Preliminary Engineering Technical Memorandum for the Paso Robles Groundwater Subbasin Water Banking Feasibility Study

San Luis Obispo County Flood Control
And Water Conservation District

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1 Introduction

The Paso Robles Groundwater Basin (Basin) located in northern San Luis Obispo County (County) is one of the largest groundwater basin in the County (Figure 1). The Coastal Branch of the California State Water Project (SWP) enters the County and the central coast just east of the Basin near the town of Shandon and continues southwest across the Basin. These two features along with the County's unused allocation of SWP water led local water leaders to want to explore the feasibility of banking water in the Basin for the benefit of the residents of the County.

This Preliminary Engineering Technical Memorandum (PETM) presents a base level of information on groundwater recharge and conjunctive use project formulation that will be utilized to develop and evaluate potential water banking opportunities in the Basin.

1.1 Project Background

The Water Banking Feasibility Study (Feasibility Study) for the Paso Robles Groundwater Basin is being led by the San Luis Obispo County Flood Control and Water Conservation District (District) in coordination with the Groundwater Banking Subcommittee (GBSC) of the Water Resources Advisory Committee (WRAC).

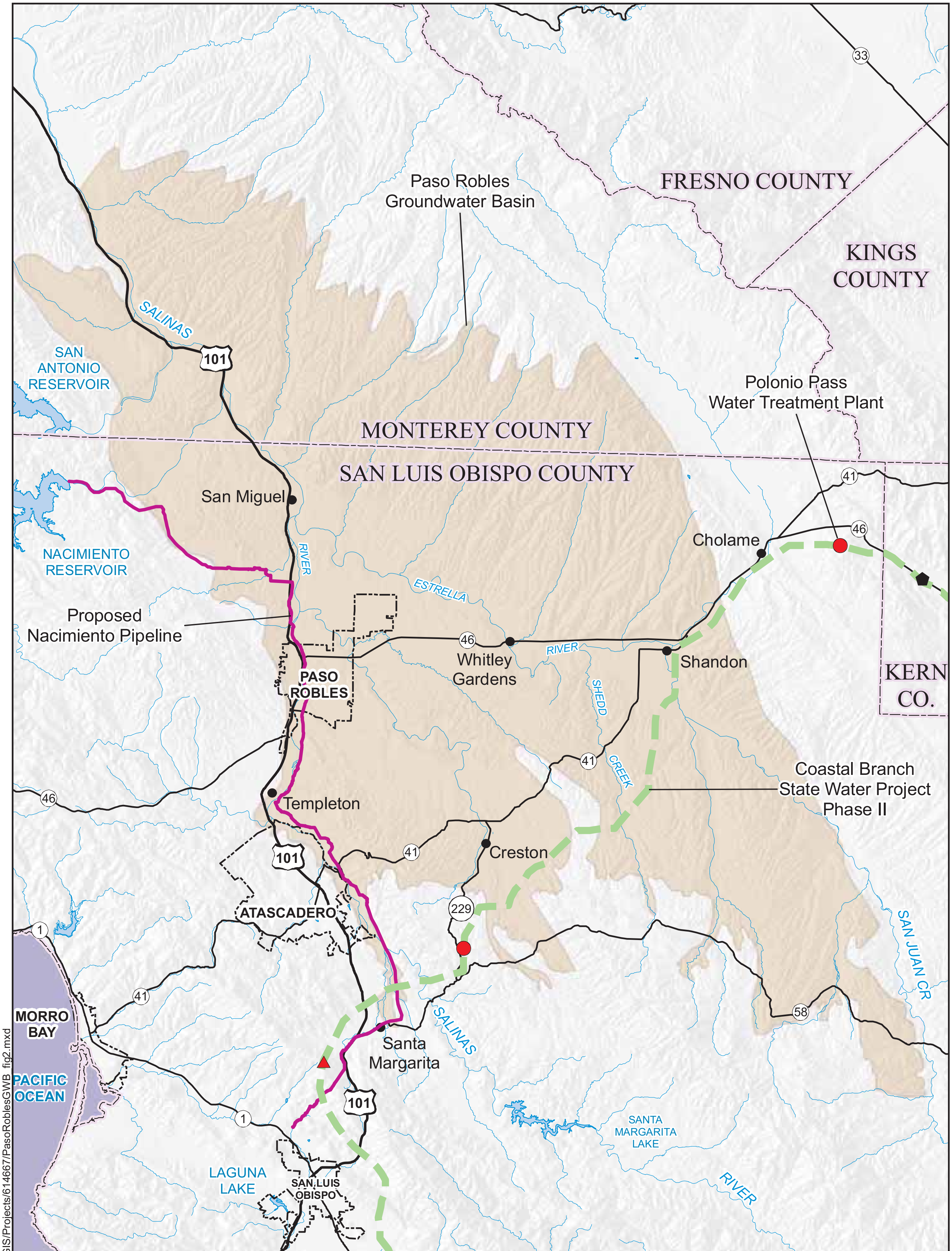
The San Luis Obispo County Integrated Regional Water Mangement Plan (IRWM Plan) identified this feasibility study of the groundwater banking potential of the Basin as a high priority project. Funding for this study, as well as several other planning projects identified in the San Luis Obispo County IRWMP, was provided in part by a Proposition 50 Chapter 8 Integrated Regional Water Mangement Program Fiscal Year 2005-2006 Planning Grant.

1.2 Previous Studies

Over the last several years, several studies have been completed which will be used to provide information for the Feasibility Study. Some of these studies are briefly summarized below.

1.2.1 San Luis Obispo County Integrated Regional Water Management Plan (2005)

The District prepared the IRWM Plan in December 2005 to align the County's water management planning efforts for achieving sustainable water resources management with the State of California's (State) planning efforts through 2030. The IRWM Plan was used to support the County's planning and implementation grant applications.



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Paso Robles Groundwater Basin
Water Banking Feasibility Study
San Luis Obispo County
Flood Control and Water Conservation District

GEI Consultants

PASO ROBLES GROUNDWATER BASIN

DECEMBER 2006 DRAFT FIGURE 1

The IRWM Plan integrates 19 different water management strategies that have or will have a role in protecting the region's water supply reliability, water quality, ecosystems, groundwater, and flood management historically or into the future. The integration of these strategies resulted in a list of action items (projects, programs, and studies) needed to implement the IRWM Plan. District staff and the WRAC Integrated Regional Water Management Subcommittee prioritized the action items.

Four short-term priority projects were identified in the IRWM Plan that will be ready to proceed within five years. These include:

- Nacimiento Water Project
- Los Osos Wastewater Project
- Lopez Water Treatment Plant Upgrade
- Nipomo Mesa Water Project

The IRWM Plan identified additional projects that support the overall plan goals, objectives, and strategies. These projects include:

- Groundwater Banking Plan (this project)
- Regional Permitting Plan
- Data Enhancement Plan
- Flood Management Plan

These planning projects were included in the Proposition 50 Chapter 8 Integrated Regional Water Mangement Program Fiscal Year 2005-2006 Planning Grant application, which is funding this Feasibility Study.

1.2.2 Paso Robles Groundwater Basin Study (2002)

In 2002, Fugro West and Cleath and Associates investigated the hydrogeologic conditions and quantified the water supply capability of the Basin by defining the lateral and vertical extent of the aquifer, groundwater flow and movement, current water quality conditions, and perennial yield.

1.2.3 Paso Robles Groundwater Basin Study Phase II – Numerical Model Development, Calibration, and Application (2005)

In 2005, Fugro West and ETIC Engineering developed a numerical groundwater flow model as a quantitative tool to evaluate future hydraulic conditions of the Basin. Using the model, the study evaluated the Basin's response to current and future water demands with and without supplemental water and identified areas of declining water levels.

1.3 Project Goals

The goal of the Feasibility Study is to determine the water banking potential in the Basin. If feasible water banking opportunities are identified in this Feasibility Study, they can then be compared to other water mangement options identified by the District to improve the long-term water supply reliability for the residents of the County and the Central Coast. Potential benefits of a water bank may include:

- Improving local groundwater conditions within the Basin.
- Increasing dry-year water supply reliability for local water users and possibly the residents of the County and the Central Coast.
- Improving local groundwater quality in the Basin.
- Providing greater flexibility of water resources management in the County and the Central Coast.
- Reducing the County's dependence on imported water supplies in below-normal years.

1.4 Project Approach and Schedule

Potential water banking opportunities within the Basin will be evaluated upon several different feasibility components that contribute to the overall feasibility, including:

- The availability of a water supply for banking.
- The ability to recharge the aquifer system.
- The ability to recover the banked water.
- The ability to deliver the banked water to the end user.

The water banking feasibility factors will be evaluated to address the hydrogeologic considerations, engineering considerations, and other considerations (such as environmental issues and overall groundwater management) to determine the overall feasibility of individual water banking opportunities. This approach is being used to complete the

Feasibility Study by the December 2007 completion date in order to satisfy the requirements of the grant identified above.

In order to satisfy the planning needs of the County and the grant requirements, a detailed project schedule was prepared which outlines the project approach. The overall project approach is presented below by task.

Task 1: Stakeholder Involvement – An extensive stakeholder involvement and public participation plan was used in the preparation of earlier studies completed in the Basin. This level of stakeholder involvement will be continued in this project. Six meetings of the consultant team with the GBSC have been scheduled during the study to provide information to the local interested parties and obtain feedback and review of project deliverables. The study kickoff meeting was held on October 4, 2006, at the GBSC meeting in Templeton. Additional scheduled GBSC meeting dates are shown on Figure 1.

Task 2: Prepare Preliminary Engineering Technical Memorandum – This task will focus on developing the initial concepts used to identify and evaluate potential groundwater banking projects in the Basin. Specific activities to be completed in this task include:

- Outline the overall project approach.
- Prepare background information on groundwater management and water banking to be used to formulate potential water banking projects.
- Identify essential data needed to define potential projects and develop initial project screening criteria that will be used to evaluate and compare water-banking opportunities.
- Identify preliminary water banking projects based on information developed in existing reports to be put through coarse screening.

After addressing comments on the draft, the final PETM will be provided to the GBSC and interested stakeholders to establish a common basis of understanding among all project participants.

Task 3: Initial Alternatives and Project Screening – This task will include the development of a coarse screening criteria and application to the initially identified groundwater banking alternatives. Application of the coarse screening criteria to the initial groundwater banking alternatives will remove those project alternatives from consideration that have significant constraints to implementation relative to other projects. This task is necessary to quickly focus the Feasibility Study on the potential recharge sites that show the best water banking opportunities in the Basin. This will be done by preparing a brief project description of the project sites and project components based on available information and applying the coarse screening criteria to identify the three sites that should be moved forward for further evaluation. This task includes presentation of the project sites and coarse screening criteria to the GBSC as part of the site selection process.

Task 4: Hydrogeologic Feasibility Evaluation – This task will provide a more detailed hydrogeologic evaluation of the three sites identified in Task 3. It will include the collection, compilation, and analysis of additional data needed to evaluate the hydrogeologic feasibility of water banking in the Basin. The existing groundwater model of the Basin may be used in this task to provide a quantitative evaluation of the water banking alternatives.

Task 5: Engineering Analysis of Selected Banking Sites – This task will provide a preliminary feasibility level design for the three alternatives identified in Task 3. This will include an estimate of the capital costs and operation and maintenance costs. It will also include a review of environmental and institutional considerations for the three identified sites. The results of the hydrogeologic and engineering feasibility evaluations (Tasks 4 and 5) will be presented to the GBSC and documented in the Water Banking Evaluation Progress Report.

Task 6: Draft Report of the Groundwater Banking Feasibility Study – The Draft Report will incorporate information presented in the prior project deliverables. It will include a general discussion of the groundwater banking opportunities in the Basin, the process used to identify and evaluate the most feasible projects, and will summarize the next steps for final project selection and implementation. If no feasible projects are identified, the Draft Report will document why banking water in the Basin is not feasible and what would need to change for any of the projects to be feasible. The Draft Report will be provided to the GBSC, WRAC, Nacimiento Water Commission, and the Shandon Advisory Council for review and comment.

Task 7: Final Report of the Groundwater Banking Feasibility Study – Comments received on the Draft Report will be reviewed and incorporated into the Final Report. The Final Report will be provided to the District by November 2007 in order to meet their grant funding requirements.

Task 8: Project Management and Coordination – This task includes general project management and coordination with the consulting team and the District. It will continue throughout the duration of the project.

1.5 Report Outline

The PETM is organized into the following sections:

- **Section 1, Introduction,** provides project background information and identifies previous studies, summarizes the project goals, and outlines the project approach and schedule.

- **Section 2, Water Banking Project Components,** provides some general background information on individual features of water banking projects that will be used to formulate and evaluate water-banking projects in the Basin.
- **Section 3, Water Banking Evaluation Criteria,** presents the preliminary evaluation criteria developed to evaluate and compare potential water banking opportunities in the Basin.

2 Water Banking Project Components

This section provides general information on individual project components that need to be considered in the formulation and evaluation of water banking projects in the Basin. These water banking project components are organized as follows:

- **Hydrogeologic Considerations** focuses on the affects of local geologic and hydrogeologic conditions on the feasibility of banking water at selected locations within the Basin.

- **Engineering Considerations** focuses on the technical requirements including water supply availability, infrastructure requirements, project operations, and the associated project costs to determine the feasibility of constructing and operating a water banking in the Basin.

- **Other Considerations** focuses on environmental issues and overall approach to groundwater management, which includes institutional issues, legal issues, and governance issues associated with groundwater management, including water-banking operations in the Basin.

Each of these elements is discussed below.

2.1 Hydrogeologic Considerations

2.1.1 Basin Definition and Boundaries

The Basin encompasses an area of approximately 505,000 acres (790 square miles). The Basin ranges from the Garden Farms area south of Atascadero to San Ardo in Monterey County, and from the Highway 101 corridor east to Shandon (Figure 1). Internally, the Atascadero subbasin was identified which encompasses the Salinas River corridor area south of Paso Robles, including the communities of Garden Farms, Atascadero, and Templeton.

2.1.2 Groundwater Occurrence, Levels, and Movement

Water level data show that over the 18-year period extending from July 1980 through June 1997 (base period) there is no definitive upward or downward water level trend for the basin as a whole. However, different water level trends are observed at specific locations within the Basin. Water levels have declined in some areas rather dramatically in the Estrella and San Juan areas, while rising water levels have been experienced in the Creston area. In general, groundwater flow moves northwesterly across the Basin towards the Estrella area, thence northerly towards the Basin outlet at San Ardo. The biggest change in groundwater flow patterns during the base period is the hydraulic gradient east of Paso Robles, along the

Highway 46 corridor, which has steepened in response to greater pumping by the increasingly concentrated development of rural ranchettes, vineyards, golf courses, and municipal supply wells.

2.1.3 Water Quality

In general, the quality of groundwater in the Basin is relatively good, with few areas of poor quality and few significant trends of ongoing deterioration of water quality. Historical water quality trends were evaluated to identify areas of deteriorating water quality. A major water quality trend is defined as a clear trend that would result in a change in the potential use of water within 50 years, if continued. Six major trends of water quality deterioration in the basin were identified, including:

- Increasing total dissolved solids (TDS) and chlorides in shallow Paso Robles Formation deposits along the Salinas River in the central Atascadero subbasin.
- Increasing chlorides in the deep, historically artesian aquifer northeast of Creston;
- Increasing TDS and chlorides near San Miguel.
- Increasing nitrates in the Paso Robles Formation in the area north of Highway 46, between the Salinas River and the Huer Huero Creek.
- Increasing nitrates in the Paso Robles Formation in the area south of San Miguel.
- Increasing TDS and chlorides in deeper aquifers near the confluence of the Salinas and Nacimiento rivers.

2.1.4 Groundwater in Storage

The total estimated groundwater in storage within the Basin is approximately 30.5 million acre-feet (af). This value changes yearly, depending on recharge and net pumpage. Between 1980 and 1997, groundwater in storage increased approximately 12,000 af, or less than 0.1 percent of the groundwater in storage. This represents an average increase in storage of less than 1,000 af per year (af/y). On one hand, this relatively small percentage could be viewed as an indication of stable basin-wide conditions; however, it is noted that steadily decreasing storage in the 1980s was offset by increased water in storage throughout the 1990s. Furthermore, not all areas of the Basin have evidenced the same trends in water levels and change in storage.

In the Atascadero subbasin, total groundwater in storage averaged about 514,000 af. Approximately 2,600 af more groundwater was in storage in the subbasin in 1997 compared to 1980, which is an increase of less than one percent in total groundwater in storage during the base period. This represents an annual increase in storage of about 200 af.

2.2 Engineering Considerations

2.2.1 Surface Water Supply Availability

Historically, California water users have relied on multiple sources of water supply in order to meet changing and increasing water demands. Typically, local water providers mix and match their supply sources to maximize water supply and quality and to minimize costs to meet both current and long-term water supply requirements. In addition to groundwater supplies, the County relies on surface supplies from local sources as well as imported supplies. Two imported water supplies to the County include the Nacimiento Water Project (under development) and the SWP.

2.2.1.1 Nacimiento Water Project

The Nacimiento Water Project is one of the high priority projects for the County and is currently in the design phase. The project consists of a pipeline, storage tanks, pump stations, and appurtenant facilities to convey water from Lake Nacimiento south to the communities of Paso Robles, Templeton, Atascadero, and San Luis Obispo, with options for future extensions. Since only about 60 percent of the supply is committed to the contracting parties, its capacity will meet additional supply reliability needs far into the future. In the meanwhile, groundwater banking opportunities and other conjunctive use possibilities can be researched and evaluated. These may include water banking and conjunctive use opportunities along the western side of the Basin.

2.2.1.2 State Water Project

Since 1963, the California Department of Water Resources (DWR) has constructed most of the SWP elements to convey water from northern California to urban and agricultural users throughout the State. The SWP delivers water under long-term contracts to 29 public water agencies, thereby providing water for about two-thirds of the State’s population and water to irrigate, in part, 700,000 acres of agriculture.

The SWP supplies originate at Lake Oroville on the Feather River. Flows released from Lake Oroville reach the Sacramento-San Joaquin Delta, where much of the water is pumped into the California Aqueduct for delivery to water users to the south. The SWP includes 32 water storage facilities, more than 600 miles of aqueducts, more than 20 pumping plants, and several hydroelectric plants.

The State designed, engineered, and constructed these facilities, and operates and maintains them with funds received from its 29 contractors. The payments from the 29 contractors allow the State to fully recover all its costs to finance, design, and build the SWP under the “take or pay” contracts.

SWP Water Supply Delivery Reliability

The general water delivery for the SWP is presented in the recent DWR report, *The State Water Project Delivery Reliability Report 2005* (Reliability Report). The Reliability Report provides information to local water agencies to help them determine how they should integrate SWP water supply into their water supply equation.

The Reliability Report describes water delivery reliability as how much one can count on a certain amount of water being delivered to a specific place at a specific time. This description addresses such things as facilities, system operations, water demand, and weather projections. In addition, water delivery reliability is based in part upon an acceptable or desirable level of dependability that is usually determined by the local water agency in coordination with the public it serves. In total, this information is used to determine the level of service and reliability, which in turn identifies the need for additional water supply sources, new facilities, demand management, and conservation programs.

Water Delivery Reliability Factors

The actual water supply available from the SWP or other imported sources depends on several factors, including:

- **Availability of water from the source** – The water source availability depends on the amount and timing of precipitation and runoff.
- **Availability of means of conveyance** – The ability to convey water from the source depends on the existence and physical capacity of the diversion, storage, and conveyance facilities, and on the contractual, statutory, and regulatory limitations on the operations of the facilities.
- **The level and pattern of water demand** – The level of water demand is affected by the magnitude and types of water demands, level of conservation strategies, local weather patterns, water costs, and other factors.

SWP Level of Demand

The SWP was built with a capacity to deliver about 4.2 million af (maf) of water. Recent annual deliveries to the 29 contractors have averaged about 2.3 maf and peaked at 3.5 maf in 2000. The following section describes SWP supplies that may be available for banking opportunities in the Basin.

Table A - Individual contractor's portion of its SWP annual allocation is presented on Table A of their contract. Table A allocations are not a guarantee of the amount available to the contractor each year, but rather a tool in an allocation process that defines an individual contractor's share. The County currently utilizes 4,830 af of their 25,000 af its Table A allocation that is delivered to 11 entities within the County. Santa Barbara County currently utilizes about 43,000 acre-feet of their 45,485 acre-feet Table A allocation that is delivered to numerous entities within the county. Santa Barbara County is currently considering reacquiring their 12,214 acre-feet of suspended Table A supply.

- **Article 21** - Article 21 refers to water supply contracts that allows additional water to be delivered to contractors under certain conditions which include:

  - It is available only when it does not interfere with Table A allocations and SWP operations.
  - It is available only when excess water is available in the Delta.
  - It is available only when conveyance capacity is not being used for SWP purposes or scheduled SWP deliveries.
  - It cannot be stored within the SWP system. In other words, the contractors must be able to use the Article water directly or store it in their own system.

In order to acquire Article 21 water, SWP contractors must be able to use the water directly or store it in their own system. Article 21 supply can be stored by being put directly into a reservoir or by offsetting other water that would have been withdrawn from storage, such as local groundwater.

Coastal Branch

Anticipating the eventual need for supplemental water supplies on the Central Coast, the San Luis Obispo County Flood Control and Water Conservation District (San Luis Obispo County) and Santa Barbara County Flood Control and Water Conservation District (Santa Barbara County) entered into water supply contracts with the State. Under the State contract, water would be delivered to these Central Coast agencies through the Coastal Branch of the SWP.

Phase I of the Coastal Branch was completed in 1968 and included a 15-mile aqueduct branching off the California Aqueduct in northwestern Kern County. San Luis Obispo and Santa Barbara Counties postponed construction of the remaining portion of the Coast Branch until 1991. The postponement in construction was permitted under the Counties' contract with the State. Even though the Coastal Branch had not been constructed, San Luis Obispo County and Santa Barbara County were obligated to make payments under their State contract for those facilities (such as Oroville Dam and the California Aqueduct) that would eventually convey SWP water to the Central Coast.

The Central Coast Water Authority (CCWA) was formed in 1992 to facilitate the development and operation of the Coastal Branch in San Luis Obispo and Santa Barbara Counties. In San Luis Obispo County, the District has maintained its contractual relationship with the State. It has signed agreements with CCWA to treat its SWP water and to operate and maintain the pipeline and facilities in the County.

Available Supplies for Water Banking

This Feasibility Study will evaluate the availability of the following SWP supplies for water banking:

- The unallocated portion of the San Luis Obispo County Table A allocation amount totaling 20,170 acre-feet.
- The unallocated portion of the Santa Barbara County Table A allocation amount totaling 2,500 acre-feet.
- Article 21 water will be evaluated to determine if it should be included as a potential banking water supply.

The raw water supplies associated with allocations listed above are assumed to be available at the Polonio Pass Pumping Plant.

The focus of this study is utilization of the County's SWP water supply, so the Nacimiento Water Project will not be considered as a potential supply source for this Feasibility Study.

2.2.2 Groundwater Recharge Methods

Groundwater recharge occurs naturally through percolation from rivers and streams, infiltration and percolation of precipitation on the groundwater basin, and the subsurface lateral movement of water into the groundwater basin from areas of relatively higher groundwater levels. In some cases, natural groundwater recharge cannot keep pace with groundwater use, resulting in long-term declines in groundwater levels, which may result in impacts to local streams, degradation of local groundwater quality, or land subsidence. Artificial recharge may be used as a groundwater mangement tool to protect and maintain the available groundwater resources for current and future uses.

There are two approaches to artificial groundwater recharge: direct recharge and indirect recharge. Direct recharge includes physically delivering water to the aquifer system, whereas indirect recharge increases groundwater storage by reducing the groundwater removed from the basin. There are advantages to each approach, and local conditions may suggest which method(s) is more appropriate for a particular location.

2.2.2.1 Direct Recharge

The types of direct groundwater recharge methods that have been identified, for consideration in this study include:

- Recharge Basins/Ponds
- Injection

- River/Stream Recharge

Each of these recharge methods is briefly described below.

Recharge Basins/Ponds

The use of surface spreading basins or spreading ponds is the most common type of artificial groundwater recharge. Typically, a recharge location would consist of a series of connected surface basins that may range in size, depending on the available space and slope of the land. Recharged water moves away laterally and vertically from the recharge ponds initially through the unsaturated zone to the unconfined aquifer system. The existence of low permeability layers in the near surface may affect the performance of the recharge ponds. If low permeability layers are encountered near the ground surface, they may be excavated and removed during pond construction, with the excavated material used to construct the dikes or berms that create the individual ponds.

The type and location of the recharge basins may dictate the level of engineering and construction needed to develop and operate recharge basins/ponds. Spreading ponds utilizing existing excavations, such as sand and gravel mines, borrow pits, or natural depressions such as low lying abandoned river channels, may require few improvements. Where these opportunities do not exist, recharge basins may require more extensive planning, engineering, and construction.

Often, recharge ponds are constructed in a series, with the initial ponds serving to settle the fine materials that may clog the pore space. Multiple settling basins are often interconnected to allow individual basins to be removed from service for maintenance. Aside from the periodic drying of the pond bottoms, maintenance may include scarifying, disking, or other mechanical means to remove fines, and maintain infiltration rates. Additional maintenance may be needed on the levees or dikes to repair erosion caused by wind or wave action.

Some of the features of recharge basins/ponds include:

- Recharge unconfined aquifer system
- Relatively low cost to design and construct
- There is no seasonal constraint on their use
- May utilize existing opportunities such as gravel pits

Factors affecting successful implementation include:

- Requires large areas of relatively flat land
- Requires permeable soils with no impermeable layers in near surface

Locations where recharge basins have been used in California include:

- Alameda County Water District (abandoned gravel pits)
- Consolidated Irrigation District (low-lying areas within district)
- Leaky Acres near Fresno (engineered recharge basins)
- Pomona Valley Productive Association (spreading basins)
- Arvin-Edison Water Storage District (engineered recharge basins)
- Kern Water Bank (low level of engineered recharge basins)
- North Kern Water Storage District (engineered recharge basins)

This method may be utilized in some locations within the Basin. Opportunities for recharge basins have been investigated by the City of Templeton and City of Atascadero along the Salinas River as part of the Nacimiento Water Project.

Injection Wells

Injection wells have been used to recharge aquifer systems for many years with varying degrees of success. Typically, injection wells have been used in areas where spreading may not be feasible due to space constraints, where land is too expensive to use more land-intensive recharge methods, or where thick, impermeable clay layers overlie the principal water bearing deposits.

Injection wells have been used in the West Coast Basin in Los Angeles for over 40 years to create a barrier to prevent seawater intrusion. These wells have only been used for recharge, and not for recovery of the injected water. More recently, specially designed and constructed wells are used to both inject water into the aquifer system and later extract the stored groundwater.

One of the difficulties associated with injection wells is maintaining adequate recharge rates. Several factors that may affect the long-term viability of injection wells include:

- Chemical reactions in the aquifer
- The formation of biosolids on the well screens
- Entraining air in the aquifer system
- Deflocculation caused by the reaction of high-sodium water with soil particles

Where it is used, injection well spacing depends upon the radius of influence of the injected water, which in turn depends on the aquifer characteristics, water levels, and well construction details such as the length of casing penetrating the aquifer, and the number of casing perforations.

This method requires the source water to be treated, and sediment must be almost completely removed. In addition, there may be water quality complications of injecting water into the aquifer system.

Injection well recharge is an expensive recharge method that is not likely to be utilized in the Basin because of the high capital costs and high operation and maintenance costs. In addition, the area does not have the space limitations that prevent other recharge methods from being used.

River/Stream Recharge

River and stream channels typically have sand and gravel beds with relatively high permeability, which provide natural recharge opportunities as described earlier. In some cases, improvements can be made to increase the amount of water that would percolate naturally by increasing the period of time that water is available for seepage and/or by increasing the wetted area of the streambed.

The length of time that water is available for recharge is usually determined by the hydrologic characteristics of the stream and watershed. The construction of dams or reservoirs may be used to regulate available supplies and therefore modify the duration of flow and increase groundwater recharge.

In addition, streambed modifications may also be used to increase the wetted area of the stream. This may include diverting water to sand and gravel areas adjacent to the main meandering stream. Another method may include extending a small weir or low dam across the bed where the stream has a very wide bottom caused by the meandering of the channel. The water behind the weir and spilling over the weir spreads out in a shallow depth over the entire streambed thereby increasing the wetted area and resultant recharge. Precautions should be taken not to create a hazard in time of flood by backing water out of its normal streambed. In this regard, rubber dams have been used to temporarily expand the wetted area.

By its nature, stream and river recharge has direct interaction between the groundwater and surface water systems. This may result in the recharged water returning to the stream at other locations, or during periods when recharge activities are not taking place.

2.2.2.2 Indirect Recharge

Indirect recharge differs from the direct recharge methods because it does not physically place the water into the aquifer system; rather, surface water replaces the use of groundwater, thereby reducing the local demand on the groundwater basin and providing the opportunity for the basin to recharge through natural sources mentioned earlier. Indirect recharge is often called in-lieu recharge and is commonly used in areas where the historical water demand has relied on the underlying groundwater basin for supply, which has resulted in declining groundwater levels.

In-lieu recharge has been used in both urban and agricultural areas and often utilizes the existing infrastructure to distribute water supply to individual customers. One of the requirements of an in-lieu recharge program is that the replacement supply must be of the appropriate quantity and quality to satisfy the existing supply requirements.

Because recharge is not concentrated as in the case of direct recharge methods, it does not result in a mound of recharge water; rather, a more gradual increase in groundwater levels over a larger area where pumping has suspended is evidenced.

In-lieu recharge programs are often used to improve overall supply reliability by using the imported surface water supply in wet years or months when the imported supplies are available, thereby reducing the dependence on the groundwater basin. Then in dry years, when imported supplies may be reduced or not available, groundwater is used to meet those demands not met by the imported supply. In this fashion, in-lieu recharge also takes advantage of the existing groundwater infrastructure.

Some of the benefits of in-lieu recharge include:

- Relatively cost effective when able to use existing local infrastructure
- Does not require construction of recharge facilities
- Effectiveness is not dependent upon near surface local hydrogeologic conditions
- Does not create a localized mound of banked water near the recharge facilities that may limit recharge capacity

Factors affecting successful implementation include:

- An existing water demand met by groundwater
- Access to reliable imported water supply of suitable quality
- Ability to utilize existing infrastructure

Locations where in-lieu recharge has been used in California include:

- Northern Sacramento County (urban area)

- Semitropic Water Storage District (agricultural area)
- Yuba County (agricultural area)

This method may be utilized in the Basin where existing groundwater demands have resulted in declines in local groundwater levels.

2.2.3 Groundwater Recovery Methods

Groundwater wells will be used to recover the banked water. The number and location of recovery wells will depend upon the size of individual banking operations and intended use of the banked water, and may include existing wells, new wells, or a combination of existing and new wells.

2.2.4 Delivery to End User

The end user of the banked water will be identified for each water-banking alternative during the project formulation. The additional facilities to convey the banked water to the end user will be required. These facilities may include pipelines, pumpstations, and other related facilities.

2.3 Other Considerations

2.3.1 Environmental Considerations

At this stage of the Feasibility Study, an environmental review will be completed to identify potential impacts and benefits, to describe environmental considerations, and to identify potential California Environmental Quality Act (CEQA) requirements for implementation. Environmental considerations will be addressed for the three selected water-banking options that will undergo more extensive hydrogeologic and engineering feasibility evaluation.

2.3.2 Groundwater Management

Groundwater management is the planned and coordinated local effort of sustaining the groundwater basin to meet future water supply needs. In 1992, with the passage of Assembly Bill AB 3030 (AB 3030), local water agencies were provided a systematic way of formulating groundwater management plans (California Water Code, Sections 10750 et seq.). AB 3030 also encouraged coordination between local entities through joint power authorities or memorandums of understanding (MOU). In 2002, Senate Bill 1938 (SB 1938) was passed, which further emphasized the need for groundwater management in California.

SB 1938 requires AB 3030 groundwater management plans to contain specific plan components to receive State funding for water projects. Groundwater management plans address a variety of issues that relate to the different elements of groundwater management, including:

- Political Issues
- Legal Issues
- Institutional Issues
- Technical Issues
- Economic Issues

The overall groundwater mangement considerations will be summarized for these elements for the three selected water-banking options that will undergo more extensive hydrogeologic and engineering feasibility evaluation.

2.3.2.1 Political Element

The political element of groundwater management deals with the process through which a local community reviews alternative groundwater management options and makes informed choices. Because California does not have a statewide groundwater mangement statute or program, the management of groundwater remains at the local level with a variety of local interests. The political issues are often addressed in part through the public involvement component of a groundwater management plan.

2.3.2.2 Legal Element

The legal component of groundwater management centers on the fundamental issue of water rights. Irrespective of the form of groundwater management being considered, groundwater rights and in some cases, surface water rights should be considered. Overlying landowners, stakeholders, and groundwater operators may face a variety of challenges due to well interference impacts, groundwater contamination migration, or decrease in groundwater storage.

2.3.2.3 Institutional Element

In addition to the physical management and operation of a groundwater basin is the question of governance, which includes the manner and function of the managing entity. The jurisdictional issues of groundwater management, include who is going to govern and how management will be accomplished, are often included in a groundwater management plan.

2.3.2.4 Technical Element

The technical element of groundwater management requires an understanding of the unique physical characteristics of the basin. This includes an understanding of the hydrogeologic setting, aquifer boundaries and characteristics, the occurrence and movement of groundwater, and water quality conditions. A groundwater mangement plan includes this information to develop an understanding of the amount and locations to recharge and discharge from the basin, where groundwater is used, and areas subject to groundwater contamination or saline intrusion.

2.3.2.5 Economic Element

The economic element of groundwater management is concerned with the ability of an agency to develop and implement a groundwater management plan that it can afford. Groundwater management projects or other water management projects cannot be implemented unless they are adequately financed. Project financing may be dependent upon the type of issues being addressed. Regional projects may have different financing opportunities and project partners compared to local projects.

3 Water Banking Evaluation Criteria

Each of the water banking opportunities will be evaluated based on their ability to satisfy the following water banking components:

- The availability of a water supply for banking.
- The ability to recharge the aquifer system.
- The ability to recover the banked water.
- The ability to deliver the banked water to the end user.

Specific hydrologic and engineering criteria will be applied to determine the overall project feasibility. Other considerations will be identified for projects that are determined to be technically feasible based upon this analysis. The initial criteria for this feasibility study are presented below.

3.1 Hydrogeologic Criteria

The specific hydrogeologic evaluation criteria are described below:

- **Geologic/Hydrogeologic Setting**
  - High Feasibility: Includes areas with a thick, highly permeable aquifer that has a simple structure.
  - Low Feasibility: Includes areas with a thin, low permeability aquifer with a complex structural setting.
- **Near Surface Conditions**
  - High Feasibility: Includes areas with highly permeable soils and near surface conditions and low relief.
  - Low Feasibility: Includes areas with clay-rich soils and saturated near surface conditions and areas with high relief.
- **Available Groundwater Storage Capacity**
  - High Feasibility: Includes areas with large available groundwater storage capacity (thick unsaturated zone).

    - Low Feasibility: Includes areas with small available groundwater storage capacity (thin unsaturated zone).

- **Ability to Recharge Aquifer System**

    - High Feasibility: Includes areas with a highly permeable aquifer, lack of clay-rich aquitards, and direct hydraulic communication with producing aquifer.

    - Low Feasibility: Includes areas with a low permeability aquifer, presence of aquitards and other impediments to vertical percolation, indirect or no hydraulic communication with producing aquifer.

- **Ability to Recover Banked Water**

    - High Feasibility: Includes areas with large pumping capability from wells penetrating the receiving aquifer.

    - Low Feasibility: Includes areas with small pumping capability from wells penetrating the receiving aquifer.

- **Interaction with Surface Water**

    - High Feasibility: Includes areas located away from surface streams.

    - Low Feasibility: Includes areas located near surface streams where the banking aquifer system and water table are near the ground surface.

- **Water Quality Considerations**

    - High Feasibility: Includes areas of generally good quality for the specific uses (agricultural or urban) of the target aquifer.

    - Low Feasibility: Includes areas of generally poor quality for the specific uses (agricultural or urban) of the target aquifer. This may include high total dissolved solids, nitrates, boron, or other natural or anthropogenic sources.

3.2 Engineering Criteria

Specific engineering evaluation criteria are described below:

- **Water Supply Availability** – Available water supplies will be determined from the three sources identified previously and assumptions respecting their reliability. The total available water supply may be available to a single water banking project or a combination of projects in the Basin. It is not expected that the water supply availability will be a criteria that elevates any project above others.

- **Ability to Utilize Existing Infrastructure -** The water banking opportunities will utilize the available infrastructure to deliver water from the SWP to the Basin, i.e. through the Coastal Branch and the Polonio Pass Pumping Plant. All potential banking projects will use this as the starting point to identify additional conveyance requirements. Additional conveyance will be needed to implement the remaining portions of any water-banking project.

- **Required Facilities –** Each of the water banking components may require new or additional facilities to implement the water-banking project. The sizing of facilities will be based on estimated water banking capacity (recharge, storage, and extraction), which will be determined from the hydrogeologic evaluation. Typical facilities that may be required include:

    - Pipelines
    - Pumping Plants
    - Recharge Basins/Ponds
    - Distribution Facilities
    - Groundwater Wells

- **Project Operations –** General project operations (put and take schedules) will identify the timing and volumes of water included in the banking operations, and will be a function of the available supplies and the available absorptive capacity.

- **Capital Cost and Operation and Maintenance Costs** - The required facilities for an individual water banking opportunity will be based upon size and location as determined by the hydrogeologic evaluation. Capital costs for the required facilities (suitable for comparative purposed between water banking alternatives) will be based on readily available local information. Recent estimates of construction costs for the Nacimiento Water Project demonstrate the effect of site-specific conditions on facility construction costs. It is expected that project costs will be a significant factor affecting the overall feasibility of water banking opportunities in the Basin.

3.3 Other Considerations

Water banking projects that are determined to be technically feasible based upon this evaluation will be further evaluated to identify any other conditions that must be considered in development and implementation of the project and may require further analysis. These may include groundwater management issues, environmental issues, or other issues that may be identified during this study.

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