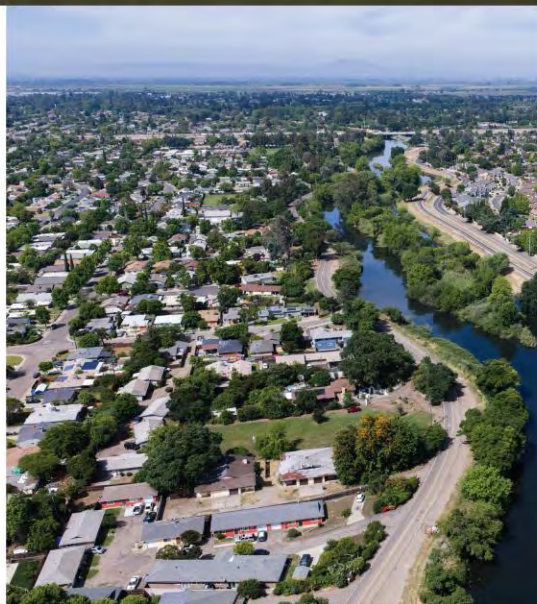


Unified Water Plan

for the
San Joaquin Valley

July 2026





This Unified Water Plan for the San Joaquin Valley was prepared by the California Water Institute at California State University, Fresno in coordination with the Water Blueprint for the San Joaquin Valley (Blueprint). Stantec Consulting Services, with support from the Blueprint Technical Committee, was the lead author of the document. Funding was provided by the U.S. Department of the Interior, Bureau of Reclamation.

The effort brought together researchers, agencies, and community stakeholders to prepare a coordinated strategy that addresses needed investments in water supply reliability, flood management, and ecosystem enhancement. Technical support was provided to the Blueprint by Hamilton Resource Economics, Hallmark Group, and others. Input and review comments were provided by a broad range of entities including Blueprint member agencies, the San Joaquin Valley Collaborative Action Program, and the California Department of Water Resources, among others.

Executive Summary

The San Joaquin Valley (SJV) in central California is one of the most productive agricultural regions in the world and a major contributor to the economies of California and the United States. The eight-county region includes seven of the nation's top 10 agricultural producing counties and is home to cities and towns whose communities and economies are closely tied to agriculture and related industries. It produces more than 250 crops with an annual value of about \$24 billion. At the same time, the SJV supports important environmental functions, including serving as an important element of the Pacific Flyway migratory corridor, providing aquatic habitat for salmon and other anadromous fish species, and providing a range of other critical habitats. California's water future is being reshaped by significant reductions in water supply availability driven by groundwater sustainability requirements, regulatory actions to protect aquatic species, and more extreme hydrologic variability. As a result, there is an urgent need for action and investments to provide water security, economic vitality, and environmental sustainability in the SJV.

The consequences of inaction are substantial. Approximately 20% of the SJV's cultivated area could be retired over the next 20 to 30 years because of water supply reductions from groundwater sustainability requirements and other regulatory changes. This level of land retirement could result in annual losses of approximately \$7.2 billion in farm revenue, \$1.9 billion in farm operating income, \$2.1 billion in wages, and 85,000 jobs. These losses would have direct, indirect, and induced effects across interconnected sectors and industries, which would negatively affect local, regional, and state community services that rely on public revenues. Adverse socioeconomic impacts would disproportionately affect the lowest-income communities. These outcomes, occurring in one of the most productive agricultural regions in the United States, would have far-reaching implications for national food supply.

In response to these challenges and consequences of inaction, the California Water Institute at California State University, Fresno, developed this Unified Water Plan for the San Joaquin Valley (UWP). The effort was carried out in coordination with the Water Blueprint for the San Joaquin Valley (Blueprint) and with support from Stantec Consulting Services as the lead author. It brought together researchers, agencies, and community stakeholders to develop a coordinated strategy for improving water supply reliability while advancing flood management and ecosystem enhancement objectives. Input was provided by Blueprint member agencies, the San Joaquin Valley Collaborative Action Program, the California Department of Water Resources (DWR), and other partners.

The UWP represents an important first step toward a coordinated, long-term water supply strategy for the SJV. It identifies opportunities for strategic investments in projects and management actions that help restore water supply, advance flood management, and promote ecosystem enhancement. The UWP also seeks to reduce the adverse effects of major water supply reductions, particularly where they can result in catastrophic loss of irrigated agriculture and associated revenue, wages, and jobs, along with broader effects on related industries and community services. The UWP makes clear that a sustained investment in the SJV is in the best interest of local, regional, state, and federal entities. The UWP and associated analyses maintain existing water right and contractual priorities and do not assume actions that would violate or supersede those established frameworks.

Key Findings

Information compiled from numerous sources combined with results from new evaluations support the following findings:

1. Projected water supply shortages in the SJV result from multiple compounding causes, including regulatory in-stream flow requirements for ecosystem protection; reduced availability of groundwater due to implementation of the Sustainable Groundwater Management Act (SGMA); reduced ability to manage changing runoff patterns with existing infrastructure; reduced reliability of Sacramento-San Joaquin River Delta (Delta) imports resulting from regulatory requirements imposed on state and federal storage and export facilities in and upstream of the Delta, more extreme hydrologic variability and sea level rise; and increased water demands driven by a hotter and drier climate.
2. With no action to address projected water supply reductions, the annual water supply-demand gap in the SJV will grow to about 2.4 million acre-feet per year by 2040, which would result in removing up to one million acres from irrigated agriculture. This estimate does not include historical reductions from implementations of regulatory actions.
3. The economic consequences of no action include \$7.2 billion annual loss in farm revenue, an annual loss of 85,000 jobs including 42,000 agricultural and service sector jobs, and \$2.1 billion in lost employee compensation. Losses would occur primarily in lower income communities, exacerbating already present economic difficulties.
4. Large scale implementation of local, regional, and statewide projects identified in the UWP could cost almost \$20 billion, yet they will not be sufficient to fully close the water supply-demand gap, even under optimistic project performance assumptions. These costs do not include investments for conversion of agricultural land.
5. The cost to implement projects that significantly reduce the water supply-demand gap may far exceed affordability thresholds for many agricultural water users, which will limit the extent of the gap that can be reduced. Federal and state funding programs will be needed to implement projects that can reduce significant economic losses.
6. Agricultural land conversion in the SJV will be necessary to help close the water supply-demand gap and achieve groundwater sustainability. Land conversion should be minimized to the extent possible and accommodate a variety of possible future uses. Some land conversions could enable continued agricultural production with reduced or no irrigation supply, while others could promote groundwater recharge, ecosystem enhancement or development of other economic uses, such as energy corridors.
7. Significant land subsidence has adversely affected the operation of large water conveyance canals in the SJV, and additional subsidence will amplify this problem. Federal, state, and regional entities are actively working to develop solutions. Sustained action to re-establish

and maintain the conveyance capability of subsided canals is needed to preserve water delivery reliability and facilitate many potential projects considered in the UWP.

8. Non-structural actions that improve the management of water supplies in the SJV, such as upper watershed land management and modified reservoir operations with improved forecasting, can help the SJV adapt to changing hydrologic variability and increase water supply availability. Non-structural action in the Delta, such as modified operations to protect species based on real-time information and enhanced adaptive management actions can increase the reliability of imported water supplies to the SJV.
9. An extensive inventory of potential projects and non-structural actions that would improve the utilization of local and imported water supplies and increase the availability and reliability of water supplies from the Delta has been compiled. Sufficient information to define a prioritized set of projects is not yet available. Project selection will require further assessment of feasibility based on water supply availability, performance, cost, and affordability criteria.
10. Water supply shortages are not uniformly distributed in the SJV. Areas with access to local water supplies have a greater ability to reduce supply-demand gaps through increased management of available water resources. Areas with limited or no access to local surface water will become more reliant on increased Delta exports.

The UWP provides background on the need for a unified approach, describes problems, needs, and opportunities to address water supply, and examines flood management and ecosystem enhancement in the SJV. It presents an inventory of potential projects and actions and evaluates how combinations of projects could reduce the water supply-demand gap and contribute to flood risk reduction and ecosystem enhancement. The document offers recommendations for future project evaluation and selection, and recommendations to local, regional, state and federal entities. Primary information presented in the UWP is provided below.

Estimated Water Supply-Demand Gap

Over the past nearly two centuries, the SJV has transformed from its pre-European settlement condition, which was characterized by expansive floodplains, wetlands, and seasonal lakes that supported diverse ecosystems, to its current role as one of the most productive agricultural regions in the world. This process was supported by local, state, and federal investments, largely made in the early to mid-20th century, to develop infrastructure in the SJV to store and convey surface water supplies and reduce flood risk to communities and farmlands. These investments included major facilities such as the Central Valley Project (CVP), developed by U.S. Department of the Interior, Bureau of Reclamation (Reclamation); the State Water Project (SWP), developed by DWR; and numerous reservoirs and flood conveyance facilities developed by the U.S. Army Corps of Engineers. Together, these systems expanded surface water supplies and helped establish the SJV as one of the strongest agricultural regions in the world.

In recent decades, state and federal regulations that re-allocated surface water supplies delivered through the major facilities to meet environmental objectives have reduced the volume and



reliability of supplies available to the SJV. As supplies became more constrained, water users invested in conservation and water use efficiency actions, reduced some demands, and increasingly relied on groundwater during periods of reduced surface water deliveries. Elevated reliance on groundwater contributed to chronic overdraft in many subbasins, resulting in undesirable results including declining groundwater levels, dry wells, degraded water quality, and regional land subsidence. The SGMA was enacted in 2014 and requires the implementation of sustainable groundwater management practices that avoid these undesirable effects across California, including in the SJV.

The SJV is now entering an unprecedented era of transition to sustainable water management. By 2040, the annual average gap in comparison to current water supplies is estimated to be about 2.4 million acre-feet per year based on overdraft reported in recent Groundwater Sustainability Plans, implementation of regulatory actions, and increased demands associated with evapotranspiration changes, and at-risk supplies. This estimate does not consider future unanticipated regulatory constraints that could further limit supplies and does not include water supply reductions that have already resulted from implementation of existing regulatory requirements. Table ES-1 summarizes the projected annual average water supply-demand gap in the SJV by groundwater subbasin as described.

Table ES-1. Annual Average Projected Future Water Supply-Demand Gap in the San Joaquin Valley Based on GSPs (TAF/YR)

Subbasin	GSP-Based Future Gap from Only Demand Changes (TAF/YR)	Groundwater	Surface Water			GSP-Based Total Supply-Demand Gap ³ (TAF/YR)
		Provision for Replenishment ¹ (TAF/YR)	SJRRP Contribution (TAF/YR)	HRLP Contribution (TAF/YR)	Reduced Delta Imports ² (TAF/YR)	
Eastern San Joaquin	54	12	-	-	-	66
Tracy	2	0	-	1	4	7
Delta-Mendota	106	6	-	8	48	168
Modesto	45	11	-	-	-	56
Turlock	67	16	-	-	-	83
Merced	147	33	-	-	-	180
Chowchilla	31	7	27	3	-	68
Madera	37	9	35	4	-	85
Westside	25	5	-	19	94	143
Pleasant Valley	15	4	-	-	-	19
Tulare Lake	90	22	-	1	10	123
Kings	227	54	17	3	5	306
Kaweah	208	51	35	4	1	299
Tule	169	40	70	8	7	294
Kern	301	69	70	17	72	529
White Wolf	1	0	-	-	-	1
Total	1,525	339	254	68	241	2,427

Notes:

¹ Provision for the future replenishment of groundwater supplies in addition to eliminating overdraft. Calculated as 25% of the GSP-reported overdraft for each subbasin.

² Includes effect of changing hydrologic variability on exports from the Delta.

³ Total estimated supply-demand gap using the GSP estimates of groundwater overdraft. Rounded to 2,400 TAF/YR in this UWP for planning purposes.

Key:

GSP = groundwater sustainability plan

SJRRP = San Joaquin River Restoration Program

UWP = Unified Water Plan

HRLP = Healthy Rivers and Landscapes Program

TAF/YR = thousand acre-feet per year

Flood Management

The UWP examines flood management conditions, infrastructure, operations, and opportunities in the SJV. It describes the major flood management facilities and the federal, state, and local agencies responsible for their operation, and it summarizes the Central Valley Flood Protection Plan and related regional flood management plans.

It also demonstrates that flood management investments can advance broader regional objectives when strategically planned. Opportunities such as upper watershed projects and management actions, diversion of high flows for groundwater recharge, revised reservoir flood operations, increased floodway conveyance capacity, and additional surface water storage can reduce flood risk while also improving water supply reliability and supporting ecosystem enhancement.

A Vision for Ecosystem Enhancement

The UWP examines the historic and current ecosystem condition in the SJV and identifies opportunities for ecosystem enhancement as part of a broader regional strategy. It summarizes current landcover and compiles restoration objectives that have been developed by numerous entities throughout the SJV.

The UWP recognizes that strategic land repurposing will be an important regional tool for converting agricultural land to habitat, groundwater recharge, energy production, and other beneficial uses in ways that maximize both environmental and economic value. As the SJV responds to the water supply challenges described in Chapter 2 and the flood management opportunities described in Chapter 3, the chapter shows that ecosystem enhancement should not be treated as a separate objective, but rather as an integral part of coordinated long-term land and water management.

Potential Projects and Actions to Address SJV Water Resources Needs

The UWP presents an expansive inventory of potential water supply and flood risk reduction projects and actions that could help reduce the SJV's water supply-demand gap. Drawing from Groundwater Sustainability Plans, state and federal plans, Blueprint technical studies, and other sources, the UWP presents information on project type, estimated yield, cost, implementation considerations, and potential to contribute to multiple benefits.

The project inventory spans a wide range of strategies, including groundwater recharge, conveyance improvements, surface and groundwater storage, recycled and reclaimed water, surface water treatment and delivery, upper watershed projects, and demand management actions. It demonstrates that the SJV does not lack possible solutions; rather, the challenge is to prioritize, fund, permit, and implement them in coordinated manner that produces meaningful regional benefit.

Evaluations and Recommendations

Three investment scenarios were evaluated based on combinations of projects and actions:

- Scenario 1 – Restore Capacity of Existing Facilities.** This scenario would restore the capacity of subsidence-impacted CVP and SWP canals and remove sediment in south Delta channels. These projects would not reduce the estimated water supply-demand gap but are needed to avoid increasing the gap and to facilitate implementation of other projects.
- Scenario 2 – Implement Non-Structural Actions and Local Water Supply Projects.** This scenario combines Scenario 1 with non-structural actions to reoperate reservoirs in the SJV to enhance water management and reduce flood flows, non-structural actions in the Delta, and implementation of numerous projects in the SJV to increase management of available supplies through reuse, groundwater recharge, and local storage.
- Scenario 3 – Implement Large Infrastructure Projects.** This scenario combines Scenarios 1 and 2 with large regional storage and conveyance projects. It includes new or expanded water storage facilities north and south of the Delta, modified Delta conveyance and diversion facilities, and enlarged and expanded conveyance facilities in the SJV that would convey greater flows and provide increased Delta water supplies to the SJV.

Table ES-2 summarizes estimated water supply, remaining gap, acreage that would be removed from irrigation, and total costs for each scenario. A significant supply-demand gap would remain under the most optimistic assumptions and up to 400,000 acres of agricultural land would need to be repurposed. Total implementation costs could range from approximately \$18 billion to \$33 billion and likely will exceed affordability thresholds for many agricultural water users. Project implementation will be driven by actual water supply availability, cost, implementation complexity, and affordability. A structured, transparent, and adaptable project evaluation and selection process is needed to support project implementation decisions.

Table ES-2. Scenario Evaluation Results

Scenario	Average Annual Potential Water Supply (TAF/YR)	Capital Cost (\$ billion)	Remaining Water Supply-Demand Gap (TAF/YR)	Agricultural Acreage Subject to Repurposing (1,000 acres)	Land Repurposing Cost (\$ billion)	Total Cost (\$ billion)
1	Preserve Baseline	7.2	2,400	>1,000	38	-
2	800 – 1,300	2.7 – 5.8	1,100 – 1,700	400 - 590	15.2 – 22.4	-
3	600 - 800	3.3 – 5.2	300 – 1,100	120 - 400	4.7 – 15.2	-
Total:	1,400 – 2,100	13 – 18	300 – 1,100	120 – 400	5 – 15	18 – 33

Note: Values are rounded; therefore, totals may not match the sum of the reported components exactly.

Key: TAF/YR = thousand acre-feet per year

Recommendations

Several recommendations are made based on the identified needs and the effectiveness of potential solutions to address water supply, flood risk management, and ecosystem enhancement in the SJV.

Recommendations for Local and Regional Entities in the SJV:

1. Restore and maintain the conveyance capacity and delivery capability of existing CVP and SWP subsidence-impacted canals and remove sediment from south Delta channels. Further lost capacity will increase the supply-demand gap and inhibit the ability to realize benefits from many local and regional projects identified in the UWP.
2. Partner with state and federal entities to determine water available for diversion from SJV rivers that can be used to enhance groundwater recharge.
3. Partner with state and federal entities to advance non-structural actions that can increase water supplies available for diversion. This includes non-structural actions in the SJV to increase the availability of local water supplies (e.g., improved forecasting and monitoring, Forecast Informed Reservoir Operations (FIRO)) and in the Delta to increase south of Delta exports (e.g., Long-Term Operations Action 5, realize physical capacity of CVP and SWP export facilities). Robust adaptive management programs should be used to inform and evaluate implementation of non-structural actions.
4. Develop and implement local conveyance, recharge, storage, and other projects identified in Groundwater Sustainability Plans, with an emphasis on advancing the shovel-readiness of projects to increase preparedness for funding opportunities. Continue to evaluate emerging approaches, technologies, and solutions.
5. Pursue large regional and statewide projects, particularly those that increase access to Delta supplies and improve regional conveyance and storage.
6. Leverage partnership opportunities with urban water users outside the SJV to jointly develop groundwater banking, recharge, and conveyance projects that produce water supply benefits to both parties and provide for project cost-sharing.
7. Establish a structured, regionally coordinated plan for agricultural land repurposing to minimize community effects and produce desired ecosystem and economic outcomes. Early strategic implementation can support groundwater recharge, ecosystem, energy, and community benefits, particularly in subbasins that will likely see larger areas of agricultural land repurposing.
8. Participate in California Water Plan updates, by engaging in committees and public workshops, providing review comments, and advocating for partnership in an analytical test of concept to estimate future water needs and evaluate potential adaptation strategies.

Recommendations for State and Federal Entities to Help Address Needs in the SJV

1. Restore and maintain the conveyance capacity and delivery capability of existing CVP and SWP subsidence-impacted canals and remove sediment from south Delta channels. The Reclamation extraordinary maintenance (XM) program was primarily designed to rehabilitate or replace aged infrastructure and requires full reimbursement by beneficiaries. The nature of regional land subsidence impacts to CVP and SWP conveyance facilities has created unique conditions in the SJV that challenge the applicability of the XM program.
2. Establish non-traditional federal funding mechanisms and a new SJV Water Supply Security program that would provide assistance to agricultural users and others to implement projects that preserve and increase the capability to manage water supplies in the SJV and Delta. Protecting the viability of agriculture in the SJV is of state and national importance that will require significant investment. Delta levee maintenance and improvements should be recognized as a water supply reliability, flood protection, ecosystem, and infrastructure priority that is directly connected to San Joaquin Valley water security. The Federal Government has extensive success in applying targeted infrastructure funding support for water supply throughout the western U.S. A program specifically tailored to the urgent needs of the SJV is warranted.
3. Establish a long-term, sustainable State of California funding mechanism specifically for investments in water resources projects in the SJV such as groundwater recharge and storage, surface water storage, and conveyance facilities. California has a long history of providing state financing to advance water resource management priorities. Establishing dedicated state funds for water system investment is not unprecedented. In 2025, Texas voters authorized a constitutional amendment to dedicate up to \$1 billion per year from existing state sales tax revenue to support funding for a broad range of water supply and related infrastructure, including: new supply sources (reservoirs, reuse, desalination, water purchases); wastewater reuse; flood control; agricultural water conservation; and repair and replacement of aging/leaking water systems.
4. Support implementation of water supply projects by streamlining permitting processes and engaging in agency cooperation. Many complex projects experience regulatory and institutional delays that contribute to increased costs over time. Permitting processes across multiple state and federal agencies should be revised where possible to improve clarity, enhance coordination and efficiency; integrate requirements across regulatory entities to avoid redundancies and inconsistencies; and establish clear criteria and accountable timelines for approval.
5. Determine if existing institutional requirements, such as the authorized places of use for SWP, CVP and other supplies in the SJV, would impede project implementation.
6. Consider expanding the definition of benefits used to evaluate financial feasibility of water resources projects to include the totality of project benefits, such as societal benefits of reliable domestic food production.

7. The State of California should continue ongoing efforts to support, enhance, and contribute to protecting and increasing water supplies and groundwater recharge. Examples include preparing the California Water Plan consistent with California Water Code section 10004 and 10004.7 as defined by California Senate Bill (SB) 659 (2023), and California Water Code section 10004, 10004.5, 10004.6, and 10013 as defined by SB 72 (2025); implementing legislation, executive orders, programs, initiatives, and other actions that increase groundwater recharge; and accelerating implementation of non-structural actions in the Delta and adaptive reservoir operations in the SJV.
8. The federal government should continue efforts to increase water supply reliability in the SJV and Delta through administrative actions, legislation, and other strategies. Examples include an emphasis on Executive Order 14181 to maximize operations of the CVP and SWP; and consideration of strategies designed to further increase water supply adequacy and reliability for entities that rely on the CVP and SWP. Such strategies should include regular review of the efficacy of existing constraints on the operations of the CVP and SWP, further integration of real-time scientific information and decision making, and the modification or elimination of those constraints that are demonstrated to be non-efficacious.

Recommendations for Unified Water Plan Implementation

1. Establish a structured approach to achieve regional agreement and support on project recommendations. Projects and actions should be recommended for further study and for implementation. Blueprint Analytical Tools could be further developed, refined, and used to assist with evaluations.
2. Continue coordinating regional and statewide partnerships to facilitate consistent messaging and to help address permitting, funding, and other constraints. Partnerships are key to overcoming financial limitations for project implementation and coordinated advocacy.
3. Prepare regular updates to the UWP that assess progress towards closing the supply-demand gap. Implementation of the UWP will unfold over several years and require transparency, adaptability, and accountability. Updates to the UWP should also include potential new actions that could further close the water supply-demand gap.
4. Prepare an updated regional economic impact study that quantifies the potential economic outcomes of inaction and fragmented land retirement in the SJV and consider effects on other regions outside of the SJV.
5. Collaborate with other entities in the SJV so that its “story” can be told in a compelling and cohesive manner.
6. Engage in California Water Plan updates including data sharing, test of concept development, and other important activities requiring partnership with DWR.

Contents

	Page
Chapter 1 Introduction.....	1-1
Call to Action.....	1-1
Background.....	1-1
Study Authorization and 2016 Report	1-2
Need for a Unified Water Plan.....	1-4
Objectives of the Unified Water Plan.....	1-5
Communication and Engagement.....	1-6
Organization of the Unified Water Plan.....	1-7
Chapter 2 Water Supply Problems, Needs, and Opportunities.....	2-1
Setting and Historical Context.....	2-1
Central Valley Project	2-4
State Water Project.....	2-7
Other Major Projects.....	2-8
Evolving Regulatory Environment.....	2-9
Environmental Values	2-9
Sustainable Groundwater Management.....	2-11
Existing and Projected Future Conditions	2-12
Existing Water Supplies.....	2-13
Future Supply Changes.....	2-21
Existing Water Demands	2-28
Future Demand Changes	2-30
Problems and Needs.....	2-31
Future Water Supply-Demand Gap	2-31
Water Supply Effects on Disadvantaged Communities	2-35
Catastrophic Risks.....	2-36
Economic and Social Considerations.....	2-36
Opportunities.....	2-36
Chapter 3 Flood Management	3-1
Setting and Historical Context.....	3-1
Existing Conditions and Future Flood Risk	3-3
Flood Control Facilities.....	3-5
Flood Control Operations	3-5
Flood Management Agencies	3-6
Central Valley Flood Protection Plan for the San Joaquin Valley	3-7
Regional Flood Management Plans	3-7
Upper San Joaquin River Flood Planning Region.....	3-10
Mid San Joaquin River Flood Planning Region	3-10
Lower San Joaquin River Flood Planning Region.....	3-11
Flood Management Opportunities.....	3-12
Upper Watershed Projects and Management Actions.....	3-12
Diversion of Water from Rivers and Streams During High Flow Conditions	3-12
Modification of Reservoir Flood Storage Operations	3-13

Increasing Conveyance Capacity of Designated Floodways	3-14
Development of Additional Surface Water Storage	3-14
Flood Management Next Steps	3-15
Chapter 4 Ecosystem Enhancement	4-1
Introduction	4-1
Historic and Current Conditions	4-4
Landcover Types of the San Joaquin Valley Floor	4-9
Currently Protected Lands	4-18
Specialty Reserves	4-20
Ecosystem Enhancement Opportunities and Objectives	4-21
Considerations for Development of Ecosystem Restoration Plans	4-22
Summary of Ecosystem Restoration Plans	4-23
Estimated Water Requirements for Ecosystem Enhancement	4-31
Chapter 5 Potential Projects and Actions	5-1
Groundwater Recharge Projects	5-2
Groundwater Recharge Suitability	5-2
On-Farm Recharge	5-8
Basin Recharge	5-11
In-Lieu Recharge	5-14
Injection Wells	5-16
Multi-Strategy, Multi-Facility, Unique, and Other Recharge Projects	5-19
Conveyance Projects	5-21
Benefits of Conveyance Projects	5-21
Implementation Considerations	5-21
Opportunities for Conveyance Projects	5-22
Water Storage Projects	5-46
Revised Reservoir Operations and Improved Forecasting	5-48
New or Expanded Surface Water Storage Projects	5-51
New or Expanded Groundwater Storage Projects	5-67
Transitional Storage	5-70
Floodplain Expansion	5-70
Other Water Supply Projects and Actions	5-71
Upper Watershed Projects and Management Actions	5-71
Local Water Supply Projects and Actions	5-73
Demand Management	5-81
Benefits of Demand Management	5-81
Implementation Considerations	5-81
Opportunities for Demand Management	5-82
Chapter 6 Advancing Potential Solutions	6-1
Key Findings	6-1
Evaluation of Potential Solutions	6-3
Project Evaluation Framework	6-3
Investment Scenarios	6-7
Potential Strategies for Future Evaluation and Project Selection	6-22
Purpose and Objectives	6-23
Potential Evaluation Considerations	6-24
Recommendations	6-26
Recommendations for Local and Regional Entities in the SJV	6-26

Recommendations for State and Federal Entities in the SJV	6-27
Recommendations for Unified Water Plan Implementation.....	6-28
Chapter 7 References	7-1
Chapter 1 References.....	7-1
Chapter 2 References.....	7-2
Chapter 3 References.....	7-6
Chapter 4 References.....	7-8
Chapter 5 References.....	7-12
Chapter 6 References.....	7-21

Figures

Figure 2-1. Study Area of the Unified Water Plan	2-2
Figure 2-2. Historical and Current Extent of Wetland, Floodplain, and Other Habitat and Land Uses in the San Joaquin Valley.....	2-3
Figure 2-3. San Joaquin Valley Map Showing Hydrologic Regions, Counties, Groundwater Subbasins, Communities and Major Water Supply Infrastructure.....	2-14
Figure 2-4. Central Valley Project Allocations Since 1996	2-17
Figure 2-5. State Water Project Table A Allocation Since 1996	2-18
Figure 2-6. Total Dissolved Salt Concentrations in the San Joaquin Valley	2-21
Figure 2-7. Land Subsidence in the San Joaquin Valley from 2015 to Present	2-28
Figure 3-1. Flood Zones and Facilities in the San Joaquin Valley	3-4
Figure 3-2. San Joaquin River Basin Flood Management Planning Regions	3-9
Figure 4-1. The Process for Developing a Conceptual Conservation Plan for the San Joaquin Valley.....	4-3
Figure 4-2. Pre-1900 Historic Vegetation Distribution in the San Joaquin Valley.....	4-4
Figure 4-3. Historical and Current Landcover Patterns	4-5
Figure 4-4. Managed Wetlands in the San Joaquin Hydrologic Region.....	4-14
Figure 4-5. Managed Wetlands in the Tulare Lake Hydrologic Region.....	4-15
Figure 4-6. Locations of Vernal Pools in the San Joaquin Valley.....	4-17
Figure 4-7. Candidate Core Areas and Potential Landscape Corridors	4-29
Figure 4-8. Habitat Connectivity in the San Joaquin Hydrologic Region.....	4-30
Figure 5-1. Summary of Soil Agricultural Groundwater Banking Index in the San Joaquin Hydrologic Region	5-4
Figure 5-2. Summary of Soil Agricultural Groundwater Banking Index in the Tulare Lake Hydrologic Region	5-5

Figure 5-3. Major Water Conveyance Facilities in the San Joaquin Valley.....	5-23
Figure 5-4. Geographic Extent of Water Conveyance Constraints Due to Reduced Capacity of Regional Conveyance Facilities Caused by Regional Land Subsidence.....	5-25
Figure 5-5. Potential New Regional Conveyance Projects in the San Joaquin Valley	5-33
Figure 5-6. Delta Conveyance Project	5-41
Figure 5-7. Folsom South Canal Extension Project	5-42
Figure 5-8. Delta Infiltration Gallery Project Concept	5-43
Figure 5-9. Infiltration Galleries would Divert Water Vertically Through Gravel Beds.....	5-44
Figure 5-10. Existing Major Water Storage Facilities in the San Joaquin Valley	5-47
Figure 5-11. Overdraft Recovery Under Flood-MAR and I-FIRM Scenarios	5-50
Figure 5-12. Proposed Large Water Storage Projects.....	5-53
Figure 5-13. Del Puerto Canyon Reservoir Project Map	5-56
Figure 5-14. San Luis Reservoir and Associated Facilities.....	5-57
Figure 5-15. San Luis Reservoir Enlargement and B.F. Sisk Dam Modification	5-58
Figure 5-16. Pine Flat Dam Spillway Enhancement.....	5-59
Figure 5-17. Farmington Reservoir Enlargement Map	5-61
Figure 5-18. Major Features of Shasta Dam Enlargement	5-64
Figure 5-19. Sites Reservoir Project Map	5-66
Figure 5-20. Kern Fan Groundwater Storage Project	5-69
Figure 6-1. Project Evaluation Approach.....	6-3
Figure 6-2. Scenario 2 Evaluation Results by Subbasin	6-16
Figure 6-3. Scenario 3 Evaluation Results by Subbasin	6-21
Figure 6-4. Recommended Project Information and Evaluation Framework.....	6-25

Tables

Table 2-1. GSP Status of Subbasins in the San Joaquin Valley.....	2-12
Table 2-2. Major Rivers in the SJV and the Downstream-Most Reservoir.....	2-15
Table 2-3. CVP Contractors in the San Joaquin Valley Area	2-16
Table 2-4. SWP Contractors in the San Joaquin Valley Area.....	2-18
Table 2-5. Estimated Historical Groundwater Extraction and Overdraft	2-20

Table 2-6. Estimated Annual Decrease in CVP and SWP Delta Imports by Subbasin Due to Changing Hydrologic Variability.....	2-23
Table 2-7. Estimated Water Supply Impacts of the San Joaquin River Restoration Program By Subbasin.....	2-24
Table 2-8. Contributions by Participant to the Healthy Rivers and Landscapes Program	2-25
Table 2-9. Estimated Contributions by Subbasin to the Healthy Rivers and Landscapes Program	2-26
Table 2-10. Existing Annual Average Water Supply-Demand Gap in the SJV.....	2-30
Table 2-11. Projected Future Changes to Existing Annual Average Demands.....	2-31
Table 2-12. Annual Average Projected Future Water Supply-Demand Gap in the San Joaquin Valley Based on GSPs.....	2-33
Table 2-13. Average Annual Projected Future Water Supply-Demand Gap in the San Joaquin Valley Based on PPIC.....	2-34
Table 4-1. Current and Historic Landcover in the San Joaquin Valley.....	4-5
Table 4-2. Listed Animals of the San Joaquin Valley Floor	4-6
Table 4-3. Listed Plants of the San Joaquin Valley Floor	4-8
Table 4-4. Number of Listed Species by County in the San Joaquin Valley	4-9
Table 4-5. Species Associated with San Joaquin Valley Landcover Types.....	4-11
Table 4-6. Large Blocks and Core Areas of Protected Natural Lands.....	4-18
Table 4-7. Natural Lands Targeted for Protection and Specialty Reserves.....	4-21
Table 4-8. Restoration Goals by Habitat Type for the San Joaquin Valley in Acres	4-31
Table 4-9. Evapotranspiration by Region in the San Joaquin Valley	4-34
Table 4-10. Estimated Ecosystem Enhancement Water Requirements for a Potential San Joaquin Valley Target Restoration Plan	4-38
Table 5-1. Land Potentially Suitable for Surface-Based Recharge Techniques	5-6
Table 5-1. Land Potentially Suitable for Surface-Based Recharge Techniques (Cont.).....	5-7
Table 5-2. Summary of Local On-Farm Groundwater Recharge Project Information Presented in Groundwater Sustainability Plans by Subbasin.....	5-10
Table 5-3. Summary of Local Basin Groundwater Recharge Project Information Presented in Groundwater Sustainability Plans by Subbasin	5-14
Table 5-4. Summary of Local In-Lieu Groundwater Project Information Presented in Groundwater Sustainability Plans	5-16
Table 5-5. Summary of All Local Injection Wells Project Information Presented in Groundwater Sustainability Plans	5-18

Table 5-6. Summary of Multi-Strategy, Multi-Facility, Unique, and Other Recharge Project Information Presented in Groundwater Sustainability Plans	5-20
Table 5-7. Summary of Local Conveyance Project Information Presented in Groundwater Sustainability Plans by Subbasin.....	5-24
Table 5-8. Cost Estimate for Mid Valley Canal Branch with Western Expansion Project.....	5-34
Table 5-9. Cost Estimate for Trans-Valley Canal Tulare Alignment	5-35
Table 5-10. Cost Estimate for Kaweah Alignment.....	5-36
Table 5-11. Cost Estimate for Western Madera Conveyances Project	5-38
Table 5-12. Summary of Surface Water Storage Projects with Known Costs and Yields	5-55
Table 5-13. Summary of Local Recycled Water Projects with Known Costs and Yields	5-75
Table 5-14. Summary of Local Reclaimed Water Projects with Known Costs and Yields	5-76
Table 5-15. Summary of Local Surface Water Treatment Projects with Known Costs and Yields.....	5-77
Table 5-16. Summary of Local Surface Water Delivery Projects with Known Costs and Yields.....	5-78
Table 5-17. Summary of Local Surface Water Trading Projects with Known Costs and Yields.....	5-79
Table 5-18. Summary of Water Purchase Projects with Known Costs and Yields.....	5-80
Table 6-1. Variables Applied in Evaluation of Investment Scenarios.....	6-6
Table 6-2. Project Categories Included in Each Investment Scenario.....	6-8
Table 6-3. Comparison of Supply-Demand Gap and Total Local Project Capability.....	6-13
Table 6-4. Scenario 2 Evaluation Results	6-15
Table 6-5. Scenario 3 Evaluation Results	6-20

Photos

Photo 1. On-Farm Recharge on a Vineyard in Lodi, CA	5-11
Photo 2. Kern Water Bank Recharge Basins	5-13
Photo 3. City of Fresno Leaky Acres Recharge Basins	5-13
Photo 4. Injection Well in Westlands Water District	5-19
Photo 5. California Aqueduct	5-27
Photo 6. Cracked Concrete Lining on the Delta Mendota Canal as a Result of Subsidence	5-28
Photo 7. Friant-Kern Canal Middle Reach Capacity Correction Project Northern Tie-In with Existing Canal.....	5-29

Photo 8. Eastman Lake and Buchanan Dam Intake Tower.....	5-60
Photo 9. Upper Feather River Watershed Meadow Restoration.....	5-72
Photo 10. The City of Fresno Supplementing Water Supply Using Recycled Water, Indicated by the Purple Pipes	5-73
Photo 11. Westlands Solar Park Project, a 2.7-Gigawatt Solar Project on Converted Farmland.....	5-83
Photo 12. Fallowed Agricultural Land in the San Joaquin Valley.....	5-84

Abbreviations and Acronyms

2016 Draft Findings	Integrated Regional Water Management Plan for the San Joaquin Valley of California
2025 LTO ROD	Long-Term Operation of the Central Valley Project and SWP on December 4, 2025
AEM	airborne electromagnetic
ASO	Airborne Snow Observatory
Banks	Harvey O. Banks
Bay-Delta	Sacramento/San Joaquin Rivers Delta and San Francisco Bay
Bay-Delta Plan	Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
BCID	Banta Carbona Irrigation District
Blueprint	Water Blueprint for the San Joaquin Valley
CALFED	California Bay-Delta Program
CAP	San Joaquin Valley Collaborative Action Program
CASGEM	California Statewide Groundwater Elevation Monitoring
CCC	Columbia Canal Company
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CVC	Cross Valley Canal
CVFPA	Central Valley Flood Protection Act of 2008
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVJV	Central Valley Joint Venture
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWD	Chowchilla Water District
CWI	California Water Institute at California State University, Fresno
DAC	disadvantaged community
DCP	Delta Conveyance Project
DCR	Delivery Capability Report
Delta	Sacramento-San Joaquin River Delta

DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
ET	evapotranspiration
FEMA	Federal Emergency Management Agency
FIRO	Forecast Informed Reservoir Operations
FKC	Friant-Kern Canal
Flood-MAR	Flood Managed Aquifer Recharge
FWA	Friant Water Authority
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HRLP	Healthy Rivers and Landscapes Program
I-FIRM	Integrated Forecast-Informed Resources Management
IRWMP	Integrated Regional Water Management plan
Jones	C.W. Bill Jones
LSJLD	Lower San Joaquin Levee District
LTO	long-term operation
M&I	municipal and industrial
MAF/YR	million acre-feet per year
MID	Merced Irrigation District
MOU	memorandum of understanding
MRCCP	Middle Reach Capacity Correction Project
MWD	Metropolitan Water District of Southern California
NEPA	National Environmental Policy Act
Optimization Model	SJV Water Infrastructure Optimization Model
PID	Patterson Irrigation District
PL	Public Law
PPIC	Public Policy Institute of California
Prop 1	Proposition 1 (California Water Quality, Supply, and Infrastructure Improvement Act of 2014)
Q4	fourth quarter
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Restoration Flows	San Joaquin River Restoration Settlement Restoration Flows
RFMP	regional flood management plan
ROD	Record of Decision
SAFER	Safe and Affordable Funding for Equity and Resilience
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
Settlement	San Joaquin River Restoration Settlement

SGMA	Sustainable Groundwater Management Act
Sites Reservoir	Sites Reservoir Project
SJRRP	San Joaquin River Restoration Program
SJV	San Joaquin Valley
SLC	San Luis Canal
SLDMWA	San Luis Delta Mendota Water Authority
SLR	San Luis Reservoir
SPFC	State Plan of Flood Control
SWP	State Water Project
TAF	thousand acre-feet
TAF/YR	thousand acre-feet per year
TBWP	Tulare Basin Wildlife Partners
TDS	total dissolved solids
tTEM	towed time-domain electromagnetic
USACE	U.S. Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
UWP	Unified Water Plan
Watershed Studies	San Joaquin Basin Flood Managed Aquifer Recharge Watershed Studies
WIIN Act	Water Infrastructure Improvements for the Nation Act
WSIP	Water Storage Investment Program
XM	extraordinary maintenance

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Chapter 1 Introduction

Call to Action

California's water future is being reshaped by groundwater sustainability and other regulatory requirements, climate uncertainty, and growing pressure on both communities and ecosystems. In the California San Joaquin Valley (SJV), these challenges are especially acute, raising an urgent need to define how the region can meet competing demands under the threat of dramatic water supply reductions. The Unified Water Plan (UWP) addresses dramatic changes in water availability driven by the Sustainable Groundwater Management Act (SGMA), forecasted changing hydrologic variability, and anticipated regulatory requirements, and evaluates a wide range of potential solutions to address these needs. It represents an important first step in developing coordinated long-term solutions to meet water supply, flood risk reduction, and ecosystem objectives, rather than leaving these changes to occur in a fragmented manner.

Background

The SJV in central California is one of the most productive agricultural regions in the world and is a cornerstone contributor to the economies of California and the United States. The eight-county region of the SJV includes seven of the top 10 agricultural producing counties in the nation (CDFA 2024; Fabian 2022). It includes significant populations within cities and towns that are hubs of social and economic value built largely to support agriculture and other industries. At the same time, the SJV functions as a robust and diverse ecosystem, supporting unique environmental processes and critical habitat, including migratory corridors and wildlife refuges.

The region relies on a complex water supply and flood management system constructed primarily during the early to mid-20th century. This system was developed from significant coordinated local, state, and federal investments designed to provide reliable surface water supplies to the region, protect it from frequent flooding, and enable expansive economic development. It was designed to be resilient to natural stressors like flood and drought, as well as expected levels of induced stressors like regional land subsidence. However, several unanticipated stressors have led to a significant imbalance between regional demands and water supplies.

During the latter portion of the 20th century, regulatory frameworks, which were already complicated by influence from local, state, and federal priorities, began reflecting changing societal values. These changing societal values led to the passage of laws like the Endangered Species Act (ESA) and the Central Valley Project Improvement Act (CVPIA), that ultimately decreased the reliability of surface water supplies available to meet agricultural and municipal and industrial (M&I) demands in the region. This necessitated a continued unsustainable reliance on groundwater to meet these demands, which caused an overdraft of groundwater aquifers and undesirable effects including but not limited to dry wells, poor water quality, and significant and unanticipated rates of regional land subsidence.

Today, residents of the SJV are dealing with the continuation of undesirable effects described above while working with local, state, and federal officials to manage surface water and groundwater supplies in a complex and ever-changing regulatory landscape. This includes protecting agricultural, M&I, and environmental demands while meeting requirements set forth in the SGMA, which requires the implementation of sustainable groundwater management practices that avoid undesirable results including groundwater overdraft. This requirement significantly limits groundwater's historical role as a backstop to meet demands not fulfilled with surface water.

As a result, the SJV is undergoing a transition in water and land management that requires demands to be met while maintaining water balance in the aquifers. Without coordinated action, this transition will occur unevenly and be driven by local constraints, regulatory compliance, and short-term economic decisions. This approach risks inefficient allocation of resources, unnecessary economic disruption due to demand management and loss of farmland, and missed opportunities to improve regional water supply reliability, flood management, and environmental outcomes.

This UWP serves a call to action to address the transition to water supply and demand balance occurring in the SJV in a coordinated and strategic manner. The UWP focuses on opportunities to make strategic investments into water supply, flood management, and ecosystem enhancement, while minimizing negative outcomes – particularly demand reduction via farmland conversion. It is in the interest of the SJV, California, and the United States to continue to invest in the region to restore a vibrant agricultural economy, dynamic communities, and a healthy environment.

Study Authorization and 2016 Report

Public Law (PL) 111-11, enacted in 2009, authorized implementation of the San Joaquin River Restoration Settlement (Settlement) and related items. Part II of the Settlement, titled “Study to Develop Water Plan: Report,” authorized the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) to provide funding to the California Water Institute at California State University, Fresno (CWI) to “conduct a study regarding the coordination and integration of sub-regional integrated regional water management plans into a unified Integrated Regional Water Management Plan.” The requirements of the plan are to address: (A) water quality; (B) water supply; (C) water conveyance; (D) water reliability; (E) water conservation and efficient use; (F) flood control; (G) water resource-related ecosystem enhancement; and (H) population growth. The legislation specified a study area for the San Joaquin River and the Tulare Lake hydrologic regions including the counties of Kern, Tulare, Kings, Fresno, Madera, Merced, Stanislaus, and San Joaquin. The stated use of the UWP is to “address and solve long-term water needs in a sustainable and equitable manner.” At the time of the legislation, preparation of Integrated Regional Water Management plans (IRWMP) was the dominant mechanism for regional water supply planning in the SJV.

In 2016, in response to PL 111-11, CWI prepared a preliminary draft plan titled Integrated Regional Water Management Plan for the San Joaquin Valley of California (2016 Draft Findings). The 2016 Draft Findings summarized the IRWMPs that had been prepared to date by regional groups within the study area, and compiled available information that addressed the required topics identified in PL 111-11. The 2016 Draft Findings made several findings and presented recommendations to

expand regional collaboration in support of water management throughout the SJV. Some key findings and recommendations in the 2016 Draft Findings are highlighted here:

- The greatest issue throughout the SJV is water supply reliability, from both surface water and groundwater sources, which varies depending on the location.
- Lack of information and integration of management plans for water sources impedes the development of comprehensive water budgets for the region. Without water source management and water budgets, uncertainty will likely continue, and water sustainability will remain an elusive goal.
- The introduction of integrated regional water management planning fostered significant improvements in water management by aggregating partners in sub-regions and implementing activities that provide lasting improvements.
- Future efforts need increased technical, legal and institutional investigation efforts on water sources and the landscapes that provide the sources. The entire watershed areas, their terrestrial and aquatic ecosystems and other critical portions of the landscape represent a gap that must be included in future organizational schemes in as much as the lack of clear and achievable goals with measurable outcomes for natural water uses will likely continue to add to the uncertainty of water availability for direct uses.
- CWI recommends augmenting integrated regional water management planning needs with integrated basin watershed planning and management that includes advanced system oversight and professional management structures that can accomplish the work of holistically assessing and managing all of the natural landscapes, the water sources and all the uses with an institutional arrangement that includes the entire watershed system.
- The SJV could benefit from additional institutional mechanisms to fairly administer the findings and recommended management strategies of that assessment.
- The greatest challenge for the SJV is to determine what the Valley watershed systems can support after all the water sources, needs and uses are calculated and management strategies optimized.

The 2016 Draft Findings do not provide specifics on needs for the SJV in the topic areas identified. Rather it states “almost all of the new (project) additions are in the early stages of their implementation and need to develop further to assess their management impacts. Therefore, developing a more comprehensive strategy for the entire San Joaquin Valley remains only a goal at this time.” In recognition of the status of available information and numerous rapid changes that were occurring in the SJV at the time, Reclamation and CWI temporarily paused further development of the UWP.

Need for a Unified Water Plan

Following preparation of the 2016 Draft Findings, several important developments occurred that significantly affect water management and planning in the SJV and establish the need for this UWP.

- SGMA was enacted in 2014, at the time the Draft Findings were being prepared. SGMA requires the formation of local Groundwater Sustainability Agencies (GSA) that are responsible for developing and implementing Groundwater Sustainability Plans (GSP) to achieve long-term groundwater sustainability within groundwater subbasins. The first plans were required to be provided to the Department of Water Resources in early 2020. Fulfilling the obligations under SGMA and the GSPs will require significant reduction in overall groundwater use throughout the SJV and the improved management of surface water and groundwater supplies.
- The 2012 to 2016 drought, which had the most extreme impacts of any drought on record, resulted in unprecedented water delivery reductions to water users throughout the SJV. The impacts and effects of this type of drought had not been considered in the development of the 2016 Draft Findings, and they underscored the severity of water resource problems in the SJV. A more intense, but shorter duration, dry period occurred from 2020 to 2022, further highlighting the gap between available water supplies and SJV demands.
- Following the dry period from 2020 to 2022, the SJV experienced an exceptionally wet period in early 2023, which caused significant flooding in the region. This was highlighted by the re-emergence of Tulare Lake, which flooded communities and thousands of acres of farmland. The flooding highlighted the need for improved water management, specifically for the benefit of flood flow reduction and groundwater recharge enhancement.
- Reclamation prepared the San Joaquin River Restoration Program Water Management Goal Investment Strategy in 2015, which identified local projects that would be beneficial in reducing or avoiding water supply impacts resulting from the release of San Joaquin River Restoration Settlement Restoration Flows (Restoration Flows) to the San Joaquin River. The study identified water supply management projects that can contribute to reducing or avoiding water delivery consequences resulting from the release of Restoration Flows to the San Joaquin River from Friant Dam.
- GSAs in the SJV submitted initial GSPs in 2020 that describe long-term groundwater sustainability objectives and identify potential projects and management actions that may be implemented to achieve those objectives. Many GSPs reflect projects specified in IRWMPs, with modifications and supplements. The GSPs have a higher degree of visibility than the IRWMPs because of SGMA requirements, especially as they are reviewed by the California Department of Water Resources (DWR) and the California State Water Resources Control Board, revised and resubmitted by GSAs. This process has been ongoing since 2020.
- DWR, in partnership with State Water Project (SWP) contractors, is evaluating the Delta Conveyance Project, which would alter the timing and volume of water exported from the

Sacramento-San Joaquin River Delta (Delta) to the San Joaquin Valley and Southern California.

- The Central Valley Flood Protection Act of 2008 (CVFPA) established the requirement for a Central Valley Flood Protection Plan (CVFPP) which must be updated every 5 years. The CVFPA directed DWR and the Central Valley Flood Protection Board (CVFPB) to lead planning and implementation efforts. The original CVFPP was prepared and adopted by the CVFPB in 2012; the latest update completed in 2022.
- The California Water Commission authorized funding for the public benefits to be provided by proposed water storage projects that may affect water supply availability in the San Joaquin Valley, including the Sites Reservoir Project (Sites Reservoir), the Kern Fan Groundwater Storage Project, and the Willow Springs Water Bank Conjunctive Use Project (CWC 2025). However, none of these projects have been constructed, and many others that were originally part of the program have been halted due to rising costs or implementation concerns.
- The Water Blueprint for the San Joaquin Valley (Blueprint) was formed as a collaborative initiative aimed at addressing the region's water supply challenges to identify water resource policies and projects that maximize accessible, affordable, and reliable supplies for sustainable and productive farms and ranches, healthy communities, and thriving ecosystems in the SJV. The Blueprint comprises the eight counties identified in Part II of the Settlement in PL 111-11, community leaders, businesses, water agencies, local governments, and agricultural representatives working together to advance a common vision of water solutions for the region. As part of their work, the Blueprint prepared preliminary technical studies on potential new infrastructure including new diversion facilities in the Delta and conveyance facilities in the SJV for the distribution of additional Delta water supplies.
- Numerous other studies on water supply availability, economic conditions, and potential land retirement implications of SGMA compliance have been prepared in the past decade by the Public Policy Institute of California (PPIC) and other entities, including Federal, State, and local agencies.

Objectives of the Unified Water Plan

This UWP identifies current and future water resources-related problems, needs, and opportunities in the SJV, and presents possible solutions and a potential path towards implementation of various solutions. It was developed to help communities, farmers, and public agencies collaborate to solve shared water challenges – including groundwater overdraft, water quality degradation, flood risk, and environmental stress – while preparing for changing conditions.

This UWP further prioritizes water supply and groundwater overdraft challenges because of the desperate need to close the water supply-demand gap to comply with SGMA, protect communities and critical infrastructure. Many opportunities are available to close the gap with disparate costs and

benefits. Additionally, there is synergy between some projects but not others. These conditions require careful consideration of how individual projects fit together and how to evaluate their benefits and costs. These interrelated complexities require the evaluation of combinations of projects under various scenarios – which is contemplated in this UWP.

Specific objectives of the UWP include:

- Identify the current and projected water related problems, needs and opportunities in the San Joaquin Valley related to: water supply and reliability, water quality, water conveyance, flood control, ecosystem enhancement, water conservation and efficient use, and population growth.
- Identify possible solutions to address the identified problems and needs in the SJV.
- Identify pathways to advance the identified potential solutions. The pathways focus on opportunities to make strategic investments into water supply, flood management, and ecosystem enhancement, while minimizing negative outcomes – particularly demand reduction via farmland conversion. It also highlights potential outcomes so that strategies can be developed in a strategic and coordinated manner.

Communication and Engagement

This UWP was developed by the CWI in close coordination with the Blueprint, with technical support from Stantec Consulting Services and funding from Reclamation. The effort was guided through regular coordination with the Blueprint Board of Directors, including presentations and discussions at monthly meetings that helped shape the study approach, key assumptions, interpretation of results, and development of findings and recommendations. Ongoing engagement with the Blueprint Technical Committee was central to the effort, including direct collaboration with technical committee members and use of Blueprint analytical tools to conduct and refine simulations.

In addition to Blueprint coordination, the UWP effort included engagement with a variety of local, state, and federal entities. This included coordination with DWR, Reclamation, GSAs, and others to review the study approach, discuss preliminary findings, and solicit feedback. Input and review comments were also obtained from the San Joaquin Valley Collaborative Action Program (CAP), the South Valley Water Users Association, the Great Valley Farm Water Partnership, and other stakeholders to incorporate broader regional perspectives.

Broader outreach was conducted through presentations at regional conferences and summits to share draft findings and recommendations. These included the Association of California Water Agencies Fall Meeting in San Diego (December 2025), Dairy Sustainability Summit in Visalia (March 2026), and the San Joaquin Valley Water Resilience Summit in Fresno (May 2026). These engagement efforts helped ensure that the UWP reflects regional priorities, incorporates stakeholder input, and supports continued collaboration across local entities in the SJV.



Organization of the Unified Water Plan

This UWP includes the following chapters:

Chapter 1 – Introduction

Chapter 2 – Water Supply Problems, Needs, and Opportunities

Chapter 3 – Flood Management

Chapter 4 – Ecosystem Enhancement

Chapter 5 – Potential Projects and Actions

Chapter 6 – Advancing Potential Solutions

Chapter 7 – References

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Chapter 2 Water Supply Problems, Needs, and Opportunities

Setting and Historical Context

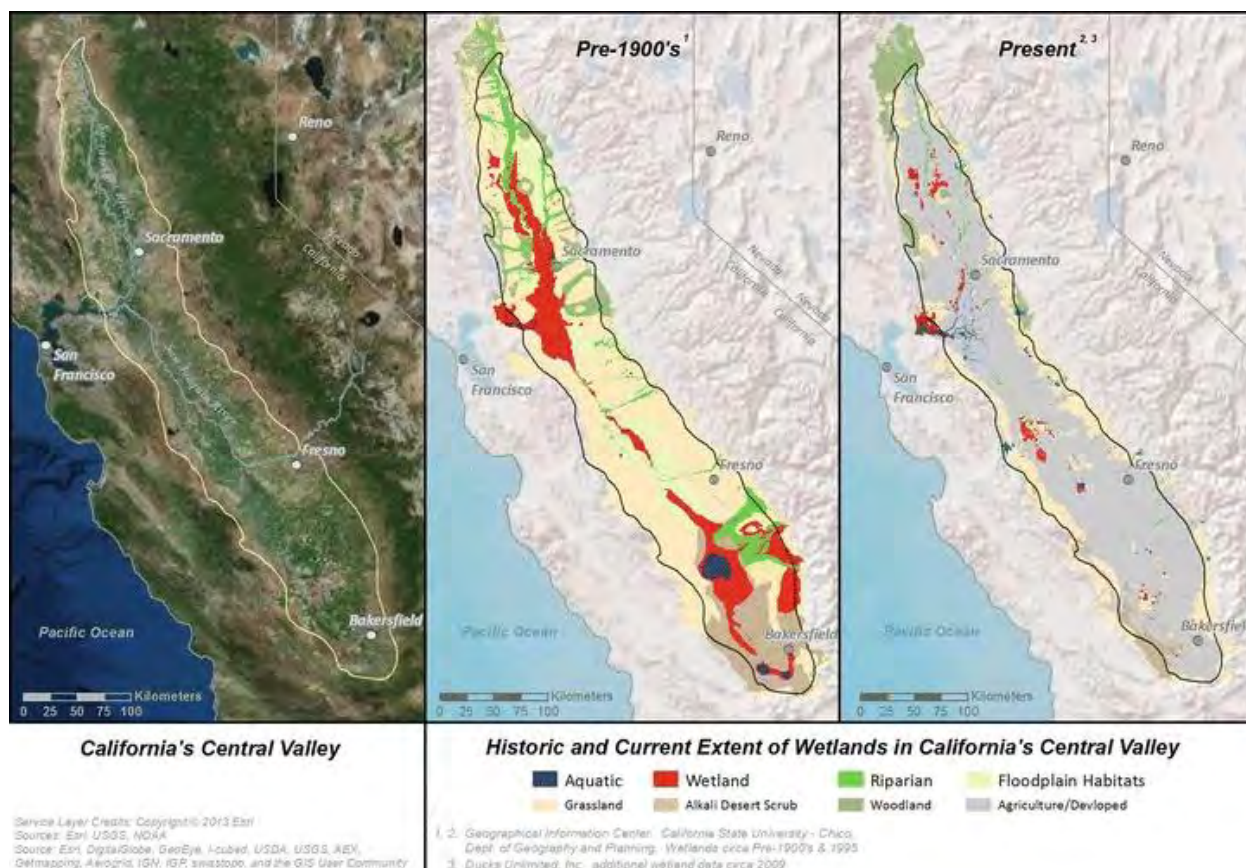
The SJV is defined by a highly managed hydrologic system shaped by natural processes and more than a century of complex water development. The region is bounded by the Delta on the north, the Tehachapi Mountains on the south, the Coastal Range on the west, and the Sierra Nevada Mountains on the east, as shown on Figure 2-1. Before European settlement, the SJV included expansive floodplains, wetlands, and seasonal lakes that supported diverse ecosystems. Today, due to transition over time, the SJV is one of the most vibrant agricultural regions in the world, producing over 250 different crops with an annual value of approximately \$24 billion (PPIC 2023a), and a critical economic and environmental resource to both the State of California and the United States. The history of water development in the SJV reflects a complex interaction of water availability, technological and economic development, and evolving societal values.

Prior to European settlement, the SJV was comprised primarily of grasslands and aquatic features like wetlands, riparian corridors, floodplains, ponds, and lakes, which were fed by rivers and streams originating in the surrounding mountains, shown on Source: Figure 2-2. Most of the region's surface water supplies originated in the Sierra Nevada Mountains on the eastern side of the SJV. Major river systems flowed north towards the Delta or east and south towards large freshwater lakes. These diverse features supported spawning and rearing habitat for salmon, extensive bird habitat supporting the Pacific Flyway, and upland habitat. A key feature was Tulare Lake, which was the largest natural lake west of the Mississippi River. Early inhabitants of the region included Native Americans and Spanish settlers. European settlement accelerated in the mid-19th century primarily driven by westward migration following the California Gold Rush.

Large-scale agricultural development in the SJV began with European settlement in the latter portion of the 19th century. At the time, water development to support agriculture and growing communities relied principally on groundwater because it was easily accessible - in some areas, it flowed through artesian wells. Early groundwater use was supplemented by surface water diverted from local streams and rivers. Land was leveled and cultivated as agricultural development expanded. Easily accessible groundwater began to diminish as development progressed and, along with access to surface water, began to limit agricultural development. However, the development and advancement of pump technology allowed deeper groundwater to become a viable and widespread option for continued agricultural development.



Figure 2-1. Study Area of the Unified Water Plan



Source: Reid et al. 2016

Figure 2-2. Historical and Current Extent of Wetland, Floodplain, and Other Habitat and Land Uses in the San Joaquin Valley.

As agricultural and water development expanded throughout the SJV, local irrigation districts were formed under the authority of the Wright Act of 1887 to manage water resources and finance water supply projects. Although local investments were made to enable the conjunctive management of surface and groundwater resources, groundwater remained the primary water supply source in the SJV through the early 20th century. The cumulative effects of groundwater extraction became apparent by the early 20th century and included declining groundwater levels and areas of regional land subsidence. Land subsidence, or the sinking of the ground surface, occurs when groundwater pumping (and other factors) causes fine-grained aquifer sediments, particularly clay layers, to compact (DWR 2025a). Regional land subsidence can result in undesirable effects including damage to linear infrastructure such as canals, leveed rivers and flood channels, and roads.

In addition to water supply, early development in the SJV was also shaped by a persistent and significant threat from flooding. One consequential event was the Great Flood of 1861 and 1862, during which a prolonged series of storms delivered approximately 30 inches of precipitation over a two-month period from December to January. The resulting runoff inundated large portions of the SJV and caused widespread loss of life. It is estimated that approximately 4,000 people died and economic damages were equivalent to several billion dollars in today's terms (Null and Hulbert 2007). The scale and severity of this flooding underscored the vulnerability of the SJV's landscape

and emerging communities, and highlighted a need for investments in reliable water supply infrastructure and a coordinated approach to flood management to support agricultural and community development.

Beginning in the early 20th century, significant local, state, and federal investments were made to develop infrastructure to capture, detain, store, and convey water supplies in the SJV. Numerous dams and reservoirs on Sierra Nevada rivers that flow into the SJV were developed to provide water supply, flood risk reduction, and other benefits. In addition, investments were made to import water supplies from sources outside of the SJV (e.g., the Sacramento Valley through the Delta). These investments continued through the mid- to late-20th century and resulted in the construction of major water supply and flood control projects including the Central Valley Project (CVP) operated by the Reclamation, the California SWP operated by DWR, and numerous reservoirs operated by the Army Corps of Engineers (USACE), as described in the subsections below.

Central Valley Project

Extending 400 miles through central California, the CVP is a complex, multi-purpose network of dams, reservoirs, canals, hydroelectric powerplants and other facilities. The CVP reduces flood risk for the Central Valley, and supplies water for agricultural, domestic, municipal and industrial use in the Central Valley and the San Francisco Bay Area. The CVP also provides electrical power, offers various recreational opportunities, and provides water supplies to restore and protect fish and wildlife, and to enhance water quality. The historical build out of the CVP is outlined below, which contains information obtained from Reclamation's CVP website (Reclamation 2026a).

Construction of major CVP facilities began in 1938 with breaking of ground for Shasta Dam on the Sacramento River near Redding in Northern California. The CVP was originally planned as a State-led project to provide surface water supplies, flood protection, and power production to the SJV and the Sacramento Valley. However, the state was unable to sell bonds to continue to fund development of the project and, in turn, California sought federal support. In 1935 the Federal Government authorized the construction of initial features of the CVP, including the Friant Division, the Kennett Division (Shasta), and the Contra Costa Division (i.e., the Delta Division). In 1937, the authorization was amended to make the CVP subject to Reclamation Law.

Over the successive five decades following initial construction, the CVP was expanded through legislation into a system of 20 dams and reservoirs that together can store nearly 12 million acre-feet of water. The CVP has long-term agreements to supply water to over 250 contractors in 29 of California's 58 counties. Average annual water deliveries by the CVP include about 5 million acre-feet of water for farms; 600,000 acre-feet of water for municipal and industrial uses (enough water to supply about 2.5 million people for a year); and water for wildlife refuges and maintaining water quality in the Sacramento-San Joaquin Delta.

Friant Division (1935)

Principal facilities of the Friant Division of the CVP include Friant Dam, the Friant-Kern Canal (FKC), and the Madera Canal, which are operated to store and deliver San Joaquin River water to area districts. Friant Dam was completed in 1942 and impounds Millerton Lake on the San Joaquin River. It has a storage capacity of approximately 520 thousand acre-feet (TAF). The FKC conveys

water from Millerton Lake south to the Kern River to provide water to Fresno, Tulare, and Kern Counties. The Madera Canal provides water from Millerton Lake north to Madera County.

Development of the Friant Division required the Federal Government to secure water rights necessary to provide a reliable water supply for the CVP. In 1939, the United States entered into a set of agreements with existing water rights holders on the San Joaquin River, downstream of Friant Dam. These agreements, primarily with Miller & Lux, Columbia Canal Company, and other water rights holders (commonly referred to as the Exchange Contractors), allowed the Federal Government to impound and divert San Joaquin River water at Friant Dam in exchange for a commitment to deliver substitute water supplies to the Exchange Contractors via the Delta Mendota Canal (DMC). Importantly, these agreements preserve seniority of the Exchange Contractor's water rights and guarantee delivery of San Joaquin River water if substitute supplies are not available. These agreements were amended over time and the current "Exchange Contract" was established in 1967.

Shasta Division (1935)

The Shasta Division of the CVP (originally named "Kennett Division") consists of Shasta Dam, impounding Shasta Lake on the Sacramento River, and Keswick Dam, impounding Keswick Reservoir on the Sacramento River. Shasta Dam has a storage capacity of approximately 4,500 TAF and provides water storage for water supply, flood control, hydropower generation, and is an important source of water for ecological purposes. Keswick Dam, acts as the Shasta Dam afterbay, and can store approximately 24 TAF for the purpose of water supply, flood control and power generation. Water stored in the Shasta Division can be released to the Delta and exported to the SJV.

Delta Division (1935)

The Delta Division (originally named "Contra Costa Division") includes critical infrastructure within and near the Delta, including facilities necessary to export water from the Delta. Principal facilities in the Delta Division include the Delta Cross Channel, Contra Costa Canal, C.W. Bill Jones (Jones) Pumping Plant (originally named "Tracy Pumping Plant"), and DMC. Delta Division facilities enable the transport water and diversion of water from the Sacramento River to the SJV as well as lands and municipalities in the Delta Division.

The Delta Cross Channel is a gate-controlled diversion channel on the east bank of the Sacramento River, downstream of Sacramento. The channel enables the diversion of freshwater from the Sacramento River into the interior Delta and towards CVP and SWP pumps located in the southern portion of the Delta. The Contra Costa Canal is a water delivery system from the Delta through communities including Antioch, Concord, and Martinez. Although originally developed primarily for agricultural use, it now primarily serves water for M&I uses. The DMC conveys water pumped through the Jones Pumping Plant from the Delta to the Mendota Pool in the SJV. Water conveyed through the DMC serves the Exchange Contractors, CVP agricultural and M&I contractors, and wildlife refuges.

American River Division (1949)

The American River Division of the CVP was authorized in 1949 and consists primarily of Folsom Dam, Nimbus Dam, Sly Park Unit and associated distribution systems. The American River Division provides water for water supply, flood control, hydropower generation, and ecological purposes.

Folsom Dam on the American River was recently modified to increase the storage capacity from the originally constructed capacity of 975 TAF to 1,010 TAF. Most water released from Folsom Lake flows to the Sacramento River and into the Delta. Nimbus Dam is on the American River downstream of Folsom Dam creates Lake Natoma Reservoir, which has a storage capacity of just under 9 TAF and provides for diversion to the Folsom South Canal. The Sly Park Unit consists of Sly Park Dam which impounds Jenkinson Lake, Camp Creek Diversion Dam and the Comino Conduit.

Sacramento Division (1950s – 1960s)

The Sacramento Division of the CVP was developed primarily to provide water for irrigation to support agricultural development in the Sacramento Valley. The Sacramento Division consists of the Corning Canal, Tehama-Colusa Canal, Red Bluff Pumping Plant and ultimately Black Butte Dam. The Corning Canal and associated pumping plant delivers water to irrigation contractors in Tehama County. The Tehama-Colusa Canal delivers water to Tehama, Glenn, Colusa, and Yolo counties for the primary purpose of agriculture. The Red Bluff Pumping Plant on the Sacramento River was completed in 2021 to bypass the Red Bluff Diversion Dam. It delivers water to the Tehama-Colusa and Corning canals, providing a water supply for over 150,000 acres of farmland. Black Butte Dam is a USACE facility built in 1963 for flood control purposes that was later integrated into the CVP as part of the Sacramento Division.

Trinity River Division (1955)

The Trinity River Division of the CVP is located in the Klamath River Basin, of which the Trinity River is a tributary. It was authorized in 1955 and includes facilities that provide for the transfer water from the Klamath Basin to the Sacramento River Basin. Principal facilities of the Trinity River Division include Trinity Dam and Powerplant; Clair Engle Lake; Lewiston Dam, Lake, and Powerplant; Clear Creek Tunnel; Judge Francis Carr Powerhouse; Clair A. Hill Whiskeytown Dam and Whiskeytown Lake; Spring Creek Power Conduit, Powerplant, Debris Dam, and Reservoir; Trinity River Fish Hatchery; and other related facilities.

Trinity Dam impounds Claire Engle Lake with a storage capacity of 2.5 TAF and regulates flows downstream on the Trinity River. Downstream from Trinity Dam, Lewiston Dam and Lake diverts water into the Clear Creek Tunnel, which discharges into Whiskeytown Lake with a capacity of 241 TAF. Water released from Whiskeytown Lake is conveyed through Spring Creek Tunnel to Keswick Reservoir on the Sacramento River. The Trinity River Fish Hatchery produces salmonid under operation by the California Department of Fish and Wildlife.

San Luis Unit (1960)

The San Luis Unit was authorized in 1960 as part of the CVP and contains the major facilities of Sisk Dam and San Luis Reservoir, O'Neill Forebay, the San Luis Canal, and Dos Amigos Pumping

Plant. Many San Luis Unit facilities are characterized as joint-use facilities that are owned by Reclamation and operated and maintained by DWR as joint features of the CVP and the SWP. The San Luis Unit provides water supply for irrigation and M&I uses in Fresno, Kings, Merced, Santa Clara, and San Benito counties. San Luis Reservoir can store over 2,000 TAF, of which the CVP share is approximately 966 TAF, and is the largest off stream storage facility in the United States. The San Luis Canal begins at the O'Neill Forebay and extends along the western side of the San Joaquin Valley delivering water south to the areas identified above. The Dos Amigos Pumping Plant lifts water in the San Luis Canal for conveyance.

East Side Unit (1962)

The Flood Control Act of 1962 reauthorized the development of a New Melones Dam and Lake on the Stanislaus River upstream of the confluence with the San Joaquin River. New Melones Lake can store 2,400 TAF and provides water to irrigation districts in the SJV. In addition to water supply, the New Melones Dam also provides flood control, and power generation.

San Felipe Division (1967)

The San Felipe Division of the CVP was authorized by Congress in 1967 to deliver water CVP water supplies to the counties of Santa Clara, San Benito, Santa Cruz, and Monterey for agricultural and M&I uses. The San Felipe Division includes a series of pumping plants, tunnels and pipelines that originate on the western side of San Luis Reservoir, including the Pacheco Pumping Plant, the Pacheco Tunnel, the Santa Clara Conduit and the Hollister Conduit. Currently, the San Felipe Division serves water supplies areas in southern Santa Clara County and northern San Benito County. Provisions for future construction of about 25 miles of closed conduit to Santa Cruz and Monterey counties are included in the division features.

State Water Project

As development continued throughout California and the SJV, the state identified a need to supplement local and federal investments to further develop projects to provide water supply and flood protection. In recognition of this need, the California Legislature authorized construction of a water storage and supply project that would capture, store, and transport water from Northern California to other parts of the state, including the SJV, in 1951. The Burns-Porter Act, enacted in 1959, provided for the issuance, following voter authorization in 1960, of \$1.75 billion in general obligation bonds to build the SWP. Construction of the SWP began in 1961 (DWR 2026a). The SWP was built to provide water supply, flood control, power generation, recreational opportunities, and enhance habitat. SWP water is used for irrigation on approximately 750,000 acres of farmland, primarily in the SJV, and provides water to urban users throughout the state.

Key features of the SWP include 26 dams; 21 reservoirs; 30 pumping plants; approximately 700 miles of canals, pipelines, and tunnels; and several power facilities (DWR 2026a). The SWP is a major consumer of energy in California, however, it is also a significant producer of energy via hydroelectric and renewables facilities. Power produced at SWP facilities is used to offset energy consumed by the SWP, predominantly consumed by pumping requirements to move water through the SWP.

Major SWP facilities are Oroville Dam, Harvey O. Banks (Banks) Pumping Plant, and the California Aqueduct. Oroville Dam and Lake captures water from the Feather River watershed and can store approximately 3,540 TAF, including 750 TAF of flood control storage. Water supply from the Feather River and Sacramento River is diverted in the southern Delta into Clifton Court Forebay. Banks Pumping Plant lifts water from Clifton Court Forebay into the California Aqueduct. The California Aqueduct carries water 443 miles south for irrigation and water supply to municipalities and industries. Key diversions from the California Aqueduct include the South Bay Aqueduct which conveys water to Alameda and Santa Clara Counties, diversions from the O'Neil Forebay to San Luis Reservoir for storage, the Coastal Branch which conveys water to San Luis Obispo and Santa Barbara Counties, the West Branch which conveys water primarily to Los Angeles County, and the East Branch which conveys water to San Bernardino and Riverside Counties along with the Inland Empire (DWR 2026a).

Together, the CVP and SWP transformed water management in California by providing water supplies from northern California to the SJV and other parts of the state. Operations of the CVP and SWP are highly regulated to protect water rights, provide for in-stream ecosystem needs, and achieve desired ecological conditions in the Delta. As described below, the Delta is the focus of a complex local, state, and federal regulatory framework that manages inflows to the Delta, exports from the Delta, and water quality in the Delta.

Other Major Projects

During approximately the same time that Reclamation developed the CVP and the State developed the SWP, significant federal investments were made to construct flood control reservoirs on the eastside of the SJV that also provide water supply and other benefits. Several reservoirs constructed by the USACE provide water supplies to local water agencies, including Pine Flat Reservoir (1,000 TAF) on the Kings River, Lake Kaweah (180 TAF) on the Kaweah River, Lake Success (80 TAF) on the Tule River, and Isabella Lake (570 TAF) on the Kern River. The Kings, Kaweah, and Tule Rivers all flow into Tulare Lake, which has been drained, cultivated, and only fills in the wettest of years. The Fresno Slough and James Bypass were developed to convey flood water from the Kings River to the San Joaquin River. The Kern River drains into the southern SJV towards Buena Vista Lake and Kern Lake, which have also been drained and cultivated. In addition, local irrigation districts developed storage and conveyance projects to provide surface water supplies.

As a result of the complex overlay of water supply development projects, many areas of the San Joaquin Valley have access to multiple sources of water supply including groundwater, local surface water, CVP, and/or SWP water supplies, whereas other areas are fully reliant on groundwater. Some locally owned projects are also used to convey regional water supplies. For example, the Cross Valley Canal was constructed by the Kern County Water Agency to provide conveyance between the California Aqueduct and the city of Bakersfield in Kern County. It flows bidirectionally and includes an intertie with the FKC. In addition, Patterson Irrigation District and Banta Carbona Irrigation District each have locally owned water distribution systems that are be used to convey water supplies from the San Joaquin River to the DMC.

As the CVP, SWP, and other projects came online, California and the SJV substantially expanded the ability to store, move, and manage water supplies across regions to meet local, state, and federal

priorities. This integrated network of reservoirs, pumping plants, canals, and other facilities helped stabilize supplies and provide flood protection for agricultural and community development.

Evolving Regulatory Environment

Environmental Values

By the mid- to late-20th century, the major local, state, and federal water supply facilities used to deliver local and imported water supplies to the SJV were largely in-place and helped establish the SJV as one of the strongest agricultural regions in the world. As a result, communities in the SJV continued to grow to support the booming agricultural economy. Significant population centers developed in Fresno, Bakersfield, Modesto, Stockton, Visalia, and other places around the SJV. The population in the SJV grew from approximately 2 million in the early 20th century to 6.5 million in the early 21st century (PPIC 2006). However, the booming economy and growing population coincided with the dawn of emerging social values that recognized the environmental value of water resources and enacted laws and regulations to allocate water supplies in consideration of environmental needs. Ultimately, the application of environmental protections to existing water supply projects reduced the availability of water supplies for agricultural and M&I uses in the SJV. A summary of key environmental protection actions that have affected water supply reliability to the SJV include:

- 1978 – the California State Water Board issued Decision D-1485, the first Sacramento/San Joaquin Rivers Delta and San Francisco Bay (Bay-Delta) Water Quality Control Plan, to regulate and protect water quality in the Delta.
- 1989 – the Sacramento River winter-run chinook salmon was listed as endangered under the federal ESA of 1973.
- 1992 – The CVPIA was enacted to protect fish and wildlife species in the Central Valley. The CVPIA allocates about 1.2 million acre-feet per year (MAF/YR) of CVP water supply for anadromous fish restoration, requires delivery of water supplies to wildlife refuges in the Central Valley, and specifies flows to be met on the Trinity River that reduce supplies available for transfer to the Central Valley.
- 1993 – the Delta Smelt was listed as endangered under the federal ESA, and its critical habitat was designated in 1994.
- 1999 – The State Water Resources Control Board adopted Decision D-1641 to implement the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (it was amended in 2000), which was informed by the Bay-Delta Accord signed in 1994. Decision D-1641 established water quality standards and other operational constraints in the Delta (SWRCB 2000).
- 2006 – The San Joaquin River Restoration Settlement, an agreement between U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council, and

the Friant Water Users Authority (now known as the Friant Water Authority [FWA]), was approved by the court. The Settlement, which followed an 18-year lawsuit, is based on two goals: (1) restore and maintain fish populations in the San Joaquin River below Friant Dam, and (2) reduce or avoid adverse water supply impacts to Friant Division contractors.

- 2008 & 2009 – Biological opinions on potential impacts of the proposed long-term operations (LTO) of the CVP/SWP on the delta smelt and salmonoids established major ESA constraints on coordinated CVP/SWP long-term operations, substantially effecting export operations and water supply reliability for users that rely on exports. Protections for other species, like the longfin smelt, for example, also affect CVP/SWP operations.
- 2009 – Congress authorized the San Joaquin River Restoration Program (SJRRP) to implement the provisions of the San Joaquin River Restoration Settlement. Since 2009, the SJRRP, has implemented habitat restoration and fish reintroduction activities in the San Joaquin River, but channel capacity constraints have limited the implementation of Restoration Flows (which are sourced from water that would otherwise be delivered to Friant Division contractors).
- 2018 –The State Water Resources Control Board adopted an amendment to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). The amendment updated San Joaquin River flow objectives to protect fish and wildlife beneficial uses and revised southern Delta salinity objectives to protect agricultural beneficial uses. The adoption of flow objectives prompted water agencies, state and federal agencies, and other stakeholders to pursue an alternative implementation approach through negotiated Voluntary Agreements (now referred to as Healthy Rivers and Landscapes Program). These agreements were developed to achieve environmental benefits while providing flexibility to balance ecosystem, water supply, and operational objectives. A 2022 memorandum of understanding (MOU) formalized commitments from several agencies, including Reclamation and the Friant Water Authority (which operates and maintains the FKC and Madera Canal), though some San Joaquin River tributary water rights holders, such as those on the Merced and Tuolumne Rivers, did not sign (HRLPP 2022). As a result, contributions from these tributaries remain uncertain, and the update to the Bay-Delta Plan Water Quality Control Plan is under litigation.
- 2024 – LTOs and biological opinions have been updated since those described above in 2008 and 2009. The biological opinions were updated in 2019 based on data collected and studies performed subsequent to the 2008 and 2009 biological opinions, and eliminated several restrictions that were shown to be ineffective – including limits on Delta exports. Most recently, in 2024, a programmatic reassessment of LTOs superseded 2019 actions and developed a coordinated framework that integrates monitoring, updated science, and operational flexibility while protecting species. The result was the implementation of Action 5 by Reclamation for the CVP, but the State has not adopted it for the SWP.



The regulation of local streams, rivers, and the Delta through actions described above resulted in progressive reductions in water supply reliability to agricultural water users and communities in the SJV. As water supplies became scarcer, the value of water increased, particularly during dry periods. This trend coincided with advancements in irrigation technology (e.g., drip irrigation) and the growth of global markets, as well as changes to state and federal requirements on agriculture management, regulation, and labor and wage practices. All of this together incentivized the planting of a greater percentage of permanent crops, such as trees and vines, that hardened water demand and increased reliance on groundwater supplies. These shifts had the unintended outcome of less groundwater recharge in the SJV while the use of groundwater increased.

Despite significant water supply challenges, the SJV remains an agricultural region of state, national and global importance. The eight-county region of the SJV includes seven of the top 10 agricultural producing counties in the nation (CDFA 2024; Fabian 2022). More than 250 different crops are grown in the SJV, generating over \$24 billion in annual crop revenues alone, with another almost \$10 billion in annual dairy and beef revenues (USGS n.d.; PPIC 2023a). Lands within a 100-mile circle centered on Fresno produces 74% of the world's almond supply; more than 95% of all garlic and pistachios grown in the U.S.; 18 times more peaches than Georgia; more milk than the entire state of Wisconsin; 100% of U.S. raisins; over 75% of nectarines, mandarins, table grapes, artichokes, kiwifruit and figs grown in the U.S.; and 10 times more fresh oranges than Florida (Harrison Company 2021).

The current water supply and regulatory environment pose significant risk to the SJV's continued agricultural and economic vitality, its residents and communities, and the environment that relies on its resources. Unstable and reducing water supply reliability causes significant constraints and long-term risk to economic viability, and several SJV counties are among the poorest in the country. The societal and regulatory shifts and resulting conditions described above provide the context for the imbalance that defines current and future conditions in the SJV.

Sustainable Groundwater Management

Groundwater has long been a crucial source of water supply to the SJV, and was instrumental in its original development and continued growth. Over reliance on groundwater in response to several factors, including reduced surface water supply availability through the late 20th and early 21st centuries, led to unsustainable groundwater use in the SJV. Groundwater overdraft resulted in adverse effects like increases in regional land subsidence; dewatering of agricultural, domestic, and small community wells; and degraded groundwater quality, which significantly affect agriculture and disadvantaged communities in the SJV. In recognition of the adverse effects of groundwater overdraft throughout California, and particularly in the SJV, the State of California enacted the SGMA in 2014. SGMA requires that all groundwater subbasins achieve sustainable groundwater management, which requires shifting groundwater use away from its historical role as a backstop to meet demands not fulfilled with surface water.

Groundwater basins experiencing the most severe overdraft, known as critically over-drafted basins, must achieve groundwater sustainability by 2040. High- and medium-priority basins must achieve sustainable management practices by 2042 (SWRCB 2026a). The designation of subbasins in the SJV are provided in Table 2-1, along with the status of the 16

subbasins in the SJV (which are shown in Figure 2-1) as of May 2026 (SWRCB 2026b). Local GSAs formed under the authority of SGMA must develop and implement GSPs that establish measurable objectives, interim milestones, and management actions to address overdraft, including demand reduction, managed aquifer recharge, and land use adjustments.

GSPs for critically over-drafted basins were submitted to DWR for review in 2020, all other GSPs of medium and high priority basins were submitted to DWR for review in 2022. After submittal and adoption by the GSA, DWR reviewed plans for adequacy. GSPs for medium and high priority basins that were determined to be inadequate were referred to the State Water Resources Control Board for State Intervention under Chapter 11 of SGMA (DWR 2026b).

Table 2-1. GSP Status of Subbasins in the San Joaquin Valley

Subbasin	Designation	GSP Approval Status
Eastern San Joaquin	Critically Overdrafted	Approved
Tracy	Critically Overdrafted	Approved
Delta-Mendota	Critically Overdrafted	Inadequate – Returned to DWR
Modesto	Medium and High Priority	Approved
Turlock	Medium and High Priority	Approved
Merced	Critically Overdrafted	Approved
Chowchilla	Critically Overdrafted	Inadequate – Returned to DWR
Madera	Critically Overdrafted	Approved
Westside	Critically Overdrafted	Approved
Pleasant Valley	Critically Overdrafted	Inadequate – Under SWRCB Intervention
Tulare Lake	Critically Overdrafted	Inadequate – Under SWRCB Intervention
Kings	Critically Overdrafted	Approved
Kaweah	Critically Overdrafted	Inadequate – Returned to DWR from SWRCB
Tule	Critically Overdrafted	Inadequate – Under SWRCB Intervention
Kern	Critically Overdrafted	Inadequate – Returned to DWR from SWRCB
White Wolf	Critically Overdrafted	Adequate

Source: SWRCB 2026b (May 2026)

Key:

DWR = California Department of Water Resources

GSP = Groundwater Sustainability Plan

SWRCB = State Water Resources Control Board

Existing and Projected Future Conditions

This section summarizes existing and projected future water supply and demands for the SJV. Water supplies are described for each of the three primary water supply sources in the SJV: (1) local surface water supplies from rivers and streams within the SJV; (2) CVP and SWP imported water supplies; and (3) local groundwater supplies. Water demands are presented for existing conditions and include a description of how water demands are projected to change in the future. This information is used to quantify the existing and projected future water supply-demand gaps (i.e., supply shortages to meet current and future demands) in the SJV. It should be noted that data used to quantify existing and projected future conditions were derived from different sources (e.g., existing simulations) with



inherently different assumptions, which was unavoidable when using existing data, but effort was taken to be as consistent as possible.

Existing Water Supplies

Local Surface Water

Local surface water supplies in the SJV are primarily sourced from rivers and streams originating in the Sierra Nevada Mountains, with smaller contributions from rivers and streams originating from other drainages. The major rivers (from north to south) in the San Joaquin Hydrologic Region are the: Mokelumne, Calaveras, Tuolumne, Merced, Chowchilla, Fresno and San Joaquin, and the major rivers (from north to south) in the Tulare Lake Hydrologic Region are the Kings, Kaweah, Tule and Kern as shown in Figure 2-3.

Table 2-2 presents average annual and the 90- and 10-percent exceedance of full natural flow for SJV rivers, and identifies the largest downstream storage facility and its total storage capacity. The range of annual full natural flows for each river, and the differences across watersheds, illustrates the significant variation of water supplies that originate in the SJV. This information is not presented to provide any interpretation or calculation for water rights and permitting. The variability of flows on major SJV rivers is a key factor affecting local water supply reliability and was the underlying consideration that led to the development of storage facilities to manage water supplies in each watershed. Generally, surface water in SJV rivers is of high quality and is suitable for agricultural and municipal uses, although high-flow events can increase suspended sediment loads. In addition, releases of high-quality water from reservoirs through rivers identified in Table 2-2 (e.g., from New Melones Reservoir) serve to supplement in-Delta water quality.



Figure 2-3. San Joaquin Valley Map Showing Hydrologic Regions, Counties, Groundwater Subbasins, Communities and Major Water Supply Infrastructure

Table 2-2. Major Rivers in the SJV and the Downstream-Most Reservoir

River	Full Natural Flow (TAF/YR)			Reservoir	Storage Capacity (TAF)
	Average Annual	90% Exceed.	10% Exceed.		
Mokelumne	736	271	1,417	Camanche	417
Calaveras	167	33	387	New Hogan	317
Stanislaus	1,178	408	2,250	New Melones	2,400
Tuolumne	1,910	820	3,620	New Don Pedro	2,030
Merced	974	325	1,971	McLure	1,025
Chowchilla	75	6	197	Eastman	150
Fresno	83	16	212	Hensley	90
San Joaquin	1,804	743	3,403	Millerton	520
Kings	1,699	681	3,293	Pine Flat	1,000
Kaweah	447	149	931	Kaweah	186
Tule	146	33	364	Success	82
Kern	727	220	1,550	Isabella	568
Total	9,945	3,704	19,595	Total	8,785

Source: NOAA 2025

Notes:

Full natural flow statistics calculated from data available via the California Nevada River Forecast Center

Key:

SJV = San Joaquin Valley

TAF = thousand acre-feet

TAF/YR = thousand acre-feet per year

CVP and SWP Supplies

The CVP and SWP include facilities that import water to the SJV from northern California, and CVP facilities that transfer water between basins within the SJV (Friant Division). For purposes of this Plan, CVP and SWP supplies are summarized using contract amounts and allocation history to illustrate the scale of project supplies and the variability in annual availability and allocation. Contract amounts represent the amount of maximum water that may be delivered under applicable contract terms. However, they do not represent a guaranteed annual supply; actual deliveries vary by hydrologic conditions, operational conditions, regulatory requirements, and allocation decisions.

CVP and SWP contract amounts for contractors in the SJV are listed in Table 2-3 and Table 2-4, respectively. Full contract amounts have not been delivered consistently over the past 30-years, as shown in Figure 2-4 and Figure 2-5 for the CVP and SWP, respectively. In general, CVP and SWP supplies delivered from the Delta for agricultural, M&I and wildlife refuge uses are of lower quality than eastside supplies sourced from runoff from the Sierra Nevada Mountains. Delta supplies typically have higher concentrations of salts, nitrates, and other constituents.

Table 2-3. CVP Contractors in the San Joaquin Valley Area

CVP Division	Unit	Maximum Contract Quantity ¹ (TAF)
Delta	Delta-Mendota Canal	330.1
Delta	Mendota Pool	60.3
Miscellaneous	Cross Valley Canal	128.3
San Felipe	-	196.3
West San Joaquin	San Luis	1,397.9
Total – South of Delta Water Service		2,112.9
Delta	Exchange Contractors	840
Delta	Mendota Pool (San Joaquin Settlement)	35.62
Total – South of Delta Water Rights Contracts		875.62
Friant (Class 1 Contracts)	See note 2	800
Friant (Class 2 Contracts)	See note 2	1,401.5
Miscellaneous	Buchanan	24
Miscellaneous	Hidden	24
Total – Friant Division		2,249.5
East Side	New Melones Dam & Reservoir ³	155
-	Tri-Dams	600
Total – Stanislaus East Side		755
Refuges (South of Delta)		271

Source: Reclamation 2016

Notes:

¹ Maximum Contract Quantity represents contract amount at full build-out and 100% allocation.

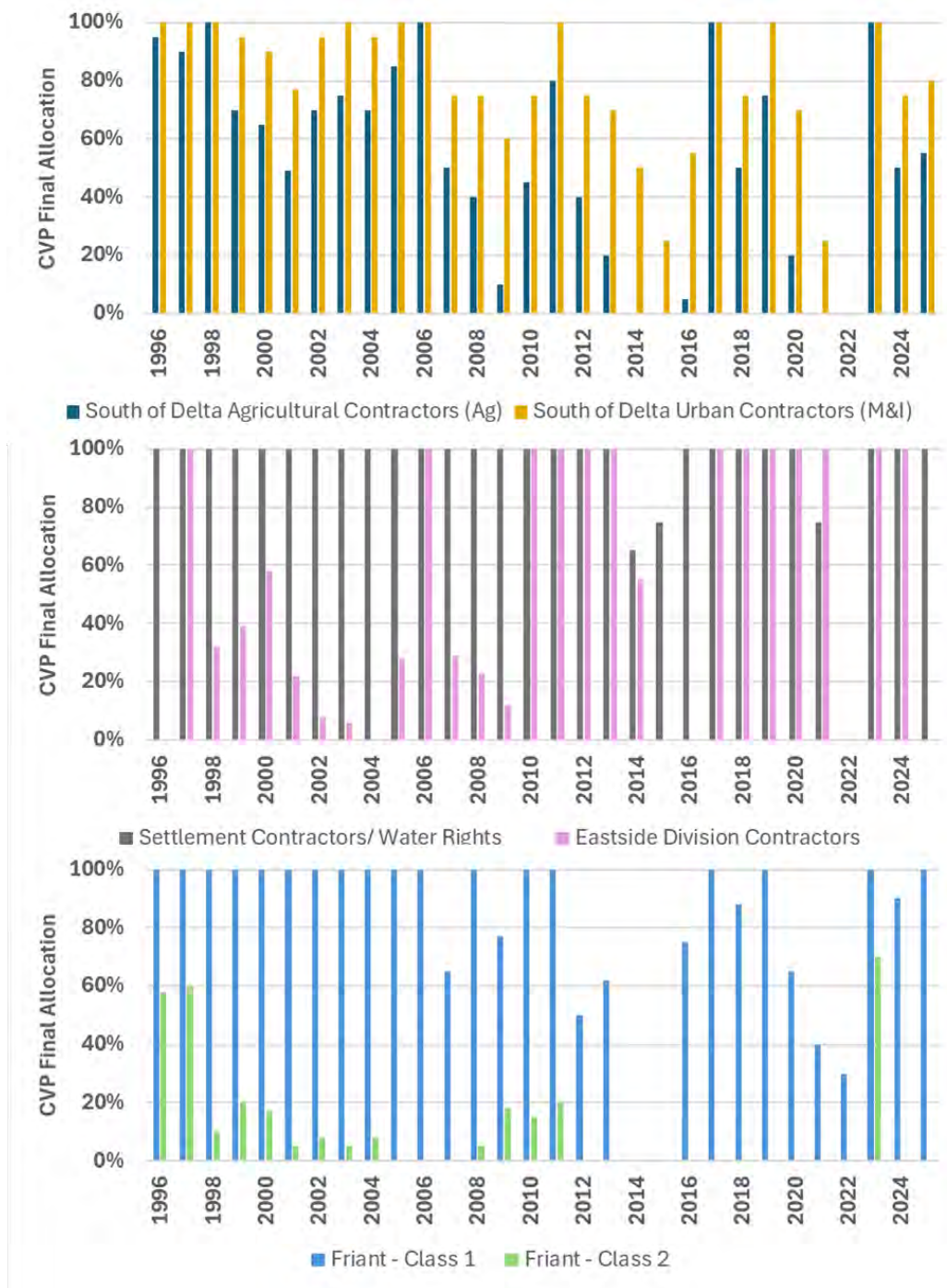
² The Friant Division is comprised of the Friant Dam & Reservoir Unit, the Friant-Kern Canal Unit, and the Madera Canal Unit.

³ The Stockton-East Water District, in the East Side Division, is not in the New Melones Dam & Reservoir Unit but is included in the 155 TAF Maximum Contract Quantity.

Key:

CVP = Central Valley Project

TAF = thousand acre-feet



Source: Reclamation 2026b

Notes:

¹ Note: Central Valley Project allocations shown in this figure are the final announced allocation for that year.

² In 2022, Urban Contractors' allocation was up to the public health and safety needs.

³ In 2022, Settlement Contractors/Water Rights' allocation was Shasta Critical as defined in their contract.

⁴ In 2022 and 2025, Eastside Division Contractors' allocation was to be determined.

⁵ The Eastside Division Contractors' allocation in 1997 – 2000 was taken from the Stanislaus Contractor's allocation.

⁶ Friant – Class 2 was in Uncontrolled Season in 2005, 2006, 2016, 2017, 2018, and 2019.

Figure 2-4. Central Valley Project Allocations Since 1996

Table 2-4. SWP Contractors in the San Joaquin Valley Area

SWP Contractor	Contracted Table 1 Amounts ¹ (TAF)	Area (acres)
County of Kings	9.31	890,780
Dudley Ridge Water District	41.35	37,600
Empire West Side Irrigation District	3	7,570
Kern County Water Agency	982.73	5,224,000
Oak Flat Water District	5.7	4,500
Santa Clarita Valley Water Agency ²	0	8,700
Tulare Lake Basin Water Storage District	87.47	185,519

Source: DWR 2026a

Notes:

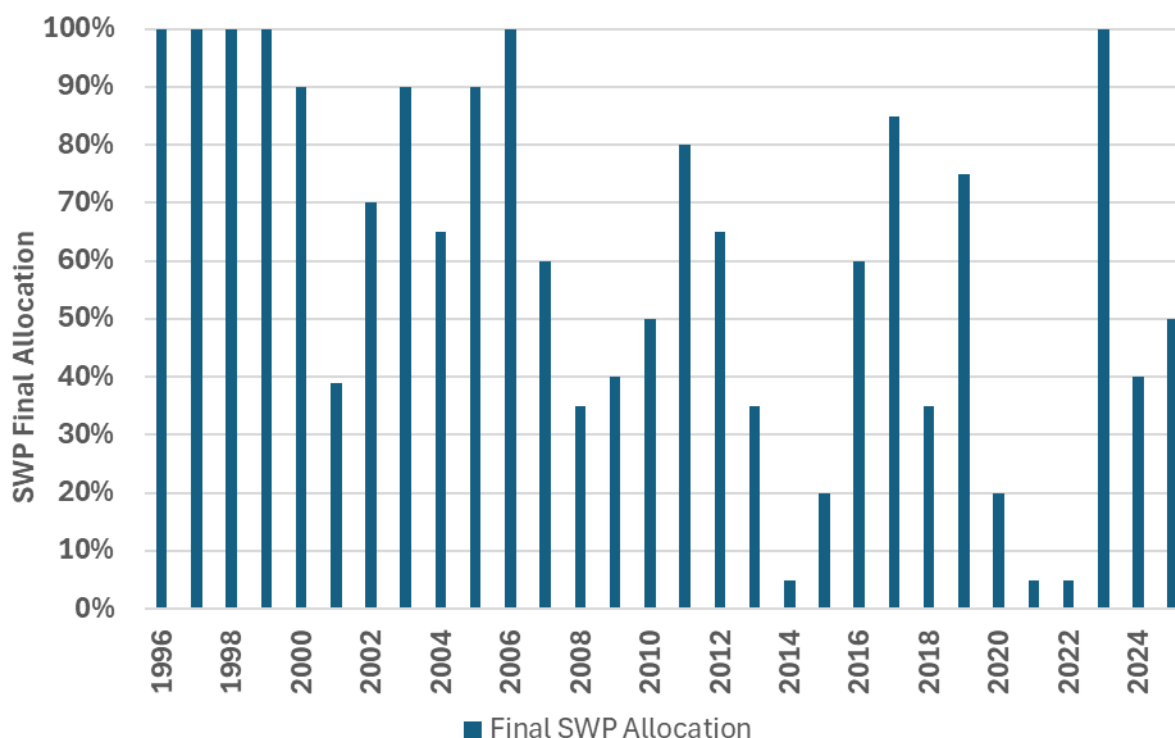
¹ These volumes are full contract amounts, delivered in non-Shasta critical years.

² Santa Clarita Valley Water Agency (Southern California Area) includes land in the San Joaquin Valley Area formerly known as Devil's Den Water District.

Key:

SWP = State Water Project

TAF = thousand acre-feet



Source: DWR 2026c

Note: State Water Project Table A allocations shown in this figure are the final announced allocation for that year.

Figure 2-5. State Water Project Table A Allocation Since 1996

Groundwater

Prior to development, vast quantities of groundwater accumulated in the aquifers of the SJV. The primary input was the natural recharge of surface water sourced primarily from rainfall and snowmelt runoff from the Sierra Nevada Mountains. As development progressed, the rate of groundwater extraction in the SJV exceeded the rate of recharge causing groundwater overdraft.



This historical overdraft motivated construction of the CVP and SWP facilities to import surface water supplies into the SJV. These facilities were initially successful at reducing and/or eliminating overdraft in many areas. As the reliability of CVP and SWP surface water supplies available from the Delta decreased in recent decades, the overdraft trend continued to grow because groundwater was used as a backstop to serve demands that could not be met by surface water during periods with reduced deliveries.

As reported in the most recently developed and publicly available GSPs (as of November 2025), it is estimated that, during the period from the mid- to late- 20th century to the mid-2010s, an average of about 8.7 million acre-feet per year of groundwater was extracted from aquifers of the SJV (Table 2-5). The corresponding total reduction in groundwater storage during the same period (i.e., the amount by which extractions exceed inputs) is estimated at over 1.3 million acre-feet per year. Similar estimates, also shown in Table 2-5, have been developed by the Public Policy Institute of California (PPIC 2023a). Irrigated acreage estimates for each subbasin were developed by the Public Policy Institute of California, based on the 2018 LandIQ mapping datasets (PPIC 2023b).

Groundwater quality in the SJV is compromised by both natural and human-induced contaminants and is generally of poorer quality than surface water supplies delivered from local sources and the Delta. Common pollutants include nitrates, pesticides, heavy metals, solvents, and disease-causing organisms, along with naturally occurring elements like arsenic and uranium. Salinity is a major concern, particularly on the west side of the SJV, where soils are derived from marine sedimentary rocks of the Coastal Range, resulting in soils being naturally high in salts and other marine-derived constituents (DWR n.d.), reflected by total dissolved solids (TDS) concentrations map shown on Figure 2-6. Agricultural practices, water imports, and long-term land use have contributed to salt accumulation, affecting over 1.5 million acres and causing significant economic losses including the removal of approximately 250,000 acres from agricultural production (CV SALTS 2025). Reducing groundwater levels also can adversely affect groundwater quality as contaminants accumulate in the aquifers. Groundwater quality is monitored through sampling wells, with data collected on TDS, nutrients, pesticides, trace elements, and radionuclides. Regulatory oversight is provided by the State Water Board and the Central Valley Water Quality Control Board, primarily through the Safe and Affordable Funding for Equity and Resilience (SAFER) program, to ensure safe drinking water access.

Table 2-5. Estimated Historical Groundwater Extraction and Overdraft

Subbasin	Approximate Total Irrigated Acreage of Subbasin ¹ (Thousand Acres)	GSPs ³			PPIC ⁴	
		Average Annual Extraction (TAF/YR) ²	Average Annual Overdraft (TAF/YR) ²	Average Annual Overdraft Normalized by Irrigated Acreage (AF/YR/Acre)	Average Annual Overdraft (TAF/YR) ²	Average Annual Overdraft Normalized by Irrigated Acreage (AF/YR/Acre)
Eastern San Joaquin	392	732	48	0.13	55	0.15
Tracy – Non-Delta	127	167	0	0	0	0
Delta-Mendota	419	410	24	0.06	88	0.21
Modesto	125	311	43	0.29	13	0.09
Turlock	221	404	64	0.29	96	0.43
Merced	251	735	130	0.52	130	0.52
Chowchilla	117	265	29	0.25	108	0.92
Madera	201	472	34	0.17	150	0.75
Westside	412	324	19	0.05	28	0.07
Pleasant Valley ⁵	ND	34	15	ND	ND	ND
Tulare Lake	283	386	86	0.30	92	0.33
Kings	626	1,374	217	0.35	198	0.32
Kaweah	293	731	203	0.69	141	0.48
Tule	300	712	160	0.64	167	0.67
Kern	691	1,586	274	0.37	578	0.78
White Wolf	35	41	0	0	5	0.14
Total	4,493	8,684	1,346	0.3	1,849	0.41

Source: PPIC 2023a, PPIC 2023b, GSPs in Appendix A

Notes: ¹ Irrigated acreage from PPIC 2023b, based on 2018 LandIQ dataset.

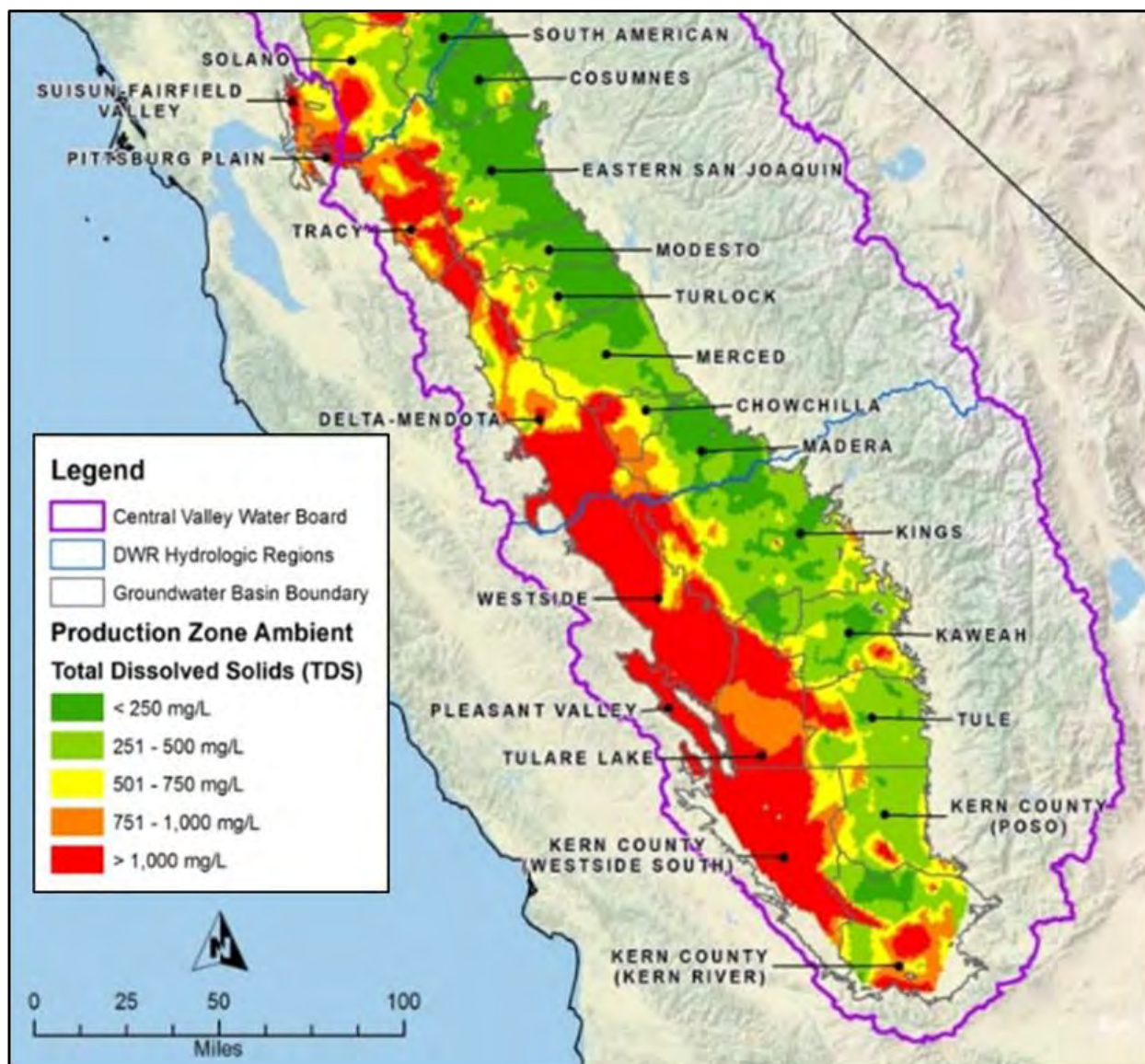
² All volumes rounded to nearest 1 TAF.

³ Data compiled using the most recent publicly available version of GSPs as of November 2025.

⁴ Data from the PPIC 2023a

⁵ Data for Pleasant Valley was not quantified in PPIC 2023a nor PPIC 2023b.

Key: AF = acre-feet GSP = Groundwater Sustainability Plan ND = No Data TAF = thousand acre-feet YR = year



Source: CV-SALTS 2025

Figure 2-6. Total Dissolved Salt Concentrations in the San Joaquin Valley

Future Supply Changes

Local Surface Water

Hydrologic Variability

California's cycles of drought and flooding are anticipated to become longer, more intense, and more frequent under changing hydrologic variability. Forecasted warmer temperatures and associated changing precipitation patterns will affect water demands and in-valley surface water supplies. Rising temperatures will increase evapotranspiration and, consequently, irrigation demand. Increasingly intensive atmospheric rivers will drive extreme precipitation events, and winter precipitation will increasingly fall as rain, as opposed to snow (Gupta et al. 2025).

Reservoirs in the SJV are designed to provide flood control for rainfall runoff during winter months and to manage snowmelt during the late spring and summer months. Many reservoirs were designed to manage snowmelt runoff in a manner to meet agricultural and municipal demands. As a greater proportion of winter precipitation falls as rain rather than snow, reservoir inflows are expected to become more concentrated during the winter. Atmospheric rivers may increase high flow events, rapidly filling reservoirs over short periods of time. These shifts may require increased flood control releases to maintain storage capacity, reducing the ability to retain water for later use. Collectively, changes in precipitation timing and form, reduced snowpack driven run-off, and limited reservoir operational flexibility are expected to result in a net decrease of regulated surface water to meet demands in the SJV.

CVP and SWP Supplies

Hydrologic Variability

Future warmer temperatures and associated hydrologic variability are expected to have a significant and adverse effect on Delta exports by the CVP and SWP. As described above, forecasted warmer temperatures and changing precipitation patterns will affect precipitation timing and intensity, evapotranspiration and irrigation demands, and reservoir volumes and operations. Salinity management in the Delta is maintained by balancing freshwater inflows regulated by upstream dams, pumped diversions, tides and climate variability (USGS 2000). Particularly in dry and critical years when natural freshwater inflows to the Delta are lower, a larger portion of the reservoir releases are needed as outflow to repel salinity. Sea level rise will increase the potential intrusion of high salinity water into the Delta, requiring more Delta outflow to meet water quality standards, reducing the volume of water available for export.

CalSim simulations performed for the Delivery Capability Report (DCR) 2023 Addendum (DWR 2025b) were used here to quantify potential future changes in Delta exports under a future climate scenario. Results for a median future scenario (i.e., 50% level of concern) developed in DCR 2023 were used to quantify potential impacts on future imports from the Delta. Simulations performed as part of DCR 2023 reflect 2020 conditions for level of development and regulatory framework for long-term operations of the CVP and SWP. Simulated average annual impacts to south of Delta CVP and SWP supplies are estimated to be 174,000 acre-feet and 273,000 acre-feet respectively, which includes exports to areas outside of the SJV. The impacts for SJV subbasins were estimated by allocating shortages for each project to contractors in proportion to the contract quantity, and aggregating contractor shortages to the subbasin level and total 241 thousand acre-feet per year (TAF/YR) for the SJV (Table 2-6). It should be noted that additional restrictions on CVP and SWP exports are not considered as part of this study and could further restrict supplies available in the future.

Table 2-6. Estimated Annual Decrease in CVP and SWP Delta Imports by Subbasin Due to Changing Hydrologic Variability

Subbasin	Decrease in Delta Imports ¹ (TAF/YR)
Tracy	4
Delta-Mendota	48
Westside	94
Tulare Lake	10
Kings	5
Kaweah	1
Tule	7
Kern	72
Total	241

Source: DWR 2025b

Notes:

¹ Simulated in CalSim and rounded to nearest 1 TAF.

Key:

CVP = Central Valley Project

SWP = State Water Project

TAF = thousand acre-feet

TAF/YR = thousand acre-feet per year

San Joaquin River Restoration Program

The SJRRP, authorized in 2009 for implementation by Reclamation in coordination with other federal and state resources management agencies, is a collaborative effort to restore naturally producing and self-sustaining fish populations to the San Joaquin River below Friant Dam. Restoration Flow requirements are defined in a flow hydrograph in Exhibit B of the San Joaquin River Restoration Settlement for water year types and average 320,000 acre-feet per year (NRDC et al. 2006). The current SJRRP flow hydrograph, referred to as the funding constrained hydrograph, differs from the hydrograph in Exhibit B because it reduces peak flows and spreads flows over longer periods in recognition of channel capacity constraints in the river. Channel capacity constraints limit the ability to release full Restoration Flow volumes in some years. As channel capacity improvements are implemented by the SJRRP, Restoration Flow releases will increase up to the full volume specified in the Settlement.

Restoration Flows released from Friant Dam would otherwise be delivered to Friant Division long-term contractors that hold CVP contracts. Current releases in accordance with the funding constrained hydrograph reduce water supplies available to the Friant Division. Pursuant to the water management provisions in the Settlement and authorizations provided in the SJRRP Act, Reclamation has taken actions to reduce water delivery reductions caused by the release of Restoration Flows by facilitating and/or participating in the following activities: recapture, recirculation, exchange, transfer, and reuse of Restoration Flows; delivery of wet year water supplies based on quantified impacts of reduced deliveries as recorded in the Recovered Water Account; construction of groundwater recharge facilities; and other activities. Additional actions and projects will be needed to minimize future water delivery reductions as Restoration Flows are increased with the implementation of channel improvements. At full implementation of restoration actions with no water management actions, the average annual decrease in available water supplies to Friant Division

long-term contractors is estimated to be 254 TAF/YR, including a 39 TAF/YR reduction to Class 1 supplies and a 215 TAF/YR reduction to Class 2 supplies (Reclamation 2011). For purposes of this Plan, the impacts to future water supply availability were allocated to each subbasin using the percentage of Class 1 and Class 2 contract amounts in each subbasin, as shown in Table 2-7.

Table 2-7. Estimated Water Supply Impacts of the San Joaquin River Restoration Program By Subbasin

Subbasin	Class 1 Contract Amounts (TAF)	Class 2 Contract Amounts (TAF)	Percent of Class 1	Percent of Class 2	Full Implementation of SJRRP ^{1, 2} (TAF/YR)
Chowchilla	55	160	7%	11%	27
Madera	85	200	11%	14%	35
Kings	107	75	13%	5%	17
Kaweah	123	190	15%	14%	35
Tule	243	380	30%	27%	70
Kern	187	396	23%	28%	70
Total	800	1401	100%	100%	254

Notes:

¹ Assumes long-term average annual contribution of 39 TAF/YR from Class 1 supplies and 215 TAF/YR from Class 2 and 215 supplies. Rounded to the nearest 1 TAF/YR.

² Based on full implementation of Restoration Goal actions and no implementation of Water Management Goal actions described in the Settlement, and no implementation of actions authorized by PL 111-11.

Key:

PL = Public Law

SJRRP= San Joaquin River Restoration Program

TAF/YR = thousand acre-feet per year

Settlement = San Joaquin River Restoration Settlement

TAF= thousand acre-feet

Healthy Rivers and Landscapes Program

The Healthy Rivers and Landscapes Program (HRLP) is a proposed, voluntary program currently under consideration and evaluation by the State Water Board and others as a potential approach to implementing updates to the Bay-Delta Plan. A memorandum of understanding signed in 2022 outlines the terms and obligations including flow contributions from the San Joaquin River Basin, Friant Division, and other sources (CNRA 2022; Table 2-8). It is important to note that participating in the HRLP is not universal, and many water rights holders in the SJV are not participants and did not sign the MOU. Water supply contributions from those users are not considered in this UWP and, therefore, it does not represent the full range of potential regulatory effects associated with implementation of the Bay-Delta Plan. Potential effects resulting from any implementation scenario that deviates from the proposed MOU are not considered, including potential alternatives under consideration by the State Water Board that could increase contributions outlined in the MOU.

For purposes of this UWP, the potential water supply effects of proposed HRLP actions are estimated for each applicable subbasin using the MOU framework and several simplifying assumptions (Table 2-9), as follows:

- The Friant Division obligation to HRLP of 50 TAF/YR in dry, below normal and above normal water year types was allocated to contractors using the same allocation as for the SJRRP and then aggregated to the subbasin level.
- The contribution of the SWP and CVP to HRLP is an export reduction of 125 TAF/YR in dry and below normal years and a reduction of 175 TAF/YR in above normal years. For modeling purposes, these reductions have been allocated equally among the SWP and CVP as shown in Table 2-9.

The estimated water supply effects of HRLP to entities in the SJV average 68 TAF/YR. These values should be interpreted as illustrative, planning-level estimates that characterize potential magnitude and do not reflect effects to non-participants that will be affected by implementation of the Bay-Delta Plan, which could increase this contribution.

Table 2-8. Contributions by Participant to the Healthy Rivers and Landscapes Program

Water Source	Annual Average Contributions (TAF/YR)						Obligation
	Water Year Type & Frequency						
	C	D	BN	AN	W	Weighted Average	
	15%	22%	17%	14%	32%		
Friant Division	0	50	50	50	0	26.5	Friant Contractors
Sacramento River Basin							
Sacramento	2	102	100	100	0	53.74	
Feather	0	60	60	60	0	31.8	
Yuba	0	60	60	60	0	31.8	
American	30	40	10	10	0	16.4	
Mokelumne	0	10	20	45	0	11.9	
Putah	7	6	6	6	0	4.23	
CVP/SWP Export Reduction	0	125	125	175	0	73.25	50/50 SWP/CVP
PWA Water Purchase Program							
Fixed Price	3	63.5	84.5	99.5	27	51.36	
Market Price	0	45	45	45	0	23.85	
Permanent State Water Purchases	65	108	9	52	123	81.68	

Source: CNRA 2022 Table 1a

Key:

AN = above normal

C = critical

D = dry

PWA = Public Water Agency

TAF = thousand acre-feet

YR = year

BN = below normal

CVP = Central Valley Project

MOU = memorandum of understanding

SWP = State Water Project

W = wet

Table 2-9. Estimated Contributions by Subbasin to the Healthy Rivers and Landscapes Program

Subbasin	Average Annual Contributions [TAF/YR]			
	Friant Division	SWP	CVP	Total*
Tracy	0	0	1	1
Delta-Mendota	0	0.05	8.09	8
Chowchilla	2.82	0	0	3
Madera	3.61	0	0	4
Westside	0	0	18.53	19
Pleasant Valley	0	0	0	0
Tulare Lake	0	1.36	0	1
Kings	1.73	0	0.85	3
Kaweah	3.76	0	0.08	4
Tule	7.27	0	0.99	8
Kern	7.32	8.88	0.85	17
White Wolf	0	0	0	0
Total	26.51	10.29	30.39	68

Notes:

Table does not include Eastern San Joaquin, Modesto, Turlock, or Merced subbasins as they are not participants in the HRLP.

SWP is 50% of the 73.25 and then allocated to contractors by Table A contract amounts, of which approximately 25% are in the San Joaquin Valley

CVP is 50% of the 73.25 and then allocated to contractors by South of Delta amounts, of which approximately 83% are in the San Joaquin Valley

*Total rounded to nearest 1 TAF.

Key:

CVP = Central Valley Project

HRLP = Healthy Rivers and Landscapes Program

SWP = State Water Project

TAF = thousand acre-feet

TAF/YR = thousand acre-feet per year

Groundwater

Hydrologic Variability

Future warmer temperatures and associated hydrologic variability are expected to have a significant and adverse effect on groundwater supplies. Forecasted warmer temperatures and projected changes in precipitation timing and intensity, along with increased evapotranspiration, will affect natural recharge to groundwater basins. Reduced snowpack and earlier runoff may shift the timing of recharge periods, while more intense storm events may limit recharge due to saturation and infiltration rates, causing pooling of water, runoff, and evaporation (Lesk & Mankin 2026). During prolonged dry and critical years, reduced surface water availability may increase reliance on groundwater pumping, further stressing aquifer systems.

Sustainable Groundwater Management

As described in the Sustainable Groundwater Management Section, GSPs were reviewed by DWR for adequacy. All critically overdrafted subbasins are required to be sustainable by 2040 and



medium- and high-priority basins are required to be sustainable by 2042, which means the reduction in groundwater storage values in Table 2-5 would be reduced to zero and groundwater management practices to avoid adverse effects would be in place.

Land Subsidence

Subsidence is an ongoing regional issue that has been occurring in the SJV for over a century. The extent of subsidence over the past decade is shown in Figure 2-7. The dominant cause of regional land subsidence has been groundwater overdraft, however it is recognized that other factors such as oil and gas extraction and some natural geologic processes also may contribute (DWR 2024).

Increased reliance on groundwater has caused subsidence to accelerate recently. The effects can extend across overlying political boundaries that define counties, communities, and local agencies and districts, including GSAs. As a result, subsidence within political sub-divisions can result from actions in other areas. Regional land subsidence adversely affects communities, infrastructure, and natural systems. At a regional level, linear features, such as roads, canals, levees, and flood control channels, can be affected by differential subsidence and are most susceptible to damage, loss of capacity and function, and other negative impacts (USGS 2013, DWR 2017, Reclamation 2020). To date, subsidence has measurably decreased the hydraulic conveyance capacity of several water conveyance facilities in the SJV, including the Friant-Kern Canal, Delta Mendota Canal, San Luis Canal, and California Aqueduct. Subsidence has also impacted the function of other systems and facilities including the San Joaquin River and Sack Dam, Chowchilla Bypass, and the Eastside Bypass.

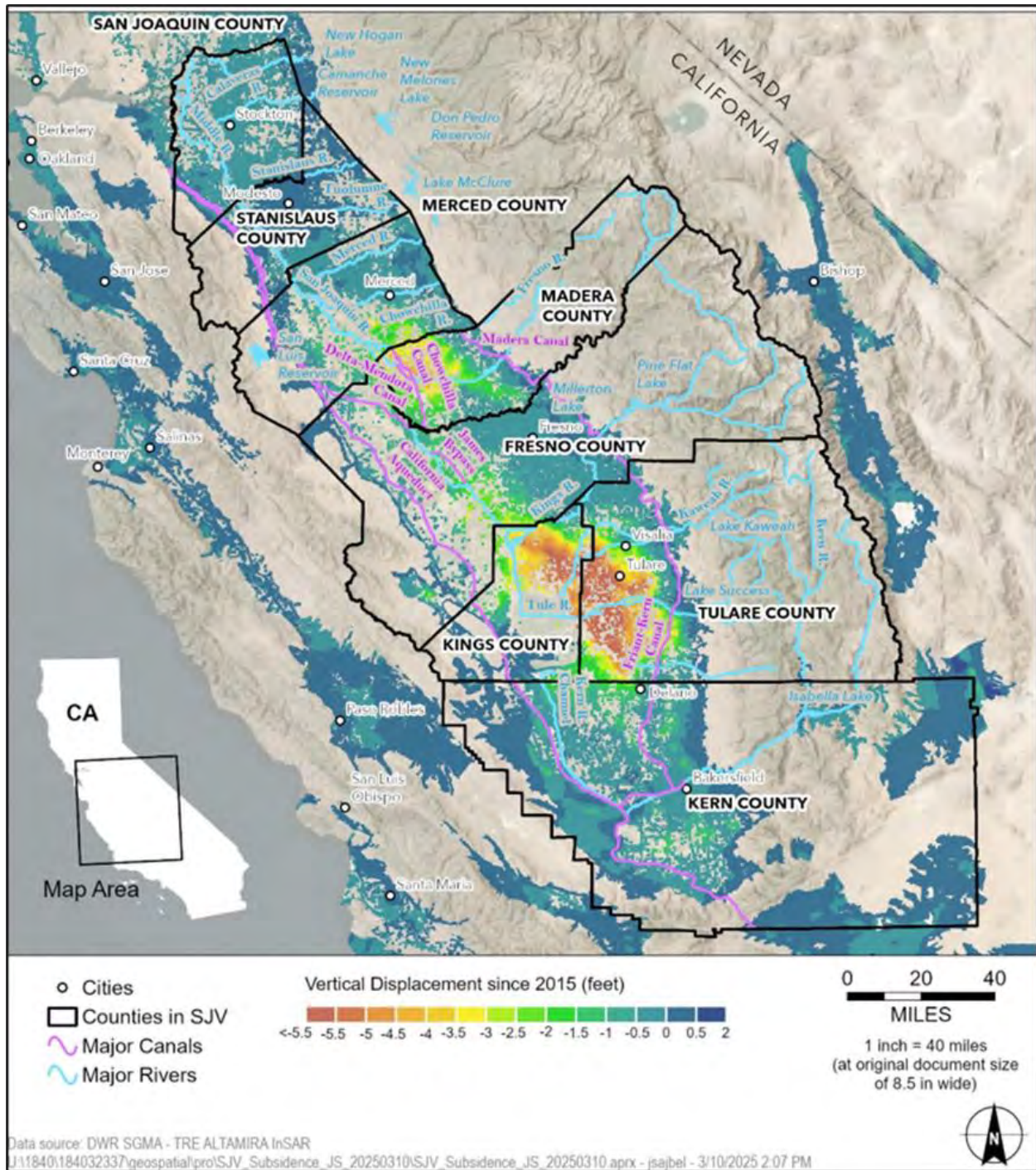


Figure 2-7. Land Subsidence in the San Joaquin Valley from 2015 to Present

Existing Water Demands

Water demands in the SJV are influenced largely by land use. For the purposes of this Plan, water demands are described in terms of their relative difference to water supplies. The relative difference, or water supply-demand gap, is estimated in this section for existing conditions – defined as the best approximation of current conditions as outlined in subsection below. Projected future changes to

the existing water supply-demand gap are estimated in this section based on demand changes only. The combined effect of projected demand changes and projected future changes to water supplies are presented in a later section to produce the total estimated future water supply-demand gap.

Unmet Incremental Level 4 Refuge Supplies

The SJV is home to 18 federal, state, and locally managed wildlife refuges that are required to receive water supplies as stipulated in the CVPIA. These water supplies, managed by Reclamation, are comprised of Level 2 and Level 4 supplies. The annual demand for full Level 4 supplies (including Level 2 supplies) in the SJV is 377 TAF/YR (Table 4.2.1 CVJV 2020). The CVPIA stipulates that a portion of those demands, referred to as Level 2 supplies, be delivered by Reclamation to the wildlife refuges annually and are subject to reductions during dry periods. Total Level 2 annual demand in the SJV is about 271 TAF/YR. The remaining annual demand of approximately 106 TAF/YR is referred to as Incremental Level 4 and is to be acquired through purchase from willing sellers, and development of conveyance facilities and wells. To date, Incremental Level 4 supplies have been derived primarily through short-term purchases from willing sellers. Due to state and federal budget constraints, increased prices of spot market water, and variability of supplies, Incremental Level 4 demands for refuges are consistently not met (CVJV 2020). Estimated unmet demand is approximately 56 TAF/YR.

Existing Supply-Demand Gap

SGMA requires that subbasins in the SJV be brought to sustainability by 2040 or 2042, depending on whether they are critically over-drafted. Assuming that groundwater has been used to meet demands that are unable to be met by surface water supplies (either in-valley or imported), it can be assumed that the minimum existing gap between available water supplies and water demands in the SJV is represented by groundwater overdraft. This existing gap quantifies water supply to serve demands and does not quantify additional water that would be required for basins to reach sustainability or address impacts due to changes in hydrologic variability. The estimated existing groundwater overdraft for each subbasin, based on information presented in GSPs, is approximately 1.3 MAF/YR, as presented in Table 2-5. Groundwater overdraft data published by PPIC is used for comparative purposes and is estimated to be 1.8 MAF/YR, as presented in Table 2-5. Combining overdraft with the current unmet water needs for wildlife refuges results in an estimated existing supply-demand gap range of 1.4 to 1.9 MAF/YR (Table 2-10).

Table 2-10. Existing Annual Average Water Supply-Demand Gap in the SJV

Subbasin	GSP Overdraft ^{1,2} (TAF/YR)	PPIC Overdraft (TAF/YR)	Existing Unmet Refuge Demands (TAF/YR)	GSP-Based Existing Gap (TAF/YR)	PPIC-Based Existing Gap (TAF/YR)
Eastern San Joaquin	48	55	0	48	55
Tracy	0	0	0	0	0
Delta-Mendota	24	88	31	55	119
Modesto	43	13	0	43	13
Turlock	64	96	0	64	96
Merced	130	130	13	143	143
Chowchilla	29	108	0	29	108
Madera	34	150	0	34	150
Westside	19	28	0	19	28
Pleasant Valley	15	ND	0	15	ND
Tulare Lake	86	92	0	86	92
Kings	217	198	0	217	198
Kaweah	203	141	0	203	141
Tule	160	167	5	165	172
Kern	274	578	7	281	585
White Wolf	0	5	0	0	5
Total	1,346	1,849	56	1,402	1,905

Source: GSPs (see Appendix A); PPIC 2023b

Notes:

¹ Data compiled using the most recent publicly available version of GSPs as of November 2025

² GSP-Based Existing Gap was calculated using the historical overdraft for consistency amongst Subbasins.

Key:

GSP = Groundwater Sustainability Plan

PPIC = Public Policy Institute of California

SJV = San Joaquin Valley

TAF/YR = thousand acre-feet per year

Future Demand Changes

Although urban development will continue in the SJV, it will likely occur on irrigated lands. A high percentage of irrigated lands are planted with permanent crops that harden water demand, and changes to water demand in response to urban conversion via population growth would be limited. As a result, future changes to water demand in the SJV will be driven by changing hydrologic variability and needs for wildlife refuges. Changing hydrologic variability will increase water demands in the SJV due to warmer temperatures and increased evapotranspiration (ET). The PPIC (2023b) estimates that ET demands will increase approximately 70 TAF/YR across the SJV (or a uniform increase of approximately 1.55% when allocated across the subbasins based on irrigated acreage). Additionally, it is possible that water supplies to meet Incremental Level 4 demands will be more difficult to acquire through annual purchases due to increases in the cost of acquiring supplies. For the purpose of quantifying a future water supply-demand gap, refuge water supply needs were calculated as the total Incremental Level 4 Supplies plus a provision for other unmet needs (CVJV

2020), which resulted in a total unmet need of 108 TAF/YR or an increase in 52 TAF/YR from the existing supply-demand gap (Table 2-11).

Table 2-11. Projected Future Changes to Existing Annual Average Demands

Subbasin	Future Unmet Water Demands		GSP-Based Future Gap from Only Demand Changes (TAF/YR)	PPIC-Based Future Gap from Only Demand Changes (TAF/YR)
	Increase in ET Demand (TAF/YR)	At Risk Refuge Demands (TAF/YR)		
Eastern San Joaquin	6	0	54	61
Tracy	2	0	2	2
Delta-Mendota	7	44	106	170
Modesto	2	0	45	15
Turlock	3	0	67	99
Merced	4	0	147	147
Chowchilla	2	0	31	110
Madera	3	0	37	153
Westside	6	0	25	34
Pleasant Valley	0	0	15	ND
Tulare Lake	4	0	90	96
Kings	10	0	227	208
Kaweah	5	0	208	146
Tule	4	0	169	176
Kern	12	8	301	605
White Wolf	1	0	1	6
Total	71	52	1,525	2,028

Key:

ET = evapotranspiration

GSP = Groundwater Sustainability Plan

ND = no data

PPIC = Public Policy Institute of California

TAF/YR = thousand acre-feet per year

Problems and Needs

Problems and needs related to water supply in the SJV are quantified as the water supply-demand gap. This section applies anticipated future changes to demand and projected future changes to water supplies to the existing water supply-demand gap to estimate the projected future total water supply-demand gap. Water supply effects on disadvantaged communities are also discussed.

Future Water Supply-Demand Gap

The existing water supply-demand gap in the SJV, as summarized in Table 2-10, ranges from 1.4 to 1.9 MAF/YR and projected future changes to demands would slightly increase the gap to 1.5 to 2.0 MAF/YR (Table 2-11). Projected future changes in the availability of groundwater and surface water



supplies in the SJV, however, are expected to decrease significantly in response to regulatory actions (e.g., SGMA, SJRRP, and Bay-Delta Water Quality Control Plan Update) and forecasted changes in hydrologic variability. Estimated reductions in future water supply the projected future total water supply-demand gap are provided in Table 2-12 using GSP-based information. Table 2-13 presents similar information using PPIC-based information. The average annual water supply-demand gap for the SJV is estimated to range from 2.4 to 3.0 MAF/YR based on the GSP- and the PPIC-based values, respectively. This range is provided only to identify uncertainty of the supply-demand gap in the SJV. The GSP-based water supply-demand gap is used throughout the remainder of the UWP. This estimate does not include historical reductions in water supply reliability resulting from implementation of regulatory actions.

Table 2-12. Annual Average Projected Future Water Supply-Demand Gap in the San Joaquin Valley Based on GSPs

Subbasin	GSP-Based Future Gap from Only Demand Changes (TAF/YR)	Groundwater	Surface Water			GSP-Based Total Supply-Demand Gap ³ (TAF/YR)
		Provision for Replenishment ¹ (TAF/YR)	SJRRP Contribution (TAF/YR)	HRLP Contribution (TAF/YR)	Reduced Delta Imports ² (TAF/YR)	
Eastern San Joaquin	54	12	-	-	-	66
Tracy	2	0	-	1	4	7
Delta-Mendota	106	6	-	8	48	168
Modesto	45	11	-	-	-	56
Turlock	67	16	-	-	-	83
Merced	147	33	-	-	-	180
Chowchilla	31	7	27	3	-	68
Madera	37	9	35	4	-	85
Westside	25	5	-	19	94	143
Pleasant Valley	15	4	-	-	-	19
Tulare Lake	90	22	-	1	10	123
Kings	227	54	17	3	5	306
Kaweah	208	51	35	4	1	299
Tule	169	40	70	8	7	294
Kern	301	69	70	17	72	529
White Wolf	1	0	-	-	-	1
Total	1,525	339	254	68	241	2,427³

Notes:

¹ Provision for the future replenishment of groundwater supplies in addition to eliminating overdraft. Calculated as 25% of the GSP-reported overdraft for each subbasin.

² Includes effect of changing hydrologic variability on exports from the Delta.

³ Total estimated supply-demand gap using the GSP estimates of groundwater overdraft. Rounded to 2,400 TAF/YR in this UWP for planning purposes.

Key:

Delta = Sacramento-San Joaquin River Delta

HRLP = Healthy Rivers and Landscapes Program

TAF/YR = thousand acre-feet per year

GSP = Groundwater Sustainability Plan

SJRRP = San Joaquin River Restoration Program

UWP = Unified Water Plan

Table 2-13. Average Annual Projected Future Water Supply-Demand Gap in the San Joaquin Valley Based on PPIC.

Subbasin	PPIC-Based Future Gap from Only Demand Changes (TAF/YR)	Groundwater	Surface Water			PPIC-Based Total Supply-Demand Gap ³ (TAF/YR)
		Provision for Replenishment ¹ (TAF/YR)	SJRRP Contribution (TAF/YR)	HRLP Contribution (TAF/YR)	Reduced Delta Imports ² (TAF/YR)	
Eastern San Joaquin	61	14	-	-	-	75
Tracy	2	0	-	1	4	7
Delta-Mendota	170	22	-	8	48	248
Modesto	15	3	-	-	-	18
Turlock	99	24	-	-	-	123
Merced	147	33	-	-	-	180
Chowchilla	110	27	27	3	-	167
Madera	153	38	35	4	-	230
Westside	34	7	-	19	94	154
Pleasant Valley ⁴	ND	-	-	-	-	ND
Tulare Lake	96	23	-	1	10	130
Kings	208	50	17	3	5	283
Kaweah	146	35	35	4	1	221
Tule	176	42	70	8	7	303
Kern	605	145	70	17	72	909
White Wolf	6	1	-	-	-	7
Total	2,028	464	254	68	241	3,055

Notes:

¹ Provision for the future replenishment of groundwater supplies in addition to eliminating overdraft. Calculated as 25% of the PPIC-based overdraft by subbasin.

² Includes effect of changing hydrologic variability on exports from the Delta.

³ Total supply-demand gap using the PPIC estimates of groundwater overdraft.

Key:

Delta = Sacramento-San Joaquin River Delta

ND = no data

SJRRP = San Joaquin River Restoration Program

HRLP = Healthy Rivers and Landscapes Program

PPIC = Public Policy Institute of California

TAF/YR = thousand acre-feet per year

Water Supply Effects on Disadvantaged Communities

Disadvantaged communities (DAC) in California are defined as areas with a median household income less than 80% of the statewide average. Over 300 DACs in the SJV face persistent water supply challenges due to environmental burdens, limited financial and institutional capacity, as well as historical disenfranchisement. Nearly all rely on groundwater for domestic use, with around 130 disadvantaged unincorporated communities among the most vulnerable. These communities often rely on groundwater that does not meet drinking water quality standards, lacks reliability, or is accessed through shallow wells prone to de-watering during droughts. Groundwater level management is particularly important to DACs, as increased groundwater levels and recharge facilities can provide several benefits, including:

- Improved water supply reliability through raised groundwater levels
- Reduced need for costly well deepening
- Protection of local infrastructure, such as roads and canals through reduced land subsidence
- Greater community resilience through implementation of projects that help replenish groundwater, incorporate green space, habitat, and flood protection
- Improve local water quality through the dilution of contaminants

Throughout California, several projects, programs, plans and other resources have been implemented to support DACs. At the forefront is the SAFER program being implemented by the State Water Board with the help of technical assistance providers including non-profit organizations. SAFER has made significant progress in identifying at-risk water supply systems and water quality issues for DACs and in implementing solutions, but much work remains in the SJV.

Many GSAs in the SJV have developed GSPs that include approaches to address supply needs of DACs. Some plans propose mitigation strategies and water level thresholds, while others lack specific programs – at least initially (PPIC 2020). Additionally, non-profit organizations such as Self-Help Enterprises, Community Water Center, Leadership Council for Justice and Accountability and Clean Water Action play a vital role by empowering community representatives to engage with GSAs, water districts, and state agencies, helping bridge the gap between technical planning and community advocacy.

To support DACs, water supply projects must promote long-term solutions that improve groundwater levels and water quality. Actions that increase surface water supplies to communities, subbasins, and regions help decrease reliance on groundwater and improve groundwater conditions for DACs. Other actions could target recharge of high-quality water near community wells and enhance drinking water over time, while setting recovery targets for groundwater levels. Additionally, the gap between water management agencies and DACs can continue to be bridged through various means such as community members serving on GSA advisory boards, providing public comments on policies and plans, attending and participating in public meetings, and

advocating for themselves with various stakeholders such as water districts, GSAs, water management agencies and governing bodies. Non-profit organizations continue to support these objectives to bridge these gaps.

Catastrophic Risks

Water resources in the SJV face critical risks from both natural and human-induced threats. Natural disasters such as earthquakes and floods can severely damage infrastructure like canals, reservoirs, and levees, which is evident in events like the 2017 Oroville Dam spillway failure caused by excess rain and high runoff. Levee failures in the Delta, including the 2004 Jones Tract flood, have caused extensive damage and pose a serious risk of saltwater intrusion, which could compromise water supplies for Southern California.

Extended droughts, including the 2020–2022 event, have led to severe water rationing and threaten the reliability of water banking programs and other dry-year supplies when reservoir levels are too low to support exchanges. Anthropogenic risks further compound these challenges. Land subsidence, driven by excessive groundwater pumping, undermines infrastructure and long-term water availability. Contamination from agricultural runoff and accidental spills has negatively affected groundwater quality. These combined risks highlight the urgent need for resilient water supply projects to protect both infrastructure and water quality in the region.

Economic and Social Considerations

Water affordability is an increasing concern in the SJV, especially during drought years when surface water deliveries are low and farmers must turn to expensive spot markets to sustain crops. In such conditions, water prices can exceed \$2,500 per acre-foot. Even under long-term contracts like those of the SWP, fixed costs remain constant regardless of how much water is delivered. Anecdotally, for example, a 20% SWP allocation can cause per-acre-foot costs to quadruple, making water unaffordable for many growers. While a project may be economically feasible over its lifetime, fluctuating commodity prices can make annual payments unsustainable for farmers, especially during prolonged downturns. Municipal water rates are also increasing across the SJV.

The broader economic consequences of unreliable water supplies are substantial. A recent economic analysis found that if groundwater sustainability in the SJV is achieved primarily through land fallowing without the development of new water supplies, up to one million acres could be taken out of production, resulting in an estimated \$7.2 billion annual loss in farm revenue (Sunding and Roland-Holst 2020). This reduced agricultural production would lead to an average loss of 42,000 agricultural and service sector jobs, with total employment effects, including related industries like transportation and food processing, reaching 85,000 jobs and \$2.1 billion in lost employee compensation annually. These losses would occur primarily in lower income communities, exacerbating already present economic difficulties.

Opportunities

Development of water supply projects at a scale needed to meaningfully reduce the existing and projected water supply-demand gap in the SJV creates a generational opportunity to also address a range of interconnected flood protection, ecosystem and social challenges. Investments to construct



new facilities or update aging existing water supply infrastructure can improve the flexibility and reliability of surface water deliveries, enhance groundwater recharge, replenish aquifers, increase the reliability of domestic wells, reduce flood risks, support wildlife refuges, and enhance ecosystem health. Facility plans should be designed to perform under climate-driven extreme conditions including more severe drought and more intensive flooding (DWR 2023).

As described in Chapters 3 and 4, potential investments in multi-purpose projects that help reduce the water supply-demand gap can also help address flood management and ecosystem objectives. Investments that address multiple benefits can also help advance water equity by improving access to water for disadvantaged communities and improving groundwater levels for municipal and domestic wells that serve disadvantaged communities and other rural communities.

Opportunities also exist to further develop regional and statewide partnerships to help address the high cost of large-scale investments. Partnership opportunities with water supply entities around the region and state could lead to the development of projects that provide multiple benefits to multiple regions. Investments in surface and groundwater storage projects in the SJV that help manage water supplies for water users outside of the SJV could help offset project development costs and provide benefits to in-valley water users and communities.

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Chapter 3 Flood Management

This chapter describes flood management facilities and challenges in the SJV. It begins with a summary of the regional setting and historical development of flood facilities; describes Federal, State, and local agencies involved in flood management; and summarizes existing and projected future flood risk. This is followed by a summary of flood management challenges and priorities identified for planning regions associated with the San Joaquin River through development of the CVFPP. The CVFPP has a strong focus on flood risks, opportunities to improve the flood system performance, and regional planning of flood management in the Sacramento and the San Joaquin River hydrologic regions, but does not address the Tulare Lake Hydrologic Region. This chapter concludes with a description of flood management actions identified through the CVFPP and other efforts that have the potential to also provide water supply and ecosystem benefits in the SJV. Many of the opportunities identified for potential application in the San Joaquin River Hydrologic Region may also be applicable in the Tulare Lake Hydrologic Region.

Setting and Historical Context

The setting of the SJV makes it naturally prone to flooding. As described in Chapter 2, it is bound by the Sierra Nevada Mountains, Tehachapi Mountains, and Coastal Range, and receives significant runoff primarily through rivers and streams originating in the Sierra Nevada Mountains. In the San Joaquin River Hydrologic Region, the San Joaquin River historically lacked sufficient channel capacity to convey high flows as it drains towards the Delta. This resulted in frequent flooding and the formation of vast floodplains with swales, oxbows, and other features that created low-lying areas prone to inundation (USACE 1999). The Tulare Lake Hydrologic Region has been prone to frequent flooding because it is a closed basin where the major rivers and streams flow towards Tulare Lake (which was once the largest natural lake west of the Mississippi River), Buena Vista Lake, and Kern Lake. A portion of flood flows on the Kings River in the Tulare Lake Hydrologic Region are conveyed to the San Joaquin River Hydrologic Region.

Flooding in the SJV is driven by rainfall that typically occurs during winter months and snowmelt that typically occurs in spring and early summer months. The variability of intensity and timing of flooding in the SJV posed a significant challenge to development of farms and communities beginning in the mid-19th century. As described in Chapter 2, the first significant flood event post-European settlement was the Great Flood of 1861 and 1862, which caused significant loss of life and economic hardship (Dowd 2022). During this same time, hydraulic mining also contributed to frequent flooding because it resulted in millions of cubic yards of earth being washed downstream and deposited into channels, further reducing conveyance capacity (USACE 1999). Other significant floods occurred every few years (USGS 1953; USACE 1999). The occurrence of major flood events influenced continuous development and reassessments of flood infrastructure and policy in the SJV, as well as in the Sacramento Valley and elsewhere in California.

Initial flood control efforts in the SJV in the 19th century included construction of earthen levees to protect low-lying lands. Through a series of local, state and federal investments and policies, a

network of weirs, bypasses, and flood control channels were constructed in the 20th century to direct flood flows away from farms and communities (USACE 1999). A summary of events and actions that drove the development of flood control infrastructure and management policies include:

- 1941 – The federal Flood Control Act of 1941 laid the groundwork for flood control projects across the United States, including significant efforts in California. It authorized civil engineering projects such as dams, levees, dikes, and other flood control measures to manage water flow and reduce flood risks.
- 1944 – The federal Flood Control Act of 1944 was the most significant federal authorization for construction of flood facilities in the SJV. It authorized the Lower San Joaquin River and Tributaries Project, which included constructing levees on the San Joaquin River below the Merced River, Stanislaus River, Old River, Paradise Cut, and Camp Slough. It also authorized construction of New Hogan Dam on the Calaveras River, New Melones Dam on the Stanislaus River, and federal costs for flood control toward the construction of Don Pedro Dam on the Tuolumne River. New Melones Dam was later reauthorized for construction under the Flood Control Act of 1962 (USACE 1999). The Flood Control Act of 1944 also authorized construction of Isabella, Success, Terminus, and Pine Flat Dams on rivers in the Tulare Lake Basin.
- 1955 – Following major flooding in 1955, the construction of levees and bypasses on the San Joaquin River upstream of the Merced River was authorized. The Chowchilla and Eastside Bypasses were also constructed during this time period by the State of California.
- 1962-63 – Congress authorized construction of Buchanan Dam on the Chowchilla River and Hidden Dam on the Fresno River, and federal participation in the cost of New Exchequer Dam on the Merced River.
- 1968 – The National Flood Insurance Act of 1968 established the National Flood Insurance Program, which provided federally backed flood insurance to property owners and introduced floodplain management standards. This program significantly influenced flood management practices in California by encouraging local governments to adopt zoning and land use policies that reduce flood risk.
- 1980s and 1990s – Major flood events in 1983, 1986, 1995, and 1997 caused extensive damage in both the Sacramento River and San Joaquin River basins. These events raised concerns about the adequacy of the flood management systems and land use practices in flood-prone areas (Reclamation 2015).
- 2006 and 2007 – In the wake of continued flood risk, California voters approved two key measures: (1) Disaster Preparedness and Flood Prevention Bond Act of 2006, and (2) the Central Valley Flood Protection Act of 2008. These acts defined the Sacramento River and San Joaquin River Federal-State flood control projects as the State Plan of Flood Control (SPFC). They also required DWR to develop, and the CVFPB to adopt, a CVFPP, which is a

comprehensive strategy updated every five years. Unlike the SPFC, the CVFPP addresses flood risk across the entire watersheds of the Sacramento and SJVs and includes land use planning requirements for local jurisdictions (Reclamation 2015; DWR 2022a; DWR 2022b).

- 2009 – The Delta Reform Act of 2009 was enacted to address water management challenges in the Sacramento–San Joaquin Delta. This legislation includes provisions to reduce flood risks by improving levee systems and integrating ecosystem restoration with flood management strategies.

Today, flow in almost all the major rivers in the SJV is regulated by dams and other flood control facilities. As described in Chapter 2, most dams and reservoirs on rivers in the SJV provide water supply and flood control benefits. Flood management facilities are operated in coordination between multiple local, state, and federal agencies.

In recent years, most investments in flood management have focused on repair and rehabilitation of facilities that were constructed in the 20th century (USACE 1999). The CVFPP, which is updated every five years and most recently in 2022, presents a coordinated strategy to improve flood management throughout the Central Valley (DWR 2022a).

Existing Conditions and Future Flood Risk

The history of flooding in the SJV has driven significant investment in the construction and maintenance of flood control infrastructure and the implementation of flood management policies. Areas of flood risk, referred to as “flood zones”, are defined by the Federal Emergency Management Agency (FEMA). FEMA defines several types of flood zones and two primary categories are Special Flood Hazard Areas and Moderate Flood Hazard Areas. Special Flood Hazard Areas are defined by areas inundated by a flood event with a 1% chance of occurring in any given year. These areas are often described as 100-year floodplains, however it should be noted that the frequency of occurrence of a flood with a 1% chance of occurring can be greater than once in 100 years. Moderate Flood Hazard Areas (often referred to as the 500-year floodplains) are defined by areas inundated by a flood event with a 0.2% chance of occurring in any given year (FEMA 2020). Figure 3-1 shows the delineated 0.2% and 1% flood zones in the SJV, which include approximately 1 million people and \$112 billion worth of structures (PPIC 2024).

Recent studies indicate that changing hydrologic variability could intensify flood events in the future (DWR 2024; Xingying and Swain 2022). This could put additional areas at risk of flooding and/or increase the flood risk of areas in the floodplains. Flooding creates risk through evacuations; damage to homes and infrastructure; loss of agricultural fields and crop; and the increased mosquito populations (Quandt et al. 2025). This could stress flood control facilities as larger floods occur more frequently, which further intensifies the need to address existing challenges with aging levees, subsidence induced capacity loss in channels, sedimentation in channels, and limited reservoir flood storage capacity (DWR 2017).

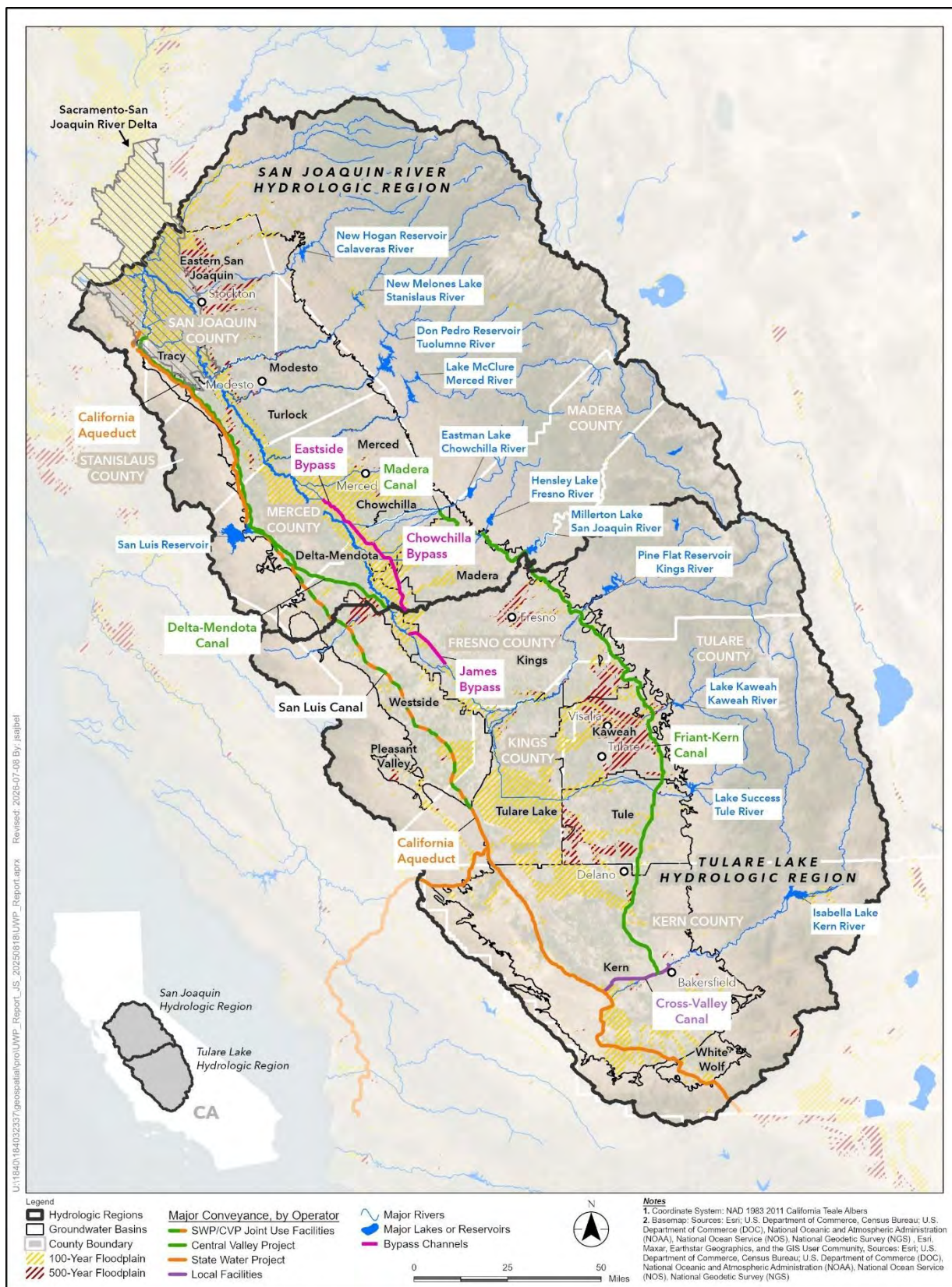


Figure 3-1. Flood Zones and Facilities in the San Joaquin Valley

Flood Control Facilities

Managed flood control storage capacity has been designated for reservoirs on most major rivers in both the San Joaquin River Hydrologic Region and the Tulare Lake Hydrologic Region, and numerous leveed channels and bypasses have been developed. These facilities work in tandem to reduce peak flows (e.g., dams/reservoirs), convey high flows as they move downstream (e.g., levees), and/or route water away from the main channel (e.g., bypasses). A summary of authorized dedicated flood control storage capacity for the major reservoirs in the SJV is included in Table 2-2 in Chapter 2. Dedicated flood control storage capacity in reservoirs typically becomes effective in late fall months and remains in effect through winter months to manage rainfall inflows. As runoff transitions from rainfall to snowmelt during spring months, dedicated flood control capacity in reservoirs is reduced and the space is used for water storage.

Hundreds of miles of levees protect farms and communities throughout the SJV. Levees confine flood flows to the channel and have been used in the SJV since the 19th century. The SPFC is the State of California's state-federal flood management system. Federal authorizations of SPFC projects in the SJV began in 1944 and state authorizations began in 1955. Infrastructure under the SPFC is subject to stricter regulations and regular rehabilitation efforts (DWR 2022b). Not all floodways that are defined by levees are a part of the SPFC and thus the levee systems of the SJV work in conjunction with each other.

Flood bypass systems are used to route water away from the main channel, through control structures. Three major flood bypass channels have been constructed to convey flood waters in the SJV:

- The James Bypass diverts flood water from the north fork of the Kings River to Fresno Slough and Mendota Pool on the San Joaquin River. It has a design capacity of 4,750 cubic feet per second (cfs) and is operated by the James Irrigation District.
- The Chowchilla Bypass diverts flood water from the San Joaquin River downstream from Friant Dam to the Fresno River and Eastside Bypass. It has a design capacity of 5,500 cfs and is managed by the Lower San Joaquin River Levee District.
- The Eastside Bypass diverts water from the Chowchilla River, Bear Creek and other tributaries to the San Joaquin River upstream of its confluence with the Merced River. It has a design capacity varying by reach from 17,500 cfs down to 14,400 cfs and it is also managed by the Lower San Joaquin River Levee District.

Flood Control Operations

Reservoir operations are governed by comprehensive documentation to meet authorized water supply and flood risk reduction purposes, and to manage operations during flood events. To ensure that the flood management operation of each of the flood management projects will be as effective as possible, it is essential that the operating agency be continually advised of possible flood hazards, weather conditions, inflows to the project and upstream reservoirs, and flows in the system downstream from the project (USACE 1999).

USACE's flood management decisions are based on the approved Water Control Plan from the Water Control Manual for each project. The Water Control Plan describes the specific operational rules for managing storage and releases day-to-day in order to fulfil its authorized purpose. The Water Control Manual includes the Water Control Plan and all supporting technical documentation (USACE 2018). The USACE also prepares and applies Water Control Manuals to direct operations of dedicated flood control space in non-USACE reservoirs with federally authorized flood control purposes. Non-USACE reservoirs that are not federally authorized for flood control manage for their authorized purposes and, to the extent possible, contribute to regional flood management objectives.

Flood Management Agencies

Flood management in the SJV involves a collaborative effort among various agencies and organizations to mitigate flood risks and protect communities and farmland. The federal, state, and local agencies primarily responsible for flood management in the SJV are:

- Federal Agencies:
 - The USACE constructs and maintains flood control infrastructure such as levees, dams, and reservoirs. The USACE has emergency authority to fight floods to protect life and property and to rehabilitate federal flood management facilities that are maintained by state and local entities (Reclamation 2015).
 - FEMA provides funding and support for flood risk reduction projects and emergency response during flood events.
- State Agencies:
 - DWR is responsible for statewide flood management planning and coordination. DWR's Division of Flood Management was established in 1977. DWR works to prepare for and manage floods including planning, risk management, emergency response, flood system operation and maintenance, and flood risk reduction (DWR 2022a).
 - The Central Valley Flood Protection Board was established to control flooding along the Sacramento and San Joaquin rivers and their tributaries, in cooperation with the USACE. The Central Valley Flood Protection Board establishes, maintains, and enforces standards for the construction, maintenance, and operation of the flood control system to protect life, property, and habitat in California's Central Valley (DWR 2022a). The Board coordinates state entities, local flood risk control agencies and the federal government to minimize damages from floods in California's Central Valley and is the non-federal sponsor for federal flood control projects in the State Plan of Flood Control. The Board serves as a public forum for flood risk reduction policy in the Central Valley and is responsible for adopting updates to the Central Valley Flood Protection Plan every five years.
- Local Agencies

- Local agencies, such as county flood control districts and water agencies, are responsible for implementing flood management projects at the local level. These agencies work to maintain and improve flood control infrastructure, conduct floodplain mapping, and develop emergency response plans. As an example, the San Joaquin Area Flood Control Agency provides flood protection for the City of Stockton and surrounding areas.
- The Lower San Joaquin Levee District (LSJLD) was created in 1955 by a special act of the State Legislature to operate, maintain, and repair levees, bypasses, and other facilities built in connection with the Lower San Joaquin River Flood Control Project (Reclamation 2015). The district encompasses approximately 108 river miles, 190 miles of levees, across 468 square miles (300,000 acres) in Fresno, Madera, and Merced counties. LSJLD is responsible for operation, maintenance and emergency management of State flood control facilities within the district boundaries. The LSJLD is not responsible for operation and maintenance of privately owned levees. Operations and maintenance activities include vegetation management activities, sediment management and removal activities, cleaning of screens and trash racks on facilities, opening and closing gates and flap gates in the bypass systems, and flood watch. Important facilities maintained by the district include the Chowchilla Bypass, the Eastside Bypass, and the Mariposa Bypass which connects the Eastside Bypass to the San Joaquin River.
- In addition to the local agencies, community members contribute to flood planning and management by participating in public meetings, providing input on flood management plans, and taking proactive measures to protect their properties from flooding.

Central Valley Flood Protection Plan for the San Joaquin Valley

The CVFPP is jointly developed by DWR and the CVFPB to prepare for and reduce flood impacts using methods that are strategic and achieve wide community support. These plans are updated every five years and identified projects are implemented as funding becomes available. The most recent update was completed in 2022 (DWR 2022a).

In developing the CVFPP and recent updates, DWR focused on three planning areas in the SJV: the Upper San Joaquin River Region, the Mid San Joaquin River Region, and the Lower San Joaquin River Region, shown on Figure 3-2. The Central Valley Flood Reduction Act of 2008 requires urban areas in the Central Valley to provide a higher standard of protection than the federal standards (PPIC 2024).

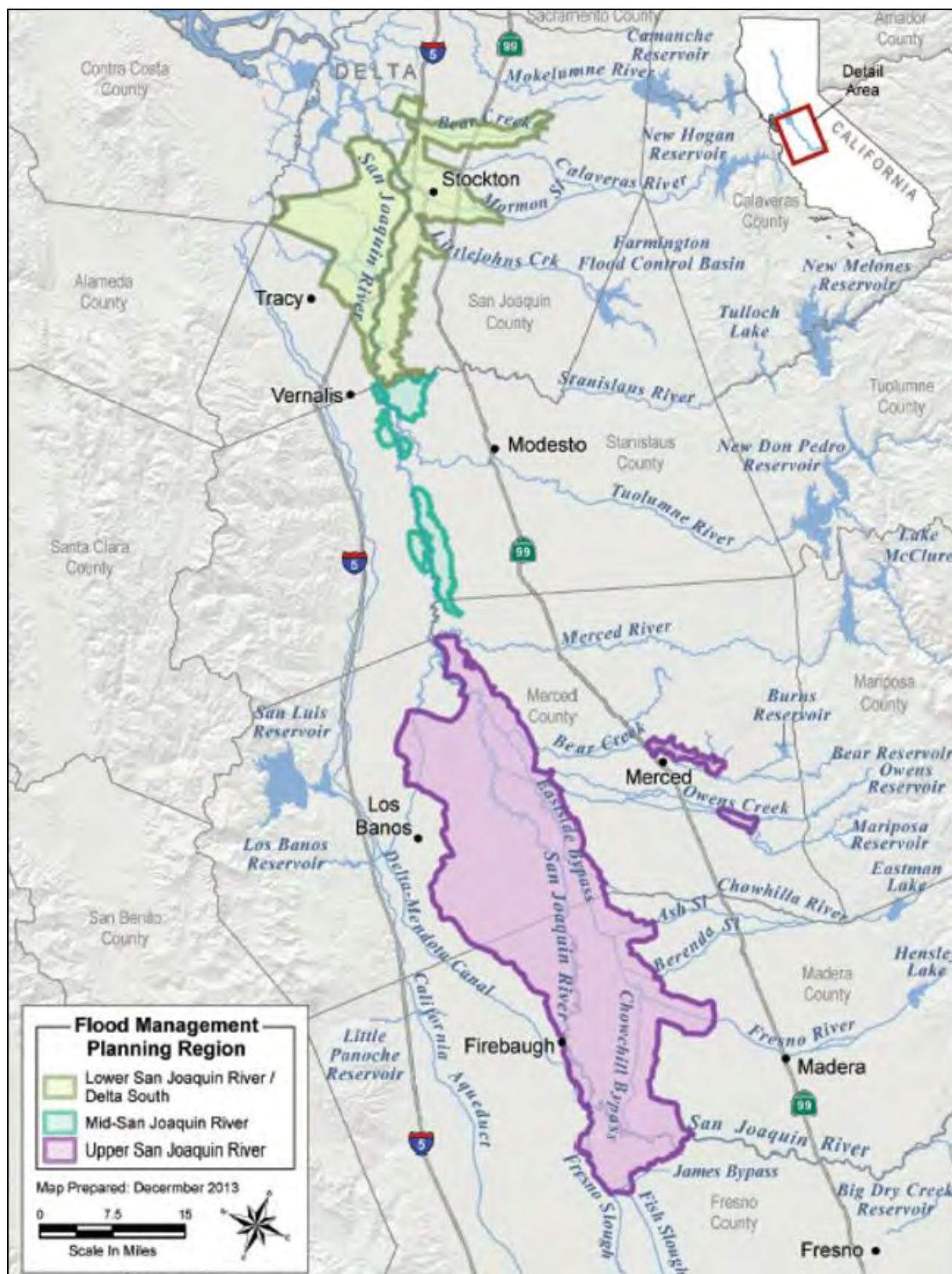
Regional Flood Management Plans

Following the adoption of the 2012 CVFPP, DWR funded three regional flood management plans (RFMP) in the SJV. The RFMPs identify and describe region-specific priorities and challenges, identify projects and management actions that inform CVFPP updates, and offer valuable insight from the perspective of local and regional flood management groups, landowners, stakeholders, and community groups. RFMPs help support DWR in planning efforts across the Central Valley, align

with CVFPP goals, inform CVFPP's investment strategy, and provide an important foundation for regional and local engagement.

The extent of the Upper San Joaquin, Mid San Joaquin, and Lower San Joaquin regions are shown on Figure 3-2. The CVFPP describes several challenges associated in regional flood management planning, including complex regulatory compliance and permitting requirements for projects and operation and maintenance, limited funding, and the presence of numerous rural and disadvantaged communities within floodplain areas. In consideration of these challenges, the CVFPP identified the following priorities that are common to all regional flood management plans in the SJV:

- Restore flood system to original design capacity or increasing capacity, where feasible, through levee and other infrastructure improvements.
- Improve infrastructure that provides flood protection to small communities.
- Implement multi-benefit actions to increase climate resilience and address subsidence
- Apply FIRO
- Implement groundwater recharge projects, including Flood Managed Aquifer Recharge (Flood-MAR).
- Implement ecosystem restoration projects.
- Improve operations and maintenance.
- Expedite permitting and construction of flood protection infrastructure improvements.
- Improving changing hydrologic variability analyses and planning at an integrated systemwide scale.
- Improve emergency response.
- Preserve the unique and historical character of agricultural communities.



Source: DWR (2017), Figure 1-1

Figure 3-2. San Joaquin River Basin Flood Management Planning Regions

Upper San Joaquin River Flood Planning Region

The Upper San Joaquin River region covers approximately 660 square miles of floodplain associated with the San Joaquin River, from Gravelly Ford to the confluence of the Merced River. Major tributaries within include the Fresno River; Ash and Berenda sloughs; and Black Rascal, Owens, and Bear creeks. About one third of the land area in this region is native vegetation and riparian habitat with contiguous wetland complexes.

Land use in the region is predominantly productive agricultural land. Urban areas include the City of Merced, with a population of 83,000 and several smaller communities, including Mendota, Firebaugh, Franklin-Beachwood, and Dos Palos among others. More than 10 communities in the area are classified as disadvantaged communities.

Flood management planning in the Upper San Joaquin River region is coordinated by local and regional entities, including counties, joint power authorities, and other entities in the region.

Challenges and Priorities

Flood infrastructure in the Upper San Joaquin River region suffers from damage and diminishing capacity, lack of funding for maintenance and repairs, and increasing maintenance and repair costs. About 192 miles of SPFC levees and critical flood facilities in the region have been deauthorized and are now ineligible for assistance. In consideration of these challenges, the following priorities for flood management were identified in the CVFPP and by local entities:

- Increase or restore flood system conveyance capacity.
- Provide 200-year flood protection for the City of Merced and the City of Chowchilla
- Provide 100-year flood protection for small communities of Franklin-Beachwood, Firebaugh, and Dos Palos.
- Modify or remove levees from the SPFC.
- Create programmatic, long-term, maintenance permit with California Department of Fish and Wildlife.
- Secure local/state financing to fund improvement projects and operations and maintenance, disaster, and rehabilitation activities

Mid San Joaquin River Flood Planning Region

The Mid San Joaquin River region comprises six non-continuous floodplain areas along the San Joaquin River between the Merced and Stanislaus Rivers within Stanislaus and Merced counties. Major tributaries include the Merced and Tuolumne rivers. The region is a network of connected floodplains and waterways managed by SPFC and non-SPFC facilities.

More than 500,000 people reside within the region, which is primarily rural and agricultural; Modesto is the region's largest city. The region does not have a regional flood management agency.

Challenges and Priorities

Levee systems in the Mid San Joaquin River Region are unable to safely convey design flows. Improvements to non-continuous SPFC and non-SPFC facilities require close coordination. Multiple Reclamation Districts lack the ability to comply with state inspection standards due, in part, to insufficient funding to maintain flood system facilities. Some Reclamation Districts have expressed a desire to remove levees from the SPFC. In consideration of these challenges, the following priorities for the Mid San Joaquin River Region were identified in the CVFPP:

- Improve engagement with, and flood protection for, disadvantaged communities
- Develop a pilot project for levee reclassification to remove levees from the SPFC
- Developing a State-federal partnership to acquire land or flowage easements in the San Joaquin River floodplain.
- Identify and implement groundwater recharge opportunities.

Lower San Joaquin River Flood Planning Region

The Lower San Joaquin River region covers approximately 260 square miles of floodplain of the San Joaquin River the Calaveras rivers immediately upstream from the legal Delta. The region extends along the mainstem of the San Joaquin River from the Stanislaus River to Bear Creek and includes the tributaries French Camp Slough and the Calaveras River.

Land use in the region includes rapidly developing urban areas and rural-agricultural areas. The region's urban population is approximately 400,000, accounting for approximately 25% of the land area. The largest urban area is the City of Stockton, and large portion of this region is designated as disadvantaged communities or severely disadvantaged communities.

Flood planning for the region is coordinated by local and regional entities, including counties, joint power authorities, and other entities in the region.

Challenges and Priorities

Flood management challenges in the Lower San Joaquin River Region include operations and maintenance challenges of current levee systems, capacity to raise local revenue for project construction and maintenance; evolving and increasingly strict standards for levee maintenance, a need for planning resilient projects; and refining the USACE Lower San Joaquin River Project to reduce costs and minimize impacts. In consideration of these broad challenges, the following priorities for the Lower San Joaquin River Region were identified in the CVFPP:

- Provide 200-year flood protection for Mossdale Tract.
- Secure local financing to fund capital improvement projects and support operations and maintenance activities.
- Implement the USACE Lower San Joaquin River Project.

- Implement Mormon Slough bank repair and channel restoration projects.
- Initiate and advance recommendations from identified feasibility-level studies.
- Improve flood emergency preparedness and response.

Flood Management Opportunities

A wide range of actions that can reduce flood risk and improve flood management have been identified through the CVFPP and other planning efforts. This section briefly describes flood management actions that have the potential to also provide water supply and/or ecosystem enhancement benefits. Actions include land use management practices in upper watersheds, diversion of flood water from stream channels, modifications to reservoir flood management rules, increased capacity of designated floodways, and development of additional surface water storage capacity. These flood control strategies, and their ability to contribute to water supply and ecosystem enhancement benefits, are described below.

Upper Watershed Projects and Management Actions

Forest management practices in upper watersheds can help enhance water retention, stabilize soils, slow runoff, and minimize debris runoff. Avoiding or minimizing disturbances in forested headwaters of river basins help maintain the capacity of forests to attenuate flood flows during high flow events by slowing the rate of runoff. Forest management practices that prevent or minimize wildfires by reducing fuel loads and improve forest health and create resilient landscapes (USFWS 2025). Minimizing burned areas can reduce fire debris inflow into streams, floodplains, and reservoirs during flood events. Reestablishing meadows within river basins creates natural retention of flood flows. Meadows that are shallow, meandering, and contain impervious features such as logs or rocks naturally slow water, allowing water to infiltrate and slow its movement through the watershed (USFWS 2020). Reducing inflow to reservoirs improves management of inflow and can help reduce the frequency and magnitude of flood releases, thereby improving the management of water supply, while improving ecosystem condition in upper watershed areas.

Diversion of Water from Rivers and Streams During High Flow Conditions

Diversion of flood flows from rivers and streams during high flow conditions can reduce flood stage at downstream locations and provide flood risk reduction benefits. In the SJV, water diverted from rivers and streams can be used to replenish groundwater using a variety of techniques (e.g., on-farm application, recharge basins, percolation through stream channels, injection wells). Specifically, for example, diversion of flood water from the Kings River can contribute to reduced flows from the Kings River to the San Joaquin River and also contribute to reducing flood risk in SJV Flood Planning regions. Diverted flood waters can also be routed to regional and statewide conveyance facilities, such as the FKC, DMC, San Luis Canal (SLC), the Kern River Intertie, and the California Aqueduct. The use of these regional conveyance facilities to intercept and convey flood flows increases the management of water supplies for delivery to areas both within and outside of the SJV (e.g., to Southern California). In 2023, Madera County Flood Control (and Water Conservation

Agency) and the Lower San Joaquin Levee District were able to facilitate 73,000 acre-feet of recharge during flood flow events.

Several actions have been taken to increase the diversion of high flows for the benefit of groundwater recharge. For example:

- California Water Code Section 1242.1 was codified to allow for temporary diversion of flood flows for the benefit of groundwater recharge if certain conditions are met. It specifically allows for the diversion of floodflows for the benefit of groundwater recharge without the need for an adjudicated water right.
- DWR has been assisting with the development of 180-day and 5-year temporary permits for groundwater recharge. These permits use criteria (e.g., the 90/20 rule) to establish thresholds for when diversions for recharge can occur. These temporary permits are issued by the California State Water Resources Control Board.
- DWR developed the Flood Diversion and Recharge Enhancement Initiative to provide funding assistance to implement managed aquifer recharge, and support other activities around the state to enhance the diversions of flood flows for the benefit of groundwater recharge.

Modification of Reservoir Flood Storage Operations

Modification of reservoir flood storage rules can improve real time decision making on the management of water during wet hydrologic periods. All major reservoirs in the SJV have rules that specify required flood storage capacity to be preserved during the winter and spring to accommodate flood flows and operational requirements to release water from flood storage. Studies of hydrologic variability indicate that future precipitation patterns will shift, with greater rainfall, rather than snow, and come earlier in the year. Resulting changes in the magnitude of inflow for specified return-frequency flood events may reduce the effectiveness of existing flood management rules to provide expected levels of flood protection.

Improvements in weather forecasting and the application of more dynamic decision making can allow adaptive management of reservoir operations to improve the flood management and provide water supply benefits. FIRO is a management strategy that uses data from watershed monitoring and modern weather and water forecasting to help water managers selectively retain or release water from reservoirs in a manner that reflects current and forecasted conditions. This allows water managers to better balance flood control, water supply, and environmental needs by retaining water when a storm is small and releasing it strategically ahead of a larger storm to reduce flood risk and also using available storage to capture more water in reservoirs.

FIRO relies on more accurate and longer-range weather forecasts, including those for atmospheric rivers, to predict precipitation and water inflows. Instead of following rigid, historically based rules, it creates a linkage between research, applications, technology, reservoir operations and water control manuals to enable continuous improvement based on state-of-the-science to enable operators to adapt their actions based on real-time and future forecast data. FIRO allows water to be

retained in the reservoir when forecasts indicate low projected precipitation, which can be released in a controlled manner to make space for more significant incoming storms. This helps capture more water for supply during dry periods.

FIRO has the potential to optimize reservoir management to achieve multiple goals. Flood control can be improved by making proactive water releases prior to forecasted flood events, which enables reservoirs to capture more inflow and release less flood flow to downstream areas. Water supplies can be increased through the delivery of pre-evacuated reservoir storage for ground recharge and subsequent capture and storage of water during flood events. For example, DWR and Merced Irrigation District recently completed the Merced River Watershed Flood-MAR Reconnaissance Study which identified FIRO as a key strategy for improving water management and highlighted the benefits of increased groundwater storage in the watershed (DWR 2024). River ecosystem conditions can be enhanced through improved management in the timing and volume of releases for ecosystem needs. Conversely, during periods when less precipitation is forecasted, water could be held in storage within designated flood space while minimizing the risk of potential flood spills.

Increasing Conveyance Capacity of Designated Floodways

Increasing conveyance capacity of designated floodways includes the restoration and expansion of the existing built flood system of bypasses as well as the expansion of floodplains. Historically the conventional strategy for managing flood has been to build levees along rivers to narrowly contain and convey flood flows. But rivers in their natural state continually evolve - depositing sediment, cutting into banks, and changing course as they meander downstream, connecting to floodplains. Actions to increase conveyance capacity of floodways should also consider integrating with associated floodplains to realize the ecosystem benefits associated with highly productive shallow water habitat for fish and nutrients for riverine ecosystems.

Achieving a balance between future water supplies and demands, as discussed in Chapter 2, may involve retiring agricultural lands, flooding agricultural land such that recharge can be achieved without crop damage, and/or creating an opportunity to repurpose land in historic flood plains. Increasing floodplain areas in the SJV would provide ecosystem benefits by improving habitat and water quality, while providing flood management benefits and potentially increase groundwater replenishments.

Like many of the conveyance facilities throughout the SJV, many flood bypass facilities are aging and investments to maintain and update the system have not kept pace with the needs. In addition, some floodways and bypasses have been affected by differential land subsidence, thereby reducing their water conveyance effectiveness. Restoring the design conveyance capacity of these systems would maintain their ability to manage flood flows and reduce risks to communities on or near these rivers and streams.

Development of Additional Surface Water Storage

The development of additional surface water storage can be achieved by expanding transitory storage in the SJV as well as expansion or development of water storage on existing river systems. Transitory storage refers to temporary surface storage of water, generally within historical floodplain locations, until it can be used at a later time meet water demands, delivered to groundwater storage,



or released to river systems after flood flows have dissipated. While not suitable for long term storage in the SJV due to the basin's shallow geometry, leading to high evaporation losses and possible increases in mosquito populations, transitory storage can provide strategic opportunities for regulating surface water, reducing flood damages, reducing groundwater pumping, and providing ecosystem benefits.

Several transitory storage projects have been proposed in GSPs or previously in IWRMPs, particularly in areas not well-suited to groundwater recharge through percolation. The expanded use of transitional storage in key areas of the SJV, such as in and around Tulare Lake, offer unique opportunities to achieve multiple benefits. Increasing the capacity of storage along the rivers and streams throughout the SJV can improve the ability to manage inflows during wet hydrologic periods.

Reservoir modifications, such as the recently completed Tule River Spillway Enlargement Project, increased the capacity of Lake Success on the Tule River by 28,000 acre-feet. This project enhanced flood risk management, increased water storage for irrigation use, and increased recreational opportunities.

Flood Management Next Steps

Collaboration and engagement among local, regional, state, federal agencies will be critical to align priorities, address regulatory considerations, and identify funding opportunities such as state and federal grants. Establishing pilot or demonstration projects (e.g., Flood-MAR, FIRO implementation, and floodplain restoration) can help validate approaches and inform broader application. Local water districts and non-districted areas may also require targeted technical, financial, and administrative support to effectively implement innovative and priority projects on an accelerated timeline to address pressing flood risk. Chapter 5 describes projects that can help address problems, needs, and opportunities described here. Chapter 6 outlines potential flood benefits associated with implementation strategies and scenarios.

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Chapter 4 Ecosystem Enhancement

Introduction

Extensive agricultural, urban and community development of the SJV has resulted in significant declines in ecosystem health, function, and species composition through expansive areas. In recognition that SGMA implementation and other contributors to the projected water supply-demand gap may result in extensive land repurposing to reduce water demands in several SJV subbasins, an opportunity arises to undertake large-scale restoration and rehabilitation efforts to recover native species, re-establish natural habitats, and provide landscape connectivity.

This chapter summarizes historical changes to landcover in the SJV, describes habitat restoration objectives of several existing programs, and identifies a potential habitat restoration target for the SJV and estimates water demands associated with that target. To be effective and efficient, large-scale ecosystem restoration in the SJV needs to be strategic, drawing on sound ecological principles and building on prior environmental planning efforts. Many landcover types that are native to the SJV have water demands that exceed supplies available through rainfall and may require managed water supplies be provided through existing or new facilities. Repurposing existing agricultural lands to establish native habitats can cause changes to existing water demands - decreasing them when irrigated land is converted to native landcover and increasing them when grasslands are being converted to higher water-use purposes. Potential water needs for habitat objectives should be considered in developing a long-range plan for the SJV.

A successful vision for the SJV involves identifying locations where repurposing of agricultural lands is appropriate to support restoration of natural landcovers and connections between those areas necessary to facilitate dispersal of animals and plants. Such effort is essential to meeting the agricultural needs, ecological requirements, and economic realities of the SJV. A five-step process, illustrated in Figure 4-1 and described below, is recommended for developing a land conversion program for the SJV.

Step 1 - Understand and Document Predevelopment Conditions and Available Resources.

Knowledge of past and present landcover is essential for building a realistic conservation plan. This chapter begins with an overview of the pre-settlement landcover in the SJV and how land use has changed over the past two centuries to help understand where restoration of specific landcover types may be most feasible.

Step 2 – Establish SJV-Wide Objectives. An ambitious objective of the ecosystem enhancement vision is to delist all species of concern and avoid future listings under federal and state Endangered Species Acts, with those species recovered to the demographic state where their existence is no longer threatened. With SGMA implementation resulting in water supply reductions that may trigger substantial land re-purposing, this chapter provides an overview of opportunities for ecosystem enhancement, including a review of considerable assessment and planning that has already been

completed that provides foundational guidance for plan development. Leveraging previous restoration studies is efficient and fosters collaboration.

Step 3 – Design Connectivity and Landscape Linkages. Connectivity is essential to maintaining demographic stability and genetic diversity in species of concern, as well as species composition in lands committed to natural cover and condition. A connecting network of landcover types draws on ecological principles, recognizing the historical context and available resources presented in step 1. A network of corridors, core areas, and specialty reserves can then be transposed from an SJV-wide planning level to a regional level for area-specific conservation planning and to the subbasin level for water planning.

Step 4 – Analysis, assessment, and review. The water supply plan to meet ecosystem enhancement needs emerges from the above programmatic approach. Once the estimated change in landcover types necessary to meet ecological objectives has been calculated, it is possible to quantify projected changes in the water supply-demand gap and explore opportunities to meet those water needs.

Step 5 – Plan Implementation. Successful implementation of a conservation plan begins with governance and leadership at both the SJV-wide level and for each ecological jurisdiction, with the thought that the protected areas and the areas to be restored would be divided into a comprehensive set of jurisdictional areas. Each jurisdictional area would establish measures for success, including abundance and habitat targets for species of concern, and acreage of different land types to be restored. Those targets, summed across jurisdictional areas should meet the SJV-wide objectives established in step 2. Work plans to achieve regional targets would be developed, prioritized and undertaken as funding becomes available. Progress towards objectives should be evaluated within an adaptive resource management framework, wherein the effectiveness of measures and activities are evaluated based on monitoring, and program activities are adjusted where expected results are not being achieved (see Reclamation District 2092 2025, Section 5.2).

This chapter begins with a focus on Steps 1 and 2, which are necessary steps to identify ecosystem enhancement objectives and determine water supply needs in the SJV. It also describes opportunities for ecosystem conservation and restoration, a component of Step 3, based on numerous plans that have been developed to achieve habitat- or region-specific objectives. An estimate of water supply requirements to support a potential habitat restoration plan for the SJV, a key component of Step 4, is also presented.

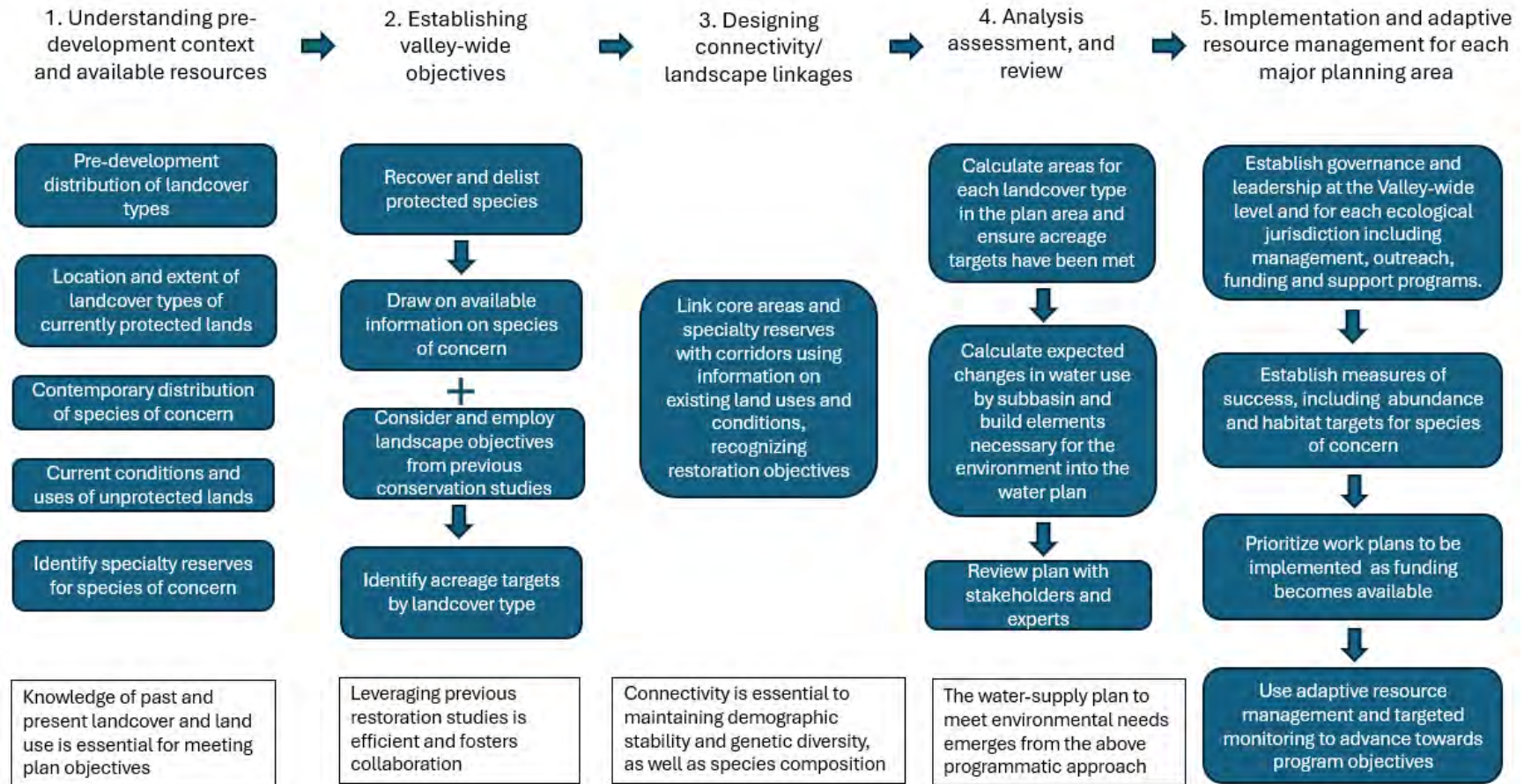
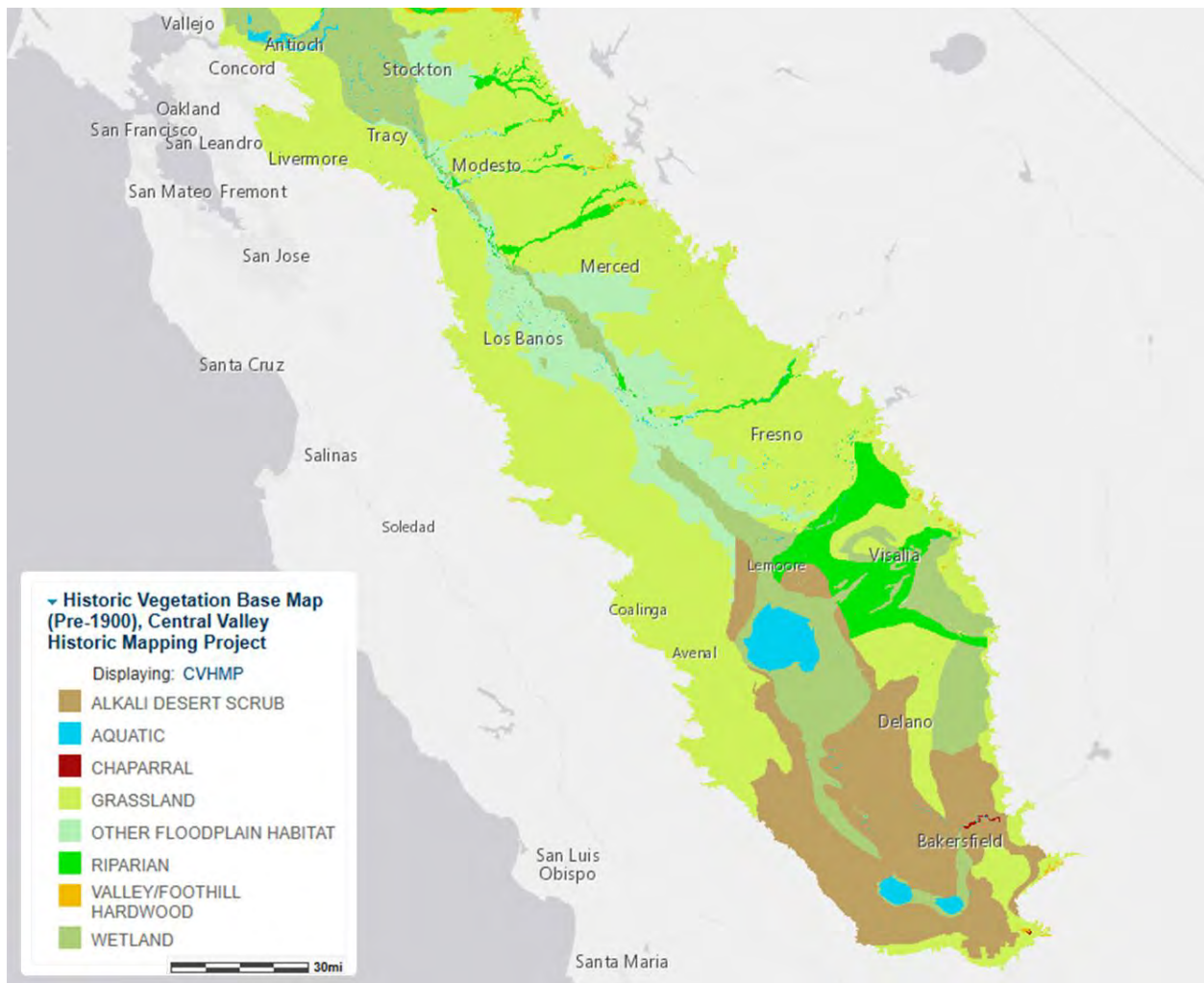


Figure 4-1. The Process for Developing a Conceptual Conservation Plan for the San Joaquin Valley

Historic and Current Conditions

Environmentally, the SJV is very different today from what it was prior to the extensive development that occurred throughout the 20th century. As demonstrated in Figure 4-2, historic natural, native ecosystems were widespread throughout the SJV and included some dominant landscape features, including Tulare Lake and extensive wetlands in the southern SJV. A summary of historical and recent (2002) land coverage for key habitat types is provided in Table 4-1. A graphic comparison of land form cover from pre-1900 to 2002 is shown in Figure 4-3. Both of these summaries reveal a significant reduction in native habitat acreage and coverage as a result of development.



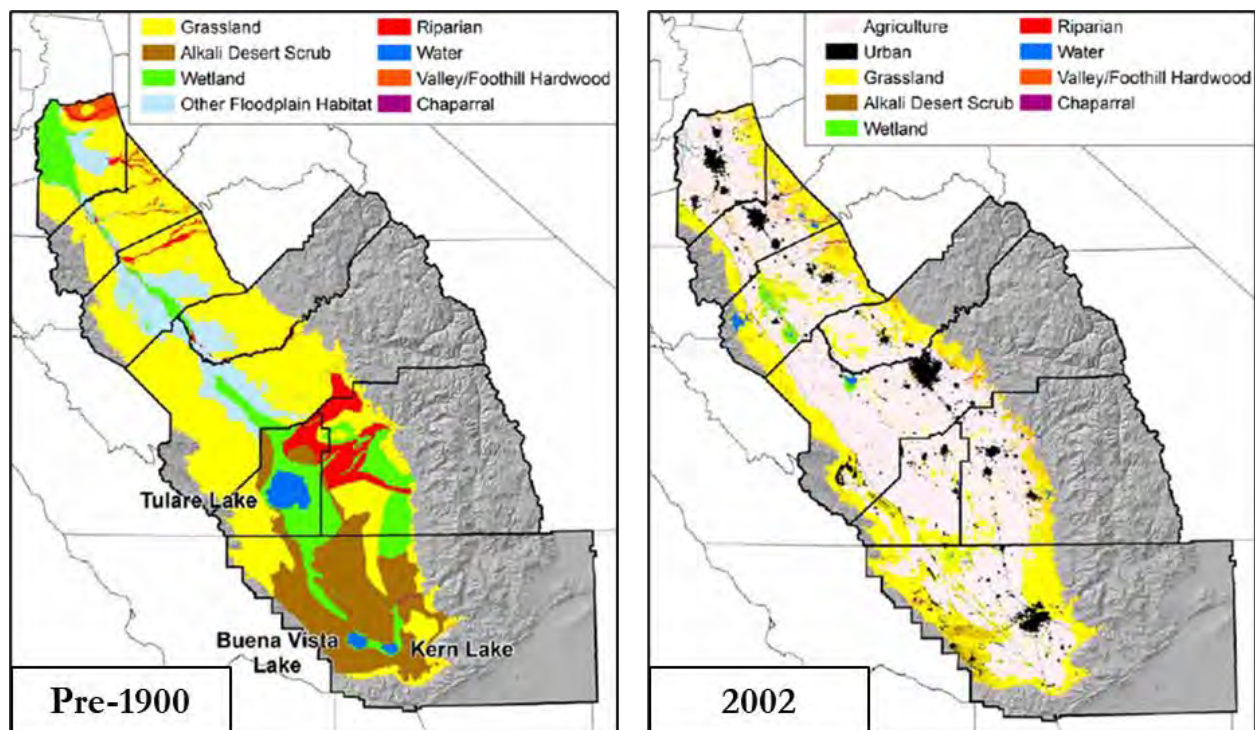
Source: Data Basin 2003

Figure 4-2. Pre-1900 Historic Vegetation Distribution in the San Joaquin Valley

Table 4-1. Current and Historic Landcover in the San Joaquin Valley

Landcover Category	Current Landcover Type Extents (Acres)	Historic Landcover Type Extents (Acres)	Change (Acres)	Change (Square Miles)
Agriculture	5,763,182	-	5,763,182	9,005
Urban	541,418	-	541,418	846
Alkali Desert Scrub	86,761	1,527,521	-1,440,760	-2,251
Chaparral	32,317	3,469	28,847	45
Grassland	2,650,489	4,814,106	-2,163,617	-3,381
Riparian and Floodplain Habitats	21,566	1,463,877	-1,442,311	-2,254
Valley/Foothill Hardwood	126,691	93,116	33,575	52
Water	78,117	186,051	-107,934	-169
Wetland	76,830	1,289,384	-1,212,554	-1,895

Source: Data Basin 2003; CAL FIRE 2002



Source: Data Basin 2003; CAL FIRE 2002

Figure 4-3. Historical and Current Landcover Patterns

Significant habitat reduction in the SJV has affected the existence of plant and animal species. As summarized in Table 4-2 and Table 4-3, about 30 animal and 20 plant species native to the SJV floor and are now listed as threatened or endangered. The number of listed species varies regionally, as summarized in Table 4-4.

Table 4-2. Listed Animals of the San Joaquin Valley Floor

Common Name	Scientific Name	State Status	Federal Status	Ecosystem
Birds				
California Condor	<i>Gymnogyps californianus</i>	E	E	Grasslands, oak savanna [D]
Greater Sandhill Crane	<i>Grus canadensis tabida</i>	T	N	Emergent wetlands, grasslands
Least Bell's vireo	<i>Vireo bellii pusillus</i>	E	E	Riparian woodland
Southwestern Willow Flycatcher	<i>Empidonax traillii extimus</i>		E	Riparian woodland
Swainson's hawks	<i>Buteo swainsoni</i>	T	N	Riparian & grassland
Tricolored Blackbird	<i>Agelaius tricolor</i>	T	N	Emergent wetlands, grain fields
Western Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	E	T	Riparian
Western Snowy Plover	<i>Charadrius nivosus nivosus</i>	N	T	Wetlands
Aquatic Species				
Delta smelt	<i>Hypomesus transpacificus</i>	E	E	Estuarine
Steelhead	<i>Oncorhynchus mykiss</i>	N	T	Riverine
Chinook salmon (fall run)	<i>Oncorhynchus tshawytscha</i>	T	T	Riverine
Longfin smelt	<i>Spirinchus thaleichthys</i>	T	N	Estuarine
Green Sturgeon	<i>Acipenser medirostris</i>		T	Riverine
Reptiles				
Blunt-nosed Leopard Lizard	<i>Gambelia sila</i>	E	E	Arid uplands
Giant Garter Snake	<i>Thamnophis gigas</i>	T	T	Wetlands
Northwestern Pond Turtle	<i>Actinemys marmorata</i>	N	T	Aquatic & wetlands
Amphibians				
California Tiger Salamander (central California DPS)	<i>Ambystoma californiense</i>	T	T	Aquatic & upland [D]
Invertebrates				
Conservancy Fairy Shrimp	<i>Branchinecta conservatio</i>	N	E	Vernal pools [D]
Longhorn Fairy Shrimp	<i>Branchinecta longiantenna</i>	N	E	Vernal pools [D]
Monarch Butterfly	<i>Danaus plexippus</i>	N	PT	
Valley Elderberry Longhorn Beetle	<i>Desmocerus californicus dimorphus</i>		T	Riparian
Vernal Pool Fairy Shrimp	<i>Branchinecta lynchi</i>	N	T	Vernal pools [D]
Vernal Pool Tadpole Shrimp	<i>Lepidurus packardii</i>	N	E	Vernal pools [D]
Mammals				
Buena Vista Lake Shrew	<i>Sorex ornatus relictus</i>	N	E	Riparian [D]
Fresno Kangaroo Rat	<i>Dipodomys nitratooides exilis</i>	E	E	Upland [D]
Giant Kangaroo rat	<i>Dipodomys ingens</i>	E	E	Grasslands
Riparian Brush Rabbit	<i>Sylvilagus bachmani riparius</i>	E	E	Riparian

Common Name	Scientific Name	State Status	Federal Status	Ecosystem
San Joaquin Kit Fox	<i>Vulpes macrotis mutica</i>	T	E	Upland
Riparian Woodrat	<i>Neotoma fuscipes riparia</i>	N	E	Riparian woodland
Tipton Kangaroo Rat	<i>Dipodomys nitratooides nitratooides</i>	E	E	Upland

Source: USFWS 2025

Notes:

Aquatic – ponds, lakes with emergent wetland perimeter

Estuarine – Water bodies where the rivers meet the sea. In the San Joaquin Valley it refers to the Sacramento-San Joaquin Delta.

Grassland – Land on which the natural dominant plant forms are grasses and forbs.

Riverine – a natural body of running water sufficiently deep for fish passage

Uplands – Land on the Valley floor that is unlikely to flood

Vernal pools – seasonal depressional wetlands resulting from rainfall

Wetland – Areas such as marshes or swamps that are covered often intermittently with shallow water or have soil saturated with

Moisture

[D] – Indicates critical habitat designated in the San Joaquin Valley.

Key:

DPS = Distinct Population Segment

E = endangered

N = not listed or information not available

PT = potentially threatened

T= threatened

Table 4-3. Listed Plants of the San Joaquin Valley Floor

Common Name	Scientific Name	State Status	Federal Status	Ecosystem*
Bakersfield Cactus	<i>Opuntia basilaris</i> var. <i>treleasei</i>	E	E	Sandy soils, arid grassland
California jewelflower	<i>Caulanthus californicus</i>	E	E	Grasslands & scrub
Chinese Camp Brodiaea	<i>Brodiaea pallida</i>		T	Vernally flooded riparian
Colusa Grass	<i>Neostapfia colusana</i>		T	Alkaline basins [D]
Fleshy Owl's-clover	<i>Castilleja campestris</i> ssp. <i>succulenta</i>		T	Vernal pools
Greene's Tuctoria	<i>Tuctoria greenei</i>		E	Vernal pools [D]
Hairy Orcutt Grass	<i>Orcuttia pilosa</i>		E	Vernal pools [D]
Hartweg's Golden Sunburst	<i>Pseudobahia bahiifolia</i>		E	Grassland
Hoover's Spurge	<i>Chamaesyce hooveri</i>		T	Vernal pools [D]
Hoover's Woolly-star	<i>Eriastrum hooveri</i>		T	Arid grassland & scrub
Ione Manzanita	<i>Arctostaphylos myrtifolia</i>		T	Woodland foothills
Keck's Checker-mallow	<i>Sidalcea keckii</i>		E	Grasslands [D]
Kern mallow	<i>Eremalche kernensis</i>		E	Arid grassland & scrub
Large Flowered Fiddleneck	<i>Amsinckia grandiflora</i>		E	Grassland
Palmate-bracted Bird's-Beak	<i>Cordylanthus palmatus</i>	E	E	Alkaline grasslands
Red Hills Vervain	<i>Verbena californica</i>		T	Grasslands
San Joaquin Adobe Sunburst	<i>Pseudobahia peirsonii</i>		T	Grassland and oak woodland
San Joaquin Valley Orcutt Grass	<i>Orcuttia inaequalis</i>		T	Vernal Pools [D]
San Joaquin woolly-threads	<i>Lembertia congdonii</i>		E	Arid grassland & scrub
Springville Clarkia	<i>Clarkia springvillensis</i>		T	Oak woodland

Source: USFWS 2025

Notes:

Grassland – Land on which the natural dominant plant forms are grasses and forbs.

Vernal pools – seasonal depressional wetlands resulting from rainfall

Moisture

[D] – Indicates critical habitat designated in the San Joaquin Valley.

Key:

E = endangered

T= threatened

Table 4-4. Number of Listed Species by County in the San Joaquin Valley

County	Number of Listed Plant Species	Number of Listed Animal Species
San Joaquin	3	11
Stanislaus	6	10
Merced	5	13
Madera	6	11
Fresno	12	23
Kings	1	10
Tulare	10	14
Kern	11	19

Source: Thorne et al. 2014

Landcover Types of the San Joaquin Valley Floor

Landcover of the SJV floor has been parsed into various categories by different ecologists, but eight vegetation communities have wide extent and ecological importance: alkali scrub and saltbush, aquatic and permanent wetlands, floodplains, grasslands, riparian communities adjoining rivers and streams, wetlands that are intermittent, woodlands, and vernal pools. Each provides habitat for a wide range of species, as summarized in Table 4 5. Each habitat type is further described in the following sections. In addition to habitat types listed in Table 4-5, the descriptions include upper watershed forest lands because management of these lands have the potential to affect water supplies reaching the SJV floor.

Table 4-5. Species Associated with San Joaquin Valley Landcover Types

Landcover Type	Species/Groups of Interest
Alkali scrub & saltbush	San Joaquin kit fox (E), blunt nose leopard lizard (E), kangaroo rats (E), Bakersfield cactus (E), California jewelflower (E), Colusa grass (T), Hoover's woolly-star (T), Kern mallow (E), palmate-bracted bird's beak (E), San Joaquin woolly-threads (E)
Aquatic and permanent wetlands	Wetland dependent reptiles and mammals, western pond turtle (T), wetland obligate plants, waterbirds and shorebirds, amphibians, dragonflies and damselflies, delta smelt (E), longfin smelt (T), California tiger salamander (T)
Floodplains	Salmonids (T), green sturgeon, river otter, American beaver, common muskrat, American mink, Chinese Camp Brodiaea (T)
Grasslands and uplands	Tule elk, mule deer, pronghorn, bobcat, gray fox, burrowing mammals (ground squirrel, kangaroo rats (E), San Joaquin kit fox (E), American badger), bumblebees and pollinators, California condor (E), Swainson's hawk (T), California jewelflower (E), Hartweg's golden sunburst (E), Keck's checker-mallow (E), large flowered fiddleneck (E), red hills vervain (T), San Joaquin adobe sunburst (T)
Riparian and river corridors	Riparian birds (yellow billed cuckoo, Least Bell's vireo (E), yellow warbler, black-headed grosbeak, bank swallow, Southwestern willow flycatcher (E), Wilson's warbler, yellow breasted chat, wood ducks), Swainson's hawk (T), amphibians (Foothill Yellow-legged frog, California Red-legged frog, California tiger salamander), giant garter snake (T), riparian brush rabbit (E), riparian wood rat (E), Buena Vista Lake shrew (E), Valley elderberry longhorn beetle (T), steelhead (T), chinook salmon (T), green sturgeon (T). Vegetation is commonly characterized by willow, mulefat, cottonwood, Valley oak, white alder, California bay-laurel, sycamore, and walnut.
Wetlands (seasonal)	Waterbirds and shorebirds such as gadwall, mallard, black-necked stilts, American avocet, and killdeer, tricolored blackbird (T), greater sandhill crane (T), western snowy plover (T), tule elk, giant garter snake (T). Dominant herbaceous vegetation includes sedges, rushes, bulrushes, cattails
Woodlands	Valley oak, yellow billed magpie, mule deer, bobcat, gray fox, burrowing mammals, cavity nesters and roosters (owls woodpeckers, nuthatches, wrens, tree swallows, bluebirds, wood ducks), lone manzanita (T), San Joaquin adobe sunburst (T), Springville clarkia (T)
Vernal Pools	Fairy shrimp (E), tadpole shrimp (E), fleshy owl's-clover (T), Greene's tuctoria (E), hairy Orcutt grass (E), Hoover's spurge (T), San Joaquin Valley Orcutt grass (T)

Notes:

(E) – state or federally listed as endangered

(T) – state or federally listed as threatened

Alkali scrub

Alkali scrub surrounded the receding shores of large prehistoric lakes or alkali playas that mark the locations of dry lake beds (Fowler and Koch 1982). Alkali scrub vegetation typically occurs at lower-to middle-SJV elevations, often interdigitated with other arid and semiarid plant communities and wildlife habitats. At lower elevations, alkali scrub may occur in patches on barren salt flats and in desert scrub. In the SJV, alkali scrub borders on annual grassland habitat. In many locations, alkali scrub overlaps with perennial grassland. Restoration of alkali scrub will occur primarily in the Tulare

Lake hydrologic region based on its historical location and distribution, shown on Figure 4-2. Alkali desert soils are generally not suited for farming, therefore much alkali scrub restoration can be expected on land that is not currently farmed.

Aquatic Ecosystems

Aquatic ecosystems include lakes, ponds and permanent wetlands. “Permanent wetlands have standing surface water year-round and include both managed and unmanaged wetlands. They are too wet for most terrestrial vegetation and tend to undergo wet and dry cycles due to fluctuating water levels. Presently, more than 90% of wetlands in the Central Valley are managed, two-thirds of which are in private ownership.” (CLCC 2018). Restoration of permanent wetlands and aquatic ecosystems should primarily occur as development of small areas -- less than 50 acres -- throughout the SJV in addition to restoring one thousand or more acres of the historic Tulare Lake footprint.

Floodplains

Stream and river flows that exceed channel conveyance capacity inundate floodplains. Floodplain inundation deposits sediment, facilitates establishment of riparian vegetation, provides for wildlife and fish habitats and other benefits, including additional food resources for fish. Many native wildlife and fish species are dependent on or benefit from inundated floodplains. The floodplain of the San Joaquin River has been greatly reduced compared to its historical extent (CALFED 2000). From the Chowchilla Bypass to Mendota Dam, berms and levees locally constrain the river and minimize the area of inundated floodplain. In addition, riparian forests have declined by more than 50% and riparian scrub by more than 80% from 1937 to 1993 (CSCC and USACE 1998). That loss of inundated floodplain and riparian vegetation contributes to a loss of animal and plant habitats and reduced habitat conditions along that section of the San Joaquin River.

Availability of floodplain habitat is essential in the life cycles of many listed species. For example, about one third of the documented occurrences of Delta coyote-thistle have been extirpated primarily from conversion of riparian vegetation to other land-cover types (FWUA and NRDC 2002; CDFW 2001). Streams and their riparian zones are ecosystems closely linked by flows of organic and inorganic materials, movements of organisms, and are strongly influenced by the exchange of materials, such as nutrients, leaves, and woody debris (Likens and Bormann 1974; Hynes 1975). Inundating the floodplain is key to providing organic nutrients to the river ecosystem. Inundated floodplains provide cover, food, and warmer temperatures from late winter through early spring (CDFW 2014). Floodplains provide important benefits to riverine productivity. Typically, restoration of floodplains requires the repurposing of agricultural land. The greatest benefits from floodplain restoration will likely occur in the San Joaquin hydrologic region.

Grasslands

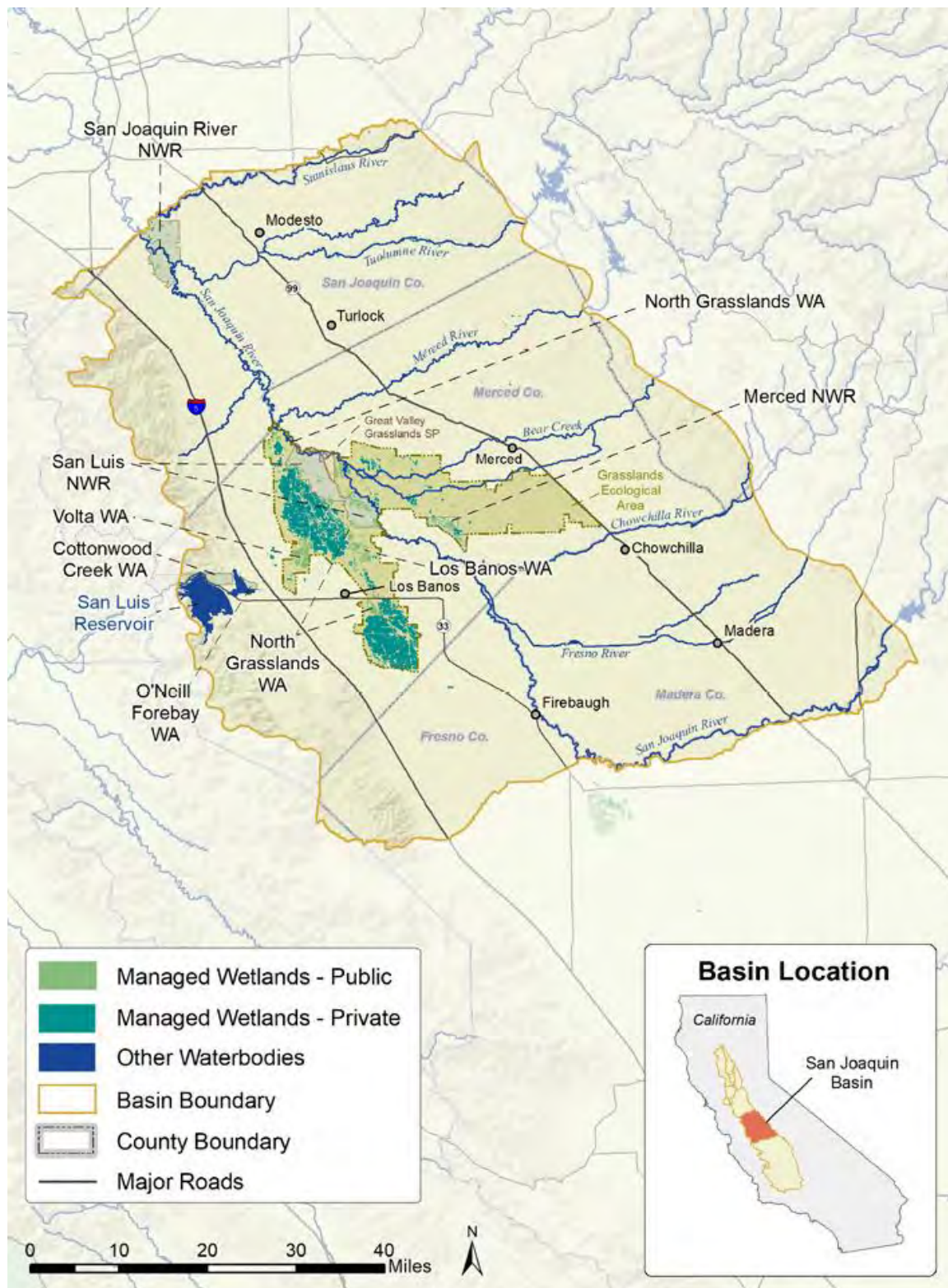
Central Valley grasslands are open grasslands that support a diversity of annual and perennial plant species. These grasslands are characterized by winter precipitation and seasonal summer drought and exhibit high temporal and spatial diversity (Lulow and Young 2011; Bartolome et al. 2014; Spiegel et al. 2014; and CLCC 2018). Historically, grassland habitat dominated the SJV floor north of the Kings River, as shown on Figure 4-2. They provide landscape corridors between other ecosystems, buffers for riparian corridors, and foraging habitat for a number of species.

Riparian Ecosystems

“Riparian vegetation/natural riverbank refers to the vegetation that grows along the shores of freshwater rivers and lakes as well as the meander-belt processes that shape this dynamic habitat. As a river meanders, the bank on one side erodes while sediments accumulate on the opposite side, destroying old habitat and creating new substrate to be colonized, creating a constant succession of vegetation types adapted to this dynamic process. Riparian vegetation is commonly characterized by willow (*Salix* spp.), mulefat (*Baccharis pilularis*), Fremont cottonwood (*Populus fremontii*), SJV oak (*Quercus lobata*), white alder (*Alnus rhombifolia*), California bay-laurel (*Umbellularia californica*), sycamore (*Platanus racemosa*), and walnut (*Juglans californica*), depending on location” (CLCC 2018). Restoration of riparian and riparian-woodland habitat is naturally suited along existing rivers and streams. Riparian corridors are key landscape components in maintaining biological connections along extended and dynamic environmental gradients (Naiman et al. 2005). Continuous riparian habitat provides natural corridors to facilitate species movement; however, those lands tend to be expensive to obtain because they generally have fertile soils and reliable water rights.

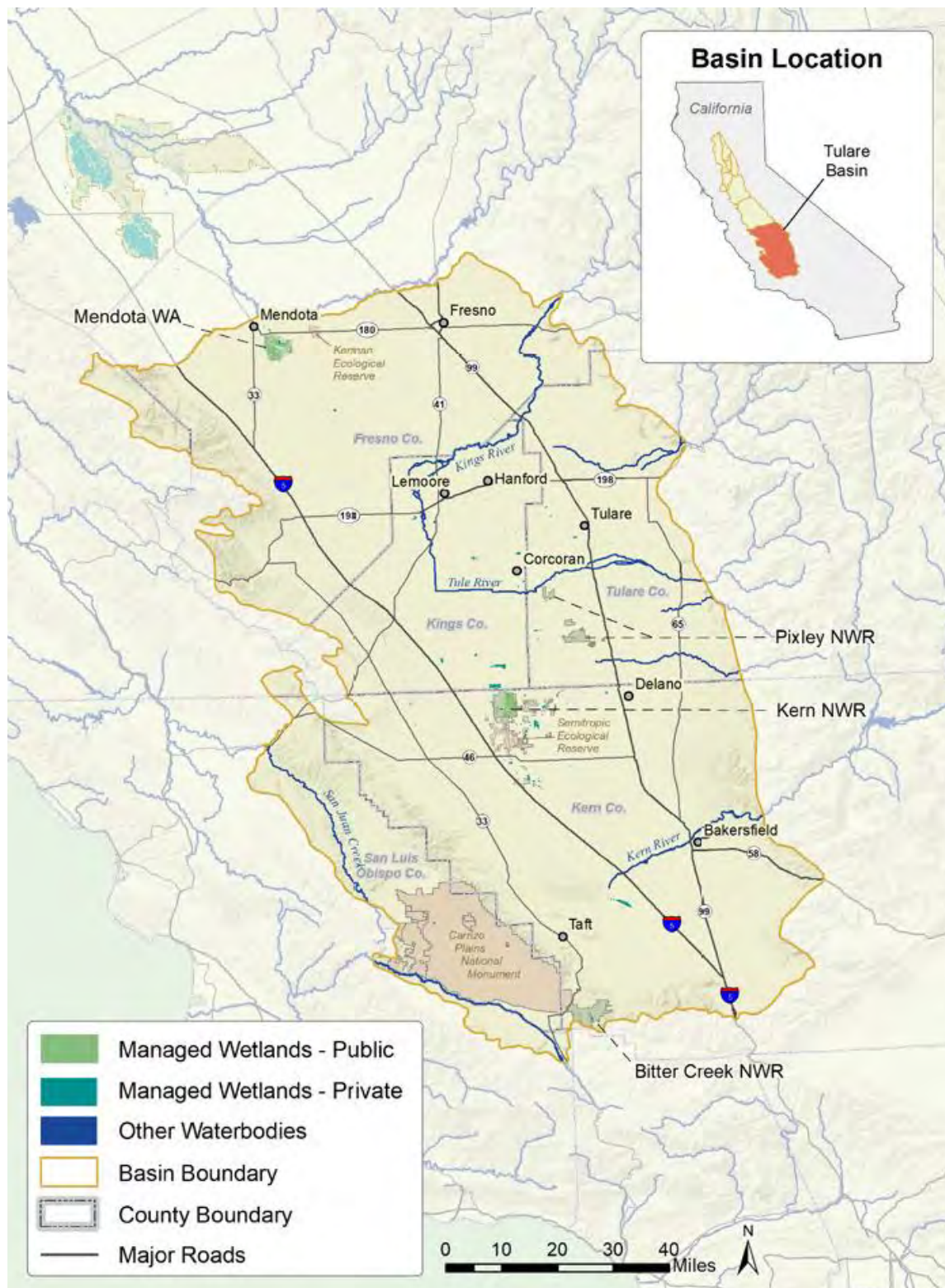
Seasonal Wetlands

“Seasonal wetlands are inundated during part of the year; most are managed by flooding, disking, and burning. Typical hydrological cycles include fall flooding and drawdown in the spring followed by irrigation to maintain soil moisture. Seasonal wetlands are dominated by herbaceous vegetation, including sedges (*Carex* spp.), rushes (*Eleocharis* spp. and *Scirpus* spp.), bulrushes (*Schoenoplectus* spp.), cattails (*Typha* spp.), and other emergent hydrophytic species. Species composition is determined partially by water depth, and many wetlands are managed for seed production of swamp Timothy (*Heleochoa schenoides*) and smartweed (*Polygonum* spp.; Ortega 2009).” Around 94% of the historic wetland habitat in the SJV has been lost (Table 4-1). Most of the historic wetland habitat occurred along the San Joaquin River, along the old Kern River, which ran through Kern Lake and Buena Vista Lake, and around Tulare Lake. Those wetlands provided important habitat for waterfowl. The locations of remaining wetlands are depicted in Figure 4-4 and Figure 4-5 for the San Joaquin Hydrologic Basin and the Tulare Lake Hydrologic Basin, respectively. Estimates of remaining wetlands in the SJV vary from 58,000 acres (CVJV 2020) to 77,000 acres (Thorne et al. 2014). The need for additional recharge facilities will create opportunities for new wetland acreage in most of the subbasins. To maximize ecosystem benefits, these recharge ponds could be designed and operated as multi-purpose ponds – that is, providing habitat as well as recharge.



Source: CVJV (2020) Figure 4.1.10

Figure 4-4. Managed Wetlands in the San Joaquin Hydrologic Region



Source: CVJV (2020) Figure 4.1.11

Figure 4-5. Managed Wetlands in the Tulare Lake Hydrologic Region

Valley Woodlands

“Oak woodlands in the Central Valley include Valley oak woodlands, blue oak woodlands, and blue oak-foothill pine woodlands. These vegetation types often grade into each other, with Valley oak woodlands occurring at the lowest elevations, and blue oak-foothill pine woodlands occupying higher elevations in the foothills” (CLCC 2018). Most of the woodland habitat restoration is expected to occur in the foothills surrounding the SJV floor. While that acreage could be large, the restoration target for the SJV floor is relatively small in this analysis.

Upper Watershed Forest Lands

While this report focuses on water management on the SJV floor, the majority of the water in the SJV originates in the watersheds above the SJV floor. The Sierra Nevada contains the headwaters of 24 major river basins, with the majority of the runoff being on the west side and draining into the Central Valley. Most of these are east-west trending watersheds that dissect the Sierra into steep canyons. The major vegetation zones of the Sierra form readily apparent large-scale elevational patterns. A broad conifer zone begins at 300-900 meters (1,000 – 3,000 feet) elevation on the west and 900 – 1,500 meters (3,000 – 5,000 feet) on the east side. Under pre-European conditions, fires and other disturbance events regularly burned patches of trees, leaving openings that passed through continuous but distinctive phases as they aged. This succession of a forest through time between major disturbances is important for plants and animals that use different stages as habitat. Within the last 100 years, human influence increased in which resource use was more regulated and forest and range protection was emphasized. Suppression of fires became a primary goal of federal, state and private efforts (Fites-Kaufmann et al. 2007).

Establishing manageable connections with the upper-watershed forest management has the potential to improve the quantity and quality of water reaching the SJV floor, which also reducing undesirable effects in upper watershed areas. Fire suppression and logging practices in the Sierra Nevada have resulted in large areas of forest that are overly dense with small trees and brush. Large-scale forest and meadow restoration is needed across the Sierra Nevada to reduce the risk of mega-fires and improve ecosystem health. Mega-fires are large, severe wildfires that burn larger and hotter than historic fires, and have more lasting unwanted human, economic, and environmental consequences (Fites-Kaufmann et al. 2007).

Vernal Pools

“Vernal pools and swales are ephemeral wetlands that form in landscape depressions where soil characteristics limit water infiltration. Vernal pools are characterized by a wet period in winter, drying during spring, and complete desiccation during late spring and summer. Swales connect or feed vernal pools but typically experience less extensive inundation. This unique habitat is home to highly specialized plants, animals, and insects, many of them endemic to the region and listed as threatened or endangered” (CLCC 2018). In 2018 there were approximately 207,000 acres of vernal pool grassland, as shown on Figure 4-6 of which 125,500 acres were estimated to be protected (United States Fish and Wildlife Service (USFWS)). The goal in this Conservation Plan is to protect existing vernal pools in the context of a wider conservation strategy.



Source: Vollmar et al (2023)

Figure 4-6. Locations of Vernal Pools in the San Joaquin Valley

Currently Protected Lands

Currently protected lands form the foundation to establish a more comprehensive ecosystem enhancement program for the SJV. They provide the core areas from which ecosystems can be expanded and connections to other areas established. Currently protected lands in the SJV exceed 350,000 acres, as summarized in, but not limited to, Table 4-6, and include the following:

- Government owned land such as national wildlife refuges, ecological reserves and wildlife areas managed by the California Department of Fish and Wildlife, and State Recreation areas managed by California Department of Parks.
- Lands with conservation easements and protections such as lands governed by habitat conservation plans.
- Land owned by environmental organizations such as Wind Wolves Preserve or the Sequoia Riverlands Trust.

Table 4-6. Large Blocks and Core Areas of Protected Natural Lands

Core Areas	Acres	Landcover Types
Alameda County		
Bethany Reservoir State Recreation Area	608	Aquatic, grasslands
Fresno County		
Kerman Ecological Reserve	1,800	Grasslands with some vernal pools, alkali scrub
Little Panoche Reservoir Wildlife Area	828	Aquatic, shrub and grasslands
Mendota Wildlife Area & Alkali Sink Ecological Reserve	12,730	Seasonal wetlands, grasslands
Pleasant Valley Ecological Reserve	1,200	Grasslands and saltbush
Upper San Joaquin River Ecological Area		
Big Table Mountain Ecological Reserve	1,000	Grasslands and volcanic vernal pools
Millerton State Recreation Area	4,900	Aquatic, riparian, grasslands
San Joaquin River Ecological Reserve	958	Riparian
Upper San Joaquin River Ecological Area Subtotal	6,858	
Kern County		
Buttonwillow Ecological Reserve	1,400	Alkali scrub and grasslands
Elk Hills	24,650	Alkali scrub and grasslands
Kern National Wildlife Refuge	11,249	Seasonal Wetlands
Kern Water Bank	20,600	Alkali scrub and grasslands, seasonal wetlands
Lokern Ecological Reserve	3,100	Saltbush scrub
Semitropic Ecological Reserve	14,900	Grasslands, alkali scrub
Tule Elk Reserve	960	Grasslands, seasonal wetlands
Windwolves Preserve	93,000	Grasslands, woodlands

Core Areas	Acres	Landcover Types
Merced County		
Grassland Ecological Area		
George J Hatfield State Recreation Area	47	Riparian
Great Valley Grasslands State Park	2,826	Grasslands, wetlands, riparian woodlands
Los Banos Wildlife Area	6,275	Wetlands
North Grasslands Wildlife Area	7,354	Wetlands, riparian, grasslands
San Luis National Wildlife Refuge	26,800	Wetlands
Grassland Ecological Area Subtotal	43,273	
McConnell State Recreation Area	74	Riparian
Merced National Wildlife Refuge	10,200	Wetlands, grasslands, vernal pools, riparian
San Luis Reservoir Ecological Area		
Cottonwood Creek Wildlife Area	6,300	Woodlands, grasslands
O'Neill Forebay Wildlife Area	700	Riparian, wetlands
Pacheco State Park	6,890	Woodlands, grasslands
San Luis Reservoir Wildlife Area	902	Woodlands, grasslands
Core Areas	Acres	Landcover Types
San Luis Reservoir State Recreation Area	64,000	Aquatic, woodlands, grasslands, aquatic
<i>San Luis Reserve Ecological Area Subtotal</i>	<i>78,792</i>	
Volta Wildlife Area	3,758	Wetlands and alkali scrub
West Hilmar Wildlife Area	346	Woodlands and grasslands
San Joaquin County		
Woodbridge Ecological Reserve	354	Wetlands
Stanislaus County		
Caswell Memorial State Park	258	Riparian woodland
Dos Rios State Park	1,563	Riparian, wetlands, grasslands
San Joaquin River National Wildlife Refuge	7,300	Riparian woodlands, grasslands, wetlands
Turlock Lake State Recreation Area	3,500	Grasslands, aquatic
Tulare County		
Capinero Creek	467	Alkali scrub
Kaweah Oaks Preserve	344	Riparian, woodlands
Dry Creek Preserve	152	Woodlands
Homer Ranch Preserve	1,819	Woodlands
McCarthy Blue Oak Ranch Preserve	908	Woodlands, chaparral
Lewis Hill Preserve	110	Grasslands, woodlands
James K. Herbert Prairie Wetland Preserve	725	Wetlands, vernal pools
Hogwallows Preserve	10	Vernal pools
Pixley Ecological Area		
Allensworth Ecological Reserve	5,100	Alkali scrub and saltbush

Core Areas	Acres	Landcover Types
Colonel Allensworth State Historic Park	240	Alkali scrub and saltbush
Pixley National Wildlife Refuge	6,939	Seasonal Wetlands
Pixley Ecological Area Subtotal	12,279	
Stone Corral Ecological Reserve	981	Vernal pool, wetlands
Kings County		
Clark Preserve	40	Alkali scrub
Total	502,367	acres

Specialty Reserves

USFWS in 1998 recognized the need to include specialty reserves as a part of any proposed habitat protection or re-establishment plan. These reserves are important for recovery of certain species with highly restricted geographic ranges or specialized habitat requirements. The reserve sites may be small areas surrounded by developed land, or may be portions of larger conservation areas that require special management. Table 4-7 summarizes natural lands in the SJV that are target for protection and specialty reserves.

Table 4-7. Natural Lands Targeted for Protection and Specialty Reserves

Location	Species of Interest
Springtown Alkali Sink	Palmate-bracted bird's-beak
Lower Stanislaus River	Riparian brush rabbit, riparian wood rat,
SJR Riparian Community	Riparian brush rabbit, riparian wood rat, San Joaquin kit fox
Lemoore Naval Air Station	San Joaquin kit fox, blunt nose leopard lizard,
North of Tulare Lake Bed	San Joaquin kit fox, blunt nose leopard lizard,
Granite Station	Bakersfield cactus
Devils Den Area	Bakersfield cactus, San Joaquin kit fox, blunt nose leopard lizard, Hoover's wooly star, Jared's peppergrass, California jewel flower, Tremblor buckwheat, short nose kangaroo rat, San Joaquin Le Conte's thrasher, Tulare grasshopper mouse, San Joaquin antelope squirrel
Lost Hills-Buena Vista Slough	Bakersfield cactus, San Joaquin kit fox, blunt nose leopard lizard, Hoover's wooly star, San Joaquin wooly threads, Lost Hills saltbush, Munz's tidy tips, short nose kangaroo rat, San Joaquin antelope squirrel
Jerry Slough to Hwy 58	Hoover's wooly star, lesser salt scale
Greater Bakersfield, North of Kern River	Bakersfield cactus, San Joaquin kit fox, blunt nose leopard lizard,
Fairfax Rd – Hwy 178	Bakersfield cactus
Kern Bluffs	Bakersfield cactus, San Joaquin kit fox, blunt nose leopard lizard, short nose kangaroo rat
Fuller Acres	Bakersfield cactus
Mouth of Kern Canyon	Bakersfield cactus
Cottonwood Creek	Bakersfield cactus
Bena Hills – Caliente Hills	Bakersfield cactus, Vazek's clarkia, California jewel flower, Comanche Point layia, Tejon poppy
Sand Ridge	Bakersfield cactus, short nose kangaroo rat, San Joaquin kit fox, San Joaquin wooly thread
Comanche-Tejon Hills	Bakersfield cactus, San Joaquin kit fox, blunt nose leopard lizard, Comanche Point layia, Tejon poppy, short nose kangaroo rat
Kern Lake – Gator Pond	Buena Vista Lake shrew, Bakersfield smallscale, Comanche Point layia
Mettler-Wheeler Ridge	Bakersfield cactus, San Joaquin kit fox, blunt nose leopard lizard, short nose kangaroo rat

Ecosystem Enhancement Opportunities and Objectives

A combination of actions, including enhanced water management, development of facilities to increase water supplies, and land repurposing will be needed to resolve the significant water supply-demand gap described in Chapter 2. Scenarios that evaluate combinations of these actions are presented in Chapter 6. The scope of potential land repurposing revealed through those evaluations underscores an unprecedented opportunity for substantial ecosystem restoration in the SJV. Even with maximum use of local supplies and increased exports from the Delta, it is unlikely that sufficient water supplies to sustain the current extent of irrigated lands in the SJV could be developed. Hence, land repurposing will be a necessary and inevitable outcome that warrants

collaborative planning and coordinate implementation. In the absence of such coordinated efforts, the retirement of agricultural land could result in a fragmented landscape of fallowed land areas that provide sources of dust to reduce air quality and increase risks to human health, including incidences of Valley Fever, chronic obstructive pulmonary disease, and asthma (Adeyemi et al. 2025; PPIC 2022). Fallowed lands could also create conditions for the proliferation of pests and weeds that adversely affect ongoing agricultural operations and communities, and do not contribute to the enhancement of remnant native ecosystems.

The SJV is home to a variety of natural land-cover types, including wetlands, grasslands, woodlands, and riparian communities that provide habitat for numerous species, including endangered species and species of conservation concern. It also is a critical component of the Pacific flyway for migratory birds. Repurposing irrigated lands in a coordinated manner can provide substantial ecosystem enhancement benefits, restoring ecosystems that have diminished in size and have been deteriorating for a century and a half, while protecting against threats to human health.

Considerations for Development of Ecosystem Restoration Plans

Ad hoc environmental restoration is unlikely to produce significant ecosystem benefits in the SJV and more likely will result in undesirable outcomes. Ecosystem enhancement objectives are more likely to be achieved through development and implementation of a strategic plan that employs widely accepted ecological principles and a targeted, balanced human presence. Active management in the form of grazing, burning, pest management, local involvement, stewardship, and education is often necessary to prevent degradation of high-quality habitat (Reclamation District 2092 2025).

Williams et al. (1998) formalized a multiple species recovery plan for imperiled species of plants and animals in the SJV. While the focus was on upland species, the document provides valuable insights on broadly applicable planning principles, including the following six key elements that comprise a recovery strategy: recovery criteria, habitat protection, emphasis on umbrella and keystone species, a monitoring and research program, adaptive management, and economic and social considerations. The document further clear guidance to be considered in developing plans for habitat protection:

“Considering that habitat loss is the primary cause of species endangerment in the SJV, a central component of species recovery is to establish a network of conservation areas and reserves that represent all of the pertinent terrestrial and riparian natural communities in the SJV.

“Existing natural lands, occupied by covered species, are targeted for conservation in preference to unoccupied natural land or retired farmland. This greatly reduces or eliminates the need for expensive and untested restoration work to make the land suitable to those species. Many covered species are concentrated in the natural communities that persist in the SJV. The recommended approach is to protect land in large blocks wherever possible. Large landscape blocks minimize edge effects, increase the likelihood that ecosystem functions will remain intact, and facilitate effective management.

“Another recommendation of the plan is that, wherever possible, blocks of conservation lands should be connected by natural landscape or land with compatible uses to allow for movement of species between blocks. Linkages are proposed both on the floor of the SJV and in foothills along the

margins of the SJV. Few SJV floor linkages exist at this time; restoration of continuous corridors or islands of suitable vegetation that can act as “stepping stones” will be necessary to provide movement corridors. Natural land remaining along the fringes of the SJV will provide both habitat and landscape linkages.

“Plants and animals depend on habitat connectivity, which is the degree to which organisms or natural processes can move unimpeded across habitats. Animals move between different patches of habitat to feed, rest, and reproduce as part of their daily and seasonal activities. Individuals disperse in search of unoccupied habitat, and some embark on long migrations on which their species depend. As fruits and seeds, plants move between patches of habitat adhered to or in the guts of animals and floating on air or water. Together these movements sustain the diversity and functioning of biological communities. They allow populations to persist through the colonization and recolonization of habitats, and the interchange of individuals and their genes. They also result in habitat patches containing greater numbers and variety of species—thereby having greater resilience.” (Reclamation District 2092 2025)

These principles and other considerations are incorporated in the development of a conceptual conservation plan for the SJV presented later in this report.

Summary of Ecosystem Restoration Plans

Several environmental restoration and ecosystem enhancement plans and initiatives have been prepared or are underway in the SJV that provide insight into opportunities to address specific habitat types within defined areas. Nearly all identified plans involve some form of land repurposing and many also would require repurposing of existing water supplies. Some of the plans are geographically-focus, such as restoration projects undertaken by The Nature Conservancy, Ducks Unlimited, River Partners and GSAs that are developing multi-benefit recharge basins. At a broader scale, numerous planning efforts have recognized needs and opportunities for ecosystem enhancement, providing helpful guidance to guide development of an SJV-wide land repurposing and ecosystem enhancement strategy. Those efforts include work from the following organizations:

- The Endangered Species Recovery Program is a cooperative research program on biodiversity conservation in central California, administered at California State University, Stanislaus. The program was established in August 1992 at the request and with the support of the U.S. Fish and Wildlife Service and the Bureau of Reclamation. Over the past decade, Endangered Species Recovery Program has grown into a cooperative research program working with local, state, and federal agencies, non-governmental organizations, corporations, and private landowners (Willams et al. 1998)
- The Tulare Basin Wildlife Partners (TBWP) was established in 2005 to serve as a catalyst for protecting and restoring natural communities and is focused on creating integrated land and water management solutions in the Tulare Basin (TBWP -About - Tulare Basin Watershed Network).
- Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta, Sacramento SJV and SJV Regions (CDFW, USFWS, and NMFS/NOAA 2014) serves as a conceptual

framework to guide environmental restoration, including development of conservation priorities and processes to identify and implement restoration opportunities, and monitoring to guide and improve its success in the Sacramento-San Joaquin Delta, and the Sacramento Valley and the SJV regions.

- SJV Greenprint (Thorne et al 2014). The SJV Greenprint is a voluntary, stakeholder-driven project to help the eight counties of the SJV create long-term environmental and economic sustainability in the face of challenges associated with economic growth, changing hydrologic variability and environmental protection and enhancement.
- The Central Valley Joint Venture (CVJV) is one of 21 habitat-based Migratory Bird Joint Ventures in North America, all of which work to protect and restore bird habitat. USFWS provides guidance for the establishment and organization of Joint Ventures. The USFWS defines Joint Ventures as self-directed partnerships of agencies, organizations, corporations, tribes and individuals that have formally accepted the responsibility of implementing national or international bird conservation plans within a specific geographic area or for a specific taxonomic group and have received general acceptance in the bird conservation community for such responsibility (USFWS 2005). The CVJV is a self-directed coalition consisting of 19 public and private organizations. For more than 30 years, the partnership has directed its efforts toward the common goal of meeting the habitat needs of migrating and resident birds in California's Central Valley (CVJV 2020).
- Sequoia Riverlands Trust is a regional nonprofit land trust dedicated to strengthening California's heartland and the natural and agricultural legacy of the southern Sierra Nevada and SJV (Sequoia Riverlands Trust 2026)
- Kaweah Groundwater Subbasin Regional Conservation Investment Strategy was developed to advance the conservation of focal species and their habitats, including working lands and natural communities, to sustain those species over time as environmental conditions in the planning area change (EKSGA 2022).
- SJV Regional Conservation Investment Strategy is a conservation vision to help guide beneficial actions to improve region-wide species and habitat recovery efforts. It is a conservation planning tool to promote the conservation of species, habitats, and other natural resources in the SJV (Reclamation District 2092 2025).
- California State Wildlife Action Plan 2025 includes conservation strategies that respond to current and future challenges with specific objectives and actions. The conservation strategies consider the anthropogenic pressures imposed by the legitimate need for food, housing, transportation, and recreation, taken together with the recognition of limited funding and time. The strategies focus on restoring ecological function and processes capable of withstanding the stresses imposed by a changing environment (CDFW 2025).

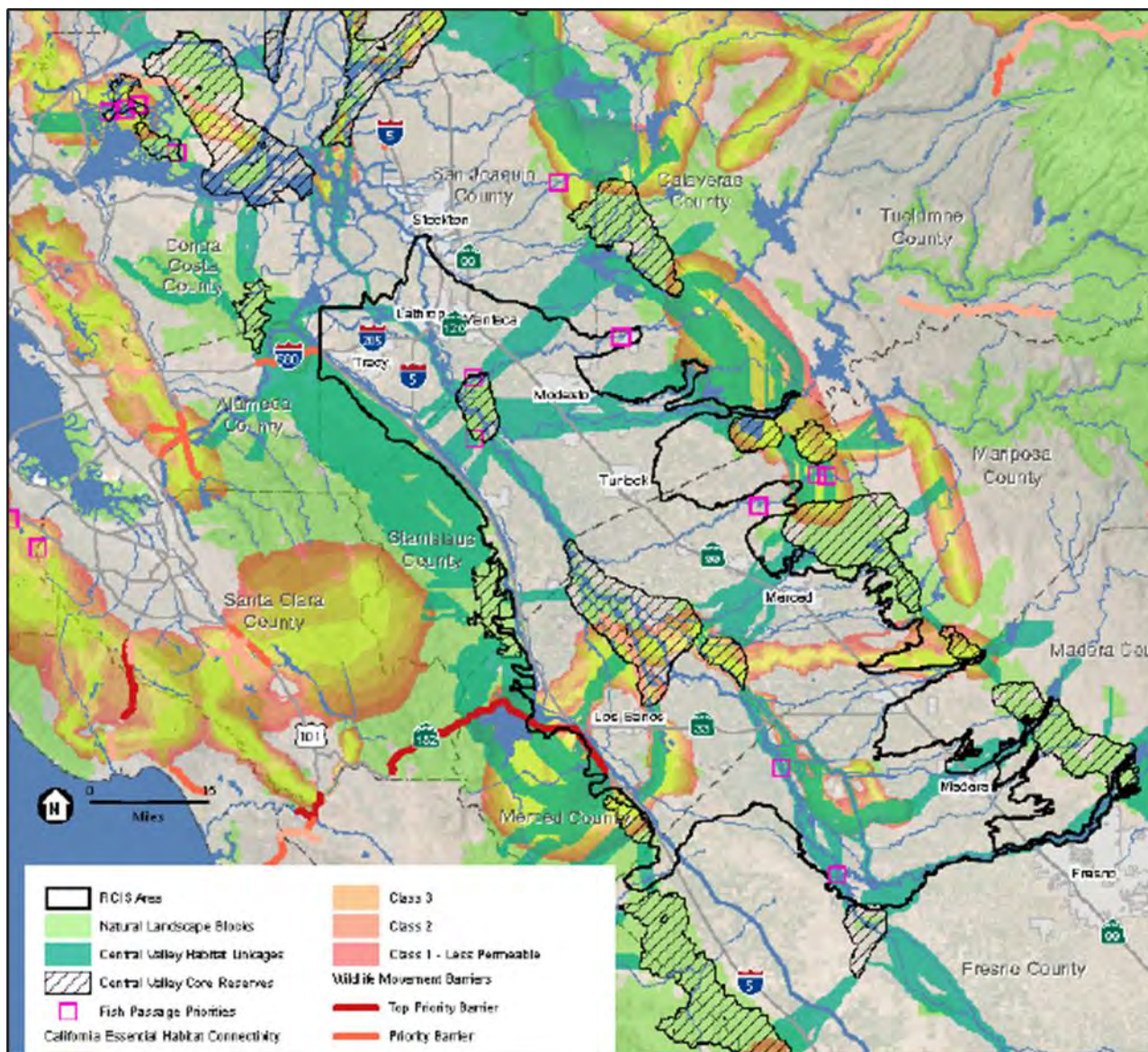
- Tulare Basin Land & Water Conservation Trust is a regional nonprofit organization working to protect, preserve, and restore the natural agricultural heritage of the southern SJV.

Most of the above-listed programs include the fundamental ecological principles of establishing core areas and connecting corridors, as illustrated in Figure 4-7 and habitat connectivity, as illustrated in Figure 4-8. Landscape corridors provide linkages that allow terrestrial species to migrate through and to move from areas experiencing temporally adverse environmental conditions. Corridors also facilitate inter-mixing of otherwise separated populations, thereby maintaining genetic diversity within populations and species.

Collectively, work products from the above-listed efforts provide valuable information that can be woven into a potential conceptual conservation strategy for the SJV. While this UWP does not propose a specific restoration plan for the SJV, it identified potential water needs based on acreage objectives by landcover type specified in other plans. Table 4 8 summarizes objective acreages of various habitat types for the SJV that are presented in existing plans others. For each plan, Table 4 8 identifies the geographic focus of the evaluation and summarizes recommended acreage for each habitat type. The Central Valley Joint Venture quantified targets for restoration of certain ecosystems. The CAP is working on establishing a range of ecological targets, however they have not yet been published and are subject to further review. The most recent objectives are provided in Table 4 8.

The final column of Table 4 8, titled “Potential SJV Target,” consolidated information from other plans into a single acreage quantity for each of the habitat types. While these total acreage quantities are not proposed here as a recommended plan, they are used later in this chapter to identify potential water supplies to support habitat establishment. Water supply needs to meet in-stream flow requirements are provided in for the SJRRP and HRLP are identified in Chapter 2.

In addition to the above plans and initiatives, groups have investigated the feasibility of implementing activities to assist with ecosystem enhancement in the SJV and in the Delta, such as predation suppression (FISHBIO n.d.; BCID 2024) and invasive aquatic weed control (CSPDBW 2026) These activities should be included in adaptive management frameworks to assist with the implementation of ecosystem enhancement activities while improving water reliability and water quality in the SJV and Delta.



Source: Reclamation District 2092 2025 Figure 2-7

Figure 4-8. Habitat Connectivity in the San Joaquin Hydrologic Region

Table 4-8. Restoration Goals by Habitat Type for the San Joaquin Valley in Acres

Source of Goal	CVFPP	CVJV	TNC	TBWP	RCIS	CAP	Potential SJV Target
Geographic or Habitat Focus of Goal	San Joaquin River	Bird habitat	Upland habitat	Tulare Lake Region	San Joaquin Region	SJV floor	SJV floor
Alkali Desert Scrub			47,000	144,500	4,230	50,000	120,000
Aquatic & Semi-permanent					8,200	16,500	16,500
Floodplain	14,600			37,700	57,600	80,000	80,000
Grassland		10,300		235,300		50,000	80,000
Riparian	7,900	17,600		28,600	8,368	17,650	30,000
Vernal Pools					49,224		20,000
Wetlands		25,100		49,900	36,300	8,650	50,000
Woodland Habitat		8,500		23,100			4,000
Total	22,500	61,500	47,000	519,100	~164,000	222,800	~400,000

Sources:

DWR (2022) Table 1.3 Sum of Lower and Upper San Joaquin River.

CVJV (2020) Table ES-1, sum of semi-permanent and managed seasonal wetlands.

TNC (2020) Focused on Upland Species

TBWP Tulare Basin Watershed Partnership - focused on Tulare Lake Hydrologic Region and included lands above the Valley floor. Estimates of habitat type were derived from corridor acreages and are approximations.

RCIS (Reclamation District 2092 2025) Floodplain acreage includes river meander.

CAP (2021). Upland acreage objective divided equally between scrub and grasslands. Floodplain acreage was increased to 80,000 ac in subsequent versions of the CAP plan.

Notes:

Reported targets have been rounded to the nearest 100 acres.

Key:

CAP = Collaborative Action Program

CVFPP = Central Valley Flood Protection Plan

CVJV = Central Valley Joint Venture

RCIS = Regional Conservation Investment Strategy

SJV = San Joaquin Valley

TBWP = Tulare Basin Watershed Partnership

TNC = The Nature Conservancy

Estimated Water Requirements for Ecosystem Enhancement

This section presents water needs to support ecosystem enhancement for potential SJV plan acreages listed in Table 4 8. Consumptive water uses for each landcover type were estimated based on evapotranspiration rates that vary regionally within the SJV as reported through the California Irrigation Management Information System, as listed in Table 4 9.

Water use calculations for each landcover type are based on the following assumptions:

- Alkali Desert Scrub – Once established, demands met through natural precipitation only.

- Aquatic – Average annual ET is estimated to range between 4.4 feet and 5.2 feet for aquatic habitat (lakes and permanent ponds) by region as specified in Table 4.9. This demand is assumed year-round.
- Semipermanent wetlands – Average annual applied water demand is estimated to be 7.4 feet to maintain wetlands from October through mid-July (CVJV 2020). It is assumed wetland vegetation will continue to draw water from the soil for the period from mid-July through September, providing water supply to support year-round evapotranspiration. Flows in the Eastside Bypass are used as a representative location to estimate the frequency of inundation, which is approximately 60% of years. Thus, the average annual applied water demand for semi-permanent wetlands is assumed to be 60% of 7.4 feet, or 4.4 feet.
- Floodplain – Demand is estimated to be 25% of full ET values for Region 14 in Table 4-9, resulting in an assumed average annual ET demand for floodplains of 1.2 feet.
- Grassland – Once established, demands met through natural precipitation only.
- Riparian – Average annual ET estimated to range between 4.4 to 5.2 feet. Vegetation is assumed to be mostly deciduous hardwood with grass and shrub undercover resulting in year-round evapotranspiration.
- Vernal Pools – Demands met through natural precipitation and local runoff only.
- Seasonal Wetlands – Demands are estimated at full ET demand from September through April, and two additional inches of water for seed germination in April through July. This is estimated to range between 2.1 to 2.5 feet. Flows in the Eastside Bypass are used as a representative location to estimate the frequency of inundation, which is approximately 60% of years. Thus, the average annual ET demand for seasonal wetlands is assumed to be 60% of 2.1 to 2.5 feet, or 1.3 to 1.5 feet.
- Woodland Habitat – Demands met through natural precipitation only.

Table 4-9. Evapotranspiration by Region in the San Joaquin Valley

Month	Region 12	Region 14	Region 15	Region 16
	Pan Evapotranspiration (inches)			
January	1.24	1.55	1.24	1.55
February	1.96	2.24	2.24	2.52
March	3.41	3.72	3.72	4.03
April	5.10	5.10	5.70	5.70
May	6.82	6.82	7.44	7.75
June	7.80	7.80	8.10	8.70
July	8.06	8.68	8.68	9.30
August	7.13	7.75	7.75	8.37
September	5.40	5.70	5.70	6.30
October	3.72	4.03	4.03	4.34
November	1.80	2.10	2.10	2.40
December	0.93	1.55	1.24	1.55
Total (inches)	53.37	57.04	57.94	62.51
Total (feet)	4.4	4.8	4.8	5.2

Source: DWR 1999

Notes:

Total Evapotranspiration is used for the water use by aquatic and riparian ecosystems.

Estimated water use requirements for habitat types, as described above, were applied to the Potential SJV Target for ecosystem restoration, listed in Table 4 8, to produce a potential range of total water demands to support future ecosystem restoration. As shown in Table 4 10, water demands associated with Potential SJV Target ecosystem restoration goals could range from approximately 370 TAF/YR to 410 TAF/YR. These quantities do not include water for instream flow requirements or supplemental water needs for wildlife refuges, both of which are described in Chapter 2. These estimated water demands are not reflected in the calculated water supply-demand gap reported in Chapter 2. It should be noted that quantities reported in Table 4 10 are gross water demands, and do not reflect net water needs for specific lands. It is possible that a portion of water supply needs for ecosystem restoration in the SJV could be derived from water sources that remain available to lands that are removed from irrigation.

Table 4-10. Estimated Ecosystem Enhancement Water Requirements for a Potential San Joaquin Valley Target Restoration Plan

Landcover Type	Unit Water Use (feet)	Goal (acres)	Water Supply Requirement ¹ (acre feet/year)
Alkali Desert Scrub	Precipitation	120,000	0
Aquatic & Semi-permanent	4.4 to 5.2	16,500	72,600 to 85,800
Floodplain	1.2	80,000	96,000
Grassland	Precipitation	80,000	0
Riparian	4.4 to 5.2	30,000	132,000 to 156,000
Vernal Pools	Precipitation	20,000	0
Wetlands (Seasonal)	1.3 to 1.5	50,000	65,000 to 75,000
Woodland Habitat	Precipitation	4,000	0
Total		~400,000	365,600 to 412,800

Notes:

¹ Water supply requirements for ecosystem enhancement are not included in the water supply-demand gap quantified in Chapter 2.



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Chapter 5 Potential Projects and Actions

This chapter presents a wide range of potential projects and actions that can contribute to reducing the water supply-demand gap, reduce flood risk, and enhance ecosystem conditions in the SJV. Projects are presented through a primary lens of reducing the water supply-demand gap, and their ability to contribute to other benefits is highlighted. Potential projects and actions were identified through review of all GSPs that cover the entire SJV, other publicly available sources, and project concepts developed by the Water Blueprint. A summary of GSPs used to compile information presented in the UWP is provided in Appendix A.

Projects and actions are classified into one of five categories, as follows:

- Groundwater recharge projects – construct new or expanded dedicated recharge facilities (basins, injection wells); deliver additional surface water for direct use to reduce groundwater pumping (in-lieu recharge); and facilitate and/or incentivize landowners to spread water onto their land (on-farm recharge).
- Conveyance projects – construct new or expand the capacity of existing canals and pipelines to convey water supplies from rivers and canals or between existing conveyance systems.
- Water storage projects – construct and operate new or expand existing surface water reservoirs; modify operations of existing reservoirs; and expand use of groundwater aquifers for managed storage.
- Other water supply projects and actions – construct new or expand existing facilities that treat wastewater, produced water from oil and gas extraction, and other impaired water sources for use as irrigation supply and/or groundwater recharge; construct new or expand existing surface water treatment capacity; expand water purchases and trading (surface water trading); and increase water supply through upper watershed management actions.
- Demand management – reduce water use through irrigation efficiency projects; remove farmland from production (land fallowing or conversion); implement groundwater pumping restrictions such as groundwater allocations, fees and other activities; and implement urban water conservation projects.

Potential projects and actions are presented for the five categories listed above. For each, the category is described in the context of the SJV and potential projects are identified and described. Estimated capital cost, annual water supply yield or project capability, and implementation status are provided for each project or project type, where such information is available. Many projects described in this chapter are currently being pursued by local proponents and/or through regional, statewide, or federal partnerships.

Project costs and yields and management actions described in this chapter are presented to demonstrate their potential capabilities or operational opportunities. Inclusion of projects in this chapter does not imply determinations on regulatory requirements and feasibility, water right availability, or economic feasibility, all of which affect timing, scale, and ultimate affordability of projects. It should be noted that water supply yields and associated costs presented in this chapter for projects identified in GSPs are based on water supply availability assumptions made in each GSP; these assumptions have not been evaluated.

Groundwater Recharge Projects

As discussed in Chapter 2, the rate of groundwater extraction over time in the SJV has far exceeded the rate of recharge. As a result, many groundwater basins in the SJV have been identified as critically overdrafted by DWR in Bulletin 118 (California Natural Resources Agency 2025).

The enactment of SGMA and creation of GSPs has dramatically advanced the widespread consideration and implementation of groundwater recharge projects, and groundwater recharge now plays an important and growing water management role in the SJV. In fact, groundwater recharge is the single largest strategy identified to help achieve SGMA sustainability goals, with well over 300 recharge projects described in the GSPs. About 70% of the recharge projects listed in GSPs for the SJV include construction costs and estimated annual yields.

Groundwater recharge is the mechanism by which surface water moves from the overlying land surface into the aquifer below. Recharge can be accomplished through infiltration or injection of water directly into the aquifer. Recharge can also be achieved indirectly through in-lieu recharge, by providing alternative water supplies to offset or replace groundwater pumping (DWR 2018). Seasonality, rate, and volume of water; reliability of available water; water quality; location and need for conveyance to move water to recharge facilities; and water rights should be considered when planning and implementing recharge projects.

This section begins with a description of groundwater recharge suitability and then describes five types of groundwater recharge projects, including on-farm recharge, basin recharge, in-lieu recharge, injection wells, and other multi-strategy recharge projects. Type-specific implementation considerations are described for each type of recharge. For each recharge project type, construction costs are presented based on data derived from publicly available GSPs. These estimated costs do not include costs to obtain and convey water supplies to recharge projects or costs to extract water from the aquifer and distribute it to users for subsequent use. The availability of the water supplies identified for each project in the GSPs has not been confirmed.

Groundwater Recharge Suitability

Groundwater recharge is a highly complex mechanism, depending on soil and sediments, aquifer characteristics, land suitability, and land usage. Due to this complexity, multiple analytical methods have been created, and resources have been made available to help assess suitability for different types of recharge.

Soil Agricultural Groundwater Banking Index

As noted in Chapter 2, groundwater pumping has chronically exceeded natural recharge in all sub-basins in the SJV for many years. A common method of recharging groundwater when surface water is available is to deliberately flood an open area, allowing water to percolate into an aquifer. However, open land suitable for this type of recharge is scarce. Flooding agricultural land during fallow or dormant periods has the potential to increase groundwater recharge substantially, but this approach is in the early stages of study and implementation.

Using data on soils, topography and crop type, the University of California, Davis developed the Soil Agricultural Groundwater Banking Index (SAGBI), a spatially explicit suitability index for groundwater recharge on agricultural land (O’Geen et al. 2015). The index provides preliminary guidance about the locations where groundwater recharge on agricultural land is likely to be more effective. The SAGBI assigns a score ranging from 0 to 100 based on five major factors that are critical to successful agricultural groundwater recharge: topography, soil surface conditions, chemical limitations, root zone residence time, and deep percolation. The analysis to develop SAGBI classifications accounts for the effect of deep tillage, which includes physical modification of restrictive shallow soil layers to improve recharge potential, resulting in an optimistic suitability assessment.

SAGBI results are presented on Figure 5-1 for the San Joaquin Hydrologic Basin and Figure 5-2 for the Tulare Lake Hydrologic Region. While SAGBI values pertain principally to shallow recharge characteristics, the effectiveness of surface recharge techniques is also affected by deeper subsurface conditions that could impede the downward migration of percolated water. Figure 5-1 and Figure 5-2 also depict the approximate areal extents of the Corcoran Clay, a low-permeability, areal extensive, lacustrine deposit as much as 200 feet thick (Data Basin 2020). This continuous clay divides the groundwater-flow system of the western SJV into an upper semi-confined zone and a lower confined zone, but pinches at the margins of the SJV, particularly on the eastside, and allows for connectivity to the deeper aquifers (Data Basin 2020). The Corcoran Clay occurs 200 feet to 800 feet beneath the surface and extends over an area greater than 6,370 square miles in the SJV. Groundwater overdraft in the SJV occurs in both the upper and lower zones, above and below the Corcoran Clay, with a greater extent of total overdraft occurring in the lower confined zone. Recharge through percolation techniques in areas above the Corcoran Clay can increase groundwater storage above the upper semi-confined zone but will have limited effectiveness in recharging the lower confined zones. The Central Valley’s Tulare Formation was classified in 1986 into six laterally extensive clay units, labeled A-F (Page 1986). The Corcoran Clay is known as the E-layer, sometimes called E-clay. Though the Corcoran Clay (E-clay) is most notable in the Central Valley, it is important to note that the five other clay units could also affect groundwater recharge.

Figure 5-1 and Figure 5-2 also include percentages of land within each sub-basin for six ranges of indices that represent recharge potential from excellent to very poor. A summary of acreage and percent of lands in each sub-basin for the three most favorable SAGBI classifications in areas within and outside the Corcoran Clay area is provided in Table 5-1. More detailed SAGBI information for each sub-basin in the SJV is provided in Appendix B.

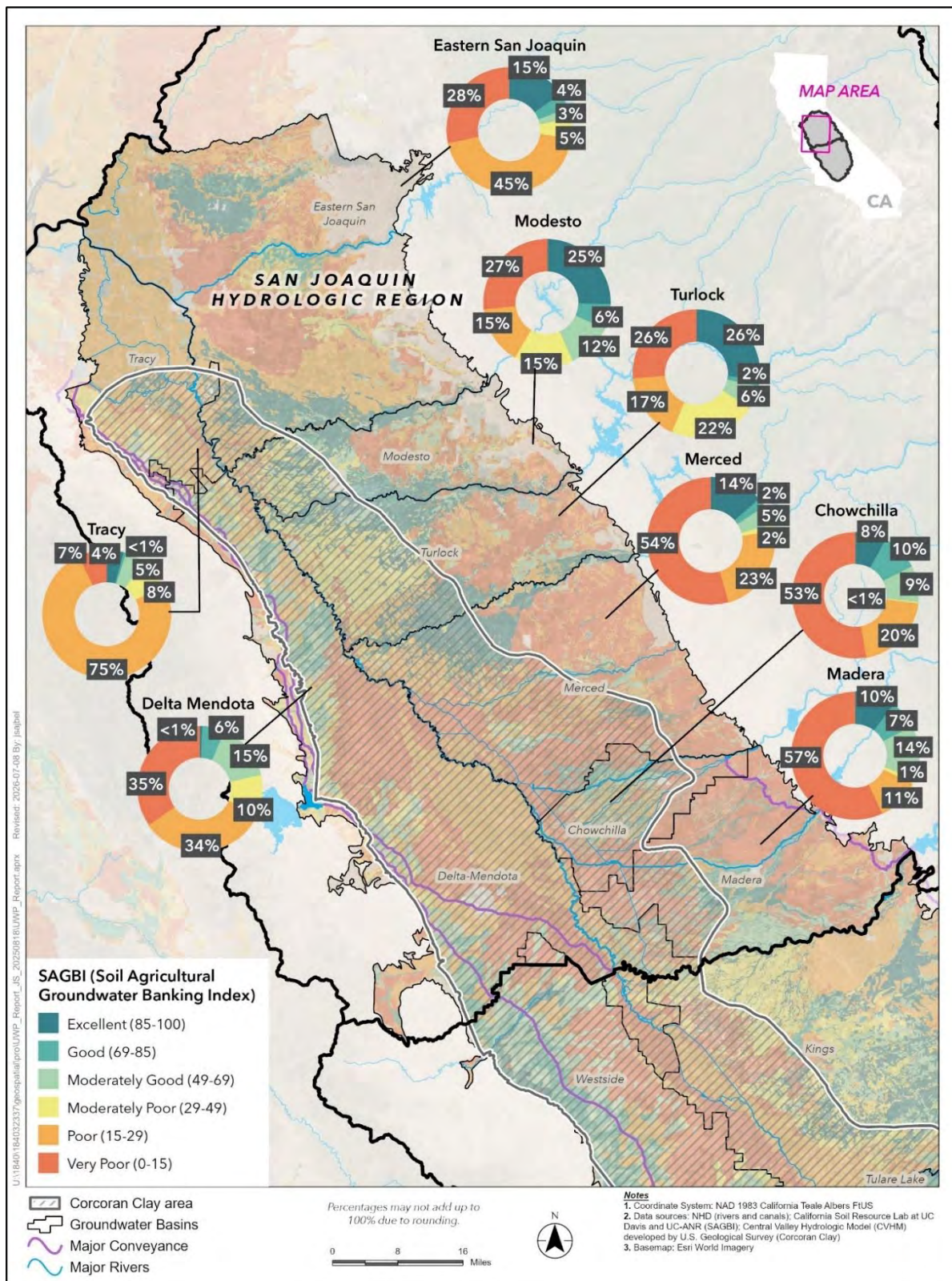


Figure 5-1. Summary of Soil Agricultural Groundwater Banking Index in the San Joaquin Hydrologic Region

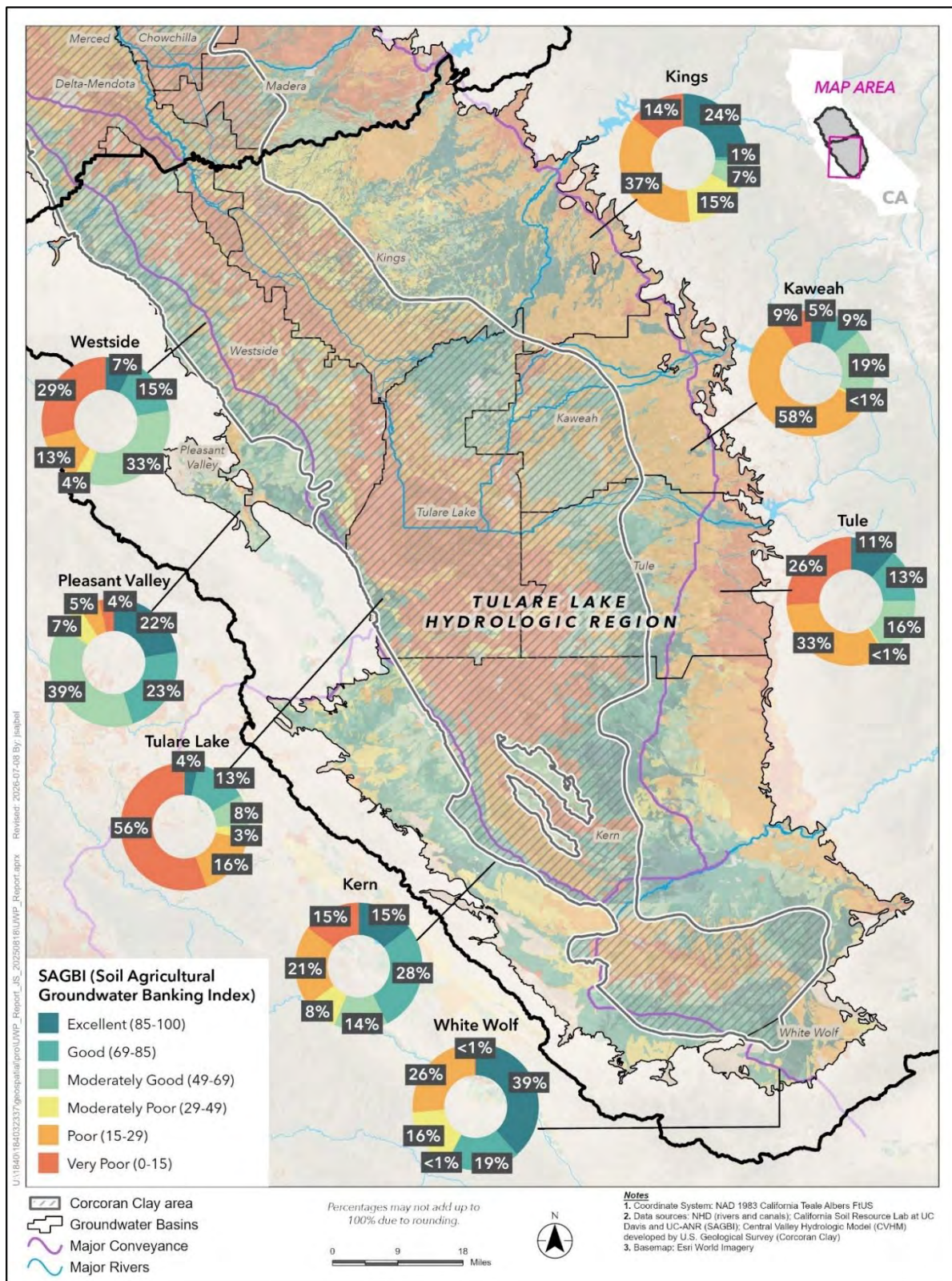


Figure 5-2. Summary of Soil Agricultural Groundwater Banking Index in the Tulare Lake Hydrologic Region

Table 5-1. Land Potentially Suitable for Surface-Based Recharge Techniques

Subbasin	Acreage and Percent of Land in Sub-Basin by SAGBI Classification Within Corcoran Clay Area				Acreage and Percent of Land in Sub-Basin by SAGBI Classification Outside of Corcoran Clay Area			
	Excellent Acres (Percent)	Good Acres (Percent)	Moderately Good Acres (Percent)	Total Acres (Percent)	Excellent Acres (Percent)	Good Acres (Percent)	Moderately Good Acres (Percent)	Total Acres (Percent)
San Joaquin Hydrologic Region								
Modesto	15,311 (29%)	3,577 (7%)	3,428 (6%)	22,316 (42%)	34,187 (24%)	8,677 (6%)	19,399 (14%)	62,263 (44%)
Turlock	49,793 (31%)	2,286 (1%)	5,379 (3%)	57,458 (36%)	37,797 (22%)	3,827 (2%)	14,468 (8%)	56,092 (33%)
Madera	5,014 (6%)	11,417 (14%)	8,639 (11%)	25,070 (31%)	29,443 (11%)	12,793 (5%)	37,156 (14%)	79,392 (31%)
Chowchilla	10,258 (9%)	13,314 (11%)	11,224 (10%)	34,796 (30%)	1,078 (4%)	434 (2%)	2,145 (8%)	3,657 (13%)
Eastern San Joaquin	12,236 (34%)	-	140 (<1%)	12,376 (34%)	79,030 (14%)	24,554 (4%)	15,452 (3%)	119,036 (21%)
Merced	42,444 (15%)	8,447 (3%)	12,752 (5%)	63,643 (23%)	24,481 (12%)	3,039 (1%)	11,417 (5%)	38,937 (18%)
Delta-Mendota	4,094 (1%)	36,454 (6%)	96,177 (15%)	136,725 (21%)	437 (1%)	5,918 (7%)	12,581 (15%)	18,936 (22%)
Tracy	8,212 (8%)	597 (1%)	8,683 (8%)	17,492 (17%)	1,153 (1%)	773 (1%)	2,266 (2%)	4,192 (4%)

Key:

SAGBI = Soil Agricultural Groundwater Banking Index

Table 5-1. Land Potentially Suitable for Surface-Based Recharge Techniques (Cont.)

Subbasin	Acreage and Percent of Land in Sub-Basin by SAGBI Classification Within Corcoran Clay Area				Acreage and Percent of Land in Sub-Basin by SAGBI Classification Outside of Corcoran Clay Area			
	Excellent Acres (Percent)	Good Acres (Percent)	Moderately Good Acres (Percent)	Total Acres (Percent)	Excellent Acres (Percent)	Good Acres (Percent)	Moderately Good Acres (Percent)	Total Acres (Percent)
Tulare Lake Hydrologic Region								
Pleasant Valley	-	-	-	-	7,209 (22%)	7,400 (23%)	12,689 (39%)	27,298 (84%)
White Wolf	5,050 (57%)	3,783 (42%)	-	8,833 (99%)	25,863 (36%)	11,311 (16%)	79 (<1%)	37,253 (52%)
Kern	97,832 (14%)	150,934 (22%)	69,006 (10%)	317,772 (46%)	123,157 (21%)	106,417 (18%)	111,028 (19%)	340,602 (58%)
Westside	27,268 (5%)	77,104 (14%)	170,709 (32%)	275,081 (51%)	16,164 (23%)	15,466 (22%)	27,754 (39%)	59,384 (84%)
Tule	20,955 (10%)	34,870 (16%)	56,277 (26%)	112,102 (52%)	32,744 (13%)	28,430 (11%)	17,788 (7%)	78,962 (31%)
Kaweah	5,801 (3%)	31,264 (15%)	74,356 (35%)	111,421 (53%)	14,471 (7%)	6,869 (3%)	6,583 (3%)	27,923 (13%)
Kings	34,037 (11%)	6,429 (2%)	9,278 (3%)	49,744 (16%)	202,794 (31%)	7,094 (1%)	61,160 (9%)	271,048 (41%)
Tulare Lake	16,866 (3%)	69,039 (13%)	40,552 (8%)	126,457 (25%)	1,213 (27%)	518 (12%)	556 (13%)	2,287 (52%)

Key:

SAGBI = Soil Agricultural Groundwater Banking Index

DWR Basin Characterization Program

DWR's Basin Characterization Program provides the latest data and information about California's groundwater basins to support local and statewide groundwater management. The following initiatives or datasets are available to local project proponents looking to better understand their groundwater:

- California's Groundwater – Bulletin 118: Bulletin 118 updates are the State's official publications on the occurrence and nature of groundwater in California. The publications define the groundwater basin boundaries and summarize groundwater information for each of the State's 10 hydrologic regions.
- California Statewide Groundwater Elevation Monitoring (CASGEM): Since 2009, the CASGEM Program has tracked seasonal and long-term groundwater elevation trends in groundwater basins and non-basin areas statewide.
- InSAR Subsidence Data: This dataset represents measurements of vertical ground surface displacement in more than 200 of the high-use and populated groundwater basins across the State of California between January 2015 and April 2022.
- Airborne Electromagnetic (AEM) surveys: DWR is conducting AEM surveys in California's high- and medium-priority groundwater basins, where data collection is feasible. The resulting information provides a standardized, statewide dataset that improves the understanding of aquifer structures. It can also help with the development or refinement of hydrogeologic conceptual models and can help identify areas for recharging groundwater.

Towed Geophysical System

The ability to identify, at potential managed aquifer recharge sites, the presence of connected pathways of hydraulically conductive sediments from the ground surface to the water table could help minimize costs and risks associated with recharge operations. The towed time-domain electromagnetic (tTEM) system is specifically designed for imaging the upper 70-100 meters of the subsurface with high lateral resolution. The tTEM images the electrical resistivity of the subsurface, which is controlled in part by the types of sediments in the ground. Combining the tTEM measurements with a small number of direct sediment type measurements (e.g., from cone penetrometer testing) enables the conversion of the tTEM resistivity models into 3-dimensional sediment type maps, mapping sediment type classified as either coarse-grain-dominated (sand and gravel) or fine-grain-dominated (silt and clay) material. Mapping of sediments creates the ability to find recharge pathways (Goebel and Knight 2021).

On-Farm Recharge

On-farm recharge is a surface recharge technique that involves applying excess surface water available during wet seasons that exceed irrigation demands to enhance groundwater recharge. It is most applicable in locations with permeable surface soils and subsurface conditions that would allow percolated water to travel downward to the water table, such as lands with SAGBI classifications of excellent, very good and moderately good recharge characteristics. Areas with moderately poor,



poor, and very poor recharge characteristics may be more suitable for non-surface-based recharge techniques, such as injection wells and in-lieu recharge.

On-farm recharge allows individual farmers and landowners to take advantage of water available from local supplies to capture and infiltrate into aquifers, offsetting groundwater overdraft. On-farm recharge can be implemented on both annual and perennial crop lands and can be integrated with practices like cover cropping to improve soil health and reduce nutrient leaching.

Benefits of On-Farm Recharge

On-farm recharge is dependent on access to water supplies during wet hydrologic conditions, and the ability to convey and spread water over irrigated lands. When successfully implemented, on-farm recharge can provide the following benefits:

- Aquifer replenishment through the managed delivery and percolation of water supplies.
- Surface water accretions from groundwater that help sustain baseflows in nearby rivers and streams.
- Reduced flood risk by providing a storage location for flood water.
- Enhanced ecosystem conditions that result from habitat compatible with agricultural practices.
- Sustained agricultural productivity.

Implementation Considerations

On-farm recharge is dependent on the ability and willingness of landowners to spread water over their fields. The following are important considerations during the development and implementation of on-farm recharge projects:

- It requires administration and coordination by GSAs and/or irrigation districts with landowners who are willing and able to receive water for recharge, generally during wet and high-flow periods. This could include developing rules and regulations, establishing delivery schedules, accounting for water delivered, and providing incentives to landowners willing to make their lands available for recharge. Areas with existing distribution facilities are better suited to implement on-farm recharge in the near-term.
- It could require modifications to irrigation systems to enable distribution of flood waters and/or to avoid or minimize adverse effects to the performance of delivery and irrigation systems.
- It requires thorough investigation for siting, and careful implementation and monitoring to manage the potential mobilization of contaminants that may be present in shallow soils from past agricultural practices, such as nitrates, pesticides, herbicides, and other constituents.

GSPs document known locations of groundwater contamination within each subbasin and can be used to inform siting.

- It requires consideration of application of recharge water's timing in relation to crop development and growth so as to avoid plant health problems.

Opportunities for On-Farm Recharge in the San Joaquin Valley

As summarized in Table 5-2, on-farm groundwater recharge projects were identified in GSPs predominately in the eastern portion of the SJV, where a large percentage of lands have higher SAGBI values. Some of the on-farm recharge projects described in the GSPs would require infrastructure modifications and would require administrative costs. On-farm land and infrastructure modifications are typically considered the responsibility of the landowner and/or captured in other infrastructure improvement projects; therefore, costs are assumed not to be included in GSP project descriptions.

Table 5-2. Summary of Local On-Farm Groundwater Recharge Project Information Presented in Groundwater Sustainability Plans by Subbasin

Basin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	1	-	-	-
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	1	1	5.4	7.1
Turlock	3	1	4.0	0.3
Merced	-	-	-	-
Chowchilla	1	-	-	-
Madera	3	2	2.2	-
Westside	-	-	-	-
Pleasant Valley	-	-	-	-
Tulare Lake	-	-	-	-
Kings	4	2	3.7	-
Kaweah	3	-	-	-
Tule	-	-	-	-
Kern	2	-	-	-
White Wolf	-	-	-	-
Total³	18	6	15.3	9.4

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of on-farm recharge projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year



Source: *The Fresno Bee* 2025

Photo 1. On-Farm Recharge on a Vineyard in Lodi, CA

Basin Recharge

Basin recharge is a surface recharge technique that involves the construction and operation of dedicated depressions, or ponds, designed to percolate water into the ground. A groundwater recharge basin is a man-made or natural depression designed to receive surface water, such as flood flows, excess surface water, or imported supply and allow it to soak into the ground to replenish groundwater. Recharge basins typically consist of depressions; large, shallow ponds; or engineered stream reaches.

Water is delivered to the recharge basin and allowed to “pond” or collect on the surface. The ponded water gradually seeps downward through the soil, past the root zone, and into the saturated zone of the unconfined aquifer below. This process mimics natural groundwater recharge, which occurs through the infiltration of rain and surface water in rivers, lakes, wetlands, and floodplains.

Benefits of Basin Recharge

Recharge basins can be strategically located in areas that have access to multiple water supplies, favorable geology, and can provide recharge to an aquifer in a location that provides regional benefits. Groundwater recharge basins can be sited, configured, and operated to provide a wide range of benefits, including:

- Aquifer replenishment through the managed delivery and percolation of water supplies.
- Reduced flood risk by providing a storage location for flood water.

- Environmental protection by preventing saltwater intrusion into freshwater aquifers in coastal areas, or near the Delta.
- Ecosystem enhancement by integrating the creation of valuable habitat for water-dependent wildlife in the facility design and operation.
- Recreation benefits by developing basins that can be used for recreational activities like walking, birdwatching, or sports during dry periods.

Implementation Considerations

Basin recharge is dependent on the ability of GSAs, communities, and/or water districts to acquire land and construct recharge basins. The following are important considerations during the development and implementation of basin recharge projects:

- It requires purchasing or otherwise acquiring land with favorable groundwater recharge suitability in areas that can provide recharge at desired aquifer locations and levels.
- It requires construction of recharge basins on acquired land.
- It could require modifications to existing delivery systems.
- It requires consideration of evaporation from ponded water in the basin.
- It requires thorough investigation for siting, and careful implementation and monitoring to manage the potential mobilization of contaminants that may be present in shallow soils from past agricultural practices, such as nitrates, pesticides, herbicides, and other constituents.
- It requires thoughtful design and maintenance to provide compatibility with protected species requirements over the range of operation.

Opportunities for Basin Recharge in the San Joaquin Valley

Development of groundwater recharge basins depends on available water, and the ability to convey water to recharge areas. The GSPs identified several local, basin recharge projects, as summarized in Table 5-3. Opportunities for recharge basin development and associated ecosystem benefits varies between agricultural and urban areas. Recharge basins on agricultural lands can be designed to take advantage of natural land slopes over a large expanse to provide natural habitat conditions. In contrast, groundwater recharge basins designed to function within the limited available land area in an urban setting may be more costly and have less opportunity to provide ecosystem enhancement benefits.



Source: PPIC 2018, Photo by Jonathan Parker, Kern Water Bank Authority

Photo 2. Kern Water Bank Recharge Basins



Source: City of Fresno 2025

Photo 3. City of Fresno Leaky Acres Recharge Basins

Table 5-3. Summary of Local Basin Groundwater Recharge Project Information Presented in Groundwater Sustainability Plans by Subbasin

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	5	3	30.0	13.7
Tracy	-	-	-	-
Delta-Mendota	2	1	3.0	8.3
Modesto	1	-	-	-
Turlock	2	2	3.7	14.6
Merced	6	2	13.9	13.8
Chowchilla	5	5	69.1	199.8
Madera	10	8	76.6	212.2
Westside	2	1	10.8	6.9
Pleasant Valley	6	3	22.1	21.2
Tulare Lake	4	4	53.9	136.7
Kings	100	80	302.8	1,102.5
Kaweah	24	23	41.4	94.8
Tule	7	1	2.0	3.5
Kern	38	30	104.2	268.3
White Wolf	3	1	0.5	0.6
Total³	215	164	734.1	2,097.1

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of basin recharge projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

In-Lieu Recharge

In-lieu recharge refers to the increased delivery of surface water supplies to reduce reliance on groundwater, thereby allowing aquifer storage to increase from natural inflow. In-lieu recharge is most effective during wet seasons when surface water is abundant and at a lower cost, although it can be applied under all hydrologic conditions if reliable water supplies are available. In-lieu recharge requires planning, coordination, and often construction of new infrastructure in combination with the operation of existing facilities. Water delivered to users in-lieu should be accounted for and credited as recharge. This approach is flexible and, depending on conveyance infrastructure needs, can be a cost-effective way to support aquifer sustainability by increasing surface water supply and reducing groundwater pumping.



In-lieu recharge can be accomplished in the following ways:

- Incentives by GSAs and/or irrigation districts to reduce groundwater pumping may motivate increased use of surface water in areas where groundwater pumping was historically more economically attractive.
- Increasing the conveyance capacity of existing surface water distribution systems to increase the amount of surface water that can be delivered to existing users.
- Expanding water distribution systems to deliver surface water supplies to areas solely reliant on groundwater.

Benefits of In-Lieu Recharge

In-lieu recharge is dependent on increasing surface water deliveries to areas that historically relied, at least partially, on pumping groundwater to meet demand. When successfully implemented, in-lieu recharge can provide the following benefits:

- Increased surface water deliveries to areas historically served by both surface water and groundwater, decreasing the reliance on groundwater.
- Aquifer replenishment through a decreased reliance on groundwater.
- Sustained agricultural productivity.
- It reduces groundwater pumping demands that contribute to subsidence.

Implementation Considerations

In-lieu recharge is dependent on the ability to reduce groundwater pumping over large areas by increasing surface water deliveries to these areas. The following are important considerations during the development and implementation of in-lieu recharge projects:

- It requires administration and monitoring by GSAs, communities, and/or water districts to ensure that additional surface water deliveries reduce groundwater pumping. Additional surface water deliveries should not be used to expand agricultural, urban, or industrial footprints, which could require rules or incentives for landowners to use surface water instead of groundwater.
- It requires capital improvements to increase the capacity of existing distribution systems and/or expand the geographic extent of water distribution systems.

Opportunities for In-Lieu Recharge in the San Joaquin Valley

As summarized in Table 5-4, in-lieu recharge is proposed primarily in GSPs for the Eastern San Joaquin and Kern basins, with little identified application elsewhere in the SJV. However, this limited identified application does not preclude in-lieu recharge from being implemented elsewhere in the SJV.

Table 5-4. Summary of Local In-Lieu Groundwater Project Information Presented in Groundwater Sustainability Plans

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	8	5	50.1	107.4
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	1	1	0.1	0.3
Turlock	1	-	-	-
Merced	-	-	-	-
Chowchilla	-	-	-	-
Madera	1	-	-	-
Westside	-	-	-	-
Pleasant Valley	-	-	-	-
Tulare Lake	-	-	-	-
Kings	-	-	-	-
Kaweah	-	-	-	-
Tule	-	-	-	-
Kern	3	3	22.8	43.4
White Wolf	1	-	-	-
Total³	15	9	72.9	151.0

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of in-lieu groundwater recharge projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

Injection Wells

Injection recharge is a water management strategy in which water is delivered directly into an aquifer at a desired depth through drilled wells. Depending on the geology of the aquifers, injection wells can be designed to operate under gravity or with applied pressure. Injection recharge is applicable in areas where opportunities for on-farm or basin recharge are limited, such as locations with limited available land area, low permeability shallow soils, the presence of subsurface clay layers or the presence of subsurface contaminants that could become mobilized through surface recharge techniques. Injection recharge minimizes losses due to evaporation; however, it may require pre-treatment to remove suspended or dissolved constituents that could contaminate the aquifer, or plug wells or the geologic formation in the vicinity of the injection well.

Benefits of Injection Wells

Injection-well recharge is dependent on the ability of a well to deliver water directly to the subsurface. When successfully implemented, injection-well recharge can provide the following benefits:

- Aquifer replenishment through the direct delivery of water into the subsurface.
- Reduced risk of mobilizing contaminants from the shallow subsurface into the aquifer as compared to surface recharge.
- The ability to “target” a specific depth for recharge.
- Allows for recharge in areas that are generally less suitable for recharge, like in areas with subsurface characteristics that result in low SAGBI values.
- In a confined aquifer, injected recharge could aid in re-pressurizing the aquifer, ameliorating subsidence.

Implementation Considerations

Injection-well recharge is dependent on the ability to access wells for groundwater recharge. The following are important considerations during the development and implementation of injection well recharge projects:

- It requires the drilling of new wells or the modification of existing wells to allow for groundwater recharge.
- It may require new or modified conveyance facilities to transport water supplies to locations of new or converted injection wells.
- It requires water of sufficient quality that will not cause aquifer contamination, or clogging of injection wells or the formation from sediment, chemical reaction, or biological processes. Onsite treatment may be required to remove suspended or dissolved constituents from water supplies prior to injection.

Opportunities for Injection Wells in the San Joaquin Valley

Injection projects described in GSPs, as summarized in Table 5-5, include both the conversion of existing extraction wells to injection wells and the construction of new injection wells. Some project descriptions include provisions for pre-treatment requirements for the assumed water sources, while others do not identify a need for or include pre-treatment considerations. Water sources for injection wells are not specified for all projects and may include water diverted from rivers or streams, which would likely require pre-treatment, and water delivered through canal systems.

Table 5-5. Summary of All Local Injection Wells Project Information Presented in Groundwater Sustainability Plans

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	2	2	3.2	1.8
Tracy	1	1	16.0	2.4
Delta-Mendota	-	-	-	-
Modesto	-	-	-	-
Turlock	-	-	-	-
Merced	-	-	-	-
Chowchilla	-	-	-	-
Madera	1	-	-	-
Westside	3	3	12.7	9.4
Pleasant Valley	1	-	-	-
Tulare Lake	1	1	13.0	16.3
Kings	1	-	-	-
Kaweah	2	1	2.0	2.6
Tule	-	-	-	-
Kern	-	-	-	-
White Wolf	-	-	-	-
Total³	12	8	46.9	32.5

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of injection well projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year



Source: Photo courtesy of Westlands Water District

Photo 4. Injection Well in Westlands Water District

Multi-Strategy, Multi-Facility, Unique, and Other Recharge Projects

The GSPs list several recharge projects that include more than one of the above techniques to recharge water, projects that list multiple facilities to enable increased recharge, projects that utilize unique recharge methods, and a small number of projects that lack detail to be identified by recharge technique. Several of these projects were identified in the GSPs, as summarized in Table 5-6.

Examples of multi-strategy, multi-facility, unique, and other recharge projects are:

- Construction of a small reservoir that would percolate water and increase surface water storage capacity.
- Development of a program with multiple recharge strategies.
- Development of new distribution conveyance from storm sewers to new recharge basins.
- New management of a distribution system to deliver water to multiple recharge projects.

- Stream restoration to widen the wetted perimeter or increase connectivity to the floodplains, increasing infiltration through streambed percolation.
- In-stream infrastructure modifications to slow instream flows to increase retention and streambed percolation.
- Projects that lack detail to identify the recharge technique.

Table 5-6. Summary of Multi-Strategy, Multi-Facility, Unique, and Other Recharge Project Information Presented in Groundwater Sustainability Plans

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	7	2	63.0	73.6
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	5	3	52.8	177.4
Turlock	8	4	32.4	28.2
Merced	5	-	-	-
Chowchilla	-	-	-	-
Madera	5	2	5.6	8.1
Westside	-	-	-	-
Pleasant Valley	2	1	0.1	1.7
Tulare Lake	1	1	0.7	1.0
Kings	4	3	15.5	51.8
Kaweah	1	-	-	-
Tule	2	2	24.0	7.7
Kern	11	6	14.4	33.6
White Wolf	-	-	-	-
Total³	51	24	208.4	382.9

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the SJV of multi-strategy, multi-facility, unique, and other recharge are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

SJV = San Joaquin Valley

TAF/YR = thousand acre-feet per year

Conveyance Projects

Water conveyance plays a critical role in the SJV for providing surface water deliveries to agricultural and M&I users, enhancing groundwater recharge, providing flood risk reduction, and providing ecosystem support. The existing CVP and SWP systems, shown on Figure 5-3, form the backbone of the water conveyance system in the SJV and provide water supplies to regional and local conveyance systems. In addition, several water conveyance systems not connected to CVP or SWP water supplies are owned and operated by local entities.

As detailed in Chapter 2, much of the existing system of conveyance facilities in the SJV are aging and have experienced reduced capacity due to degrading conditions and regional land subsidence. In addition, many existing aging facilities are operated differently than originally expected in response to hydrologic variability and regulatory environments. The restoration of existing conveyance facilities and the development of new facilities would improve conveyance capabilities and interconnectivity within the SJV, allowing for the increased use of local water supplies and the ability to convey surface water supplies to areas currently not served by surface water. Conveyance projects increase operational flexibility but do not introduce additional water supply. These projects would provide water supply benefits for both agricultural and M&I users, improve flood control, and provide opportunities for ecosystem enhancement.

Benefits of Conveyance Projects

Conveyance projects convey existing, local surface water supplies to water users for a variety of uses including agricultural, M&I, groundwater recharge, and ecosystem enhancement. Conveyance projects can be developed and operated to provide a wide range of benefits, including:

- Delivery of water supply to support agricultural and M&I uses and contribute towards groundwater sustainability, including supplies conveyed for on-farm, basin, or injection recharge as described in their respective sections.
- Improved operational flexibility in the management of water supplies, including water transfers, exchanges, and the management of groundwater banks.
- Flood risk reduction through the diversion of flood flows from rivers and streams.
- Ecosystem enhancement through increased delivery to wildlife refuges and other environmentally sensitive areas.

Implementation Considerations

The following are important considerations during the development and implementation of conveyance projects:

- It requires coordination with owners and operators of federal, state, and/or local conveyance facilities, as well as local, regional, and state districts that receive contracted water supplies.

- If modifying existing facilities, modification of the existing facility complicates and/or limits the delivery of water to users during the construction period.
- It requires the consideration of potential future stressors on conveyance systems and surrounding lands during the planning and design process, including but not limited to subsidence, climate variability, regulatory requirements, and changing demands – all of which are persistent in the SJV. The performance of gravity-driven conveyance facilities (e.g., canals) is especially sensitive to subsidence.

Opportunities for Conveyance Projects

Opportunities for conveyance projects are presented below in four categories: (1) local conveyance projects, (2) restore authorized design capacity of regional facilities, (3) modified, expanded, or new regional conveyance facilities, and (4) modified, expanded, or new Delta facilities and operations.

Local Conveyance Projects

Local conveyance projects are defined as those that can be implemented by local agencies and generally would be located within a single sub-basin. GSAs in the SJV identified more than 100 projects in GSPs that would restore or expand local conveyance and distribution within their subbasins (Table 5-7). Projects in this category include the following types:

- New or expanded facilities to divert flood water from local streams and rivers and convey the water to areas for use to either meet demand and/or recharge groundwater.
- New or expanded distribution facilities to deliver surface water to areas that are currently dependent on groundwater to provide in-lieu groundwater recharge, but not including the in-lieu groundwater recharge facilities.
- New or expanded interties to increase connectivity within a district to improve distribution of water supplies and potentially increase capabilities to recharge groundwater.
- New or expanded interties between districts to facilitate additional water transfers and exchanges to support increased groundwater recharge.
- In district infrastructure improvements to increase delivery capability including replacement or rehabilitation of siphons, replacement of pipelines, and other distribution infrastructure.
- Canal lining or pipeline conversion projects to reduce seepage losses from conveyance facilities, including in areas with subsurface contaminants that would limit the beneficial use of the water that seeps from conveyance facilities into the ground.

Capital costs and potential annual yield estimates, in TAF/YR, are provided for approximately 60 of these projects, as summarized by subbasin in Table 5-7. It is not known if projects that would convey additional surface water or enable greater diversion of flood flows from local streams and rivers would also require additional projects to recharge groundwater or expand distribution systems to realize reported benefits.

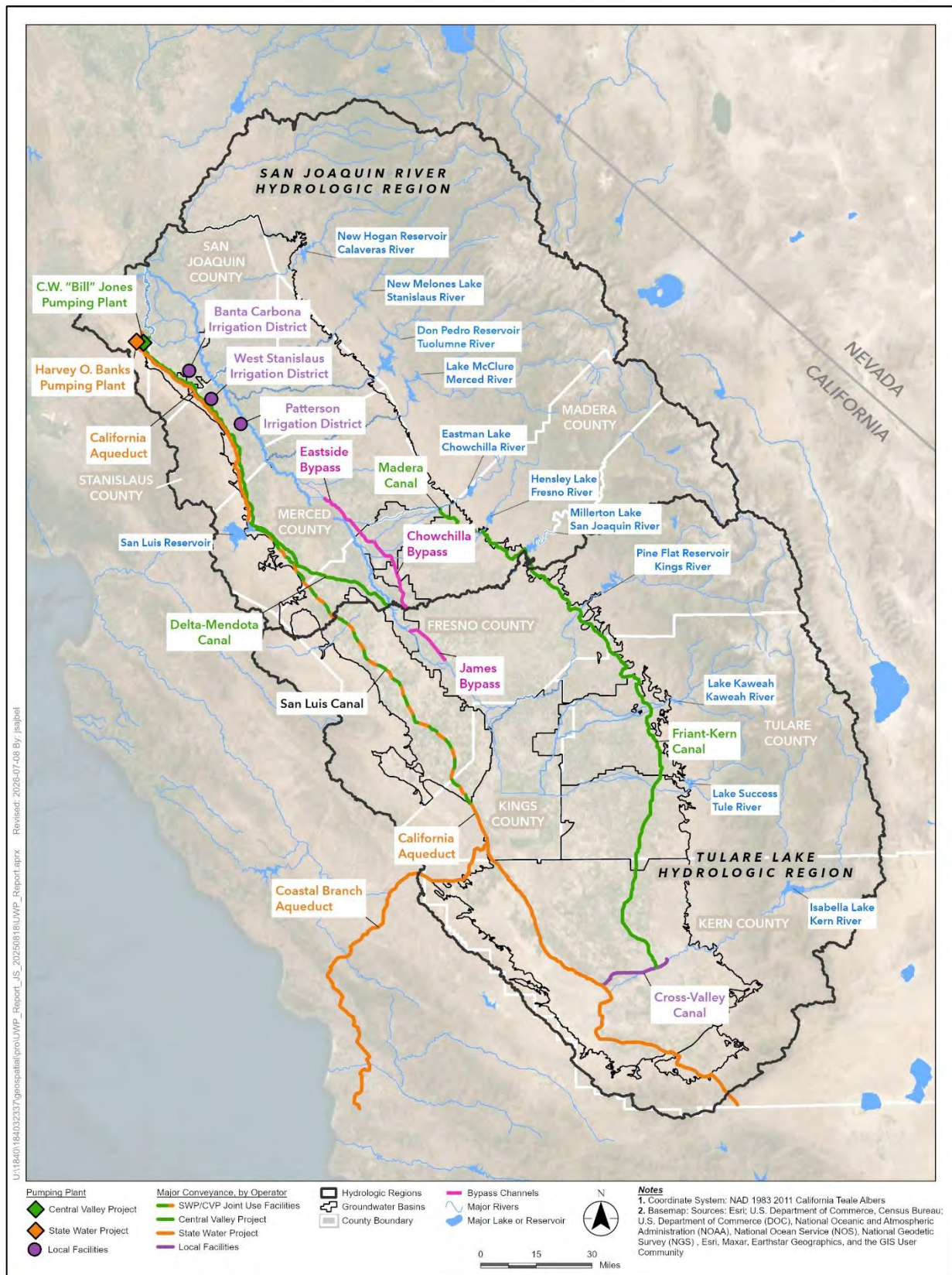


Figure 5-3. Major Water Conveyance Facilities in the San Joaquin Valley

Table 5-7. Summary of Local Conveyance Project Information Presented in Groundwater Sustainability Plans by Subbasin

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	6	4	30.2	85.7
Tracy	2	2	4.0	4.7
Delta-Mendota	4	2	37.0	21.9
Modesto	-	-	-	-
Turlock	7	4	21.4	261.7
Merced	18	4	32.1	7.3
Chowchilla	2	2	15.0	12.4
Madera	6	4	5.5	3.2
Westside	-	-	-	-
Pleasant Valley	4	1	4.0	2.6
Tulare Lake	3	3	31.5	114.6
Kings	16	16	47.8	185.1
Kaweah	6	5	10.1	7.3
Tule	-	-	-	-
Kern	32	15	63.2	370.1
White Wolf	2	1	24.0	17.8
Total³	108	63	325.8	1,094.6

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of conveyance projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

Restore Authorized Design Capacity of Regional Conveyance Facilities

The four largest water supply canals in the SJV – the Friant-Kern Canal, San Luis Canal, California Aqueduct, and Delta Mendota Canal – have each experienced reductions in conveyance capacity because of regional land subsidence and other factors. These projects are essential to provide authorized benefits to CVP and SWP contractors in the SJV and elsewhere. The geographic extent of conveyance constraints due to reduced capacity on the operation of each canal is shown on Figure 5-4. It is important to note that these conveyance constraints are the result of regional land subsidence along localized reaches of the canals affecting the hydraulic profile, as described in Chapter 2. Each of these facilities is being investigated and modified to restore conveyance capacity through one or more projects, as described below.

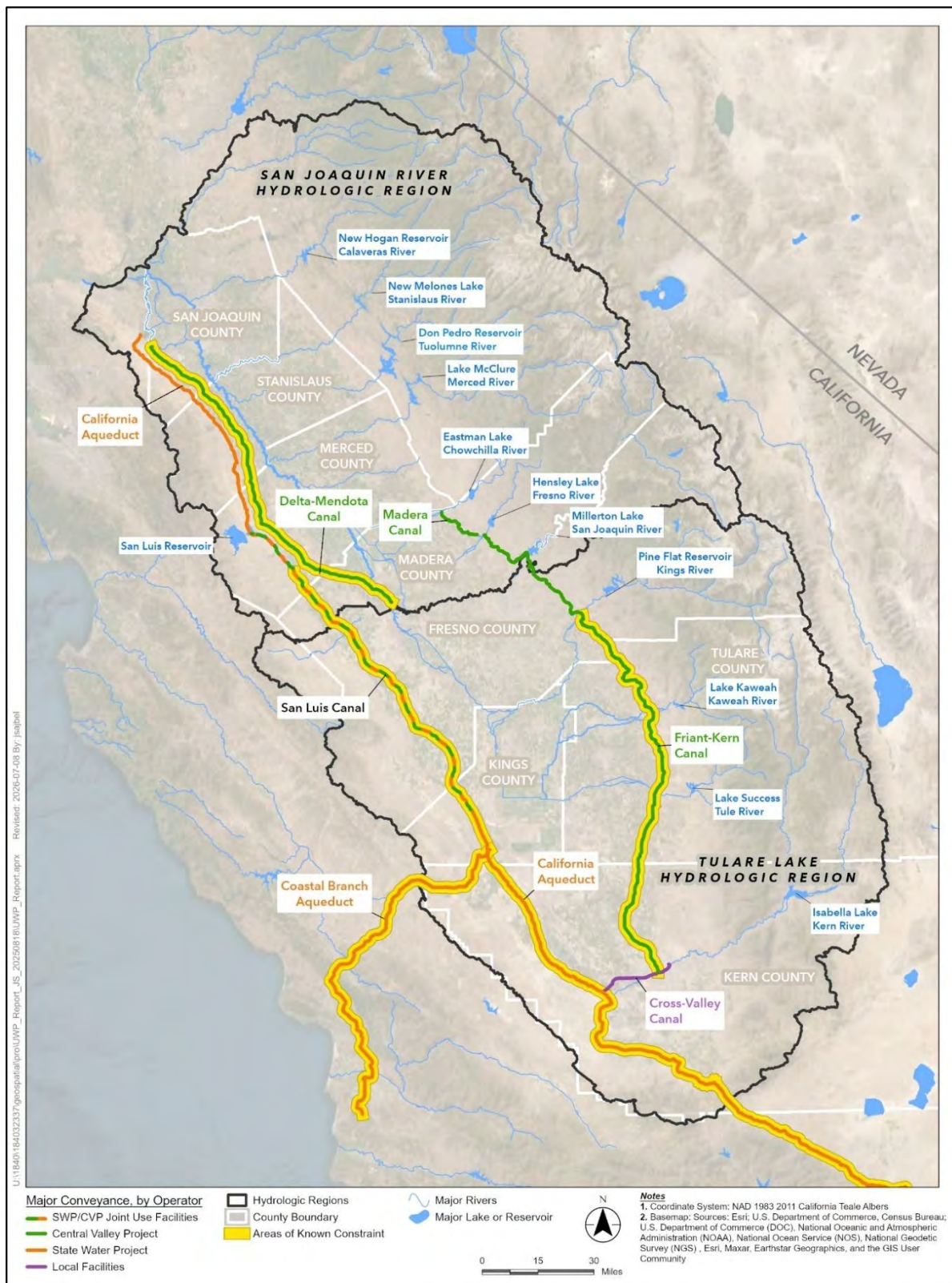


Figure 5-4. Geographic Extent of Water Conveyance Constraints Due to Reduced Capacity of Regional Conveyance Facilities Caused by Regional Land Subsidence

Restore Capacity of the San Luis Canal / California Aqueduct

The California Aqueduct is the principal conveyance facility of the SWP, extending from the Banks Pumping Plant in the Delta to service areas in Southern California. The San Luis Canal, an approximately 100-mile portion of the California Aqueduct in the SJV, is owned by Reclamation and operated by DWR as a joint-use facility of the SWP and CVP. The SLC conveys water supplies to South of Delta CVP contractors and provides for conveyance of SWP water supplies to the California Aqueduct at Check 21 near Kettleman City. The California Aqueduct delivers an average of approximately 2,000 TAF/YR of water to SWP contractors in central and southern California for agricultural and M&I purposes.

When designed in the 1960s, the SLC and Aqueduct included provisions to account for anticipated future subsidence. Following completion of construction, regional land subsidence has differentially lowered the SLC and Aqueduct beyond original expectation between the Dos Amigos Pumping Plant near O'Neill Forebay and the Edmonston Pumping Plant. Over several decades, DWR and Reclamation implemented localized projects in subsided areas to reduce conveyance capacity constraints caused by subsidence. However, subsidence has continued and has caused reduced conveyance capacity and water delivery capability to CVP and SWP contractors. As summarized in the Impacts of Subsidence Addendum to the 2023 Delivery Capability Report (DWR 2025a), it is estimated that subsidence has reduced existing delivery capability of the SWP by about 3% under 2023 subsided conditions. The report also states that continuation of current operations with potential future subsidence could cause SWP water delivery reductions up to 87% by 2043.

Potential solutions to subsidence impacts on conveyance capacity in the SLC and California Aqueduct are being investigated by DWR, in coordination with Reclamation, under the California Aqueduct Subsidence Program. Details on the potential alternatives and estimated costs are under evaluation and have yet not been published, however DWR and other agency staff have cited a preliminary cost estimate of approximately \$3.1 billion in fourth quarter (Q4) 2025 dollars (Mavens Notebook 2025).



Source: DWR 2026

Photo 5. California Aqueduct

Restore Capacity of the Delta Mendota Canal

The DMC was designed and constructed by Reclamation as an initial feature of the CVP and is operated and maintained by the San Luis Delta Mendota Water Authority (SLDMWA). Water pumped into the DMC at the Jones Pumping Plant in the Delta flows 116 miles by gravity to its terminus at the Mendota Pool on the San Joaquin River. Design capacity decreases from 4,600 cfs at the headworks to 3,210 cfs at Mendota Pool. However, regional land subsidence has affected capacity of the DMC since its construction in the early 1950s, and Reclamation implemented corrective action projects in 1969 and 1977 to address subsidence-caused impacts at the time.

Currently, SLDMWA is undertaking the Delta Mendota Canal Correction Project in coordination with Reclamation to address the impacts of existing and projected future subsidence on the long-term operation of the DMC (SLDMWA 2023). As of 2023, it was estimated that subsidence has reduced the conveyance capacity of the DMC by up to 31%. In addition, regional subsidence has caused physical damage to the DMC. If no action is taken, additional physical damage is likely to occur and conveyance capacity is expected to be reduced to a maximum of 44% of design capacity.

The SLDMWA and Reclamation are jointly developing solutions to restore the design capacity of the DMC under current and projected subsided conditions. The proposed project for subsidence correction was identified as the Raise Deficient Structures Alternative which included raising the

lining, embankment, and impacted structures to restore the originally authorized conveyance capacity. The estimated total cost for the project is \$840 million in Q4 2025 dollars, of which Reclamation has committed to funding approximately \$279 million (SLDMWA 2025). The SLDMWA and Reclamation are currently evaluating a phased approach for project construction.



Source: Brian van der Brug at the Los Angeles Times

Photo 6. Cracked Concrete Lining on the Delta Mendota Canal as a Result of Subsidence

Restore Capacity of the Friant-Kern Canal

The FKC was constructed as an initial feature of the CVP, completed in 1951, and serves water supplies to more than 1 million acres of farmland and several cities in the eastern portion of the SJV in the Tulare Lake Hydrologic Region. The gravity-flow canal, which extends 152-miles from Friant Dam on the San Joaquin River to the Kern River in Bakersfield, is owned by Reclamation and is operated and maintained by the FWA as part of the Friant Division of the CVP. Extensive regional land subsidence, combined with an original design deficiency, has resulted in conveyance capacity that is less than original design capacity over significant portions of the FKC. PL 111-11, which authorized federal implementation of the San Joaquin River Restoration Settlement in 2009, also authorized modifications to restore the original design capacity of the entire FKC, as a means to help reduce or avoid water delivery reductions caused by the release of Restoration Flows to the San Joaquin River.

Following the severe drought of 2012-2016 that induced significant land subsidence through the SJV, FWA and Reclamation jointly initiated the Friant-Kern Canal Middle Reach Capacity Correction Project (MRCCP) in 2018 to restore capacity in a roughly 33-mile portion of the canal in Tulare County (milepost 88.1 to 121.5). Phase 1 of the MRCCP, completed in 2024 at a cost of about \$326 million, included approximately 10 miles of new replacement canal that restored the conveyance capacity in the most significantly subsided section of the FKC from an estimated 1,600 cfs to the originally designed 4,000 cfs. State and federal environmental compliance has been completed for the entire MRCCP and federal construction authorization has been provided (Reclamation 2021a).

Capacity constraints in the upper reach of the FKC continue to limit the amount of water that can be conveyed to the middle reach, and downstream conveyance constraints in the lower reach further limit water delivery capability to the most downstream users. FWA and Reclamation are continuing to evaluate the feasibility of modifications to restore capacity to the remaining portions of FKC. The cost to restore system-wide capacity of the FKC is approximately \$1,100 million in Q4 2025 dollars (FWA 2025a).



Source: *Water Finance & Management 2024*

Photo 7. Friant-Kern Canal Middle Reach Capacity Correction Project Northern Tie-In with Existing Canal

Modified, Expanded, or New Regional Conveyance Facilities

Modified, expanded, and new regional conveyance facilities in the SJV are being considered to enhance movement of water supplies within the SJV. These facilities would primarily include canals, pipelines, and/or pump stations that would provide greater flexibility in delivering water supplies to districts. Some of the proposed projects could be developed based on water supplies that exist or would be developed within the SJV; others would increase the geographic distribution of water exported from the Delta, some with connections to existing in-valley facilities that would enhance operational flexibility.

Modified Conveyance Facilities for Reverse Flow

Modifying canal facilities to create the opportunity for reverse flow operations is one way to enhance the movement of water supplies within the SJV without needing to pursue major construction projects. Reverse flow projects typically involve placing a lift station and/or temporary pump at a check structure and then operating the pump to lift water over the check structure into the upstream pool. This allows water to move in the opposite direction from typical gravity flow operations. Reverse flow operations typically involve multiple pumps at multiple check structures to move water through multiple pools.

Upper Delta-Mendota Canal Reverse Flow Pumpback Project

The Upper Delta Mendota Canal Reverse Flow Pumpback Project would consist of three permanent lift stations along the upper reaches of the DMC that would allow reverse flow operations in canal reaches north of San Luis Reservoir (SLR). This would allow CVP and non-CVP water stored in SLR to be pumped up the DMC and delivered directly to the CVP contractors along the upper reaches of the DMC. The Central Valley Water Solution Act included \$25 million (Q4 2025 dollars) to be authorized for designing and constructing this project (U.S. House of Representatives 2025).

Lower Delta-Mendota Canal Reverse Flow Pumpback Project

The Lower Delta Mendota Canal Reverse Flow Pumpback Project would consist of pump stations and other modifications that would allow reverse flow operations in the DMC from the Mendota Pool to O'Neil Forebay. It would also allow for the interconnection of the Central California Irrigation District Outside and Main Canals to the DMC to convey flood water into SLR for storage, direct use, or exchange. The Central Valley Water Solution Act included \$280 million (Q4 2025 dollars) to be authorized for designing and constructing the project (U.S. House of Representatives 2025).

Friant-Kern Canal Pump-Back Project

The Friant-Kern Canal Pump-Back Project is currently being implemented by the Friant Water Authority and will consist of pumps at two check structures on the FKC upstream of the FKC-Cross Valley Canal (CVC) Intertie. Pumps with a capacity of up to 200 cfs will be placed at the Shafter-Wasco check structure and 75 cfs will be placed at the Lake Woollomes check structure (FWA 2024). These two facilities will supplement the FKC-CVC Intertie, which provides 500 cfs of reverse flow capacity, to provide reverse flow on the FKC from the Cross Valley Canal to the Deer Creek check structure. This project will increase the operational flexibility and long-term reliability of Friant Division water supplies and will allow for direct delivery of water available in the California Aqueduct including recaptured Restoration Flows, Cross Valley Canal contract water supplies, water

from banking projects, and other supplies available via the California Aqueduct and/or Cross Valley Canal. FWA has largely completed the planning phase, including National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) requirements, and is moving into the construction phase (FWA 2025b). The cost to Friant Water Authority is approximately \$3 million in Q4 2025 dollars (FWA 2025a).

California Aqueduct Reverse Flow Concept

Entities have been investigating the concept of reverse flow of the California Aqueduct for quite some time. Installing lift stations at check structures on the California Aqueduct between the Cross Valley Canal and SLR could facilitate reverse flow operations under a variety of scenarios. For example, reverse flow could be used to make direct deliveries of groundwater banked in Kern County to SLR and/or CVP and SWP contractors between the Cross Valley Canal and SLR during dry years when exchanges are limited by the CVP and SWP surface water allocations necessary to facilitate exchanges. Reverse flow operations could also be used to make direct delivery of banked supplies during emergency situations when water supplies are unable to be conveyed by gravity from the Delta. Although the short-term need was ultimately averted, in 2021, DWR issued a CEQA notice of exemption for reverse flow operations at four check structures on the Aqueduct to meet the emergency needs of water districts on the west side of the SJV. Other California Aqueduct reverse flow concepts could be pursued to increase water supply reliability in the SJV.

Expanded East-West Conveyance

Three irrigation districts on the west side of the San Joaquin River downstream from the Merced River confluence – Patterson Irrigation District (PID), West Stanislaus Irrigation District and Banta Carbona Irrigation District (BCID)– own and operate facilities that can divert water from the San Joaquin River and convey it to the DMC (together referred to east-west conveyance facilities). The PID and BCID diversion facilities are equipped with state-of-the-art fish screens and have been used by Reclamation to recapture (divert) Restoration Flows from the San Joaquin River and recirculate (convey) them to the DMC. These east-west conveyance facilities are also used to facilitate regional water transfers and exchanges of other water supplies in the SJV. Opportunities to convey Restoration Flows and other water sources can be limited by available capacity in east-west conveyance facilities.

Increasing the capacity to convey water from the lower San Joaquin River to the DMC would increase opportunities to recapture and recirculate Restoration Flows and wheel other water supplies. Current east-west conveyance capacity at PID is 35 cfs, and capacity at BCID is 90 cfs. PID has been incrementally constructing the Main Canal Rehabilitation Project (also referred to as the East-West Conveyance Project) to modernize their canal system and increase its east-west conveyance capacity to approximately 200 cfs (PID 2025). The East-West Conveyance Project is being implemented in phases using a combination of local, state, and federal investments. PID has completed planning, design, and permitting of final phases of the East-West Conveyance Project and is actively working to secure construction funds.

New In-Valley Regional Canals

CVP and SWP conveyance facilities provide a backbone infrastructure for the distribution of water supplies from the Delta and the San Joaquin River. Over the past several decades, several entities

have considered extending and/or expanding the conveyance network to increase the geographic distribution of surface water supplies. Recently, the Water Blueprint prepared conceptual evaluations of five potential new regional conveyance facilities in the SJV that would provide surface water supplies to additional areas, improve operational flexibility, and contribute to filling the water supply-demand gap. Some projects would provide access to both SWP and CVP facilities, whereas others would be connected to SWP facilities only. The alignments are intended to be alternatives or future additions that can be combined to meet different needs. The following sections describe the five new water conveyance project concepts in the Tulare Lake Hydrologic Region, as depicted in Figure 5-5:

- Mid-Valley Canal Main Branch with Western Alignment
- Trans-Valley Canal Tulare Alignment
- Northern Kern Alignment
- Kaweah Alignment
- Western Madera Conveyance

The conveyance capacities and alignments for these projects were selected to help communicate the opportunity and develop a cost estimate. All conveyance facility alignments and associated cost estimates presented in this section are for one-directional facilities that would increase the delivery of surface water to additional areas in the SJV. Many of the alignments could also be considered for development of bi-directional facilities that would deliver water supplies and support potential groundwater banking. Smaller or larger design capacities could also be considered. Prior to selecting any of these projects for implementation, additional study is needed to define available water supplies, identify lands to be served, determine operational requirements, and develop detailed alignments and facility designs.

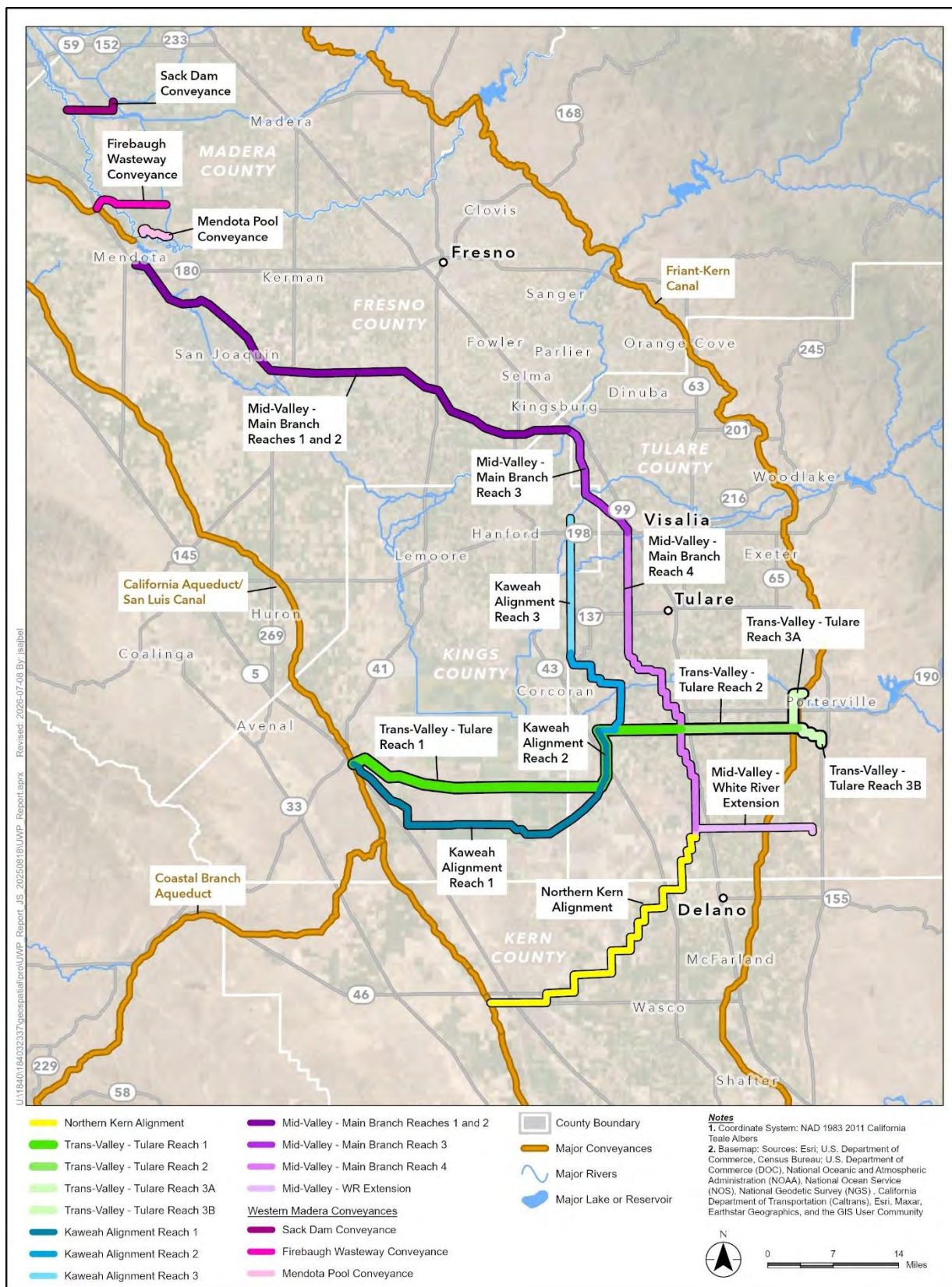


Figure 5-5. Potential New Regional Conveyance Projects in the San Joaquin Valley

Mid-Valley Canal Main Branch with Western Alignment

In the 1970s, Reclamation evaluated a Mid-Valley Canal as a proposed feature of the CVP East Side Division to provide supplemental water supply to the east side of the SJV to replace a portion of groundwater pumping (Reclamation 1981). As evaluated at the time, the Mid-Valley Canal would originate at Mendota Pool and convey CVP water diverted from the Delta to agricultural lands and communities in portions of Merced, Madera, Fresno, Kings, and Tulare counties, and by exchange furnish a water supply to Kern County. Water supply would also be provided to three national wildlife refuges and two state wildlife management areas.

As now envisioned, this project differs from the concept proposed by Reclamation in the 1970s in two significant ways. The Main Branch follows a more westerly alignment south of the Kings River that would be designed as a bi-directional facility, and the project could connect to the Trans-Valley Canal Tulare Alignment, thereby providing greater operational flexibility and access water supplies conveyed through CVP and SWP facilities.

The Main Branch of the Mid-Valley Canal Project would extend 109 miles from Mendota Pool, southeast to the White River near Earlimart, just north of the Kern County line. The canal would consist of four reaches with a starting capacity of 2,000 cfs. Seven pumping plants would be constructed to incrementally raise water about 140 feet from Mendota Pool to the head of Reach 4. The White River Extension would be a lined canal with a capacity of 1,000 cfs beginning at the terminus of Reach 4 West and extending about 13 miles to the east, generally paralleling the White River, crossing Highway 99 and the Friant-Kern Canal, to a terminus at the White River near Highway 65. The elevation change along the Reach 4 White River Extension is nearly 260 feet and would require 11 pumping plants, each with a capacity of 1,000 cfs. Table 5-8 provides a summary of construction costs for the Mid-Valley Canal Main Branch with Western Extension. The total cost, escalated to Q4 2025 dollars, is \$2,500 million. It should be noted that this cost estimate does not include potential expansion of all or portions of the DMC to convey increased flows to Mendota Pool for diversion into the Mid-Valley Canal.

Table 5-8. Cost Estimate for Mid Valley Canal Branch with Western Expansion Project

Mid-Valley Canal Reach Name	Reach Description	Total Construction Cost (\$ million)
Main Branch Reaches 1 and 2	Mendota Pool to Kings River	\$760
Main Branch Reach 3	Kings River to Highway 198	\$280
Main Branch Reach 4	Highway 198 to White River at Highway 99	\$640
White River Extension	White River at Highway 99 to Highway 65	\$550
Total Cost, escalated to Q4 2025		\$2,500

Key:

Q4 = fourth quarter

Trans-Valley Canal Tulare Alignment

The concept of a Trans-Valley Canal to connect the Friant-Kern Canal and the California Aqueduct, was originally evaluated by the FWA in the early 2000s in support of a potential partnership with the

Metropolitan Water District of Southern California (MWD). The partnership considered opportunities to provide high quality water to MWD in exchange for equivalent or greater supplies imported from the Delta to the Friant Division contractors. Concept-level layouts were prepared for facilities that could convey water exported from the Delta to the Friant Division and convey water from the Friant-Kern Canal to the California Aqueduct. A variety of alignments and capacities were considered, but none were developed beyond conceptual levels.

As further developed by the Blueprint, the Tulare Alignment of the Trans-Valley Canal would extend about 60 miles from the California Aqueduct just south of Kettleman City to the east, crossing the Tulare Lake Basin and terminating in Tulare County South of Porterville. The primary canal would consist of two reaches starting at a capacity of 3,600 cfs in Reach 1 and a capacity of 880 cfs in Reach 2, which potentially could connect to the Friant-Kern Canal. Two optional segments could extend the Trans-Valley Canal Tulare Alignment further north on the Friant-Kern Canal (Reach 3A) and/ or extend water supply to lands east of the Friant-Kern Canal (Reach 3B). Water would be incrementally lifted about 220 feet from the Tulare Lakebed, at the lowest portion of the facility, to the Friant-Kern Canal immediately upstream from Deer Creek through 14 pumping plants. Table 5-9 provides a summary of construction costs for the Trans-Valley Canal Tulare Alignment. The total cost, escalated to Q4 2025 dollars, is \$1,600 million.

Table 5-9. Cost Estimate for Trans-Valley Canal Tulare Alignment

Reach	Description	Total Construction Cost (\$ million)
1	California Aqueduct to Mid Valley Canal Western Alignment (3,600-880 cfs)	\$940
2	Mid Valley Canal Western Alignment to Friant-Kern Canal (880 cfs)	\$330
3A	Friant-Kern Canal to Tule River (330-880 cfs, depending on construction of 3B)	\$75
3B	Friant-Kern Canal to Deer Creek (500 cfs)	\$75
Total Cost, escalated to Q4 2025		\$1,600

Key:

cfs = cubic feet per second

Q4 = fourth quarter

Northern Kern Alignment

The Northern Kern Alignment concept is currently defined as a new canal that would convey water from the California Aqueduct to lands in the northwestern portion of Kern County and southwestern portion of Tulare County. This concept differs from the Trans-Valley Canal by not providing a connection between the California Aqueduct and the Friant-Kern Canal.

The Northern Kern Alignment would extend approximately 39 miles from the California Aqueduct south of Lost Hills, northeast across Kern County and into Tulare County, terminating west of Highway 99 between the City of Delano and community of Earlimart. In addition to serving agricultural lands, this alignment would facilitate delivery of water to Kern National Wildlife Refuge and wetlands in Northern Kern County. The lined canal would maintain a conveyance capacity of 2,700 cfs across the entire length and require four pumping plants to lift the water about 48 feet

over the length of the canal. The estimated construction cost for a one-directional Northern Kern Alignment, escalated to Q4 2025 dollars, is \$640 million.

Kaweah Alignment

The Kaweah Alignment is a concept for a new canal to move wet-year water supplies from the California Aqueduct to the groundwater recharge areas along the Tulare and Kings County line. This concept combines portions of the Mid Valley Canal Main Branch and Trans-Valley Canal Tulare Alignment to serve areas that historically have not had access to surface water supplies.

The Kaweah Alignment begins on the California Aqueduct south of Kettleman City and heads toward the southeast, following the topography of the Tulare lakebed and crossing into Tulare County east of the community of Alpaugh. The alignment continues north and borders the Pixley National Wildlife refuge before heading north along the Tulare and Kings County line, near existing groundwater recharge facilities. The proposed alignment includes a total lined canal length of approximately 69 miles in 3 reaches. The Kaweah Alignment would have a conveyance capacity of 3,000 cfs across the Tulare Lakebed for the first 39.1 miles (Reach 1), 2,000 cfs for the next 15.5 miles (Reach 2), and 1,000 cfs for the final 14.4 miles (Reach 3). Reach 1 would require 2 pumping plants to provide approximately 24 feet of lift, Reach 2 would require 3 pumping plants to provide approximately 40 feet of lift, and Reach 3 would require 3 pumping plants to provide approximately 45 feet lift. Table 5-10 provides a summary of construction costs for the Kaweah Alignment. The total cost, escalated to Q4 2025 dollars, is \$900 million.

Table 5-10. Cost Estimate for Kaweah Alignment

Reach	Description	Total Construction Cost
1	California Aqueduct to 6th Ave (39.1 miles, 3,000 cfs)	\$410
2	6th Ave to 4th Ave Siphon (15.5 miles, 2,000 cfs)	\$250
3	4th Ave Siphon to Cross Creek (14.4 miles, 1,000 cfs)	\$150
Total Cost, Escalated to Q4 2025		\$900

Key:

cfs = cubic feet per second

Q4 = fourth quarter

Western Madera Conveyances

The 1981 Reclamation feasibility report on the Mid-Valley Canal included a North Branch that would convey water from the Mendota Pool to lands in western Madera County not served by the Madera Canal or Mendota Pool. Upon review of the North Branch concept, the Blueprint developed an alternative set of conveyance facilities that, in combination, would provide similar benefits as the North Branch of the Mid-Valley but at a considerably lower cost.

The Western Madera Conveyances project would comprise up to three separate lined canals to convey water from the San Joaquin River and the Firebaugh Wasteway to the Chowchilla Bypass. The Chowchilla Bypass would be used to convey water to distribution systems to be developed by local water users. The new conveyance facilities would enable delivery of water to areas that currently rely exclusively on groundwater and flood flows. The Western Madera Conveyance project

would involve facilities that cross rivers, roads, canals, and other infrastructure, and would require proper design considerations, including fish passage provisions.

This project concept was not identified by GSAs in western Madera County and has not been discussed in detail with potential participants or other interested parties. In addition, several details regarding the use of a flood bypass facility to convey water supplies, such as authorization, operations and maintenance costs, and operational priorities, would need to be determined. Three conveyance facilities that comprise the Western Madera Conveyances project – the Mendota Pool Conveyance, the Firebaugh Wasteway Conveyance, and the Sack Dam Conveyance – are shown above in Figure 5-5 and described below.

- The Mendota Pool Conveyance would use the Columbia Canal Company (CCC) intake and available unused pumping plant capacity to convey water from Mendota Pool water to a new 100 cfs canal adjacent to CCC canal facilities. Water would be conveyed primarily during off-peak irrigation and non-irrigation seasons, when capacity in the CCC pumping plant may be available. The new, lined canal would generally parallel the CCC Ponomo canal east from the San Joaquin River for about 3.7 miles. A new pump station would lift the water from the new canal into the Chowchilla Bypass. Total lift from the CCC Pumping plant to the Chowchilla Bypass would be an elevation difference of about 13 feet plus head losses. Three siphons and one timber farm bridge would be required for canal and road crossings.
- The Firebaugh Wasteway Conveyance would convey approximately 500 cfs of water about 6.8 miles from an intake on the Firebaugh Wasteway through a siphon below the San Joaquin River and to the Chowchilla Bypass. The lined canal will head due east, crossing the Columbia canal, for approximately 0.7 miles before following Eastside Drive southeast for approximately 0.9 miles. The last stretch of the conveyance would parallel Avenue 6 to its terminus at the Chowchilla Bypass. It is estimated that two pumping stations would be required to provide a total lift of about 24 feet plus head losses. A large siphon would be needed to convey water from the Firebaugh Wasteway below the San Joaquin River. An additional six smaller siphons and nine timber farm bridges would be required for canal and road crossings.
- The Sack Dam Conveyance would convey approximately 200 cfs of water 5.9 miles from a new screened intake at Sack Dam near the headworks at the Arroyo Canal Gates to the Chowchilla Bypass. The lined canal would run east for about 5 miles, before turning North for about a mile to its terminus in the Chowchilla Bypass canal. It is estimated that two pumping stations would be required to provide a total lift of about 20 feet plus head losses. A fish screen would be required at the new intake on the San Joaquin River adjacent to the Sack Dam. Three siphons and six timber farm bridges would be required for crossing canals and roads.

Table 5-11 provides a summary of construction costs for the Western Madera Conveyances Alignments. The total cost, escalated to Q4 2025 dollars, is \$430 million.

Table 5-11. Cost Estimate for Western Madera Conveyances Project

Western Madera Conveyances Feature	Total Construction Cost (\$ million)
Mendota Pool Conveyance	\$23
Firebaugh Wasteway Conveyance	\$105
Sack Dam Conveyance	\$66
Combined Project	\$194
Total Cost, escalated to Q4 2025	\$430

Key:

Q4 = fourth quarter

Modified, Expanded, or New Delta Facilities and Operations

The SWP and CVP utilize large-capacity pumping facilities to export water from the Delta into their respective conveyance systems. The Banks Pumping Plant is an SWP facility that lifts water from the south Delta into Bethany Reservoir and the California Aqueduct. Similarly, the Jones Pumping Plant is a CVP facility that lifts water from the south Delta into the DMC. These large pumping plants are efficient for water transport but have the potential to harm protected fish species. Despite mitigation measures for fish like upstream salvage and diversion louvres, state and federal regulatory agencies have also established rules that limit pumping diversions and, consequently, export volumes from the Delta through the Banks and Jones pumping plants.

A variety of project types are being considered to enhance Delta operations including revisions and modifications to existing operations, and well as new and modified Delta facilities. These projects aim to restore the volume of exports while safeguarding the environment, including protected fish species. There is also a desire to increase the water quality of South of Delta exports. Three types of projects are presented below: (1) modified Delta operations, (2) modified existing Delta facilities, and (3) new or expanded Delta conveyance facilities.

Modified Delta Operations

Reclamation approved a record of decision titled Long-Term Operation of the Central Valley Project and SWP on December 4, 2025 (2025 LTO ROD). It was implemented in response to Executive Order (EO) 14181 issued by President Trump titled “Emergency Measures To Provide Water Resources In California and Improve Disaster Response in Certain Areas.” The 2025 LTO ROD implements the “Action 5” Operations Plan for the LTO, which modifies previous operations by increasing delivery of water supplies from the Delta to areas in need by increasing storage and conveyance (Reclamation 2025c). It specifically modifies Alternative 2 in the 2024 LTO ROD to be consistent with EO 14181 and ensures that restrictions to water supplies “provide a material benefit to listed species through the use of predictive tools for real-time assessment of environmental conditions.” It is estimated that Action 5 could increase CVP and SWP deliveries by 180 TAF and 220 TAF, respectively (Reclamation 2025c). Reclamation has implemented Action 5 but DWR has not.

Modified Delta Facilities

The modification of existing Delta Facilities could be used to enhance both South of Delta exports and the Delta ecosystem. The primary method of modifying existing facilities without new or expanded conveyance is through dredging of channels in the South Delta. This management action has been investigated for a long time as a key component of the South Delta Improvements Program (Reclamation 2006), and more recently by the State Water Contractors as part of the South Delta Channel Depth Restoration Program (State Water Contractors 2022). Sediment has been deposited from rivers into the Delta channels over a long period of time. This buildup of sediment fundamentally alters hydrodynamics in the Delta and decreases channel depth and channel capacity, which negatively affects water volumes available for diversion, flood control capacity, recreation, water quality, and ecosystem health (State Water Contractors 2022). The State Water Contractors estimated that approximately \$670 million to \$1,150 million (Q4, 2025 dollars) would be needed to design, permit, and implement construction and dredging activities along 75 miles in the south Delta.

The South Delta Improvements Program Environmental Impact Report (EIR)/Environmental Impact Statement (EIS), published in October 2005, proposed to improve water quality, water conveyance, and fish habitat conditions in the south Delta by constructing and operating a fish control gate at the head of the Old River, operating flow control structures, dredging various channels in the delta, and extending a number of agricultural diversion intake facilities (Reclamation 2006). More recently, DWR's South Delta Gates Project identifies gates in Old River, Grant Line Canal, and/or the Middle River as providing potential benefits to improve water quality, fish passage, maintenance of water levels, and reduce environmental impacts (DWR 2025h). New permanent operable gates would replace the existing, annually constructed temporary rock barriers.

New or Expanded Delta Conveyance Facilities

New or modified Delta conveyance facilities would increase the efficiency of conveyance from north to south through the Delta, and/or increase the ability to lift water into the SWP and CVP conveyance systems, as detailed in the subsections below.

Delta Conveyance Project

The concept of routing SWP and CVP supplies that originate north of the Delta around or under the Delta to improve the reliability and quality of water deliveries south of the Delta has been studied for decades. The Peripheral Canal was the initial through-Delta concept and was formally studied in the 1960s, 70s, and early 80s until its implementation was defeated by voters in 1982 (DWR 2023). The subsequent California Bay-Delta Program (CALFED) and the Delta Vision process in the 1990s and early 2000s ultimately led to the development of the California WaterFix. The California WaterFix concept included two tunnels under the Delta (DWR 2023). This was pursued until 2019 when, at the direction of Governor Newsom, DWR abandoned the two-tunnel concept for a single-tunnel concept.

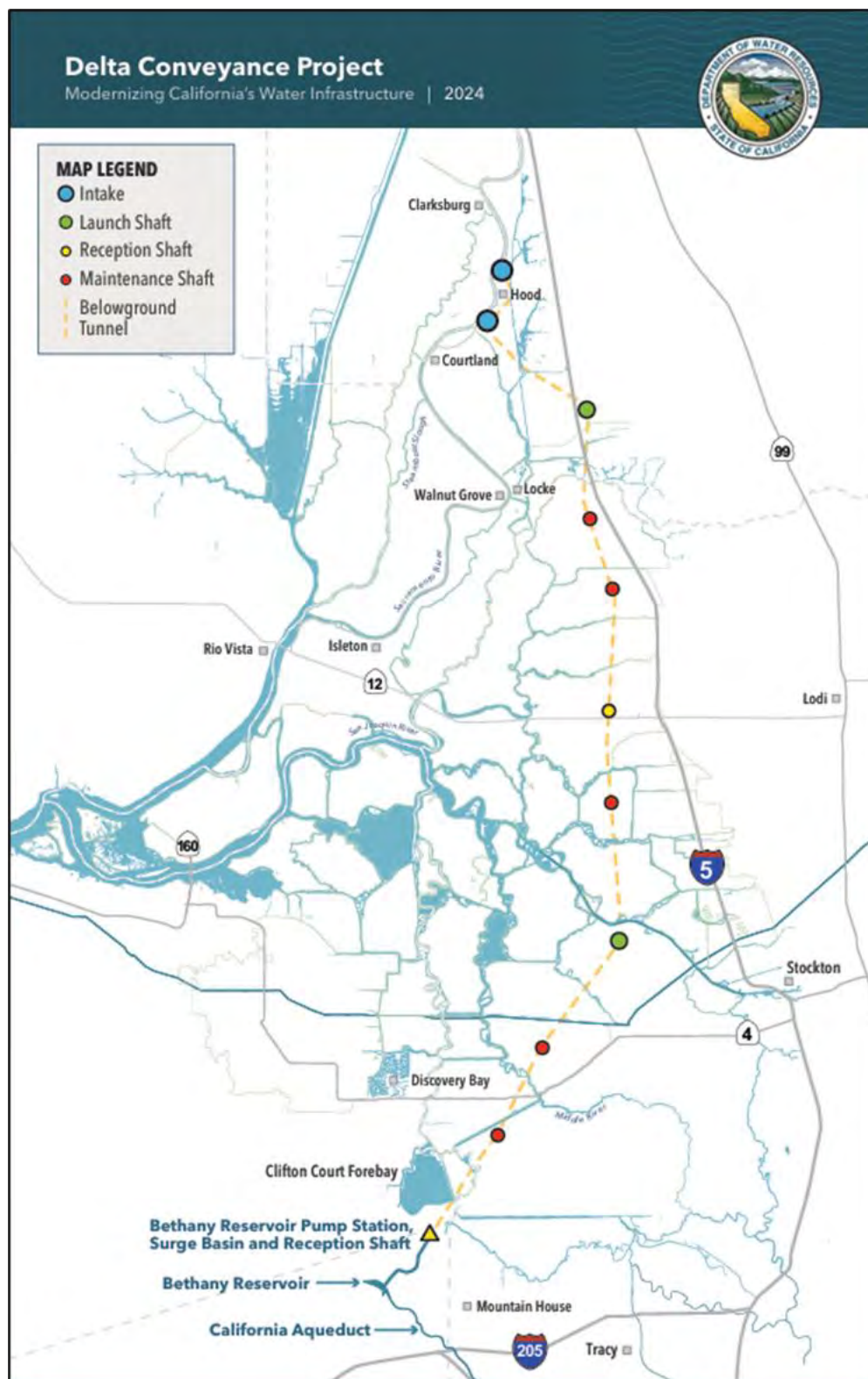
The single tunnel concept now being pursued is known as the Delta Conveyance Project (DCP) and is described on Figure 5-6. As currently configured, the DCP would convey 6,000 cfs below the Delta and deliver it to Bethany Reservoir via a 45-mile tunnel with a 36-foot diameter (DWR 2025c). Water would then be delivered to South of Delta contractors from Bethany Reservoir via the

California Aqueduct, as occurs today. Routing water under the Delta would improve the quality and reliability of South of Delta exports because water would not be pumped from the Delta and subject to Delta pumping restrictions. It is estimated that DCP would increase deliveries from the Delta by approximately 403 TAF/YR and benefits would exceed the costs by approximately 2 to 1 (Sunding and Browne 2024). The estimated total project cost is \$21,000 million in Q4 2025 dollars (DCDCA 2024).

DWR is currently working through the planning, permitting, and design processes for DCP. The Final Draft Environmental Impact Report for DCP was certified in 2023 (DWR 2023). Most recently DWR submitted a Certification of Consistency to the Delta Stewardship Council, which is required by law, and states that the DCP is consistent with the Delta Plan (DWR 2025f). It is estimated by state officials that construction of DCP would take about 15 years and could be operational by the mid-2040s if it begins in 2029 (James 2024). As currently envisioned, the DCP would provide limited benefits for agricultural water use in the SJV. Numerous urban water agencies continue to fund the development of DCP with limited participation from agricultural water users in the SJV.

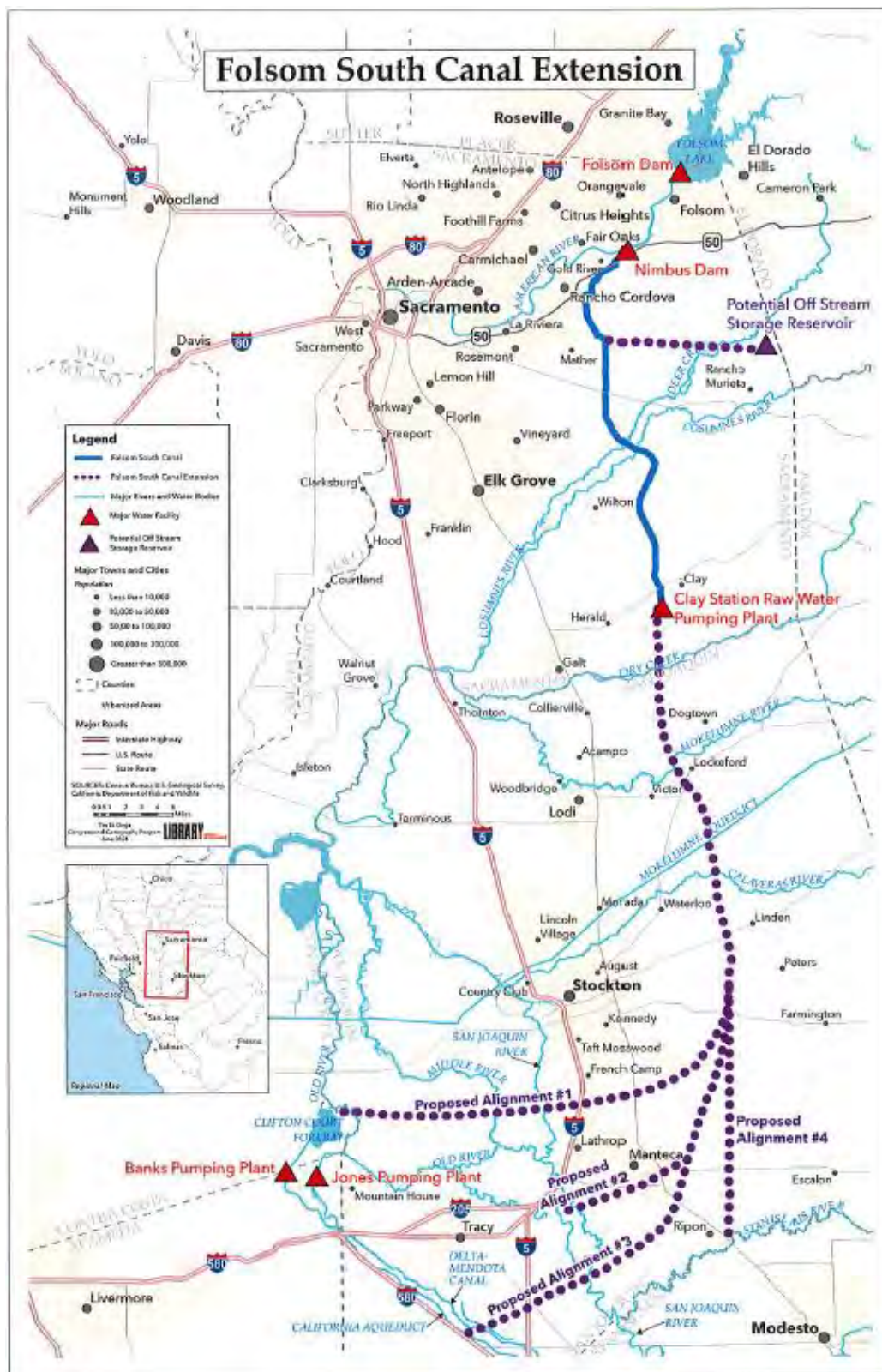
Folsom South Canal Extension Project

The Folsom South Canal was constructed by Reclamation as part of the CVP. It originates on the American River at Nimbus Dam and terminates about 27 miles south near Clay Station. Five reaches were originally planned but only two were constructed. The capacity of the first two reaches is 3,500 cfs. A canal extension project that would connect the existing canal to the Delta region, as shown on Figure 5-7; has been proposed for consideration (Miller et al. 2024). In 2024, members of Congress formally requested the initiation of a Reclamation planning study into the Folsom South Canal Extension Project (Duarte 2024). In their letter, the members also requested studying potential off-channel storage opportunities along the Folsom South Canal. The letter references the following potential benefits: increased diversion of flood flows to improve water supply reliability across California; enhanced opportunities for water transfers; enhanced ability to meet environmental requirements in the Delta; improved operations at Folsom Dam; and reduced flooding below Folsom Dam. A federal appraisal or feasibility study has not yet been initiated, and cost estimates have not been developed for the canal extension or other aspects of this concept.



Source: DWR 2025g

Figure 5-6. Delta Conveyance Project



Source: Duarte et al. 2024

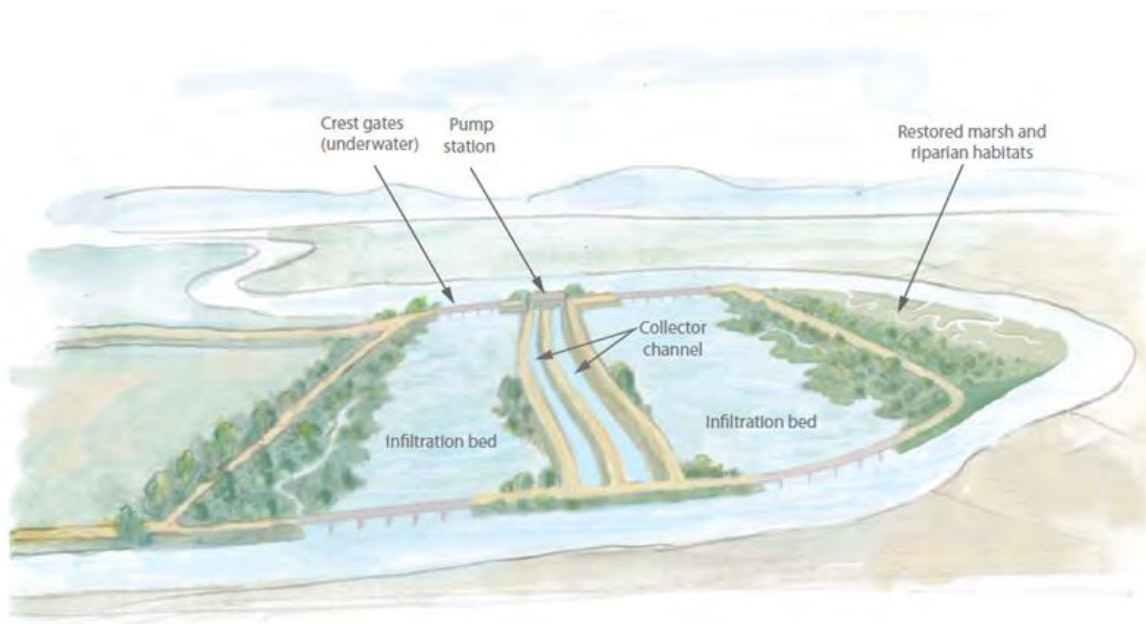
Figure 5-7. Folsom South Canal Extension Project

Delta Infiltration Galleries

The concept of infiltration galleries (also referred to as fish-friendly diversion facilities) within the Delta has been suggested as a means to improve the efficiency of routing water through the Delta. The concept is based on successful application of sub-surface infiltration galleries. Similar facilities have been constructed on the Tuolumne River for water diversion that minimizes effects on aquatic species, and also in Orange County to remove sediment from flood waters. Preliminary studies have been performed and conceptual designs have been prepared to demonstrate the potential effectiveness of this approach.

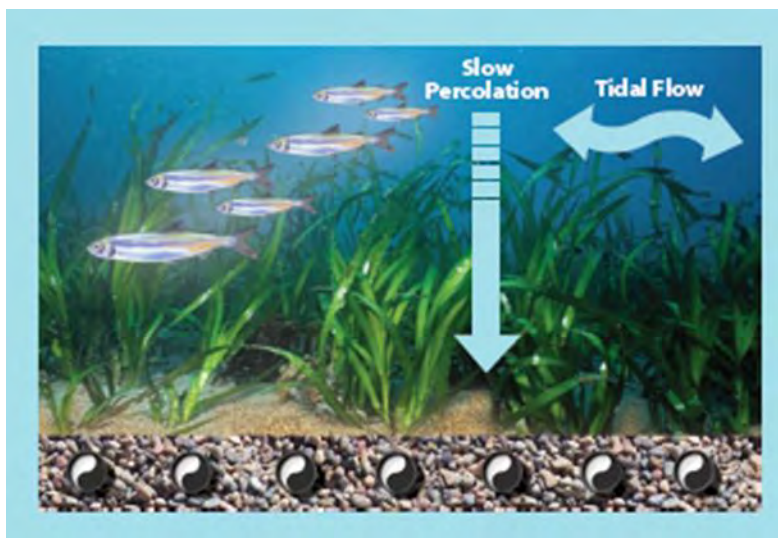
Infiltration galleries would be constructed at major diversion locations where the operation of pumps and/or other facilities are limited by the presence of protected fish. A concept plan of large-scale infiltration galleries and associated facilities is shown on Figure 5-8. The facilities would be operated to make continuous diversions from channels in the Delta using a large system of perforated pipes buried in gravel beds at the bottom of channels, shown on Figure 5-9. The facility would be designed to cause water to flow vertically through the channel beds at rates that would not harm fish. The buried pipes would provide water to collector channels and pump stations that would convey water to existing Delta export facilities. The galleries and associated facilities would be sized such that the pump stations could be operated without draining the collector channels (Water Blueprint 2022a).

The viability of infiltration galleries to meet the needs of water users in the SJV and elsewhere is being investigated by the South Valley Water Resources Authority. Current evaluations are focused on the long-term sustainable performance and maintenance of the buried perforated pipes, which could be subject to fouling or siltation.



Source: Water Blueprint 2022a

Figure 5-8. Delta Infiltration Gallery Project Concept



Source: Water Blueprint 2022b

Figure 5-9. Infiltration Galleries would Divert Water Vertically Through Gravel Beds.

Delta Mendota Canal Recirculation

The DMC Canal Recirculation concept project would improve water quality and increase flows in the lower San Joaquin River by routing water exported from the Delta back into the lower San Joaquin River through CVP facilities. Under this concept, water would be pumped into the DMC via the Jones pumping plant and would be released through the Newman or Westley Wasteways to re-enter the San Joaquin River upstream of Vernalis, helping to meet flow and salinity objectives (Reclamation 2010). The objective is to reduce reliance on New Melones releases for meeting regulatory flow requirements in the lower San Joaquin River, while improving water quality and water supply reliability.

A plan formulation report was developed for this project by Reclamation in 2010. It outlined several project alternatives, assessed their potential environmental and operational effects, compared their performance against study objectives, and found none to be feasible. Although each alternative would increase flow in the San Joaquin River at Vernalis, most alternatives also would cause a degradation of water quality and negative changes to combined CVP deliveries in the Stanislaus River and export areas. The report also noted an increased potential to entrain fish due to increased pumping at Jones necessary to recirculate water. Although not currently being pursued, this project could be reconsidered in light of changes in the regulatory and operational environment in the Delta and CVP service areas.

Flood Bypass Channels

Flood bypass channels in the SJV are engineered floodways designed to divert high flows out of river channels, convey them through broad, leveed corridors, and reduce flood stages downstream. Unlike leveed river channels that confine flow, bypasses intentionally allow controlled overflow into designated areas where water can spread, slow, and safely rejoin the river system downstream. These channels protect levees and downstream infrastructure that would otherwise be damaged by



uncontrolled flooding. Flood bypass channels can be used to improve fish passage, create ecological connectivity, and support infiltration.

Paradise Cut Bypass Expansion

Under current conditions, water periodically spills from the San Joaquin River over a rock weir into Paradise Cut during high flows. Water flows northwest through Paradise Cut for approximately six miles and discharges into Old River. Paradise Cut has a design capacity of 15,000 cfs, but due to sedimentation this capacity has been reduced (SJAFCA 2025).

The Paradise Cut Bypass Expansion project would expand the existing Paradise Cut Bypass, restore capacity in South Delta channels via dredging, and increase habitat. By significantly lowering flood stage along nearly 30 miles of the San Joaquin River between Vernalis and Stockton, the project would increase public safety, as well as protect property and farmland from uncontrolled flooding. The project is anticipated to help achieve 200-year level of protection for urban areas in the region (DWR 2022).

The San Joaquin County Resource Conservation District completed Phase 1 (2019) and Phase 2 (2022) of the project in partnership with the Sacramento-San Joaquin Delta Conservancy, the South Delta Water Agency, the California Department of Water Resources, American Rivers, reclamation districts, and other interested parties. In 2022, the project partners chose the San Joaquin Area Flood Control Agency to serve as the lead agency for Phase 3, the Paradise Cut Feasibility Study, which is expected to be completed in 2026 (SJAFCA 2025). Costs and benefits have not yet been quantified for the project.

Water Storage Projects

Water storage plays a critical role in the SJV for providing surface water deliveries to agricultural and municipal users, providing flood control benefits, other economic benefits, and ecosystem support. Most of the major reservoirs are located on the east side of the valley, shown on Figure 5-10. All major rivers originating in the Sierra Nevada Mountains, from the Calaveras River in the north to the Kern River in the south, have storage facilities owned and operated by the Bureau of Reclamation or the USACE. San Luis Reservoir provides off-channel storage of SWP and CVP supplies exported from the Delta and is the only major existing storage facility on the west side of the valley, as seen on Figure 5-10. The region also includes large facilities to convey water supplies to the San Francisco Bay Area, and smaller scale storage facilities used primarily to store lesser volumes of water, re-time flows through local and regional conveyance systems, provide local flood control benefits, and generate hydropower.

Several management actions and projects are available to enhance water storage in the SJV. Some strategies involve revising the operations of existing reservoirs without modifying the existing facilities. Other projects include modifying the reservoir's existing facilities to increase storage capacity or constructing new storage facilities. Potential projects and management actions are grouped into three categories for this section: (1) revised reservoir operations and improved forecasting, (2) new or expanded surface water storage projects, and (3) new or expanded groundwater storage projects. Each section explains potential benefits, implementation considerations, and opportunities associated with projects and management actions in that category.

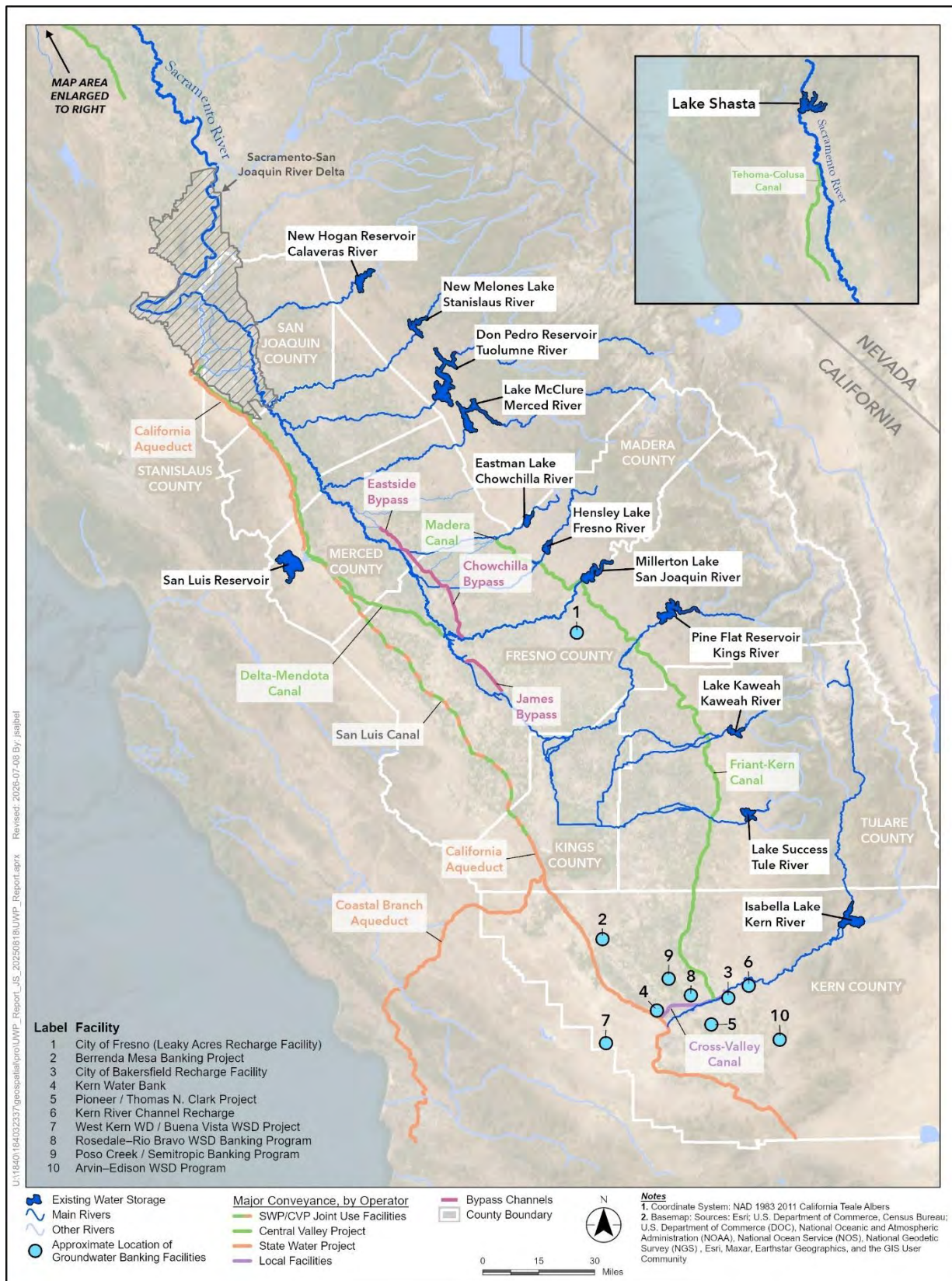


Figure 5-10. Existing Major Water Storage Facilities in the San Joaquin Valley

Revised Reservoir Operations and Improved Forecasting

DWR and other local and federal agencies have been investigating the feasibility of adjusting operations of existing reservoirs to enhance water supply, flood control, and ecosystem enhancement benefits of existing storage facilities. Revised operations, combined with improved forecasting, would allow water managers to increase releases prior to storm events. This would create available capacity for storage of flood flows when they arrive from the upper watershed. Benefits, implementation considerations, and opportunities are described below.

Benefits of Revised Reservoir Operations and Improved Forecasting

Revised reservoir operations and improved forecasting can be developed to provide a wide range of benefits, including:

- Increasing water supply, flood control, and environmental benefits without needing to invest in large capital construction projects.
- Enhanced flood control by capturing additional supplies during storm events, which also increases water supply availability.
- Enhanced ecosystem conditions that result from additional dry year releases.

Implementation Considerations

Revised reservoir operations and improved forecasting actions rely on the ability to modify existing reservoir operations and forecasting methods. The following are important considerations during the development and implementation of revised reservoir operations and improved forecasting projects:

- It requires coordination with necessary owners and operators of federal, state, and/or local storage facilities, as well as local, regional, and state agencies and/or districts that receive contracted water supplies, provide flood control, and enforce environmental requirements.

Opportunities for Revised Reservoir Operations and Improved Forecasting in the San Joaquin Valley

Opportunities for revised reservoir operations and improved forecasting in the SJV are provided below.

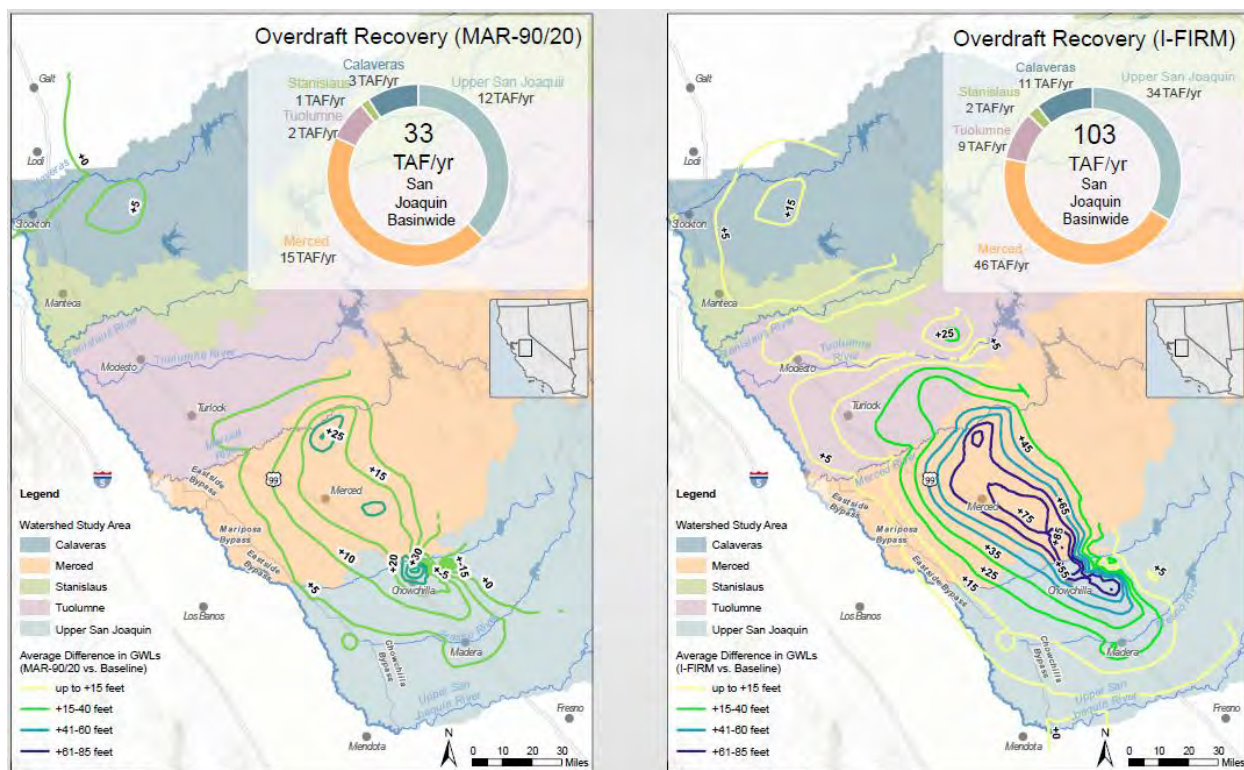
Forecast Informed Reservoir Operations

FIRO is a water management strategy that integrates advanced weather forecasting and hydrologic modeling to improve reservoir operations for both flood control and water supply. Developed through a collaborative approach between federal, state, and local agencies, FIRO enables more flexible decision making by improving forecasts and allowing water managers to better anticipate incoming storm events like atmospheric rivers. As a result, managers can preemptively release water from reservoirs to create storage space prior to the arrival of these events. This allows for increased water supply for groundwater recharge and decreased flood risk during storm events.

DWR and the Merced Irrigation District (MID) examined the potential benefit of FIRO and Flood-MAR to reduce flood risk, improve water supply, and provide ecosystem enhancements in the Merced River Watershed (DWR and MID 2024). This study evaluated varying levels of management actions including implementation of Flood-MAR (Level 1), implementation of Flood-MAR and FIRO (Level 2), and implementation of Flood-MAR, FIRO, and investments into infrastructure (Level 3). In all scenarios examined, the combination of FIRO and Flood-MAR activities lowered simulated 100-year peak flows and associated flood risks, decreased groundwater overdraft, and improved spawning habitat for fish when compared to only implementing Flood-MAR activities. DWR and MID noted the importance of continued study across the SJV.

In addition to the work performed for the Merced River Watershed, DWR has been performing additional studies throughout the SJV (not including the Tulare Lake Basin), namely the San Joaquin Basin Flood-MAR Watershed Studies (Watershed Studies). Specifically, DWR has been investigating the effectiveness of a combination of Flood-MAR, FIRO, and enhancements to existing infrastructure (together referred to as Integrated Forecast-Informed Resources Management [I-FIRM]) at reducing flood risk, improving water supply, and providing ecosystem enhancements in the Calaveras, Stanislaus, Tuolumne, Merced and Upper San Joaquin sub-basins (DWR 2025d). This study evaluated two strategies, MAR-90/20 and I-FIRM. MAR-90/20 is derived from the existing permitting guidelines governed by the State Water Resources Control Board, targeting diversions when streamflow exceeds the 90th percentile of historical daily flow and limits diversions to 20% of the available flow. I-FIRM coordinates reservoir reoperations, infrastructure improvements, and targeted recharge. Published in December 2025, results suggest that I-FIRM would deliver 410 TAF/YR of recharge, a 314 TAF/YR increase as compared to MAR-90/20's 96 TAF/YR (DWR 2025d). DWR estimates that this increase in recharge could increase future overdraft recovery by approximately 70 TAF/YR, described on Figure 5-11. Furthermore, DWR indicates that I-FIRM strategies could increase recharge while reducing peak flows at Vernalis in wet and above normal water-year types and increasing flows in dry and critical water-year types. Under I-FIRM, the net reduction in annual flow at Vernalis averages approximately 50% of the total water diverted for recharge upstream. The water recharged enters the groundwater aquifer where it slowly returns to the river system as baseflow during subsequent months and years.

During DWR's initial briefings on the expanded SJV studies, they include a call to action focused on partnerships, pilot projects, and basin wide implementation (DWR 2025d). They stress the importance of working together to implement these solutions and have highlighted the following themes that will require partnerships and creative solutions: water rights and permitting; landowner participation; flood management and reservoir operations; integrated surface and groundwater management; ecosystem protections and enhancements; and Delta operations. Expansion of the Watershed Studies to the Tulare Basin has been proposed in the past but requires state funding.



Source: DWR 2025d

Figure 5-11. Overdraft Recovery Under Flood-MAR and I-FIRM Scenarios

Snow Surveys

Local, state, and federal operations in the SJV rely upon current and projected water supplies that originate from rainfall runoff and snow melt. There remains significant uncertainty in the accurate characterization of snowpack and runoff potential due to the spatial distribution of snowpack and hydrologic modeling capabilities to accurately reflect how that snowpack will transition to runoff and ultimately be available for storage or other uses. Improving capabilities to characterize the snowpack and volume of runoff directly results in more refined operations maximizing the use of available water, improved flood risk management, environmental improvement, hydropower production, and recreation. There are several emerging technologies that will improve snowpack measurement and characterization of runoff. These include improved ground-based technologies, air and space-based technologies, and modeling capabilities.

One significant area of emerging technology is air and space-based measurements. This includes aircraft lidar (e.g., Airborne Snow Observatory [ASO]) which utilizes aircraft mounted lidar-derived snow depth, albedo estimates with modeled snow water equivalent to create fine detailed estimates of snowpack and water available for runoff. ASO has shown extremely promising results over the past decade for improving water supply forecasting for both flood risk management and agricultural water supplies. Anecdotally water supply forecasts greatly improved operations during drought years in the late 2010s and during potential flooding in 2023. Additionally, emerging technologies utilizing satellite information is showing promise that may help inform snow forecasts in the future.

Ground based measurements are the historical basis for snow water forecasting primarily through the use of the U.S. Department of Agriculture Natural Resources Conservation Service SNOwpackTELEmetry Network and Snow Course system. There are potential improvements to these networks that include snow temperature sensors and radiometers that help characterize temperatures of both the snowpack and ground. There are modeling technologies that are also improving characterization of spatially distributed snowpack. Some examples of these improvements include National Oceanic and Atmospheric Administration Snow Data Assimilation System. Universities, such as the University of Colorado have been working on statistical modeling of snow water equivalents. And there are advancements, such as iSnobal that are improving modeling of snow physics spatially. All of these technologies will help advance snow characterizations and will drive improvements in hydrologic modeling ultimately leading to better more efficient characterization of future water availability.

New or Expanded Surface Water Storage Projects

Water storage in the SJV can be enhanced through the development of new or expanded water storage projects. Over the past several decades, key initiatives to increase water storage in the Central Valley included CALFED and the Water Storage Investment Program (WSIP). CALFED was initiated in 1995 with the objective to resolve water resources conflicts in the Bay-Delta, focusing on ecosystem health, water quality, and water supply reliability (CRS 2005). The CALFED Programmatic Record of Decision identified five surface storage projects for further consideration (1) In-Delta storage project, (2) expand CVP storage in Shasta Lake, (3) expand Los Vaqueros, (4) Sites Reservoir, and (5) additional storage in the upper San Joaquin River watershed (CALFED 2000).

WSIP was established by Proposition 1, approved by California voters in 2014, to allocate \$2.7 billion in non-reimbursable funds toward the public benefits to be provided from new water storage projects. Public benefits were defined as ecosystem enhancement, flood risk reduction, recreation, water quality improvement, and emergency water supplies (CWC 2025a). The California Water Commission, responsible for the administration of WSIP, approved conditional funding for eight water storage projects in 2017 (four surface water and four groundwater) that would provide water supplies and public benefits to the SJV and elsewhere in California.

To date, three of the four WSIP surface water projects that would have provided water supply and/or ecosystem benefits to the SJV have been withdrawn by the proponents – Temperance Flat Reservoir (identified as Upper San Joaquin River Basin Storage Investigation in the CALFED Record of Decision (ROD)), the Los Vaqueros Reservoir Expansion (also identified in the CALFED ROD), and the Pacheco Reservoir Enlargement Project (a recommended alternative from studies of the San Luis Reservoir Low Point Improvement Project, also identified in the CALFED ROD). Remaining WSIP storage projects that would potentially provide water supplies to the SJV include Sites Reservoir in the Sacramento Valley (identified in the CALFED ROD) and the Kern Fan Groundwater Storage Project.

Benefits of Water Storage Projects

New or expanded water storage projects can be developed to provide a wide range of benefits, including:

- Enhanced ecosystem conditions that result from appropriate timing and temperature of environmental flow releases from surface water storage facilities.
- Decreased evacuation of water storage for fixed flood control purposes.
- Increased capture and storage of runoff and flood flows, increasing water availability, flexibility, and reducing flood risk.
- Increased hydroelectric power generation from surface water storage facilities.
- New opportunities for recreational activities associated with surface water storage facilities.

Implementation Considerations

The following are important considerations during the development and implementation of new or expanded water storage projects:

- It requires coordination with necessary federal, state, and/or local agencies that oversee facilities and permits, as well as local, regional, and state districts that receive contracted water supplies.
- If modifying existing facilities, it complicates and/or limits the delivery of water to users that rely on the existing facilities.
- It requires the consideration of potential future stressors on water storage systems and surrounding lands during the planning and design process, including but not limited to: subsidence, climate variability, regulatory requirements, and changing demands.
- It may require special attention to environmental effects to vegetation and wildlife due to the modification of a river system's flow.
- SGMA and associated pumping restrictions can complicate the operation of groundwater storage projects.

Opportunities for Water Storage Projects

Opportunities for new or expanded water storage projects are presented below in three categories: (1) local storage projects, (2) new or increased capacity in the SJV, and (3) new or increased capacity north of the Delta. Figure 5-12 shows the locations of potential large water storage projects in the SJV.

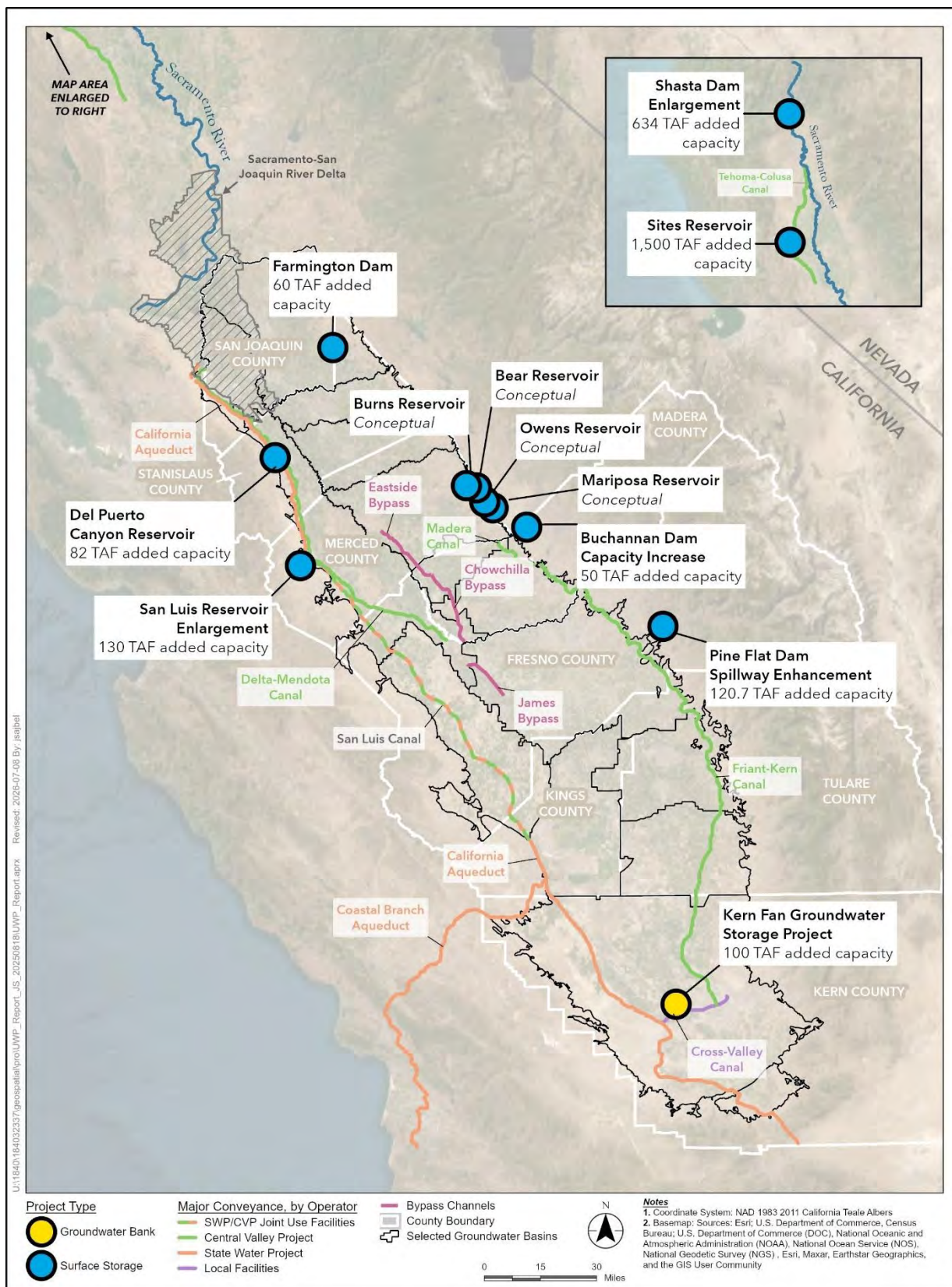


Figure 5-12. Proposed Large Water Storage Projects

Local Water Storage Projects

GSA in the SJV have identified more than 30 projects in the GSPs that increase local storage capacity within their subbasins (Table 5-12). Projects in this category include the following types:

- Enlarge existing or construct new storage facilities (e.g., reservoirs and tanks) and regulating reservoirs that capture additional surface water supplies, allow for improved conjunctive management of surface and groundwater supplies, and/or increase flood protection.
- Modification of outlet works of existing facilities to allow for better control of water supply to meet demands, provide flood control, and manage water for groundwater recharge.
- New or enhanced facilities to manage runoff and floodflows.
- Transitional storage.

Capital costs and potential annual yield estimates are provided for approximately 30 of these projects, as summarized by subbasin in Table 5-12. It is unclear in the GSPs to what extent these local surface water storage projects would also require additional projects to convey, distribute, and/or recharge groundwater to realize reported benefits. All local storage projects identified in the GSPs are retained for further inclusion in UWP strategies. The GSPs are the primary source of local projects and incorporate projects identified through other planning efforts, such as IRWMPs. As such, they were assumed to provide the most current representation of local project planning.

Table 5-12. Summary of Surface Water Storage Projects with Known Costs and Yields

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin		0	-	-
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	1	1	0.9	8.9
Turlock	4	2	7.4	19.8
Merced	11	1	0.9	0.8
Chowchilla	-	-	-	-
Madera	-	-	-	-
Westside	-	-	-	-
Pleasant Valley	-	-	-	-
Tulare Lake	3	3	43.0	164.3
Kings	-	-	-	-
Kaweah	2	2	4.2	8.5
Tule	2	1	1.4	7.7
Kern	9	7	6.4	96.7
White Wolf	1	1	0.5	11.9
Total ³	34	18	64.6	318.5

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of surface water storage projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

New or Increased Water Storage Capacity in the San Joaquin Valley

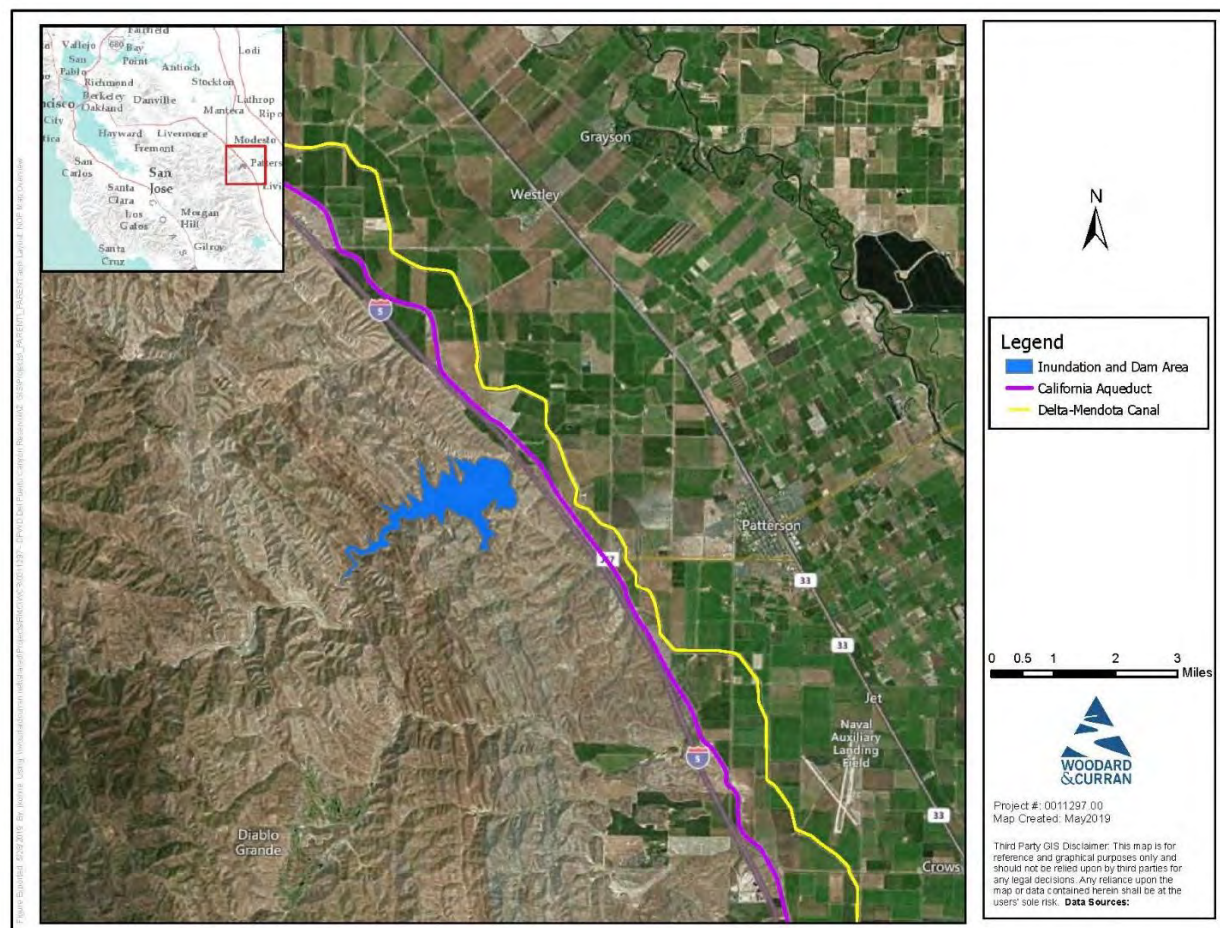
CVP and SWP facilities pump water from the Delta, when conditions allow, and convey water through the SJV where portions are stored water until it is needed. SWP and CVP facility operations are coordinated with one another to obtain maximum yields (Reclamation 2022). In wet years, storage facilities South of Delta frequently fill to capacity and pumping is curtailed because all immediate SWP and CVP demands have been met (DWR 2025b). New or increased South of Delta capacity creates additional opportunities to store CVP and SWP water when conditions allow.

Del Puerto Canyon Reservoir

The Del Puerto Canyon Reservoir Project is a proposed off-stream storage project near the town of Patterson, shown on Figure 5-13. The project is currently being pursued by the Del Puerto Water District and the San Joaquin River Exchange Contractors Water Authority. The Del Puerto Water District completed an initial study in 2019 and a Final EIR in October 2020.

As currently configured, the project includes: an off-stream reservoir with a proposed storage capacity of about 82 TAF, conveyance facilities to transport water to and from the DMC, and utilities relocations. The proposed reservoir would receive CVP water supplies from the Delta-Mendota Canal when available during wet periods to store for later usage (DPWD 2020). The project would provide water supply benefits for agriculture, supplement existing deliveries to wildlife refuges, as well as provide flood control benefits on the Del Puerto Creek, which would benefit downstream communities like Patterson. The total project costs were estimated to be approximately \$1,350 million dollars in Q4 2025 dollars (CWC 2021), and the estimated yield is 55 to 60 TAF/YR (DPWD 2025).

In October 2022, the Stanislaus County Superior Court ordered the Del Puerto Water District to decertify the EIR and vacate approval of the project. The court declared that the planned relocation of Canyon Road, which was developed at a conceptual level in the Final EIR, was not adequate (Modesto Bee 2022a). In early 2025, a new road alignment of Del Puerto Canyon Road was proposed, and the court decision was overturned. The ruling requires additional work on the Final EIR (Modesto Bee 2025). The project is being advanced by the project proponents and is retained as part of the consideration of the UWP.

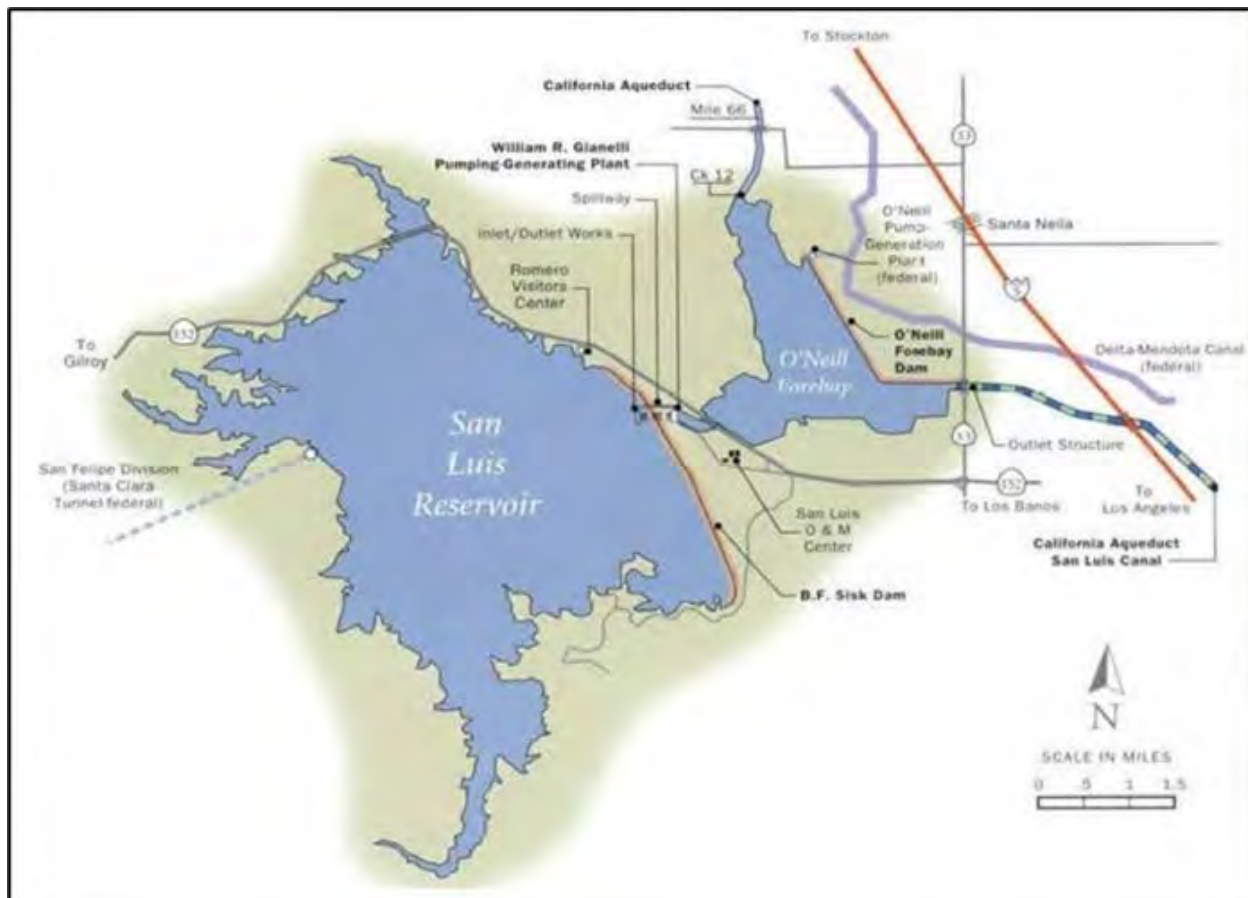


Source: DPWD 2020 Figure ES-1

Figure 5-13. Del Puerto Canyon Reservoir Project Map

San Luis Reservoir Enlargement

B.F. Sisk Dam is the 380-foot-high earthfill embankment that impounds the off-stream San Luis Reservoir, described on Figure 5-14. The dam's construction concluded in 1967 and provides 55% of its storage for SWP supplies and 45% for CVP supplies (Reclamation 2025a). A 2006 risk analysis of B.F. Sisk Dam concluded that action is required to reduce risk to the downstream public during a seismic event. The 2019 B.F. Sisk Dam Safety of Dams Modification Final EIS/EIR selected an alternative that raises the dam's crest elevation 12 feet to increase freeboard, preventing reservoir overtopping and failure. The construction is moving forward with a 10-foot increase to the dam (Reclamation 2023). This alternative does not provide additional storage capacity. PL 114-113 authorized Reclamation to develop additional project benefits, such as increased storage capacity, in conjunction with the B.F. Sisk Dam Safety of Dams Modification project (Reclamation 2019).

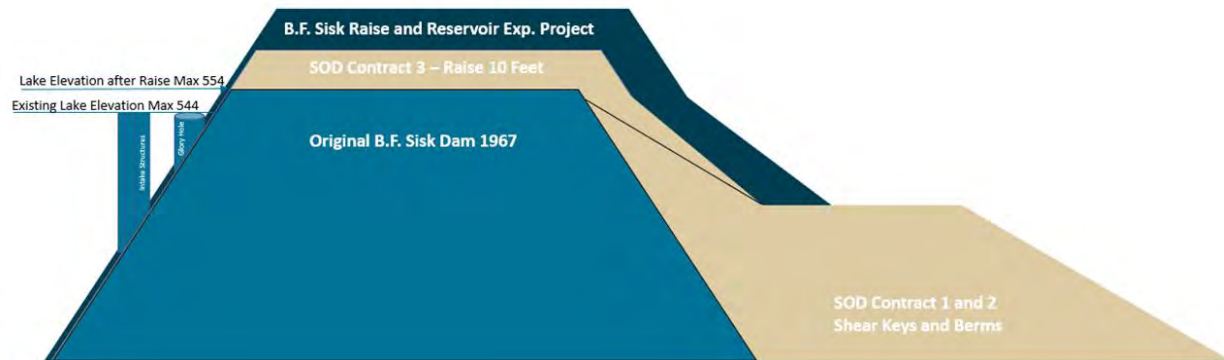


Source: Reclamation 2025b

Figure 5-14. San Luis Reservoir and Associated Facilities

While implementing the Sisk Dam modifications, the San Luis Reservoir Expansion Project is being led by Reclamation in collaboration with DWR and local agencies (Reclamation 2025b). The project involves raising the B.F. Sisk Dam by 10 feet, in addition to the 10-foot Sisk Dam modification as shown on Figure 5-15, increasing the capacity of San Luis Reservoir by approximately 130 TAF. The increased capacity will increase the water supply reliability of existing CVP municipal, agricultural, and environmental water users by approximately 53 TAF/YR. The San Luis Reservoir Expansion

Project includes seismic retrofitting the dam to improve safety, and the rerouting of Highway 152. The total estimated cost is around \$990 million in Q4 2025 dollars, with 30% funded by federal sources, and the remaining 70% from state and local agencies (Valley Water 2024; Reclamation 2025b). Construction of the San Luis Reservoir Expansion is in progress and scheduled to be completed in the early 2030s. Once the project is finished, it will provide long-term water supply benefits by enabling greater water capture during wet years improving water supply reliability to users south of the Delta (Reclamation 2025b).



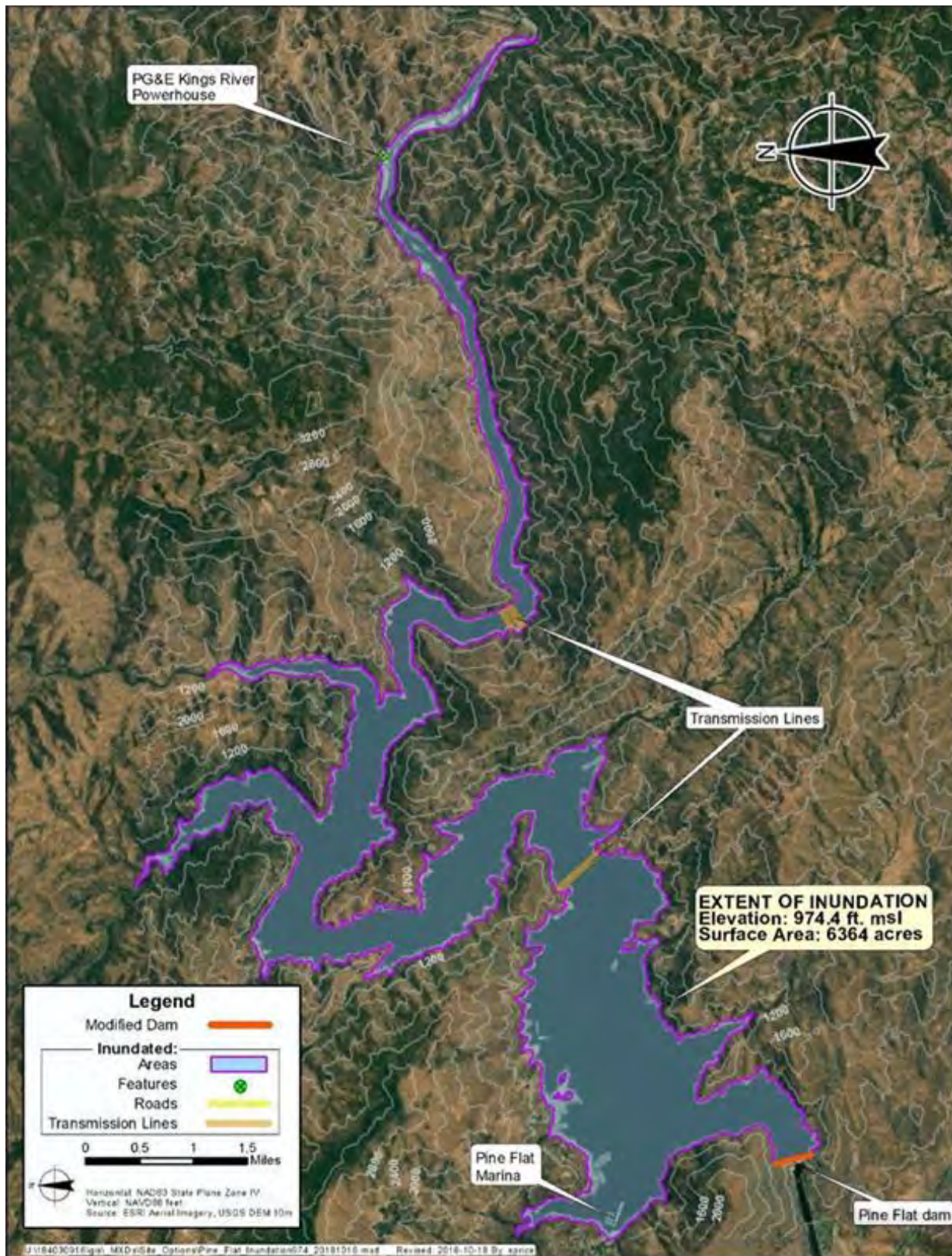
Source: Reclamation 2025b

Figure 5-15. San Luis Reservoir Enlargement and B.F. Sisk Dam Modification

Pine Flat Dam Spillway Enhancement

The Pine Flat Dam Project was constructed pursuant to the Flood Control Act of 1944 in which the U. S. Congress authorized ninety projects throughout the United States for design, construction and operation by the USACE (Kings River Water Users Committee 1979). Completed in 1954, Pine Flat Dam, shown on Figure 5-16, is 429-foot tall dam on the Kings River, and its maximum capacity is about 1,000 TAF (USACE 2025). Pine Flat Dam is in the Kings River watershed approximately 25 miles east of Fresno, California.

Authorized for initial study in the Water Resources Development Act (2024), the proposed Pine Flat Dam Spillway Enhancement would be a 12-foot raise to the spillway, increasing the reservoir's storage capacity by approximately 120.7 TAF. The spillway enhancement is estimated to cost \$1 billion in Q4 2025 dollars (KRCD 2025). The increased capacity improves water storage, increased flood protection, flexibility for water users, hydroelectric power generation, and environmental benefits of downstream riverine habitat. The authorization requires a federal feasibility study to be conducted. The Kings River Conservation District applied for federal funding for the U.S. Army Corps of Engineers' 3x3x3 program for fiscal years 2026 and 2027. The program supports federal feasibility study completion in three years at a cost of less than \$3 million (KRCD 2025).



Source: KRCD 2020

Figure 5-16. Pine Flat Dam Spillway Enhancement

Buchanan Dam Capacity Increase

The Buchanan Dam Capacity Increase Project proposes enlarging Buchanan Dam, which is owned and operated by the USACE, to increase the storage capacity of Eastman Lake from 150 to 200 TAF (Chowchilla Subbasin GSP Advisory Committee 2025). The dam crest and spillway would be raised 24 feet, and a new saddle dam would be constructed to maintain the flood pool capacity in Eastman Lake, while increasing the storage pool for Chowchilla Water District (CWD). The objective of the proposed project is to increase surface water deliveries to CWD and decrease groundwater pumping to meet demand. This project is a key component of the CWD's strategy to reduce groundwater overdraft and improve long-term water supply reliability.



Source: USACE 2026

Photo 8. Eastman Lake and Buchanan Dam Intake Tower

Implementation would involve design, permitting, environmental documentation, and construction. The planning phase, which would include everything but construction, is anticipated to begin in 2025 and be completed by 2037. The permitting would be complex and would require approvals from local, state, and federal agencies. It is assumed construction would take 3 years and be completed in 2040. The total capital cost is estimated to be approximately \$51 million in Q4 2025 dollars and would provide an average annual benefit of approximately 8.8 TAF/YR. The average annual operation and maintenance cost would be approximately \$0.2 million.

Farmington Reservoir Enlargement

This project, shown on Figure 5-17 recommended for study in the Eastern San Joaquin GSP (see Appendix A), would convert Farmington Dam, currently a flood detention dam, for long-term water supply storage. The existing Farmington Reservoir has a flood control capacity of 52 TAF. The proposed project would increase the total reservoir capacity to 112 TAF which includes 60 TAF for water supply and 52 TAF for flood control. The water supply could be stored and used in drought conditions. The increased water supply would also encourage growers to switch to surface water irrigation instead of reliance on groundwater. USACE completed a reconnaissance report in 1997 with an estimated cost of \$91.4 million based on an effective pricing date of October 1996. Including environmental and cultural resources mitigation costs, which were not included in the 1997 study, the cost today would be approximately \$185 million in Q4 2025 dollars.



Source: Stockton East Water District 2025

Figure 5-17. Farmington Reservoir Enlargement Map

Mariposa Reservoir Enlargement and Downstream Levee and Channel Improvements

This project was recommended for study in the Merced GSP (see Appendix A) and described in Merced's 2018 Integrated Regional Water Management Plan (Merced IRWMP 2018). Mariposa Reservoir was constructed in the early 1950s as an element of the Merced Streams Group Project authorized by Congress's 1944 Flood Control Act. The Flood Control Act of 1970 called for three additional flood control reservoirs, enlargement of existing reservoirs, and 52 miles of levee and channel modifications. To date only one additional reservoir has been built (Castle Dam). The enlargement of Mariposa Reservoir and downstream levee and channel improvements would increase the level of flood protection to Planada and Le Grand. Both are disadvantaged communities in Merced County. Mariposa Reservoir was originally constructed to provide protection for up to a 50-year storm event. In 2007, the State of California adopted legislation (Senate Bill (SB) 5) that calls for a minimum of 200-year flood protection for urbanized areas. This project would meet the requirements of the new flood control legislation (Merced IRWMP 2018). The project would cost approximately \$15.5 million in Q4 2025 dollars.

Owens Reservoir Enlargement and Downstream Levee and Channel Improvements

This project was recommended for study in the Merced GSP (see Appendix A) and described in Merced's 2018 Integrated Regional Water Management Plan (Merced IRWMP 2018). Owens Reservoir was constructed in the early 1950s as an element of the Merced Streams Group Project

authorized by Congress's 1944 Flood Control Act. The enlargement of Owens Reservoir and downstream levee and channel improvements would increase the level of flood protection to Planada and Le Grand, both disadvantaged communities. Owens Reservoir was originally constructed to provide protection for up to a 50-year storm event. In 2007, the State of California adopted legislation (SB 5) that calls for a minimum of 200-year flood protection for urbanized areas. This project would meet the requirements of the new flood control legislation (Merced IRWMP 2018). The project would cost approximately \$15.5 million in Q4 2025 dollars.

Bear Reservoir Enlargement and Downstream Levee and Channel Improvements

This project was recommended for study in the Merced GSP (see Appendix A) and described in Merced's 2018 Integrated Regional Water Management Plan (Merced IRWMP 2018). Bear Reservoir was constructed in the early 1950s as an element of the Merced Streams Group Project authorized by Congress's 1944 Flood Control Act. The enlargement of Bear Reservoir and downstream levee and channel improvements would increase the level of flood protection to the most populated areas of Merced County. Bear Reservoir was originally constructed to provide protection for up to a 50-year storm event. In 2007, the State of California adopted legislation (SB 5) that calls for a minimum of 200-year flood protection for urbanized areas. This project would meet the requirements of the new flood control legislation (Merced IRWMP 2018). The project would cost approximately \$21 million in Q4 2025 dollars.

Burns Reservoir Enlargement and Downstream Levee and Channel Improvements

This project was recommended for study in the Merced GSP (see Appendix A) and described in Merced's 2018 Integrated Regional Water Management Plan (Merced IRWMP 2018). Burns Reservoir was constructed in the early 1950s as an element of the Merced Streams Group Project authorized by Congress's 1944 Flood Control Act. The enlargement of Burns Reservoir and downstream levee and channel improvements would increase the level of flood protection to the most populated areas of Merced County. Burns Reservoir was originally constructed to provide protection for up to a 50-year storm event. In 2007, the State of California adopted legislation (SB 5) that calls for a minimum of 200-year flood protection for urbanized areas. This project would meet the requirements of the new flood control legislation (Merced IRWMP 2018). The project would cost approximately \$15.5 million in Q4 2025 dollars.

Tuolumne River Water Supply Augmentation and Enhanced Flood Control

Turlock Irrigation District and other local entities are evaluating a range of water storage options that would increase water supplies available from the Tuolumne River while increasing flood protection. Options under consideration include raising the spillway at New Don Pedro Dam, raising Tulloch Dam, constructing one or more new off stream reservoirs, and constructing an intertie between Don Pedro Lake and New Melones Lake (TID 2025).

The Turlock Irrigation Intertie Project was recommended in the 2025 Central Valley Water Solution Act (U.S. House of Representatives 2025). The Central Valley Water Solution Act requested \$800 million in non-reimbursable funds to support this project. This project would connect New Melones Reservoir to Don Pedro Reservoir. Identified previously by Modesto Irrigation District and Turlock Irrigation District, the northernmost arm of Don Pedro Reservoir could be connected to the southern end of New Melones Reservoir via pipeline or tunnel (Modesto Bee 2022b). Connecting

the two would increase water management opportunities to move water from the larger New Melones Reservoir to the smaller Don Pedro Reservoir.

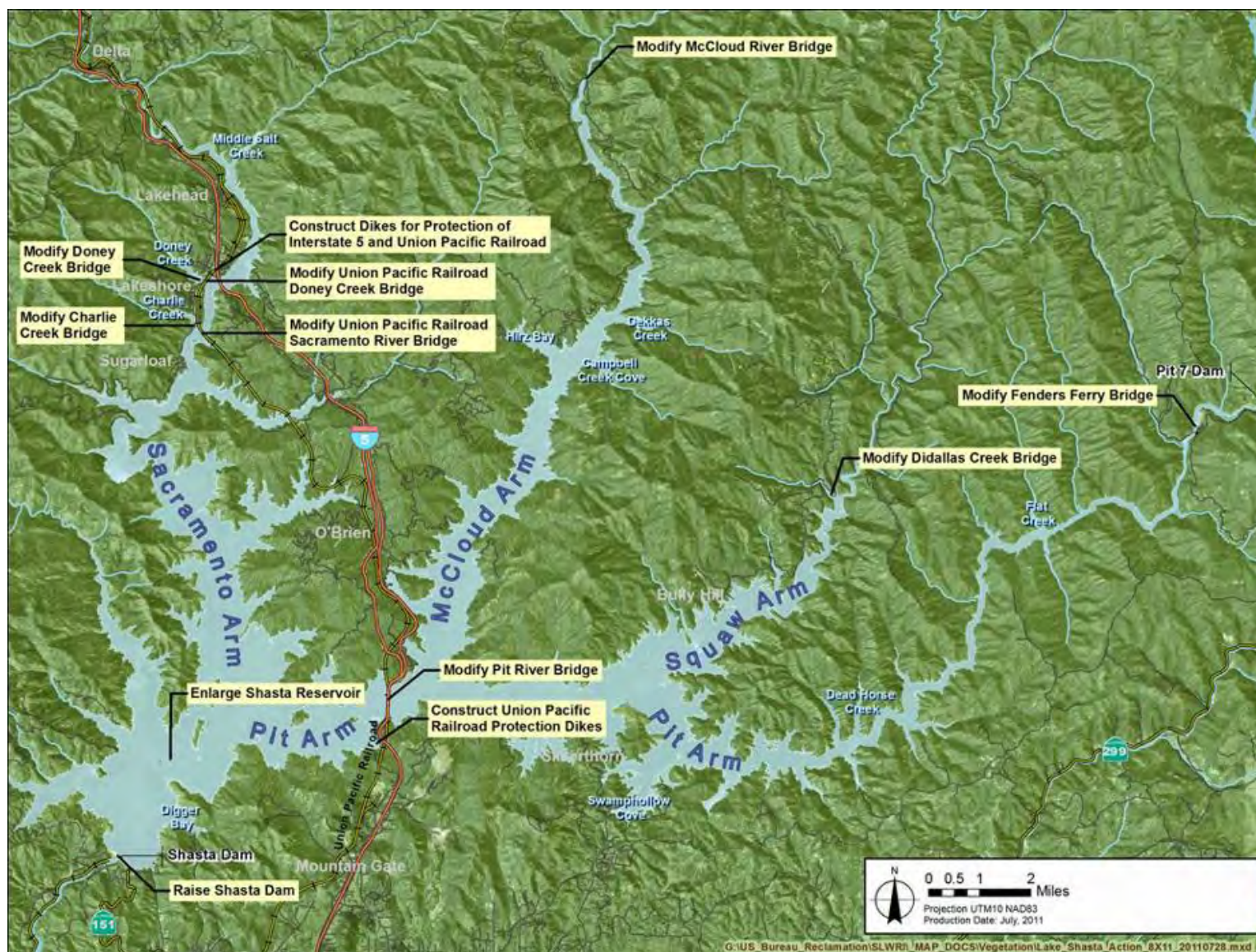
New or Increased Surface Water Storage Capacity North of Delta

North of Delta capacity enables the capture of Sacramento River Watershed water, which is the largest surface water resource in California and accounts for one-third of total runoff water into the Delta (Reclamation 2020). The opportunity to increase capacity North of Delta would improve CVP/SWP operations and increase water supply reliability. The following projects have been recently considered by either federal, state, or local proponents for increasing storage North of Delta.

Shasta Dam Enlargement

The Shasta Lake Dam and Reservoir Enlargement idea was authorized for feasibility study in 1980 by PL 96-375. In 2000, the Shasta Lake Water Resources Investigation was one of five recommended water storage studies in the CALFED Bay-Delta Program Programmatic EIS/EIR and Programmatic ROD (Reclamation 2015). In 2004, Feasibility authorization was granted under PL 108-361 to use the CALFED ROD as a general framework. Following this decision, Shasta Dam had multiple reports published leading to the 2015 Feasibility Report/EIS, which recommended the 18.5-foot dam raise with focus on fish survival alternative. The Water Infrastructure Improvements Act for the Nation (PL 114-322) was passed in December 2016 and appropriated \$20 million for Shasta pre-construction activities (Reclamation 2018).

The proposed Shasta Dam and Reservoir Enlargement project would raise Shasta Dam by up to 18.5 feet increasing the storage capacity of Shasta Reservoir by up to 634 TAF, increasing the regulated supply for water users and the environment, especially benefiting Sacramento River temperatures and water quality below the dam to improve anadromous fish survival. The recommended alternative would reserve 191 TAF for additional storage for cold water supply for anadromous fish, and restores riparian, floodplain, and side channel habitat along the upper Sacramento River. The project would also have power generation and flood protection benefits. An overview of project facilities is shown in Figure 5-18. The total cost of the project was estimated to be approximately \$2,100 million in Q4 2025 dollars, with an estimated average annual yield of 14.4 to 31.3 TAF/YR, representing about 45% of the water supply benefits. The project had a 1.5 benefit-cost ratio (2014 dollars) (Reclamation 2015). Total cost borne and benefits realized by water users in the SJV would likely be less than the project's total cost and average annual yield, as the water users in the SJV are not the only project proponents.



Source: Reclamation 2015, Figure 4-1

Figure 5-18. Major Features of Shasta Dam Enlargement

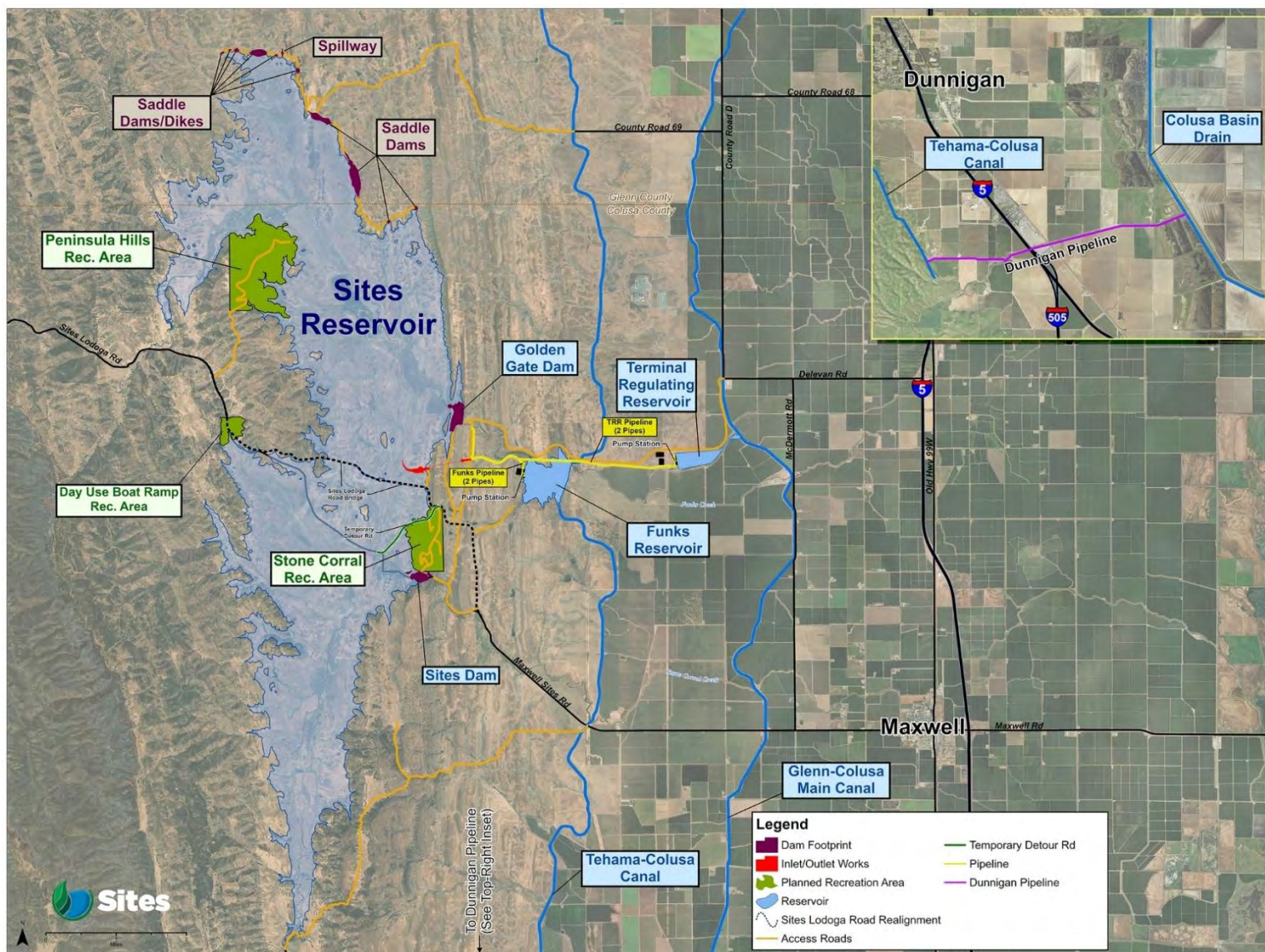
Sites Reservoir

Sites Reservoir, originally proposed by Reclamation in 1964, is a proposed off-stream reservoir that would store water pumped from the Tehama-Colusa Canal in the winter and spring seasons (DWR 1981). In 2000, Sites Reservoir, also known as the North-of-Delta Offstream Storage Investigation, was one of five recommended water storage studies in the CALFED Bay-Delta Program Programmatic EIS/EIR ROD (Reclamation 2015). In 2014, the California Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1) allocated \$2,700 million to water supply infrastructure projects. The California Water Commission conditionally determined that Sites Reservoir could receive up to \$816 million under Proposition 1 (Prop 1). Under the Water Infrastructure Improvements for the Nation Act (WIIN Act) (Public Law 114-322), the Secretary of the Interior can participate in up to 25% of the total cost of a state-led project.

Pursuant to NEPA, a Draft EIR/EIS was released for public review and comment in 2017. Consistent with the requirements of the WIIN Act, and to accompany the Draft EIR/EIS, Reclamation completed a Final Feasibility Report for the North-of-Delta Offstream Storage Investigation (Reclamation 2020). A Value Planning Alternatives Appraisal Report was completed in 2020 and reduced the size of the reservoir's capacity (Sites 2020). A Revised Draft EIR/Supplementary Draft EIS based on the Value Planning Report alternatives was released in 2021, and the Final EIR/EIS was published in 2023 (Sites 2023).

Currently, Sites Reservoir is being proposed as a 1,500 TAF offstream reservoir on the west side of the Sacramento Valley, 10 miles west of the town of Maxwell. It would be filled from the Sacramento River via the Tehama-Colusa Canal. The reservoir is shown in Figure 5-19. Reclamation could have an investment of up to 25%, resulting in up to 25% of Sites Reservoir storage space being dedicated to Reclamation's use to meet CVP objectives of water supply reliability and environmental needs (Sites 2023). Currently, the project is expected to cost approximately \$6,300 – 6,900 million in Q4 2025 dollars (Sites 2025a). The estimated average annual yield is in the order of 250 TAF/YR, but the actual yield would depend on how participants manage their share of the project (Sites 2023). Total cost borne and benefits realized by water users in the SJV would likely be less than the project's total cost and average annual yield, as the water users in the SJV are not the only project proponents.

The process of securing necessary environmental permits, selecting contractors, and purchasing land to construct Sites Reservoir has begun (Sites 2025b; Sites 2024). The California Water Commission announced an inflationary increase, increasing Sites Reservoir's maximum eligibility under Prop 1 to \$1,094 million, and awarded \$10.9 million in early Prop 1 funding for work on permitting and environmental documents (Sites 2025c; Sites 2025d). Sites Reservoir received an additional \$134 million in federal funding under the WIIN Act, with total federal contributions of \$780 million as of March 2025 (Sites 2025e). Sites Reservoir is anticipated to be operational around 2032 (Sites 2025a).



Source: Sites 2025f

Figure 5-19. Sites Reservoir Project Map

New or Expanded Groundwater Storage Projects

Groundwater banking is a form of water storage that uses conveyance and recharge facilities to infiltrate water to be stored in a groundwater aquifer. These “deposits” are managed as credits. Then, dedicated extraction facilities and/or exchanges are used to recover water stored in the groundwater aquifer for later use. These “withdrawals” are managed as debits. Groundwater banks are often managed to provide a net-benefit to the subbasin (i.e., withdrawals are often limited to a portion of deposits) resulting in an increase of water in storage. In a typical scenario, water is delivered to banks when excess supplies are available during wetter periods and withdrawn during drier periods when supplies are limited. Benefits, implementation considerations and opportunities for groundwater storage projects are detailed below.

Benefits of Groundwater Storage Projects

Groundwater storage projects can be developed to provide a wide range of benefits, including:

- Aquifer replenishment through the managed delivery and percolation of water supplies, new opportunities for groundwater sustainability associated with exchange ratios and/or “leave behinds” on groundwater storage projects.
- Potential to raise groundwater levels thereby reducing pumping costs.
- Reduced flood risk by providing a storage location for flood water.
- Sustained agricultural productivity.
- Ecosystem enhancement by integrating the creation of valuable habitat for water-dependent wildlife in the facility design and operation.
- Recreation benefits by storage projects that can be used for recreational activities like walking, birdwatching, or sports during dry periods.

Implementation Considerations

The following are important considerations during the development and implementation of groundwater storage projects:

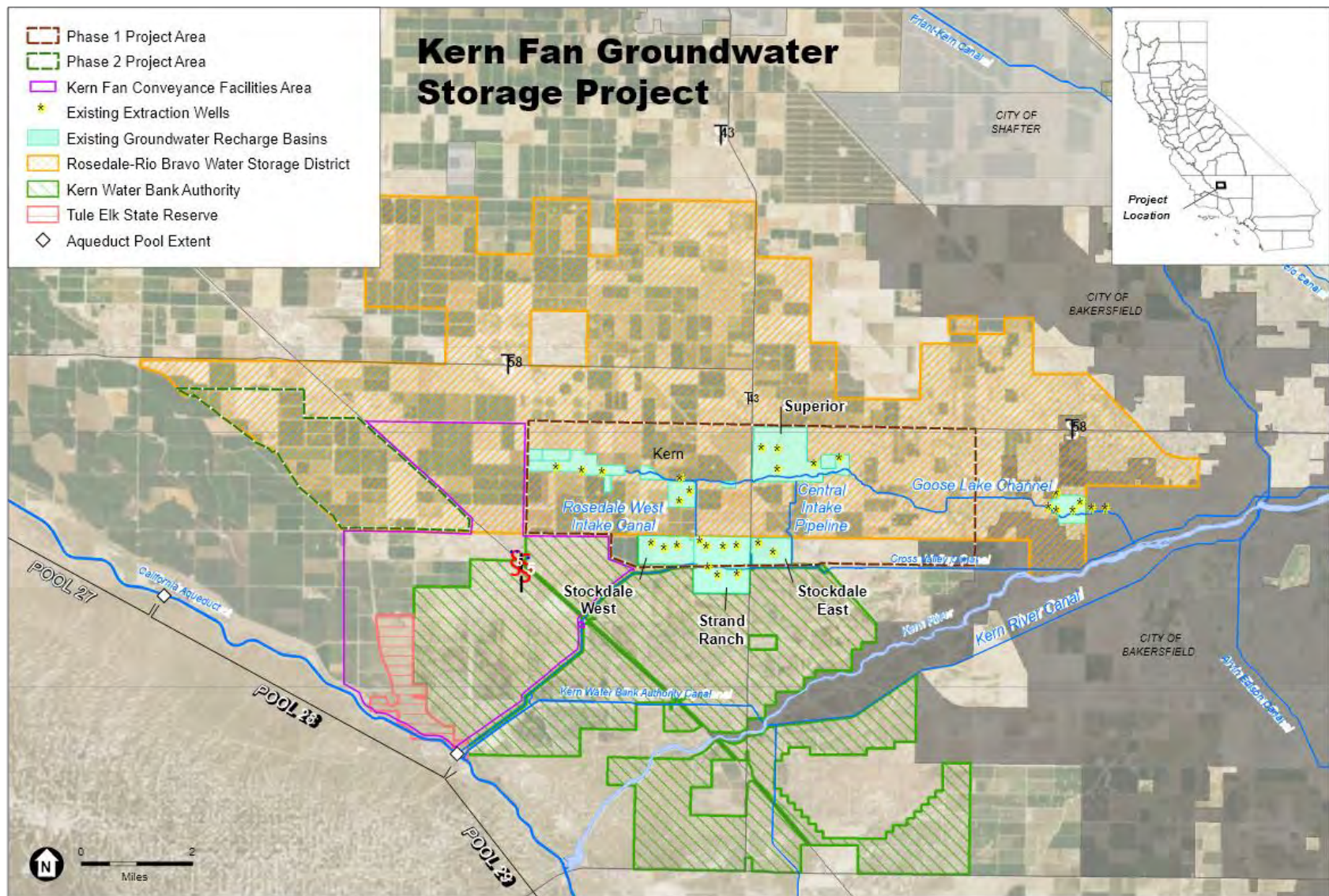
- It requires purchasing or otherwise acquiring land with favorable groundwater recharge suitability in areas that can provide recharge at desired aquifer locations and levels.
- It can require modifications to delivery systems and construction of groundwater storage on acquired land.
- It requires thoughtful implementation because of the potential to mobilize into the aquifer contaminants suspended in the shallow subsurface (e.g., nitrates, pesticides, etc.).

Opportunities for Groundwater Storage Projects

Groundwater banking programs have been established throughout the SJV from Kern County to San Joaquin County. The GSPs in the SJV identified infrastructure to increase groundwater recharge capabilities that can increase the amount of managed groundwater banking projects. The WSIP program had several projects that involved the infrastructure to develop groundwater banking, the only project located in the SJV was the Kern Fan Groundwater Storage Project. Lawmakers have highlighted the need for additional groundwater storage projects, specifically calling out projects in H.R. 6641 (U.S. House of Representatives 2025).

Kern Fan Groundwater Storage Project

The Kern Fan Groundwater Storage Project, selected for funding under Proposition 1 under the WSIP, is a proposed regional water bank in the Kern Subbasin, west of Bakersfield, with storage capacity of 100 TAF. The Kern Fan Groundwater Storage Project would consist of construction of up to 1,300 acres and include 12 recovery wells. (Kern Fan Project 2025). The project is being proposed by the Groundwater Banking Joint Powers Authority that is made up of the Rosedale-Rio Bravo Water Storage District and the Irvine Ranch Water District. The groundwater bank would use unallocated SWP Article 21 water, in wetter hydrologic conditions, when it can be conveyed through the California Aqueduct. The water would be recovered during dryer hydrologic periods by the members of the Groundwater Banking Joint Powers Authority. A 25% portion of the storage volume of the project is dedicated to supporting ecosystem benefits and emergency response through exchange of banked water supplies. The project includes newly constructed recharge basins, recovery wells, conveyance facility, and new turnout from the California Aqueduct. The total project cost is estimated at \$370 million in Q4 2025 dollars (CWC 2024; CWC 2025b). The general location of the project is shown Figure 5-20.



Source: Kern Fan Project 2025

Figure 5-20. Kern Fan Groundwater Storage Project

Other Groundwater Storage and Banking Projects

The SJV's vast aquifer capacities create ideal physical conditions for storing and recovering large volumes of water in the subsurface, especially in areas with near-surface soil characteristics that favor groundwater recharge (i.e., areas with high SAGBI values). Groundwater storage projects take advantage of these conditions to store access water supplies recharged during wet years for extraction (via pumping) and use during dry years.

The GSPs, as discussed in above sections, identified infrastructure to increase groundwater recharge capabilities. The Central Valley Water Solution Act, introduced in 2025, identified additional groundwater storage and recharge projects (U.S. House of Representatives 2025):

- Westlands Water District Recharge Basins
- East San Joaquin Valley Groundwater Banking and Storage Program
- Lindsay-Strathmore Irrigation District– Rancho de Kaweah Groundwater Bank
- Pixley Irrigation District Joint Groundwater Bank
- Shafter-Wasco Irrigation District Annex Groundwater Bank
- City of Tracy Aquifer Storage and Recovery Program

Most groundwater projects described in GSPs for SJV basins are based on providing recharge for aquifer replenishment to improve local groundwater management toward achieving sustainable management practices. There may be opportunities to reconsider some of these projects in support of groundwater banking. During wet years, allocated water supplies to CVP or out-of-basin SWP contractors that exceed their annual needs could be banked within SJV aquifers. Groundwater banking agreements would likely require some percentage of banked supply to remain in the aquifer as “leave-behind,” creating mutual benefits for both parties. The adaptation of groundwater recharge projects to groundwater banking features will require careful consideration of aquifer physical and water quality conditions, conveyance facility requirements, and operational guidelines.

Transitional Storage

Transitional storage is the temporary holding of water within natural or engineered features that slows runoff and reduces peak flows before the water continues downstream. Transitional storage can be used in the SJV to capture excess flood water, allow for storage and infiltration, and then release water bank downstream. Transitional storage could occur in floodplains, flood bypasses, agricultural fields, recharge basins, or detention ponds. Neither costs nor benefits of transitional storage have been quantified for projects in the SJV in this document.

Floodplain Expansion

Similar to both flood bypass channels and transitional storage, floodplain expansion intentionally increases the area available for rivers to spread out and be stored during high flows, rather than confining water within narrow leveed channels. Water would leave the main channel to spread



across a widened floodplain, leading to attenuated peak flows and temporary storage before returning to the river downstream or infiltrating into the ground. Neither costs nor benefits of floodplain expansion have been quantified for projects in the SJV in this document.

Other Water Supply Projects and Actions

Other water supply projects and actions can generally be described as projects that do not fall into the major project types identified above (recharge, conveyance, and storage). These other projects include upper watershed management activities, as well as projects like recycled water projects, reclaimed water projects, and other projects that are largely implementable at a local level. Potential projects are grouped here into two categories: (1) upper watershed management and (2) local water supply projects and actions, which are further delineated by project type.

Upper Watershed Projects and Management Actions

Activities in the upper watershed of the SJV (e.g., areas in the Sierra Nevada Mountains above the major storage reservoirs) can influence the timing and quantity of water supplies available in the lower watershed. These upper watershed management projects and actions typically involve activities that improve the health of the upper watershed ecosystems and, as a result, runoff conditions. Potential benefits, implementation considerations, and opportunities for upper watershed management are outlined below.

Benefits of Upper Watershed Management

Upper watershed management techniques can be developed to provide a wide range of benefits, including:

- Improved runoff conditions including the quantity, timing, and quality of runoff.
- Improved forest health including habitat, ecosystem, and fire management benefits.
- Opportunity to work with multiple groups and entities to identify funding sources for these projects that provide forest health and water supply benefits.

Implementation Considerations

The following are important considerations during the development and implementation of upper watershed management techniques:

- It requires coordination across multiple groups and agencies potentially at the local, state and federal level.
- To the extent that these projects increase the volume of water supply available, additional coordination and/or action (e.g., projects) from local, state, and federal agencies will be necessary to deliver water to users.

Opportunities for Upper Watershed Management

Projects and management actions that result in healthy meadows and well-managed forests in the upper watersheds are necessary for improving water resources conditions in the SJV. Upper watershed ecosystems influence the timing, quantity, and quality of runoff from headwater areas, directly affecting inflows to reservoirs and other water supplies. Healthy forests provide quantity and supply benefits by limiting evapotranspiration losses and stabilizing soils, while healthy meadows control runoff. These healthy ecosystems create a complementary system that enhances water resources conditions under variable hydrologic conditions, as described below.

Healthy meadows act as natural detention basins, storing water during wet periods and gradually releasing it during dry months (DWR 2025e). Their shallow, meandering channels and natural features slow runoff, enhance infiltration, and improve downstream water quality. Meadows that are shallow, meandering, and contain impervious features such as logs or rocks naturally slow water, allowing water to infiltrate and slow its movement through the watershed (USFWS 2020). The restoration of degraded meadows to restore these functions attenuates peak flows from storms, decreases runoff on upland slopes, and improves downstream water quality. In addition, healthy meadows provide environmental benefits, such as wildfire mitigation via natural firebreaks, and wet refuge habitat (DWR 2025e).



Source: DWR 2025e

Photo 9. Upper Feather River Watershed Meadow Restoration

Large-scale forest management projects and management actions enhance watershed function by reducing evapotranspiration losses and stabilizing soils. As observed in one study in the upper Sierra Nevada Mountains, proper spacing between trees and selective thinning reduces evapotranspiration losses, increases water retention, and enhances the volume and timing of water supplies available from runoff (UC Merced 2011). This enhances water supply by attenuating peak flows during storm events and retaining water for release/runoff during dry periods. These practices also reduce fire fuel loads and reduce the risk of catastrophic fires that negatively affect watershed health and water supplies (USFWS 2025). Additionally, limiting burn areas and extents during fires can reduce fire debris inflow into streams and reservoirs during flood events.

Local Water Supply Projects and Actions

Several local water supply projects aimed at optimizing water resources within the basin through innovative technologies and management strategies are identified in GSPs and elsewhere. These projects include, for example, recycled water, reclaimed water, and surface water treatment projects to convert previously unusable sources into viable supplies. Additionally, projects and management actions that allow for additional surface water deliveries and surface water trading mechanisms enhance access to water across regions, while water purchases enable users with available capital to secure supplemental supplies. Collectively, these projects contribute to a more resilient and diversified water portfolio for the SJV. In addition to the projects identified in the GSPs, urban water management is described. Benefits, implementation considerations, and opportunities for local water supply projects are described in the subsections below.



Source: City of Fresno 2026

Photo 10. The City of Fresno Supplementing Water Supply Using Recycled Water, Indicated by the Purple Pipes

Benefits of Local Water Supply Projects and Actions

Water supply projects and actions can be developed to provide a wide range of benefits, including:

- Increased sustainable and reliable water supply volumes to support agricultural and M&I uses and contribute towards groundwater sustainability.
- Optimized usage of water supply sources that are present within the district or can be accessed locally.
- Diversified water supply portfolios.

Implementation Considerations

The following are important considerations during the development and implementation of water supply projects and actions:

- Recycled and reclaimed water treatment products must be properly handled and disposed of.
- For the delivery of new water supply, it may require coordination with necessary owners and operators of federal, state, and/or local conveyance facilities, as well as local, regional, and state districts that receive contracted water supplies.
- For the delivery of new water supply, if modifying existing facilities, it complicates and/or limits the delivery of water to users that rely on the existing facilities.
- Surface water trading or purchases may require long-term coordination and agreements between parties

Opportunities for Local Water Supply Projects and Actions

Opportunities for local water supply projects and actions are provided below. The primary sources for data presented in this section are the GSPs in the SJV.

Urban Water Management

Improved urban water management is a technique that could benefit communities in the SJV. A 2022 study by the Pacific Institute evaluates the potential of urban water efficiency and urban stormwater capture to improve water supply conditions across California. The study also evaluates water reuse, which is addressed in the subsection below. The study found that the San Joaquin River Hydrologic Region has the potential to capture approximately 46 to 200 TAF of urban stormwater under dry and wet years, respectively; and the Tulare Lake Hydrologic Region has the potential to capture approximately 35 to 180 TAF under dry and wet years, respectively (Pacific Institute 2022). It also highlights the importance of recharge and the ability to store captured water in aquifers. Additionally, the study found that the San Joaquin River Hydrologic Region has the potential to save 130 to 200 TAF under moderate and high urban efficiency actions, respectively, and the Tulare Lake Hydrologic Region has the potential to capture approximately 160 to 250 TAF under moderate and high urban efficiency actions. The study does not evaluate any effects on the subbasins if the stormwater is captured (e.g., the study does not evaluate if the urban stormwater would have

infiltrated into the ground and if the action of capturing stormwater would otherwise affect the subbasin.) The study does not estimate costs for implementation but notes that water efficiency projects are almost always cheaper than other water supply projects, and water reuse and urban stormwater capture projects are often more expensive than other supply projects but cheaper than seawater desalination.

Recycled Water

Recycled water is stormwater or wastewater that has been treated and purified so that it can be safely used for other purposes. Potable reuse is recycled water for drinking water purposes; non-potable reuse includes purposes such as groundwater recharge, irrigation, and industrial uses. The GSPs identified a small number of recycled water projects, described in Table 5-13. The GSPs identify irrigation, wildlife refuges, and direct groundwater recharge as typical recipients of the recycled water supply. Use of recycled water can reduce strain on groundwater pumping by functioning as an in-lieu groundwater source, however some recycled water projects in the SJV may not provide a net increase in available water supply.

Table 5-13. Summary of Local Recycled Water Projects with Known Costs and Yields

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	5	1	3.7	6.3
Tracy	-	-	-	-
Delta-Mendota	1	1	59.0	101.0
Modesto	-	-	-	-
Turlock	1	1	2.0	10.5
Merced	1	-	-	-
Chowchilla	-	-	-	-
Madera	-	-	-	-
Westside	-	-	-	-
Pleasant Valley	1	-	-	-
Tulare Lake	-	-	-	-
Kings	2	2	10.6	96.4
Kaweah	-	-	-	-
Tule	-	-	-	-
Kern	3	1	0.4	14.6
White Wolf	1	-	-	-
Total³	15	6	75.7	228.8

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of recycled water projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key: GSP = Groundwater Sustainability Plan Q4 = fourth quarter TAF/YR = thousand acre-feet per year

Reclaimed Water

Reclaimed water is produced water from oil and gas production and reclaimed brackish groundwater. Produced water is naturally brought to the surface during oil and gas production activities (SWRCB 2025). Produced water can be disposed through class II injection wells or produced water ponds. Brackish groundwater, otherwise unusable due to the water's quality, is treated through a desalination facility. Produced water and brackish water, together reclaimed water, can be recycled through specialized water treatment and put to use as an additional water supply. Produced water or brackish water can also be blended with other water supplies, potentially reducing the intensiveness of water treatment needed to make the supplies usable. The GSPs identified a small number of projects to treat reclaimed water to a quality suitable for irrigation or groundwater recharge, described in Table 5-14. Reclaimed water alleviates strain on groundwater pumping by functioning as an in-lieu groundwater source.

Table 5-14. Summary of Local Reclaimed Water Projects with Known Costs and Yields

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ¹
Eastern San Joaquin	-	-	-	-
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	-	-	-	-
Turlock	-	-	-	-
Merced	-	-	-	-
Chowchilla	-	-	-	-
Madera	-	-	-	-
Westside	1	-	-	-
Pleasant Valley	-	-	-	-
Tulare Lake	-	-	-	-
Kings	1	1	5.1	119.4
Kaweah	-	-	-	-
Tule	-	-	-	-
Kern	8	5	76.4	81.1
White Wolf	3	0	-	-
Total³	13	6	81.5	200.6

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Key:

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of reclaimed water projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

Surface Water Treatment

The GSPs identified a small number of surface water treatment projects, described in Table 5-15. These projects aim to increase capacity, through upgraded or new facilities, to treat surface water at local treatment plants. Additional surface water alleviates strain on groundwater pumping by functioning as an in-lieu groundwater source.

Table 5-15. Summary of Local Surface Water Treatment Projects with Known Costs and Yields

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	1	1	4.8	4.2
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	1	1	11.2	8.7
Turlock	-	-	-	-
Merced	1	-	-	-
Chowchilla	-	-	-	-
Madera	-	-	-	-
Westside	-	-	-	-
Pleasant Valley	-	-	-	-
Tulare Lake	-	-	-	-
Kings	7	7	166.7	751.9
Kaweah	-	-	-	-
Tule	-	-	-	-
Kern	-	-	-	-
White Wolf	-	-	-	-
Total³	10	9	182.6	764.9

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of surface water treatment projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

Surface Water Deliveries

The GSPs identified a small number of surface water delivery projects, described in Table 5-16. None of the projects presented in the GSPs report both cost and yield information. These projects would exercise existing water rights, develop access to surface water, or import surface water to increase water delivered to districts. Additional surface water alleviates strain on groundwater pumping by functioning as an in-lieu groundwater source.

Table 5-16. Summary of Local Surface Water Delivery Projects with Known Costs and Yields

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	-	-	-	-
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	-	-	-	-
Turlock	-	-	-	-
Merced	1	-	-	-
Chowchilla	-	-	-	-
Madera	2	-	-	-
Westside	-	-	-	-
Pleasant Valley	-	-	-	-
Tulare Lake	-	-	-	-
Kings	-	-	-	-
Kaweah	-	-	-	-
Tule	1	-	-	-
Kern	2	-	-	-
White Wolf	-	-	-	-
Total³	6	-	-	-

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of surface water delivery projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

Surface Water Trading

Surface water trading facilitates the voluntary transfer of surface water between users to address regional supply imbalances and improve water use efficiency. Surface water trading can also occur during periods of high flow. Surface water is traded through the short or long-term leases, purchases, or exchanges of water rights of the surface water. Physical water trading typically occurs between interconnected users, or it can be facilitated through exchanges. The GSPs identified a number of surface water trading projects, described in Table 5-17. Surface water trading can alleviate strain on groundwater pumping by bringing additional water to users and optimizing usage of surface water regionally. Some of the surface water trading projects described in the GSPs would require infrastructure modifications and would require administrative costs. Surface water trading infrastructure modifications and administrative costs are considered the responsibility of the landowner and, therefore, costs are not included in project descriptions.

Table 5-17. Summary of Local Surface Water Trading Projects with Known Costs and Yields

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	2	-	-	-
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	-	-	-	-
Turlock	-	-	-	-
Merced	-	-	-	-
Chowchilla	1	1	3.0	1.0
Madera	6	3	14.7	33.6
Westside	1	1	475.0	-
Pleasant Valley	1	-	-	-
Tulare Lake	-	-	-	-
Kings	2	-	-	-
Kaweah	6	3	12.0	0.2
Tule	3	1	5.0	2.6
Kern	7	-	-	-
White Wolf	1	-	-	-
Total³	30	9	509.7	37.4

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of surface water trading projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

Water Purchases

The GSPs identified a small number of water purchase projects, described in Table 5-18. These projects seek to purchase additional water supplies for their districts, whether purchased during high flow events or long-term supplemental agreements.

Table 5-18. Summary of Water Purchase Projects with Known Costs and Yields

Subbasin	Number of Projects Described in GSPs for Basin (count)	Number of Projects in GSPs w/ Estimated Costs and Annual Yields (count)	Total Yield of Projects w/ Estimated Costs and Annual Yield (TAF/YR) ¹	Total Cost of Projects w/ Estimated Costs and Annual Yield (\$ million) ^{1,2}
Eastern San Joaquin	-	-	-	-
Tracy	-	-	-	-
Delta-Mendota	-	-	-	-
Modesto	-	-	-	-
Turlock	-	-	-	-
Merced	-	-	-	-
Chowchilla	-	-	-	-
Madera	1	1	2.8	15.5
Westside	-	-	-	-
Pleasant Valley	-	-	-	-
Tulare Lake	-	-	-	-
Kings	-	-	-	-
Kaweah	-	-	-	-
Tule	-	-	-	-
Kern	2	-	-	-
White Wolf	-	-	-	-
Total³	3	1	2.8	15.5

Sources: Refer to Appendix A for a summary of GSPs used to compile information presented in this table.

Notes:

¹ Total costs and yield as reported in the compiled GSPs.

² Costs are escalated to Q4 2025 dollars.

³ The ultimate cost and benefits to the Valley of water purchases projects are not limited solely to projects described with costs and annual yields in the GSPs.

Key:

GSP = Groundwater Sustainability Plan

Q4 = fourth quarter

TAF/YR = thousand acre-feet per year

Precipitation Enhancement

Precipitation enhancement, also known as “cloud seeding,” is a technique that could contribute water supplies to the SJV. Winter orographic cloud seeding (cloud seeding where wind blows over a mountain range, thereby causing clouds and rain or snow by lifting the air) has been practiced in California, particularly on the western side of the Sierra Nevada, since the early 1950s. Precipitation enhancement artificially stimulates clouds to produce more rainfall or snowfall than they would produce naturally by injecting substances such as silver iodide or liquid propane into the clouds. Precipitation enhancement can be rapidly implemented, to increase water supply and offset some of the loss in snowpack expected under changing hydrologic conditions projections. This could benefit upper watershed mountain meadows and help delay the onset of the fire season in forests. Policy statements by both the American Meteorological Society in 1998 and the World Meteorological Organization in 2007 support the effectiveness of winter orographic cloud- seeding projects, although they acknowledge that results may be uncertain because of the high degree of background variability of weather (DWR 2024).

Demand Management

Demand management includes a wide set of policies or actions that reduce water use (demand), rather than increasing supply, to balance limited water resources with agricultural, urban, and environmental needs. Demand management can be tailored to specific needs as various demand management techniques can be combined.

The GSPs identified several demand management techniques to reduce strain on limited existing water supplies in the SJV. Some strategies directly modify interactions with land usage. Other projects include the implementation of tools, technologies, or studies for future changes. Potential projects and management actions are grouped into five categories for this section: (1) irrigation efficiency (2) land conversion, (3) land fallowing, (4) pumping restrictions and related tools, and (5) urban conservation. Benefits, implementation considerations, and opportunities are described below.

Benefits of Demand Management

Demand management techniques can be developed to provide a wide range of benefits, including:

- Aquifer replenishment through a decreased reliance on groundwater, including reducing groundwater pumping demands that contribute to subsidence.
- Increased adoption of technologies that aid in water use efficiency, management, and decision-making.
- Enhanced ecosystem conditions.

Implementation Considerations

The following are important considerations during the development and implementation of demand management techniques:

- Planning is required for strategic demand management implementation to avoid undesirable and unplanned economic outcomes related to employment, economic activity, loss of taxes, and other economic considerations. Other outcomes, like demand hardening, must be considered during implementation.
- It requires administration and coordination by GSAs and/or irrigation districts with landowners who are willing to or forced to participate in demand management action. This could include developing rules and regulations, establishing delivery schedules, accounting for water delivered, and providing incentives to landowners who take action and/or implement demand management projects and management actions.
- Demand management techniques should be planned and implemented to sustainably support flood and ecosystem enhancement benefits. Chapters 3 and 4 outline potential opportunities that could be applied strategically to reduce water demand.

Opportunities for Demand Management

Opportunities for demand management in the SJV are described below.

Irrigation Efficiency

Irrigation efficiency is the effectiveness with which water is applied through irrigation to crops. Investments to improve irrigation efficiency are generally made to minimize losses to evaporation, percolation, or runoff. Irrigation efficiency could also include measures such as the recovery of agricultural runoff, the application of soil amendments to improve soil health and crop production, and/or other water saving measures. The GSPs identified approximately 15 irrigation efficiency projects that include technological improvements such as evapotranspiration measurements or controls that monitor weather data to make irrigation decisions; or management actions such as efficiency incentive programs or outreach and educational programs. During implementation of irrigation efficiency techniques, it is important to consider that past investments were not coupled with policies to preserve conserved water. Instead, water “conserved” was used to expand irrigation which increased agricultural demand and reliance on conserved supplies. Application of irrigation efficiency techniques should result in a decrease in demands.

Land Conversion

Land conversion is the permanent conversion of land use type from an agricultural use to another use that potentially reduced water demand, including:

- Conversions that continue agricultural production:
 - Dryland farm implementation – crops and farming techniques could be modified to rely solely on precipitation. However, even though dryland farming has limited economic potential, the cover on the ground preserves soil, prevents dust, and creates habitat.
 - Changes in crop patterns – farms could shift to less water intensive crops. However, this strategy requires significant investment in land and crop modification, particularly where permanent crops would be replaced.
- Conversions through land repurposing:
 - Agricultural land retirement – agricultural land could be strategically retired. This must occur strategically and potentially in consideration with flood and ecosystem enhancement opportunities outlined in Chapter 3 and 4, respectively (which is discussed further below), or simply to reduce water demand regardless of the new permanent use.
 - Managed flood and ecosystem enhancement – opportunities for flood and ecosystem enhancement outlined in Chapter 3 and 4 could be implemented on land that is currently in agricultural production. The water demand of the new use must be considered if the goal is to both decrease demand and provide other benefits.
 - Energy development – Implementation of renewable energy projects, like wind and solar, could occur on lands that are currently in agricultural production. In addition,

lands could be considered for transmission lines, data centers, and other energy-related needs.

It is very important to consider during the planning process that the permanent conversion of productive agricultural land has potential negative effects. As a strategy for long-term land use modification in the SJV, an unorganized or random application of land fallowing can result in undesirable conditions, such as loss of agricultural jobs in agriculture-dependent communities, degraded air quality and threats to human health due to windblown dust from idled land – particularly in low-income rural areas in the SJV – and other related regional socioeconomic and environmental concerns (PPIC 2022). The GSPs identified approximately 15 land conversion projects, which must be implemented strategically and in consideration of the above.



Source: *The Business Journal* 2022

Photo 11. Westlands Solar Park Project, a 2.7-Gigawatt Solar Project on Converted Farmland

Land Fallowing

Land fallowing is the temporary cessation of irrigation of agricultural land to reduce water demand. Fallowed land can be left idle or repurposed with cover crops that do not require irrigation. Historically, land fallowing decisions have been made by individual landowners in consideration of water availability, production costs, soil nutrient replenishment, and agricultural market decisions. The temporary fallowing of land could lead to similar undesirable socioeconomic and environmental

outcomes as permanent land conversion. These outcomes should be minimized to the extent possible. The GSPs identified approximately 30 land fallowing projects.



Source: AgNet West Radio Network 2022

Photo 12. Fallowed Agricultural Land in the San Joaquin Valley

Pumping Restrictions and Related Tools

Pumping restrictions and related tools are management actions to correct groundwater overuse and land subsidence. Groundwater fee increases, groundwater allocations, and pumping restrictions aim to reduce demand. Well registrations and cataloging, mandatory extraction volume reporting, and groundwater/land subsidence studies aim to increase information and proper management of resources. The GSPs identified approximately 100 restrictions and related tools projects.

Urban Conservation

Urban conservation projects are management actions or technology installations that reduce demand at the local level. Projects include implementation of supervisory control and data acquisition technology or advanced metering infrastructure, domestic well mitigation programs, water efficiency rebate programs, rate structure changes, or other similar projects. The GSPs identified approximately 30 urban conservation projects. This could also include projects identified in the Urban Water Management subsection earlier in this chapter.

Flood Management and Ecosystem Enhancement

In addition to flood management and ecosystem enhancement opportunities associated with permanent land retirement, opportunities outlined in Chapters 3 and 4 could be evaluated for their potential to co-exist with existing agricultural and other land uses and/or implementation with land fallowing and other potential projects and management actions. For example, land fallowing and conversion creates the opportunity for intermittent or permanent land uses for other purposes



including flood management (e.g., levies, detention basins, etc.) and ecosystem enhancement (e.g., wetland and riparian restoration, wildlife corridors, etc.). Unique tools like mitigation banks could be used to implement these land conversion projects at scale and in a coordinated manner. In every case, water use should be considered. For example, environmental lands and/or projects have a water demand that needs to be considered during the planning process.

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Chapter 6 Advancing Potential Solutions

The SJV is the cornerstone of California’s robust agricultural economy but faces a water supply-demand gap that threatens the region’s economic vitality, environmental sustainability, and the nation’s food security. The consequences of inaction to address this growing problem are substantial. A 2020 economic study estimated that up to one million acres of farmland, or approximately 20% of the SJV’s cultivated area, could be fallowed over the next 20 to 30 years because of water supply reductions from SGMA implementation and other regulatory changes (Sunding and Roland-Holst 2020). The study calculates that this level of land retirement could result in annual losses of approximately \$7.2 billion in farm revenue, \$1.9 billion in farm operating income, \$2.1 billion in wages, and 85,000 jobs. These losses would have direct, indirect, and induced effects across interconnected sectors and industries, which would negatively affect local, regional, and state community services that rely on public revenues. Adverse socioeconomic impacts would disproportionately affect the lowest-income communities. These outcomes, occurring in one of the most productive agricultural regions in the United States, would have far-reaching implications for national food security.

This chapter presents potential implementation strategies to address water resources and ecosystem needs described in Chapters 2, 3 and 4, through the implementation of projects and actions described in Chapter 5. A set of preliminary analyses were performed to identify ranges of potential benefits, costs, and remaining gaps that could result from implementation of various implementation strategies. A recommended approach for project selection is proposed, and actionable recommendations to local, regional, state, and federal entities for near-term and long-term actions and investments are provided.

Key Findings

Information presented in this UWP supports the following key findings that emphasize the seriousness of water supply challenges in the SJV and underscore the urgency for action:

1. Projected water supply shortages in the SJV result from multiple compounding causes, including regulatory in-stream flow requirements for ecosystem protection; reduced availability of groundwater due to implementation of the SGMA; reduced ability to manage changing runoff patterns with existing infrastructure; reduced reliability of Delta imports resulting from regulatory requirements imposed on state and federal storage and export facilities in and upstream of the Delta, more extreme hydrologic variability and sea level rise; and increased water demands driven by a hotter and drier climate.
2. With no action to address projected water supply reductions, the annual water supply-demand gap in the SJV will grow to about 2.4 million acre-feet per year by 2040, which would result in removing up to one million acres from irrigated agriculture. This estimate does not include historical reductions from implementations of regulatory actions.

- 
3. The economic consequences of no action include \$7.2 billion annual loss in farm revenue, an annual loss of 85,000 jobs including 42,000 agricultural and service sector jobs, and \$2.1 billion in lost employee compensation. Losses would occur primarily in lower income communities, exacerbating already present economic difficulties.
 4. Large scale implementation of local, regional, and statewide projects identified in the UWP could cost almost \$20 billion, yet they will not be sufficient to fully close the water supply-demand gap, even under optimistic project performance assumptions. These costs do not include investments for conversion of agricultural land.
 5. The cost to implement projects that significantly reduce the water supply-demand gap may far exceed affordability thresholds for many agricultural water users, which will limit the extent of the gap that can be reduced. Federal and state funding programs will be needed to implement projects that can reduce significant economic losses.
 6. Agricultural land conversion in the SJV will be necessary to help close the water supply-demand gap and achieve groundwater sustainability. Land conversion should be minimized to the extent possible and accommodate a variety of possible future uses. Some land conversions could enable continued agricultural production with reduced or no irrigation supply, while others could promote groundwater recharge, ecosystem enhancement or development of other economic uses, such as energy corridors.
 7. Significant land subsidence has adversely affected the operation of large water conveyance canals in the SJV, and additional subsidence will amplify this problem. Federal, state, and regional entities are actively working to develop solutions. Sustained action to re-establish and maintain the conveyance capability of subsided canals is needed to preserve water delivery reliability and facilitate many potential projects considered in the UWP.
 8. Non-structural actions that improve the management of water supplies in the SJV, such as upper watershed land management and modified reservoir operations with improved forecasting, can help the SJV adapt to changing hydrologic variability and increase water supply availability. Non-structural action in the Delta, such as modified operations to protect species based on real-time information and enhanced adaptive management actions can increase the reliability of imported water supplies to the SJV.
 9. An extensive inventory of potential projects and non-structural actions that would improve the utilization of local and imported water supplies and increase the availability and reliability of water supplies from the Delta has been compiled. Sufficient information to define a prioritized set of projects is not yet available. Project selection will require further assessment of feasibility based on water supply availability, performance, cost, and affordability criteria.
 10. Water supply shortages are not uniformly distributed in the SJV. Areas with access to local water supplies have a greater ability to reduce supply-demand gaps through increased management of available water resources. Areas with limited or no access to local surface water will become more reliant on increased Delta exports.

This section describes the evaluation of a range of potential investment scenarios to address water resources needs in the SJV. Simulations are predominantly focused on quantifying changes in water supply that contribute to reducing the estimated supply-demand gap. The simulations maintain existing water right and contractual priorities and do not assume actions that would violate or supersede those established frameworks. Project details presented in Chapter 5 are not sufficiently detailed to evaluate the effect of individual projects to support implementation recommendations. Simulations were completed using analytical tools developed by the Blueprint were formulated as combinations of potential projects and actions described in Chapter 5 to quantify their potential cumulative effect. For each investment scenario, results are presented as a range of potential water supply, cost, remaining un-met need, and agricultural land subject to repurposing.

An overall evaluation framework to select recommended projects and actions requires an analysis of individual and combined project performance. Factors to be considered include water supply availability and potential implementation constraints such as permitting, technical feasibility, and affordability to prioritize recommendations and quantify realized water supply. As shown in Figure 6-1, the UWP includes evaluations to identify the range of potential water supply benefits that may be possible through investment scenarios. Additional evaluation of individual and combined projects is needed to recommend specific projects for implementation.



July 2026 – 6-3



Blueprint Analytical Tools

Evaluations performed for the UWP were designed to identify a range of potential water supply benefits, and associated costs, for various investment scenarios. A set of three inter-related spreadsheet-based models, developed by the Water Blueprint for the SJV (herein referred to as the ‘Blueprint Analytical Tools’), were used to evaluate alternative scenarios.

Delta Flows Model

The Delta Flows Model is used to simulate Delta flows on a daily basis under a variety of regulatory and operational conditions. The model is used to identify “excess” Delta flows, defined as flows that exceed requirements to meet water quality and minimum Delta outflow standards. Flows identified as “excess” in the Delta Flows Model are considered potentially available for export as constrained by available capacity of Delta export facilities, available storage capacity in San Luis Reservoir, and water demands. The model also identifies when San Joaquin River flows limit exports, to determine conditions when the upstream diversion of additional flow, such as for groundwater recharge, could constrain Delta exports. Water supplies identified for additional diversion from the Delta are assigned to subbasins in proportions the distribution of CVP and SWP contracts.

Project performance estimates in the Delta Flows Model are based on results from a study by MBK Engineers to estimate additional exports that may be possible given a range of modified and relaxed Delta regulations, new Delta infrastructure, and increased demands for water from the Delta (MBK 2020). A summary report of the Delta operations study performed by MBK Engineers is provided in Appendix C.

Watershed Outflow Model

The San Joaquin Valley Watershed Outflow Model (“outflow model”) is used to estimate local surface water supplies available for diversion from major rivers in the SJV, as constrained by instream flow requirements and downstream demands. The outflow model uses historical daily gage data for the period 1998 through 2024, where available, to quantify flow that could potentially be diverted to new projects. Monthly data was used for the Kaweah and Tule rivers because daily data was not available.

The outflow model only allows for diversions when water supply is potentially available. It considers in-basin flows that coincide with Delta “excess” conditions as identified in the Delta Flows Model and does not simulate water project operations in the Delta. If the Delta is not in “excess” condition or minimum San Joaquin River flows entering the Delta are not met, diversion is not permitted. No temporal adjustment is made to account for routing time from the point of in-stream flow measurement to the Delta. The outflow model can operate under two conditions using output from the Delta flows model, a “constrained” Delta condition limits diversions to amounts that would not affect Delta exports, and an “unconstrained” Delta enables diversion without consideration of effects on Delta exports.

Diversions from SJV streams are determined by comparing water available for diversion to demand associated with diversion, delivery and recharge projects. The model allows for the application of adjustment factors to limit the portion of flows available for diversion and the assumed performance capability (yield) of projects. For each simulation, the total capacity of additional projects is limited



to the capacity that corresponds with projects utilized at least 5% of simulated days. This constraint is applied to generally represent the likelihood that infrequently used facilities may be economically infeasible. No project-specific analysis was performed to determine project economic feasibility.

San Joaquin Valley Water Infrastructure Optimization Model

The SJV Water Infrastructure Optimization Model (Optimization Model) is a linear programming model used to “select” sets of projects that maximize water deliveries to subbasins for the least cost subject to constraints on water supplies available locally and from the Delta, capacity and yield of projects, and subbasin demands for water. Demands for water at the subbasin level were assumed to be the GSP-based total supply-demand gap, as defined in Table 2-12. Estimates of yield and costs of projects were derived using the best available data, as presented in Chapter 5. To the extent possible, estimates were made for input to Blueprint Analytical Tools for projects that do not have estimated performance or cost information. Ranges for costs and water supply by subbasin for sets of projects were developed by adjusting projections on the water supply available and project yields under both constrained and unconstrained Delta conditions.

Application of Blueprint Analytical Tools

A range of variables were applied in the evaluation of investment scenario simulations presented in this chapter, as summarized in Table 6-1. While the model has the capacity to limit the projects selected to those that are assumed to be affordable for agriculture, such a constraint was not implemented in the results presented in this report. The model also estimates the reduction in flood flows at Vernalis and in Tulare Lakes as well as the acreage of land likely to be repurposed in each subbasin given the remaining gap between water supplies and demands.

Table 6-1. Variables Applied in Evaluation of Investment Scenarios

Variable	Lower Estimate Simulations	Upper Estimate Simulations
Water available for diversion from SJV rivers	• 50% of water historically leaving subbasins that is assumed to be surplus to instream needs and downstream use for the Merced River and rivers north of the Merced where future requirements for Healthy Rivers and Landscapes may further limit diversions. • 75% of water historically leaving subbasins that is assumed to be surplus to instream needs and downstream uses for all other subbasins.	• 100% of water historically leaving subbasins that is assumed to be surplus to instream needs and downstream uses for all subbasins.
Project performance (yield) of local projects	• 50% of project yield as reported in GSPs.	• 100% of project yield reported in GSPs.
Project performance (yield) of storage and Delta conveyance projects	• 75% of calculated increase in exports from the MBK Delta Study (MBK 2020) for new Delta infrastructure and 75% of the estimated increase in yield projected using CalSim 3 for Reclamation's proposed Action 5. • 50% of estimated yield of storage projects.	• 100% of calculated increase in exports from MBK Delta Study (MBK 2020) for new Delta infrastructure and 75% of the estimated increase in yield projected using CalSim 3 for Reclamation's proposed Action 5. • 100% of estimated yield of storage projects.

Key:

GSP= Groundwater Sustainability Plan

MBK = MBK Engineers

Reclamation = U.S. Department of the Interior, Bureau of Reclamation

SJV = San Joaquin Valley

Collectively, the Blueprint Analytical Tools were used to develop projections by subbasin for the total potential water supply from a wide variety of sources and identify the types of projects that appear efficient in supply development. Results from Blueprint Analytical Tool simulations provide valuable information on potential water supply, project costs, remaining unmet demand, and agricultural acreage that may require repurposing.

The Blueprint Analytical Tools were designed to use best available information to support the level of analysis they perform. The analyses were performed to evaluate a range of potential implementation strategies and reveal the sensitivity of key assumptions. Considerable uncertainty remains in the estimates of available supply, potential project benefits and costs. Precision should not be attributed to numerical results presented in model outputs.

Costs of Land Conversion

The CAP estimated the costs for land repurposing (acquisition and restoration) in the 2024 Regional Investment Plan (CAP 2024). The cost of land acquisition, estimated at \$20,000 per acre, is the average of orchard properties, row crops, and agricultural land with access to surface water. The cost to perform restoration activities on the acquired land, estimated at \$18,000 per acre, includes costs associated with design, permitting, seed collection/propagation, land preparation, planting, and three years of post-planting weed control. The total cost to repurpose land is \$38,000 per acre.

Investment Scenarios

A range of potential water supply investment scenarios were evaluated based on three broad types of investments:

1. Restore authorized design capacity of existing facilities.
2. Implement non-structural actions and local water supply projects in the SJV.
3. Implement large regional water supply projects that increase Delta exports and make use of increased Delta export supplies.

To formulate investments scenarios, projects and management actions (herein referred to as ‘projects’) described in Chapter 5 were organized into twelve categories. Each project was categorized based on the primary method by which it can contribute to reducing the water supply-demand gap in the SJV (e.g., recharge, conveyance, etc.); project characteristics, such as location (e.g., in-valley, north of Delta, etc.); and project scale (e.g., local, regional, etc.).

Each investment scenario is comprised of a set of project categories, as follows:

- Investment Scenario 1 – Restore authorized design capacity of existing facilities.
 - a. Restore authorized design capacity of subsidence-impacted CVP and SWP canals.
 - b. Restore south Delta flood-flow capacity and reservoir storage capacity.
- Investment Scenario 2 – Implement non-structural actions and local water supply projects in addition to projects and actions described in Investment Scenario 1.
 - a. Upper watershed actions that improve timing and volume of reservoir inflow
 - b. Re-operate in-valley reservoirs (FIRO/I-FIRM)
 - c. Non-structural actions in the Delta to increase diversions with existing facilities
 - d. Local conveyance, recharge, storage, and other water supply projects included in GSPs and identified through other sources.

e. Expanded east-west conveyance capacity to increase recirculation of recaptured SJRRP flows and facilitate additional in-Valley water transfers.

- Investment Scenario 3 – Implement large regional water supply projects that increase Delta exports and make use of increased Delta exports in addition to projects and actions described in Investment Scenario 2.

a. Modify diversion facilities in the Delta.

b. Add north-of-Delta storage and add south-of-Delta storage.

c. Enlarge existing and expand existing south-of-Delta conveyance.

Table 6-2 summarizes the investment scenarios by project category and shows how they are considered sequentially.

Table 6-2. Project Categories Included in Each Investment Scenario

Project Category	Investment Scenario 1	Investment Scenario 2	Investment Scenario 3
Restore authorized design capacity of subsidence-impacted CVP and SWP canals	X	X	X
Restore south Delta flood-flow capacity	X	X	X
Upper watershed actions that improve timing and volume of reservoir inflow		X	X
Re-operate in-valley reservoirs (FIRO/I-FIRM)		X	X
Non-structural actions in the Delta to increase diversions with existing facilities		X	X
Local conveyance, recharge, storage, and other water supply projects included in GSPs and identified through other sources.		X	X
Expanded east-west conveyance capacity to increase recirculation of recaptured SJRRP flows and facilitate additional in-Valley water transfers.		X	X
Modify diversion facilities in the Delta.			X
Add north-of-Delta storage			X
Add south-of-Delta storage			X
Enlarge existing south-of-Delta conveyance capacity.			X
Expand south-of-Delta conveyance system			X

Key:

CVP = Central Valley Project

FIRO = Forecast Informed Reservoir Operations

GSP = Groundwater Sustainability Plan

I-FIRM = Integrated Forecast-Informed Resources Management

SJRRP = San Joaquin River Restoration Program

SWP = State Water Project

Scenario 1 – Restore Authorized Design Capacity of Existing Facilities

Scenario 1 Description

Projects included in Scenario 1 would restore the authorized design capacity of existing facilities. Capacity restoration projects would restore the design capacity CVP and SWP canals that have been adversely affected by regional land subsidence and the capacity of channels in the south Delta. As outlined in previous chapters, the SJV relies on existing surface water storage and conveyance facilities to deliver surface water to farms and communities to meet demands. Loss of conveyance capacity in CVP and SWP canals from regional land subsidence has reduced operational flexibility and water delivery capability, which will continue to degrade with additional subsidence. In addition, south Delta channel conveyance capacity and reservoir storage capacity reductions due to sedimentation have reduced the performance of these facilities, which will continue to degrade if no action is taken.

Scenario 1 projects listed below, and described in Chapter 5, would require capital cost in excess of \$7.2 billion. Potential yield estimates, in acre-feet per year, also have not been estimated for these projects and their impact on water delivery is not reflected in the supply-demand gap reported in Chapter 2.

Projects to Restore Authorized Design Capacity of Existing Facilities

- Restore design capacity of the San Luis Canal and California Aqueduct
- Restore design capacity of the Delta Mendota Canal
- Restore design capacity of the Friant-Kern Canal
- Dredge south delta channels

Restoring design capacity of conveyance facilities, particularly CVP and SWP canals, is essential to enable delivery of assumed baseline supplies and avoid further increasing the supply-demand gap. In addition, the existing operating requirements for the CVP and SWP and several ongoing feasibility studies of potential water storage and conveyance projects in the Central Valley, such as enlarged or new storage and conveyance facilities, are based on the availability of original design capacity of existing conveyance and storage facilities. Accordingly, Scenario 1 projects are considered foundational to avoid further reductions in water supply, flood management and ecosystem conditions, and will be needed to achieve the benefits associated with many of the projects evaluated in Scenarios 2 and 3.

Scenario 1 Evaluation

Blueprint analytical tools were not used to simulate outcomes of projects and actions in Scenario 1. As noted above, the supply-demand gap presented in Chapter 2 does not include water supply impacts associated with reduced capacity in subsided canal systems and further sedimentation of South Delta channels.



The supply-demand gap also does not include any additional supply as a result of Scenario 1. As such, at a supply-demand gap of approximately 2.4 MAF/YR (Notes: Table 2-13), approximately 1 million acres of farmland would be required to be repurposed (Sunding and Roland-Holst 2020). At \$38,000 per acre, this would require an investment of approximately \$38 billion. The total cost of Scenario 1, full restoration of authorized design capacity and land repurposing, would be approximately \$45 billion.

Scenario 1 Findings

The following findings can be drawn regarding implementation of Scenario 1 projects:

- Restoring design capacity to CVP and SWP canals in the SJV to address adverse impacts caused by regional land subsidence will cost approximately \$6 billion.
- If existing cost allocation and repayment methods are applied to the costs to restore CVP and SWP canal capacity, a significant proportion San Luis Canal and California Aqueduct costs would be allocated to entities outside of the SJV.
- Dredging South Delta channels to restore conveyance capacity will require approximately \$1 billion.
- Under full restoration of authorized design capacity, up to 1 million acres of land repurposing will be required and will cost approximately \$38 billion; the total cost of Scenario 1 would be approximately \$45 billion.
- Delivery of existing water supplies and development of projects to increase water supplies rely on the ability of these facilities to operate at design capacity.
- It is also important to note that flood management and ecosystem enhancement activities rely on the ability of these facilities to operate at design capacity. For example, these facilities convey flood flows for delivery to water users, recharge facilities, and storage facilities; as well as water supplies delivered to refuges and other ecosystem enhancement projects.
- The costs, benefits, and the feasibility of restoring authorized capacity of existing reservoirs are unknown. Preliminary findings suggest that removal of sediment from reservoirs in the SJV to restore storage capacity may not be cost-beneficial; evaluations should focus on facility enlargement.

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- Funding is a significant barrier to implementation of Scenario 1 projects and costs may be unaffordable for agricultural water users, which underscores the need for financial assistance.

Scenario 2 – Implement Non-structural Actions and Local Water Supply Projects

Scenario 2 Description

Scenario 2 combines implementation of non-structural actions and investments in local water supply projects in the SJV with all projects described in Scenario 1. As noted above, Scenario 1 projects are foundational and necessary for the successful implementation of many projects in Scenario 2, thus all Scenario 2 assessments assume the implementation of Scenario 1 projects.

Non-structural actions in Scenario 2 include upper watershed actions that can modify the timing and volume of runoff (e.g., meadow restoration, forest management, and other related actions), the reoperation of SJV reservoirs in combination with improved forecasting supported by monitoring programs, and changes in the operation of Delta export facilities that increase the diversion of water to the SJV. These actions are important because they increase and/or improve the timing of water supply available for water users in the SJV in response to changing hydrologic variability and increased water demands resulting from the implementation of recharge and water distribution projects. These actions, as explained in Chapter 5, can provide multiple benefits in combination with increased water supplies. For example, nature-based solutions in upper watersheds can improve ecosystem conditions by restoring natural habitat and runoff patterns, which improves ecosystem health and reduces flood risk. The reoperation of in-valley reservoirs can increase water supply available to meet various demands and reduce flood risk. Similarly, non-structural actions in the Delta can increase water supply availability while protecting Delta species.

Structural water supply projects in Scenario 2 include local conveyance, recharge, storage, and other water supply projects, and projects that increase the capacity of east-west conveyance from the San Joaquin River to the Delta-Mendota Canal to support recapture of SJRRP flows and regional water transfers. Local water supply projects, principally those identified in GSPs, can increase the efficient management of supplies already available in the SJV – both from in-Valley sources and supplies imported from the Delta.

Projects and management actions included in Scenario 2 include:

- Upper watershed actions that improve timing and volume of reservoir inflow
- Reoperation of in-valley reservoirs
- Non-structural actions in the Delta to increase diversions with existing facilities
- Local conveyance, recharge, storage, and other supply projects, including GSP projects
- Increased capacity of east-west conveyance

The combined reported water supply capability of local projects, as described in the GSPs and summarized in Chapter 5, included in Scenario 2 evaluations by subbasin is shown in Table 6-3. The



reported total water supply capability of these projects exceeds the water supply-demand gaps in many subbasins, however the actual capability will be constrained by water supply availability and other implementation considerations. As indicated in Table 6-3, potential project capability exceeds the average annual supply-demand gap in some subbasins have identified project capabilities that exceed the local supply-demand gap, whereas other subbasins have not.

Table 6-3. Comparison of Supply-Demand Gap and Total Local Project Capability

Subbasin	GSP-Based Total Supply-Demand Gap (TAF)	Total Reported Project Capability of Local Projects (TAF/YR) ¹	Total Reported Project Capability Compared to Supply-Demand Gap ² (TAF/YR)	Total Project Capability Compared to Supply-Demand Gap (%)
Eastern San Joaquin	66	191	Exceeds ³	>100%
Tracy	7	20	Exceeds ³	>100%
Delta-Mendota	168	99	-58	65%
Modesto	56	70	Exceeds ³	>100%
Turlock	83	71	Exceeds ³	>100%
Merced	180	47	-107	41%
Chowchilla	68	87	Exceeds ³	>100%
Madera	85	204	Exceeds ³	>100%
Westside	143	504	Exceeds ³	>100%
Pleasant Valley	19	26	Exceeds ³	>100%
Tulare Lake	123	167	Exceeds ³	>100%
Kings	306	545	Exceeds ³	>100%
Kaweah	299	84	-208	30%
Tule	294	52	-242	18%
Kern	529	378	-94	82%
White Wolf	1	26	Exceeds ³	>100%

Notes:

¹ Total project capability includes projects in GSPs with estimated costs and yields.

² Total Project Capability is not Potential Yield or Realized Yield – this table is totaling reported project capabilities from the GSPs by subbasin and does not imply that capabilities represent realized yield.

³ Water supply capacity of local projects identified exceeds supply-demand gap, this does not guarantee water supply or limitations due to other implementation constraints.

Key:

GSP = Groundwater Sustainability Plan

TAF/YR = thousand acre-feet per year



Scenario 2 Evaluation

Blueprint Analytical Tools were used to evaluate the potential range of water supply, costs, remaining unmet demand, and acreage of agricultural land that may require repurposing from implementation of projects included in Scenario 2. Several simulations were made to investigate a range of uncertainty regarding flood water available for diversion and project performance (yield), by applying the approach described in Table 6-1.

As summarized in Table 6-4, the development of projects to increase access to water supplies that originate in the SJV and the implementation of non-structural actions in the Delta could increase water supply by approximately 800 to 1,300 TAF/YR, at a capital cost ranging from about \$2.7 to \$5.8 billion. The analysis reveals that these outcomes are limited by water supply, not available projects, and that additional investments beyond those assumed in the simulation likely would not further increase yield. It is important to note that realizing the full potential of many local projects included in Scenario 2 will require implementation of projects described in Scenario 1, which is estimated to cost \$7.2 billion. Accordingly, total capital cost needed to realize the water supply benefits reported for Scenario 2 ranges from approximately \$10 billion to 13 billion.

The full implementation of water supply projects in Scenario 2 would result in approximately 1,100 to 1,700 TAF/YR of unmet demand, which the Blueprint estimates would result in the loss of approximately 400,000 acres to 590,000 acres of farmland to close the water supply-demand gap. At approximately \$38,000 per acre, land repurposing would cost approximately \$15 to \$22 billion.

The full implementation of Scenarios 1 and 2, and the remaining land to be repurposed, would range from approximately \$25 to \$35 billion.

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Table 6-4. Scenario 2 Evaluation Results

Project Types	Average Annual Potential Water Supply (TAF/YR)	Capital Cost (\$ billion)	Remaining Water Supply-Demand Gap (TAF/YR)	Agricultural Acreage Subject to Repurposing (1,000 acres)	Land Repurposing Cost (\$ billion)	Total Scenario Cost (\$ billion)
Total Scenario 1	Preserve Baseline	7.2	2,400	>1,000	38	45.2
Incremental Scenario 2: - Non-structural Actions - Local Water Supply Projects¹	800 – 1,300	2.7 – 5.8	1,100 – 1,700	400 - 590	15.2 – 22.4	-
Total Combined Scenario 1 and Scenario 2	800 – 1,300	9.9 – 13	1,100 – 1,700	400 – 590	15.2 – 22.4	25.1 – 35.4

Notes:

Values are rounded; therefore, totals may not match the sum of the reported components exactly.

¹ Local water supply projects include recycled or reclaimed projects, and other types of projects that develop local surface water supplies.

Key:

TAF/YR = thousand acre-feet per year

Simulated outcomes for Scenario 2 are presented by subbasin in Figure 6-2. Results are reported for water supplies from recycled or reclaimed water sources, water supplies from local projects, additional water supplies from the Delta, and the remaining supply-demand gap. For each subbasin, outputs from a range of simulated conditions are summarized as lower estimate and upper estimate results. The sum of results for all subbasins corresponds with the ranges of potential water supply reported in Table 6-4.

As illustrated in Figure 6-2, a supply-demand gap would remain in nearly every subbasin under every simulated condition, after implementation of Scenario 2 actions. The greatest remaining gaps would occur in subbasins that are partially reliant on Delta exports as a source of water supply. Additional actions, both within and outside of the SJV, would be required to increase Delta supplies and further reduce the remaining supply-demand gap. If the Delta were less constrained, additional water supply exports may be possible.

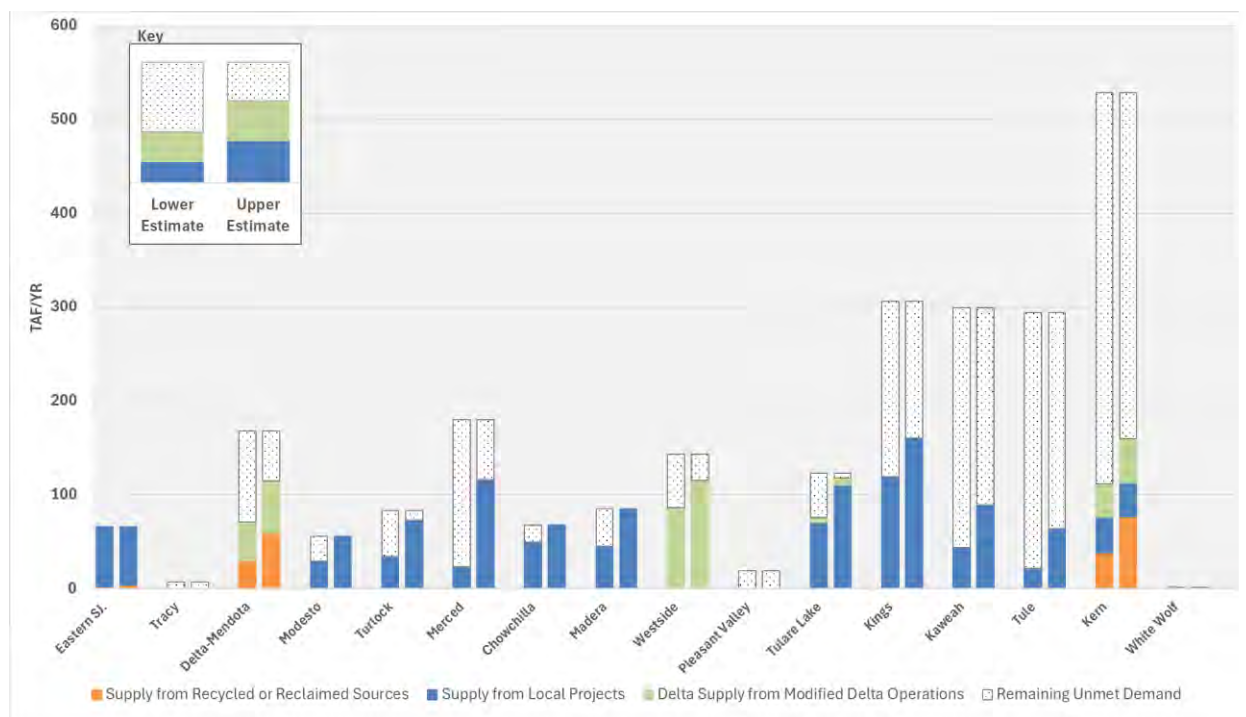


Figure 6-2. Scenario 2 Evaluation Results by Subbasin

Scenario 2 Findings

The following findings can be drawn from review of Scenario 2 evaluations:

- Non-structural actions can be implemented sooner than infrastructure projects because they utilize existing facilities and do not require large capital investment. Actions such as re-operation of in-valley reservoirs and actions in the Delta could provide additional water supply in excess of 500 TAF/YR, while also reducing peak flows during flood events. The water supply effects that would result from upper watershed projects and actions should be investigated further.

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- The ability to implement Scenario 2 projects will be subject to available water supply, economic feasibility, and funding availability. It is unlikely that the water supply benefits associated with upper limit simulations could be fully realized in all subbasins.
 - Full implementation of all Scenario 2 projects would still result in a significant supply-demand gap. Subbasins that would be primarily served through the development of local water supplies would have less supply-demand gap than subbasins that rely on Delta supplies.
 - Funding will be a significant barrier to implementation of Scenario 2 projects, which are estimated to cost \$10 to \$13 billion when combined with Scenario 1 projects. This cost may be unaffordable for agricultural water users, which underscores the need for financial assistance and/or funding partnerships.
 - Under the implementation of Scenarios 1 and 2, between 400 to 590 thousand acres of land repurposing would be required and would cost approximately \$15 to \$22 billion; the total cost of Scenarios 1 and 2 would be between \$25 to \$35 billion.
 - Partnerships with urban water users outside of the SJV could be beneficial for implementation of groundwater recharge and conveyance projects that could support groundwater banking programs.
 - Additional imported supplies from the Delta will be needed to further reduce the supply-demand gap that would remain with partial or full implementation of Scenario 2 projects and management actions. Additional Delta supplies would likely be first used by existing Delta water users.
 - It is also important to note that Scenario 2 projects provide flood management and ecosystem enhancement benefits. For example, re-operation of in-valley reservoirs could be optimized to provide water supply benefits while reducing peak flows and increasing deliveries for recharge. Flood flows that would otherwise move to the Delta through the San Joaquin River and its tributaries, and/or cause flooding in the Tulare Lake or Kern subbasins, could be delivered to local recharge and storage projects. These projects have other flood management and ecosystem enhancement potential benefits, which are outlined in Chapter 5.

Scenario 3 – Implement Large Infrastructure Projects

Scenario 3 Description

Investments into large infrastructure projects will be necessary to bring new or otherwise uncaptured water into the SJV to further reduce the water supply-demand gap beyond what is possible with projects in Scenario 2. Scenario 3 combines implementation of projects that primarily increase or facilitate imports from the Delta with all actions and projects described under Scenario 2. Scenario 3 projects are needed to provide increased water supplies to current export-dependent areas and to areas that lack access to adequate local supplies.



Project types included in Scenario 3 include modified diversion facilities in the Delta, increased north-of-Delta and south-of-Delta storage capacity, and enlargement and expansion of conveyance capacity in the SJV. These projects are generally larger, more costly, and more complex than projects described in Scenario 2. The costs and capabilities of Scenario 3 projects are summarized in Chapter 5. Scenario 3 includes the following potential additional facilities:

- Modify diversion facilities in the Delta
- Additional north-of-Delta storage capacity
- Additional south-of-Delta storage capacity
- Enlargement of existing south-of-Delta conveyance capacity
- Expansion of the SJV water conveyance system

Scenario 3 Evaluation

The Blueprint Analytical Tools were applied to estimate the potential water supply, costs, remaining unmet demand, and acreage of agricultural land that might require repurposing for projects in Scenario 3. As shown in Table 6-5, implementation of Scenario 3 projects could yield approximately 600 to 800 TAF/YR, and would cost from \$3.3 to \$5.2 billion. These investments would be in addition to those made included in Scenarios 1 and 2 projects, because many of actions in Scenarios 3 will rely on the restored capacity of existing facilities to convey Delta water supply, and the availability of some local projects to receive additional supplies from the Delta.

The combined effect of implementing Scenario 1, 2 and 3 projects could provide water supplies ranging between 1,400 TAF/YR and 2,100 TAF/YR, at a cost ranging from \$13.2 billion to \$18.2 billion for the benefits provided to the SJV. Note that some projects included in Scenario 3 would provide benefits to areas outside the SJV. Blueprint Analytical Tools include assumptions on the regional allocation of project costs based on expected location of water supply delivery. As a result, the total range of costs to implement projects in Scenario 3 would be greater than those reported for SJV water users. It is also important to note that the estimated water supply benefits for Scenario 3 projects are limited by available water supplies, and that additional investments may not result in significant greater supplies.

Even with the investments and yields described above, the potential water supply of projects in Scenario 3 would still result in approximately 300 to 1,100 TAF/YR of unmet demand, which the Blueprint estimates would result in the loss of approximately 120,000 acres to 400,000 acres of farmland to fully close the water supply-demand gap. At approximately \$38,000 per acre, land repurposing would cost approximately \$5 to \$15 billion.

The full implementation of Scenarios 1, 2, and 3, and the remaining land to be repurposed, would range from approximately \$18 to \$33 billion.

Table 6-5. Scenario 3 Evaluation Results

Project Types	Average Annual Potential Water Supply (TAF/YR)	Capital Cost (\$ billion)	Remaining Water Supply-Demand Gap (TAF/YR)	Agricultural Acreage Subject to Repurposing (1,000 acres)	Land Repurposing Cost (\$ billion)	Total Scenario Cost (\$ billion)
Total Scenario 1	Preserve Baseline	7.2	2,400	>1,000	38	45.2
Total Scenario 2¹	800 – 1,300	9.9 – 13	1,100 – 1,700	400 – 590	15.2 – 22.4	25.1 – 35.4
Incremental Scenario 3 • Large Infrastructure Projects	600 - 800	3.3 – 5.2	300 – 1,100	120 - 400	4.7 – 15.2	-
Total Combined Scenario 1, Scenario 2, and Scenario 3	1,400 – 2,100	13.2 – 18.2	300 – 1,100	120 – 400	4.7 – 15.2	17.9 – 33.4

Notes:

Values are rounded; therefore, totals may not match the sum of the reported components exactly.

¹ Local water supply projects in Scenario 2 include reuse, recycled, and other projects that develop local surface water supplies.

Key:

TAF/YR = thousand acre-feet per year

As illustrated in Figure 6-3, a supply-demand gap would remain in many subbasins after implementation of Scenario 3 actions, particularly in subbasins that are reliant on Delta exports as a source of water supply, and land repurposing will be required to close the remaining gap. Results are shown for the lower and upper estimates coincide with the ranges for potential water supply reported in Table 6-5.

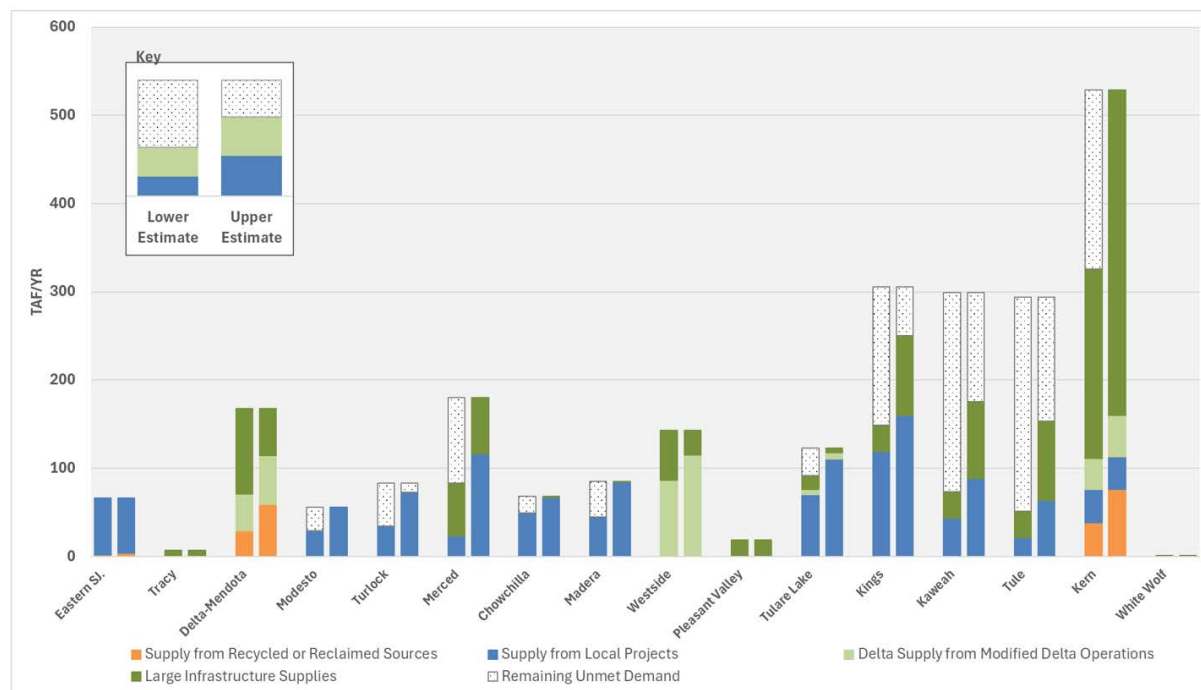


Figure 6-3. Scenario 3 Evaluation Results by Subbasin

Scenario 3 Findings

The following findings can be drawn from review of Scenario 3 evaluations:

- The ability to fully implement Scenario 3 projects will be subject to available water supply, economic feasibility, permitting challenges, and funding availability. It is unlikely that the water supply benefits associated with upper limit simulations listed in Table 6-5 could be fully realized.
- Even if Scenario 3 projects could be implemented to achieve the upper estimated water supply shown in Table 6-5, a significant supply-demand gap would remain. A gap would remain in nearly all subbasins, with the greatest gaps likely in the Kings, Kaweah, Tule, and Kern subbasins, all located in the Tulare Lake Hydrologic Region. A strategic approach to farmland conversion across the SJV should be implemented in a manner that can produce ecosystem, economic, and community benefits while minimizing adverse effects.
- Funding will be a significant barrier to implementation of Scenario 3 projects. The combined cost to SJV for Scenario 1, 2, and 3 projects is estimated to range from \$13 billion to 18



billion. This cost may be unaffordable for agricultural water users, which underscores the need for financial assistance and/or funding partnerships.

- Under the implementation of Scenarios 1, 2, and 3, between 120 to 400 thousand acres of land repurposing would be required and would cost approximately \$5 to \$15 billion; the total cost of Scenarios 1, 2, and 3 would be between \$17 to \$35 billion.
- Some of the projects and actions included in Scenarios 2 and 3 would provide benefits and have associated costs for users outside of the SJV. Partnerships with urban water users outside of the SJV could be beneficial for implementation of in-Valley groundwater recharge and conveyance projects that could support groundwater banking programs and produce benefits to all participating entities.
- It is possible that subsets of projects in Scenario 3 could be pursued by local or regional entities to target specific areas in the SJV. For example, some projects in Scenario 3 could be developed to provide Delta water supplies to the Kaweah, Tule and Kern subbasins. Other projects in Scenario 3 could be developed to provide Delta water supplies to the Kings, Madera, Chowchilla, and Merced subbasins. Regional projects to increase Delta water supplies should be further investigated.
- Scenario 3 projects provide integrated water supply, flood management, and ecosystem enhancement benefits. Most of these projects would add significant storage and/or conveyance capacity to the CVP, SWP, and/or other regional systems, and would be able to manage high flows while also providing water supplies for ecosystem enhancement activities. These projects have other flood management and ecosystem enhancement potential benefits, which are outlined in Chapter 5.

Potential Strategies for Future Evaluation and Project Selection

The three investment scenarios described above demonstrate how a range of investments into different types of projects could produce a range of potential water supply benefits to the SJV. Each evaluated scenario would result in unmet needs and would require some degree of agricultural land repurposing. The findings make it clear that investments ranging up to approximately \$33 billion will be required to address water supply needs in the SJV through the development of projects in combination with a variety of non-structural actions. This estimate includes costs for land repurposing to produce ecosystem enhancement benefits. The availability of water to support economically viable projects will ultimately limit the water supply yield, and project implementation will be constrained by affordability and funding availability.

Each project type evaluated in the scenarios is a compilation of several individual projects that have information at varying levels of development and each have different costs, benefits, and implementation complexities. Even though many projects are locally supported and considered feasible from a technical perspective, constraints associated with financial, institutional, regulatory, and other considerations will make it unrealistic to pursue all projects simultaneously. Reducing the



water supply-demand gap through the implementation of projects and actions, while contributing to ecosystem needs and enhancing flood management, is a long-term strategy that will unfold over decades. As such, a deliberate, transparent, and adaptable project evaluation and selection process is needed to guide how projects are prioritized, sequenced, funded, and implemented over time. A potential process for a long-term project evaluation and selection process could occur is described below as a starting point.

Purpose and Objectives

The primary purpose of the evaluation and selection process would be to support consistent, defensible, and regionally coherent decisions about which projects and actions should be prioritized for further study and implementation within and across different scenarios. By doing so, the process seeks to ensure that limited public and private sector resources are invested in a way that maximizes total regional benefit.

The overarching objectives that guide the process are to:

- **Begin with local and foundational projects.** Begin the process by addressing the supply-demand gap with foundational projects that protect existing infrastructure and water supplies and allow for the optimization of water supply management using existing facilities, and with projects that can be implemented at a local level.
- **Be cost-effective.** Prioritize projects and portfolios that deliver the greatest net water supply benefits, while also considering flood and ecosystem enhancement objectives.
- **Maintain geographic diversity.** Ensure that regional investments are distributed across the SJV to benefit as many subbasins as possible so that all regions remain engaged and invested in implementation of the UWP.
- **Maintain a backlog of shovel-ready projects.** Always have a set of projects that are sufficiently planned, permitted, designed and ready for implementation when funding opportunities arise. This means that investments should be made into the continued evaluation of potential future projects that are early in the planning process.
- **Invest across all types of projects.** Make steady progress across all major types of projects – local and regional water supply projects, access to north-of-Delta supplies, flood management, ecosystem enhancement, and demand management and land repurposing – rather than advancing only one category of solutions at a time.

The projects and actions considered under this process are those that advance the purposes and objectives authorized under PL 111-11 and related federal and state policies, including improving water supply reliability, restoring and protecting ecosystem functions, enhancing flood-risk management and supporting sustainable groundwater management. Framing project evaluation and selection within both the overarching objectives and this broader statutory and policy context helps ensure that investments are aligned with both regional needs and state and national interests.



Potential Evaluation Considerations

The evaluation process is designed to function as a robust but flexible tool for evaluation and selection of projects as described above. Potential evaluation criteria are described below:

Water Supply Reliability. Priority should be given to projects with a demonstrated or highly credible ability to access water supplies sufficient to achieve their stated yields. This includes consideration of hydrologic modeling results, operational constraints, regulatory limitations, and interannual variability.

Benefit-Cost Performance. Projects should be evaluated based on the magnitude and reliability of their benefits relative to total life-cycle costs, including capital, operations, maintenance, and eventual rehabilitation or replacement. Benefits should include not only water supply yield, but also flood-risk reduction, ecosystem enhancement, water-quality improvement, and avoided economic losses.

Project Affordability. Projects should be evaluated individually and collectively based on affordability to end users and consider the availability and applicability of funding from other sources.

Multi-Benefit. Project selection should consider the value of multi-benefit outcomes. Examples of benefits beyond water supply include water quality, flood risk reduction, ecosystem enhancement, recreation, and community resilience.

Interdependencies with Other Projects. Some projects are prerequisites for the effective functioning of many others. For example, the restoration of conveyance capacity to subsidence impacted canals in the SJV will establish a functional baseline for surface water deliveries in the region. Interdependencies should be considered so that local water supply – including for recharge – is balanced with projects that supply additional yield.

Portfolio Balance. Project selection should reinforce the desired distribution of effort across different types of projects. Even if one type contains many apparently high-benefit projects, exclusive or near-exclusive investment in that portfolio would leave other strategic needs unaddressed and increase long-term vulnerability.

Permitting and Regulatory Complexity. Projects with a clear and feasible permitting pathway, including compliance with CEQA, NEPA, ESA, and water-rights requirements, should be advanced as quickly as possible, while more complex projects with lengthier permitting processes are also developed.

Implementation Complexity and Speed to Benefit. Projects that are relatively simple, locally controlled, and quick to implement can deliver near-term benefits and build momentum for the UWP. While the benefits of such actions likely will be limited and locally confined, their successful implementation can help build momentum toward necessary larger actions that will require partnerships, broad regional support, and state and federal participation.

Project Maturity and Life-Cycle Position. The overall project portfolio should include a mix of shovel-ready projects and projects that are still in earlier stages of planning, feasibility analysis, or design. Selection criteria should therefore explicitly recognize life-cycle position, with the goal of continuously replenishing the pipeline of future shovel-ready projects.

All projects listed in Chapter 5 and evaluated above, as well as any other potential projects that could be viable for implementation in the SJV, should be evaluated by local, regional and other entities using a structured evaluation using the criteria outlined above or a method with similar criteria. The criteria requires consistent and adequate project information to enable accurate evaluations. Consequently, project information such as, but not limited to, benefits, costs, sources of water supply, or participating entities should be compiled, monitored and updated to perform the evaluation. A proposed process for consideration for project evaluation is outlined in Figure 6-4. The results of the evaluation process would highlight beneficial projects to the SJV. The process could be used to bring forth options of shovel-ready projects; highlight projects that require further evaluation, planning, and/or design; and highlight uncertainties to be resolved. The process could also include collaboration with other entities like the CAP, and could use project evaluation tools developed by them and/or other groups.

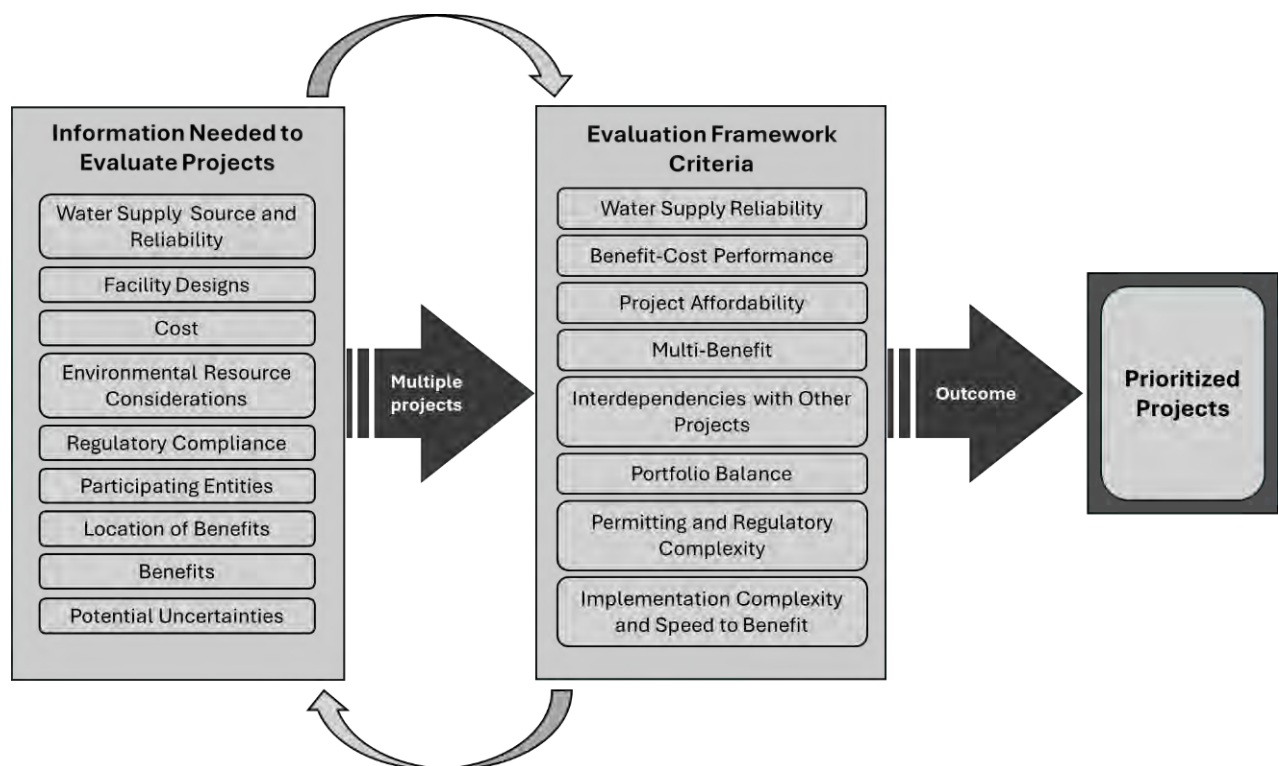


Figure 6-4. Recommended Project Information and Evaluation Framework



Recommendations

This section provides a concise compilation of specific recommendations to local, state, and federal entities based on the findings described above.

Recommendations for Local and Regional Entities in the SJV

The following are near-term recommendations for local and regional entities in the SJV based on the findings of this UWP:

1. Restore and maintain the conveyance capacity and delivery capability of existing CVP and SWP subsidence-impacted canals and remove sediment from south Delta channels. Further lost capacity will increase the supply-demand gap and inhibit the ability to realize benefits from many local and regional projects identified in the UWP.
2. Partner with state and federal entities to determine water available for diversion from SJV rivers that can be used to enhance groundwater recharge.
3. Partner with state and federal entities to advance non-structural actions that can increase water supplies available for diversion. This includes non-structural actions in the SJV to increase the availability of local water supplies (e.g., improved forecasting and monitoring, FIRO) and in the Delta to increase south of Delta exports (e.g., Long-Term Operations Action 5, realize physical capacity of CVP and SWP export facilities). Robust adaptive management programs should be used to inform and evaluate implementation of non-structural actions.
4. Develop and implement local conveyance, recharge, storage, and other projects identified in Groundwater Sustainability Plans, with an emphasis on advancing the shovel-readiness of projects to increase preparedness for funding opportunities. Continue to evaluate emerging approaches, technologies, and solutions.
5. Pursue large regional and statewide projects, particularly those that increase access to Delta supplies and improve regional conveyance and storage.
6. Leverage partnership opportunities with urban water users outside the SJV to jointly develop groundwater banking, recharge, and conveyance projects that produce water supply benefits to both parties and provide for project cost-sharing.
7. Establish a structured, regionally coordinated plan for agricultural land repurposing to minimize community effects and produce desired ecosystem and economic outcomes. Early strategic implementation can support groundwater recharge, ecosystem, energy, and community benefits, particularly in subbasins that will likely see larger areas of agricultural land repurposing.

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8. Participate in California Water Plan updates, by engaging in committees and public workshops, providing review comments, and advocating for partnership in an analytical test of concept to estimate future water needs and evaluate potential adaptation strategies.

Recommendations for State and Federal Entities in the SJV

The following are recommendations for state and federal entities based on the needs in the SJV:

1. Restore and maintain the conveyance capacity and delivery capability of existing CVP and SWP subsidence-impacted canals and remove sediment from south Delta channels. The XM program was primarily designed to rehabilitate or replace aged infrastructure and requires full reimbursement by beneficiaries. The nature of regional land subsidence impacts to CVP and SWP conveyance facilities has created unique conditions in the SJV that challenge the applicability of the XM program.
2. Establish non-traditional federal funding mechanisms and a new SJV Water Supply Security program that would provide assistance to agricultural users and others to implement projects that preserve and increase the capability to manage water supplies in the SJV and Delta. Protecting the viability of agriculture in the SJV is of state and national importance that will require significant investment. Delta levee maintenance and improvements should be recognized as a water supply reliability, flood protection, ecosystem, and infrastructure priority that is directly connected to San Joaquin Valley water security. The Federal Government has extensive success in applying targeted infrastructure funding support for water supply throughout the western U.S. A program specifically tailored to the urgent needs of the SJV is warranted.
3. Establish a long-term, sustainable State of California funding mechanism specifically for investments in water resources projects in the SJV such as groundwater recharge and storage, surface water storage, and conveyance facilities. California has a long history of providing state financing to advance water resource management priorities. Establishing dedicated state funds for water system investment is not unprecedented. In 2025, Texas voters authorized a constitutional amendment to dedicate up to \$1 billion per year from existing state sales tax revenue to support funding for a broad range of water supply and related infrastructure, including: new supply sources (reservoirs, reuse, desalination, water purchases); wastewater reuse; flood control; agricultural water conservation; and repair and replacement of aging/leaking water systems.
4. Support implementation of water supply projects by streamlining permitting processes and engaging in agency cooperation. Many complex projects experience regulatory and institutional delays that contribute to increased costs over time. Permitting processes across multiple state and federal agencies should be revised where possible to improve clarity, enhance coordination and efficiency; integrate requirements across regulatory entities to avoid redundancies and inconsistencies; and establish clear criteria and accountable timelines for approval.

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5. Determine if existing institutional requirements, such as the authorized places of use for SWP, CVP and other supplies in the SJV, would impede project implementation.
 6. Consider expanding the definition of benefits used to evaluate financial feasibility of water resources projects to include the totality of project benefits, such as societal benefits of reliable domestic food production.
 7. The State of California should continue ongoing efforts to support, enhance, and contribute to protecting and increasing water supplies and groundwater recharge. Examples include preparing the California Water Plan consistent with California Water Code section 10004 and 10004.7 as defined by California SB 659 (2023), and California Water Code section 10004, 10004.5, 10004.6, and 10013 as defined by SB 72 (2025); implementing legislation, executive orders, programs, initiatives, and other actions that increase groundwater recharge; and accelerating implementation of non-structural actions in the Delta and adaptive reservoir operations in the SJV.
 8. The federal government should continue efforts to increase water supply reliability in the SJV and Delta through administrative actions, legislation, and other strategies. Examples include an emphasis on Executive Order 14181 to maximize operations of the CVP and SWP; and consideration of strategies designed to further increase water supply adequacy and reliability for entities that rely on the CVP and SWP. Such strategies should include regular review of the efficacy of existing constraints on the operations of the CVP and SWP, further integration of real-time scientific information and decision making, and the modification or elimination of those constraints that are demonstrated to be non-efficacious.

Recommendations for Unified Water Plan Implementation

The following are recommendations for next steps for continued implementation of the UWP and to support regional decision-making on project prioritizations:

1. Establish a structured approach to achieve regional agreement and support on project recommendations. Projects and actions should be recommended for further study and for implementation. Blueprint Analytical Tools could be further developed, refined, and used to assist with evaluations.
2. Continue coordinating regional and statewide partnerships to facilitate consistent messaging and to help address permitting, funding, and other constraints. Partnerships are key to overcoming financial limitations for project implementation and coordinated advocacy.
3. Prepare regular updates to the UWP that assess progress towards closing the supply-demand gap. Implementation of the UWP will unfold over several years and require transparency, adaptability, and accountability. Updates to the UWP should also include potential new actions that could further close the water supply-demand gap.

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4. Prepare an updated regional economic impact study that quantifies the potential economic outcomes of inaction and fragmented land retirement in the SJV and consider effects on other regions outside of the SJV.
 5. Collaborate with other entities in the SJV so that its “story” can be told in a compelling and cohesive manner.
 6. Engage in California Water Plan updates including data sharing, test of concept development, and other important activities requiring partnership with DWR.



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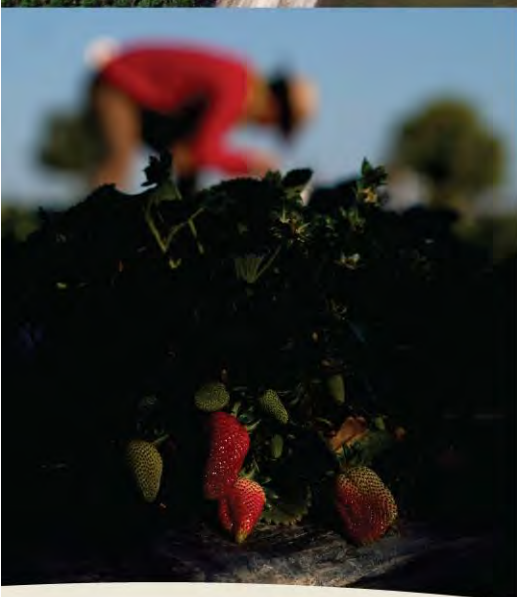
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Unified Water Plan for the San Joaquin Valley

Appendix A
July 2026



Appendix A

Table A-1. Most Recent Publicly Available GSP (as of November 2025) used in the Unified Water Plan by Basin

Basin	GSP	GSP Date	Source
Eastern San Joaquin	Eastern SJ GSP	Nov-24	https://sgma.water.ca.gov/portal/gsppe/update/view/47
Modesto	Modesto GSP	Jul-24	https://sgma.water.ca.gov/portal/gsp/preview/85
Turlock	Turlock GSP	Jul-24	https://sgma.water.ca.gov/portal/gsp/preview/110
Merced	Merced GSP	Jan-25	https://sgma.water.ca.gov/portal/gsppe/update/view/9
Chowchilla	DEID GSP	Jan-25	https://sgma.water.ca.gov/portal/gsp/preview/160
Madera	Madera Subbasin Joint GSP	Jan-25	https://sgma.water.ca.gov/portal/gsppe/update/view/21
	Gravelly Ford GSP	Jan-25	https://sgma.water.ca.gov/portal/gsppe/update/view/61
	New Stone GSP	Dec-24	https://sgma.water.ca.gov/portal/gsppe/update/view/49
	Root Creek GSP	Dec-24	https://sgma.water.ca.gov/portal/gsppe/update/view/45
Delta-Mendota ¹	Northern & Central Delta-Mendota GSP	Jul-24	https://deltamendota.org/final-gsp-documents/
	Aliso WD GSP		
	SJRECWA GSP		
	Grasslands GSP		
	Fresno County Farmers		
Kings	Central Kings GSP	Jan-25	https://sgma.water.ca.gov/portal/gsppe/update/view/22
	Kings River East GSP	Jan-25	https://sgma.water.ca.gov/portal/gsppe/update/view/23
	McMullin GSP	Nov-24	https://sgma.water.ca.gov/portal/gsppe/update/view/28
	North Fork GSP	Jan-25	https://sgma.water.ca.gov/portal/gsppe/update/view/25
	North Kings GSP	Jan-25	https://sgma.water.ca.gov/portal/gsppe/update/view/24
	South Kings GSP	Jan-25	https://sgma.water.ca.gov/portal/gsppe/update/view/26
	James ID GSP	Dec-24	https://sgma.water.ca.gov/portal/gsppe/update/view/31
Westside	Westside	Dec-24	https://sgma.water.ca.gov/portal/gsppe/update/view/8
Pleasant Valley	Pleasant Valley	Jul-24	https://sgma.water.ca.gov/portal/gsp/preview/145

Kaweah	East Kaweah GSP	Nov-24	https://lindmoreid-my.sharepoint.com/personal/chunter_lindmoreid_com/layouts/15/onedrive.aspx?id=%2Fpersonal%2Fchunter%5Flindmoreid%5Fcom%2FDocuments%2FEKGSAWebShare%2FEKGSA%5FGSP%5Fwith%5Fappendices%5F2024%5FFinal%2Epdf&parent=%2Fpersonal%2Fchunter%5Flindmoreid%5Fcom%2FDocuments%2FEKGSAWebShare&ga=1
	Greater Kaweah GSP	Dec-24	https://www.dropbox.com/scl/fi/1ey3lx4tqaqighnsb19qu/GSP-Adopted-20241112.pdf?rlkey=apjfwqtqjizlqgibsp5i1a98u5&e=1&st=8v1z2dip&dl=0
	Mid Kaweah GSP	Jul-22	https://sgma.water.ca.gov/portal/gsp/preview/50
Tulare Lake	Tulare Lake GSP	Jul-22	https://sgma.water.ca.gov/portal/gsp/preview/42
Tule	Tri County WA GSP	Sep-25	https://tcwater.org/
	DEID GSP	Sep-24	https://www.deid.org/gsa/#gsp
	Pixley GSP	Jan-22	https://sgma.water.ca.gov/portal/gsp/preview/65
	Lower Tule River GSP	Jul-24	https://ltrid.org/wp-content/uploads/2024/09/Lower-Tule-River-Irrigation-District-July-2024-Revision-hyperlinks.pdf
	Alpaugh GSP	Aug-24	https://alpaughgsa.wordpress.com/
	Eastern Tule GSP	Sept-24	https://easterntulegsa.com/gsp/
Kern ¹	Kern Groundwater Authority GSP	Aug-25	https://kerngsp.com/wp-content/uploads/2025/09/Kern-County-Subbasin-Groundwater-Sustainability-Plan-2025-Clean.pdf
	Olcese GSP		
	Henry Miller WD GSP		
	South of Kern River GSP		
	Buena Vista GSP		
	Kern River Groundwater Sustainability Agency GSP		
Tracy	Tracy Subbasin GSP	Nov-21	https://sgma.water.ca.gov/portal/gsp/preview/122
White Wolf	White Wolf GSP	Dec-21	https://sgma.water.ca.gov/portal/gsp/preview/123

Notes:

¹ In most recently publicly available GSP document, the GSPs in Delta-Mendota and Kern combined into one document for their Subbasin's respective GSP.

Unified Water Plan

for the
San Joaquin Valley

Appendix B
July 2026



Appendix B

Soil Agricultural Groundwater Banking Index (SAGBI) maps are shown basin-wide for the San Joaquin and Tulare Lake Basin Hydrologic Regions in Chapter 5. Here, in Appendix B, individual maps and specific details are presented for each of the subbasins in the study area. These maps are intended to compliment Figure 5-1 and Figure 5-2 in Chapter 5 by providing additional details related to the spatial distribution of SAGBI values within and outside of the Corcoran clay extents within each subbasin.

Eastern San Joaquin Subbasin

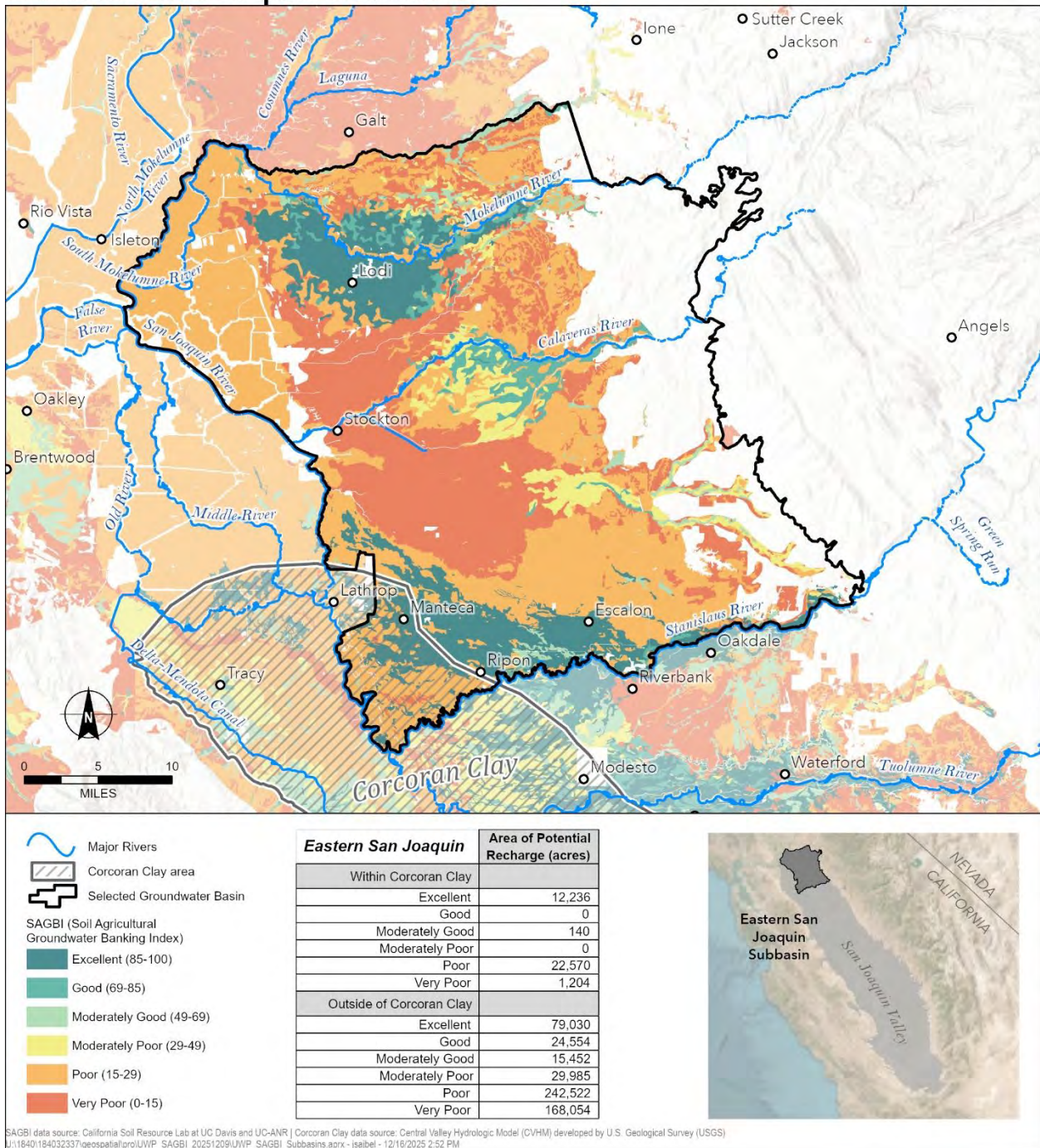


Figure B-1. Eastern San Joaquin Soil Agricultural Groundwater Banking Index

Tracy Subbasin

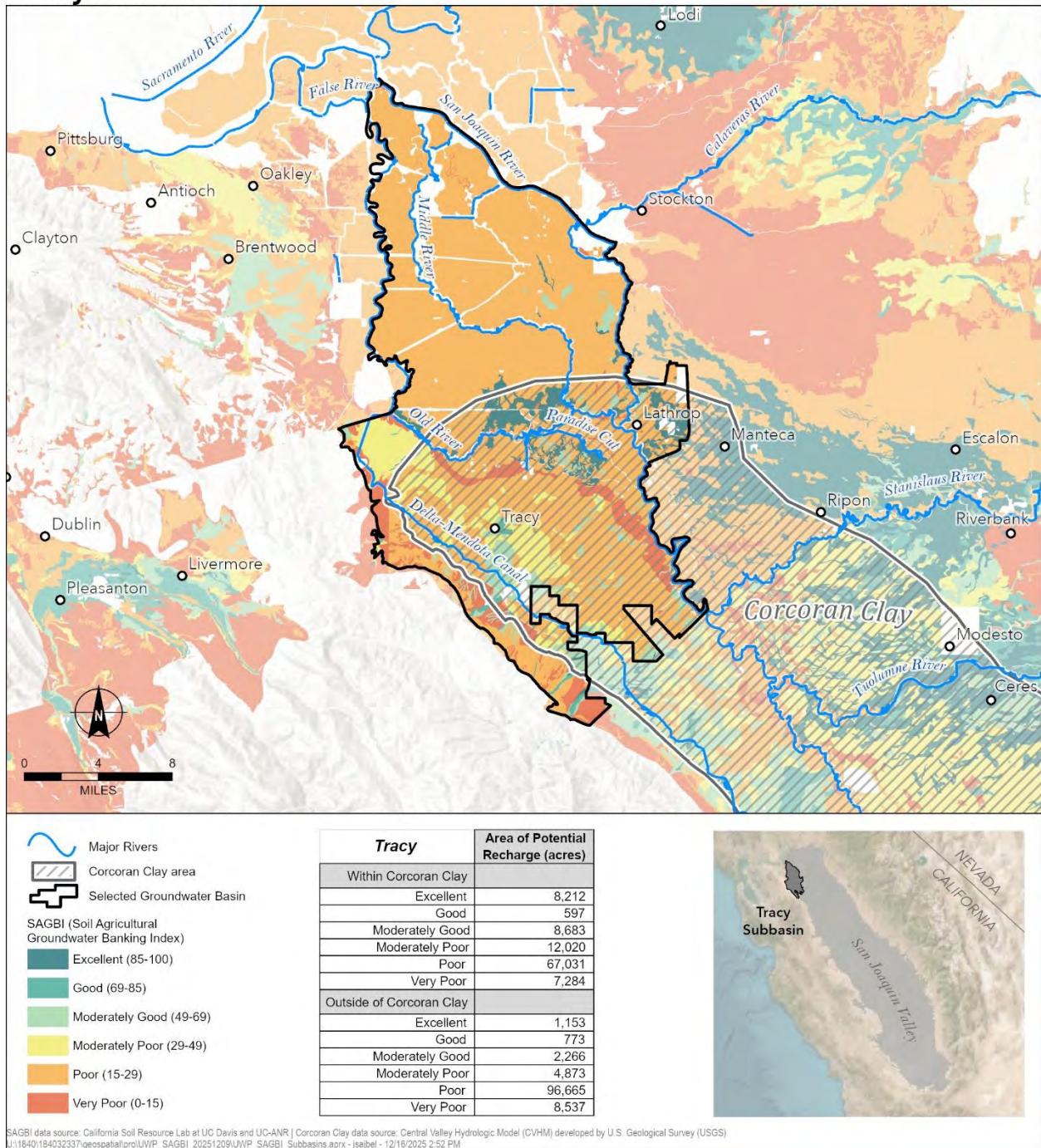


Figure B-2. Tracy Soil Agricultural Groundwater Banking Index

Delta-Mendota

Area of Potential Recharge (acres)	
Within Corcoran Clay	
Excellent	4,094
Good	36,454
Moderately Good	96,177
Moderately Poor	48,801
Poor	224,363
Very Poor	230,195
Outside of Corcoran Clay	
Excellent	437
Good	5,918
Moderately Good	12,581
Moderately Poor	22,029
Poor	20,512
Very Poor	22,907

Delta-Mendota Subbasin

SAGBI (Soil Agricultural Groundwater Banking Index)

- Excellent (85-100)
- Good (69-85)
- Moderately Good (49-69)
- Moderately Poor (29-49)
- Poor (15-29)
- Very Poor (0-15)

Corcoran Clay area

Selected Groundwater Basin

SAGBI data source: California Soil Resource Lab at UC Davis and UC-ANR | Corcoran Clay data source: Central Valley Hydrologic Model (CVHM) developed by U.S. Geological Survey (USGS) | 11/18/2018 10:33:33Z | geospatial.com | LWP: SAGBI 20251208 | LWP: SAGBI Subbasins app - isabel - 12/18/2025 2:52 PM

Modesto Subbasin

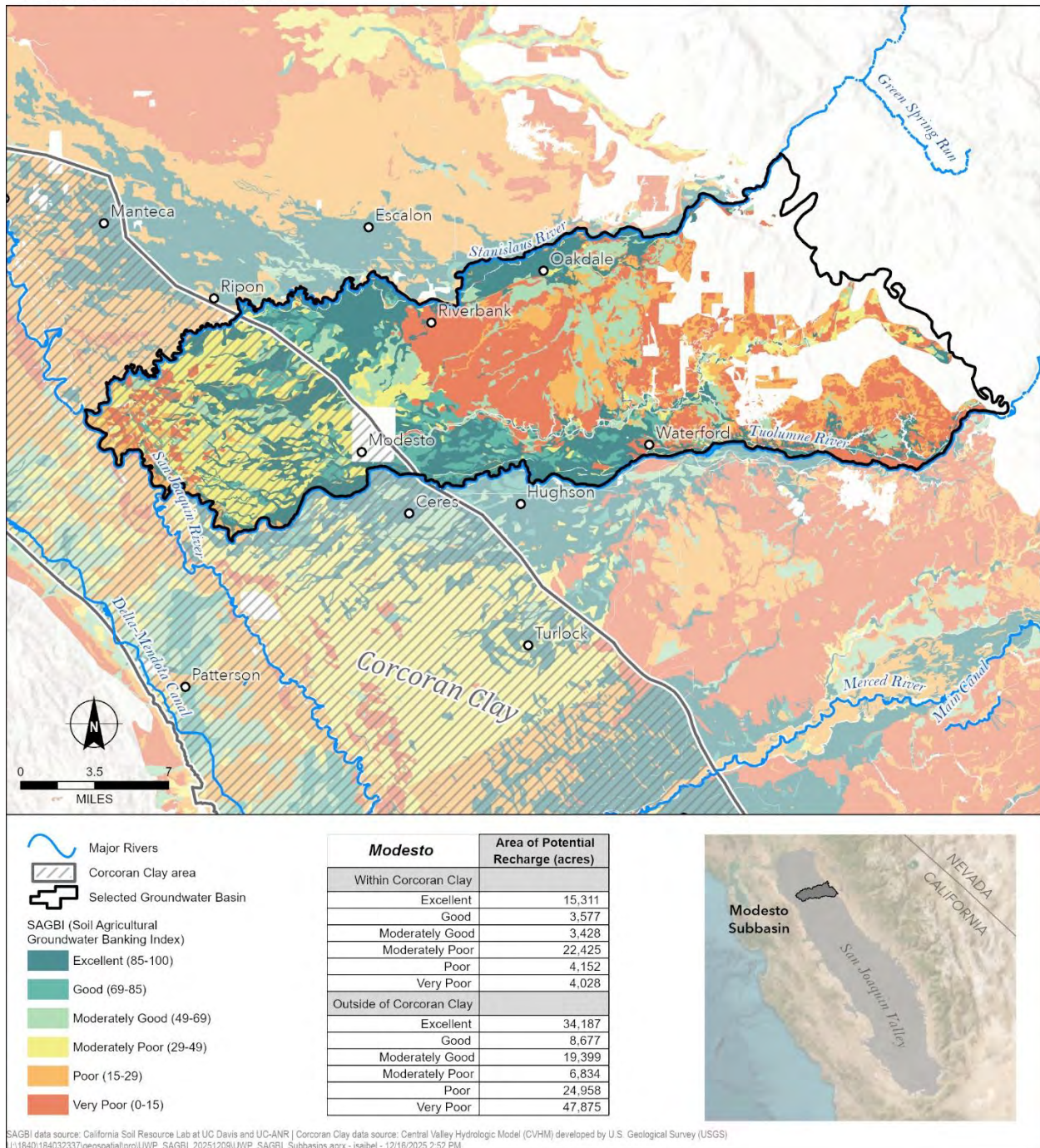


Figure B-4. Modesto Soil Agricultural Groundwater Banking Index

Turlock Subbasin

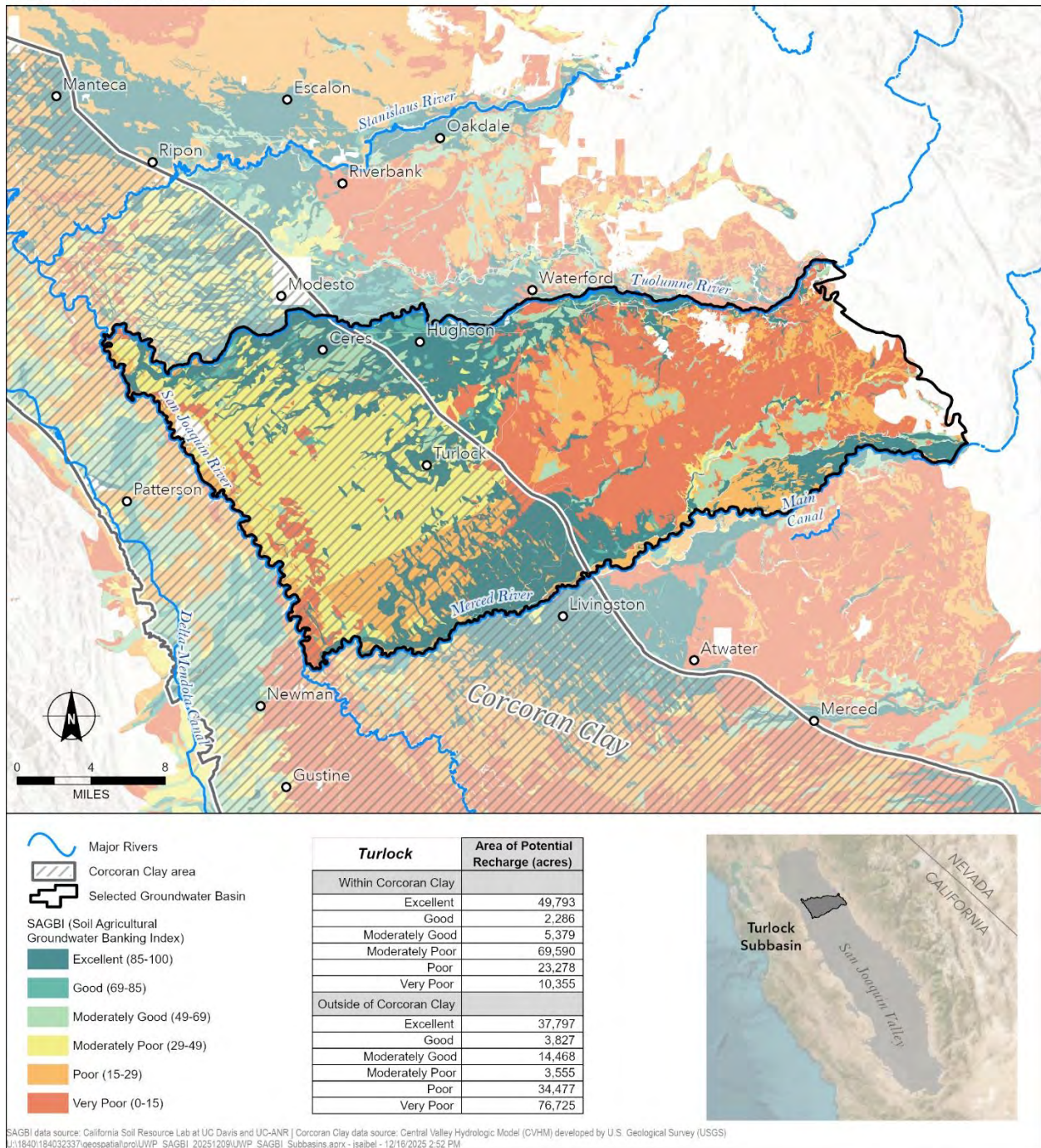


Figure B-5. Turlock Soil Agricultural Groundwater Banking Index

Merced Subbasin

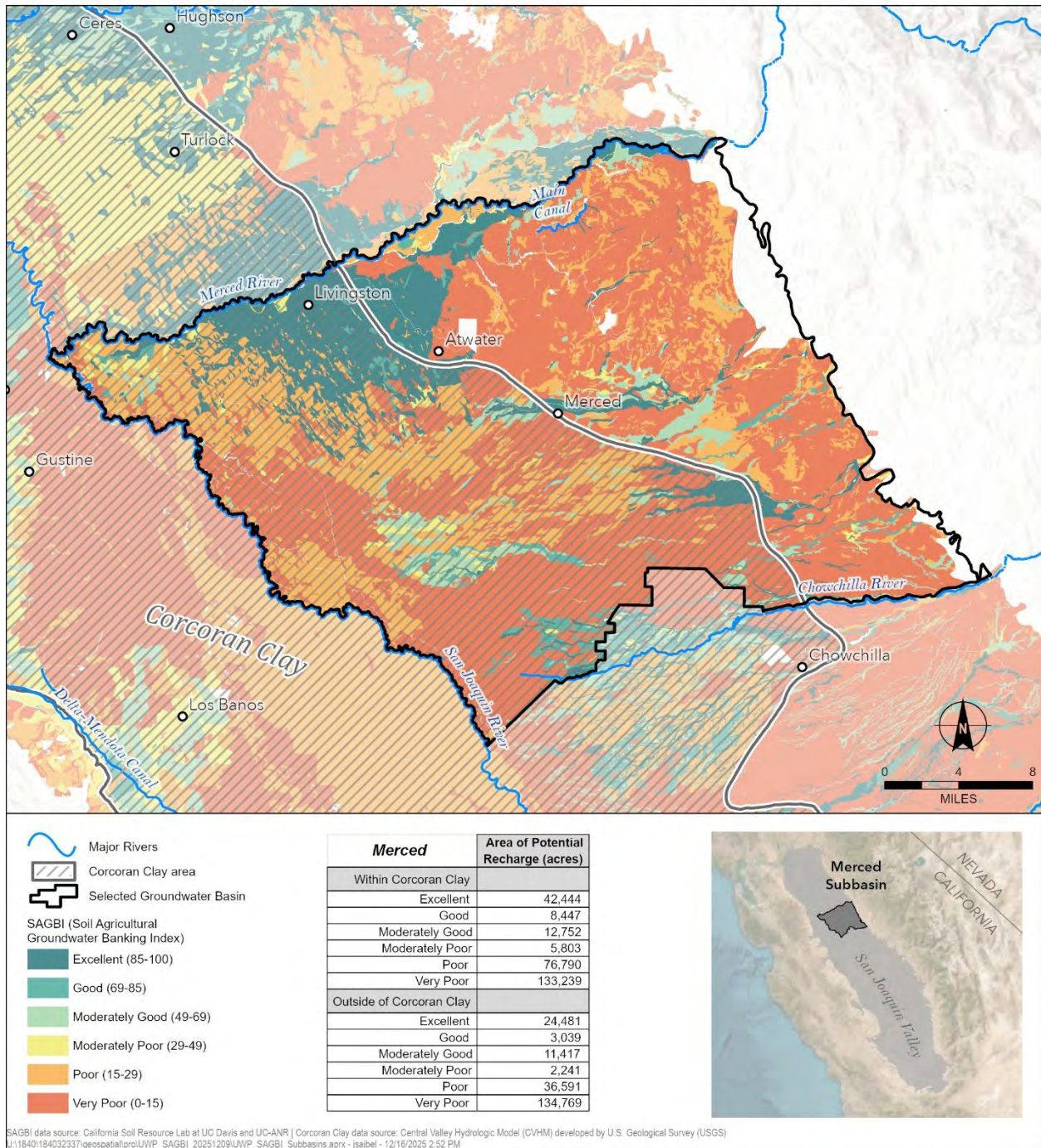


Figure B-6. Merced Soil Agricultural Groundwater Banking Index

Chowchilla Subbasin

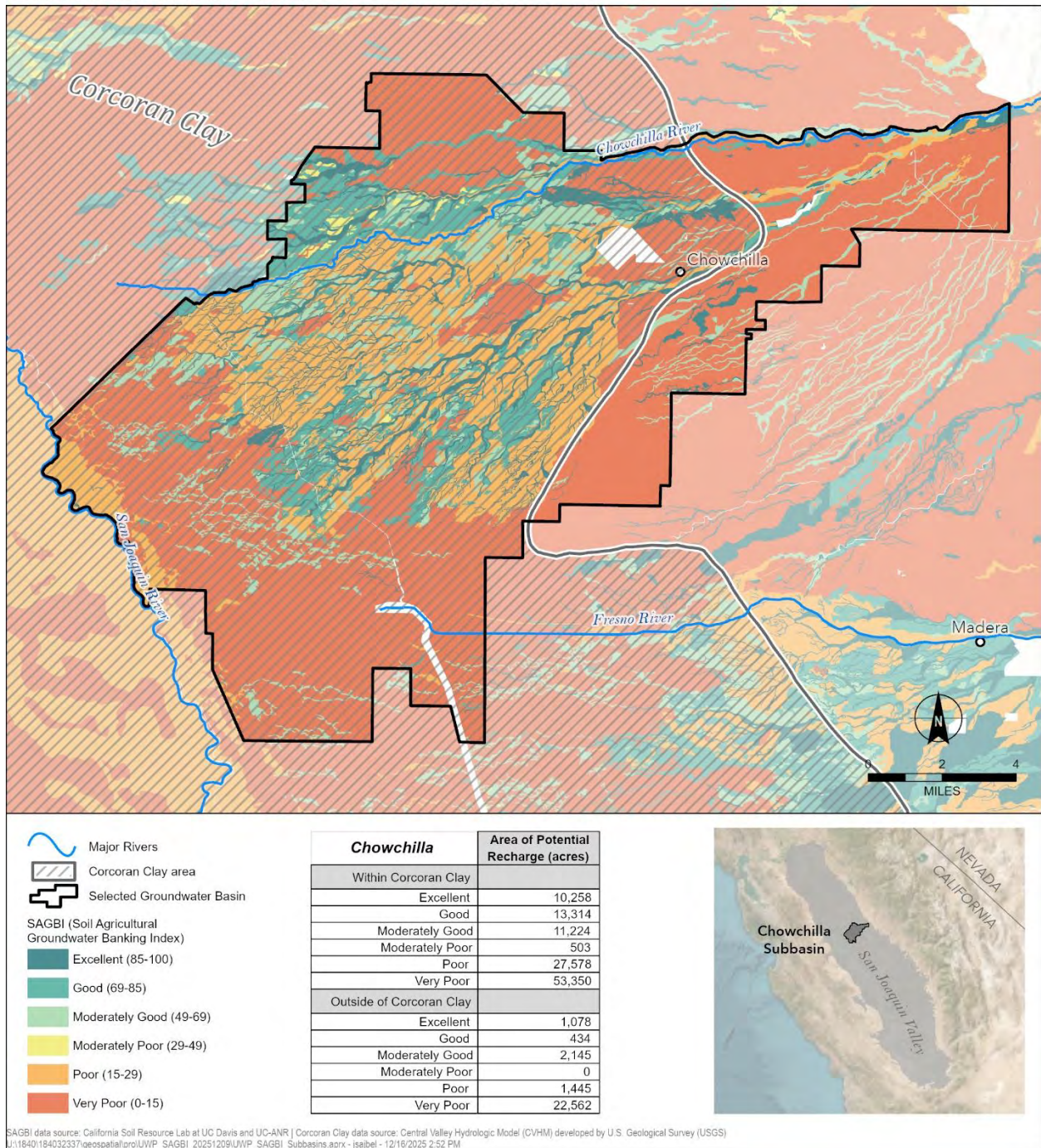


Figure B-7. Chowchilla Soil Agricultural Groundwater Banking Index

Madera Subbasin

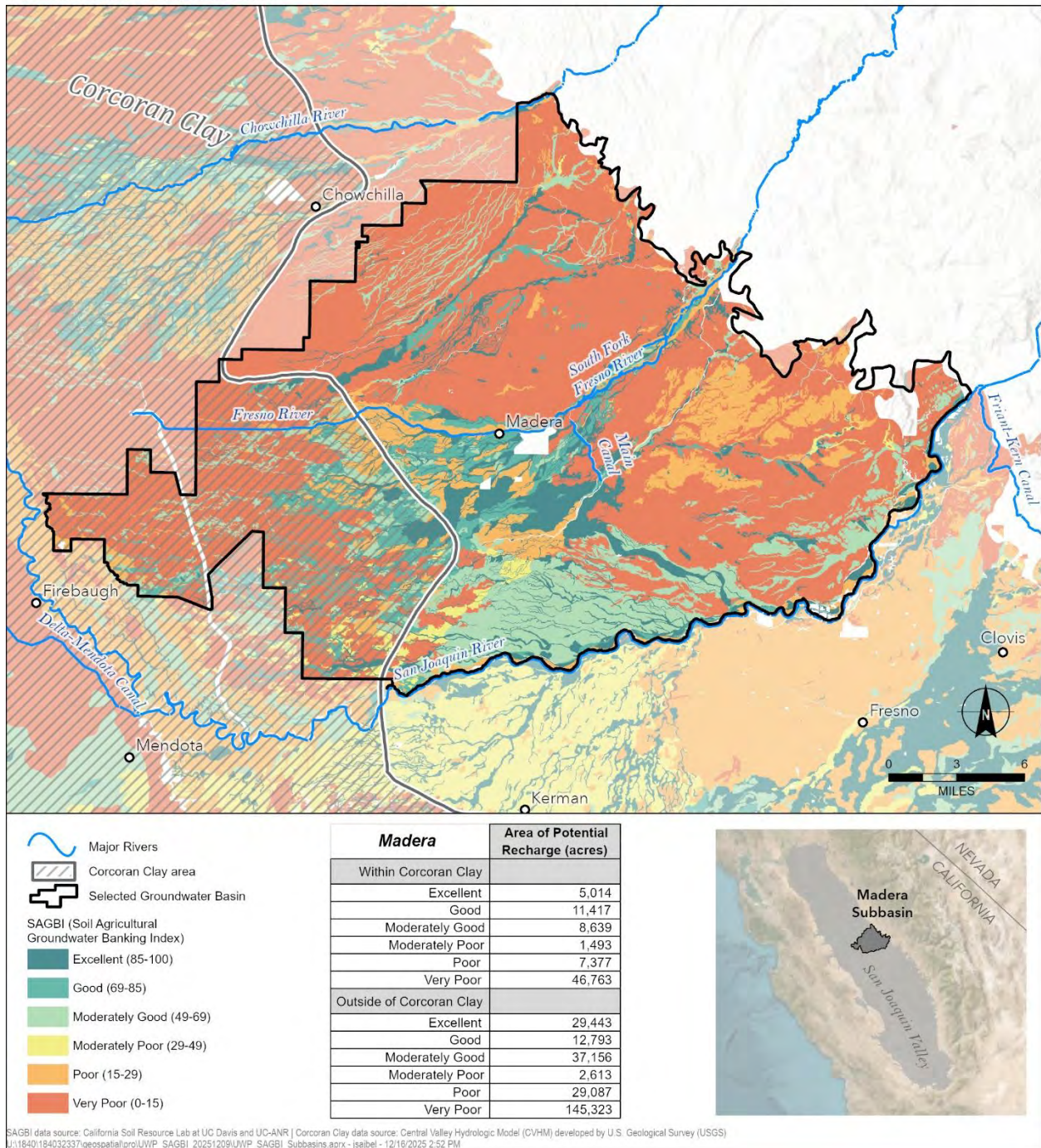


Figure B-8. Madera Soil Agricultural Groundwater Banking Index

Westside Subbasin

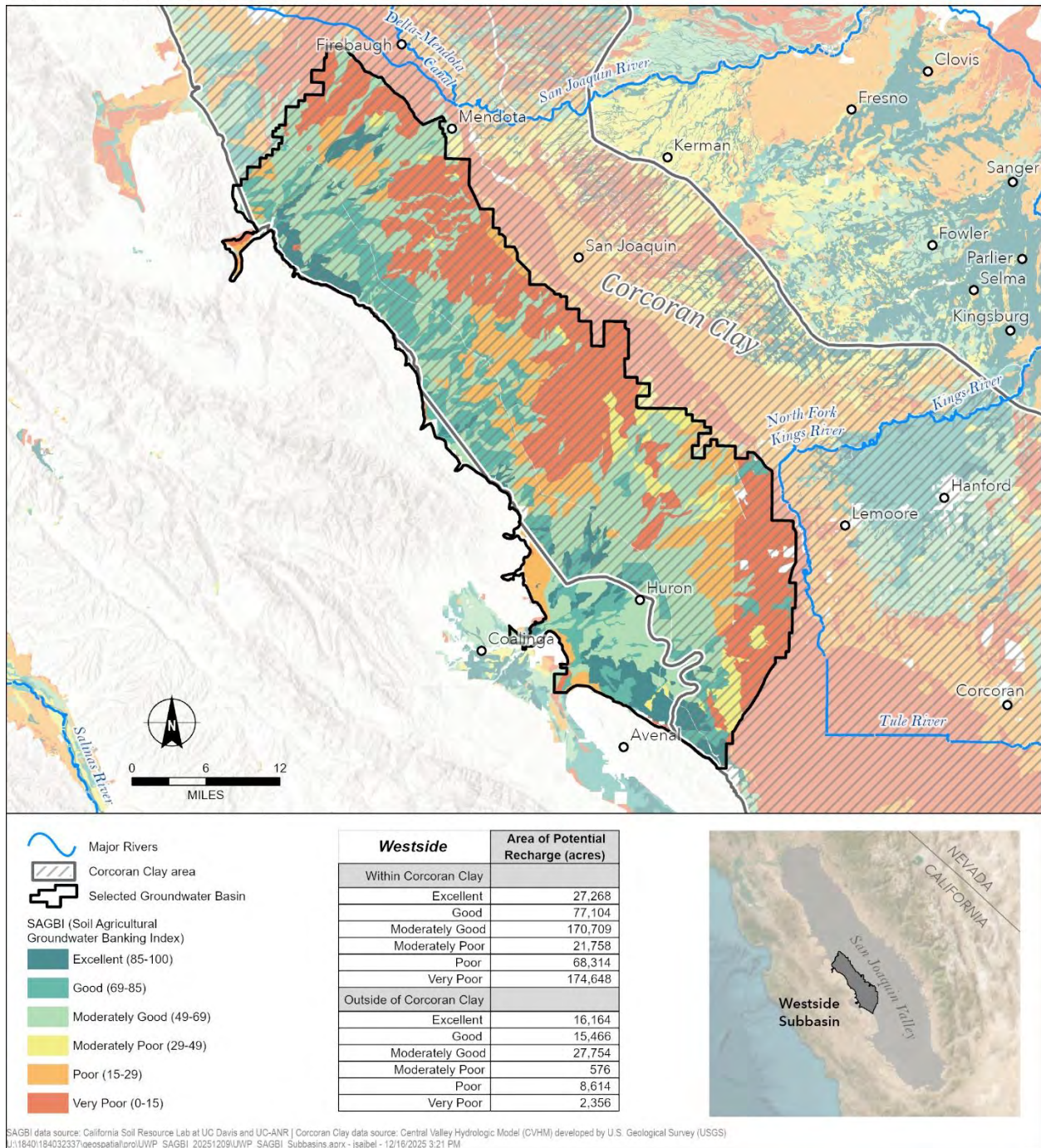


Figure B-9. Westside Soil Agricultural Groundwater Banking Index

Pleasant Valley Subbasin

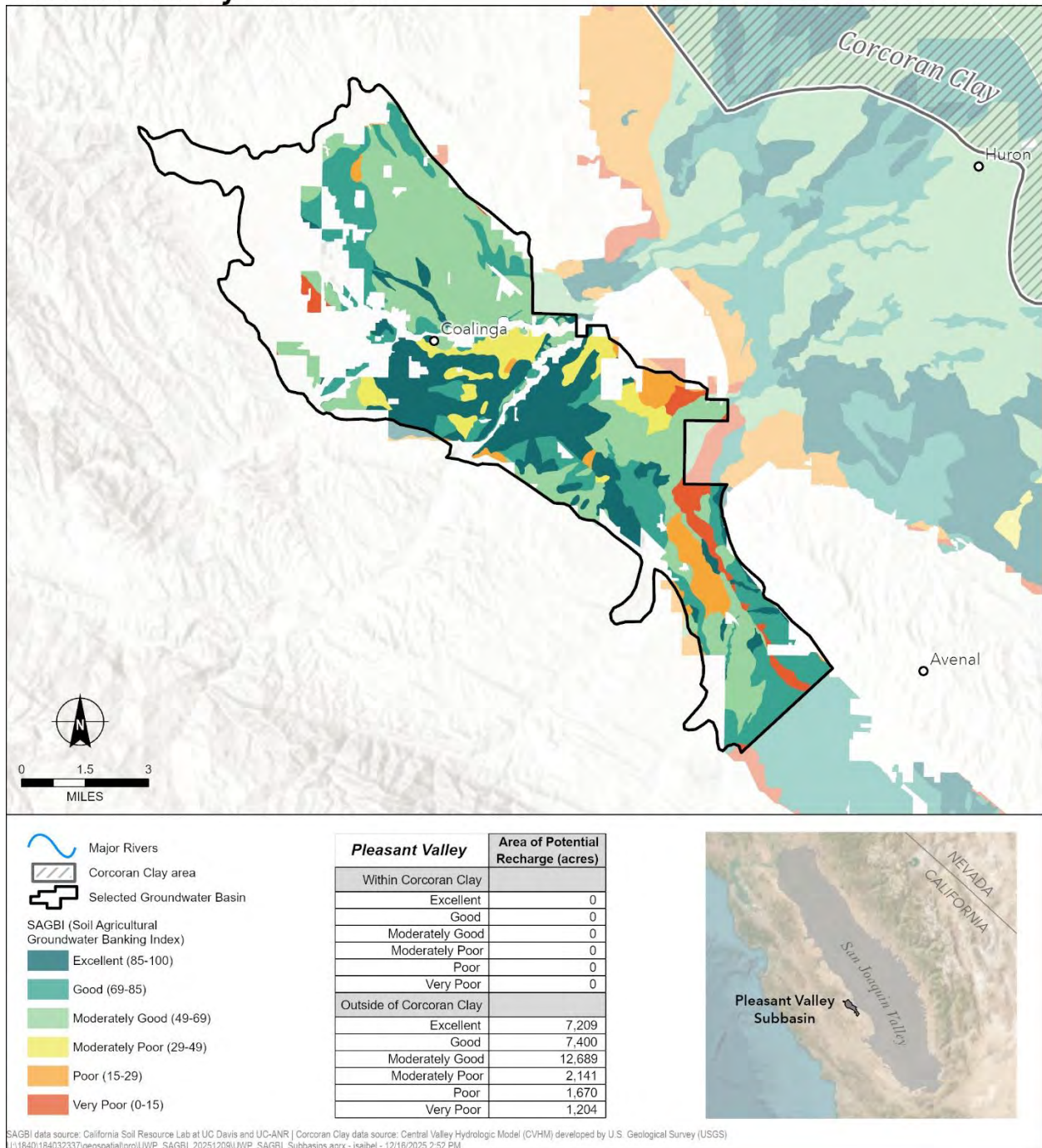


Figure B-10. Pleasant Valley Soil Agricultural Groundwater Banking Index

Tulare Lake Subbasin

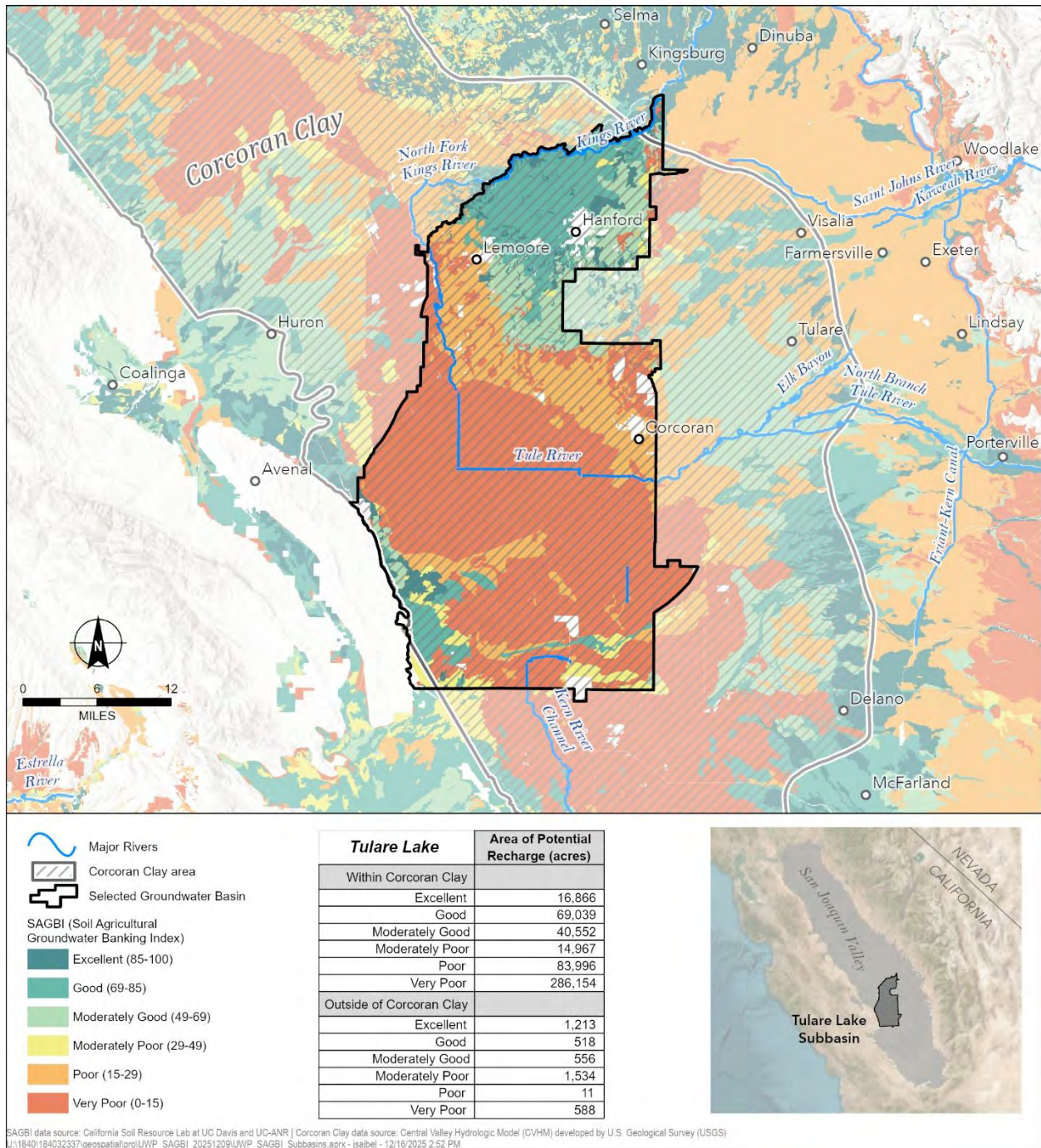


Figure B-11. Tulare Lake Soil Agricultural Groundwater Banking Index

Kings Subbasin

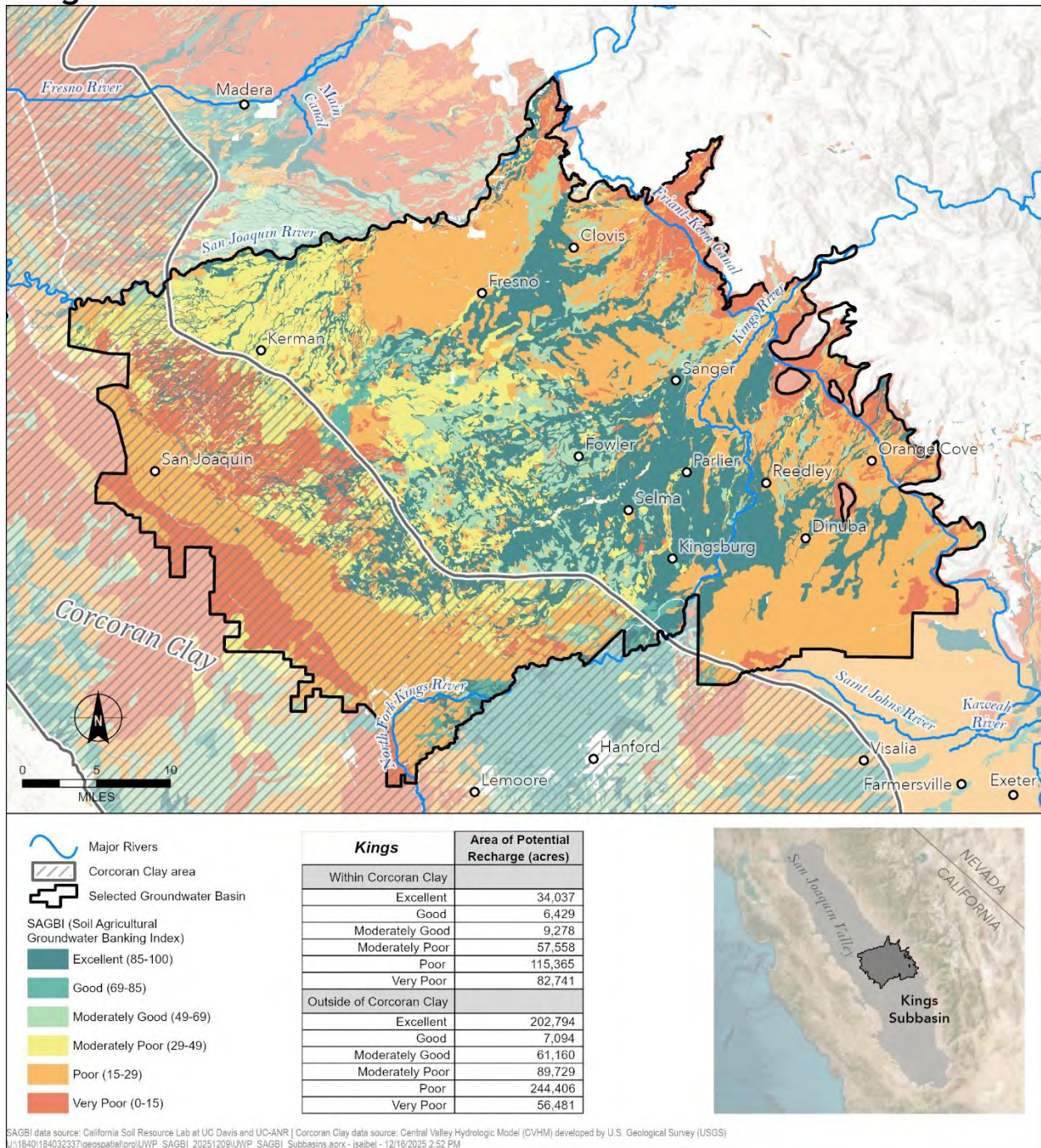


Figure B-12. Kings Soil Agricultural Groundwater Banking Index

Kaweah Subbasin

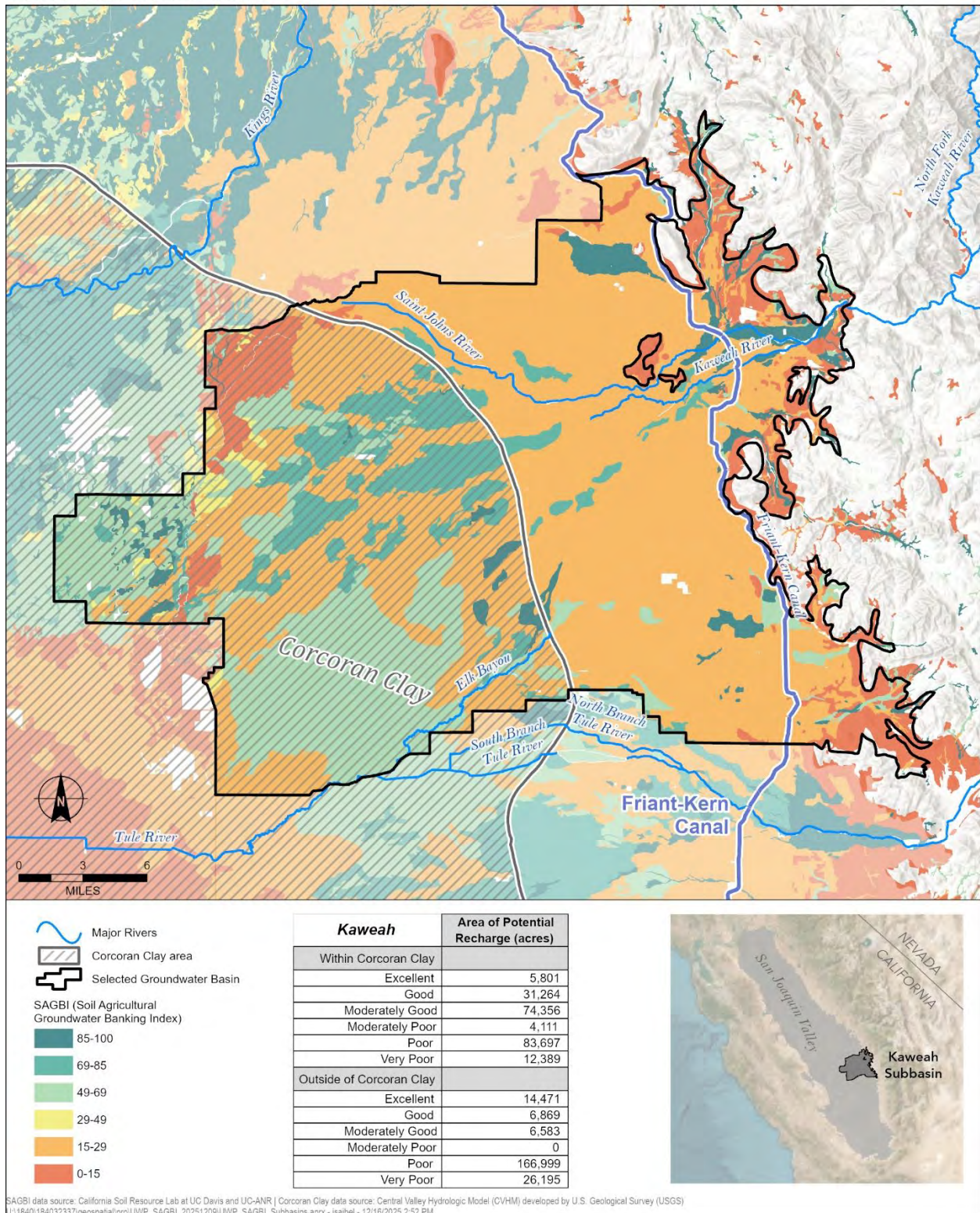


Figure B-13. Kaweah Soil Agricultural Groundwater Banking Index

Tule Subbasin

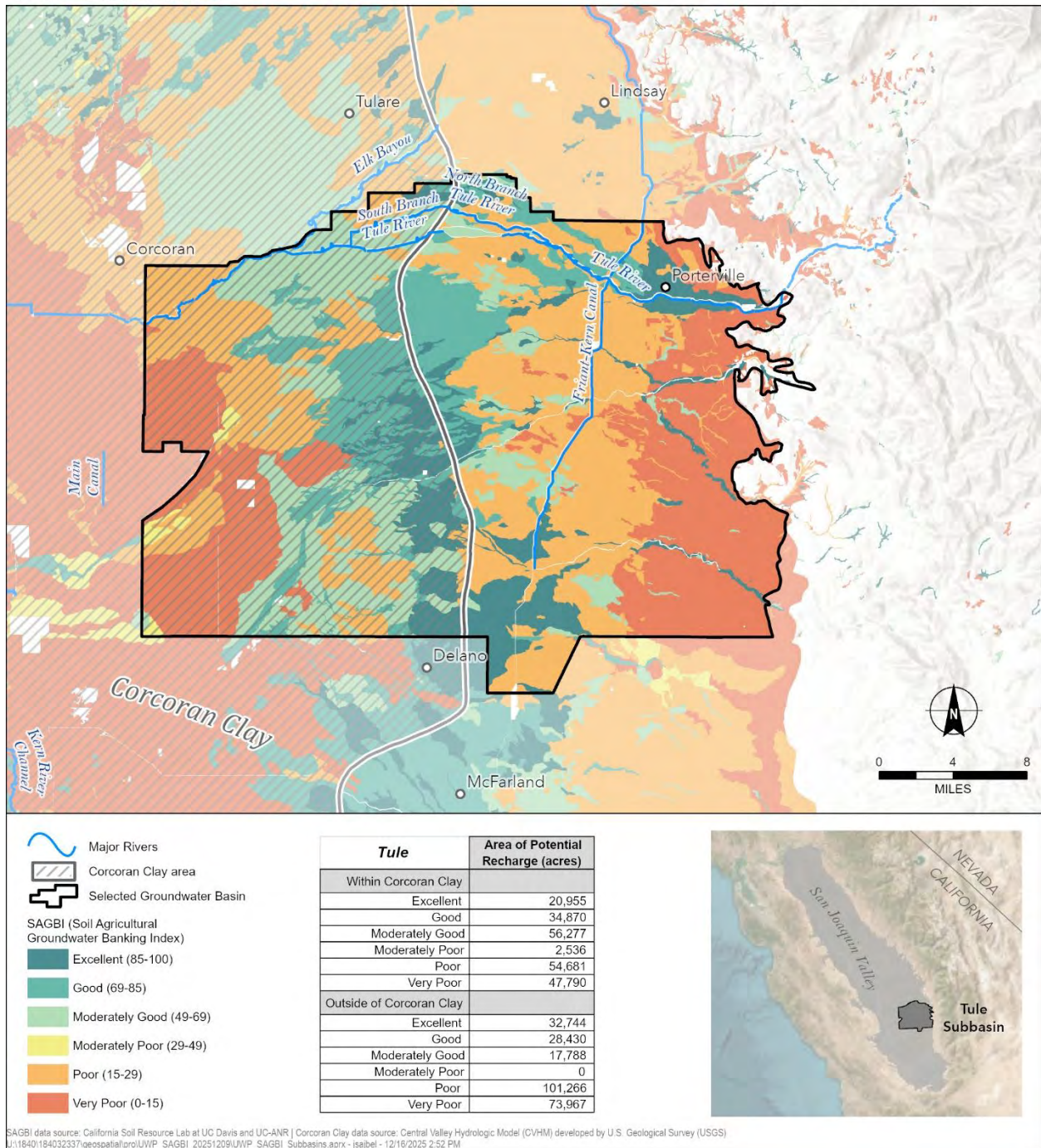


Figure B-14. Tule Soil Agricultural Groundwater Banking Index

Kern Subbasin

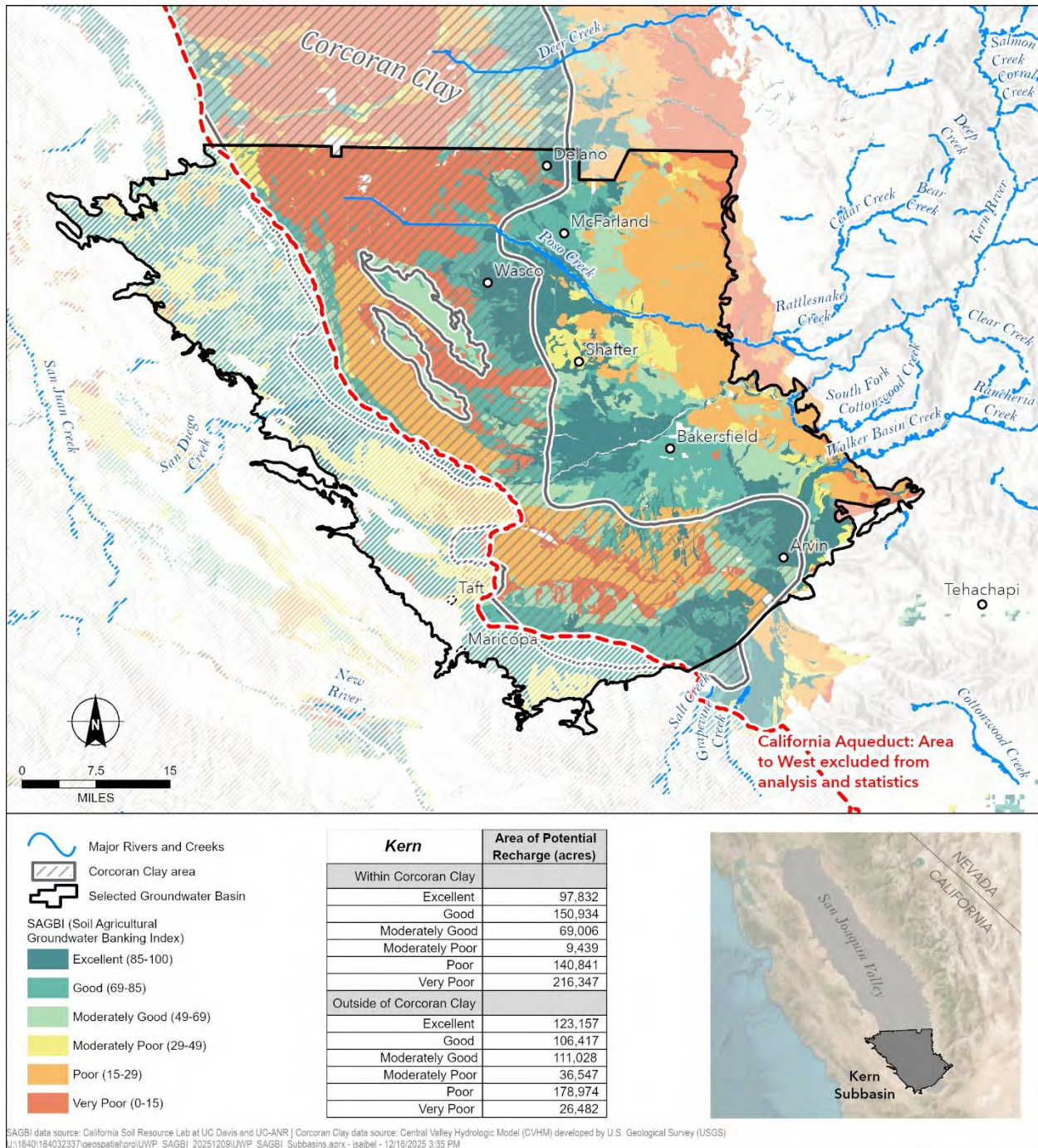


Figure B-15. Kern Soil Agricultural Groundwater Banking Index

White Wolf Subbasin

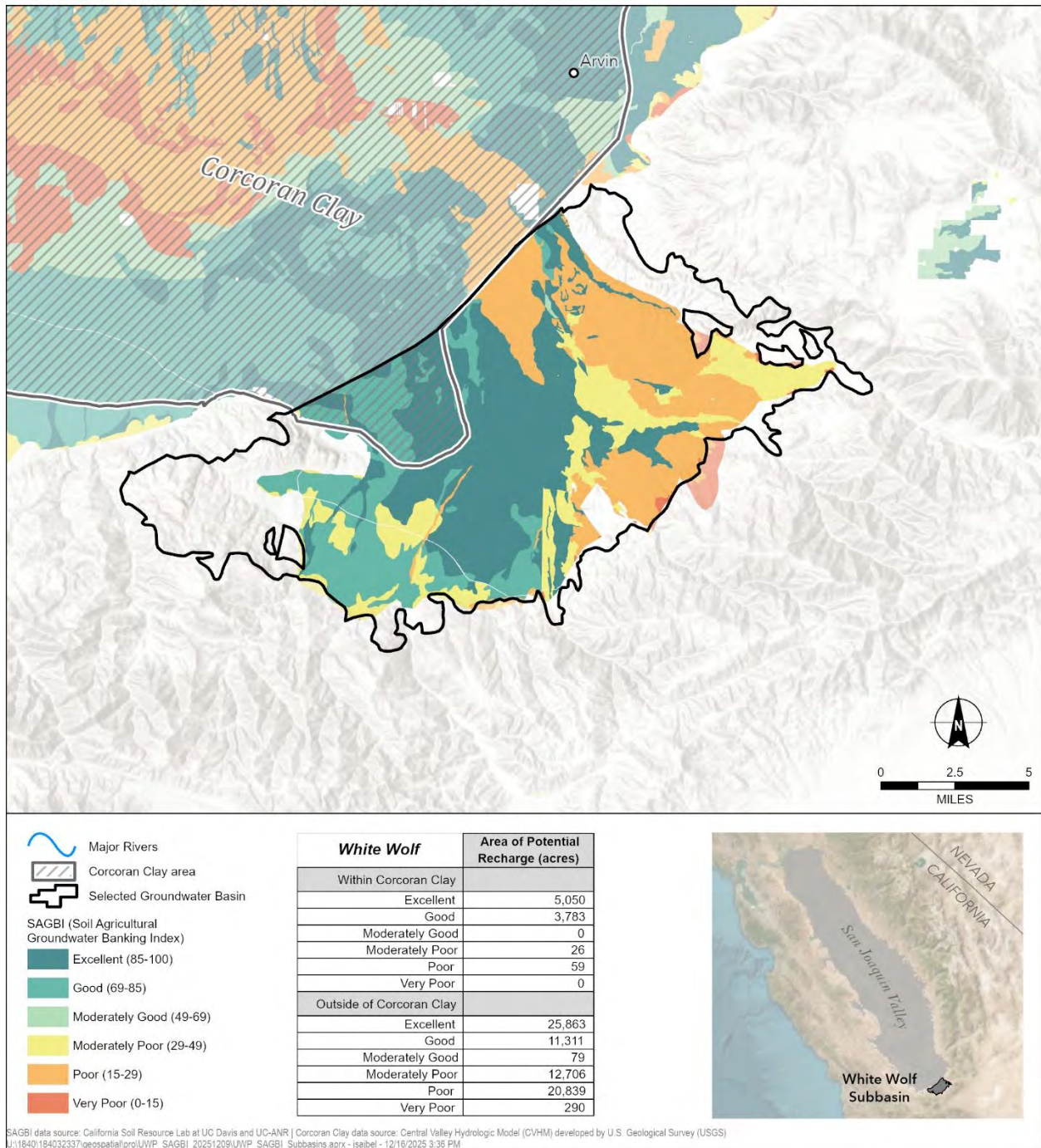


Figure B-16. White Wolf Soil Agricultural Groundwater Banking Index

References

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Unified Water Plan

for the
San Joaquin Valley

Appendix C
July 2026





Water Resources ♦ Flood Control ♦ Water Rights

TECHNICAL MEMORANDUM

DATE: May 29, 2020
TO: Austin Ewell, Tal Eslick, Scott Hamilton
PREPARED BY: Walter Bourez P.E. and Shankar Parvathinathan
SUBJECT: Summary of Operations Modeling Results

Background

The San Joaquin Water Blueprint group has recognized an annual water deficit in the valley of as much as 2.5 million acre-feet that it must reconcile to be compliant with the Sustainable Groundwater Management Act (SGMA) by 2040. The San Joaquin Valley Water Blueprint group is developing a comprehensive and strategic plan that, if implemented among partners, would result in a long-term water balance in the San Joaquin Valley in a way that minimizes land retirement of agricultural lands and allows the region's economy to thrive under future conditions.

While new projects that maximize retention of water from the Valley's eastside rivers are essential, these projects will fall far short of meeting projected water shortages. In addition to first optimizing efficiency within the Valley, water supplies from the Delta are an essential component of the Blueprint. The blueprint group acknowledges that increases in Delta diversions must occur in a way that do not jeopardize listed species.

Introduction

Water supply available from the Sacramento-San Joaquin River Delta varies depending on numerous regulations from several agencies, hydrologic conditions, infrastructure, Delta hydrodynamics, water quality, CVP and SWP operations, agency policies, and more. Evaluations under this effort quantifies changes in available Delta supply by varying these factors. Analyses performed for this effort are at a reconnaissance level. This study is designed to produce approximate quantification of changes in Delta water supply by varying factors governing Delta export and Delta conditions.

Numerous modeling scenarios were developed by varying factors affecting Delta export to capture a range of potential changes in water supply. This report presents a summary of modeling results from scenarios that would improve water supply reliability for South of Delta water users in the future.

The purpose of the report is to provide information on alternative projects and should not be interpreted as advocating an alternative. The Blueprint is simply performing reconnaissance to understand alternative water supply and does not have preference for any alternative.

Methodology

This technical investigation required the use of two operations models, CalSim II and a spreadsheet model called ProjectSim. CalSim II is the most commonly applied CVP/SWP operations modeling tool for evaluating water supply reliability of CVP/SWP projects. The ProjectSim model (ProjectSim) is a spreadsheet model of CVP and SWP operations that can be used to evaluate various CVP/SWP operations. This analysis required rapid, reconnaissance-level evaluation of several scenarios to understand the variability in future water supplied from the Delta that prompted the use of ProjectSim. CalSim II model was also used to validate the results from ProjectSim for selected scenarios. Comparison of the model results from the two models show that average annual exports can vary by up to 20% due to differences in modeling and data uncertainties, discretionary operating criteria and other uncertain operational factors.

The CalSim II model scenario used for this effort is developed from the United States Bureau of Reclamation's Re-initiation of Consultation of Long-Term Operations (ROC-ON-LTO) modeling for the 2019 BiOp. Modeling used for this effort represents the 2008 BiOps and 2019 BiOp using the same model representation as the Federal EIS. Modifications to CalSim II modeling were made to represent historically based hydrology rather than hydrology with climate change. Hydrology and operating criteria from CalSim II are input to the ProjectSim model so that both models have consistent inputs.

Studies Description

Several different scenarios were simulated in this analysis which can be broadly grouped into local projects and those affecting Delta conveyance. Modeling scenarios are used to assess variations in Delta regulations, CVP/SWP operating criteria, Delta infrastructure, south of Delta conveyance infrastructure, and more. Although many modeling scenarios were developed for this effort, the 13 scenarios included in this summary capture the range of potential changes in Delta water supply. The following is a list of projects analyzed for this effort:

Local Projects

1. Restoration of essential conveyance capacity
2. Mid-Valley Canal
 - This project focuses on improving canal conveyances that would bring additional CVP water into the east side of the San Joaquin Valley. This project requires that the capacity of Jones Pumping Plant Delta-Mendota Canal be increased from 4,600 cfs to 6,600 cfs to allow for delivery of surplus water.
3. Trans-Valley Canal
 - Allows increased delivery of Article 21 and Section 215 supply
4. Groundwater storage projects
 - Increases recharge in wetter years through development of dedicated and in lieu recharge projects

Delta Conveyance

1. Export sharing (JPOD)

Sharing of Delta export facilities between State Water Project (SWP) and Central Valley Project (CVP) known as JPOD has occurred since both Projects have been in operation in the early 1970s. Because the SWP export facility has more capacity than the CVP facility, most of the past export sharing has been done by the CVP using SWP Banks to convey CVP supplies. Use of JPOD provides increased export of surplus water from the Delta and is a critical element in the water supply reliability for South of Delta exporters and were considered in the scenarios that involved an expansion of SWP export facilities.
2. Regulatory Changes
 - a. Re-initiation of Consultation of Long-Term Operations (ROConLTO)

Under this 2019 Biological Opinion scenario, export restrictions are eased as compared to 2008/2009 Biological Opinion. 2019 Biological Opinion proposes to eliminate Action IV.2.1 in the 2009 NMFS biological opinion (San Joaquin River inflow: export action) thus eliminating export curtailments during April/May period.
 - b. Remove of Fall X2 Requirements

RPA's issued under the 2008/2009 Biological Opinion required management of X2 conditions in the Delta by increased Delta outflows during September and October, respectively if the water year containing the preceding spring was classified as wet or above normal. This Fall outflow element of the RPA is meant to alleviate both jeopardy to delta smelt and adverse modification of delta smelt critical habitat. The RPA also states that the performance of the action shall be investigated with a research and monitoring program. Recent studies do not indicate any significant improvements in the smelt habitat due to Fall X2 which may lead to the removal of this requirement in the future. Removal of Fall X2 means a significant increase in Delta exports and are thus included in this scenario as a potential scenario that could enhance water supply reliability for South of Delta exporters.

3. South Delta Improvement Project (SDIP)
The SDIP is a joint California Department of Water Resources (DWR) and Reclamation project that contains elements of the CALFED Record of Decision for long-term comprehensive actions to restore the ecological health and improve water management of the Sacramento-San Joaquin River Bay-Delta system. This project consists of several components that involve dealing with modification of Delta hydrodynamics such as construction of barriers etc. In this modeling analysis, the primary operations component of increase in diversions through Clifton Court Forebay from 6,680 cfs to 8,500 cfs is simulated to assess the increase in Delta exports along with other combinations of changes in the Delta conditions and regulations.
4. Fish Friendly Diversion (FFD)
This scenario evaluates potential increases to Delta exports resulting from the Fish Friendly Diversion which assumes a new Delta Intake located north of Bacon Island with a capacity of 12,000 cfs. This intake facility is exempted from OMR and SJR IE restrictions but not from other export restrictions under D-1641. It assumes existing permit and physical capacities at Banks and Jones.

Model Scenarios

There are 13 model scenarios used to summarize the range Delta water supply. Following is a brief description of these scenarios:

Study1 (2008/2009 Biological Opinion Study)

This is the Baseline Study used to compare other studies and includes the 2008/2009 Biological Opinion with historical hydrology.

Study2 (2019 Biological Opinion)

Contains the 2019 Biological Opinion. There are several differences between this study and Study1. Primarily, there is no SJR I/E in the 2019 Biological Opinions, OMR regulations are different between the two studies, and Fall X2 requirements differ.

Study3 (NoFall X2)

Similar to Study2, except there is no FallX2 requirements.

Study4 (Increased SOD demands)

Based on Study2 and assumes greater demands in the valley. Tulare Basin demands were assumed to be increase so that demands do not limit diversion from the Delta, for the purpose of this analysis this represents an “infinite demand”. CVP demands are increased by 400 TAF/year, which is distributed throughout the year based on the agricultural demand pattern. Article 21 demands were increased in this scenario from 200 TAF/month during January through March by 200 TAF/month during December through March, totaling 400 TAF/month.

Study5 (Increased Banks)

Based on Study2 and assumed Banks export capacity of 10,300 cfs with increased capacity for groundwater recharge in the valley.

Study6 (South Delta Improvement Project (SDIP))

Based on Study2 and contains SDIP with increased maximum SWP pumping limit to 8500 cfs (currently at 6680 cfs).

Study7 (NoFall X2 and SDIP)

Includes SDIP with Banks export capacity at 8,500 cfs and has no FallX2 requirements. Other assumptions are similar to Study2.

Study8 (NoFall X2, SDIP and FFD)

Similar to Study7. This includes SDIP with Banks export capacity at 8,500 cfs and FFD (no OMR and no SJR inflow/export ratio) along with the removal of FallX2 requirements. Contains 2019 Biological opinion and other assumptions similar to Study2.

Study9 (NoFall X2, FFD and Increased SOD demands and Banks Exports)

Similar to Study8 with increased SOD demands in the valley and increased Banks exports at 10,300 cfs. Tulare Basin demands were assumed to be increase by 400 TAF/year which is distributed throughout the year based on the agricultural demand pattern. Article 21 demands were increased in this scenario from 200 TAF/month during January through March by 200 TAF/month during December through March, totaling 400 TAF/month. Contains 2019 Biological opinion and other assumptions similar to Study2.

Study10 (Mid Valley Canal with increased capacities at Jones, DMC and increased demands in the Valley)

This study assumes the construction of Mid Valley Canal which includes an increased capacity at Jones pumping plant from 4,600 cfs to 6,600 cfs along with an increase in DMC capacity by 2,000 cfs. Tulare Basin demands were assumed to be increase by 400 TAF/year which is distributed throughout the year based on the agricultural demand pattern. Article 21 demands were increased in this scenario from 200 TAF/month during January through March by 200 TAF/month during December through March, totaling 400 TAF/month. Additionally, Mid Valley Canal demand was set at 480 TAF/year spread between December and March to capture surplus flows from Delta. Contains 2019 Biological opinion and other assumptions similar to Study2.

Study11 (NoFall X2, SDIP, FFD and Increased SOD demands)

Similar to Study8 with increased demands in the valley. Tulare Basin demands were assumed to be increase by 400 TAF/year which is distributed throughout the year based on the agricultural demand pattern. Demands were assumed to be increase so that

demands do not limit diversion from the Delta, for the purpose of this analysis this represents an “infinite demand”. Article 21 demands were increased in this scenario from 200 TAF/month during January through March by 200 TAF/month during December through March, totaling 400 TAF/month. This includes SDIP and FFD (no OMR and no SJR inflow/export ratio) with the removal of FallX2 requirements. Other assumptions are similar to Study2.

Study12 (NoFall X2, FFD, Mid Valley Canal and Increased SOD demands and Banks Exports)

Similar to Study8 with increased Banks exports (10,300 cfs) and additional Article 21 demand. Tulare Basin demands were assumed to be increase by 400 TAF/year which is distributed throughout the year based on the agricultural demand pattern. Article 21 demands were increased in this scenario from 200 TAF/month during January through March by 200 TAF/month during December through March, totaling 400 TAF/month. Additionally, Mid Valley Canal demand was set at 480 TAF/year spread between December and March to capture surplus flows from Delta. Contains 2019 Biological opinion and other assumptions similar to Study2.

Study13 (NoFall X2, SDIP, FFD, Mid Valley Canal and Increased SOD demands and Banks and Jones Exports)

Similar to Study12 with Jones capacity at 6,600 cfs. Tulare Basin demands were assumed to be increase by 400 TAF/year which is distributed throughout the year based on the agricultural demand pattern. Article 21 demands were increased in this scenario from 200 TAF/month during January through March by 200 TAF/month during December through March, totaling 400 TAF/month. Additionally, Mid Valley Canal demand was set at 480 TAF/year spread between December and March to capture surplus flows from Delta. Contains 2019 Biological opinion and other assumptions similar to Study2.

Results

CalSim II and ProjectSim were both applied to evaluate the relative changes in Delta water supply for this effort. CalSim II is the industry standard for evaluating Project operations and has a much greater level of detail than ProjectSim. However, ProjectSim produces similar answers as CalSim II and, because it is much simpler, is ideal for this reconnaissance level analysis. Figure 1 compares changes in Delta exports between the two models. Changes in exports calculated using ProjectSim were found to be slightly greater than CalSim II which were not investigated in detail. CalSim II model scenarios were not retrained to change the Water Supply Index – Delivery Index (WSI-DI) curve or other allocation parameters for the different studies and making these adjustments could result in the models producing more similar results. In addition, these comparisons do not include changes in CVP/SWP storage, which would provide a more complete picture of changes in operations. ProjectSim results show greater drawdown in upstream reservoirs as compared to the Baseline indicating the model results contain uncertainties. Changes in exports can be expected to vary by ± 20 percent

depending on how the model is operated and others changes in operational criteria for the scenarios. Overall, given the reconnaissance level of investigation, results from ProjectSim are shown to be reasonable based on a comparison with CalSim II. It is noted that the results from this modeling effort be used with proper understanding of the limitations and scope of the ProjectSim model.

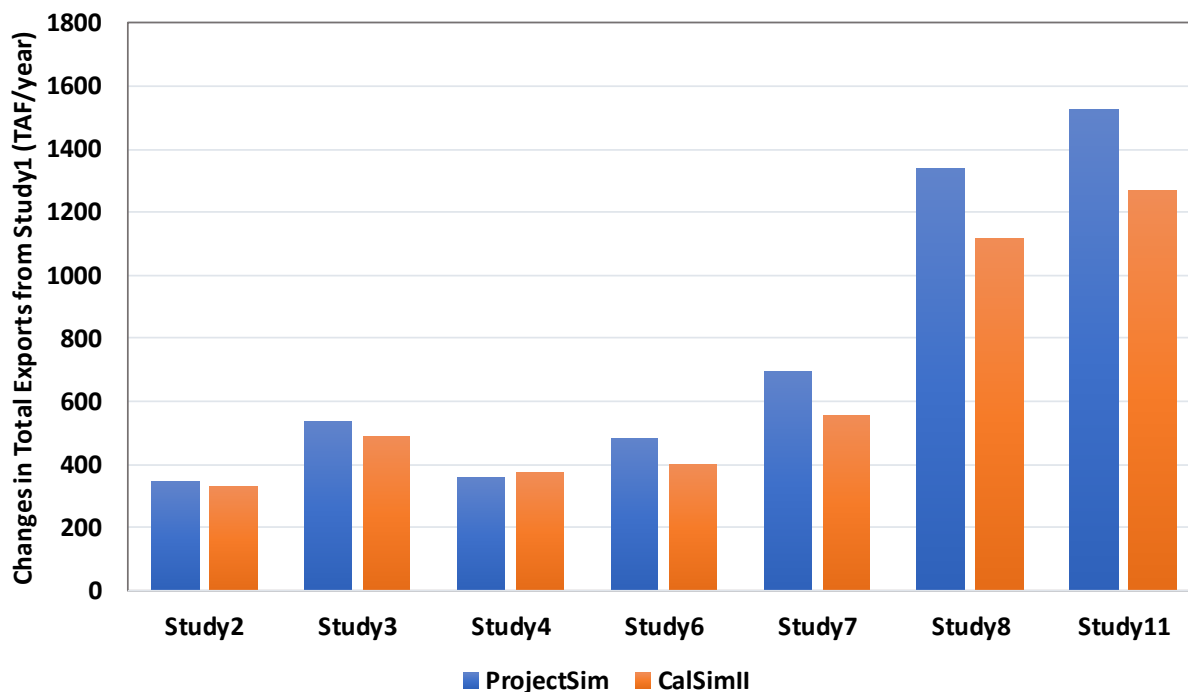


Figure 1: Comparison of CalSimII and ProjectSim results.

Table 1 summarizes results from different studies that were performed using CalSim II and ProjectSim (Spreadsheet Operations Model). Results shown in Table 1 are primarily taken from ProjectSim modeling with the last row indicating changes in total exports from CalSim II. These results are further shown in Figure 2 which summarizes changes in exports under a study as difference from Study1 with 2008/2009 BiOps. Results show changes in exports can range from approximately 350 TAF/year to 2 MAF/year.

As expected, Delta exports increase with increase in export and conveyance capacities. Results also show how increase in SOD demands affect water supply in conjunction with capacity changes in the Delta. An increase in SOD demand without any changes to physical infrastructure or regulatory conditions do not show any substantial increase in Delta exports as the system under the current conditions is mostly limited by supply.

Results show that removal of Fall X2 yields nearly 200 TAF/year of increased exports. Increasing Banks exports to 8,500 cfs yields an additional 150 TAF/year of total exports. FFD project presents the greatest change in Delta exports with an additional 650 TAF/year which is primarily a result of removal of OMR restrictions. Mid Valley Canal study shows a potential for

an additional 250 TAF/year. Overall, the four highest yielding scenarios provide an additional 1.5 to 2 MAF of deliveries per year.

Table 1: BluePrint Modeling Summary

		08BOps	2019BO	NoFallX2	INFDEM	B10300_INFDEM	SDIP	NoFallX2_SDIP	NoFallX2_SDIP_FFD	NoFX2_SDIP_FFD_INFDEM_B10300	DMC2000_INFDEM_J_MV	NoFX2_SDIP_FFD_INFDEM	NFX_SDIP_FFD_INFDEM_B10300_Art21_MV	NFX_SDIP_FFD_INFDEM_B10300_Art21_MV_J
Study	Study1	Study2	Study3	Study4	Study5	Study6	Study7	Study8	Study9	Study10	Study11	Study12	Study13	
Modeling Assumptions [Facilities/Regulations]														
CVP/SWP Operations	2008/09 BO	2019 BO	2019 BO	2019 BO	2019 BO	2019 BO	2019 BO	2019 BO	2019 BO	2019 BO	2019 BO	2019 BO	2019 BO	
Jones Exports (cfs)	4600	4600	4600	4600	4600	4600	4600	4600	4600	6600	4600	4600	6600	
Banks Exports (cfs)	8500	8500	8500	8500	10300	8500	8500	8500	8500	8500	8500	10300	10300	
Mid Valley Canal (cfs)	0	0	0	0	0	0	0	0	0	2000	0	2000	2000	
SDIP	No	No	No	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	
Fish Friendly Diversion	No	No	No	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes	
CVP Additional Tulare Basin Inlieu Demand (TAF/Year)	0	0	0	400	400	0	0	0	400	400	400	400	400	
Mid Valley Canal Demand (TAF/Year)	0	0	0	0	0	0	0	0	0	480	0	480	480	
Additional Art 21 (TAF/Year)	0	0	0	800	800	0	0	0	800	800	800	1600	1600	
Fall X2	No	Yes	No	Yes	Yes	Yes	No	No	No	Yes	No	No	No	
Old and Middle River Regulation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No	No	
SJR I/E Ratio	Yes	No	No	No	No	No	No	No	No	No	No	No	No	
Modeling Results														
		Difference from Study1 (TAF)												
Total Exports (TAF)	4823	345	537	359	497	483	693	1338	1527	597	1524	1688	2019	
CVP Sacramento River Basin Carryover Storage (TAF)	4631	79	73	80	65	57	29	-3	-6	-152	-6	-7	-202	
Oroville Carryover (TAF)	921	18	14	17	24	10	4	-6	-5	18	-5	11	14	
		Difference from Study2 (TAF)												
Total Exports (TAF)	-345	5167	193	15	152	139	349	993	1182	252	1180	1343	1674	
Sacramento River Basin Carryover Storage (TAF)	-79	4710	-6	2	-13	-22	-50	-82	-84	-231	-85	-85	-281	
Oroville Carryover (TAF)	-18	939	-4	0	7	-8	-14	-23	-23	0	-23	-7	-4	
Difference from Study1 (TAF)														
CalSim II	4910	328	488	375		399	554	1118			1267			

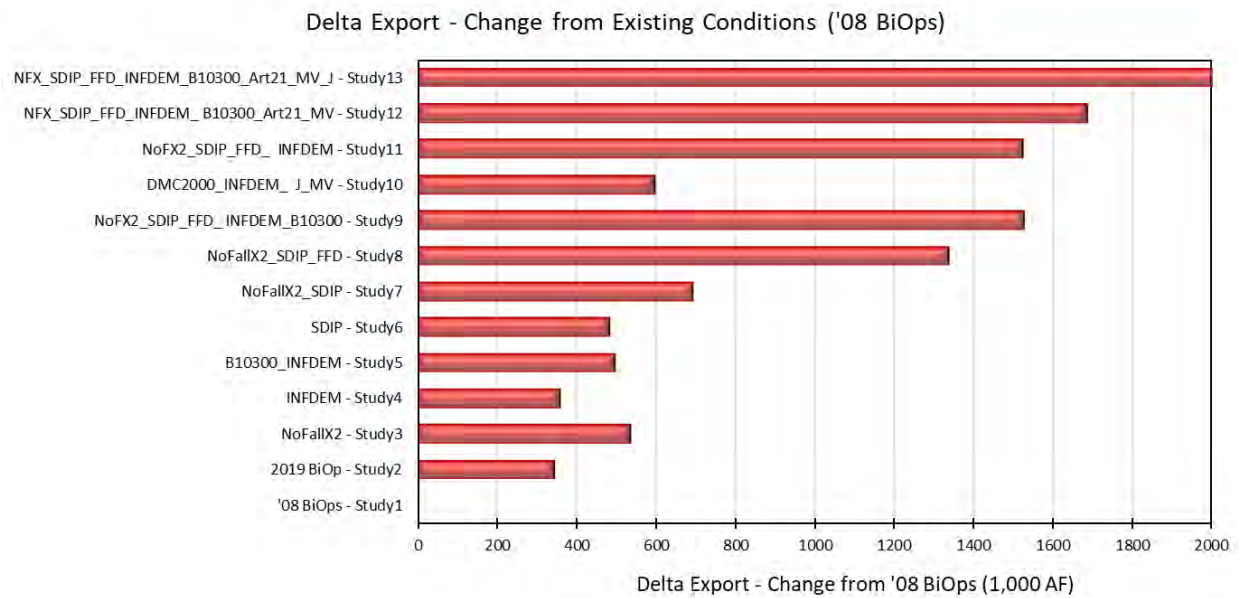


Figure 2: Change in Export