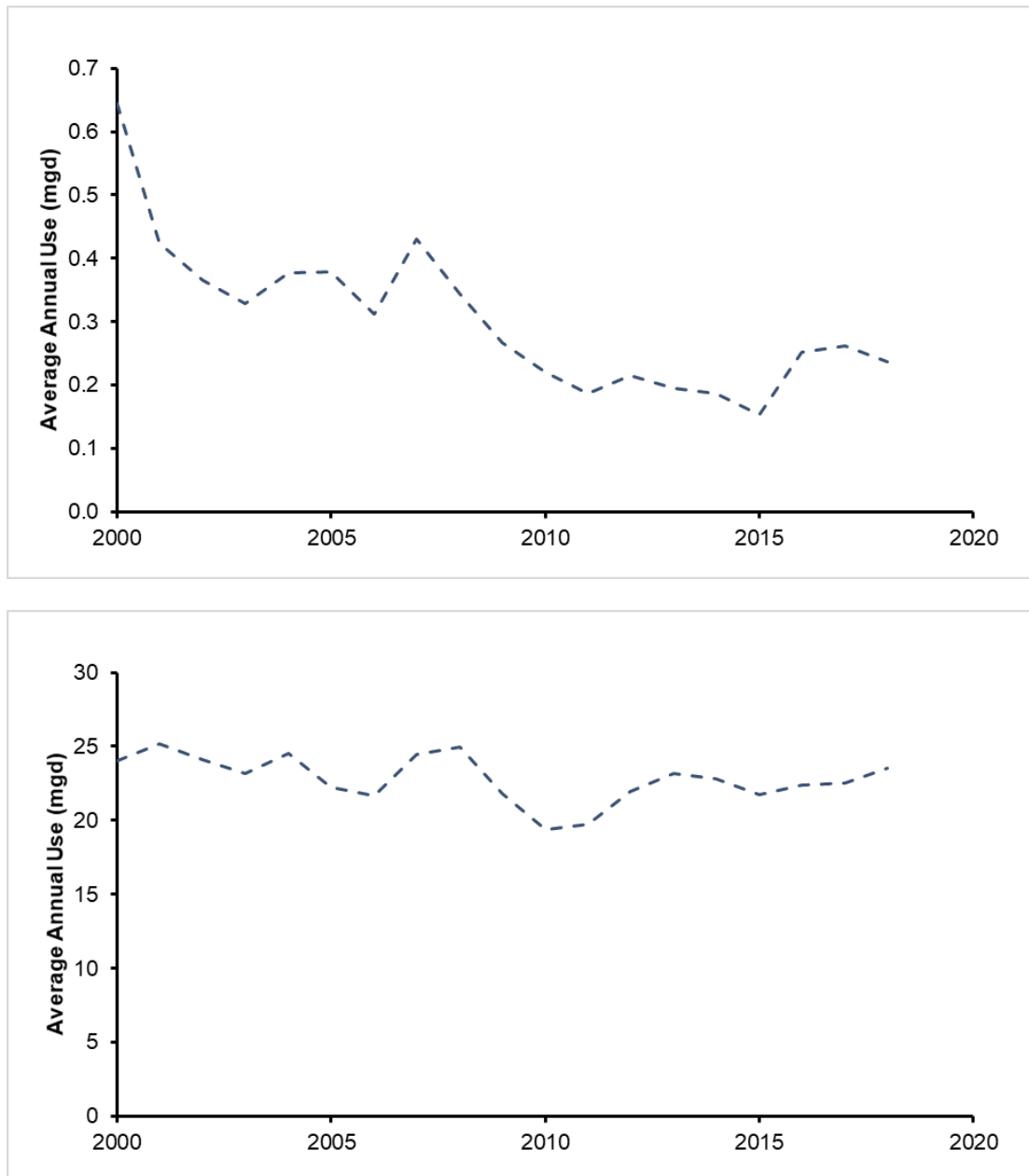


Figure 5-3: Observed Agricultural Demand for Groundwater Basin W2 (top) and W5 (bottom)

6. Summary / Conclusions

In summary, the statistical/econometric regressions presented in TM 2/4 show strong performance in explaining historical patterns of consumption over the last 20 years, including two major droughts and the Great Recession. All regressions had R-squared values of 0.81 or greater. The retailer-specific regressions, which represent the majority of water use in the County, had R-squared values of 0.94 or greater. None of the regressions demonstrated a large consistent bias. Based on this analysis, the regression reflects a suitable basis for forecasting.

The overall model approach allows for demand forecast scenario analysis based on varying assumptions of future conditions. Several forecast scenarios may be explored, including climate change-adjusted weather, alternate assumptions around the timing and magnitude of drought recovery, alternate assumptions around urban development, and/or different assumptions around future economic conditions. For any of these future scenarios, the model coefficients developed in this TM should be maintained as they reflect the best fitted estimates of causal relationships between external socioeconomic conditions and historical water demand given the available modeling data. Model scenarios can also be developed to address uncertainties in future predictor variables, such as housing / job growth and density. Future inputs in these scenarios could be conducted as a sensitivity analysis or be driven by alternate growth projections.

On a regular basis, overall model performance should be evaluated. Annually, forecasted consumption and input assumptions (e.g., driver unit counts, economic conditions, water rates, etc.) can be compared with observed conditions as data becomes available to monitor predictive performance. Less frequently (around every 5 years) model predictors should be reevaluated using the process outlined in Figure 1-2. Major events, such as another drought or a severe economic recession may necessitate reexamination and/or refitting model coefficients and may cause changes in longer term expectations over the forecast period. As more data becomes available on the impacts of COVID-19 on County demographics and water use (e.g., potential shifts in CII to residential demand), reexamination of the underlying sectoral rates of water use as well as model coefficients should be conducted.



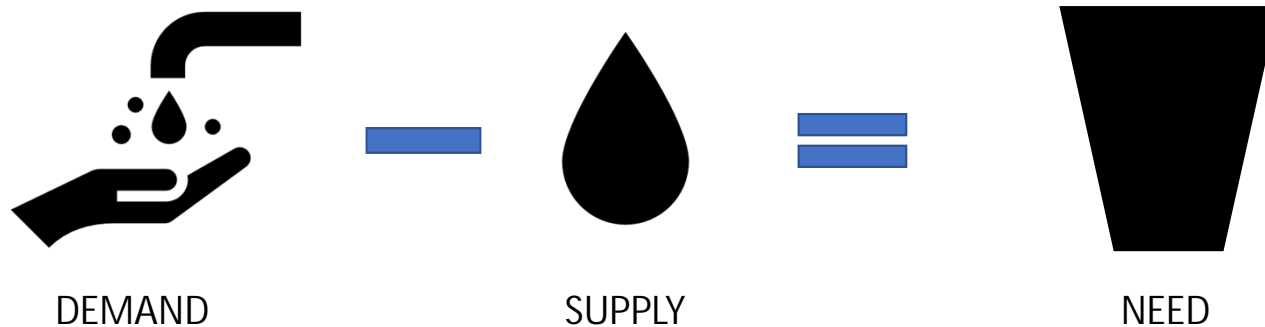
Valley Water Demand Model and Forecast

Presented by: Samantha Greene, Ph.D., Water Supply Planning and Conservation Unit
Water Conservation and Demand Management Committee, August 28, 2023

Water Supply Master Plan

2

Goal: Determine investment needs given different water use and supply scenarios

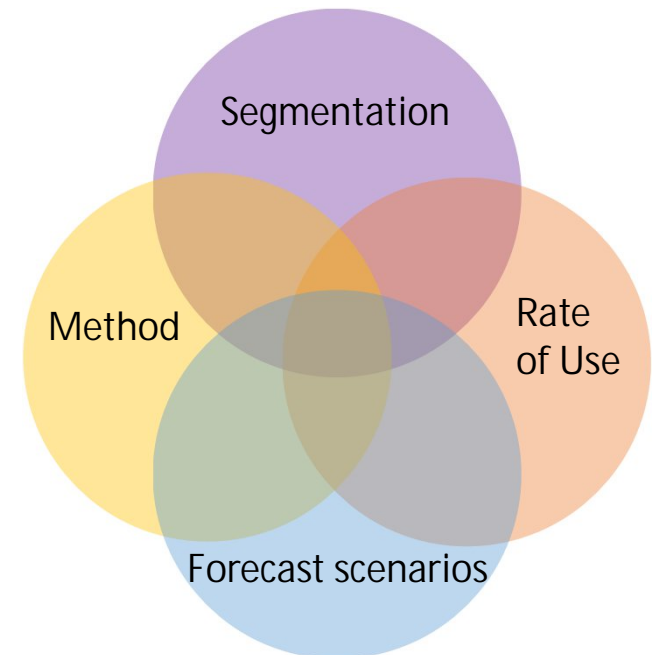


Model Framework and Approach

3

Model build is based on:

- **Segmentation** – retailer -> sector -> time
- **Method** – Statistical / econometric
- **Rate of use** - defined for each water use sector based on historic data
- **Forecast scenarios** – climate, housing, water rates, drought rebound, etc.



Defining Model Segmentation

4

- First segmentation: Billing group/Spatial
 - retailer
 - groundwater zone of benefit for independent pumpers
- Second Segmentation (retailers only): Sectoral
 - single family, multi-family, and commercial/industrial/institutional (CII)
- Time (all segments): historic and future

Method Selection

5

- Driven by data availability
- Sufficient data at sufficient scale available for statistical approach
- Benchmarked peer agencies

Defining Rate of Use

6

Residential Sectors	CII Sectors
Temperature	
Precipitation	
Price	
Water shortage restrictions	
Economic index	
Water efficiency	
Median income	Productivity
Household size	Mix of industries
Housing density	

Data Used in Demand Model Development 7

- Retailer: billing data
- CA Department of Finance: housing units
- US Census Bureau: sectoral employment, median income, housing density, persons per household
- Federal Reserve: economic indices, unemployment rate
- Academics: weather data and climate change modeling
- Valley Water: water rates by retailer, drought restrictions

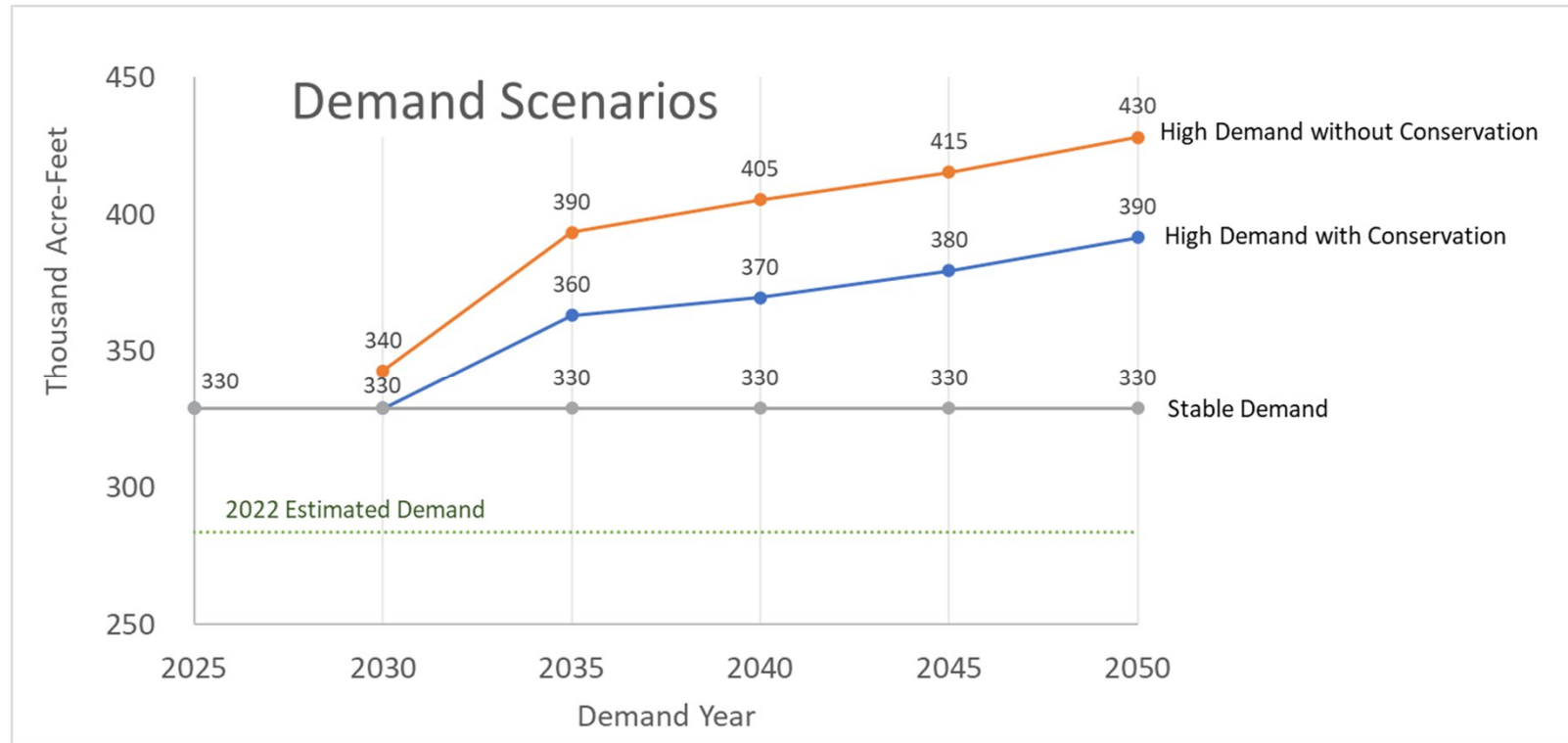
Forecast Development – Scenario Analysis

- Housing density: external stakeholders, city general plans
- Housing and CII growth: ABAG and city general plans
- Median income: Plan Bay Area, experts
- Economic indices: Federal Reserve, Economic Cycle Research Inst., experts
- Drought restrictions: Valley Water
- Water rates: Valley Water
- Weather (climate change): global climate models

Forecasts are baseline from which projected long-term conservation program savings can be deducted

Forecast Results

9



Model only goes to 2045. Extrapolated to 2050 using trend for 2030-2040.

Next Steps

10

- Continue to track demands, variables that can impact demand forecasts
- Use demand forecast in Water Supply Master Plan 2050 analyses



Santa Clara Valley Water District

File No.: 23-0809

Agenda Date: 8/28/2023

Item No.: 4.5.

COMMITTEE AGENDA MEMORANDUM **Water Conservation and Demand Management Committee**

Government Code § 84308 Applies: Yes ☐ No ☒
(If "YES" Complete Attachment A - Gov. Code § 84308)

SUBJECT:

Review the Water Conservation and Demand Management Committee (WCaDMC) Work Plan, the Outcomes of Board Action of Committee Requests; and the Committee's Next Meeting Agenda.

RECOMMENDATION:

Review the Committee work plan to guide the committee's discussions regarding policy alternatives and implications for Board deliberation.

SUMMARY:

The attached Work Plan outlines the approved topics for discussion to be able to prepare policy alternatives and implications for Board deliberation. The work plan is agendaized at each meeting as accomplishments are updated and to review additional work plan assignments by the Board.

BACKGROUND:

Governance Process Policy-8:

The District Act provides for the creation of advisory boards, committees, or commissions by resolution to serve at the pleasure of the Board.

Accordingly, the Board has established Advisory Committees, which bring respective expertise and community interest, to advise the Board, when requested, in a capacity as defined: prepare Board policy alternatives and provide comment on activities in the implementation of the District's mission for Board consideration. In keeping with the Board's broader focus, Advisory Committees will not direct the implementation of District programs and projects, other than to receive information and provide comment.

Further, in accordance with Governance Process Policy-3, when requested by the Board, the Advisory Committees may help the Board produce the link between the District and the public through information sharing to the communities they represent.

ENVIRONMENTAL JUSTICE IMPACT:

There are no Environmental Justice impacts associated with this item.

ATTACHMENTS:

Attachment 1: WCaDMC 2023 Work Plan

UNCLASSIFIED MANAGER:

Candice Kwok-Smith, 408-630-3193

WCaDMC 2023 WORKPLAN

Task	Agenda Item	January	February	March	April	May	June	July-Aug. meeting	August	September	October	November	December
FY 23	Drought Response												
1.1	Monthly Drought Status			X	X	X							
1.2	Drought Response Plan						X					X	
1.3	Outreach Efforts.			X									
FY 23	WSMP Strategy 1: Secure Existing Supplies - 99,000 AF Conservation by 2030												
2.1	Annual Water Conservation Savings				X								
2.2	Water Conservation Strategic Plan			X									
2.3	Water Conservation Savings Model			X									
2.4	Water Conservation as a Way of Life recommendations (including water waste restrictions)						X						
2.5	New Programs (Lawn Busters, Pilot programs, landscape design assistance)			X						X			
2.6	Outreach (including to Renters/Landlords)												
2.7	SCW funding (Safe Clean Water Conservation Program - Project A2: Water Conservation Rebates and Programs Update)								X				X
2.8	Affordability discussion/supporting underserved communities												
2.9	Collaboration with retailers												
2.9	Demand Model and water use data								X				
FY 23	WSMP Strategy 2: Increase Water Conservation (109,000 AF) and Stormwater Capture (1,000 AF) by 2040												
3.1	Investments in no-regrets package/stormwater resource plan implementation								X				
3.2	Collaboration with UC Water on Flood Managed Aquifer Recharge (Flood MAR)								X				
3.3	Find opportunities to ensure new development has improved water wise features (MWENDO, land use coordination)										X		
3.4	Resource Needs												
3.5	Review long-term goals as part of WSMP update										X		
FY 23	WSMP Strategy 3 Optimize the Use of Existing Supplies and Infrastructure												
4.1	Sustainable Groundwater Management Act (SGMA) - annual update										X		
4.2	South County Recharge												
4.3	Well control zone for Purified Water Project											X	
FY 23	Other Demand Management Items												
5.1													
5.2													

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