# Monetized Benefits Analysis

The Willow Springs Water Bank Conjunctive Use Project (WSWB or Water Bank) will leverage one-half million acre-feet of existing groundwater storage facilities and operate conjunctively with the State Water Project (SWP) to improve flexibility of SWP operations and provide tangible, near-term, and lasting benefits for the environment.

## Benefits Preface

Compared to proposals for new large surface storage facilities, WSWB is a project of modest scale and scope. Nevertheless, the project offers important benefits both as a stand-alone effort and as a project able to leverage the functionality of other storage and conveyance facilities.

Key attributes of the WSWB are:

- **Timeliness**: Because the proposed project is an expansion of an existing groundwater storage facility, the project can be implemented quickly and, once operational, can generate benefits immediately. The WSWB would thus begin generating benefits as early as 2020, ten years or more before a new surface water reservoir might be able to provide new benefits with the actual stream of benefits being governed by post-implementation hydrology.
- **Location**: Situated in the Antelope Valley, the WSWB is in a location where groundwater storage can be developed and operated at costs lower than those of similar facilities in the L.A. Basin while providing comparable responsiveness of service. The WSWB will be able to deliver water to Southern California under normal conditions as well as under emergency conditions (e.g., Delta levee failures) or during periods when hydrology or other factors restrict conveyance from the Delta.
- **Ecosystem:** Feather River pulse flow operations were identified as the preferred alternative for demonstrating ecosystem benefit, based on directly addressing two of the high priority flow and water quality objectives identified by the California Department of Fish and Wildlife (CDFW). These benefits are expected to increase as climate change impacts increase.
- **Emergency supply:** Expanding storage south of the Delta would mitigate the risk to water supplies in the event of Delta levee failure or damage to SWP conveyance facilities resulting from earthquakes or floods. It also avoids the risk posed by future dam safety issues and from operational issues such as toxic algae blooms.
- **New yield:** WSWB is very flexible and adaptable. In addition to ecosystem and emergency supply benefits, through modest reoperation of Lake Oroville and San Luis Reservoir to shift stored water to the Water Bank, the existing SWP system could more effectively divert and store water during intermittent high flow periods when Delta outflows are above and beyond

regulatory requirements. A portion of this water will be transferred to others and will offset the costs of supplying ecosystem benefits.

- **Value**: The project will provide a substantial return on the State's investment, with a 2.3-to-1 ratio of benefits to costs, and public benefits equal to 82 percent of total benefits. Additional non-monetized benefits include reduced groundwater pumping lift, flood control, and recreation.

## Proposed Operations of Willow Springs Water Bank

Conjunctive operations of WSWB and the SWP were modeled using the Calsim II water operations model jointly developed by DWR and USBR to simulate joint operation of the SWP and Central Valley Project (CVP). Operation of WSWB was applied to the 2030 and 2070 climate change scenarios supplied by the CWC. The model was operated to meet all environmental flow requirements, while not diminishing water deliveries to SWP or CVP contractors. Other factors, such as keeping San Luis Reservoir from dipping below Low Point levels more frequently, were also constrained to avoid impacts.[1]

Under these proposed operations, water is pre-released from San Luis or pre-positioned from Oroville and delivered to the water bank during periods when water can be conveyed through the Delta. Lowered levels in San Luis allows for the capture of Delta flows in wetter years in excess of those needed to meet established operational and regulatory requirements, creating new yield. Releases are made from the Water Bank to the East Branch to allow a like amount of water to remain upstream to 1) provide "backstop" flows to mitigate potential supply reductions; 2) to allow pulse flow releases from Oroville Reservoir for fishery enhancement, and 3) for improved water supply reliability. Ten percent of the water recharged will remain in the groundwater basin as "leave-behind" as required by the Antelope Valley Groundwater Basin adjudication.[2]

Operation of the Water Bank inflows and outflows is summarized in Table 1 and shown schematically in Figure 1 and Figure 2. At times, all the extraction capacity of WSWB will be dedicated to creating new yield for fish protection and backstop operations. This justifies its description as a conjunctive use project with the primary purpose of fishery enhancement.

[1] Low water levels in San Luis Reservoir, generally regarded as around 300,000 acre-feet, may facilitate blooms of toxic algae which may compromise the water supply to Santa Clara Valley Water District.

[2] The adjudication states, "Any Stored Water that originated as other Imported Water may be exported from the Basin, subject to a requirement that the Watermaster make a technical determination of the percentage of the Stored Water that is unrecoverable and that such unrecoverable Stored Water is dedicated to the Basin.

*Table 1 - Summary Average Annual Water Budget of Project Operation under 2030 and 2070 Hydrologic Conditions (thousand acre-feet per year)*

| | 2030 | 2070 |
|---|---|---|
| **WSWB INFLOW (SOURCES)** | | |
| Pre-release from San Luis | 16.3 | 20.1 |
| Pre-position from Oroville | 17.6 | 19.1 |
| WSWB SOURCES | 34.0 | 39.2 |
| **WSWB OUTFLOW (SINKS)** | | |
| Water supply reliability improvements | 13.7 | 12.1 |
| SWP backstop | 2.4 | 5.9 |
| San Luis backstop | 6.1 | 7.6 |
| Environmental benefits | 8.4 | 9.7 |
| Leave-behind in groundwater basin | 3.4 | 3.9 |
| WSWB SINKS | 34.0 | 39.2 |

*Figure 1 - Summary Water Budget for 2030 Hydrology (thousand acre-feet per year)*

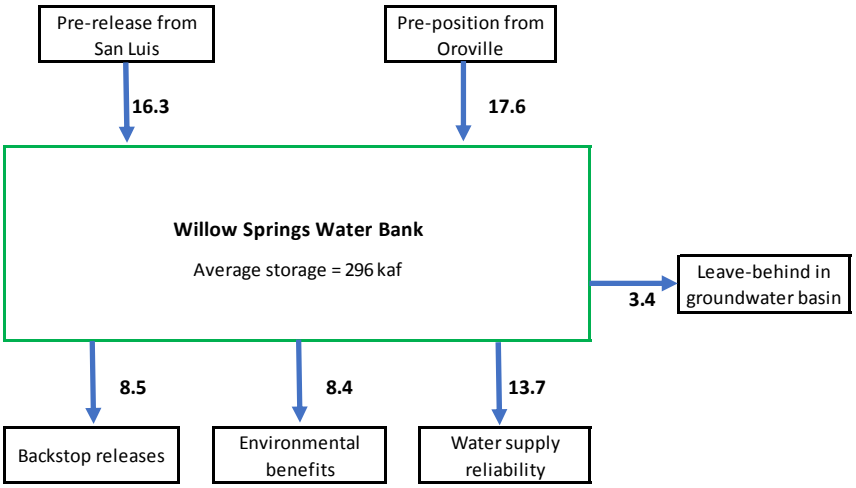
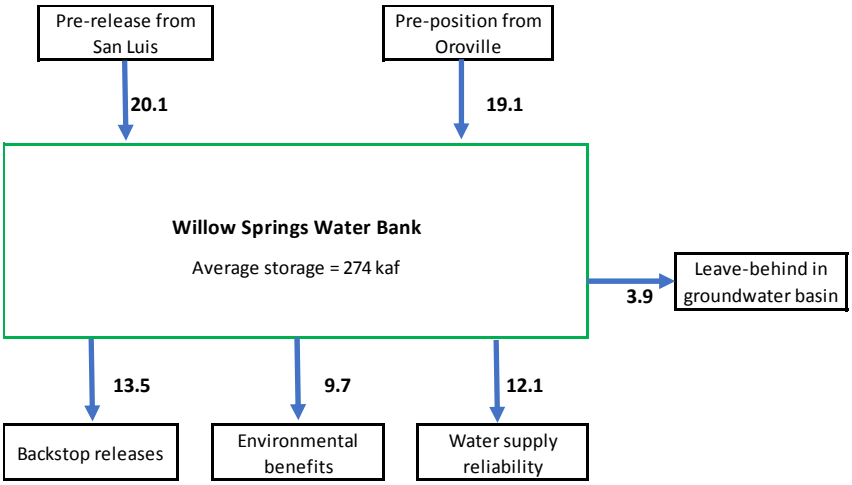



*Figure 2 - Summary Water Budget for 2070 Hydrology (thousand acre-feet per year)*




## Public Benefit Categories

"Public benefits(s)" are benefits associated with water storage projects outlined in Water Code section 79753(a). These are:

- **Ecosystem improvements**, including changing the timing of water diversions, improvement in flow conditions, temperature, or other benefits that contribute to restoration of aquatic ecosystems and native fish and wildlife, including those ecosystems and fish and wildlife in the Delta.
- **Water quality improvements** in the Delta, or in other river systems, that provide significant public trust resources, or that clean up and restore groundwater resources.
- **Flood control benefits** including, but not limited to, increases in flood reservation space in existing reservoirs by exchange for existing or increased water storage capacity in response to the effects of changing hydrology.
- **Emergency response**, including, but not limited to, securing emergency water supplies and flows for dilution and salinity repulsion following a natural disaster or act of terrorism.
- **Recreational purposes**, including, but not limited to, those recreational pursuits generally associated with the outdoors.

As outlined in the following section, monetized net public benefits of the WSWB have been determined for ecosystem improvement, and emergency response while non-quantified benefits are described for flood control, greenhouse gas emission reduction and recreation purposes. Changes in water quality (e.g., expected reductions in water temperature) result from implementation of the WSWB and are among the factors that contribute to ecosystem improvements.

## Monetized Public Benefits

### *Ecosystem Benefits*

**Physical Benefit.** Yield from WSWB that is dedicated to ecosystem benefits would be subject to the terms of an agreement to be developed and executed with CDFW. While this dedicated yield could be

used flexibly and adaptively managed, pulse flow operations on the Feather River were determined to be the "preferred alternative" that provides the greatest monetized benefit for water dedicated to ecosystem improvement. These benefits directly address Ecosystem Priorities 2 and 6, two of the high priority objectives identified on pages 4-90 and 4-91 of the WSIP Technical Reference. These priorities are:

- P2 – Provide flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids.
- P6 – Increase attraction flows during upstream migration to reduce straying of anadromous species into non-natal tributaries.

In addition to focusing on Priority 2 and Priority 6, the Water Bank would address four other Relative Environmental Values (REVs) as described by CDFW. The preferred alternative would most directly improve habitat conditions during spring months in the Feather River low flow channel, followed by the high flow channel and all subsequent downstream reaches including the San Francisco Bay Delta.

As described, the preferred alternative would also address the following two primary and two secondary Recovery Actions for the Feather River outlined by NMFS in the 2014 Recovery Plan:[3]

1. Identify and implement actions intended to minimize straying of Feather River Hatchery salmon and steelhead (Primary Recovery Action).
2. Manage releases from Oroville Dam with instream flow schedules and criteria to provide suitable water temperatures for all life stages, reduce stranding and isolation, protect incubating eggs from being dewatered, and promote habitat availability (Primary Recovery Action).
3. Negotiate agreements with landowners and Federal and State agencies to provide additional instream flows or purchase water rights in the Feather River (Secondary Recovery Action).
4. Evaluate pulse flow benefits in the Feather River for adult immigration and juvenile outmigration during peak migration periods for years with low water availability. If pulse flows are determined to be effective for attracting adult spring-run Chinook salmon and steelhead or for improving survival during juvenile outmigration, implement the most beneficial pulse flow regime (Secondary Recovery Action).

In addition to benefiting the Recovery Actions, the preferred alternative would address three of the five listing factors identified by NMFS for the decline in Central Valley spring-run Chinook and steelhead abundance.

The ecosystem benefits are discussed in detail in the Ecosystem Benefits attachment.[4]

[3] NMFS. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead.
[4] See Public Benefits Tab, Attachment A2 - Ecosystem Benefits, File WSWB_EcoBenefit_1of1, Section 4-2

### *Emergency Response Benefits*

Emergency response benefits are the second important monetized public benefit to be generated by the WSWB project. This benefit arises because the location of the WSWB insulates the facility from conditions that may interrupt conveyance into or through the Delta. In addition, as a groundwater storage facility, Willow Springs is resistant to damage from seismic activity that may jeopardize surface water storage and conveyance facilities. Conversion of dry year storage into emergency storage will increase the amount of water available to Southern California in the event of earthquakes or other catastrophic events.

The emergency response benefits are discussed in detail in the Emergency Response Benefits attachment.[5]

## Ecosystem Benefit Quantification

Benefits resulting from Water Bank operations to Endangered Species Act (ESA) protected fish species in the Central Valley, as well as a variety of other resident and anadromous fish species, can be achieved through exchanges of pre-positioned WSWB water for use in making pulse flow releases from Oroville Reservoir into the lower Feather River during the spring of critically dry and dry water years. These releases are intended to improve survival and migration of juvenile fall-run and spring-run Chinook salmon and steelhead and increase attraction of adult spring-run Chinook salmon.

For the purpose of demonstrating environmental benefit, pulse flow operations on the Feather River were identified as the preferred alternative for this analysis based on directly addressing two of the high priority objectives identified in the guidance document of the California Department of Fish and Wildlife (CDFW Ecosystem P2 and P6). The benefits of spring pulse flows have been monetized in the analysis below, in addition to a discussion of non-monetized fishery benefits of these actions.

## Preferred Alternative: Feather River Pulse Flows in Spring of Dry and Critical Years

The lower Feather River provides habitat for a variety of fish including spring-run Chinook salmon (listed as threatened under the California and federal Endangered Species Acts) and fall-run Chinook salmon that support recreational and commercial fisheries. Juvenile salmon migrate downstream from the Feather River during the late winter and spring before entering the Pacific Ocean where they typically rear 2.5 years before returning to the Feather River to spawn.

Under this alternative, the project would provide spring pulse flows to benefit juvenile spring-run and adult fall-run Chinook Salmon, addressing Ecosystem Priority 1 to provide cold water at times and locations to increase the survival of salmonid eggs and fry.[6]

[5] See Public Benefits Tab, Attachment A1 - Emergency Response Benefits Supporting Documents, File WSWB_EmergencyBenSupport_1of1, Section 4-3

[6] Technical Reference Table 4-10

The pulse flow benefit would be achieved by exchanging up to 40,000 acre-feet of water pre-positioned in the Water Bank for water stored in Oroville Reservoir for release into the Feather River low flow channel and subsequently the high flow channel during spring of critically dry and dry water years to benefit salmonid migration and survival. Pulse flow releases would occur in April and May, although pulse flow releases could be made earlier in the spring based on results of real-time monitoring of salmonid migration. Flow released into the low flow channel would be increased to 2,500 cubic feet per second during four two-day pulse flow releases (approximately 10,000 acre-feet per pulse).

Assuming a value of $100,000 per adult spring-run based on grant submittal guidance, the estimated monetized value is $1,500,000 in each dry or critically dry year that pulse flow releases are made as shown in Table 2.

*Table 2 - Pulse Flow Benefits to Adult Spring-Run Chinook Salmon*

| | Base Case | With WSWB Pulse Flows |
|---|---|---|
| Adult Spawners | 2,934 | 2,934 |
| Stray Rate | 1.0% | 0.5% |
| Number Adults Straying per year | 29 | 14 |
| Improvement from Base Case | | 15 |
| Value per Fish[\2] | | $100,000 |
| Value per Dry/Critical Year | | $1,500,000 |
| Frequency of Dry and Critical Years | | 36.6% |
| Average Annual Benefit | | $549,000 |
| Present Value Benefit (P/A,50,3.5%) | | $10,800,000 |

[\2] From CWC Technical Reference, p. 3-23

## Delta Habitat Restoration Alternative

Water stored in the Willow Springs Water Bank south of the Delta has a high value for municipal water supplies, especially in critical water years. As an alternative to the pulse flow operations, water stored in the Water Bank could be transferred to a third party in dry and critical water years and the proceeds used to fund shallow water aquatic habitat in the Delta (Priority 11).

For purposes of this analysis it was assumed that 28,800 acre-feet of stored water would be sold to south-of-Delta buyers during dry and critical water years (approximately 36.6 percent of all years) when, based on grant submittal guidance, water stored south of the Delta would have its greatest value. Proceeds of the water sale would fund aquatic habitat restoration in the Delta. These restoration activities are assumed to benefit juvenile winter-run, spring-run, and fall-run Chinook through improved rearing and growth contributing to increased juvenile survival in the Delta and ocean (habitat restoration would also benefit other species). The National Marine Fishery Service Central Valley salmonid recovery plan[7] includes information on typical costs of aquatic habitat restoration including

[7] NMFS 2014

land acquisition (assumed in this analysis to be $20,000 per acre) and restoration (assumed in this analysis to be $10,000 per acre) for a combined cost of $30,000 per acre. Based on the sale of 115,200 AF at an average price of $322/AF (based on the average unit value for dry and critical year water sales in the south of Delta Export Area) from the groundwater bank in dry and critical water years, it was estimated that approximately 1,000 to 1,500 acres of aquatic habitat could be protected and restored.

## Summary of Monetized Ecosystem Benefits

The estimated monetized ecosystem benefits to salmonids of the WSWB are presented in Table 3 below.

*Table 3 – Summary of Ecosystem Fishery Benefits*

| | Spring-Run Chinook | Fall-Run Chinook | Winter-Run Chinook | Total Annual Salmonid Benefit | Present Value Benefit |
|---|---|---|---|---|---|
| **Preferred Pulse Flow Alternative** | | | | | |
| Spring Pulse for juvenile survival | $24,330,000 | $12,610,000 | -- | $36,940,000 | $755,100,000 |
| Spring pulse for spring-run adult attraction | $549,000 | -- | -- | $549,000 | $10,800,000 |
| Total | $24,879,000 | $12,610,000 | $0 | $37,489,000 | $765,800,000 |
| **Delta Habitat Restoration Alternative** | | | | | |
| 1,000 acres of Delta shallow water habitat[\1] | $17,000,000 | $8,920,000 | $4,160,000 | $30,080,000 | $520,500,000 |

[\1] Present value adjusted for on-line dates of 2026 and 2031 for first and second 500-acre habitat additions

## Emergency Response Benefits

WSWB will enter into agreements to provide water for emergency response to events such as a seismic failure of Delta levees or outages of the California Aqueduct north of the WSWB facilities. Up to 215,000 acre-feet of storage will be loaned from the stored reoperation yield, with the loan to be repaid within five years. It is assumed that such an event will happen once in the 50-year life of the project, and the chance of the event occurring is equal in all years. It is assumed that the water would be valued at the value for critical year Delta export water given in Table 5-5 of the Technical Reference. Assuming an average rate of filling, the storage benefit will be available after seven years of operation and will have a present value of $38.4 million.

## Non-monetized Public Benefits

### *Flood Control Benefits*

A challenge in quantifying flood control benefits is that the volume of storage needed to reduce flood peaks sufficiently to generate quantifiable flood control benefits (e.g., reduce flooding damage) exceeds the volume of releases needed to develop ecosystem benefits. Therefore, while the volume of "pre-positioned" WSWB storage that will be released from Oroville is sufficient to apply standard methodologies to estimate physical ecosystem benefits, the volume of storage created by releases of "pre-positioned" water will not reduce flood peaks adequately to support a reliable calculation of

avoided flood damages. Therefore, no quantitative estimate of flood management benefits attributable to this project is attempted.

Although when viewed as a stand-alone project, the flood control benefits of the WSWB are marginal, flood management is an instance where, when taken within the context of other activities that may be supported by the WSIP, the reduction in flood peaks resulting from the full array of projects may generate a worthwhile flood control benefit.

### *Recreational Benefits*

The project will generate local recreation benefits by construction of hiking and walking trails through 320 acres in the immediate vicinity of the recharge facilities. Conjunctive operations with the SWP could allow reservoirs like Perris and Castaic to be operated for recreational enhancement.

### *Greenhouse Gas Emissions Reductions*[8]

Greenhouse gas creation benefits due to the onsite solar, the lack of surface storage, and the impact of the water/energy bank.

### *Non-Monetized Ecosystem Benefits*

The project would result in pulse flow releases of 2,500 cubic feet per second for each pulse flow (40,000 acre-feet total) during the spring of critically dry and dry water years.

In addition to the monetized benefits discussed above, pulse flows and/or Delta habitat restoration would provide incremental benefits that have not been monetized which include, but are not limited to the following:

- Pulse flow releases would provide an incremental contribution to increased Delta outflow and the downstream location of X2[9] during the spring of critically dry and dry years that is expected to improve downstream transport of fish eggs and larvae, increase the area of the low salinity estuarine habitat, and provide increased transport of nutrients, phytoplankton, and zooplankton downstream;
- Shallow water habitat restoration in the Delta is expected to increase primary and secondary production and food resources for resident and migratory fish and invertebrates;
- Shallow water habitat restoration is expected to provide additional juvenile and adult foraging habitat for species such as green and white sturgeon, delta smelt, splittail, and other native species as well as for non-native species such as striped bass and largemouth bass that support recreational fisheries in the Delta;
- Shallow water habitat is expected to provide recreational angling and boating opportunities;

[8] See Eligibility Tab, Attachment A6 - Other Application Information, File WSWB_Other_2of2, Section 3-6

[9] The discussion of Delta salinity often invokes "X2," the point identified by its distance from the Golden Gate Bridge where salinity at the channel bottom is 2 parts per thousand (ppt) and is the basis for standards to protect aquatic life (seawater salinity is about 35 ppt).

- Shallow water habitat is expected to provide added habitat for migratory waterbirds and other wildlife.

## Non-Public Benefit Categories

"Non-public benefit" is a benefit provided by a proposed project other than the public benefits identified in Water Code section 79753(a). Among the benefits generated by operation of the WSWB that are not recognized as public benefits in the pertinent section of the Water Code are:

- Sustaining groundwater elevations in aquifers underlying Willow Springs. Beneficiaries include nearby households and disadvantaged communities dependent on groundwater whose water supply security will increase while their pumping costs will decline.
- The conjunctive operation of the WSWB and SWP facilities will generate new net water supplies of about 14,000 acre-feet per year to improve water supply reliability for agencies entering voluntary agreements. The new yield increases the overall yield of the State Water Project.
- The WSWB will reduce energy costs by shifting pumping of imported water from peak hours to non-peak hours. This will be accomplished through onsite storage to avoid pumping wells and booster pumping to the California Aqueduct during peak hours. WSWB may also enable a seasonal shift of when imported water is delivered to Southern California. This is the purpose of an ongoing study of a water/energy bank recently funded by the CEC (EPC-16-026).

## WSWB Operating Costs

### Project costs are categorized as follows:

- Project operating costs: The annual costs for delivering water to the water bank for recharge and for recovering water from the bank are accounted for as negative benefits in the computation of annual net benefits and are expressed in the benefit component of the project's cost/benefit ratio.
- Project construction and maintenance costs: The costs to construct and maintain project facilities are detailed in the feasibility study included in this application and are expressed as the cost component of the project's cost/benefit ratio.

The following section describes the annual operating costs that are components of the net benefit analysis.

### *Delivery*

Although the WSWB will be served from a new turnout from the California Aqueduct to be constructed by the project, it was assumed that the costs of water delivery to the turnout would be comparable to those of water delivered to AVEK turnouts. Table 31 of the DWR documents *Southern Field Division, Monthly Delivery (East Branch)* report locations (by reach) and volumes of water delivered to each turnout supplying water to AVEK. These tables show the AVEK turnout in Reach 20A to be the most important point of delivery. Table B-25 - *Equivalent Unit Transportation Costs of Water Delivered from or*

*through Each Aqueduct Reach* from Bulletin 132-15 was used to determine the cost of transportation to Reach 20A ($186.35). The total cost of delivery to Reach 20a was then computed by adding the Delta Water Rate ($58.03) to the cost of transportation to arrive at a total delivery cost of $244. This cost has been rounded to $250 to estimate the cost of delivering water via SWP facilities to the proposed WSWB turnout. From the turnout, water would then flow by gravity through the proposed bi-directional conveyance pipeline to the bank's recharge facilities.

### *Recovery*

The cost for recovering water from the WSWB is based on a total energy requirement of 1,100 kWh (550 kWh/AF for pumping from wells plus 550 kWh/AF to lift the water to the California Aqueduct). At a $0.10/kWh melded electricity cost, the energy needed to recover water yields a total recovery cost of $110/AF. This cost is applied to all returned water including water that is extracted from the WSWB for exchange with AVEK.

## Summary of Benefits and Costs

Time series of benefits and operations and maintenance (O&M) costs are presented as **Table 4**.[10] This table also shows the present value of the benefits and costs discounted at 3.5% per year to 2015 levels. The project will provide $984 million in total benefits and $806 million in total net benefits over its 50-year project life.

[10] This table is presented in a larger format in the Benefit Calculation Tab, Attachment A6 - Monetization Table , File WSWB_EconTables_1of1, Section 6-6

*Table 4 – Time Series of Benefits and O&M Costs*

| | Water Supply Benefit | | | | Public Benefits | | | | | | | Operating & Maintenance Costs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Benefits in Delta and Tributaries Spring Pulse Flows | | | Emergency Supply Benefit | | | | | |
| Year | Water Supply | Unit Value | Annual Benefit | PV Annual Benefit | Juvenile survival benefit | Spring-run adult attraction benefit | PV Annual Benefit | Emergency Supply Benefit[\1] | Unit Value | Annual Benefit | PV Annual Benefit | Annual O&M Cost | PV Annual O&M Cost |
| | (kaf/yr) | $/af | ($M) | (2015$M) | ($M) | ($M) | (2015$M) | (kaf/yr) | $/af | ($M) | (2015$M) | ($M) | (2015$M) |
| 2020 | 14.10 | $360 | $5.1 | $4.3 | $36.9 | $0.0 | $31.1 | 0.00 | $360 | $0.00 | $0.0 | ($8.6) | ($7.2) |
| 2021 | 14.06 | $360 | $5.1 | $4.1 | $36.9 | $0.5 | $30.5 | 0.00 | $360 | $0.00 | $0.0 | ($8.6) | ($7.0) |
| 2022 | 14.02 | $360 | $5.0 | $4.0 | $36.9 | $0.5 | $29.5 | 0.00 | $360 | $0.00 | $0.0 | ($8.6) | ($6.8) |
| 2023 | 13.98 | $360 | $5.0 | $3.8 | $36.9 | $0.5 | $28.5 | 0.00 | $360 | $0.00 | $0.0 | ($8.6) | ($6.5) |
| 2024 | 13.94 | $360 | $5.0 | $3.7 | $36.9 | $0.5 | $27.5 | 0.00 | $360 | $0.00 | $0.0 | ($8.6) | ($6.3) |
| 2025 | 13.90 | $360 | $5.0 | $3.5 | $36.9 | $0.5 | $26.6 | 0.00 | $360 | $0.00 | $0.0 | ($8.6) | ($6.1) |
| 2026 | 13.86 | $360 | $5.0 | $3.4 | $36.9 | $0.5 | $25.7 | 0.00 | $360 | $0.00 | $0.0 | ($8.6) | ($5.9) |
| 2027 | 13.82 | $360 | $5.0 | $3.3 | $36.9 | $0.5 | $24.8 | 3.14 | $360 | $1.13 | $0.7 | ($8.6) | ($5.7) |
| 2028 | 13.78 | $360 | $5.0 | $3.2 | $36.9 | $0.5 | $24.0 | 3.14 | $360 | $1.13 | $0.7 | ($8.6) | ($5.5) |
| 2029 | 13.74 | $360 | $4.9 | $3.1 | $36.9 | $0.5 | $23.2 | 3.14 | $360 | $1.13 | $0.7 | ($8.6) | ($5.3) |
| 2030 | 13.7 | $360 | $4.9 | $2.9 | $36.9 | $0.5 | $22.4 | 3.14 | $360 | $1.13 | $0.7 | ($8.7) | ($5.2) |
| 2031 | 13.66 | $406 | $5.5 | $3.2 | $36.9 | $0.5 | $21.6 | 3.15 | $406 | $1.28 | $0.7 | ($8.7) | ($5.0) |
| 2032 | 13.62 | $452 | $6.2 | $3.4 | $36.9 | $0.5 | $20.9 | 3.15 | $452 | $1.43 | $0.8 | ($8.7) | ($4.8) |
| 2033 | 13.58 | $498 | $6.8 | $3.6 | $36.9 | $0.5 | $20.2 | 3.16 | $498 | $1.57 | $0.8 | ($8.7) | ($4.7) |
| 2034 | 13.54 | $544 | $7.4 | $3.8 | $36.9 | $0.5 | $19.5 | 3.17 | $544 | $1.72 | $0.9 | ($8.7) | ($4.5) |
| 2035 | 13.50 | $590 | $8.0 | $4.0 | $36.9 | $0.5 | $18.8 | 3.18 | $590 | $1.87 | $0.9 | ($8.7) | ($4.4) |
| 2036 | 13.46 | $636 | $8.6 | $4.2 | $36.9 | $0.5 | $18.2 | 3.18 | $636 | $2.03 | $1.0 | ($8.7) | ($4.2) |
| 2037 | 13.42 | $682 | $9.2 | $4.3 | $36.9 | $0.5 | $17.6 | 3.19 | $682 | $2.18 | $1.0 | ($8.7) | ($4.1) |
| 2038 | 13.38 | $728 | $9.7 | $4.4 | $36.9 | $0.5 | $17.0 | 3.20 | $728 | $2.33 | $1.1 | ($8.7) | ($3.9) |
| 2039 | 13.34 | $774 | $10.3 | $4.5 | $36.9 | $0.5 | $16.4 | 3.21 | $774 | $2.48 | $1.1 | ($8.7) | ($3.8) |
| 2040 | 13.30 | $820 | $10.9 | $4.6 | $36.9 | $0.5 | $15.9 | 3.21 | $820 | $2.64 | $1.1 | ($8.7) | ($3.7) |
| 2041 | 13.26 | $866 | $11.5 | $4.7 | $36.9 | $0.5 | $15.3 | 3.22 | $866 | $2.79 | $1.1 | ($8.7) | ($3.6) |
| 2042 | 13.22 | $912 | $12.1 | $4.8 | $36.9 | $0.5 | $14.8 | 3.23 | $912 | $2.95 | $1.2 | ($8.7) | ($3.4) |
| 2043 | 13.18 | $958 | $12.6 | $4.8 | $36.9 | $0.5 | $14.3 | 3.24 | $958 | $3.10 | $1.2 | ($8.7) | ($3.3) |
| 2044 | 13.14 | $1,004 | $13.2 | $4.9 | $36.9 | $0.5 | $13.8 | 3.24 | $1,004 | $3.26 | $1.2 | ($8.7) | ($3.2) |
| 2045 | 13.10 | $1,050 | $13.8 | $4.9 | $36.9 | $0.5 | $13.4 | 3.25 | $1,056 | $3.43 | $1.2 | ($8.7) | ($3.1) |
| 2046 | 13.06 | $1,050 | $13.7 | $4.7 | $36.9 | $0.5 | $12.9 | 3.26 | $1,050 | $3.42 | $1.2 | ($8.8) | ($3.0) |
| 2047 | 13.02 | $1,050 | $13.7 | $4.5 | $36.9 | $0.5 | $12.5 | 3.27 | $1,050 | $3.43 | $1.1 | ($8.8) | ($2.9) |
| 2048 | 12.98 | $1,050 | $13.6 | $4.4 | $36.9 | $0.5 | $12.0 | 3.27 | $1,050 | $3.44 | $1.1 | ($8.8) | ($2.8) |
| 2049 | 12.94 | $1,050 | $13.6 | $4.2 | $36.9 | $0.5 | $11.6 | 3.28 | $1,050 | $3.45 | $1.1 | ($8.8) | ($2.7) |
| 2050 | 12.90 | $1,050 | $13.5 | $4.1 | $36.9 | $0.5 | $11.2 | 3.29 | $1,050 | $3.45 | $1.0 | ($8.8) | ($2.6) |
| 2051 | 12.86 | $1,050 | $13.5 | $3.9 | $36.9 | $0.5 | $10.9 | 3.30 | $1,050 | $3.46 | $1.0 | ($8.8) | ($2.5) |
| 2052 | 12.82 | $1,050 | $13.5 | $3.8 | $36.9 | $0.5 | $10.5 | 3.30 | $1,050 | $3.47 | $1.0 | ($8.8) | ($2.5) |
| 2053 | 12.78 | $1,050 | $13.4 | $3.6 | $36.9 | $0.5 | $10.1 | 3.31 | $1,050 | $3.48 | $0.9 | ($8.8) | ($2.4) |
| 2054 | 12.74 | $1,050 | $13.4 | $3.5 | $36.9 | $0.5 | $9.8 | 3.32 | $1,050 | $3.49 | $0.9 | ($8.8) | ($2.3) |
| 2055 | 12.70 | $1,050 | $13.3 | $3.4 | $36.9 | $0.5 | $9.5 | 3.33 | $1,050 | $3.49 | $0.9 | ($8.8) | ($2.2) |
| 2056 | 12.66 | $1,050 | $13.3 | $3.2 | $36.9 | $0.5 | $9.1 | 3.33 | $1,050 | $3.50 | $0.9 | ($8.8) | ($2.2) |
| 2057 | 12.62 | $1,050 | $13.3 | $3.1 | $36.9 | $0.5 | $8.8 | 3.34 | $1,050 | $3.51 | $0.8 | ($8.8) | ($2.1) |
| 2058 | 12.58 | $1,050 | $13.2 | $3.0 | $36.9 | $0.5 | $8.5 | 3.35 | $1,050 | $3.52 | $0.8 | ($8.8) | ($2.0) |
| 2059 | 12.54 | $1,050 | $13.2 | $2.9 | $36.9 | $0.5 | $8.3 | 3.36 | $1,050 | $3.53 | $0.8 | ($8.8) | ($1.9) |
| 2060 | 12.50 | $1,050 | $13.1 | $2.8 | $36.9 | $0.5 | $8.0 | 3.36 | $1,050 | $3.53 | $0.8 | ($8.8) | ($1.9) |
| 2061 | 12.46 | $1,050 | $13.1 | $2.7 | $36.9 | $0.5 | $7.7 | 3.37 | $1,050 | $3.54 | $0.7 | ($8.8) | ($1.8) |
| 2062 | 12.42 | $1,050 | $13.0 | $2.6 | $36.9 | $0.5 | $7.4 | 3.38 | $1,050 | $3.55 | $0.7 | ($8.9) | ($1.8) |
| 2063 | 12.38 | $1,050 | $13.0 | $2.5 | $36.9 | $0.5 | $7.2 | 3.39 | $1,050 | $3.56 | $0.7 | ($8.9) | ($1.7) |
| 2064 | 12.34 | $1,050 | $13.0 | $2.4 | $36.9 | $0.5 | $6.9 | 3.39 | $1,050 | $3.56 | $0.7 | ($8.9) | ($1.6) |
| 2065 | 12.30 | $1,050 | $12.9 | $2.3 | $36.9 | $0.5 | $6.7 | 3.40 | $1,050 | $3.57 | $0.6 | ($8.9) | ($1.6) |
| 2066 | 12.26 | $1,050 | $12.9 | $2.2 | $36.9 | $0.5 | $6.5 | 3.41 | $1,050 | $3.58 | $0.6 | ($8.9) | ($1.5) |
| 2067 | 12.22 | $1,050 | $12.8 | $2.1 | $36.9 | $0.5 | $6.3 | 3.42 | $1,050 | $3.59 | $0.6 | ($8.9) | ($1.5) |
| 2068 | 12.18 | $1,050 | $12.8 | $2.1 | $36.9 | $0.5 | $6.1 | 3.42 | $1,050 | $3.60 | $0.6 | ($8.9) | ($1.4) |
| 2069 | 12.14 | $1,050 | $12.7 | $2.0 | $36.9 | $0.5 | $5.8 | 3.43 | $1,050 | $3.60 | $0.6 | ($8.9) | ($1.4) |
| 2070 | 12.1 | $1,050 | | | | | | 3.44 | | $0.00 | $0.0 | $0.0 | |
| Total | | | | $179.5 | | | $765.8 | | | | $38.3 | | ($177.9) |
| Total Public Benefit ($M) | | | | | | | | | $804.1 | | | | |
| Percent of Public Benefits in Delta or Tributaries | | | | | | | | | 95% | | | | |
| Total Benefits ($M) | | | | | | | $983.6 | | | | | | |
| Percent Public Benefits | | | | | | | 82% | | | | | | |
| Total Net Benefits ($M) | | | | | | | $805.7 | | | | | | |

Extrapolated | Interpolated
Held Constant | Modeled Values

[\1] 225 kaf/yr for 1.5 yrs, once in 50 yrs

**Table 4** is further described in the sections below.

## Public Benefit Ratio

The "Public Benefit Ratio" (PBR) is the ratio of the monetized net public benefits to the Program funding request. The net public and non-public physical benefits demonstrate improvements in physical and biological conditions that can be attributed to the WSWB while recognizing the negative impacts of the project as compared to the without-project conditions.

In this application, the net physical and economic public and non-public benefits of the WSWB are quantified, and these net benefits are allocated to support the project's request for Program funding. These analyses present benefits and impacts at similar locations and times and in the same physical units to provide an accurate, reproducible calculation of major monetized net public and non-public benefits. This section also includes qualitative descriptions of ancillary benefits, such as flood control, that are difficult to quantify at the level of benefit expected from the WSWB as a stand-alone effort.

As the detailed analysis of benefits illustrates, 95 percent of the total monetized public benefits are attributable to ecosystem benefits to the Delta and its tributaries.

The funding request for this project (Total Grant Request) is $306 million[11] and, as displayed in **Table 5** below, is expected to produce total net benefits having a present value of $806 million. Of these net benefits, 82 percent will be public benefits for both the ecosystem and for emergency supply. The project is a conjunctive use and reservoir reoperation project, both classes that are exempted from the 50 percent cost match.

As the project is not expected to generate impacts to the ecosystem or other public benefit categories, the estimated present worth of the net public benefits is $804 million or 100 percent of the $804 million present value of the total public benefits.

Given a present value of net monetized public benefits of $804 million and an estimated total WSIP cost share of $306 million, the project's Public Benefit Ratio (PBR) is estimated to be 2.6. The costs of project operation and maintenance are allocated to the non-public water supply benefit as revenue generated by this benefit will be used to defray operation and maintenance costs. For this reason, the PBR is higher than the B/C ratio of 2.3 which has been computed to confirm the project's overall economic viability. Details of allocation of public funds to public benefits categories are presented in the Cost Allocation[12] section.

The public benefits to be provided assume that 100 percent of the grant funding requested will be approved by the Water Commission. A 100 percent grant is being requested. If a lesser grant is awarded, the public benefits would need to be proportionately reduced.

[11] See Benefit Calculation Tab, Attachment A8 - Total Project Cost Estimate, File WSWB_ProjectCosts_1of1, Section 6-8
[12] See Benefit Calculation Tab, Attachment A10 - Cost Allocation, File WSWB_CostAllocation_1of1, Section 6-10

## Benefit/Cost Ratio

The analysis of project feasibility presented in this application compares the present value of economic net public and non-public benefits with total project costs. As required by the regulations, this analysis provides the following information:

- The present value of the expected value of economic net public benefits over the planning horizon, expressed in 2015 dollars, discounted to the first year of project operations.
- The estimated Program cost share for each public benefit category, in present value dollars at the first year of project operation and an explanation of how the cost share was calculated, consistent with Technical Reference section 8.

As shown in **Table 5**, the project has a Benefit/Cost ratio of 2.3 based on a total capital cost of $343 million and a total net benefit present value of $806 million.[13]

*Table 5 - Present Value Benefit and Cost Summary*

| | Present Value Benefit (2015$M) |
|---|---|
| **Preferred Pulse Flow Alternative** | |
| Spring Pulse for juvenile survival benefit | $754.6 |
| Spring pulse for spring-run adult attraction benefit | $11.2 |
| Public Benefits in Delta/Tribs | $765.8 |
| Emergency Response Benefit (215 kaf, once in 50 yrs) | $38.3 |
| Total Public Benefits | $804.1 |
| Net Public Benefits | $804.1 |
| Water Sale Benefits | $179.5 |
| Total Benefits | $983.6 |
| Operation and Maintenance Costs | ($177.9) |
| Net PV Benefits | $805.7 |
| Total Capital Cost | $343.1 |
| Existing Facilities Contribution | ($37.4) |
| Grant Request | $305.8 |
| Percent of Public Benefits provided to Delta and tributaries | 95% |
| Public Benefit Ratio (net public benefits / WSIP funding request) | 2.6 |
| Benefit:Cost Ratio (total net benefits / total capital cost) | 2.3 |

[13] Using a critical year water sale value of $1,050 in 2030, the B:C ratio would be 3.5

### *Other relevant information*

Other benefits of the Willow Springs Water Bank include:

#### Water Management Benefits

a. Diversifies the Storage Portfolio. The bank's location allows the State to have a more geographically distributed storage portfolio and moves the center of mass of the storage portfolio closer to the center of demand. Water is stored downstream of the large pumping lift at Edmonston Pumping Plant, increasing the flexibility of when energy is needed to pump water over the Tehachapi Mountains. This can provide operational flexibility for the State and optimize the timing of pumping to Southern California. Expanding storage south of the Delta is important because it mitigates the risk to water supplies in the event of Delta levee failure after earthquakes, floods, etc. It also reduces the risks posed by future dam safety issues and from operational issues such as toxic algae blooms.

b. Mitigates East Branch bottleneck. The Bank enhances the capacity of the East Branch of the California Aqueduct by providing a place to store water upstream of the hydraulic bottleneck at Pearblossom Pumping Plant.

c. Stabilizes Groundwater Elevations. The project will be operated within a managed operating range. The 10 percent leave-behind will contribute to protecting groundwater elevations in the project area.

d. Environmental Benefits. As a groundwater bank, it does not flood habitat, archeological sites, or Native American sites. Instead, it maintains the agricultural character of the area by growing crops when not used for percolation.

e. Helps DACs. The project also has the potential to help Disadvantaged Communities (DACs) in the region. It will provide hiking trails for recreation. It can also provide storage for imported surface water that can be used to replace well water in DAC systems with water quality problems. By stabilizing groundwater elevation, the project will also reduce the well pumping costs for local DACs by raising the water table overall.

f. WSWB becomes more effective with climate change. As climate change increases over time, WSWB's conjunctive use benefits become greater. Total capture rises from 34,000 acre-feet per year in 2030 to 39,200 acre-feet per year in 2070. This reflects more extremes of the wet and dry cycle and the ability of a groundwater bank used conjunctively with surface reservoirs to capture an increasing volume of Delta outflow at times when it provides low environmental value.

#### Green Energy Benefits

a. Water/Energy Bank. The Water Bank was awarded a California Energy Commission grant of $1.0 M to conduct a "proof of concept" study of a water/energy bank (EPC-16-029). WSWB will use

the water bank to reduce the cost of energy generation by shifting electric load out of the peak summer period by shifting when imported water is delivered. The underlying concept of the Water/Energy Bank is use of WSWB storage capacity to shift pumping from Edmonston Pumping Plant and three other SWP pumping plants from peak summer hours to periods when energy costs are lower and a greater proportion of generation capacity can be served by renewable sources.

b. Pumped Storage. The Water Bank is evaluating the potential for a 5.2 MW pumped storage component, funded via a grant from the California Energy Commission (CEC). The project had the highest ranking of all 21 projects submitted to the CEC for funding requests (GFO-15-309 Group 11). Energy could be generated during peak hours. Also, the onsite reservoir storage that is part of the pumped storage component can be used to shift hourly electric load estimated to be equivalent to 27.3 MW of Demand Response capacity.

c. Solar co-location. Water Bank facilities are co-located with 640 acres of solar panels, enhancing the ability to meet the State's renewable energy goals. Existing solar facilities produce about 110 MW of renewable energy. Co-location of additional solar panels on planned percolation ponds is being evaluated as one of the areas of study in the CEC-funded water/energy bank study noted below.

d. Reduced greenhouse gas emissions. Activities associated with the WSWB as expected to reduce greenhouse gases through the following mechanisms:

- onsite solar energy, and
- load shifting to periods when high proportions of energy generation are served by renewable sources so that load shifting drives source shifting.

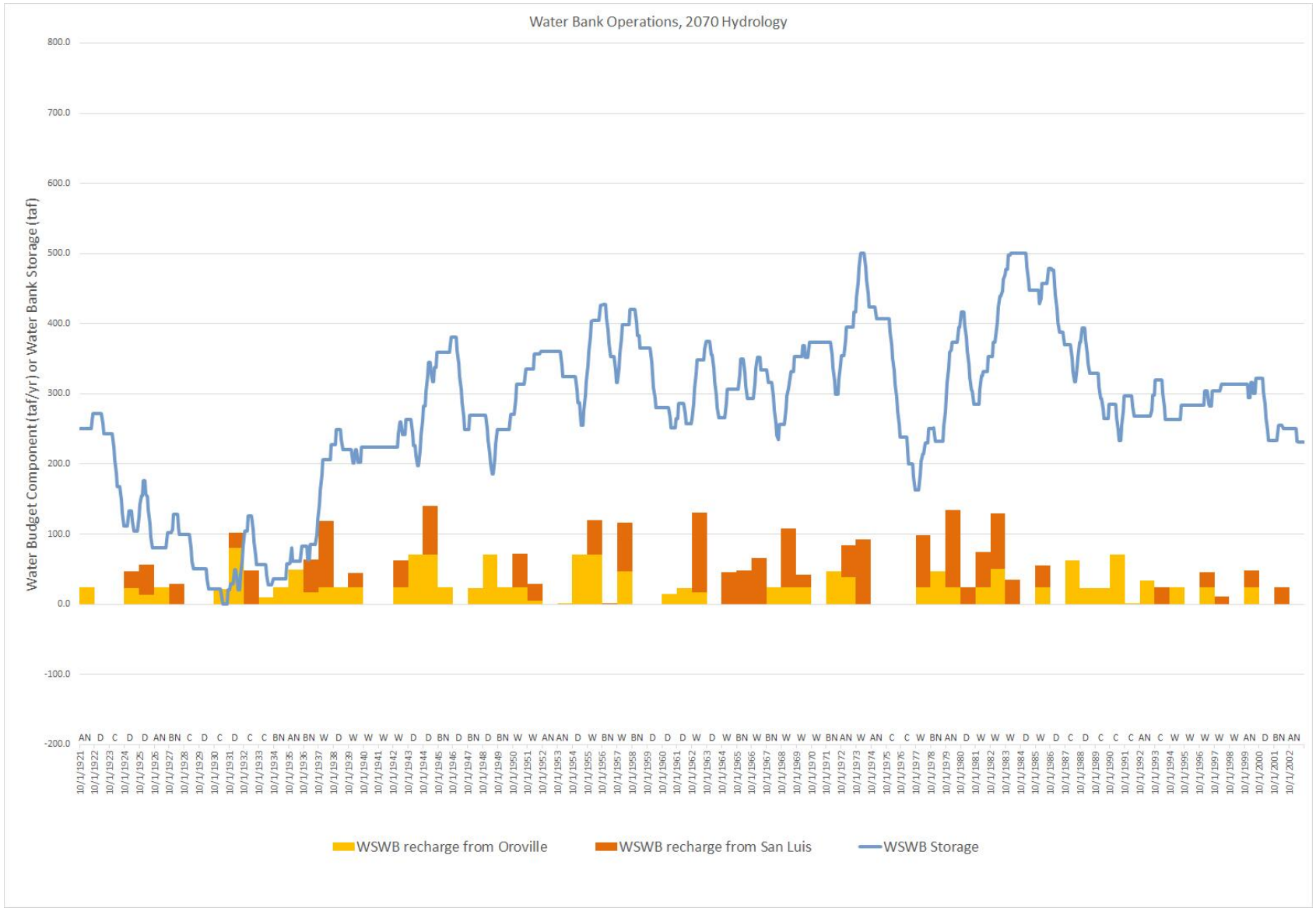
In addition to these established benefits, GHG reductions due to avoidance of reliance on surface water storage reservoirs is a new and emerging area of environmental science. At present, this may be regarded as a potential benefit of groundwater storage when compared with surface water storage alternatives. However, future research may quantify the magnitude of this benefit.

# Contents

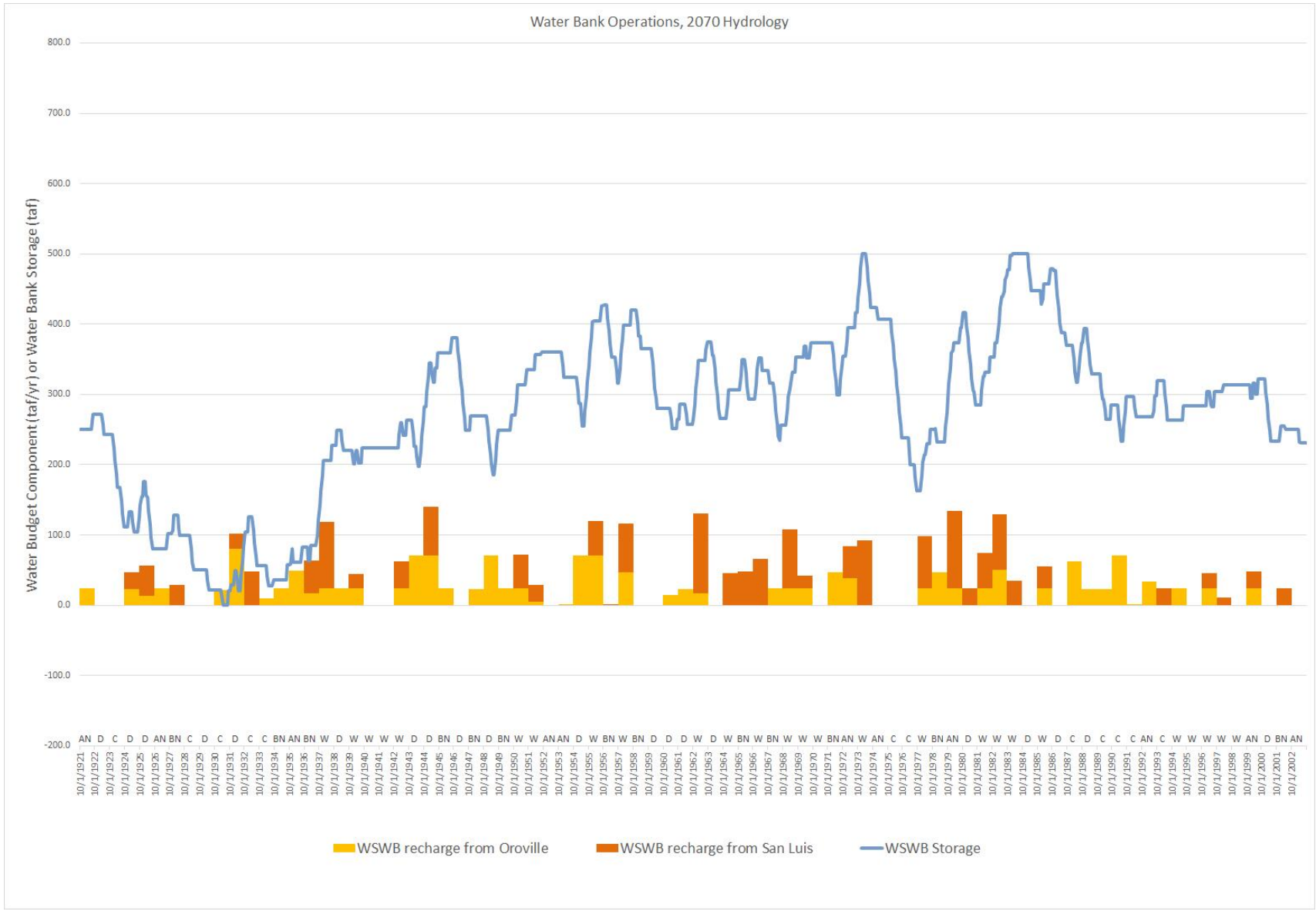
## Tables



## Figures


Water Bank Operations, 2070 Hydrology
Water Budget Component (taf/yr) or Water Bank Storage (taf)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
-100.0
-200.0
WSWB recharge from Oroville
WSWB recharge from San Luis
WSWB Storage

-


Water Bank Operations, 2070 Hydrology
Water Budget Component (taf/yr) or Water Bank Storage (taf)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
-100.0
-200.0
WSWB recharge from Oroville
WSWB recharge from San Luis
WSWB Storage

-