REGIONAL WATER AUTHORITY

WATER ACCOUNTING SYSTEM FOR WATER BANKING IN NORTH AND SOUTH AMERICAN SUBBASINS

Version 1

March 17, 2025

Regional Water Authority
BUILDING ALLIANCES IN NORTHERN CALIFORNIA

SACRAMENTO REGIONAL
WATER BANK
A Sustainable Storage & Recovery Program

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A Sustainable Storage & Recovery Program

TABLE OF CONTENTS

FIGURES

ABBREVIATIONS AND ACRONYMS

ASR	aquifer storage and recovery
CVP	Central Valley Project
DMS	Data Management System
DWR	California Department of Water Resources
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RWA	Regional Water Authority
Sac Water Bank	Sacramento Regional Water Bank
Subbasins	North and South American Subbasins

GLOSSARY OF TERMS

This concept paper draws upon the following commonly used terms in water management:

- **Adaptive management**: A process of adjusting water management practices to ensure long-term sustainability. This process is based on ongoing monitoring data, evaluation of changing conditions, and stakeholder input to ensure long-term sustainability.
- **Alternative water supplies**: Water supplies used as an alternative to pumping groundwater, such as surface water, recycled water, and storm water. Note that in the context of recharge, “surface water” is used throughout this paper to represent not only surface water but also other alternatives water supplies.
- **Banking action**: An activity within a groundwater banking program involving the recharge (deposit), recovery (withdrawal), and/or transfer of stored (banked) water.
- **Banking losses**: Stored (banked) groundwater that becomes physically unrecoverable due to factors such as migration out of a groundwater basin or seepage into interconnected surface water bodies.
- **Banking participant:** An entity that actively participates in a groundwater banking program. These participants contribute to and utilize the groundwater bank by recharging (depositing) water into the aquifer and recovering (withdrawing) stored water to meet their water supply needs.
- **Conjunctive Use**: The coordinated and planned use and management of the different sources of water in time and space. Conjunctive use involves the efficient use of groundwater and surface water through the planned and managed operation of a groundwater basin and available surface water in the basin (DWR, 2024).
- **Direct (physical) recovery**: The process of extracting banked groundwater from a groundwater basin and physically delivering it to the end user through pipelines, canals, or other conveyance systems for beneficial use. Unlike in-lieu recharge, direct recovery involves no exchange of surface water, only the physical transfer of groundwater.
- **Direct recharge**: A recharge method where water is directly added to a groundwater basin using spreading basins, injection wells, dry wells, or similar methods. Direct recharge affects the groundwater budget by increasing inflows to the aquifer; therefore, increasing groundwater storage.
- **Forgone surface water**: Surface water supplies intentionally left unused by an entity due to substituting its use with stored (banked) groundwater.
- **Groundwater bank (groundwater banking program, or water bank)**: A system that manages the storage of surplus water in a groundwater basin through recharge methods and allows for its recovery during times of need. A groundwater bank functions as a water savings account with formalized accounting, tracking, management, financial, operational, and ownership agreements. A water

groundwater bank typically operates under a water accounting system.

- **Groundwater banking:** The managed aquifer recharge and extraction by a managing entity that facilitates in-lieu or direct recharge or extraction from a groundwater basin (DWR, 2024). Groundwater banking is a specific practice within the broader conjunctive use strategy that typically involves agreements, formalized accounting of stored (or banked) groundwater, and tracking of recharge and recovery.
- **Groundwater storage rights:** Legal entitlements and permissions that allow entities to store water in a groundwater bank. These rights outline the conditions under which water can be stored, the types of water eligible for storage, and the limitations on its recovery and subsequent use.
- **Groundwater substitution transfer**: A practice of transferring surface water to another user or region while replacing the transferred supply by increasing groundwater pumping in the source region. A groundwater substitution transfer is a practice within the broader conjunctive use strategy but typically does not require stored (or banked) groundwater.
- **In-Lieu (indirect) recharge**: A recharge method where surface water or alternative supplies replace groundwater pumping, allowing natural recharge to accumulate in the groundwater basin. In-lieu (or indirect) recharge affects the groundwater budget by reducing outflows from the groundwater basin; therefore, increasing groundwater storage.
- **In-lieu recovery**: The process of delivering (stored) banked groundwater to an end user through in-lieu transactions and facilitated exchanges. In-lieu recovery occurs when an entity uses banked (stored) groundwater to replace its baseline surface water use, allowing the forgone surface water to be delivered to the end users.
- **Leave-behind**: A portion of banked groundwater intentionally left in a groundwater basin to support groundwater sustainability and enhance local water supply reliability.
- **Operational baseline:** A benchmark of an entity's typical surface and groundwater use without banking activities. It enables accurate tracking of recharge and recovery, which are measured as change from the baseline. It is reviewed every five years to reflect changes in water management and ensure alignment with GSP updates.
- **Recharge (deposit)**: The addition of water to a groundwater basin, either directly or indirectly, to increase groundwater storage.
- **Recovery (withdrawal)**: The extraction of stored (banked) groundwater for beneficial use. It Recovery typically involves the transfer of banked groundwater to another user or region through in-lieu transactions, facilitated exchanges, or physical delivery.
- **Subbasin**: A distinct hydrological unit within a groundwater basin used for water resource management. California Department of Water Resources (DWR) Bulletin 118 delineates groundwater subbasins— based on natural features (such as geologic or hydrologic boundaries) and administrative or management

considerations, to support localized groundwater management.

- **Water accounting system**: A framework of policies, procedures, and tools to manage and track the deposit, storage, withdrawal, losses, and balances of stored water in a groundwater banking system program.
- **Water budget**: A water budget is a quantitative accounting of all the inflows, outflows, and changes in storage within a specific hydrological system or subbasin over a defined period. A water budget is used to evaluate the balance between water inputs and outputs to assess hydrologic conditions and support sustainable management.

In addition, the paper also uses terms associated with the Central Valley Project (CVP), as defined in the *Groundwater Banking Guidelines for Central Valley Project Water* (Reclamation, 2019). These terms are used in relation to federal acknowledgement of a groundwater bank and/or use of CVP supplies.

- **Article 3(f) Water**: Excess water under a CVP contract, periodically made available during specific conditions, such as flood events.
- **Banking of CVP Water**: A process whereby a Contractor's CVP Water is deposited and stored in a groundwater bank outside of the Contractor's Service Area and made available for beneficial use in a subsequent month(s) or period(s) consistent with Reclamation's CVP Water rights, permits, and/or licenses and provisions of the applicable CVP contract.
- **Contractor's Contract Service Area**: The area to which the Contractor is permitted to provide CVP Water under its contract(s) as described in the contract(s), which may be modified from time to time in accordance with the contract without amendment to the contract.
- **CVP Contract Allocation**: CVP Water made available pursuant to a Contractor's CVP contract, typically expressed as a percentage of contract total.
- **CVP Contractor:** A party having a contract with the United States for the use of CVP Water pursuant to Federal Reclamation law.
- **CVP Water**: All water that is developed, diverted, stored, or delivered by the Secretary of the Interior in accordance with the statutes authorizing the CVP and in accordance with the terms and conditions of water rights acquired by Reclamation pursuant to California law.
- **Section 215 Water**: Excess non-storable water from the CVP made available during specific conditions, such as flood events.

1.0 INTRODUCTION

This concept paper presents a structured Water Accounting System designed to effectively and transparently manage and monitor water banking activities within the North and South American Subbasins (Subbasins) (Figure 1). This Water Accounting System, overseen by the Regional Water Authority (RWA), has been developed in collaboration with RWA members, Groundwater Sustainability Agencies (GSA), and other stakeholders.

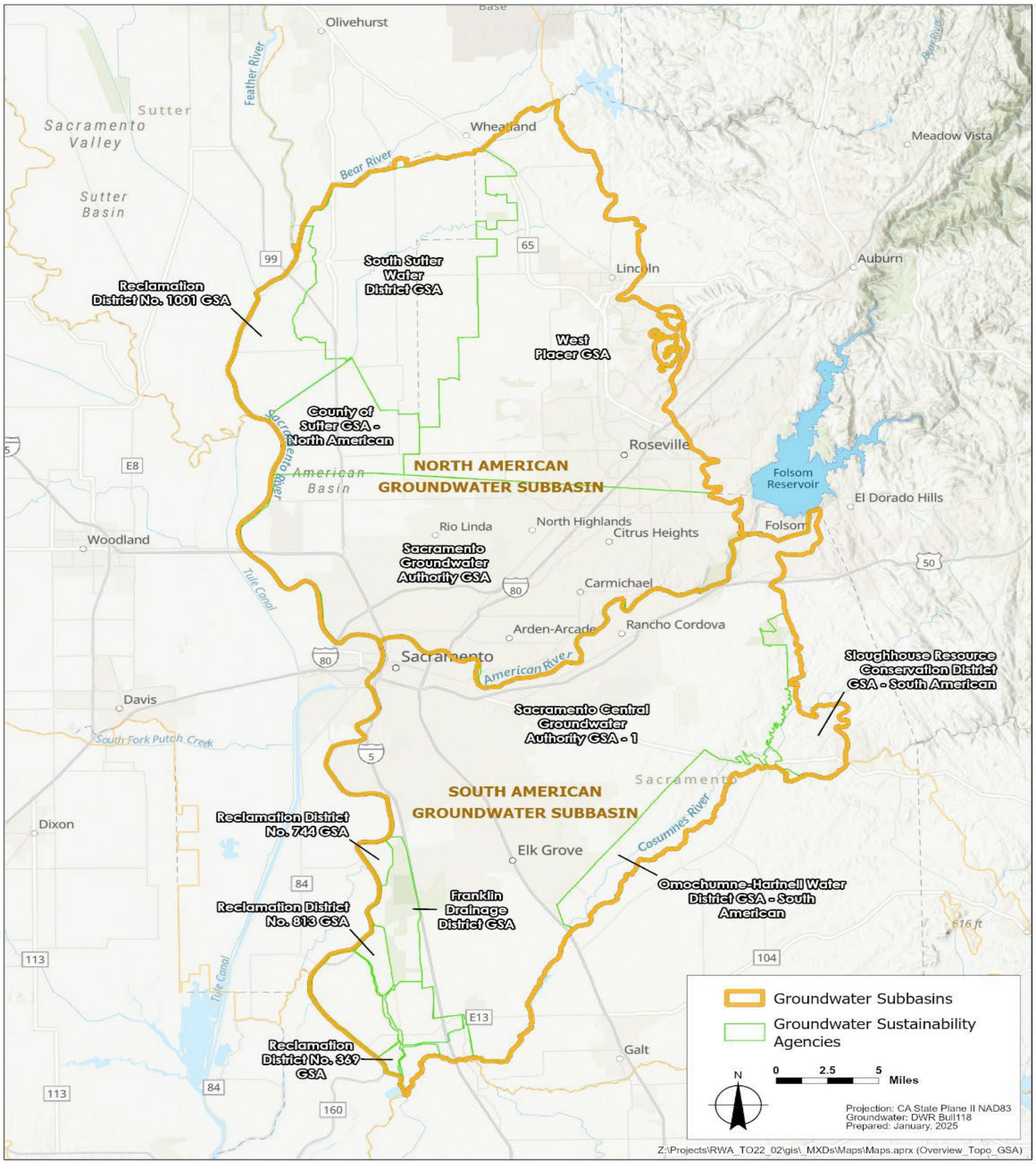


Figure 1. North and South American Groundwater Subbasins

1.1 Need for a Water Accounting System

As part of the efforts to develop the Sacramento Regional Water Bank (Sac Water Bank), RWA and its members recognized the need for a formalized and unified Water Accounting System for the North and South American Subbasins that supports:

- **Effective Management**: Provides a structured approach to facilitate adaptive management of water banking operations within the Subbasins. By accurately tracking recharge, recovery, losses, and storage balances, the Water Accounting System supports operational efficiency and basin health.

- **Compliance Support**: Ensures alignment with approved Groundwater Sustainability Plans (GSP) to meet regulatory requirements. This adherence promotes the sustainable management of groundwater resources while maintaining compliance with State and federal mandates.

- **Transparency and Accountability**: Offers clear and reliable records of groundwater banking activities, fostering accountability and building trust among banking participants, regulatory agencies, and other interested parties. The Water Accounting System reduces conflicts and promotes collaboration through transparent reporting.

- **Operational Clarity**: Defines processes, roles, and responsibilities, to support the sustainable operation of groundwater banking programs in the Subbasins.

The Water Accounting System is designed to establish consistent accounting procedures for all banking programs within the subbasins, including the Sac Water Bank, Harvest Water, and other current and future initiatives (see Figure 2). It ensures standardized recharge and recovery accounting, tracking of banked water balances and losses, adaptive management, conflict resolution, reporting, and coordination with GSAs. While WAS provides uniform procedures and protocols, it also allows each banking program the flexibility to align with its specific goals, objectives, and operational needs.

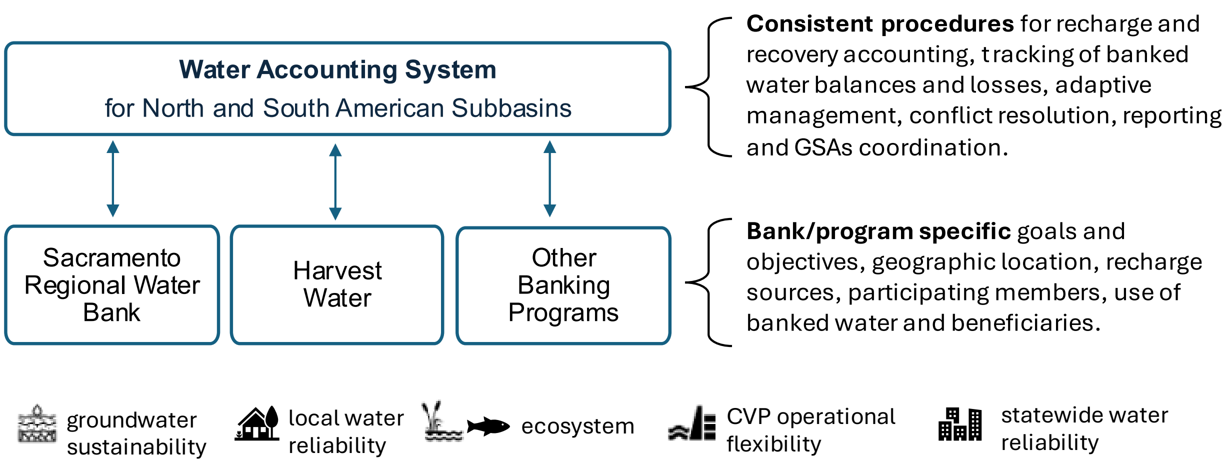


Figure 2. Water Accounting System Relationship to Banking Programs

1.2 Document Scope

The concept paper provides a framework for the Water Accounting System that:

- Defines the fundamentals (or principles) that guided its formulation (**Section 2**).
- Describes the components necessary for tracking and monitoring groundwater banking activities (**Section 3**).
- Ensures alignment with sustainability goals outlined in the GSPs and effective coordination with the GSAs (**Section 4**).
- Outlines administrative and implementation activities and responsibilities (**Section 5**).

Describes the establishment of the Sacramento Regional Water Bank within the Water Accounting System (**Section 6**).

- Demonstrates the application of recharge and recovery accounting procedures for entities with different water supply portfolios using hypothetical examples (**Appendix A**).

2.0 WATER ACCOUNTING SYSTEM FUNDAMENTALS

The Water Accounting System is comprised of a set of policies, procedures, and tools that support the expansion of conjunctive use and water banking programs in the basin, consistent with the following fundamentals:

- **Recharge First**—Track that recharge actions occur before recovery actions.
- **Responsible Banking**: Track that no more than the net banked water in the Subbasins is recovered, while accounting for the leave-behind and banking losses.
- **Geographically Balanced Recharge and Recovery**: Ensure that banking operations do not result in localized impacts to groundwater sustainability and minimizes the risk of over-pumping or over-recharging in specific areas of the subbasins.
- **Program-Specific Accounts**: Allow for program-specific accounts to facilitate separate tracking of different banking transactions and projects while preserving the ability to observe the banking activities for the entire region. Each banking program/project may specify a geographic area/zone for the purpose of tracking its deposits, withdrawals, and balances. The program-specific accounts will help accommodate unique requirements for each water banking program/project.
- **Separate Water Budgets for each GSP**: Implement separate tracking of deposits (recharge), withdrawals (recovery), and balances for the North and South American subbasins to facilitate reporting and basin operations with knowledge and understanding of current GSP water budgets. This will support long-term sustainability of the region's groundwater subbasins by ensuring that accounting rules are consistent with the adopted and governing GSPs.
- **Transparency and Consistency**: Establish a framework for consistent water accounting practices across the subbasins, while allowing for program/project-specific requirements. Maintain transparency of water banking operations through coordination with and reporting to the applicable GSAs.
- **Applicable Regulatory Requirements**: Allow tracking of banking activities consistent with the conditions and guidelines outlined in (1) the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) *Groundwater Banking Guidelines for Central Valley Project Water* (Reclamation, 2019), (2) the *Draft Technical Information for Preparing Water Transfer Proposals* (DWR, 2019), (3) GSPs for the Subbasins, and/or (4) other applicable regulations and requirements.
- **No Restriction on Local Water Management**: Identify and track the activities recognized as banking actions. The Water Accounting System does not restrict local water agencies from managing their water supplies and operations, including, but not limited to, groundwater substitution transfers.

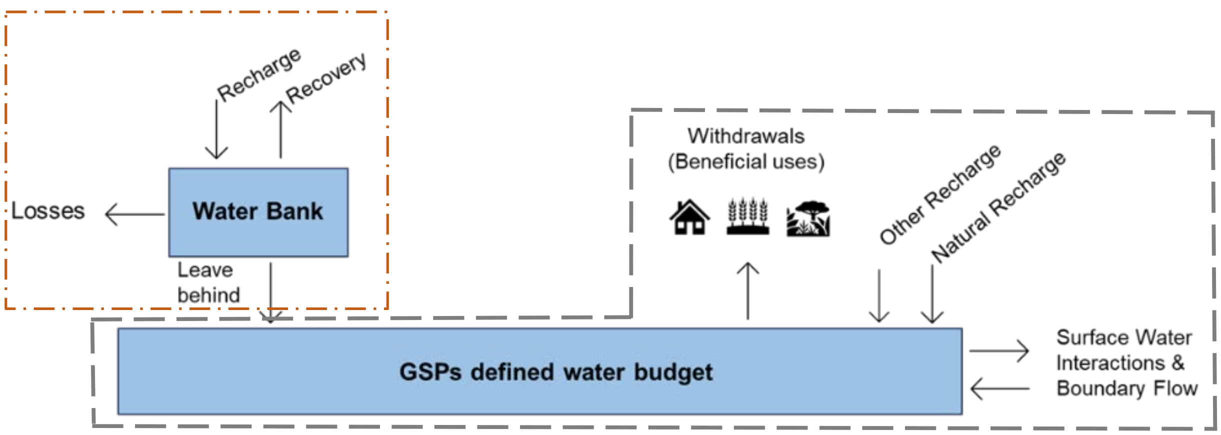
3.0 WATER ACCOUNTING SYSTEM COMPONENTS

3.1 Overview

Water banking involves recharging additional surface water, recycled water, or stormwater into a groundwater basin for temporary storage, with the intention of later recovery and beneficial use. It functions similarly to a savings account, storing surplus water during periods of availability for future needs. However, water banking must operate within a groundwater basin alongside existing and planned beneficial uses. To protect these uses, water banks must be managed to prevent the depletion of native groundwater storage and ensure compliance with groundwater sustainability goals (DWR, 2024).

Water banking programs and their associated accounting systems must align with the water budgets established in the approved GSPs for the region. Notably, both GSPs for the Subbasins recognize expansion of conjunctive use and establishment of water banking as key management actions to promote long-term groundwater sustainability.

To achieve clear and transparent accounting, a water banking program is conceptualized as a "savings account" that “floats” above the GSP-established water budgets (see Figure 3). Note that the GSP water budgets should already account for all beneficial uses in the Subbasins. Any banking programs are additional management actions. The Water Accounting System function is to ensure that water banking activities do not reduce overall groundwater storage levels as reflected in GSP-established water budgets. Instead, a leave-behind volume ensures that water banking actively contributes to enhancing storage in the Subbasins and improving long-term sustainability (see Figure 3).



Key: GSP = groundwater sustainability plan

Figure 3. Relationship of Water Banking Programs to Groundwater Sustainability Plans

The Water Accounting System tracks the following components of water banking activities:

- Recharge: Deposits made directly or indirectly into the groundwater basin.
- Recovery: Withdrawals of stored (banked) groundwater for beneficial use

- Banking balance: The remaining amount of banked water available for recovery after banking losses and leave-behind volume.

- Banking losses: Banked groundwater that becomes physically unrecoverable due to factors such as migration out of a groundwater basin or seepage into interconnected surface water bodies.

- Leave-behind: A portion of banked groundwater intentionally left in a groundwater basin to support groundwater sustainability and enhance local water supply reliability.

- Operational baseline: A benchmark of an entity's typical surface and groundwater use without banking activities. It enables accurate tracking of recharge and recovery, which are measured as change from the baseline. It is reviewed every five years to reflect changes in water management and ensure alignment with GSP updates.

- Forgone surface water: Surface water supplies intentionally left unused by an entity due to substituting its use with stored (banked) groundwater.

- Groundwater storage rights: Legal entitlements and permissions that allow entities to store water in a groundwater bank. These rights outline the conditions under which water can be stored, the types of water eligible for storage, and the limitations on its recovery and subsequent use.

Additional details on the on these components of the Water Accounting System are presented in the following sections.

3.2 Operational Baselines for Accounting

Recharge (deposits) and recovery (withdrawals) accounting requires establishing an operational baseline for each entity participating in banking. This is especially critical for in-lieu banking. For each entity, this operational baseline characterizes its operations (in terms of surface water and groundwater usage) in the absence of water banking. The defensibility and credibility of each entity's operational baseline are critical to ensure accuracy and acceptance of the water accounting.

Each entity will define its operational baseline(s) to (1) reflect representative operations during recent years, and (2) be consistent with water budget information in the applicable and approved GSP(s). The operational baseline(s) may also incorporate planned revisions to entity operations to account for operations and maintenance activities and/or infrastructure modifications.

Depending on its water supply sources and operational practices, an entity may have a single operational baseline or different operational baselines for dry and wet conditions. An entity primarily dependent on either surface water or groundwater will likely have a single operational baseline. In contrast, an entity that utilizes both surface water and groundwater may opt for different operational baselines for wet and dry conditions to reflect its conjunctive use operations.

For each entity, its operational baseline(s) will have three components:

1. Average annual demand based on its most recent Urban Water Management Plan, another equivalent plan, or recent water use trends.
2. The portion of annual demand to be met using groundwater.
3. The portion of annual demand to be met using surface water.

An entity's operational baseline(s) will be reviewed and revised on a 5-year cycle, concurrent with the updates to GSPs. Documentation of the rationale and justification for an operational baseline update must be provided by that entity.

3.3 Recharge Accounting

Recharge (deposit) accounting encompasses tracking all sources of water recharged (deposited) into the Subbasins via both direct and indirect (in-lieu) recharge methods. Both direct and in-lieu recharge methods result in net increases in groundwater storage, yet each impacts different components of the water budget. Direct recharge boosts net inflow to a groundwater basin, whereas in-lieu recharge reduces outflow (withdrawals, in this case pumping) from a groundwater basin.

Figure 4 illustrates recharge for three types of entities: (1) a surface water-reliant entity, (2) a groundwater-reliant entity, and (3) an entity that uses both surface water and groundwater. Direct recharge occurs when additional water supplies are directly added to a groundwater basin using spreading basins, injection wells, dry wells, or other methods. Any of the three entity types can participate in direct recharge, if the local hydrogeological setting allows. However, in-lieu recharge occurs only when surface water use replaces baseline groundwater pumping (i.e., baseline groundwater pumping is a prerequisite for in-lieu recharge). In addition, a surface water reliant entity may provide surface water to another entity for direct or in-lieu recharge.

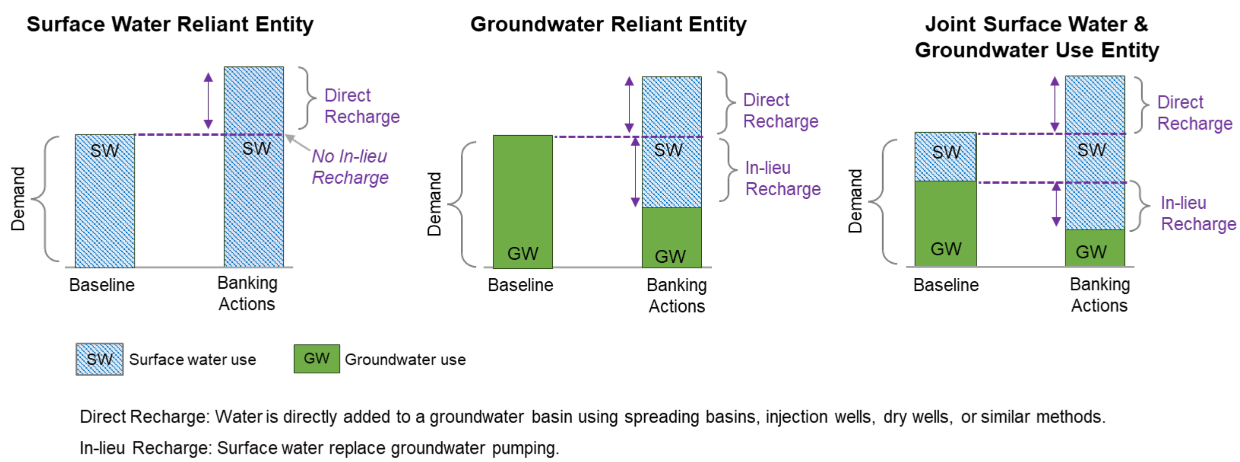


Figure 4. Illustration of Recharge Accounting for Different Water Supply Portfolios

3.3.1 Direct Recharge

Direct recharge (deposit) occurs when surface water is directly added to a groundwater basin. It affects the groundwater budget by increasing inflows to the basin; therefore, increasing groundwater storage. It can be achieved through spreading basins that allow surface water to percolate into the basin. Injecting surface water into the groundwater basin can also be conducted using wells specifically designed for recharge only (i.e., injection wells) or for both recharge and recovery (i.e., aquifer storage and recovery (ASR) wells). Another recharge method is dry wells, which are gravity-fed excavated pits through layers of poor infiltration to allow for more rapid infiltration of water.

Recharge accounting for direct recharge methods entails the precise measurement or metering of surface water that is applied to a spreading basin or injected via wells. For spreading basins, it is also necessary to monitor and track evaporation and potential overflow losses.

3.3.2 In-lieu Recharge

In-lieu (or indirect) recharge (deposit) occurs when surface water or alternative supplies replace groundwater pumping, allowing natural recharge to accumulate in a groundwater basin. It affects GSP water budgets by reducing outflows from the groundwater basin; therefore, increasing groundwater storage. In-lieu recharge is an efficient and scalable solution, especially in areas where geology and soils may not be suitable for direct recharge methods.

In-lieu recharge can be calculated as the reduction in groundwater use, i.e.,

[operational baseline groundwater use] – [groundwater use under water banking] ①

It can also be calculated as the increase in use of surface water or alternative supplies, i.e.,

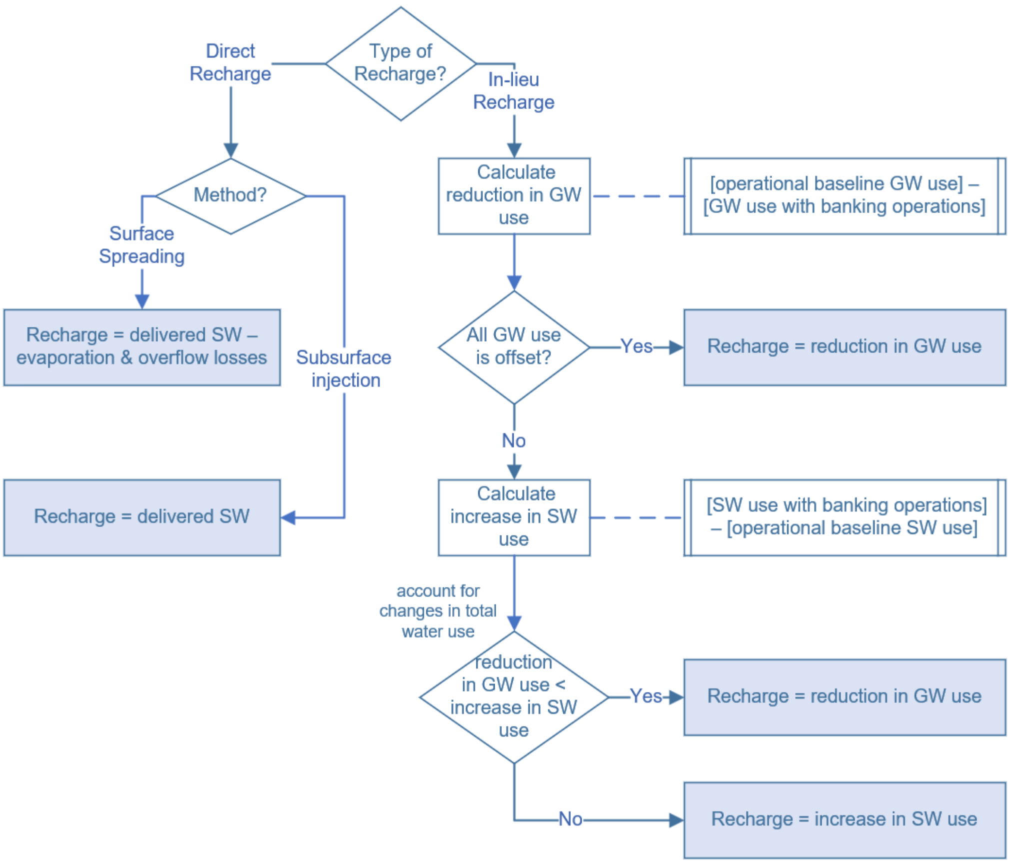
[surface water use under water banking] – [operational baseline surface water use] ②

<u>If groundwater use is fully replaced by surface water</u> or alternative supplies, then in-lieu recharge can simply be considered equivalent to the amount of delivered surface water or alternative supplies. This is particularly relevant in agricultural settings, where irrigation demand can vary due to climatic conditions. It is reasonable to assume that any increase in demand would have been met by groundwater pumping, provided there were no changes to irrigated acreage or irrigation practices.

<u>When groundwater use is partially replaced by surface water</u> or alternative supplies, it is important to ensure accurate recharge accounting to prevent overestimation of recharge volumes. Seasonal variations in water demand, in both municipal and agricultural settings, can lead to fluctuations in water needs that may be met by either groundwater or surface water. In the absence of banking actions, it may not be clear which source—groundwater or surface water—would have been used to meet the increased demand. Therefore, for a more accurate and conservative estimation of in-lieu recharge, the following two conditions must be met:

1. Surface water use exceeds that under the operational baseline.
2. There is a corresponding reduction in groundwater pumping relative to the operational baseline (i.e., in-lieu recharge is the lesser of ① or ②).

Figure 5 summarizes the recharge accounting procedures. Attachment A also provides detailed examples of direct and in-lieu recharge accounting for various types of entities and under different operational scenarios.



Key: GW = groundwater SW = surface water

Figure 5. Summary of Recharge Accounting Procedure

3.4 Recovery Accounting

Accurate recovery (withdrawal) tracking is essential for maintaining the sustainability of the groundwater subbasins and ensuring that the volume of water extracted does not surpass the banked water balance. It is also a critical component for determining each entity's banked water balance. Recovery accounting tracks the extraction (recovery) of a volume of banked water for beneficial uses, after reflecting banking losses and leave-behind amounts.

Figure 6 illustrates recovery for three types of entities: (1) a surface water-reliant entity, (2) a groundwater-reliant entity, and (3) an entity that uses both surface water and groundwater. Direct recovery occurs when banked groundwater is extracted and physically conveyed to another entity. Any of these entity types can participate in direct recharge, if local geological setting allows for groundwater extraction. However, in-lieu recovery occurs when banked groundwater replaces baseline surface water use (i.e., baseline surface water use is a prerequisite for in-lieu recovery).

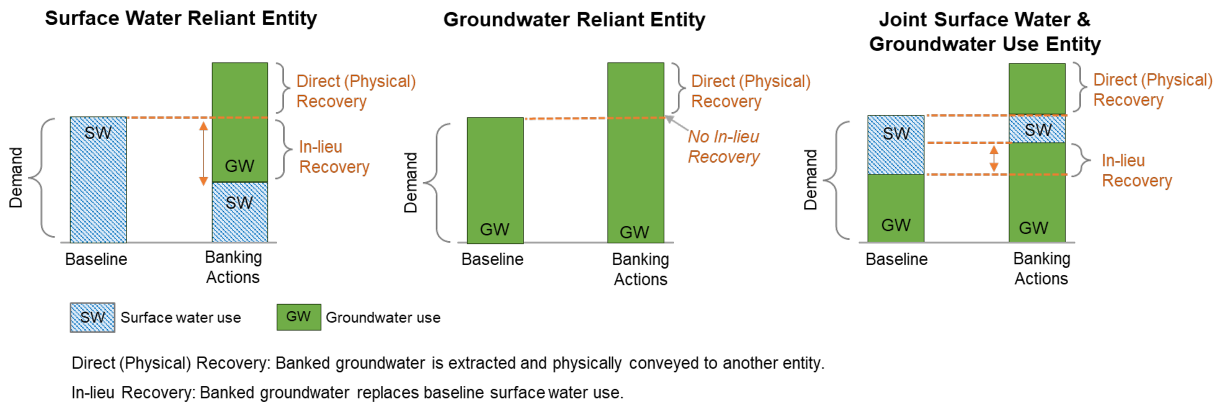


Figure 6. Illustration of Recovery Accounting for Different Water Supply Portfolios

3.4.1 Direct Recovery

Direct (physical) recovery (withdrawal) is the process of extracting banked groundwater from a groundwater basin and physically delivering it to the end user through pipelines, canals, or other conveyance systems for beneficial use. Unlike in-lieu recharge, direct recovery involves no exchange of surface water, only the physical transfer of groundwater.

3.4.2 In-lieu Recovery

In-lieu recovery (or withdrawal) is the process of delivering (stored) banked groundwater to an end user through in-lieu transactions and facilitated exchanges. It occurs when an entity uses banked (stored) groundwater to replace its baseline surface water use, allowing the forgone surface water to be delivered to the end users. An in-lieu recovery action can be conducted by a single entity or coordinated through multiple entities. For example, banked groundwater may be extracted (recovered) by an entity and provided to one or more neighboring entities to offset their surface water use, which are then made available to end users. Note that baseline surface water use is required to allow for in-lieu recovery recognition (see Figure 6).

In-lieu recovery is calculated as the increase in use of banked groundwater, i.e.,

[groundwater use under water banking] – [operational baseline groundwater use] ③

It can also be calculated as the reduction in use of surface water or alternative supplies, i.e.,

[operational baseline surface water use] – [surface water use under water banking] ④

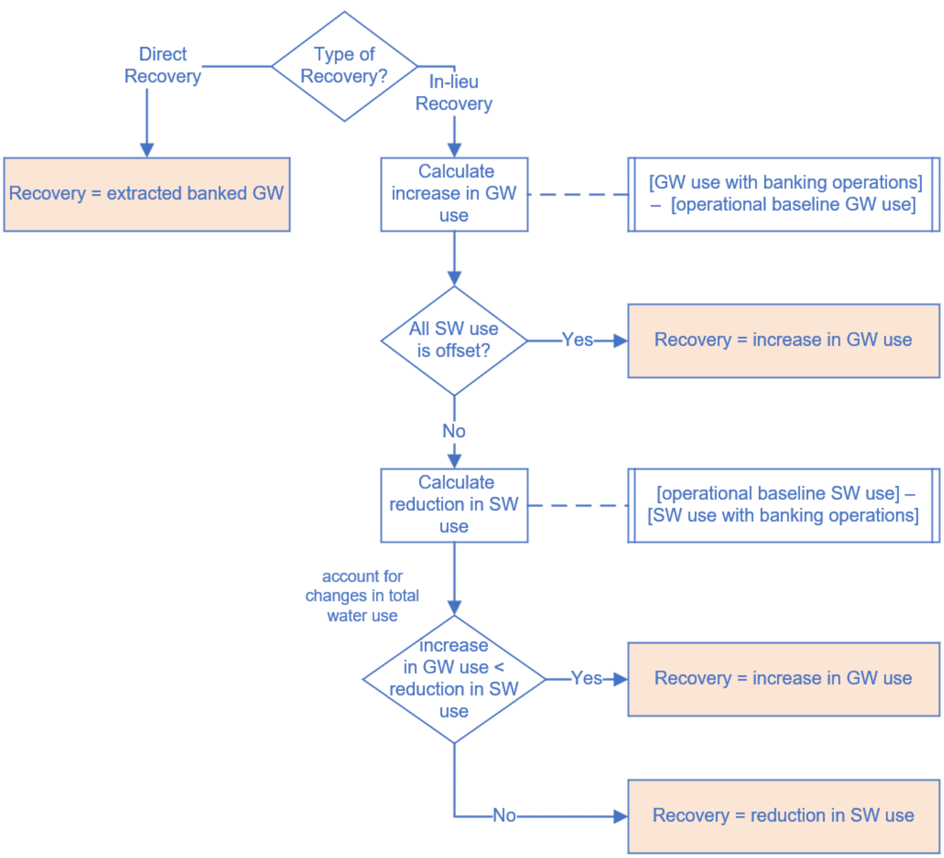
<u>If surface water use is fully replaced by banked groundwater</u>, the in-lieu recovery can simply

be considered equivalent to the amount of extracted banked groundwater.

When surface water use is only partially replaced by banked groundwater, there is a need to ensure accurate recovery accounting, to mitigate the risk of overestimation. Seasonal variations in water demand, in both in municipal and agricultural settings, can lead to fluctuations in water needs that may be met by either groundwater or surface water. In the absence of banking actions, it may not be clear which source—groundwater or surface water— would have been used to meet the increased demand. Therefore, for a more accurate and conservative estimation of in-lieu recovery, the following two conditions must be met:

1. Groundwater pumping exceeds that under the operational baseline.
2. There is a corresponding reduction in surface water (or alternative supplies) relative to the operational baseline (i.e., in-lieu recovery is the lesser of ③ or ④)

Figure 7 summarizes the recovery accounting procedures. Attachment A provides detailed examples of recovery accounting for various situations and conditions.



Key: GW = groundwater SW = surface water

Figure 7. Summary of Recovery Accounting Procedure

3.5 Leave-Behind and Banking Losses Accounting

Accuracy of accounting for both leave-behind and banking losses is needed to demonstrate that banking activities are not affecting other beneficial users of the groundwater basin or the interconnected surface waters. It involves calculating and tracking the portion of banked water that is not available for recovery (withdrawal).

3.5.1 Banking Losses Accounting

Banking losses refer to the portion of banked water that becomes physically unrecoverable due to factors such as migration out of the basin to adjacent water bodies or basins. While these losses reduce the recoverable water, net higher seepage into interconnected surface waters can provide ecosystem benefits to these water bodies and downstream areas. Similarly, outflows to adjacent basins can benefit those areas as well. Accurate estimates of these surface and subsurface flows are crucial, as they impact both the water balances of a banking program and the availability of banked water for withdrawal (recovery).

The average rates of horizontal groundwater movement within a groundwater basin vary spatially due to diverse geological formations and their differing hydraulic properties. The rate of groundwater movement is influenced by factors such as the hydraulic conductivity of aquifer materials, the hydraulic gradient (the slope of the water table or potentiometric surface), and the effective porosity of the geological formations. Sandy or gravel layers often exhibit relatively high hydraulic conductivities, allowing groundwater to move at rates of several feet per day. In contrast, silt and clay layers, which have much lower hydraulic conductivities, result in significantly slower groundwater movement, potentially just a few feet per year or less.

Various analytical methods, numerical modeling tools, and geophysical techniques can be employed to estimate the rate of subsurface flows to adjacent basins or surface water bodies. To estimate banking losses, a regional groundwater model (the Integrated Water Flow Model for the Cosumnes, South American, and North American subbasins) will be utilized to simulate subsurface flow and stream-aquifer interactions. The model simulations reflect the hydrogeological properties of the aquifer (e.g., permeability and porosity), boundary conditions, recharge rates, and water demands from municipal, industrial, irrigation, and environmental uses. The model is validated using data from the regional monitoring network and is typically updated on a 5-year cycle as part of GSP update processes.

Banking losses are estimated by comparing modeled groundwater budget components with- and without water banking operations. Banking losses are then calculated as the net increase in outflows from the subbasins, including changes in subsurface flows to adjacent basins and changes in seepage to interconnected surface water bodies.

3.5.2 Leave-Behind Accounting

Leave-behind refers to a designated portion of banked groundwater that is set aside to support sustainability of the groundwater subbasins and enhance local water supply reliability. The leave-behind also helps to address uncertainty in the banking losses estimates. It is recommended that each banking program establish a leave-behind amount that is earmarked specifically for bolstering groundwater storage.

All leave-behind volumes will be integrated into the groundwater subbasin's overall storage—independent of banking program balances—and will not be accessible for future banking program operations. Instead, they benefit all users of water in the groundwater subbasin.

3.6 Storage Rights Tracking

Effective groundwater banking also requires compliance with the legal and regulatory aspects of water rights. Water banking will use a mix of water types such as surface water rights, CVP water, and other contract water. Entities participating in groundwater banking should maintain records of these surface waters to track their rights to stored supplies and any limitations on use of recovered water.

For proper and transparent accounting and to support compliance with the various legal and contractual requirements, the Water Accounting System will provide for separate subaccounts to track groundwater inputs, withdrawals, and balances associated with different types of water.

3.7 Recovery Tracking

During recovery operations, banked groundwater is extracted for use by the recovering entity or delivered to other entities, where it is used to offset equivalent quantities of surface water. These forgone surface water supplies may span various water types, such as pre-1914 water rights, post-1914 water rights, CVP water allocations, and other types of water contracts.

Tracking of forgone surface water involves documenting the movement of water rights, water allocations, and contract water from transferring entities (or sellers) to the receiving entities (or buyers). This tracking includes recording the source(s) of the transferred water, the volume(s) of water transferred, delivery schedules, and other relevant information. The tracking of forgone surface water supplies is the responsibility of the transfer parties (both sellers and buyers). The Water Accounting System will document these transactions as reported by the transfer parties.

The transfer parties (sellers and buyers) are responsible for negotiating the terms and conditions of any transfer transaction. Additionally, a transfer transaction must be legally and regulatorily compliant, including adherence to local, State, and Federal regulations, water rights laws, and environmental requirements. This responsibility may entail securing the necessary approvals or permits for a transfer. Furthermore, it is incumbent upon these parties to document all aspects of a transfer agreement including, but not limited to, conveyance of the volume of water transferred, the price of the transfer, the duration of the transfer, and any specific conditions upon which they mutually agree.

3.8 Conserved Water

Surface water saved through efficiency improvements, operational changes, or demand reduction measures is considered "real water" under California law for the purposes of water transfers. Water rights holders are permitted to transfer conserved water provided the transfers comply with legal and environmental requirements[1]. However, conserved surface water is not tracked within this Water Accounting System, as its scope is focused on tracking groundwater banking activities.

While conserved groundwater resulting from efficiency improvements, operational changes, or demand reductions reduce groundwater pumping and enhance groundwater storage, it is not tracked within the Water Accounting System. Incorporating conserved groundwater would add significant complexity, requiring verification of savings and assurance of the long-term reliability and sustainability of these conservation measures.

[1] The legal framework for these transfers is outlined in the California Water Code Sections 1011, 1020-1030, and 1700-1707

4.0 CONSISTENCY WITH GROUNDWATER SUSTAINABILITY PLANS

This section describes the Water Accounting System's consistency with the current approved GSPs and how it will maintain consistency with the GSPs over time.

4.1 Consistency with Adopted GSPs Data and Tools

The operational baselines, which define how each entity operates in the absence of water banking activities, align with the water budgets outlined in the pertinent and approved GSPs. This alignment also extends to banking losses that will be in accordance with the assumptions made in the GSPs regarding flow exchanges with neighboring groundwater subbasins and interconnected surface waters.

As the GSPs undergo their scheduled 5-year review cycles, there will be parallel reassessment and potential update of the Water Accounting System. This update will ensure that the operational baselines and banking losses maintain consistency with the assumptions set out in the water budgets of the GSPs.

The inclusion of water banking as a management action in the GSPs of both the North and South American subbasins highlights its role in promoting groundwater sustainability. The Water Accounting System plays a critical role in monitoring and ensuring that contributions made by water banking programs, through the leave-behind, are in accordance with water budget assumptions in the GSPs.

4.2 Coordination with GSAs

Water banking, implemented through considerable and purposeful oversight and adaptive management, will contribute to long-term groundwater sustainability through the leave-behind that overtime will enhance groundwater conditions for all beneficial users in the basin.

However, the success of the Sac Water Bank depends on maintaining sustainable pumping levels across the basin, consistent with adopted GSP sustainable management criteria. If non-bank-related pumping exceeds sustainable thresholds over time, it could hinder a water bank's ability to meet its obligations and limit its capacity to recover stored water.

Conversely, basin sustainability under SGMA can only be maintained if all pumpers, including those outside of water banking activities, operate in a way that does not create or worsen unsustainable groundwater conditions. To achieve this, water banking participants and GSAs must collaborate to address these challenges and ensure that groundwater use remains sustainable for the long term.

The geographic distribution of recharge and recovery (pumping) can have short-term and localized effects due to the complex dynamics of lateral and vertical flows in the subbasins. Despite positive water banking balances, water banking program operations to recover banked water may require additional coordination with the pertinent GSAs primarily to avoid or minimize any localized negative effects associated with water level declines during recovery operations, especially during droughts. Water banking programs should implement adaptive management actions to adjust the timing and location of water extraction to mitigate these effects.

Note that similar localized effects could occur during recharge cycles (especially in the proximity of known contamination sites). These areas are identified in the GSPs and coordination with the applicable entities is necessary to ensure that containment activities are not affected.

Each banking program will make available an annual report of its banking activities and balances. To support the required GSP annual reports due on April 1st, these banking reports should be made available at least one month prior to the GSP submission deadline. As part of the adaptive management actions, additional reporting and/or coordination efforts may be requested of banking programs, as needed and upon mutual agreement.

4.3 Adaptive Management

Adaptive management is an approach where current and historical data and information are analyzed to improve future management activities and practices. Applying adaptive management can be of critical importance to effectively manage groundwater due to the inherent uncertainties associated with tracking and evaluating human activities on a resource that in most cases can only be evaluated based upon a limited dataset (especially in comparison to surface water). However, the overarching challenge confronting any effort to implement adaptive management is the tension between the needs for stability and flexibility.

Quantitative metrics are necessary for effectively implementing adaptive management, as they provide clear decision points for reassessing management activities when necessary. The ability to implement adaptive management is enhanced by the built-in metrics required in the GSPs to define sustainability through minimum thresholds (MTs) and measurable objectives (MOs)[2].

While these metrics do not impose operational limitations on any specific banking entity, they can serve as valuable guidelines for adaptive management decisions in water banking operations. By utilizing these metrics, banking entities and GSAs can work collaboratively to achieve their shared goals of basin sustainability and the successful implementation of water banking.

To ensure sustainable water banking operations and alignment with applicable GSPs, the following adaptive management procedures are established based on GSP-defined sustainability metrics.

1. Annual Planning and Coordination

[2] MTs and MOs as defined in SGMA aid GSAs in the ability to define sustainability in GSPs, however MTs and MOs set at individual representative monitoring sites can be exceeded without causing unsustainable conditions in a given subbasin.

- Annual Operations Plan – Each banking program will develop a yearly outline of target recharge and recovery volumes for its participants. The annual plan typically considers available capacity, operational constraints, and prevailing hydrological and groundwater basin conditions. This plan outlines general expectations for recharge and recovery levels rather than imposing restrictions, allowing flexibility for operational adjustments as needed.

- GSA Notification and Coordination: Each banking program will provide its annual operational plan to the relevant GSAs in each subbasin, ensuring transparency and facilitating effective coordination. Notification is expected to be submitted no later than June 1 of each year.

2. Monitoring and Early Warning:

   - Regular Groundwater Monitoring: Banking participants shall adhere to the Monitoring Plan (e.g., tracking groundwater levels, storage changes, and trends). Monitoring frequency and reporting will align with applicable GSP requirements to detect early signs of threshold exceedances.

   - Trigger-Based Assessment: If groundwater levels approach an MT exceedance, GSAs and banking participants will conduct a review of operational impacts and determine necessary adjustments. MO trends will be evaluated to ensure long-term sustainability goals are met.

3. Response Actions for Areas with MT Exceedances:

   - No new or additional Sac Water Bank pumping will occur in areas where an MT exceedance is already present unless approved by the overlying GSA.

   - Alternative operational adjustments may include redistributing pumping activities to areas with available capacity, delaying or reducing pumping volumes to prevent further groundwater declines, increasing recharge efforts to offset declines and stabilize levels.

4. Response Actions for Areas Approaching MT Exceedances:

   - GSAs will coordinate with banking participants to assess if pumping can be shifted to areas with more sustainable conditions.

   - Banking participants will evaluate reductions in pumping volumes to avoid large drawdowns.

   - Beneficiaries will explore changing the timing of withdrawals to allow for system recovery.

5. Adaptive Management Review:

   - GSAs and banking participants will meet annually to review monitoring data, operational impacts, and necessary adjustments to water banking activities.

- Adaptive management strategies will evolve in response to climate variability, hydrologic trends, and basin-wide sustainability goals.
- If systemic issues arise, GSAs and banking participants will collaborate to modify operational plans and ensure long-term groundwater basin health.

4.4 Dispute Resolution

To ensure effective collaboration and conflict resolution, a structured dispute resolution framework is established for addressing issues arising from banking operations. The dispute resolution process aims to:

a. Address disputes related to operations of water banking, particularly groundwater pumping and recovery impacts, to ensure water banking activities continue to contribute to the sustainability of the subbasin and do not lead to non-compliance with SGMA.

b. Promote collaborative, transparent, and cost-effective conflict resolution.

c. Maintain legal compliance and procedural fairness while supporting basin-wide sustainability goals.

d. Strengthen working relationships among GSAs, banking participants, and interested parties in the basin to prevent future conflicts.

The dispute resolution process may be initiated by any banking participant or a GSA identifying a conflict related to water banking operations. To formally initiate the conflict resolution process, a written notice outlining the dispute must be submitted to all parties involved.

The parties in the conflict are expected to attempt in good faith to resolve the dispute through informal means. Best practices for conflict resolution recommend a tiered approach to addressing conflicts collaboratively and efficiently while minimizing legal action. This process includes:

a. Negotiation: Direct discussions between parties to resolve disputes during an agreed upon period following notification.

b. Facilitation: If negotiation fails, a neutral facilitator may guide discussions to explore solutions during an agreed upon period. Facilitation is a process-driven approach used in collaborative settings to help groups organize discussions, make decisions, and ensure productive dialogue.

c. Mediation: If facilitation is unsuccessful, the dispute may escalate to mediation with a mutually agreed upon mediator. The mediator acts as a neutral third party, helping parties negotiate, clarify their positions, and reach a mutually acceptable agreement. An effective mediator should be knowledgeable about the subbasins and with no vested interest in the outcome.

Resolutions of conflicts will be documented, and an annual review will assess effectiveness and identify improvements. If disputes occur, banking participants may consider modifying water banking operations to prevent future conflicts. Costs for facilitation and mediation will be shared equally among disputing parties

5.0 IMPLEMENTATION AND ADMINISTRATION

This section outlines responsibilities for administering the Water Accounting System and its key implementation activities.

5.1 Roles and Responsibilities

RWA will lead the implementation and administration of the Water Accounting System. RWA will coordinate data collection, management, and maintenance of the Water Accounting System.

Participating Agencies will conduct recharge and recovery activities as well as provide information on banking activities to RWA.

5.2 Data Collection and Management

It is envisioned that the data and records associated with water banking activities will be maintained within a Data Management System (DMS). This DMS will facilitate transparency, allowing for all information to be queried by banking participants and by RWA, which would allow RWA to promptly provide information when necessary. At minimum, the records maintained will include detailed monthly accounts during active periods of recharge and recovery. Water banking agreements will outline the types, protocols, and frequency of data collection that are pertinent to their activities. Data collection will make use of the existing data collection and reporting activities, to the extent possible, to minimize duplication of efforts and provide efficiency.

Data management, archiving, and security would be consistent with SGMA best management practices. This involves implementing robust data storage solutions, regular backups, and secure access protocols to ensure data integrity and availability. All data would be stored in secure, encrypted formats, with access strictly controlled through authentication and authorization mechanisms. Archiving strategies would be designed to ensure that data is retrievable and well-organized for long-term storage, while adhering to relevant legal and regulatory requirements.

5.3 Reporting

The Water Accounting System will support reporting of recharge and recovery balances, offering an in-depth look at the transactions conducted during a specific reporting period. The intention is for this reporting to be coordinated with reporting activities of the GSAs, whenever possible. The Water Accounting System could also support the specific reporting needs of banking programs (i.e. the Sac Water Bank and others).

As described in Section 4.2, each banking program will make available an annual report of its banking activities and balances. These banking reports should be made available at least one month prior to the GSP submission deadline of April 1st.

6.0 APPLYING THE WATER ACCOUNTING SYSTEM TO THE SACRAMENTO REGIONAL WATER BANK

The Sac Water Bank is a regional banking program operated by its Participating Agencies[3], with support from RWA. The Water Accounting System fundamentals are consistent with the established goals, objectives, and principles of Sac Water Bank (RWA, 2023)[4]. The Water Accounting System will support tracking of banking activities and transactions for the Sac Water Bank, support its compliance with pertinent and approved GSPs, and provide assurances and transparency about its operations to its Banking Partners,[5] regulatory agencies,[6] and stakeholders.[7]

Sac Water Bank implementation within the Water Accounting System will include the elements discussed below.

6.1 Accounts

One Bank— Sac Water Bank operations will be monitored and accounted as one bank that covers portions of the North and South American subbasins (as several local water agencies, cities, and counties overlie both subbasins, and recognizing the existing inter- connectivity of local water agencies across the subbasins).

Multiple Subaccounts—Implement separate subaccounts to track (1) activities subject to the guidelines for banking of CVP water,[8] (2) activities not related to banking of CVP water (see Figure8). In addition, other subaccounts may be created, as needed, to tack banking activities in specific geographies, using specific sources of supplies, involving specific banking participants, etc.

The banked CVP water account will track the following sources of supplies:

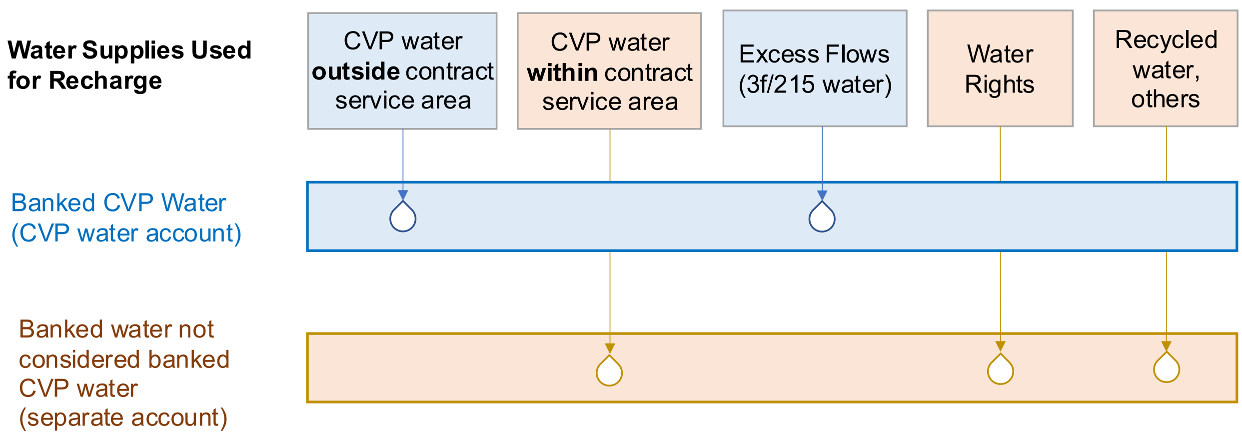
- CVP contract water banked ***outside*** a CVP contractor service area: This banked water may include CVP water allocations from American River Division CVP contractors or from other CVP contractors. Any banking action that includes CVP water requires Reclamation's approval in accordance with Reclamation's current Water Banking guidelines. Reclamation may place quantity limitations based on the proposed timing of the banking action; historic CVP water use of the contractor seeking to bank CVP water; or any other factor(s) that may cause harm to the CVP, CVP operations, or Reclamation's ability to meet regulatory and other contractual obligations.

[3] Participating Agencies are RWA Members/Associate Members actively involved in recharge and/or recovery actions under the Sac Water Bank.
[4] The Sacramento Regional Water Goal, Objectives, Principles, and Constraints. RWA. July 7, 2023.
[5] Banking Partners are entities that are not Participating Agencies but have entered (or are exploring entering) into banking and transfer agreements with the Sac Water Bank.
[6] Regulatory agencies are entities with authority over some aspects of Sac Water Bank implementation.
[7] Stakeholders are interested parties, non-governmental organizations, other organizations, and individuals that are interested in, or potentially affected by, operations of the Sac Water Bank.
[8] *Groundwater Banking Guidelines for Central Valley Project Water* (Reclamation, 2019).

- Article 3(f) water of the applicable CVP contract and section 215 water: Reclamation periodically makes these excess non-storable waters in CVP facilities available. Reclamation does not place limits on the use of flood excess water for recharge.[9]

The banked water not considered banked CVP water includes the following sources of supplies:

- CVP water banked within a CVP contractor service area.
- American and Sacramento rivers water available to the Banking Partners through existing water rights.
- Water from other sources when available.



Key: CVP = Central Valley Project

Figure 8. Tracking of Sacramento Regional Water Bank Recharge Using Different Water Supply Sources

6.2 Leave-Behind and Banking Losses

- **Leave-Behind** — The Participating Agencies have agreed there will be a "leave behind" no less than 5 percent of recovered water to be transferred out of a subbasin. To further enhance local water supply reliability, a Participating Agency may opt to designate an additional percentage of its banked water as leave-behind, exceeding the minimum 5 percent requirement, potentially up to 100 percent.
- **Banking Losses**— The banking losses will be calculated using the approach established in the Water Accounting System, ensuring consistency with water budgets in the GSPs.

[9] *Groundwater Banking Guidelines for Central Valley Project Water* (Reclamation, 2019).

6.3 Incorporation of Existing Banking Programs

For decades, conjunctive use has been a foundation of water management across the North American Subbasin and South American Subbasin. By coordinating the use of surface water and groundwater, this approach has reversed historical groundwater declines, enhanced basin sustainability, and created a more resilient water supply system. This success has demonstrated that carefully managed groundwater banking can provide regional water security while supporting environmental needs.

The Sac Water Bank is built upon these past and ongoing efforts. There is a need for a fair and equitable approach that recognizes past groundwater banking efforts, ensures transparency and fairness in groundwater banking credits, and protects long-term basin sustainability through adaptive management.

Banked water volumes under these past banking activities must be reconciled with the adopted methodologies under this Water Accounting System to maintain accuracy and consistency:

- Past banking activities must be validated using historical records that align with the direct and in-lieu recharge definitions established under this Water Accounting System.
- Banking losses, consistent with Section 6.2, will be applied to ensure that reported volumes reflect recoverable groundwater.
- Past groundwater substitution transfers must be deducted from banked water to prevent double-counting.
- Banked water amounts must be adjusted to align with the adopted GSP budgets, sustainable management criteria, and SGMA requirements.

While incorporating past banked volumes is essential, it is equally important to ensure that groundwater recovery operations do not jeopardize basin sustainability or disrupt existing users. Therefore, in addition to the framework and requirements described in Sections 2, 3, 4, 5, and 6, several adaptive management safeguards will guide the integration of past banking balances.

- To prevent excessive drawdowns, banked groundwater recovery will be subject to annual caps and multi-year drought restrictions.
- Water extraction will be spatially distributed to avoid localized groundwater declines.
- The recovery of banked water must not compromise the operational margin for other basin users, particularly during dry years.
- Ensure the water bank operations do not cause undesirable results in the subbasins.

7.0 REFERENCES

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APPENDIX A—EXAMPLES OF RECHARGE AND RECOVERY ACCOUNTING

Attachment A provides examples of recharge (deposits) and recovery (withdrawals) accounting and tracking using this Water Accounting System for hypothetical entities that represent the three types of water supply portfolios:

- Primarily reliant on surface water
- Primarily reliant on groundwater
- Makes use of both surface water and groundwater

Table A-1 is an example of in-lieu recharge accounting over a 5-year period for a hypothetical entity that is primarily reliant on groundwater. The table does not show recovery because this groundwater reliant entity does not have established surface water use in its operational baseline.

Table A-2 is an example of recovery accounting over a 5-year period for a hypothetical entity that is primarily reliant on surface water. The table does not show in-lieu recharge because this surface water reliant entity does not have established groundwater use in its operational baseline.

Table A-3 is an example of in-lieu recharge and recovery accounting over a 5-year period for a hypothetical entity that uses both surface water and groundwater.

Table A-4 is an example of direct recharge using ASR wells, in-lieu recharge, and recovery accounting over a 5-year period for a hypothetical entity that uses both surface water and groundwater.

Table A-5 is an example of direct recharge using spreading basins, in-lieu recharge, and recovery accounting over a 5-year period for a hypothetical entity that uses both surface water and groundwater.

Table A-6 is an example of in-lieu recharge using recycled water to fully replace groundwater use over a 5-year period for a hypothetical entity that historically used groundwater.

Each table illustrates how the recharge and recovery accounting is conducted using the rules described in Sections 3.2 and 3.3. For these examples, note the following:

- The total water use fluctuates from year to year relative to the assumed average use under the operational baseline. These fluctuations are typical and do not result in recharge or recovery actions by themselves.
- A reduction in groundwater use is not a recharge action unless it is accompanied by an equivalent increase in surface water use.

- An increase in groundwater use is not a recovery action unless it is accompanied by an equivalent reduction in surface use.

- Leave-behind and banking losses accounting are not reflected in these examples.

- Surface water is used for illustration purposes. Other local supply sources such as recycled water and storm water can be accounted for in a similar manner.

In the examples presented in Tables A-1 through A-5, accounting of recharge and recharge reflects the following rules:

- In-lieu recharge for urban water purveyors only occurs when → groundwater use decreases and surface water use increases.

- In-lieu recharge through direct supply of alternative water supplies is calculated as the volume of alternative water supply provided when groundwater use is completely replaced.

- Recovery only occurs when → groundwater use increases and surface water use decreases.

- Estimated in-lieu recharge (or recovery) is the lesser of change in groundwater use or surface water use. This helps to distinguish recharge and recovery actions from the normal variations (fluctuations) in annual water consumption relative to the operational baseline.

- Direct recharge is calculated as:

    - The amount of water injected using wells.

    - The amount of water applied to spreading basins – operational losses (evaporation and overflow).

- Direct recovery is calculated as the metered volume of water extracted using groundwater wells.

Table A-1. In-lieu Recharge Accounting for Hypothetical Groundwater Reliant Entity

	a = b + c	*b*	*c*	*d = (b - baseline)*	*e = (c - baseline)*			*f = min (|d|, |e|)*			*g = 0*	
	Total Water Use	**GW Use**	**SW Use**	**Change in GW Use**	**Change in SW Use**	**GW decrease?**	**SW increase?**	**In-lieu Recharge**	**GW increase?**	**SW decrease?**	**Recovery**	**Explanation**
Operational Baseline	**5,000**	**5,000**	**0**									
Year 1	5,050	5,050	0	50	0	No	No	0	Yes	No	0	• GW use decreased and SW use: no change. • No in-lieu recharge.
Year 2	4,750	3,400	1,350	-1,600	1,350	Yes	Yes	1,350	No	No	0	• GW use: decreased and SW use: increased. • In-lieu recharge occurred. • In-lieu recharge is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.
Year 3	4,200	4,200	0	-800	0	Yes	No	0	No	No	0	• GW use: decreased and SW use: no change. • No in-lieu recharge. • Reduction in GW use alone is not a recharge (fluctuation in total water use relative to the baseline).
Year 4	5,700	5,200	500	200	500	No	No	0	Yes	No	0	• GW use: increased and SW use: increased • No in-lieu recharge. • SW use increase to meet higher demand.
Year 5	5,300	3,300	2,000	-1,700	2,000	Yes	Yes	1,700	No	No	0	• GW use: decreased and SW use: increased. • In-lieu recharge occurred. • In-lieu recharge is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.

Key:
GW = groundwater min = minimum SW = surface water

Table A-2. Recovery Accounting for Hypothetical Surface Water Reliant Entity

	a = b + c	*b*	*c*	*d = (b - baseline)*	*e = (c - baseline)*			*f = 0*			*g = min (|d|, |e|)*	
	Total Water Use	**GW Use**	**SW Use**	**Change in GW Use**	**Change in SW Use**	**GW decrease?**	**SW increase?**	**In-lieu Recharge**	**GW increase?**	**SW decrease?**	**Recovery**	**Explanation**
Operational Baseline	**8,500**	**0**	**8,500**									
Year 1	7,650	0	7,650	0	-950	No	No	0	No	Yes	0	• GW use no change and SW use: decreased. • No recovery.
Year 2	8,600	0	8,600	0	600	No	Yes	0	No	No	0	• GW use: no change and SW use: increased. • No recovery
Year 3	7,700	1,700	6,000	1,700	-2,500	No	No	0	Yes	Yes	1,700	• GW use: increased and SW use: decreased. • Recovery occurred. • Recovery is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.
Year 4	8,950	300	8,650	300	150	No	Yes	0	Yes	No	0	• GW use: increased and SW use: increased. • No recovery.
Year 5	7,200	7,200	0	7,200	-8,500	No	No	0	Yes	Yes	7,200	• GW use: increased and SW use: decreased. • Recovery occurred. • Recovery is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.

Key:
GW = groundwater min = minimum SW = surface water
Notes:
Assumes that the entity already has sufficient banked water for this recovery.

Table A-3. In-lieu Recharge and Recovery Accounting for Hypothetical Joint Surface Water-Groundwater Use Entity

	a = b + c	*b*	*c*	*d = (b - baseline)*	*e = (c - baseline)*			*f = min (|d|, |e|)*			*g = min (|d|, |e|)*	
	Total Water Use	**GW Use**	**SW Use**	**Change in GW Use**	**Change in SW Use**	**GW decrease?**	**SW increase?**	**In-lieu Recharge**	**GW increase?**	**SW decrease?**	**Recovery**	**Explanation**
Baseline	**8,000**	**4,500**	**3,500**									
Year 1	7,500	4,300	4,200	-200	700	Yes	No	200	No	No	0	• GW use: decreased and SW use: increased. • In-lieu recharge occurred • In-lieu recharge is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.
Year 2	8,100	5,700	2,400	1,200	-1,100	No	No	0	Yes	Yes	1,100	• GW use: increased and SW use: decreased. • Recovery occurred. • Recovery is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.
Year 3	8,600	4,850	3,750	350	250	No	Yes	0	Yes	No	0	• GW use: increased and SW use: increased. • No in-lieu recharge. No recovery.
Year 4	7,650	3,100	4,550	-1,400	1,050	Yes	Yes	1,050	No	No	0	• GW use: decreased and SW use: increased. • In-lieu recharge occurred. • In-lieu recharge is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.
Year 5	7,200	4,200	3,000	-300	-500	Yes	No	0	No	Yes	0	• GW use: decreased and SW use: decreased. • No in-lieu recharge. No recovery.

Key:
GW = groundwater use min = minimum SW = surface water use
Notes:
Assumes that the entity already has sufficient banked water for this recovery.

Table A-4. Combined Direct (Injection) and In-lieu Recharge, and Recovery Accounting

	a = b + c1	*b*	*c1*	*c2*	*d = (b - baseline)*	*e = (c1 - c2 - baseline)*	*f1= c2*			*f2 = min (|d|, |e|)*			*g = min (|d|, |e|)*	
	Total Water Use	**GW Use**	**SW Use**	**Well Injection**	**Change in GW Use**	**Change in SW Use *(less injection)***	**Direct Recharge**	**GW decrease?**	**SW increase?**	**In-lieu Recharge**	**GW increase?**	**SW decrease?**	**Recovery**	**Explanation**
Baseline	**8,000**	**4,500**	**3,500**	**0**										
Year 1	8,500	4,300	4,200	0	-200	700	0	Yes	Yes	200	No	No	0	• GW use: decreased and SW use: increased. • In-lieu recharge occurred. • In-lieu recharge is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.
Year 2	7,700	3,700	4,000	300	-800	200	300	Yes	Yes	200	No	No	0	• Direct recharge occurred. • GW use: decreased and SW use: increased. • In-lieu recharge occurred. • In-lieu recharge is minimum of change in SW use (less injection) or GW use to account for total water use fluctuation relative to the baseline.
Year 3	8,300	5,400	2,900	500	900	-1,100	500	No	No	0	Yes	Yes	900	• Direct recharge occurred. • GW use: increased and SW use: decreased. • Recovery occurred. • Recovery is minimum of change in SW use (less injection) or GW use to account for total water use fluctuation relative to the baseline.
Year 4	8,600	4,850	3,750	800	350	-550	800	No	No	0	Yes	Yes	350	Same as year 3.
Year 5	7,650	3,100	4,550	400	-1,400	650	400	Yes	Yes	650	No	No	0	Same as year 2.

Key: GW = groundwater use min = minimum SW = surface water use
Notes:
Assumes that the entity already has sufficient banked water for this recovery.

Table A-5. Combined Direct (Spreading Basins) and In-lieu Recharge, and Recovery Accounting

	a = b + c1	*b*	*c1*	*c2*	*c3*	*d = (b - baseline)*	*e = (c1 - c2 - baseline)*	*f1 = c2 - c3*			*f2 = min (|d|, |e|)*			*g = min (|d|, |e|)*	
	Total Water Use	**GW Use**	**SW Use**	**Spreading Basins SW Use**	**Evap. & Overflow Losses**	**Change in GW Use**	**Change in SW Use** *(less Spreading Basin use)*	**Direct Recharge**	**GW decrease?**	**SW increase?**	**In-lieu Recharge**	**GW increase?**	**SW decrease?**	**Recovery**	**Explanation**
Baseline	**8,000**	**4,500**	**3,500**	**0**											
Year 1	8,500	4,300	4,200	0	0	-200	700	0	Yes	Yes	200	No	No	0	• GW use: decreased and SW use: increased. • In-lieu recharge occurred. • In-lieu recharge is minimum of change in SW use or GW use to account for total water use fluctuation relative to the baseline.
Year 2	7,700	3,700	4,000	300	50	-800	200	250	Yes	Yes	200	No	No	0	• Direct recharge occurred. • GW use: decreased and SW use: increased. • In-lieu recharge occurred. • In-lieu recharge is minimum of change in SW use (less spreading basins use) or GW use to account for total water use fluctuation relative to the baseline.
Year 3	8,300	5,400	2,900	500	150	900	-1,100	350	No	No	0	Yes	Yes	900	• Direct recharge occurred. • GW use: increased and SW use: decreased. • Recovery occurred. • In-lieu recharge is minimum of change in SW use (less spreading basins use) or GW use to account for total water use fluctuation relative to the baseline.
Year 4	8,600	4,850	3,750	800	300	350	- 550	500	No	No	0	Yes	Yes	350	Same as year 3.
Year 5	7,650	3,100	4,550	400	100	-1,400	650	300	Yes	Yes	650	No	No	0	Same as year 2.

Key:
GW = groundwater use min = minimum SW = surface water use

Table A-6. In-lieu Recharge Accounting for Hypothetical Groundwater Reliant Entity Using Recycled Water to Fully Replace Groundwater Use

	a = b + c	*b*	*c*	*d = (b - baseline)*	*e = (c - baseline)*			*f = min (|d|, |e|)*			*g = 0*	
	Total Water Use	**GW Use**	**Recycled Water Use**	**Change in GW Use**	**Change in ReW Use**	**GW decrease?**	**ReW increase?**	**In-lieu Recharge**	**GW increase?**	**ReW decrease?**	**Recovery**	**Explanation**
Operational Baseline	**5,000**	**5,000**	**0**									
Year 1	5,050	0	5,050	-5,000	5,050	Yes	Yes	5,050	No	No	0	• GW use: decreased and ReW use: increased. • In-lieu recharge occurred. • In-lieu recharge is the increase in ReW because it replaced the entire GW use.
Year 2	4,750	0	4,750	-5,000	4,750	Yes	Yes	4,750	No	No	0	• GW use: decreased and ReW use: increased. • In-lieu recharge occurred. • In-lieu recharge is the increase in ReW because it replaced the entire GW use.
Year 3	4,200	0	4,200	-5,000	4,200	Yes	Yes	4,200	No	No	0	• GW use: decreased and ReW use: increased. • In-lieu recharge occurred. • In-lieu recharge is the increase in ReW because it replaced the entire GW use.
Year 4	5,700	0	5,700	-5,000	5,700	Yes	Yes	5,700	No	No	0	• GW use: decreased and ReW use: increased. • In-lieu recharge occurred. • In-lieu recharge is the increase in ReW because it replaced the entire GW use.
Year 5	5,300	0	5,300	-5,000	5,300	Yes	Yes	5,300	No	No	0	• GW use: decreased and ReW use: increased. • In-lieu recharge occurred. • In-lieu recharge is the increase in ReW because it replaced the entire GW use.

Key:
GW = groundwater   min = minimum   ReW = recycled water   SW = surface water