Kern Fan Groundwater Storage Project

FEASIBILITY REPORT

Attachment 1: Public Benefit Ratio Appeal Package

October 21, 2019
Updated April 13, 2020

Irvine Ranch WATER DISTRICT

Rosedale-Rio Bravo WATER STORAGE DISTRICT

Kern Fan Groundwater Storage Project

FOR CALIFORNIA'S WATER STORAGE INVESTMENT PROGRAM

PUBLIC BENEFIT RATIO APPEAL

February 23, 2018

Irvine Ranch
WATER DISTRICT

Rosedale-Rio Bravo
WATER STORAGE DISTRICT

Appeal Contents

I. Appeal Letter

Summary

Physical and Monetized Benefits

Water Operations Review- Water Operations Analysis Methodology

California Department of Fish and Wildlife Review

Economics Review for Public Benefit Ratio

Project Costs

Other Kern Fan Project Benefits

Conclusion

II. Attachments included as Appendices

Appendix A: MBK Engineers Technical Memorandum

Appendix B: First Amended Memorandum of Understanding

Appendix C: Thomas Harder & Co. Technical Memorandum

Appendix D: Cramer Fish Sciences Technical Memorandum--Chinook Salmon Benefits

Appendix E: M.Cubed Technical Memorandum

III. Other Supporting Documentation Uploaded

1. MBK Spreadsheet Model
2. Cramer Fish Sciences Models
    - 2a. Feather Analysis Spreadsheet
    - 2b. Smolt Survival to Bay Spreadsheet
    - 2c. Delta Passage Model 'Player Version
3. M.Cubed Spreadsheet quantification support
4. Benefit and Cost Analysis Spreadsheets
5. Physical and Economic Summary Tables
6. Ecosystem Priority Worksheet—General Information
7. Ecosystem Priority 2 Worksheet
8. Ecosystem Priority 14 Worksheet
9. Thomas Harder & Co. Analytical Model for Groundwater Level Benefits
10. Supplemental Information Related to Other Benefits Not Quantified
    - 10a. Cramer Fish Sciences Technical Memorandum: Steelhead Benefits
    - 10b. M.Cubed Spreadsheet quantification support for Steelhead Benefits
    - 10c. Supplemental Ecosystem Priority 2 Worksheet Revised for Steelhead Benefits
    - 10d. Benefit and Cost Analysis Spreadsheets updated to include Steelhead Benefits

Public Benefit Ratio Appeal of
Water Storage Investment Program Public Benefit Ratio Review for
the Kern Fan Groundwater Storage Project

Prepared by Irvine Ranch Water District and Rosedale-Rio Bravo Water Storage District
February 23, 2018

Summary

The California Water Commission (CWC) has evaluated the Water Storage Investment Program (WSIP) Application submitted by the Irvine Ranch Water District (IRWD) and Rosedale-Rio Bravo Water Storage District (Rosedale) which are jointly referred to as "Applicants" for the Kern Fan Groundwater Storage Project (Kern Fan Project or Project). The CWC staff review of the Public Benefit Ratio (PBR) for the Project is included in the Kern Fan PBR Review Package (PBR Review) as submitted by the CWC on February 1, 2018. The PBR Review includes the CWC's Economics Review for PBR, Water Operations Review for PBR, and California Department of Fish and Wildlife's review for ecosystem benefits (CDFW Review). As stated in the PBR Review, the CWC staff found that additional supporting information or clarification is needed to properly verify the PBR associated with the Project and as a result, the CWC staff adjusted the Applicant's claimed PBR for the Kern Fan Project.

Appeal of CWC Staff Revised PBR

Pursuant to section 6008(a)(2) of the California Code of Regulations Title 23, Section 6000 et seq., the Applicants submit this Appeal to provide written rebuttal to the specific adjustments described in the PBR Review, and to identify the PBR that the Applicants believe to be a correct value.

Correct PBR for the Kern Fan Project

The Applicants have revised the PBR in response to the PBR Review, and find that the correct PBR value for the Kern Fan Project is 2.05. **Table 1** shows the summary of the Applicant's submitted PBR, the CWC staff's revised PBR, and the Applicant's correct PBR value submitted through this Appeal.

Table 1. Summary of Adjustments and Corrections to Public Benefit Ratio

PBR Summary	As Submitted by Applicants	As Adjusted by CWC Staff	Correct PBR Value As Submitted with This Appeal
Total Public Benefit ($ millions)	$125.8	$49.7	$176.10
Program Funding Request ($ millions)	$85.7	$85.7	$85.7
Public Benefit Ratio	**1.47**	**0.58**	**2.05**

The Applicants have provided supplementary documentation, models, analytical methods, data and information, including references to the existing Application information, in support of the correct PBR value, as provided in this Appeal of the CWC adjusted PBR for the Project.

Physical and Monetized Benefits

The PBR Review of the Project's physical and monetized benefits highlighted several overarching water operations issues identified in the Application, which are explained in the Water Operations Review. These concerns are addressed first in this Appeal document because the analysis of the Project water operations provides the baseline for all other analyses associated with the claimed physical benefits, the economic evaluation, and the monetization of these benefits. The PBR Review detailed the following water operations related issues identified with the Project Application, for which the Applicants provide the following responses.

Water Operations Review - Water Operations Analysis Methodology

CalSim II Model Version

<u>PBR Review</u>: *CalSim II models and results used in the spreadsheet model are the September 9, 2016 versions. Section 6004(a)(1) of the regulations requires applicants to "use the CalSim II and DSM2 model products provided by the SWIP on November 2, 2016."*

<u>Response</u>: The analytical approach used by MBK Engineers involves the use of CalSim II model results to depict the without Project (Baseline) scenario. The operation of the Project is then simulated in a spreadsheet model that layers the Project onto the Baseline operation of the Central Valley Project and State Water Project as simulated in CalSim II. In response to the CWC's comment, MBK Engineers has revised the analysis to use the WSIP 2030 CalSim II model dated November 2, 2016 for the Baseline operation. MBK Engineers has also updated the spreadsheet model to utilize the November 2, 2016 CalSim II model and results to simulate the with-Project scenario. MBK Engineers' technical memorandum has been revised to address these changes. The revised technical memorandum by MBK Engineers is included as **Appendix A** and the modeling results from the November 2, 2016, version of CalSim II is provided under **"Other Supporting Documentation Uploaded" item 1.**

Recharge Losses

<u>PBR Review</u>: *The application states that evaporation losses during recharge are estimated to be 6 percent. The spreadsheet model does not include this loss rate.*

<u>Response</u>: As stated on page 17 of the Kern Fan Project Description (Tab3-A3 IRWD_Project Description_FINAL.pdf), as water is being recharged at the spreading basins, the evaporation losses are estimated at 6%. This estimate is derived from compliance with the First Amended Memorandum of Understanding Regarding Operation and Monitoring of the Rosedale-Rio Bravo

Water Storage District Groundwater Banking Program (MOU). Rosedale entered into the MOU with adjoining entities in the Kern Fan area and the MOU provides guidelines for operation and monitoring of Rosedale's groundwater banking programs. The Kern Fan Project would be subject to the operating requirements in the MOU. The MOU is also described in Section 2.2 of the Kern Fan Project Description (Tab3-A3 IRWD_Project Description_FINAL.pdf) and a copy of the MOU is included as **Appendix B.** The losses for groundwater banking programs are defined in Section 10 of the MOU. Under 10(a) of the MOU, it states surface recharge losses share be fixed and assessed at a rate of 3% which includes a "safety factor" of 1% of water diverted for direct recharge. An additional surface recharge loss of 3% shall be fixed and assessed against water directly recharged that is subsequently extracted for out-of-district use. This combined 6% of surface recharge loss is considered in the MOU as the evaporative loss that was referenced on page 17 of the Kern Fan Project Description (Tab3-A3 IRWD_Project Description_FINAL.pdf). As also shown on page 5 of MBK Engineers' Technical Memorandum (**Appendix A**), each of the loss percentages applied to the water stored in each of the three accounts, Ecosystem, Rosedale and IRWD, includes an estimated 6% loss for evaporation. Although water stored for Rosedale's own use as a non-public water supply is only subject to 3% of surface recharge loss, the model conservatively applies 6% evaporation surface loss for all water recharged.

Availability of Lake Oroville Pulse Flows

PBR Review: *Availability of water in years with extremely low water conditions at Oroville was uncertain. The application and the spreadsheet model show that IRWD and Dudley Ridge Water District could have access to 17.9 TAF of water during dry and critical years. During water years with extremely low State Water Project (SWP) Table A allocations, this water supply may not be available.*

Response: The Kern Fan Project operates to create increased environmental pulse flows of approximately 18,000 AF in dry and critical years by offsetting State Water Project (SWP) Table A water demands through exchanges that make water available for instream flows from Lake Oroville releases that flow along the Feather and Sacramento Rivers, and in the Delta estuary. Project participants have SWP contracts for maximum Table A volumes of 41,350 AF for Dudley Ridge Water District (DWRD) and 29,900 AF for Rosedale's share through the Kern County Water Agency. The combined DRWD and Rosedale Table A amounts during a 100% Table A allocation equals 71,250 AF. MBK Engineers documents in its updated technical memorandum, that is provided as **Appendix A**, how the Kern Fan Project ensures sufficient water supply is available and certain for the recommended pulse flows. MBK Engineers describes, how based on the updated modeling results from the use of the updated version of CalSim II, that the Kern Fan Project will be operated to support and establish certainty of the associated pulse flow volumes in each year. (See **Appendix A**, under "Results" section). MBK Engineers also describes how using Project extraction capacity to ensure the ability to extract water to offset Table A deliveries in years when pulse flows are released, results in less water available for non-public water supply benefits to Rosedale and IRWD.

Spring-Run and Winter-Run Chinook Salmon Survival

PBR Review: *The applicant states the Kern Fan Project will provide ecosystem benefits in dry and critical years by releasing pulses of water from Lake Oroville for Delta outflow. The applicants' spreadsheet model results show that pulse flows, with a magnitude of 17.9 TAF each, occur in 5 of the 18 dry years and 1 of the 12 critical years under the 2030 conditions, and 5 of the 18 dry years under the 2070 conditions.*

Response: The Kern Fan Project will provide pulses for the ecosystem during Dry and Critical years when Feather River flows are lower to create a higher ecosystem benefits. Based on the updated CalSim II modeling, MBK Engineers document that the Project will provide pulse flows, with a magnitude of 17.9 TAF each, occurring in 5 of the 18 dry years and 2 of the 12 critical years, for a total of 7 pulses under the 2030 conditions. MBK Engineers also documents that the Project will provide pulse flows in 4 of the 18 dry years and 1 of the 12 critical years, for a total of 5 pulses under the 2070 conditions. (See **Appendix A**)

Groundwater Level Improvement

PBR Review: *The applicant relies on inferred qualitative assessments of the benefits to the groundwater system that would result from implementation of the Kern Fan Project. The applicant does not provide the groundwater model used to assess groundwater level changes. The reviewers were not able to verify groundwater level improvements resulting from the Kern Fan Project.*

Response: The Kern Fan Project will provide a water supply benefit to the Kern County groundwater basin. A portion of banked groundwater will accrue to losses that benefit the basin per the existing Memorandum of Understanding (MOU) described in Section 2.2 of the Kern Fan Project Description (Tab3-A3 IRWD_Project Description_FINAL.pdf). A copy of the MOU is included as **Appendix B.** The loss factors are applied to gross water deliveries into the Kern groundwater basin. The loss portions of the water will not be recovered and will remain in the ground to bolster local groundwater levels. As modeled by MBK Engineers, water is simulated as stored in the project in each of the three accounts: public or ecosystem, IRWD and Rosedale. Water stored in each account is subject to a loss percentage of 10% for Rosedale, 12.5% for ecosystem, and 15% for IRWD. These losses include an estimated 6% loss for evaporation (See **Appendix A).** After evaporative losses, an average of 6.5% of the groundwater stored in the Project will not be recovered and this amount would benefit groundwater levels in the Kern County groundwater basin.

To evaluate the groundwater improvement benefits from the project, the Applicants have provided a modeling work that was prepared to analyze and quantify potential groundwater level benefits from the project. Hydrogeologists at Thomas Harder & Co., prepared a numerical model to analyze the portion of Project water that would remain in the basin and the groundwater level benefits over a 50-year project operational scenario as developed by MBK Engineers. This modeling work is described in technical memorandum provided as **Appendix C and "Other Supporting Documentation Uploaded" item 9**. Based on the analysis from Thomas Harder & Co., the project will result in measurable increases in groundwater elevations and therefore a groundwater level benefit to the Kern County groundwater basin.

Water Supply

PBR Review: *The application and the spreadsheet model are consistent in showing that the Kern Fan Project will provide an average of 4.5 TAF per year of additional water supply under the 2030 conditions, and 4.1 TAF under the 2070 conditions.*

Response: Based on the updated CalSim II modeling results, MBK Engineers document the Kern Fan Project will provide an average of 2.7 TAF per year of additional water supply under the 2030 conditions, and 3.0 TAF per year under the 2070 conditions (see **Appendix A and also "Other Supporting Documentation Uploaded" item 1**).

California Department of Fish and Wildlife Review

<u>PBR Review</u>: *The California Department of Fish and Wildlife (CDFW) was unable to identify sufficient support in the methods used or values supplied for monetized ecosystem benefits. CDFW finds the conclusions presented from the analysis for spring-run and winter-run Chinook salmon survival insufficiently supported by the information in the application.*

<u>Response:</u> Cramer Fish Sciences (CFS) has provided supporting documentation for the use of its methods in evaluating and quantifying the ecosystem benefits related to Chinook salmon. This is described more fully in CFS' revised Technical Memorandum in **Appendix D**. CDFW review indicated the analysis of Chinook salmon benefits utilized excessive precision and CDFW identified Technical Reference Table 4-10 as a source for appropriate metrics to quantify ecosystem benefits. CFS's analysis of pulse flow benefits utilized multiple metrics that are listed in Table 4-10 of the WSIP Technical Reference including abundance, survival percentage and routing probabilities within the Delta Passage Model (DPM). The level of precision for the inputs matched source data from which the inputs for the analysis were taken (referenced in CFS's Technical Memorandum – **Appendix D and also "Other Supporting Documentation Uploaded" items 2a, 2b, and 2c**). For example, the CDFW annual summary of Chinook salmon spawning escapement (GrandTab) reports up to five significant digits (e.g. 17,296 winter-run Chinook in 2006, not 17,000). Also, since the quantification of benefits methodology required values for individual fish, it was reasonable to round results to the nearest whole-fish number rather than rounding to the nearest ten or hundred fish.

<u>PBR Review:</u> *The DPM is not intended to be used to predict survival to adulthood…The analysis generated adult survival estimates using the model despite this limitation and presented results as a single point estimate…typical outputs from a DPM analysis present juvenile survival (total or route specific) for different project alternatives and also include a range of survival estimates as opposed to a point estimate.*

<u>Response:</u> CDFW review indicated the Application of the DPM was inappropriate. In the analysis performed, the DPM was not used to predict survival to adulthood but was used to estimate survival through the Delta in a comparative framework (project vs. no project) as part of the larger analysis. Survival estimates provided by the DPM are displayed in the Excel spreadsheet "Smolt_Surv_to_Bay_V2". As described further in the updated CFS Technical Memorandum and supporting modeling documentation (see **Appendix D and also "Other Supporting Documentation Uploaded" items 2a, 2b and 2c**), the comparative application of the DPM used in CFS's analysis is consistent with its application described in Zeug et al. (2011) and also consistent with its application for California Water Fix and other project planning documents. It is important to note that survival estimates for other life stages are also included in the analysis in order to quantify possible changes in adult abundance associated with the Project. Briefly, each year in the model, error distributions for parameters are resampled to produce a new parameter estimate to apply in

that year. A total of 82 years of flow data were run and model uncertainty is expressed across those years. Additional uncertainty in survival values were incorporated in the revised analysis to provide a range of potential adult abundances under each scenario. The updated information provided by CFS includes more recent documentation that describes how uncertainty is incorporated in the DPM (see **Appendix D and also "Other Supporting Documentation Uploaded" items 2a, 2b, and 2c**)**.**

PBR Review: *CDFW comment on Delta entry distribution: It may not be appropriate to use the Delta entry distributions to calculate a number of spring-run smolts entering the Sacramento River from the Feather River, as this increases uncertainty in the conclusions of the analysis. No justification was provided for utilizing the Delta entry distribution of Chinook salmon smolts, nor was the increased uncertainty from this assumption discussed.*

Response: CDFW review identified a potential mismatch in the timing of juvenile salmonids reaching the Delta. CFS has revised its Technical Memorandum for Chinook salmon ecosystem benefits to clarify and correct this issue (**Appendix D**). The version of the DPM used in the analysis includes a reach from Verona (confluence of the Feather and Sacramento River) to Freeport. Timing of fish entry in the model at Verona was adjusted based on travel time estimates in that reach from acoustic tagging studies of Chinook salmon juveniles. The DPM documentation provided in CFS' Technical Memorandum describes model entry and adjustments in detail (See **Appendix D and also "Other Supporting Documentation Uploaded" items 2a, 2b and 2c**).

PBR Review: *CDFW comment: The derivation of the model parameter for smolt survival in the Feather River is unclear. The application did not include a description of how the survival values identified in the reference led to the model input…using a constant value for survival may not be representative of actual population dynamics.*

Response: The CFS revised Technical Memorandum (**Appendix D**) for Chinook salmon ecosystem benefits provides an expanded and improved description of how this model parameter was estimated. Per CFS, it is true that releases of Feather River Hatchery produced have occurred at different locations over time. CFS has clarified in its documentation that for simplicity CFS assumes all future hatchery releases will occur near Gridley. Though future hatchery release locations are unknown, the California Hatchery Scientific Review Group has recommended all hatchery production be released as close to the source hatchery as possible. Given this recommendation and concerns about straying Feather River Hatchery spring-run Chinook (see NMFS 2016a from Technical Memorandum), future spring-run Chinook releases downstream of the Yuba River confluence (e.g. Boyd's Pump) are unlikely.

PBR Review: *CDFW comment: The derivation and justification model inputs for the annual number of winter-run and spring-run smolts is unclear. The references cited are inconsistent between application documents. The applicant did not describe the value for natural origin spring-run smolt* *production from the Feather River was derived from the cited references. CDFW is unable to verify model inputs.*

Response: CFS' Technical Memorandum for Chinook salmon ecosystem benefits has been revised to include additional information to explain sources for these values (see **Appendix D and also "Other Supporting Documentation Uploaded" items 2a, 2b, and 2c**).

The Applicants have updated the Ecosystem Priority Worksheets for the General Information Worksheet and Ecosystem Priority 2 worksheet to reflect the revisions in the modeling and results for the physical benefits to the spring-run and winter-run Chinook salmon (see **"Other Supporting Documentation Uploaded" item 6 - Ecosystem Priority Worksheet – General Info and item 7 - Ecosystem Priority 2 Worksheet**).

Economics Review for Public Benefit Ratio

Monetized Public Benefits: Ecosystem Salmon

PBR Review of Physical Benefits: *Per the CDFW review, CDFW found the monetized ecosystem benefit for spring-run and winter-run Chinook salmon survival to be insufficiently supported by information in the application. These physical benefits were removed.*

Response: The modeling and technical information in support of the Appeal to the CDFW review for the physical benefits for the spring-run and winter-run Chinook salmon is found under the Section "California Department of Fish and Wildlife Review " as shown above and also more fully described in **Appendix D and "Other Supporting Documentation Uploaded" items 2a, 2b and 2c**.

PBR Review of Monetization: *The PBR Review adjusted the monetization of the ecosystem benefit for spring-run and winter-run Chinook salmon to utilize the Technical Reference unit value for Sacramento Valley water.*

Response: M.Cubed revised its analysis for the spring-run and winter-run Chinook salmon benefit claimed by the Project based upon the updated CalSim II modeling and corresponding Technical Memorandum prepared by MBK Engineers (see **Appendix A**), and the resultant revised modeling by Cramer Fish Sciences (See **Appendix D).** M.Cubed addresses the Commission's review and suggestion to consider the use of voluntary water transfers in the Sacramento Valley in its updated economic analysis. M.Cubed also provides the detailed evaluation of the basis of water values used for the monetization of the ecosystem benefit for spring-run and winter-run in its analysis (see **Appendix E and also "Other Supporting Documentation Uploaded" item 3).**

The resulting net present value of ecosystem benefit for spring-fun and winter-run Chinook salmon is $30.83 million at the project start, in 2015 dollars.

Monetized Public Benefits: Ecosystem Incidental Wetland

PBR Review of Monetization: *The PBR Review adjusted the monetization of the ecosystem wetland habitat benefits to include only the alternative cost of water as provided by the applicant. The PBR Review finds that land purchase is not the lowest-cost feasible alternative and land that is already dedicated to groundwater recharged could be flooded, or a limited easement could be acquired. The PBR Review states the inundation would not necessarily need to occur during the same years and months as the project recharge. These adjustments resulted in a present value of ecosystem wetland habitat benefit of $34.6 million.*

Response: Based on the updated CalSim II modeling and corresponding Technical Memorandum prepared by MBK Engineers (see **Appendix A and also "Other Supporting Documentation Uploaded" item 1**), M.Cubed revised the Ecosystem Incidental Wetland benefit from the Project to $98.25 million. M.Cubed evaluates all of the PBR Review of the monetization and provides substantiation for the adjusted, claimed wetland benefit for the Project. The evaluation for the monetization of the correct claimed benefit value is described more fully in **Appendix E and also "Other Supporting Documentation Uploaded" item 3.**

The resulting net present value of the ecosystem wetland habitat benefit is $98.25 million at the project start, in 2015 dollars.

The Applicants have updated the Ecosystem Priority 14 Worksheet to reflect the revisions in the modeling and results for the benefits claimed related to incidental wetland habitat (see **"Other Supporting Documentation Uploaded" item 8 - Ecosystem Priority 14 Worksheet**).

Monetized Public Benefits: Emergency Response - Drought Emergency Water Supply

PBR Review of Monetization: *The PBR Review adjusted the monetization of the drought emergency water supply benefits for the agricultural water unit value to utilize the Technical Reference unit value of $360 per AF plus $12.07 per AF for SWP conveyance costs to the Rosedale and DRWD service areas. The PBR Review also adjusted the M&I unit values removing the escalation of the M&I rate from the MWDSC rate used. These adjustments resulted in a present value of drought emergency water supply benefit of $2.91 million.*

Response: With regards to the unit value used for agricultural water supply, Section 5.3.3 of the WSIP Technical Reference states that "competition for water through a water transfer market should also be considered". As a more appropriate evaluation of unit cost, in **Appendix E**, M.Cubed provides information supporting a range of water unit pricing for water available to agricultural users in Rosedale and DRWD service areas through the water transfer market. It is reasonable that there would be competition for water transfers during a prolonged drought and this information provides a basis for this approach. This information is taken from actual water offered and purchased from years 2014, 2015 and 2016, which are representative years from the most recent five-year drought. M.Cubed's analysis uses the actual costs for SWP conveyance (in 2015) as provided by DRWD (see SWP cost documentation provided in **Appendix E and also "Other Supporting Documentation Uploaded" item 3**).

M.Cubed updated the M&I water unit rate escalation from Metropolitan Water District of Southern California (MWDSC) based on proposed future rates as published by MWDSC in its 2018 budget forecast (See MWDSC rate documentation provided in **Appendix E and also "Other Supporting Documentation Uploaded" item 3**). M.Cubed utilized the MWDSC forecasted rates and the derived escalation factor in evaluating the drought emergency water supply benefit for M&I.

The resulting net present value of drought emergency water supply benefit is $18.57 million at the project start, in 2015 dollars.

Monetized Public Benefits: Emergency Response - Delta Failure

PBR Review of Monetization: *The PBR Review adjusted the monetization of the Delta emergency benefits for agricultural water supply to utilize the Technical Reference unit value of $1,056 per AF plus $12.07 per AF for SWP conveyance costs to the Rosedale and DRWD service areas. The PBR Review also adjusted the M&I unit values removing the escalation of the M&I rate from the MWDSC rate used. This adjustment resulted in a present value of Delta emergency water supply benefit of $12.19 million.*

Response: With regards to the unit value used for agricultural water supply, Section 5.3.3 of the WSIP Technical Reference states that "competition for water through a water transfer market should also be considered". M.Cubed provides rationale for a reasonable approach based on actual water unit pricing for water transferred from north of the Delta to the Rosedale and DRWD service areas for agricultural use through the water transfer market. This information reflects actual water offered from 2014, 2015 and 2016. (See water transfer unit cost documentation provided in **Appendix E and also "Other Supporting Documentation Uploaded" item 3**). M.Cubed's analysis uses the average costs for SWP conveyance (2001 to 2017) as provided by DRWD (see SWP cost documentation provided in **Appendix E and also "Other Supporting Documentation Uploaded" item 3**).

M.Cubed updated the M&I water unit rate escalation from MWDSC proposed future rates as published by MWDSC in its 2018 budget forecast (See MWDSC rate documentation provided in **Appendix E and also "Other Supporting Documentation Uploaded" item 3**). M.Cubed utilized the MWDSC forecasted rates and the derived escalation factor in evaluating the Delta emergency water supply benefit for M&I.

The resulting net present value of the Delta emergency water supply benefit is $28.45 million at the project start, in 2015 dollars.

Monetized Non-Public Benefits: Water Supply

PBR Review of Monetization: *The PBR Review adjusted the monetization of the M&I water supply be adjusting the M&I unit values to reflect the MWDSC rate of $676 per AF to IRWD, but removed the escalation factor. This resulted in an adjusted present value of water supply benefit of $46.56 million.*

Response: M.Cubed updated the M&I water unit rate escalation from MWDSC proposed future rates as published by MWDSC in its 2018 budget forecast. M.Cubed utilized the MWDSC forecasted rates and the derived escalation factor in evaluating the water supply benefit for M&I. (See MWDSC rate documentation provided in **Appendix E and also "Other Supporting Documentation Uploaded" item 3**).

The resulting net present value of the water supply benefit is $50.44 million at the project start, in 2015 dollars.

Monetized Non-Public Benefits: Groundwater Level Improvement

PBR Review of Monetization: *The PBR Review adjusted the monetization of the groundwater level improvement physical benefit. The PBR Review added $12.07 per AF for SWP conveyance costs to the Rosedale and DRWD service areas that adjusted the present value of groundwater level improvement benefit to $5.35 million.*

Response: M.Cubed's analysis uses the average cost for SWP conveyance incurred by DRWD (2001 to 2017) as provided by DRWD (SWP cost documentation provided in **Appendix E**). M.Cubed utilized the Delta Export costs provided in the WSIP Technical Reference and added the revised SWP conveyance costs.

The resulting net present value of groundwater level improvement is $3.49 million at the project start, in 2015 dollars.

Project Costs

PBR Review: *The PBR Review adjusted the Applicant-stated project costs by using 2025 as the start of project operations as the basis for the present value calculations and adjusted costs accordingly.*

Response: The Applicants have recalculated the project costs to match the 2025 start date of project operations. The revisions to project costs are included under **"Other Supporting Documentation Uploaded" Benefit and Cost Analysis Spreadsheets, item 4**.

PBR Review: *The PBR Review adjusted the Applicant-stated capital costs to remove the residual value of the Project land and facilities from the calculation of eligible capital costs. The adjusted total capital cost is $171.3 million.*

Response: Although the inclusion of residual or salvage value of facilities is a standard economic method in determining project feasibility using benefit/cost analyses, the Applicants have recalculated the project costs to remove the residual value of the Project land and facilities from the calculation of eligible capital costs. In the original Application the deduction of residual value in the project capital costs was only used to calculate the Benefit Cost Ratio and was not utilized in the Applicant's calculation of the PBR. The revised project costs are included under "**Other Supporting Documentation Uploaded" Benefit and Cost Analysis Spreadsheets, item 4.**

Based on revisions to the physical and monetized benefits of the Project, the Applicants have updated the WSIP Physical and Economic Summary Tables with the results contained in this Appeal. The updated Tables are included under **"Other Supporting Documentation Uploaded" Physical and Economic Summary Tables, item 5.**

Adjusted PBR and Eligible Funding

Table 2 shows the value of the public benefits as submitted by the Applicants, as adjusted by the CWC in the PBR Review and the correct public benefit value as appealed by the Applicants.

Table 2. Summary of Adjustments to Monetized Public Benefits (in $ millions)

Public Benefits	As Submitted	As Adjusted by CWC Staff in PBR Review	Correct Public Benefit Value As Appealed
Ecosystem			
- Salmon	$20.98	$0.0	$30.83
- Wetland	$39.80	$34.6	$98.25
Emergency Response			
- Extended Drought	$ 5.06	$2.91	$18.57
- Delta Failure	$59.92	$12.19	$28.45
TOTAL	**$125.76**	**$49.70**	**$176.10**

Table 3 shows the summary of the Applicant's submitted PBR, CWC staff's PBR as adjusted in the PBR Review, and the Applicant's correct PBR as appealed by the Applicants.

Table 3. Summary of Adjustments to Public Benefit Ratio			
PBR Summary	As Submitted	As Adjusted by CWC Staff in PBR Review	Correct Public Benefit Ratio As Appealed
Total Public Benefit ($ millions)	$125.8	$49.7	$176.10
Program Funding Request ($ millions)	$85.7		$85.7
Public Benefit Ratio	**1.47**	**0.58**	**2.5**

Table 4 shows the summary of all Project benefits (public and non-public) and total Project cost as submitted, as adjusted in the PBR Review and the correct value as appealed by the Applicants.

Table 4. Summary of Adjustments to Monetized Benefits and Total Project Cost (in $ millions)			
	As Submitted	As Adjusted by CWC Staff in PBR Review	Correct Value As Appealed
Public Benefits			
Ecosystem			
- Salmon	$20.98	$0.00	$30.83
- Wetland	$39.80	$34.60	$98.25
Emergency Response			
- Extended Drought	$ 5.06	$2.91	$18.57
- Delta Failure	$59.92	$12.19	$28.45
Sub-Total	**$125.76**	**$49.70**	**$176.10**
Non-Public Benefits			
Water Supply	$47.74	$46.56	50.44
Groundwater Level Improvement	$4.29	$4.29	$3.49
Sub-Total	**$52.03**	**$50.85**	**$53.93**
Total Benefits	**$177.79**	**$100.55**	**$230.03**
Total Project Cost	**$119.60**	**$206.70**	**$197.82**

Table 5 shows eligible WSIP funding based on benefits and costs as submitted, as adjusted and appealed.

Table 5. Summary of Adjustments to Eligible Program Funding (in $ millions)			
Eligible Costs	As Submitted	As Adjusted by CWC Staff in PBR Review	Correct Values As Appealed
Capital Cost	$90.4	$171.3	$171.3
Program Funding Request	$85.7		$85.7
Adjusted Program Cost Share		$49.7	$85.7

Other Kern Fan Project Benefits

The Kern Fan Project provides certain benefits stated in the Project Application that were not quantified or monetized in the initial Application. Among these stated additional public benefits are the potential for integration with other projects and benefits to other salmonid species. An additional unquantified or monetized benefit that has been identified is the ability of the Applicants to loan water to provide ecosystem benefits. These additional public benefits are discussed below and are not included in the Appeal as monetized benefits in the tables provided above. The discussion and supporting material related to these additional public benefits is provided as supplemental information that can be used to better understand the flexibility and resiliency of the Kern Fan Groundwater Storage Project.

Project integration with other potential storage projects

The Project offers opportunity to further improve the operation of the State water system through the integration of operations with other projects funded through WSIP, thereby increasing the overall funded public benefits. For example, Sites Reservoir participants could have the opportunity to store water in the Project to avoid reservoir spills. Such integration could improve the yield of the State water system, improve water supply reliability, reduce competition for water supplies during dry periods and reduce stresses on ecosystems. (See Application: Tab3-A3_Project Description_FINAL.pdf)

Benefits to other salmonid species

The Project provides pulse flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids. As described in Section 7.1 of the Project Description, Cramer Fish Sciences' assessment of ecosystem benefits from the Project indicates April is a period of "high" relative abundance for downstream migration and rearing of juvenile spring Chinook and juvenile steelhead in the Feather River (See Application: Tab3-A3_Project Description_FINAL.pdf). Also under Priority 2 Worksheet of the Project Application, it is stated that "steelhead smolts emigrating from the Feather and Sacramento River basins will also benefit, but insufficient data are available to quantify these benefits." (See IRWD Tab 4_Attach 1_Priority 2_FINAL.pdf). The Applicants have included as supplemental information the assessment of salmonid species to include juvenile steelhead which were excluded from the Project quantitative analysis in the Application.

Cramer Fish Sciences provided a supplemental quantitative assessment of the benefit to the juvenile steelhead range of survival in the Feather River from 50 years with Project operations. Cramer Fish Sciences evaluation shows the increase in adult steelhead abundance by 95 in 2030 and 62 in 2070. This analysis and evaluation has been included in this Appeal under: **"Other Supporting Documentation Uploaded" item 10a - Supplemental Information Related to Other Benefits Not Quantified - Cramer Fish Sciences Technical Memorandum: Steelhead Trout.**

M.Cubed monetized the benefits for the steelhead from the Project pursuant to the WSIP TR resulting in a benefit of $4.0 million over the life of the project. This monetization of the steelhead benefit was not included in the public benefits claimed by the Applicants in this Appeal but provided as supplemental information to better understand the full benefits and resiliency of the Kern Fan Groundwater Storage Project. (See M.Cubed Technical Memorandum **Appendix E and "Other Supporting Documentation Uploaded" item 10b.**) The Applicants have prepared and included a supplemental Priority 2 Worksheet describing the benefit to the steelhead from the Project (See **"Other Supporting Documentation Uploaded" item 10c**.) A revised Benefit-Cost analysis incorporating the steelhead, resulting in a PBR of 2.1, is also provided in the supplemental documentation (See **"Other Supporting Documentation Uploaded" item 10d.**)

Extended incidental wetland habitat period

The Project would be operated to capture and recharge unallocated Article 21 water, which MBK Engineers' updated modeling results show would be available for the Project in 15 of the 50 operating years over a total estimated 21 months of recharge. The Application quantifies and monetizes the incidental wetland habitat benefit for the 21 months of recharge time associated with the unallocated Article 21 water. However, significant qualitative benefit from extended wetland habitat will exist as a result of the Project recharge basins being fully used by the Applicants after the Project demands have been met. In the Project Application, under the Eligibility/General Project Tab, Question 6, the Applicants describe how the Project facilities, when not used to meet the primary Project objectives, would be used to recharge and store other available water supplies, such as Kern River water or other excess State Water Project supplies. Based on historical availability of other water supplies during normal and wet years, the Applicants expect the benefits from the incidental wetland habitat could be extended by up to 12 operating months.

Other Water Supplies Available for Loan to Public Benefits

Applicants each have substantial existing quantities of water in long term storage in Kern County. Rosedale and IRWD combined have on average up to 200,000 AF of water in storage that could be made available as a loan for ecosystem benefits. The Applicants could provide up to 10,000 AF of stored water on a loan basis to the Department of Water Resources (DWR) to utilize to supplement pulse flows for ecosystem benefits if needed. Applicants could loan this water in advance of Article 21 recharge events with any borrowed water being returned to the Applicants from the Project ecosystem account by the end of 10 years. This supply could be made available for the DWR's use under dry and critical years to supplement pulse flow volumes as needed or under emergency conditions during extended drought or event of Delta failure.

Conclusion

The Kern Fan Project will manage available surplus Article 21 water supplies, which would be otherwise lost to the ocean, to serve dry year demands, for emergency response and ecosystem benefits that include improved habitat conditions, enhanced access to fish spawning and rearing in the Feather and Sacramento Rivers downstream of Oroville Dam. Other public benefits will include temporary wetlands and water supply that will be available during emergency situations such as long-term drought or Delta levee failures. In response to the CWC staff review of the public benefits, revisions have been made to the water operations modeling and results, which in turn led to revisions to the ecosystem benefits and economic analyses, all of which are described above and detailed in the supplemental documentation to the Appeal. The revisions resulted in total public benefits of $176.10 million, and total project benefits of $230.03 million. The project capital cost of $171.3 million and funding request of $85.7 million remain unchanged, and result in a corrected PBR value of 2.05 for the Kern Fan Project.

The Appeal also identifies additional public benefits from the project that were only qualitatively discussed in the Application, such as integration with other storage projects and ecosystem benefits from steelhead trout. Benefits for the steelhead trout were quantified in the supplemental documentation as a result of updating and re-running models necessary to respond to the Appeal, but are not included in the public benefits for the project and therefore not included in the corrected PBR of 2.05. Integration with other projects could increase public benefits from funding awarded through the WSIP. Finally, the Applicants have identified opportunities to loan other water supplies as necessary to further increase and ensure the claimed public benefits are realized. The discussion and supporting material provided in this Appeal related to these additional public benefits is provided as supplemental information that can be used to better understand the flexibility and resiliency of the Kern Fan Groundwater Storage Project. If these additional public benefits were included and considered by the Commission, the PBR for the project could be significantly higher.

Attachments included as Appendices

Appendix A: MBK Engineers Technical Memorandum – Analysis of Kern Fan Groundwater Storage Project for Water Storage Investment Program
Appendix B: First Amended Memorandum of Understanding Regarding Operation and Monitoring of the Rosedale-Rio Bravo Water Storage District Groundwater Banking Program
Appendix C: Thomas Harder & Co. Technical Memorandum – Estimation of Groundwater Level Benefits Associated with the Kern Fan Groundwater Storage Project Concept
Appendix D: Cramer Fish Sciences Technical Memorandum - Chinook Salmon Benefits from Kern Fan Groundwater Storage Project
Appendix E: M.Cubed Technical Memorandum – Estimate of Benefits from the Kern Fan Groundwater Storage Project

Other Supporting Documentation Uploaded

1. MBK Spreadsheet Model originally submitted under Tab 6 Attachment 2 (Tab 6-A2_IRWD_Preliminary Operations Excel_FINAL.xlsx)
2. Cramer Fish Sciences Models originally submitted in response to Completeness and Basic Eligibility Review- Should have been submitted under Tab 4 Attachment 2
   a. Feather Analysis- Spreadsheet
   b. Smolt Survival to Bay Spreadsheet
   c. Delta Passage Model 'Player Version'
3. M.Cubed Spreadsheet quantification support originally submitted as Tab 6 Attachment 5 (Tab6-A5_IRWD_WSIP_Econ Benefits_081117_FINAL.xlsx)
4. Benefit and Cost Analysis Spreadsheets originally submitted under Tab 6 Attachment 9 (Tab6-A9-A10_IRWD_Benefit-Cost_Analysis_Cost_Allocation.xlsx)
5. Physical and Economic Summary Tables originally submitted as Tab 6 Attachment 11 (Tab6-A-11_IRWD-Physical and Economic Benefits Summary Tables_FINAL.xlsx)
6. Ecosystem Priority Worksheet – General Info Worksheet originally submitted as Tab 4 Attachment 1 (Tab4_A1_IRWD_Ecosystem_GeneralInfo_FINAL.pdf)
7. Ecosystem Priority 2 Worksheet originally submitted as Tab 4 Attachment 1 (IRWD_Tab 4_Attach 1_Priority 2_FINAL.pdf)
8. Ecosystem Priority 14 Worksheet originally submitted as Tab 4 Attachment 1 (IRWD_Tab 4_Attach 1_Priority 14_FINAL.pdf)

9. Thomas Harder & Co. Analytical Model for Groundwater Level Benefits - NOT submitted with original Application
10. Supplemental Information Related to Other Benefits Not Quantified
    a. Cramer Fish Sciences Technical Memorandum: Steelhead Benefits from Kern Fan Groundwater Storage Project
    b. M.Cubed Spreadsheet quantification support for Steelhead Benefits
    c. Supplemental Ecosystem Priority 2 Worksheet Revised for Steelhead Benefits
    d. Benefit and Cost Analysis Spreadsheets originally submitted under Tab 6 Attachment 9 (Tab6-A9-A10_IRWD_Benefit-Cost_Analysis_Cost_Allocation.xlsx) updated to include steelhead benefit.

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

APPENDIX A:

MBK ENGINEERS TECHNICAL MEMORANDUM

Analysis of Kern Fan Groundwater Storage Project for Water Storage Investment Program

FEBRUARY 23, 2018

Water Resources ◆ Flood Control ◆ Water Rights

TECHNICAL MEMORANDUM

DATE:	February 23, 2018
TO:	Paul Weghorst, Fiona Sanchez, and Natalie Palacio of Irvine Ranch Water District
PREPARED BY:	Lee Bergfeld, P.E., and Shankar Parvathinathan, P.E., of MBK Engineers
SUBJECT:	Analysis of Kern Fan Groundwater Storage Project for Water Storage Investment Program

Introduction

This technical memorandum presents information on the numerical modeling analysis for the Kern Fan Groundwater Storage Project (Project) in support of a grant application for the Water Storage Investment Program (WSIP). The Project will recharge and store up to 100,000 acre-feet (af) of water from the Sacramento-San Joaquin Delta (Delta), when available. The Project will provide both public and non-public benefits by storing additional water in the aquifers that underlie the Kern River Fan in wet years, and by extracting water in dry years, to provide both ecosystem and water supply benefits. This technical memorandum has been updated to address comments from California Water Commission (CWC) staff after their public benefit ratio review. CWC staff comments are included in the CWC's February 1, 2018 letter.

Project Operations Overview

The Project will operate by recharging and storing water supplied by the State Water Project (SWP) from the Delta, under the Article 21 Program. Article 21 water is available, in accordance with long-term Water Supply Contracts, for State Water Contractors that have signed the Monterey Amendment. Article 21 water is available when there is water in excess of SWP needs. This typically occurs in wet years when precipitation and runoff in the Delta watershed exceed long-term averages. Article 21 water will be delivered to the Project utilizing available capacity in the California Aqueduct and the Cross Valley Canal. The Project includes 400 cubic feet per second (cfs) of dedicated conveyance capacity to move water in either direction between the Project spreading basins and the Cross Valley Canal.

The Project also includes approximately 1,200 acres of spreading basins, with a recharge rate of approximately 13,000 to 26,000 af per month, depending on antecedent conditions, and an extraction capacity of 45,000 af per year. Project storage capacity will be split between accounts for public benefits (25,000 af), Irvine Ranch Water District (IRWD) (37,500 af) and Rosedale-Rio Bravo Water Storage District (Rosedale) (37,500 af). Water will be stored in the Project based on the percent of capacity dedicated to each account, i.e., 37.5% to IRWD, 37.5% to Rosedale, and 25% to public benefits.

The Project will be operated to provide both public and non-public benefits. An overview of operations to provide each type of benefit is provided in the following sections.

Operations for Public Benefits

Water can be withdrawn from the Project to provide multiple benefits. The Project can be integrated with Oroville Reservoir operations because water stored in the Project can be extracted and delivered to the California Aqueduct to meet a portion of SWP Table A demands that would otherwise be met with water released from Oroville Reservoir and exported from the Delta at Banks Pumping Plant. An operational agreement with the Department of Water Resources (DWR) will allow the Project to integrate with Oroville operations to provide public benefits.

Under the operational agreement, DWR will release short-term pulse flows (Ecosystem Pulse) from Oroville, in April or May, to improve habitat conditions for rearing, downstream migration of spring and fall-run Chinook, and benefits to other fish species. Ecosystem Pulses are expected to improve conditions in the Feather River, downstream of Oroville Dam, and the Sacramento River, from the confluence with the Feather River through the Delta. DWR will make Ecosystem Pulses when water is available in the Project's public benefits account. The magnitude and duration of the Ecosystem Pulse will be determined based on the volume of water available in the Project and the expected fisheries benefit. The Project will target making Ecosystem Pulses in drier years when Oroville Reservoir will not make flood control releases.

After making an Ecosystem Pulse, water in storage in Oroville Reservoir will be lower by the volume of the pulse. However, the Project will be providing water to meet SWP demands in the export service area, thereby providing a means to "recover" storage in Oroville. Oroville storage will recover by reducing releases to support demands in the export service area, typically in the July through September period. Under this operation, Oroville carryover storage at the end of September is expected to be essentially the same as without the Project.

Figure 1 illustrates the Project's effects on Oroville Reservoir storage and flows in the Feather River for an example year, from April through September.

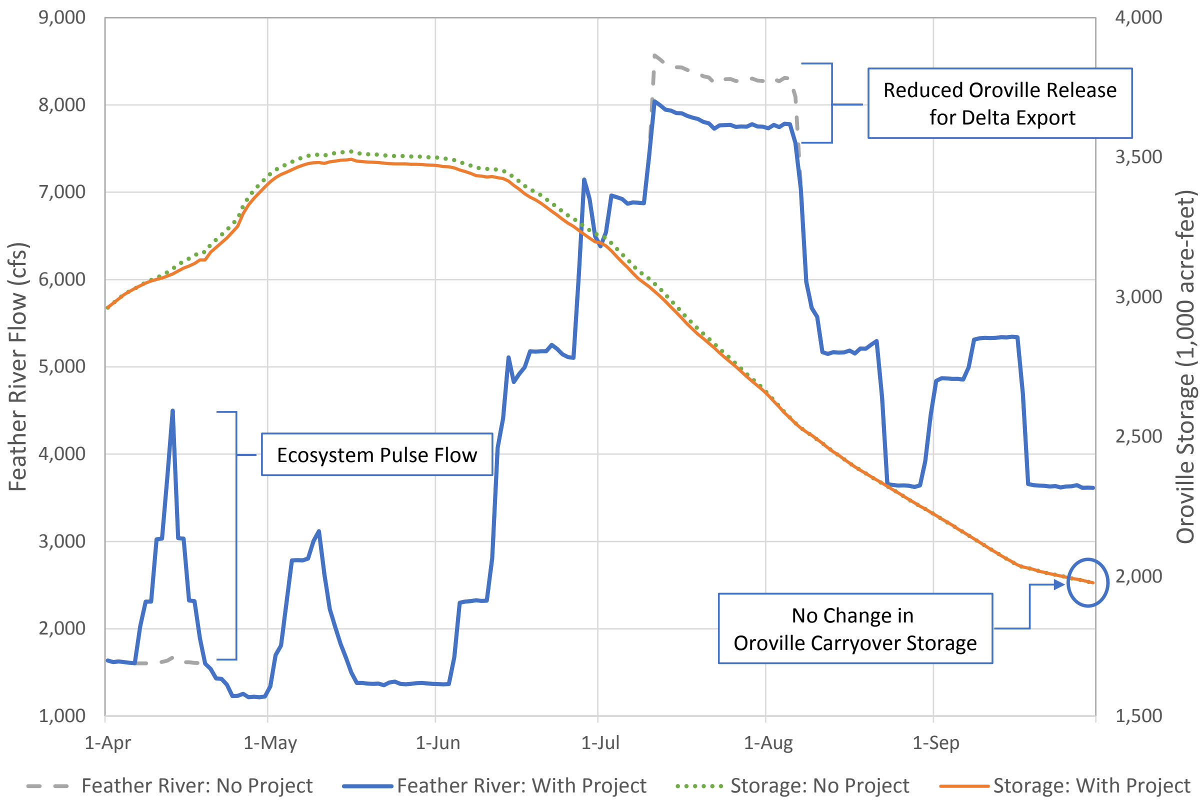


Figure 1. Example of Project Public Benefits through Integration with Oroville Reservoir

Once it is determined that an Ecosystem Pulse will be made, the Project will begin extracting water from the public benefits account for delivery back to the California Aqueduct and SWP Table A contractors. This will likely begin shortly before or after the Ecosystem Pulse is released from Oroville. Water extracted from the Project will replace SWP water that would otherwise be provided from San Luis Reservoir. Therefore, water provided by the Project can essentially be stored in the SWP portion of San Luis Reservoir and will increase storage in San Luis compared to a without-project condition. SWP storage in San Luis will also be affected by a reduction in Banks pumping expected to occur when Oroville release is reduced for a short period in the July through September period. Immediately following this period of reduced Banks pumping, SWP storage in San Luis may be lower than under a without-project condition. Project extraction will continue until the volume of Ecosystem Pulse has been extracted and SWP San Luis storage has returned to the same level as it would have originally been, absent the Project.

Figure 2 illustrates the potential start and end dates for Project extraction from the Public Benefits account, and the Project's effects on storage in SWP San Luis and Banks pumping for an example year, from April through November.

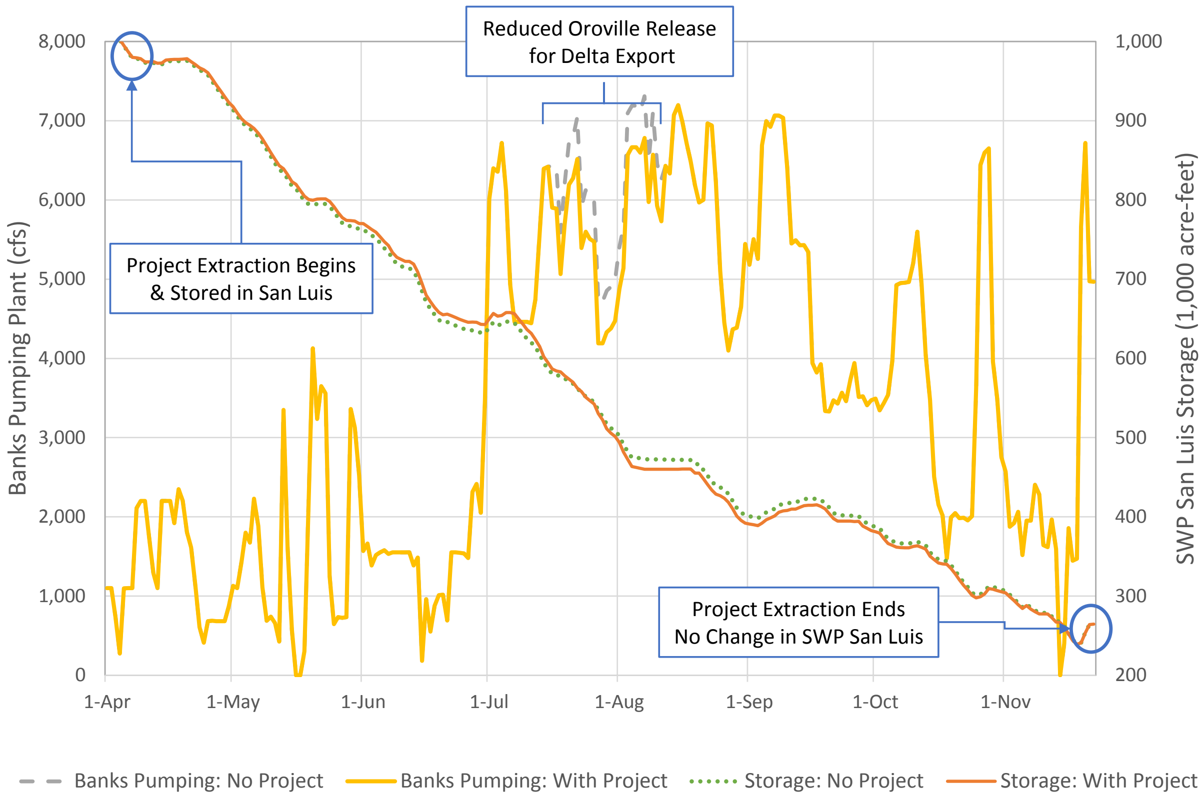


Figure 2. Example of Effect of Project Operations on SWP San Luis Reservoir and Banks Pumping

Operations for Non-Public Benefits

Water stored in accounts for IRWD and Rosedale provides a water supply benefit for these two agencies. These deliveries would be made on behalf of IRWD as a landowner in Dudley Ridge Water District (DRWD) and Rosedale as a sub-unit of the Kern County Water agency. IRWD will physically extract water from the Project for delivery during years of reduced available supply from other sources in their supply portfolio; these may include years of below average SWP Table A allocations. Rosedale will manage water stored in the Project account as another source in their water supply portfolio.

Analytical Approach

The analytical approach involves the use of CalSim II model results to depict the without-Project (Baseline) scenario. The CalSim II model simulates operations of Central Valley Project (CVP) and SWP in order to meet existing environmental and regulatory requirements, contract obligations, and other system requirements. The operation of the Project is then simulated in a spreadsheet model that layers the Project onto the Baseline operation of the CVP and SWP as simulated in CalSim II. The spreadsheet model simulates the with-Project scenario. The Project benefits and effects are then determined and quantified by comparison of the with-Project and without-Project scenarios.

The Baseline scenario for this analysis is the WSIP 2030 CalSim II model dated November 2, 2016, and available from the WSIP website. This model simulation is described as a without-project, 2030 future condition with projected climate and sea-level conditions for a thirty-year period centered at 2030. The Project scenario is simulated using a spreadsheet operations model which operates on a monthly time-step similar to CalSim II for the period October 1921 through September 2003 and utilizes CalSim II baseline depiction of CVP/SWP operations.

Study Area

While the project is located in Kern County, effects of the Project extend to the Delta for the source of water and upstream on the Feather River for ecosystem benefits. Additionally, water supply developed by the Project may be delivered within the SWP service area.

The Project is expected to affect the following locations:

1. Delta outflows
2. SWP Delta exports
3. Flows in Feather and Sacramento rivers and inflows to Delta
4. Storage in Lake Oroville
5. Storage in San Luis Reservoir
6. Water supplies for IRWD, DRWD, and Rosedale

Spreadsheet Model Assumptions

The spreadsheet model calculates the water supply available to the Project as additional Article 21 available from the Delta. The CalSim II Baseline simulation include existing Article 21 demands and deliveries. The spreadsheet model simulates the additional Article 21 demand of the Project and the associated increase in SWP Delta exports. Additional Article 21 deliveries to the Project are simulated when there is:

a. Available surplus in the Delta in excess of the existing regulatory requirements and demands
b. Available export capacity at Banks Pumping Plant
c. The SWP portion of San Luis Reservoir is full in the Baseline

The spreadsheet model simulates the additional Article 21 export from the Delta at times when there is available capacity in the California Aqueduct to convey the water to the Project and recharge the water based on Project recharge capacity. There is an estimated conveyance loss of 3 percent between the Delta and the Project.

Water is simulated as stored in the Project in each of the three accounts: public or ecosystem, IRWD, and Rosedale. Water stored in each account is subject to a loss percentage of 10% for Rosedale, 12.5% for ecosystem, and 15% for IRWD. These losses include an estimated 6% loss for evaporation. Project recharge rates are simulated as a function of recharge in preceding months based on information provided by IRWD (Figure 3).

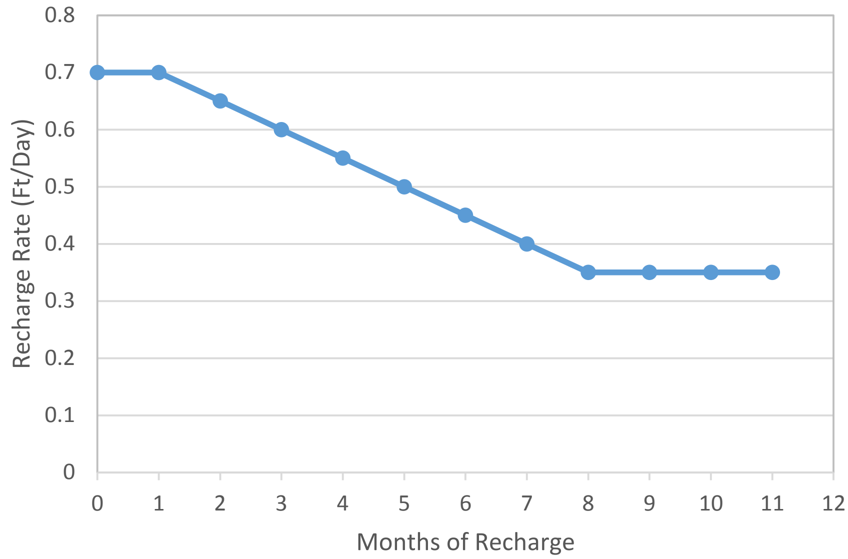


Figure 3. Project Recharge Rate

Water is extracted from the Project to provide both public and non-public benefits. Public benefits are achieved when the volume of water stored in the public benefits or ecosystem account is adequate to provide an Ecosystem Pulse flow of sufficient magnitude to create benefits. A volume of 18 thousand acre-feet (TAF), or 300 cfs for a period of one month, was assumed in the spreadsheet model as the threshold to create ecosystem benefits. Additionally, this volume is increased by Delta carriage[1] water costs that are saved in the year the Ecosystem Pulse is released. The reduced carriage water costs are a benefit of the Project, because Project water was exported during periods of Delta surplus with no carriage water cost and stored in the export service area. The spreadsheet model assumes 20 percent carriage water and the 3 percent conveyance loss can be saved when extracting water from the Project for delivery within the export service area instead of meeting those demands from Oroville Reservoir.

The spreadsheet model simulates water is extracted from the Project for water supply benefits to Rosedale and IRWD based on SWP Table A allocations, with more water extracted when Table A allocations are lower.

Available Water Supply

This section presents a summary of available Article 21 water supply for the Project. Figure 4 shows a summary of available Article 21 supply by water year type (Sacramento Valley Year Type Index) at the Project based on WSIP 2030 CalSim II modeling results. This available supply

[1] Carriage water is defined as marginal export costs, or the extra water needed to carry a unit of water across the Delta to the CVP and SWP pumping plants in the South Delta while maintaining a constant salinity. Or more practically, when the exports are increased by one unit, the Sacramento flow is increased by one unit plus the amount of carriage water to maintain a constant Delta salinity. In other words, carriage is the water cost of Delta exports when salinity standards are controlling.

is calculated by considering constraints on available Banks pumping capacity, conveyance capacities in the California Aqueduct, and capacity to convey water from the California Aqueduct to the Project, and conveyance losses.

On an average annual basis, available Article 21 supply at the project diversion from the California Aqueduct is 8 TAF with most of the supply available during Wet years. There is no Article 21 supply during Dry and Critical years. Figure 5 shows a summary of Article 21 supply by month. March shows the greatest supply of Article 21 followed by February. Article 21 is mostly available between December and May, with no supply available during the reminder of the year. Figure 6 shows available supply on an annual basis. As stated earlier, most of the water supply is available during Wet years and in a few Above Normal and Below Normal years. There is no water supply for the Project during Dry and Critical years.

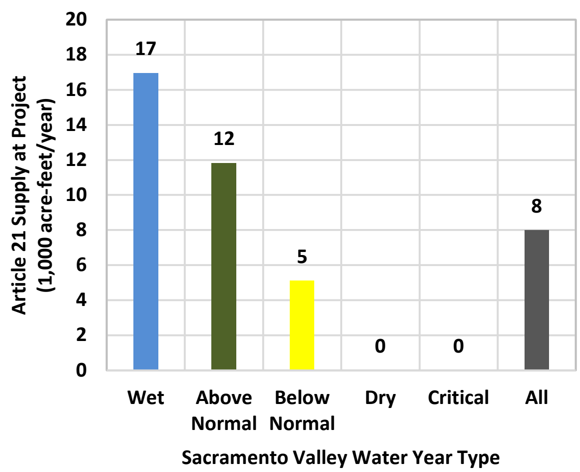


Figure 4. Available Article 21 Supply at Project by Sacramento Valley Water Year Type

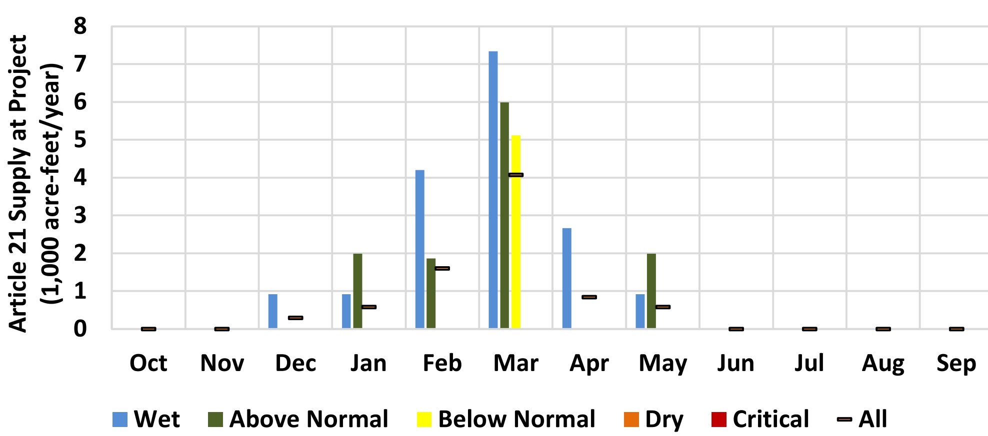


Figure 5. Average Monthly Available Article 21 Supply at Project

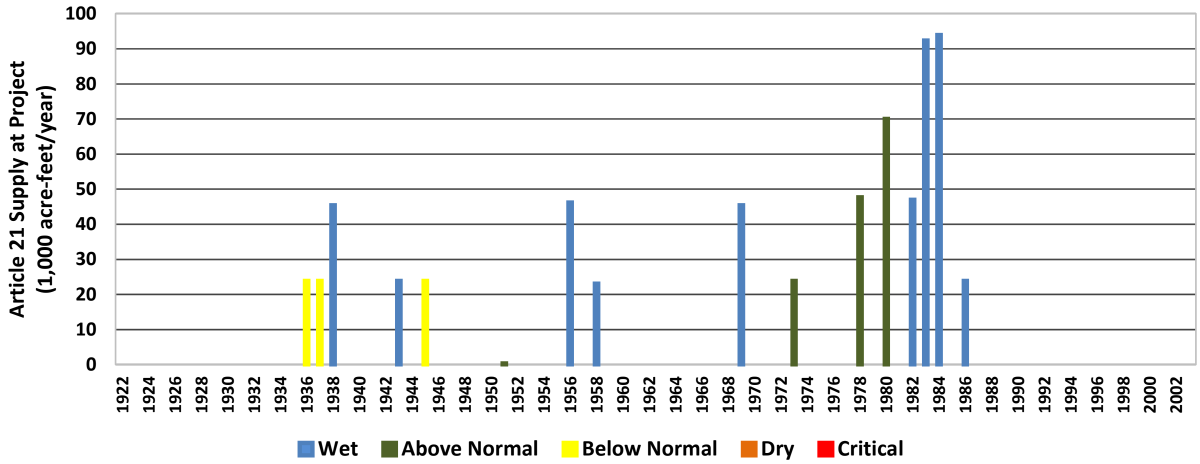


Figure 6. Annual Time-Series of Available Article 21 Supply at Project

Results

This section summarizes the results for the Project operations based on a comparison of Baseline and with-Project results. Results are presented as the change from Baseline operations to quantify the effects of the Project. Results also include the potential benefits of the Project related to emergency response to an event that disrupts water supply operations in the Delta (Delta event).

Table 1 presents a summary of the Project performance. Of the 8 TAF average annual flow available at the California Aqueduct, Project recharge is approximately 4.4 TAF and occurs primarily in Wet and Above Normal years. This water is stored in the Project and extracted to provide public and non-public benefits. Under 2030 WSIP conditions, the Project could provide seven pulse releases from Oroville Reservoir over the 82-year period analyzed, and provide an average annual ecosystem water supply of 1.5 TAF. This includes 1.2 TAF of Project extraction from the ecosystem account, a 23% savings in carriage and conveyance losses that is available upstream of the Delta as a result of the Project, and a 0.2 TAF reduction in Oroville flood control releases. Local water supply benefits are 2.7 TAF annually, with 1.3 TAF for IRWD and 1.4 TAF for Rosedale.

Table 1. Summary of the Project Performance

Year Type	Project Recharge (TAF)	Number of Pulses (Years)	Ecosystem Water Supply (TAF)	IRWD Water Supply (TAF)	Rosedale Water Supply (TAF)
Wet	7	0	0	0	0
Above Normal	9	0	0	1	0
Below Normal	5	0	0	1	0
Dry	0	5	5	2	4
Critical	0	2	3	4	4
All Years	**4.4**	**7**	**1.5**	**1.3**	**1.4**

Figure 7 shows the frequency of the Ecosystem Pulses by water year type. As noted earlier, the pulses are made during Dry and Critical years when Feather River flows are lower and pulses may create a higher potential for benefits to the ecosystem.

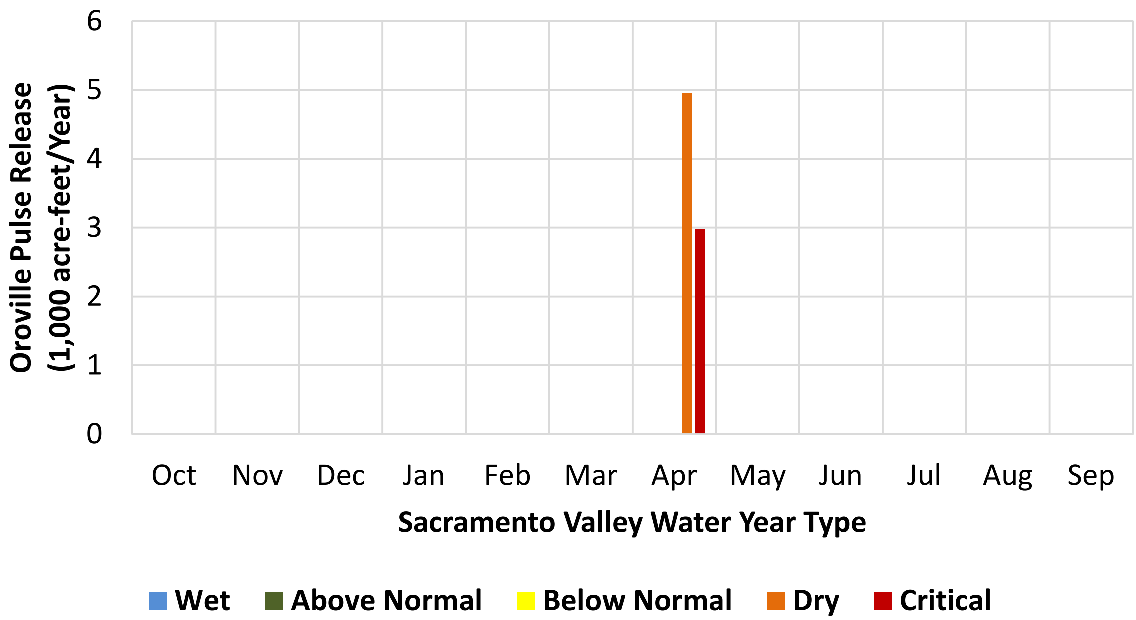


Figure 8 shows an average pulse flow rate by month. In this analysis, April was selected as the month for Ecosystem Pulses. The operations could be modified to provide Ecosystem Pulses in May, under actual operations.

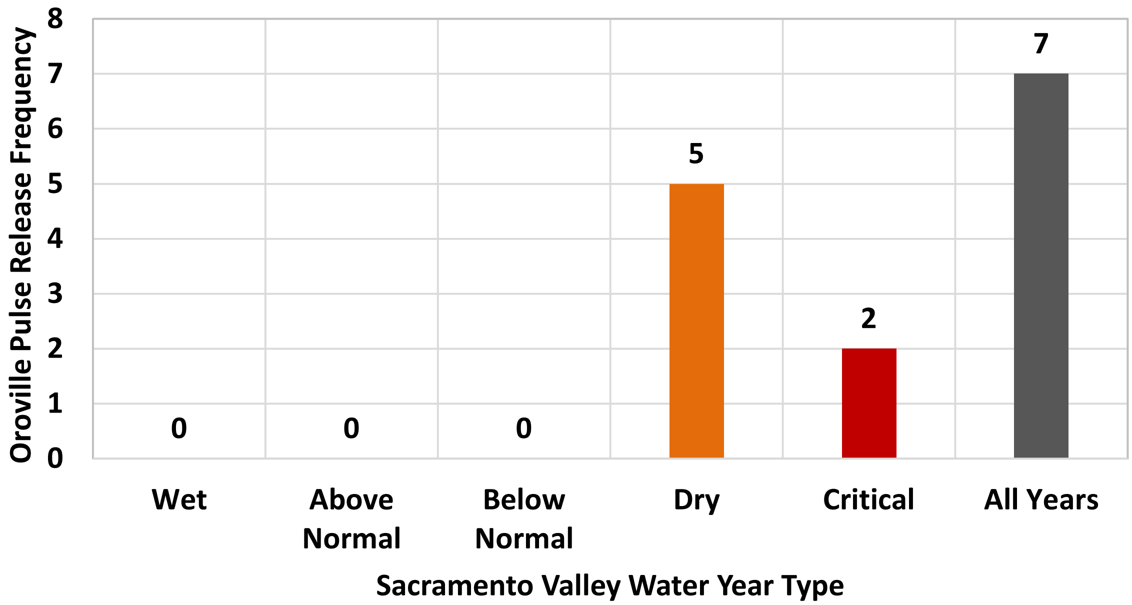


Figure 7. Frequency of Ecosystem Pulses

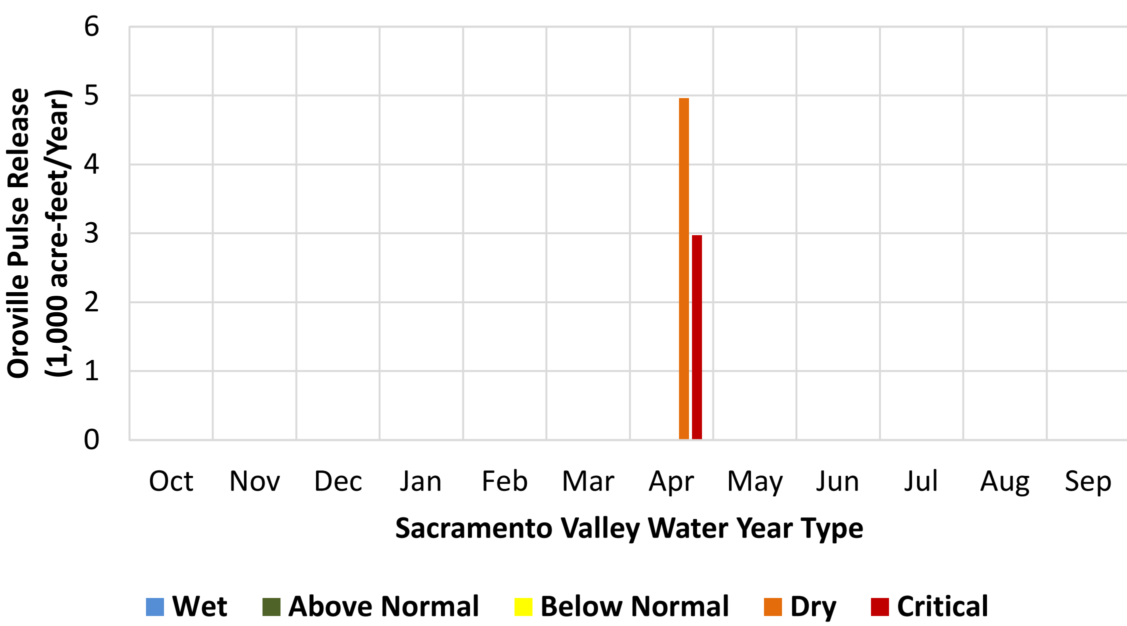


Figure 8. Pulse Release Volume

Figure 9 shows changes in Oroville Reservoir releases with the Project. Flows in the Feather River are higher under the Project conditions during April when Ecosystem Pulses are made from Oroville. The release of Ecosystem Pulses results in lower Oroville storage under the Project conditions after making Ecosystem Pulse releases. Storage in Oroville would be recovered in later months by reducing releases from Oroville when Feather River flows are in excess of the minimum instream flow requirements and Oroville is releasing water to support SWP Delta exports. Oroville Reservoir is typically releasing water to support Delta exports in the July through September period. Oroville releases are reduced in this period to compensate for the Ecosystem Pulses resulting in lower Feather River flows under the Project conditions to recover the volume of the Ecosystem Pulse. Analysis in the spreadsheet model attempts to recover the Ecosystem Pulse volume in Oroville in the same year as when the pulse is made, such that Oroville carryover storage is not affected. In actual operations, it may be possible to develop an operational plan that would pre-deliver water into Oroville in other years, such that Oroville storage is increased, as compared to Baseline, prior to making the Ecosystem Pulse release.

Figure 9 also shows a reduction in Oroville Reservoir releases in February. In most years, the reduction of Oroville Reservoir release occurs in July following release of Ecosystem Pulse in April, with the exception of in 1976. In 1976, the Ecosystem Pulses are made in April and Oroville storage remains lower under the Project conditions until the next available opportunity to refill the reservoir, which comes in February of 1978, when the reservoir releases are reduced to compensate for Ecosystem Pulses released in April 1976. Thus, Oroville Reservoir releases are lower in February 1978 under the Project conditions, as compared to the Baseline. Simulated changes in Oroville release are expected to create the same change in Feather River flows below Oroville and Sacramento River flow from the confluence with the Feather into the Delta.

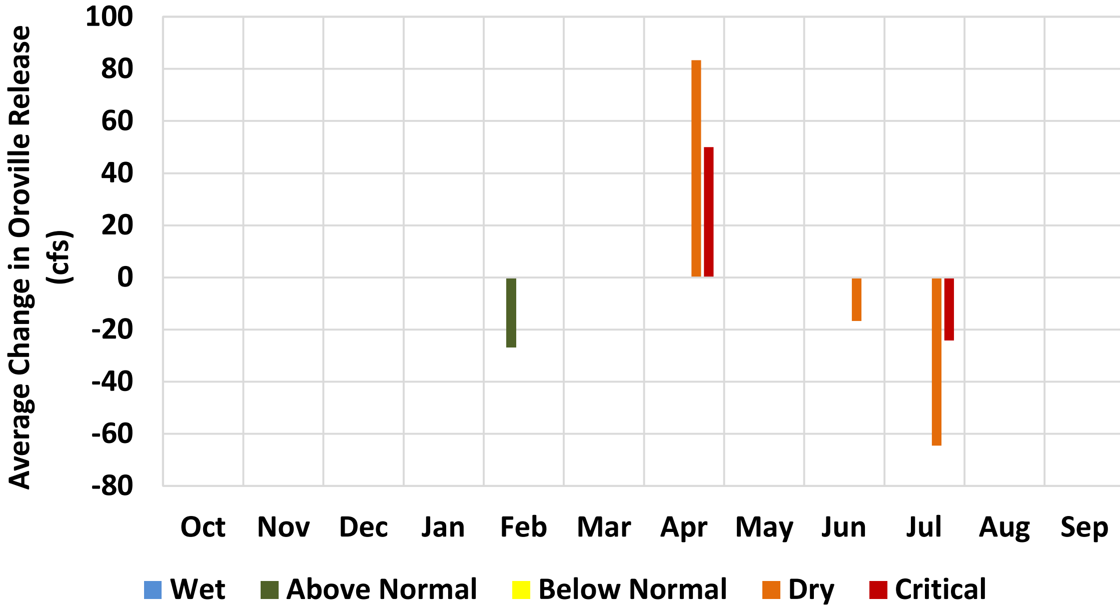


Figure 9. Change in Oroville Releases

An important consideration in evaluation of the pulse flow operation is whether Table A allocations to project participants are adequate to offset the volume of the Feather River pulse flow. The spreadsheet model ensures that pulse flows are not released when Table A allocations to project participants are not adequate to provide the needed offset in Table A deliveries. Additionally, Project extraction capacity must be available to extract water to offset Table A deliveries in years when pulse flows are released. Therefore, less water is extracted for water supply benefits to Rosedale and IRWD when Table A allocations are above the threshold for pulse flows, and more water is extracted for water supply when Table A allocations are not adequate to support a pulse flow. While the total volume of the pulse flow is 18 TAF, the volume of the pulse flow includes the avoided losses for moving Table A water from Oroville to Kern County. As described above, the spreadsheet model includes Delta carriage water losses of 20% and conveyance losses of 3%. Therefore, 23% of the pulse flow volume is avoided losses and the remaining 13,860 acre-feet is offset Table A delivery in Kern County.

Project participants have contracts for a maximum Table A volume of 41,350 acre-feet for Dudley Ridge Water District and 29,900 acre-feet for Rosedale-Rio Bravo Water Storage District, for a maximum volume at 100% Table A allocation of 71,250 acre-feet. Therefore, the minimum Table A allocation needed to offset 13,860 acre-feet is approximately 20% (13,860 of Table A offset divided by 71,250 of Table A contract). The following table shows the year of the simulated pulse flow, the final Table A allocation from the WSIP 2030 CalSim II model, and the volume of Table A water allocated to project participants.

Table 2. Pulse Flow Years and SWP Table A Supplies

Pulse Flow Year	Table A Offset Volume (TAF)	SWP Table A Allocation (% Contract)	Project Participant Table A Allocation (TAF)
1939	13.9	100%	71.3
1944	13.9	29%	20.7
1960	13.9	55%	39.3
1976	13.9	71%	50.7
1981	13.9	81%	57.4
1985	13.9	79%	56.4
1988	13.9	23%	16.6

Results in Table 2 show that project participants would be allocated more than the 13,860 acre-feet of Table A offset needed to support the associated pulse flow volume in each year.

Figure 10 shows changes in Delta outflows under the Project conditions. Delta outflows are greater during April of Dry and Critical years under the Project condition when Oroville is making Ecosystem Pulses. Ecosystem Pulses in April and May of Dry and Critical years are expected to increase Delta outflow because Delta exports are typically constrained in these months by regulatory requirements such as San Joaquin River inflow-to-export ratio or Old and Middle River flow requirements. Delta outflows can be lower in January through May of Below Normal and wetter years when Delta outflow is diminished either due to capture of Article 21 surplus water for the Project or due to a reduction in Oroville releases. Figure 11 presents a similar plot, showing change in SWP Delta exports under the Project conditions. SWP Delta exports are typically greater under Project conditions, as surplus flows are captured at the export pumps and delivered to the Project. SWP Delta exports show a reduction in Dry and Critical years as compared to the Baseline due to a reduction in Oroville releases.

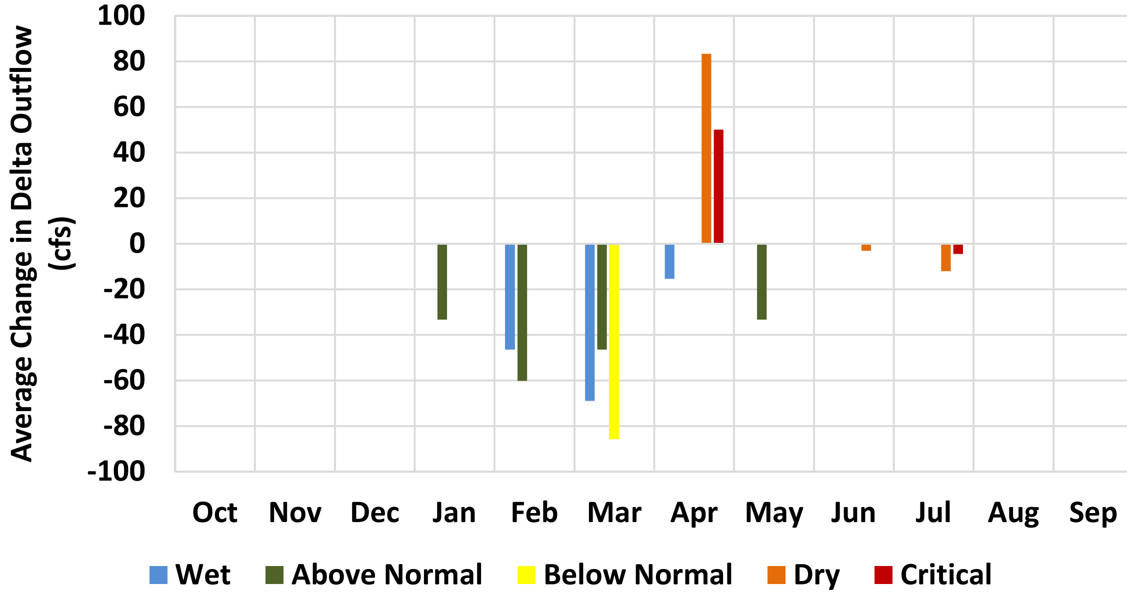


Figure 10. Change in Delta Outflow

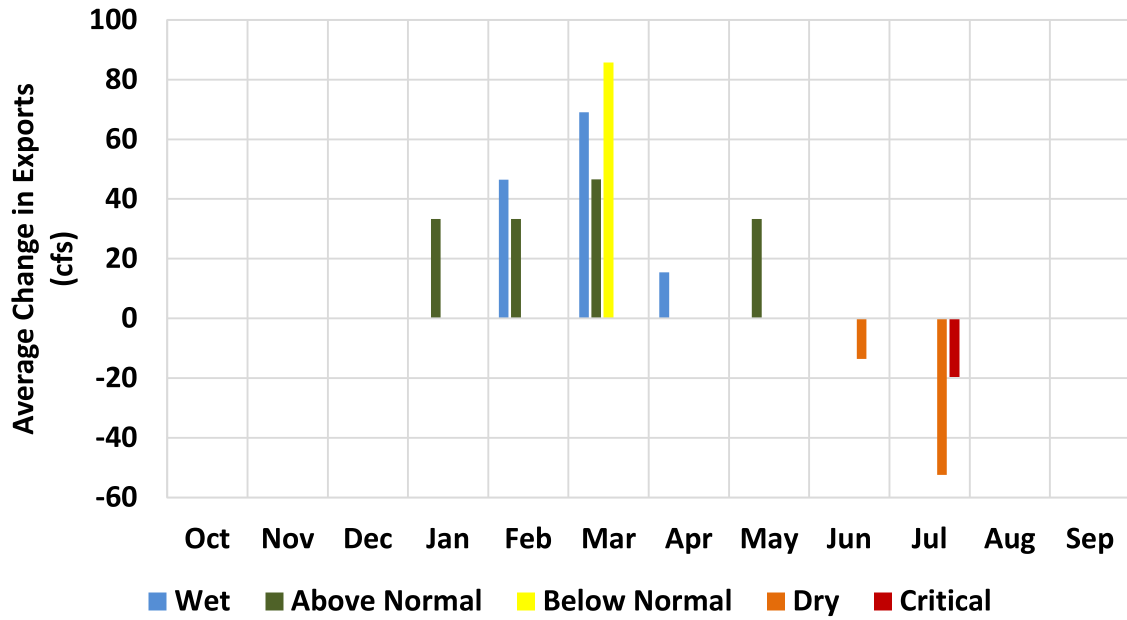


Figure 11. Change in SWP Delta Exports

Figure 12 shows end of October storage in the Project by water year type. On an average annual basis, Project storage is 38 TAF at the end of October. Project storage varies significantly by year type, from 54 TAF in Wet years to 11 TAF in Critical years. Higher storage in Wet years is expected, as it corresponds to periods where Article 21 water is available. Project storage during a Dry or Critical year is water carried over from previous years. Overall, Project storage is dependent on water supply, demand, and operations. Project storage at the end of October may be an indication of potential water available as an emergency supply for IRWD, Rosedale, or for other purposes.

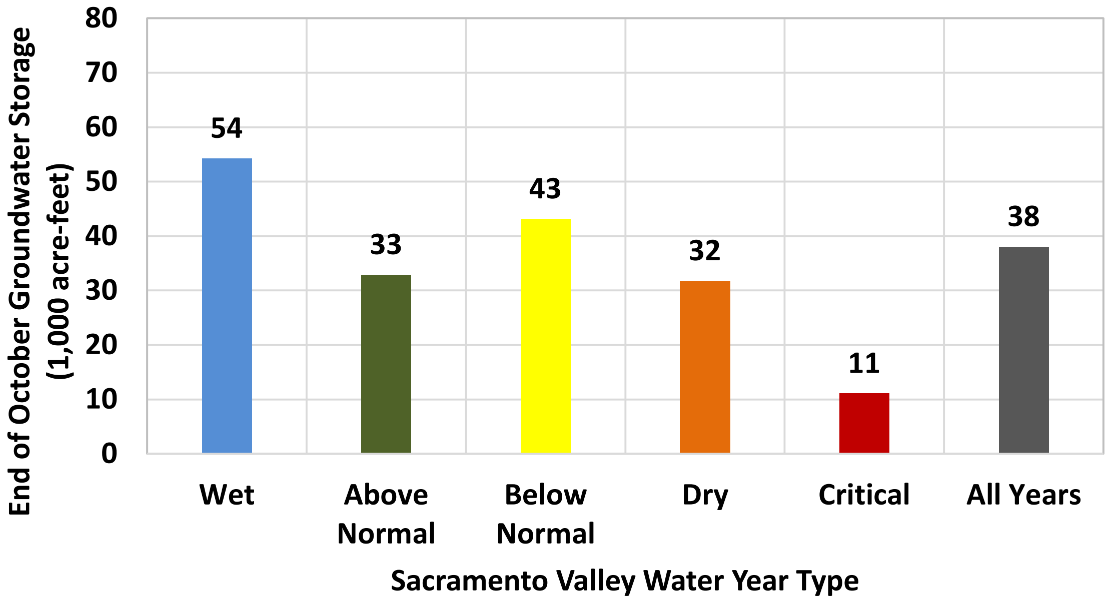


Figure 12. End of October Project Groundwater Storage

Emergency Response Benefits

The WSIP technical guidance document provides directions for analysis of emergency response benefits of potential Projects. WSIP technical guidance states that for an event in the Delta that disrupts water supply operations (Delta event), applicants should assume a single event that occurs 30 years into the Project operation period. Applicants must also show how the emergency response operation affects the Project's normal operations and benefits in years following the event.

The Project can provide emergency response benefits by storing water south of the Delta that can be extracted and made available after a Delta event. The probability of water being stored in the Project in any year is one measure of potential emergency response benefit. Figure 13 shows the probability of exceedance for the end of October Project storage in the combined three accounts. A marker at approximately 23.5 TAF, corresponding to an exceedance probability of approximately 55 percent, shows the simulated Project storage 30 years into the Project operation period.

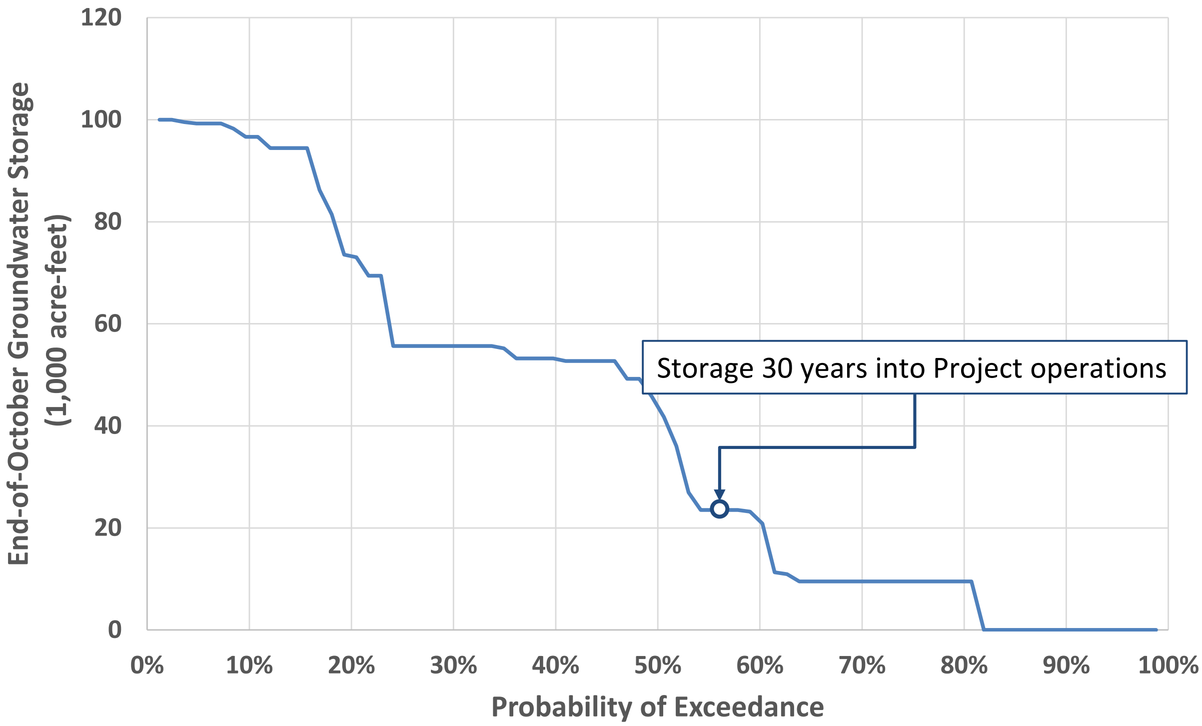


Figure 13. Probability of Exceedance for End of October Project Groundwater Storage

As illustrated in Figure 13, Project storage is 23.5 TAF 30 years into the Project operation period. Water in storage in each account is 8.5 TAF in the ecosystem account, 7.9 TAF in the IRWD account, and 7.2 TAF in the Rosedale account. In response to a Delta event at this time, it is assumed the entire 23.5 TAF could be available for emergency response benefits over a period of approximately six months using the Project extraction capacity of 3.8 TAF per month.

The effect of emergency response operations on the Project performance was evaluated by simulating extraction of 23.5 TAF at 30 years into the Project operation and then comparing the results for Project operations without the emergency response operations. There is a marginal reduction in water supply benefits to IRWD and Rosedale by approximately 0.1 TAF/year, but results reported in Table 1 reflect the extraction of water for emergency response.

Uncertainty Analyses

This section presents uncertainty analyses related to potential future (WSIP 2070) climate change, including Project performance during critical droughts, and the California WaterFix. Uncertainty analyses were performed using the same technical approach as analysis at the future 2030 level wherein a CalSim II baseline was used to represent the without-project scenario and serve as an input to the spreadsheet model to simulate the with-project scenario. The spreadsheet model has the capability to post-process CalSim II model results for simulations that include California WaterFix to determine availability of additional Article 21 for the Project.

Climate Change

Climate change analysis is performed using the WSIP 2070 CalSim II model that reflects future climate and sea level conditions in the year 2070. Table 3 presents a summary of the Project performance under 2070 climate change conditions. Results are presented as average annual Project operations under a 2070 conditions by Sacramento Valley Year Type Index. The final row of the table "Change" represents the change in Project performance from the 2030 condition, presented in Table 1. With climate change, Project benefits increase slightly, though the frequency of Ecosystem Pulses is reduced. Average annual recharge is increased by 0.1 TAF as compared to 2030 conditions. The frequency of Ecosystem Pulses is reduced from seven years under 2030 conditions, to five years under 2070 climate conditions. Water supply benefits also increase by approximately 0.3 TAF (12%) on an average annual basis. Though Project performance changes with climate conditions, as depicted in the WSIP 2070 baseline, it is similar to the expected performance in 2030. The Project is still able to provide both public and non-public benefits under the assumed, future climate change.

Table 3. Summary of the Project Performance under WSIP 2070 Climate Change

Year Type	Project Recharge (TAF)	# of Pulses (Years)	Eco. Water Supply (TAF)	IRWD Water Supply (TAF)	Rosedale Water Supply (TAF)
Wet	9	0	0	0	0
Above Normal	11	0	0	1	0
Below Normal	0	0	0	1	1
Dry	0	4	5	4	6
Critical	0	1	1	2	1
All Years	**4.5**	**5**	**1.3**	**1.5**	**1.5**
Change	**+0.1**	**-2**	**-0.2**	**+0.2**	**+0.1**

Project Performance during Drought

Section 10 of the WSIP Technical Reference document, requires that applicants assess the volume of water stored in a Project at the beginning and end of a five-year drought that may be used for public benefits, under the 2070 condition. In the period of analysis, the most significant five-year or longer droughts occurred from 1929 through 1934, and 1987 through 1992. This section presents a discussion on Project performance during these two drought sequences.

In the model simulation period of 1921-2003, Article 21 water is available for the first time in the year 1937. Therefore, Project storage is zero at the beginning of the drought in 1929 as there is no water stored prior to the drought and the conditions remain unchanged as there is no water available for recharge during the 1929-1934 drought.

Figure 14 shows an annual time series plot of the groundwater storages, recharge and pumping for the drought sequence beginning in water year 1987. Figure 14 shows there is no recharge of Article 21 water during the drought; however, Project storage at the beginning of this drought is nearly 100 TAF due to carryover from previous years. Stored water is pumped out of the ground from the IRWD account, and is exchanged out from the Rosedale account, for water supply in the first six months of this drought, and extracted again in 1988 from the environmental account after making an Ecosystem Pulse in 1988. Storage gradually declines to approximately 9.5 TAF by the end of 1988. Approximately 9.5 TAF remains in the Project's ecosystem account throughout the drought period because the volume of stored water is not adequate to initiate another Ecosystem Pulse release from Oroville for fishery benefits.

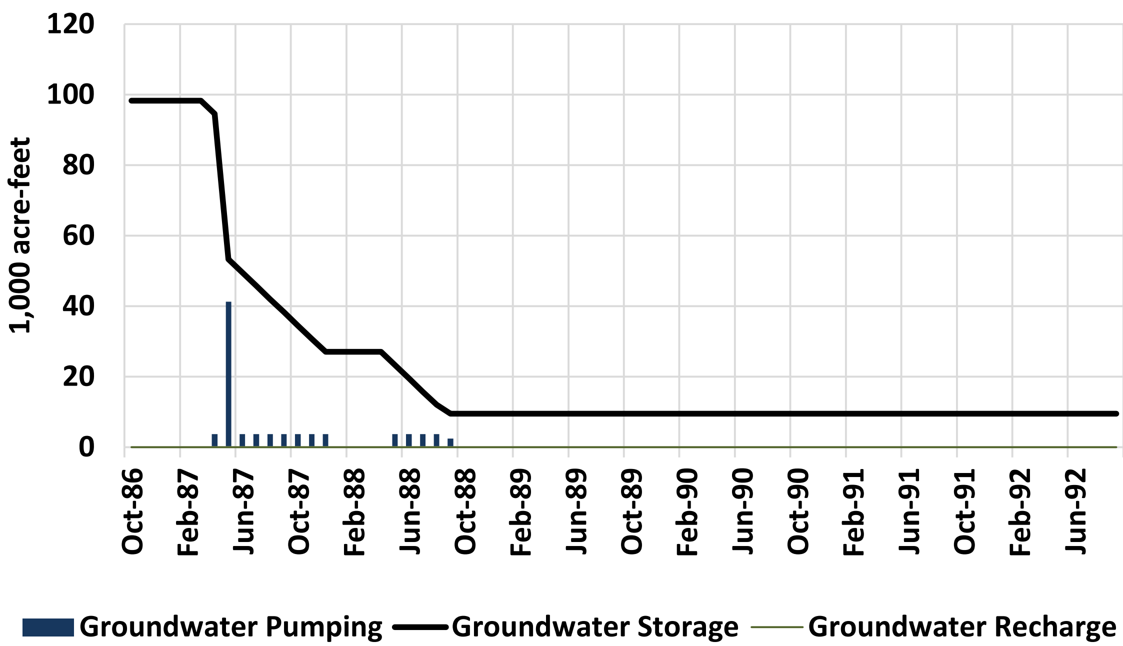


Figure 14. Performance of the Project during 1987-1992 Drought

Figure 15 shows a comparison of recharge and pumping for the three different Project accounts for this six-year period. During this drought, there is pumping of water from the environmental account to support an Ecosystem Pulse release from Oroville in 1988. After the pulse release and pumping, approximately 9.5 TAF of stored water is available for public benefits during this drought sequence. Additionally, the Project provided an average of 12.4 TAF of water supply benefits to IRWD and Rosedale over the six-year drought.

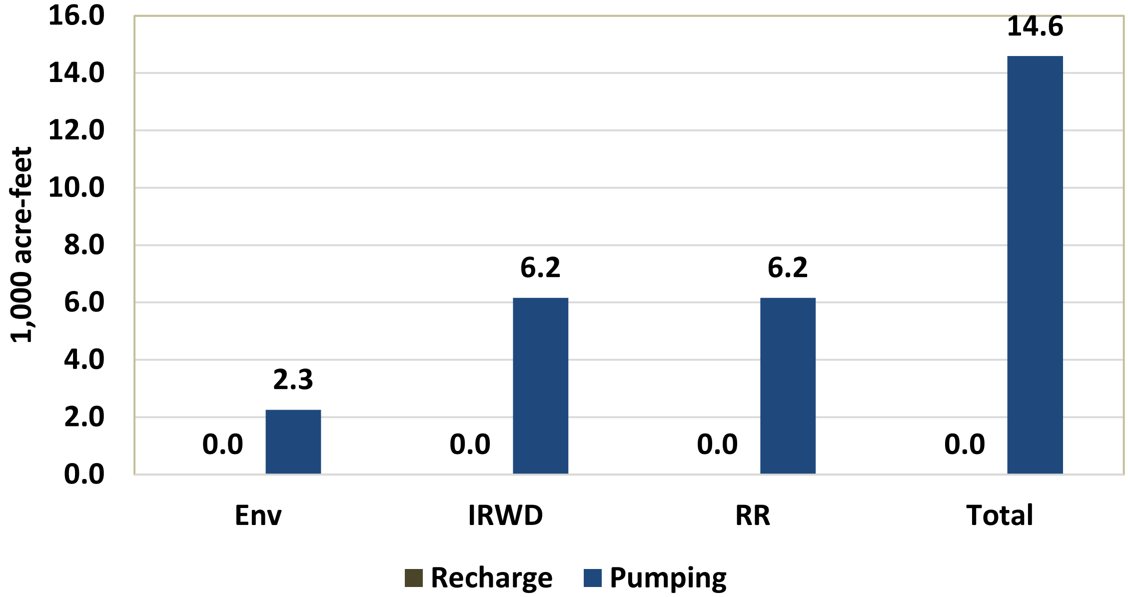


Figure 15. Annual Summary of the Project Yield during 1987-1992 Drought

The Project provides emergency supply, public benefits for both a Delta outage emergency and prolonged drought. Table 4 is a summary of these public benefits.

Table 4: Summary of Emergency Supply Public Benefits

Emergency	Public Benefit (TAF)
Delta Outage	23.5
Drought	9.5

California WaterFix

This section summarizes results from the sensitivity analysis performed to assess Project performance with California WaterFix (CWF). For this analysis, CalSim II models developed by

DWR and Reclamation for the Biological Assessment for CWF were used. The DWR CWF CalSim II models include 2025 Early Long Term (ELT) climate change assumptions that differ from the WSIP 2030 climate change assumptions. Therefore, it is not appropriate to compare Project performance based on a WSIP 2030 model baseline to Project performance based on a DWR ELT model baseline. In order to provide a proper comparison of the potential Project performance, Project operations were first simulated using the DWR ELT without CWF baseline. Table *5* shows a summary of the Project performance under DWR ELT model without WaterFix.

Table 5. Summary of the Project Performance under DWR ELT without CWF

Year Type	Project Recharge (TAF)	Number of Pulses (Years)	Ecosystem Water Supply (TAF)	IRWD Water Supply (TAF)	Rosedale Water Supply (TAF)
Wet	8	0	0	0	0
Above Normal	6	0	0	1	0
Below Normal	3	0	0	1	0
Dry	0	5	5	2	3
Critical	0	1	1	3	3
All Years	**3.9**	**6**	**1.3**	**1.2**	**1.2**

Table 6 contains the same metrics for Project performance under DWR ELT model with CWF. Results are presented as average annual Project operations with CWF by Sacramento Valley Year Type Index. The final row of the table (Change) represent the change in Project performance from the DWR ELT without CWF condition presented in Table 5. Average annual Project recharge is approximately 6.2 TAF with CWF, 2.3 TAF greater than DWR ELT without CWF. Increases in the ability to recharge water with CWF increase the frequency of Ecosystem Pulses from six years to ten. The Project yield to IRWD is unchanged, while the Project yield to Rosedale is increased by approximately 0.3 TAF with CWF.

Table 6. Summary of the Project Performance under DWR ELT with CWF

Year Type	Project Recharge (TAF)	Number of Pulses (Years)	Ecosystem Water Supply (TAF)	IRWD Water Supply (TAF)	Rosedale Water Supply (TAF)
Wet	12	0	0	0	0
Above Normal	10	0	0	1	0
Below Normal	6	0	0	0	0
Dry	0	8	8	2	4
Critical	0	2	3	3	4
All Years	**6.2**	**10**	**2.2**	**1.2**	**1.5**
Change	**+2.3**	**+4**	**+0.9**	**0.0**	**+0.3**

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

APPENDIX B:

FIRST AMENDED MEORANDUM OF UNDERSTANDING REGARDING OPERATION AND MONITORING OF THE ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT BANKING PROGRAM

FIRST AMENDED
MEMORANDUM OF UNDERSTANDING
REGARDING OPERATION AND MONITORING
OF THE
ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
GROUNDWATER BANKING PROGRAM

This Memorandum of Understanding is entered into the Effective Date hereof by and among **ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT**, hereinafter referred to as "Rosedale", and **SEMITROPIC WATER STORAGE DISTRICT, BUENA VISTA WATER STORAGE DISTRICT, HENRY MILLER WATER DISTRICT, KERN COUNTY WATER AGENCY, KERN WATER BANK AUTHORITY, IMPROVEMENT DISTRICT NO. 4 OF THE KERN COUNTY WATER AGENCY**, and **WEST KERN WATER DISTRICT**, collectively referred to as "Adjoining Entities."

RECITALS

WHEREAS, Rosedale expects that certain real property more particularly shown on the map attached hereto as Exhibit A and incorporated herein by this reference ("Project Site"), or portions thereof, will be used in connection with the Project; and

WHEREAS, Rosedale intends to develop and improve the Project Site as necessary to permit the importation, percolation and storage of water in underground aquifers for later recovery, transportation and use for the benefit of Rosedale, all as more fully described in Exhibit B attached hereto and incorporated herein by this reference ("Project"); and

WHEREAS, Adjoining Entities encompass lands and/or operate existing projects lying adjacent to the Project Site as shown on said Exhibit A; and

WHEREAS, in recent years, water banking, recovery and transfer programs in Kern County have become increasingly numerous and complex; and

WHEREAS, it is appropriate and desirable to mitigate or eliminate any short-term and long-term significant adverse impacts of new programs upon potentially affected projects and landowners within the boundaries of Adjoining Entities; and

WHEREAS, Adjoining Entities and Rosedale desire that the design, operation and monitoring of the Project be conducted and coordinated in a manner to insure that the beneficial effects of the Project to Rosedale are maximized but that the Project does not result in significant adverse impacts to water levels, water quality or land subsidence within the boundaries of Adjoining Entities, or otherwise interfere with the existing and ongoing programs of Adjoining Entities; and

WHEREAS, on October 26, 1995, the Kern Water Bank Authority and its Member Entities, as the "Project Participants," and Buena Vista Water Storage District, Rosedale-Rio Bravo Water Storage District, Kern Delta Water District, Henry Miller Water District and West Kern Water District, as the "Adjoining Entities," entered into a Memorandum of Understanding, similar to this Memorandum of Understanding, which provided among other things at Paragraph 8 that for "any future project within the Kern Fan Area, the Parties hereto shall use good faith efforts to negotiate an agreement substantially similar in substance to this MOU," and by entering into this MOU the Adjoining Entities find that this MOU satisfies such requirement for the Project; and

WHEREAS, Rosedale intends to operate its Project such that the same does not cause or contribute to overdraft of the groundwater basin; and

WHEREAS, in connection with its environmental review for the Project, Rosedale commissioned a hydrologic balance study for a period of years, which study shows that the District is not currently operating in a state of overdraft, and, further, Rosedale has projected said hydrologic balance study into the future, assuming completion of the Project, and said projection demonstrates that the District is not expected to operate in state of overdraft following implementation of the Project, which studies have not been independently verified by the Adjoining Entities; and

WHEREAS, in the hydrologic balance studies conducted by Rosedale in connection with the Project, the annual safe yield from the groundwater basin is assumed to be .3 acre-feet per acre times the gross developed acres in the District and no assumption is included with respect to groundwater inflow or outflow; and

WHEREAS, this MOU affects the Project and other similar banking programs operated for the benefit of third parties. Conversely, this MOU does not apply to or permit any project involving the sale by Rosedale of water banked in the name of, and within the boundaries of, Rosedale to third parties for a use outside the boundaries of Rosedale.

NOW, THEREFORE, BE IT RESOLVED that, based upon the mutual covenants contained herein, the parties hereto agree as follows:

1. Project Design and Construction. Rosedale has completed a preliminary Project Description of the Project described in Exhibit B hereto representing the contemplated facilities for the Project. Said preliminary description has been reviewed by the parties hereto. The foregoing shall not be interpreted to imply consent to any aspect of any future project not described in existing approved environmental documentation. Rosedale will construct the Project consistent with such preliminary description. Any major modifications of the facilities and/or significant changes from that described in Exhibit B and in the environmental documentation for the Project will be subject to additional environmental review pursuant to CEQA and will be subject to review of the Monitoring Committee prior to implementation.

2. Project Operation. The Project shall be operated to achieve the maximum water storage and withdrawal benefits for Rosedale consistent with avoiding, mitigating or eliminating to the greatest extent practicable, significant adverse impacts resulting from the Project. To that end, the Project shall be operated in accordance with the following Project Objectives and Minimum Operating Criteria:

a. Project Objectives. Consistent with the Project description, Rosedale will make a good faith effort to meet the following objectives, which may or may not be met:

(1) The parties should operate their projects in such manner as to maintain and, when possible, enhance the quality of groundwater within the Project Site and the Kern Fan Area as shown in Exhibit C.

(2) If supplies of acceptable recharge water exceed recharge capacity, all other things being equal, recharge priority should be given to the purest or best quality water.

(3) Each project within the Kern Fan Area should be operated with the objective that the average concentration of total dissolved salts in the recovered water will exceed the average concentration of total dissolved salts in the recharged water, at a minimum, by a percentage equal to or greater than the percentage of surface recharge losses. The average shall be calculated from the start of each project.

(4) To maintain or improve groundwater quality, recovery operations should extract poorer quality groundwater where practicable. Blending may be used to increase recovery of lesser quality groundwater unless doing so will exacerbate problems by generating unfavorable movement of lesser quality groundwater. It is recognized that the extent to which blending can help to resolve groundwater quality problems is limited by regulatory agency rules regarding discharges into conveyance systems used for municipal supplies, which may be changed from time to time.

(5) All groundwater pumpers should attempt to control the migration of poor quality water. Extensive monitoring will be used to identify the migration of poor quality water and give advance notice of developing problems. Problem areas may be dealt with by actions including, but not limited to:

(a) limiting or terminating extractions that tend to draw lesser quality water toward or into the usable water areas;

(b) increasing extractions in areas that might generate a beneficial, reverse gradient;

(c) increasing recharge within the usable water area to promote favorable groundwater gradients.

(6) It is intended that all recovery of recharged water be subject to the so-called "golden rule." In the context of a banking project, the "golden rule" means that, unless acceptable mitigation is provided, the banker may not operate so as to create conditions that are worse than would have prevailed absent the project giving due recognition to the benefits that may result from the project, all as more fully described at paragraph 2(b)12 below.

(7) The Project shall be developed and operated so as to prevent, eliminate or mitigate significant adverse impacts. Thus, the Project shall incorporate mitigation measures as necessary. Mitigation measures to prevent significant adverse impacts from occurring include but are not limited to the following: (i) spread out recovery area; (ii) provide buffer areas between recovery wells and neighboring overlying users; (iii) limit the monthly, seasonal, and/or annual recovery rate; (iv) provide sufficient recovery wells to allow rotation of recovery wells or the use of alternate wells; (v) provide adequate well spacing; (vi) adjust pumping rates or terminate pumping to reduce impacts, if necessary; (vii) impose time restrictions between recharge and recovery to allow for downward percolation of water to the aquifer; and (viii) provide recharge of water that would otherwise not recharge the Kern Fan Basin. Mitigation measures that compensate for unavoidable adverse impacts include but are not limited to the following: (i) with the consent of the affected groundwater pumper, lower the pump bowls or deepen wells as necessary to restore groundwater extraction capability to such pumper; (ii) with the consent of the affected groundwater pumper, provide alternative water supplies to such pumper; and (iii) with the consent of the affected groundwater pumper, provide financial compensation to such pumper.

b. Minimum Operating Criteria.

(1) The Monitoring Committee shall be notified prior to the recharge of potentially unacceptable water, such as "produced water" from oilfield operations, reclaimed water, or the like. The Monitoring Committee shall review the proposed recharge and make recommendations respecting the same as it deems appropriate. Where approval by the Regional Water Quality Control Board is required, the issuance of such approval by said Board shall satisfy this requirement.

(2) Recharge may not occur in, on or near contaminated areas, nor may anyone spread in, on or near an adjoining area if the effect will be to mound water near enough to the contaminated area that the contaminants will be picked up and carried into the uncontaminated groundwater supply. When contaminated areas are identified within or adjacent to the Project, Rosedale shall also:

(a) participate with other groundwater pumpers to investigate the source of the contamination;

(b) work with appropriate authorities to ensure that the entity or individual, if any, responsible for the contamination meets its responsibilities to remove the contamination and thereby return the Project Site to its full recharge and storage capacity;

(c) operate the Project in cooperation with other groundwater pumpers to attempt to eliminate the migration of contaminated water toward or into usable water quality areas.

(3) Operators of projects within the Kern Fan Area will avoid operating such projects in a fashion so as to significantly diminish the natural, normal and unavoidable recharge of water

native to the Kern Fan Area as it existed in pre-project condition. If and to the extent this occurs as determined by the Monitoring Committee, the parties will cooperate to provide equivalent recharge capacity to offset such impact.

(4) The mitigation credit for fallowed Project land shall be .3 acre-feet per acre per year times the amount of fallowed land included in the Project Site in the year of calculation.

(5) The lands shown in Exhibit A may be utilized for any purpose provided, however, the use of said property by Rosedale for the Project shall not cause or contribute to overdraft of the groundwater basin.

(6) Each device proposed to measure recharge water to be subsequently recovered and/or recovery of such water will be initially evaluated and periodically reviewed by the Monitoring Committee. Each measuring device shall be properly installed, calibrated, rated, monitored and maintained by and at the expense of the owner of the measuring device.

(7) It shall be the responsibility of the user to insure that all measuring devices are accurate and that the measurements are provided to the Monitoring Committee at the time and in the manner required by the Monitoring Committee.

(8) A producer's flow deposited into another facility, such as a transportation canal, shall be measured into such facility by the operator thereof and the measurement reported to the Monitoring Committee at the time and in the manner required by such Monitoring Committee.

(9) The Monitoring Committee or its designee will maintain official records of recharge and recovery activities, which records shall be open and available to the public. The Monitoring Committee will have the right to verify the accuracy of reported information by

inspection, observation or access to user records (i.e., P.G.&E. bills). The Monitoring Committee will publish or cause to be published annual reports of operations.

(10) Losses shall be assessed as follows:

(a) Surface recharge losses shall be fixed and assessed at a rate of 3%, which includes a "safety factor" of 1% of water diverted for direct recharge. An additional surface recharge loss of 3% shall be fixed and assessed against water directly recharged which is subsequently extracted for out-of-district use. Such initial 3% loss may be modified in the future if studies acceptable to the parties demonstrate that such modification is appropriate, providing that a 1% "safety factor" shall be maintained and the total loss when directly recharged water is subsequently extracted for out-of-district use shall not exceed 6%. Notwithstanding anything to the contrary provided herein, water banked in Rosedale for or on behalf of third parties (i.e., creating a third party bank account) shall be subject to surface recharge losses calculated at 6% of water diverted for direct recharge.

(b) To account for all other actual or potential losses (including migration losses), a rate of 4% of water placed in a bank account shall be deducted to the extent that Rosedale has been compensated within three (3) years following the end of the calendar year in which the water was designated as banked at the SWP Delta Water Rate charged by DWR at the time of payment; provided further, however, that the water purchased and subtracted from a groundwater bank account pursuant to this provision shall only be used for overdraft correction within the District purchasing the water.

(c) An additional 5% loss shall be assessed against any water diverted to the Project Site for banking by, for, or on behalf of any out-of-County person, entity or organization (except current SWP Agricultural Contractors).

(d) All losses provided for herein represent amounts of water that are non-bankable and non-recoverable by Rosedale.

(11) Recovery of banked water shall be from the Project Site and recovery facilities shall be located therein. Recovery from outside the Project Site may be allowed with the consent of the District or entity having jurisdiction over the area from which the recovery will occur and upon review by the Monitoring Committee.

(12) Recovery of banked water may not be allowed if not otherwise mitigated if it will result in significant adverse impacts to surrounding overlying users. "Adverse impacts" will be evaluated using data applicable in zones including the area which may be affected by the Project of approximately five miles in width from the boundaries of the Project as designated by the Monitoring Committee. In determining "adverse impacts," as provided at this paragraph and elsewhere in this MOU, consideration will be given to the benefits accrued over time during operation of the Project to landowners surrounding the Project Site including higher groundwater levels as a result of operation of the Project. In determining non-Project conditions vs. Project conditions, credit toward mitigation of any otherwise adverse impacts shall be recognized to the extent of the 4% loss and 5% losses recognized under paragraphs 2.b.(10)(b) and (c), for the mitigation credit recognized under paragraph 2.b.(4), if any, and to the extent of recharge on the Project Site for overdraft correction.

(13) To the extent that interference, other than insignificant interference, with the pumping lift of any existing active well as compared to non-Project conditions, is attributable to pumping of any wells on the Project Site, Rosedale will either stop pumping as necessary to mitigate the interference or compensate the owner for such interference, or any combination thereof. The Monitoring Committee will establish the criteria necessary to determine if well interference, other than insignificant interference, is attributable to pumping of Project wells by conducting pumping tests of Project wells following the installation of monitoring wells (if not already completed) and considering hydrogeologic information.

(14) The Kern Fan Element Groundwater Model, with input from Rosedale and the Adjoining Entities, and utilizing data from a comprehensive groundwater monitoring program, may be used by the Monitoring Committee as appropriate to estimate groundwater impacts of the Project.

(15) The parties recognize that the Project shall be operated with a positive balance, i.e., there shall be no "borrowing" of water for recovery from the basin.

3. Project Monitoring. Adjoining Entities agree to participate in a comprehensive monitoring program and as members of a Monitoring Committee, as hereinafter more particularly described, in order to reasonably determine groundwater level and water quality information under Project and non-Project conditions. The monitoring program will more particularly require the following:

a. Monitoring Committee: Rosedale and the Adjoining Entities shall form a Monitoring Committee for the Project upon terms and conditions acceptable to the participants. The Monitoring Committee shall:

(1) Engage the services of a suitable independent professional groundwater specialist who shall, at the direction of the Committee, provide assistance in the performance of the tasks identified below;

(2) Meet and confer monthly or at other intervals deemed to be appropriate in furtherance of the monitoring program;

(3) Establish a groundwater evaluation methodology or methodologies;

(4) Prepare a monitoring plan and two associated maps, "Well Location, Water Quality Network," and "Well Location, Water Level Network," which plan and maps depict the location and types of wells anticipated to be used in the initial phase of groundwater monitoring (said plan and maps are expected to be modified from time to time as the monitoring program is developed and operated);

(5) Specify such additional monitoring wells and ancillary equipment as are deemed to be necessary or desirable for the purposes hereof;

(6) Prepare annual water balance studies and other interpretive studies, which will designate all sources of water and the use thereof within the study area;

(7) Develop criteria for determining whether excessive mounding or withdrawal is occurring or is likely to occur in an area of interest;

(8) Annually or as otherwise needed determine the impacts of the Project on each of the Adjoining Entities by evaluating with and without Project conditions; and

(9) Develop procedures, review data, and recommend Project operational criteria for the purpose of identifying, verifying, avoiding, eliminating or mitigating, to the extent practicable, the creation of significant imbalances or significant adverse impacts.

b. Collection and Sharing of Data. The Adjoining Entities will make available to the Monitoring Committee copies of all relevant groundwater level, groundwater quality, and other monitoring data currently collected and prepared by each. Rosedale shall annually report, by areas of interest, water deliveries for banking and other purposes, groundwater withdrawals from bank accounts, transfers and other changes in account balances.

c. Monitoring Costs.

(1) The cost of constructing monitoring wells and ancillary equipment within Rosedale shall be borne by Rosedale. The cost of any new or additional monitoring wells and ancillary equipment outside the boundaries of Rosedale shall be borne as may be determined by separate agreement of Rosedale and the Adjoining Entities.

(2) Each of the parties shall be responsible for the personnel costs of its representative on the Monitoring Committee. In addition, the Adjoining Entities shall be responsible for all costs of monitoring operations and facilities within their respective boundaries and Rosedale shall be responsible for all costs of monitoring operations and facilities within the Project Site

(3) All other groundwater monitoring costs, including employment of the professional groundwater specialist, collection, evaluation and analyses of data as adopted by the Monitoring Committee, shall be allocated among and borne by the parties as they shall agree among themselves. Cost sharing among Adjoining Entities shall be as agreed by them. Any additional monitoring costs shall be determined and allocated by separate agreement of those parties requesting such additional monitoring.

4. Modification of Project Operations. The Monitoring Committee may make recommendations to Rosedale, including without limitation recommendations for modifications in Project operations based upon evaluation(s) of data which indicate that excessive mounding or withdrawal is occurring or is likely to occur in an area of interest. The Monitoring Committee and its members shall not act in an arbitrary, capricious or unreasonable manner.

5. Dispute Resolution.

a. Submission to Monitoring Committee. All disputes regarding the operation of the Project or the application of this MOU, or any provision hereof, shall first be submitted to the Monitoring Committee for review and analysis. The Monitoring Committee shall meet and review all relevant data and facts regarding the dispute and, if possible, recommend a fair and equitable resolution of the dispute. The Monitoring Committee and its members shall not act in an arbitrary, capricious or unreasonable manner. In the event that (1) the Monitoring Committee fails to act as herein provided, (2) any party disputes the Monitoring Committee's recommended resolution or (3) any party fails to implement the Monitoring Committee's recommended resolution within the time allowed, any party to this MOU may seek any legal or equitable remedy available as hereinafter provided.

b. Arbitration. If all of the parties agree that a factual dispute exists regarding any recommendation of the Monitoring Committee made pursuant hereto, or implementation thereof, such dispute shall, be submitted to binding arbitration before a single neutral arbitrator appointed by unanimous consent and, in the absence of such consent, appointed by the presiding judge of the Kern County Superior Court. The neutral arbitrator shall be a registered civil engineer, registered geologist, or other person agreeable to the parties, preferably with a background in groundwater hydrology. The arbitration shall be called and conducted in accordance with such rules as the contestants shall agree upon, and, in the absence of such agreement, in accordance with the procedures set forth in California Code of Civil Procedure section 1282, et seq. Any other dispute may be pursued through a court of competent jurisdiction as otherwise provided by law.

c. Burden of Proof. In the event of arbitration or litigation under this MOU, all parties shall enjoy the benefit of such presumptions as are provided by law but, in the absence thereof, neither party shall bear the burden of proof on any contested legal or factual issue.

d. Landowner Remedies. Nothing in this MOU shall prevent any landowner within the boundaries of any party from pursuing any remedy at law or in equity in the event such landowner is damaged as a result of projects within the Kern Fan Area.

6. Term. The Effective Date of this MOU shall be January 1, 2003 regardless of the date of actual execution. This MOU shall continue in force and effect from and after the Effective Date until terminated by (1) operation of law, (2) unanimous consent of the parties, or (3) abandonment of the Project and a determination by the Monitoring Committee that all adverse impacts have been fully eliminated or mitigated as provided in this MOU.

7. Complete Agreement/Incorporation Into Banking Agreements. This MOU constitutes the whole and complete agreement of the parties regarding Project operation, maintenance and monitoring (amending and replacing the original MOU between the parties regarding Rosedale's Groundwater Banking Program). Rosedale shall incorporate this MOU by reference into any further agreement it enters into respecting banking of water in or withdrawal of water from the Project Site.

8. Future Projects. With respect to any future project within the Kern Fan Area, the Parties hereto shall use good faith efforts to negotiate an agreement substantially similar in substance to this MOU.

9. Notice Clause. All notices required by this MOU shall be sent via first class United States mail to the addresses shown on the signature page of this agreement and shall be deemed delivered three days after deposited in the mail. Notice of changes in the representative or address of a party shall be given in the same manner.

10. California Law Clause. All provisions of this MOU and all rights and obligations of the parties hereto shall be interpreted and construed according to the laws of the State of California.

11. Amendments. This MOU may be amended by written instrument executed by all of the parties. In addition, recognizing that the parties may not now be able to contemplate all the implications of the Project, the parties agree that on the tenth anniversary of implementation of the Project, if facts and conditions not envisioned at the time of entering into this MOU are present, the parties will negotiate in good faith amendments to this MOU. If the parties cannot

agree on whether conditions have changed necessitating an amendment and/or upon appropriate amendments to the MOU, such limited issues shall be submitted to an arbitrator or court, as the case may be, as provided above.

12. Successors and Assigns. This MOU shall bind and inure to the benefit of the successors and assigns of the parties.

13. Severability. The rights and privileges set forth in this MOU are severable and the failure or invalidity of any particular provision of this MOU shall not invalidate the other provisions of this MOU; rather all other provisions of this MOU shall continue and remain in full force and effect notwithstanding such partial failure or invalidity.

14. Force Majeure. All obligations of the parties shall be suspended for so long as and to the extent the performance thereof is prevented, directly or indirectly, by earthquakes, fires, tornadoes, facility failures, floods, drownings, strikes, other casualties, acts of God, orders of court or governmental agencies having competent jurisdiction, or other events or causes beyond the control of the parties. In no event shall any liability accrue against a party, or its officers, agents or employees, for any damage arising out of or connected with a suspension of performance pursuant to this paragraph.

15. Counterparts. This MOU, and any amendment or supplement thereto, may be executed in two or more counterparts, and by each party on a separate counterpart, each of which, when executed and delivered, shall be an original and all of which together shall constitute one instrument, with the same force and effect as though all signatures appeared on a single document. In proving this MOU or any such amendment, supplement, document or

instrument, it shall not be necessary to produce or account for more than one counterpart thereof signed by the party against whom enforcement is sought.

IN WITNESS WHEREOF the parties have executed this MOU the day and year first above written at Bakersfield, California.

ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
P. O. Box 867
Bakersfield, CA 93302-0867

By:____________________

By:____________________

WEST KERN WATER DISTRICT
800 Kern Street
P. O. Box 1105
Taft, CA 93268-1105

By:____________________

By:____________________

SEMITROPIC WATER STORAGE DISTRICT
P. O. Box Z
Wasco, CA 93280-0877

By:____________________

By:____________________

BUENA VISTA WATER STORAGE DISTRICT
P. O. Box 756
Buttonwillow, CA 93206

By:____________________

By:____________________

HENRY MILLER WATER DISTRICT
P. O. Box 9759
Bakersfield, CA 93389-9759

By:____________________

By:____________________

KERN WATER BANK AUTHORITY
P. O. Box 80607
Bakersfield, CA 93380-0607

By:____________________

By:____________________

KERN COUNTY WATER AGENCY
P. O. Box 58
Bakersfield, CA 93302-0058

By:____________________

By:____________________

IMPROVEMENT DISTRICT NO. 4
P. O. Box 58
Bakersfield, CA 93302-0058

By:____________________

By:____________________

instrument, it shall not be necessary to produce or account for more than one counterpart thereof signed by the party against whom enforcement is sought.

IN WITNESS WHEREOF the parties have executed this MOU the day and year first above written at Bakersfield, California.

ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
P. O. Box 867
Bakersfield, CA 93302-0867

By:____________________

By:____________________

WEST KERN WATER DISTRICT
800 Kern Street
P. O. Box 1105
Taft, CA 93268-1105

By:____________________

By:____________________

SEMITROPIC WATER STORAGE DISTRICT
P. O. Box Z
Wasco, CA 93280-0877

By:____________________

By:____________________

BUENA VISTA WATER STORAGE DISTRICT
P. O. Box 756
Buttonwillow, CA 93206

By:____________________

By:____________________

HENRY MILLER WATER DISTRICT
P. O. Box 9759
Bakersfield, CA 93389-9759

By:____________________

By:____________________

KERN WATER BANK AUTHORITY
P. O. Box 80607
Bakersfield, CA 93380-0607

By:____________________

By:____________________

KERN COUNTY WATER AGENCY
P. O. Box 58
Bakersfield, CA 93302-0058

By:____________________

By:____________________

IMPROVEMENT DISTRICT NO. 4
P. O. Box 58
Bakersfield, CA 93302-0058

By:____________________

By:____________________

instrument, it shall not be necessary to produce or account for more than one counterpart thereof signed by the party against whom enforcement is sought.

IN WITNESS WHEREOF the parties have executed this MOU the day and year first above written at Bakersfield, California.

ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
P. O. Box 867
Bakersfield, CA 93302-0867

By:____________________

By:____________________

WEST KERN WATER DISTRICT
800 Kern Street
P. O. Box 1105
Taft, CA 93268-1105

By:____________________

By:____________________

SEMITROPIC WATER STORAGE DISTRICT
P. O. Box Z
Wasco, CA 93280-0877

By:____________________

By:____________________

BUENA VISTA WATER STORAGE DISTRICT
P. O. Box 756
Buttonwillow, CA 93206

By:____________________

By:____________________

HENRY MILLER WATER DISTRICT
P. O. Box 9759
Bakersfield, CA 93389-9759

By:____________________

By:____________________

KERN WATER BANK AUTHORITY
P. O. Box 80607
Bakersfield, CA 93380-0607

By:____________________

By:____________________

KERN COUNTY WATER AGENCY
P. O. Box 58
Bakersfield, CA 93302-0058

By:____________________

By:____________________

IMPROVEMENT DISTRICT NO. 4
P. O. Box 58
Bakersfield, CA 93302-0058

By:____________________

By:____________________

instrument, it shall not be necessary to produce or account for more than one counterpart thereof signed by the party against whom enforcement is sought.

IN WITNESS WHEREOF the parties have executed this MOU the day and year first above written at Bakersfield, California.

ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
P. O. Box 867
Bakersfield, CA 93302-0867

By:____________________

By:____________________

WEST KERN WATER DISTRICT
800 Kern Street
P. O. Box 1105
Taft, CA 93268-1105

By:____________________

By:____________________

SEMITROPIC WATER STORAGE DISTRICT
P. O. Box Z
Wasco, CA 93280-0877

By:____________________

By:____________________

BUENA VISTA WATER STORAGE DISTRICT
P. O. Box 756
Buttonwillow, CA 93206

By:____________________

By:____________________

HENRY MILLER WATER DISTRICT
P. O. Box 9759
Bakersfield, CA 93389-9759

By:____________________

By:____________________

KERN WATER BANK AUTHORITY
P. O. Box 80607
Bakersfield, CA 93380-0607

By:____________________

By:____________________

KERN COUNTY WATER AGENCY
P. O. Box 58
Bakersfield, CA 93302-0058

By: Peter Frick

By:____________________

IMPROVEMENT DISTRICT NO. 4
P. O. Box 58
Bakersfield, CA 93302-0058

By: Peter Frick

By:____________________

instrument, it shall not be necessary to produce or account for more than one counterpart thereof signed by the party against whom enforcement is sought.

IN WITNESS WHEREOF the parties have executed this MOU the day and year first above written at Bakersfield, California.

ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
P. O. Box 867
Bakersfield, CA 93302-0867

By:____________________

By:____________________

WEST KERN WATER DISTRICT
800 Kern Street
P. O. Box 1105
Taft, CA 93268-1105

By: [signature]

By: [signature]

SEMITROPIC WATER STORAGE DISTRICT
P. O. Box Z
Wasco, CA 93280-0877

By:____________________

By:____________________

BUENA VISTA WATER STORAGE DISTRICT
P. O. Box 756
Buttonwillow, CA 93206

By:____________________

By:____________________

HENRY MILLER WATER DISTRICT
P. O. Box 9759
Bakersfield, CA 93389-9759

By:____________________

By:____________________

KERN WATER BANK AUTHORITY
P. O. Box 80607
Bakersfield, CA 93380-0607

By:____________________

By:____________________

KERN COUNTY WATER AGENCY
P. O. Box 58
Bakersfield, CA 93302-0058

By:____________________

By:____________________

IMPROVEMENT DISTRICT NO. 4
P. O. Box 58
Bakersfield, CA 93302-0058

By:____________________

By:____________________

instrument, it shall not be necessary to produce or account for more than one counterpart thereof signed by the party against whom enforcement is sought.

IN WITNESS WHEREOF the parties have executed this MOU the day and year first above written at Bakersfield, California.

ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
P. O. Box 867
Bakersfield, CA 93302-0867

By: ____________________

By: ____________________

WEST KERN WATER DISTRICT
800 Kern Street
P. O. Box 1105
Taft, CA 93268-1105

By: ____________________

By: ____________________

SEMITROPIC WATER STORAGE DISTRICT
P. O. Box Z
Wasco, CA 93280-0877

By: ____________________

By: ____________________

BUENA VISTA WATER STORAGE DISTRICT
P. O. Box 756
Buttonwillow, CA 93206

By: ____________________

By: ____________________

HENRY MILLER WATER DISTRICT
P. O. Box 9759
Bakersfield, CA 93389-9759

By: ____________________

By: ____________________

KERN WATER BANK AUTHORITY
P. O. Box 80607
Bakersfield, CA 93380-0607

By: ____________________

By: ____________________

KERN COUNTY WATER AGENCY
P. O. Box 58
Bakersfield, CA 93302-0058

By: ____________________

By: ____________________

IMPROVEMENT DISTRICT NO. 4
P. O. Box 58
Bakersfield, CA 93302-0058

By: ____________________

By: ____________________

instrument, it shall not be necessary to produce or account for more than one counterpart thereof signed by the party against whom enforcement is sought.

IN WITNESS WHEREOF the parties have executed this MOU the day and year first above written at Bakersfield, California.

ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
P. O. Box 867
Bakersfield, CA 93302-0867

By:________________________

By:________________________

WEST KERN WATER DISTRICT
800 Kern Street
P. O. Box 1105
Taft, CA 93268-1105

By:________________________

By:________________________

SEMITROPIC WATER STORAGE DISTRICT
P. O. Box Z
Wasco, CA 93280-0877

By:________________________

By:________________________

BUENA VISTA WATER STORAGE DISTRICT
P. O. Box 756
Buttonwillow, CA 93206

By:________________________

By:________________________

HENRY MILLER WATER DISTRICT
P. O. Box 9759
Bakersfield, CA 93389-9759

By:________________________

By:________________________

KERN WATER BANK AUTHORITY
P. O. Box 80607
Bakersfield, CA 93380-0607

By:________________________

By:________________________

KERN COUNTY WATER AGENCY
P. O. Box 58
Bakersfield, CA 93302-0058

By:________________________

By:________________________

IMPROVEMENT DISTRICT NO. 4
P. O. Box 58
Bakersfield, CA 93302-0058

By:________________________

By:________________________

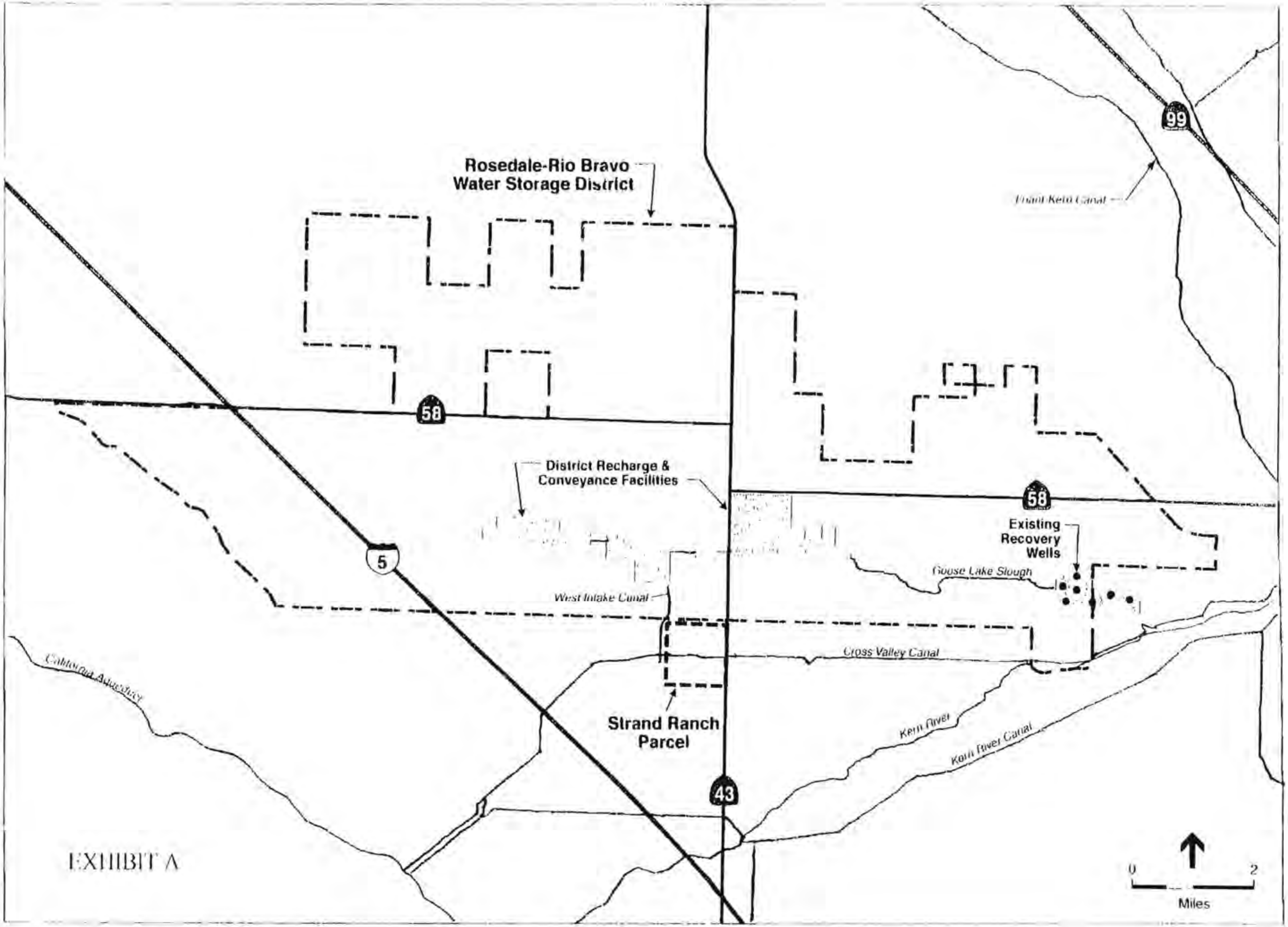

Rosedale-Rio Bravo
Water Storage District
99
Friant-Kern Canal
58
District Recharge &
Conveyance Facilities
58
Existing
Recovery
Wells
5
Goose Lake Slough
West Intake Canal
Cross Valley Canal
California Aqueduct
Strand Ranch
Parcel
Kern River
Kern River Canal
43
0
2
Miles

EXHIBIT A

EXHIBIT B

PROJECT DESCRIPTION

Purposes

The primary water management objective of Rosedale-Rio Bravo Water Storage District is to enhance water supplies for its landowners. One method of attaining this goal is to sponsor third party banking programs. Under such programs surface water will be stored in aquifers during times of surplus and either recovered during times of shortage or remain in the ground to assist with overdraft correction.

Sources of Water

Kern River water, being Rosedale-Rio Bravo WSD's primary supply water right, as well as other sources will be recharged. Such sources include: the Kern River, Friant-Kern, SWP, CVP, flood water and other sources that may be available from time to time.

Facilities

To achieve its water management objectives through third party banking programs, the Rosedale-Rio Bravo Water Storage District may require the construction of recharge ponds, water conveyance facilities, and water wells in addition to its existing facilities.

Of the approximately 43,000 acres that presently constitute Rosedale-Rio Bravo Water Storage District all may be used for in-lieu and/or direct recharge. In addition, adjacent lands within non-districted areas may also be used for in-lieu and direct recharge. It is anticipated that in the wettest of years as much as 300,000 acre-feet can be recharged.

It is proposed that water would be conveyed to and from the property using available capacity in any of the canals and conveyance facilities that may serve the property including: the Cross Valley Canal, the Kern River, the Friant Kern Canal, the California Aqueduct, and the Goose Lake Slough. It is also proposed to build additional conveyance facilities as future projects are developed.

As many as 20 wells may be added within the District boundaries before the project is complete to provide adequate recovery capacity and the necessary operational flexibility to avoid or minimize adverse impacts. District/Landowner programs may include the use of landowner wells by District wide reduction in surface supply allocations or by individual volunteer well lease programs. Once build out of the recovery facilities is complete, the recovery capacity will be maintained by constructing new wells to replace the capacity of older wells as they fail. New District owned wells shall be placed no closer than 880 feet from property and/or District boundaries. Wells inside the District boundaries shall be located and operated so as to prevent significant non-mitigable adverse impacts to neighboring landowners.

Operation

The project shall be managed by the Rosedale-Rio Bravo Water Storage District. Day-to-day operation of portions of the project may be contracted to other parties. Operation of the project shall be coordinated with adjoining projects. The total storage capacity intended to be utilized at any one time for banking project purposes is 500,000 AF and the total recovery capacity intended to be utilized for banking project purposes is 63,250 AF year.

Banking Projects

The project includes all third party banking programs whether pending or completed. These programs include, without limitation, the following:

ROSEDALE CONJUNCTIVE USE PROGRAM PARTNERSHIP AGREEMENTS

Banking Partner	Type	Annual Recharge (af)	Maximum Return Obligation (afy)	Maximum Storage (af)	Banked Water Source
Arvin-Edison WSD (draft terms)	2:1 Banking	30,000	10,000	90,000	CVP
Kern-Tulare/Rag Gulch WD	2:1 Banking	20,000	7,500	50,000	varies
Castaic Lake Water Agency	Banking	20,000	20,000*	100,000	varies
Buena Vista WSD	Banking	80,000	8,250	200,000	Kern River
Irvine Ranch Water District	Banking	17,500	17,500	50,000	varies
TOTAL			63,250	490,000	

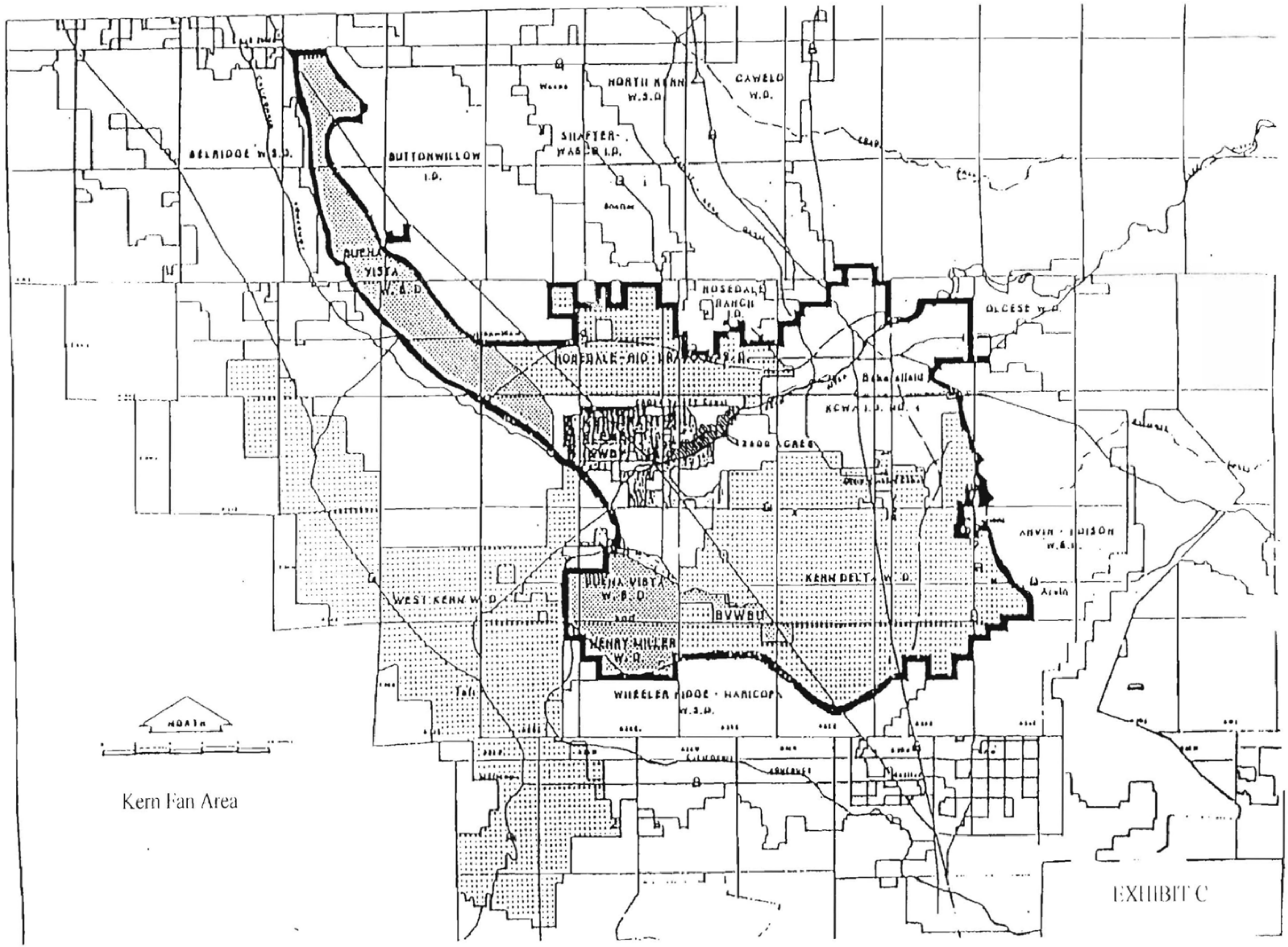
*surplus capacity of existing wells

A detailed description of each program is found in the environmental documentation relating thereto which includes, without limitation, the following: (1) Master EIR for Groundwater Storage, Banking, Exchange, Extraction and Conjunctive Use Program, certified July 17, 2001; (2) Addendum No. 1 to Master EIR, adopted in 2003; (3) FEIR for the BVWSD/RRBWSD Water Banking and Recovery Program, certified October 11, 2002; (4) Negative Declaration for Kern Tulare Program; (5) Negative Declaration for Groundwater Banking - Allen Road Wellfield (AEWSD) Program; and (6) FEIR for the Strand Ranch Integrated Banking Project (IRWD), certified May 27, 2008.

Addenda

(1) Notwithstanding paragraph 2.b.(10)(a) of this agreement, the surface recharge losses for the Strand Ranch property shall be fixed and assessed at a rate of 6% whether the recharge is intended for in-district or out-of-district use; provided, however, such 6% loss may be modified in the future if studies acceptable to the parties demonstrate that such modification is appropriate; provided further, however, that a 1% safety factor shall be maintained and the total loss when directly recharged water is extracted for out-of-district use shall not exceed 6%.

(2) It is understood and agreed by and among all parties that issues involving project operations may be presented to and addressed by the Monitoring Committee whether or not such issues were discussed, reviewed and/or considered during the environmental evaluation of the project.



Kern Fan Area

EXHIBIT C

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

APPENDIX C:

THOMAS HARDER & CO. TECHNICAL MEMORANDUM

Estimation of Groundwater Level Benefits Associated with the Kern Fan Groundwater Storage Project Concept

FEBRUARY 23, 2018

Technical Memorandum

To:	Mr. Dane Johnson Irvine Ranch Water District
From:	Jim Van de Water, P.G., CH.G. Thomas Harder & Co. (TH&Co)
Date:	23-Feb-18
Re:	Estimation of Groundwater Level Benefits Associated with the Kern Fan Groundwater Storage Project

1 INTRODUCTION

As per your request, Thomas Harder & Company (TH&Co) has prepared this technical memorandum to estimate potential groundwater level benefits associated with Irvine Ranch Water District's (IRWD's) Kern Fan Groundwater Storage Project. It is our understanding that IRWD is considering a phased project that includes acquisition of 1,280 acres of property in the Rosedale-Rio Bravo Water Storage District (RRBWSD) service area for construction of two recharge and recovery facilities ('Phase I' and 'Phase II'; see project concept figure from Dee Jaspar & Associates, Inc [2017][1] included as **Attachment A**). These facilities are to be supplied by Article 21 water via the Goose Lake Slough and a new conveyance canal connecting Phase II and the California Aqueduct. Long-term groundwater level benefits from the project would be associated with 'leave behind' water volumes from recharging the Article 21 water during wet years. IRWD has already monetized 'leave behind' groundwater benefits from the project in an initial funding request to the California Water Commission (CWC). However, the CWC has requested a model analysis to quantify potential groundwater level benefits from the project.

2 OBJECTIVE AND APPROACH

The objective of the analysis is to provide a model analysis to quantify potential groundwater level benefits from the project to IRWD to meet the request of the CWC. Our approach for quantifying potential groundwater level benefits from the project involves the construction of a numerical model of the proposed project area. The numerical model is used to analyze Article 21 'leave behind' benefits over a 50-year project operational scenario developed based on data provided by MBK Engineers[2]. Water is stored in the project in each of the three accounts: public or ecosystem ('ENV'), IRWD, and Rosedale. After accounting for the loss percentages (including evaporation), the leave behind percentages for these three accounts are as follows:

[1] Dee Jaspar & Associates, Inc. (DJ&A), 2017. *Kern Fan Groundwater Storage Project, Draft Concept Study*. August 10th.
[2] Electronic mail correspondence from IRWD to TH&Co, January 29, 2018.

Thomas Harder & Co.
1260 N. Hancock St., Suite 109
Anaheim, California 92807
(714) 779-3875

ENV = 6.5%, IRWD = 9%, and Rosedale = 4%. These values are used as multipliers for historical operational data spanning 1922 through 2003 as provided by MBK Engineers to derive the recharge rates used as input to the model. The historical data, along with leave behind recharge rates, are listed in **Table 1**. For this analysis, the first 50 years of the record (i.e., 1922 to 1972) is used. As shown in this table, there are nine recharge events that occur over the 50-year time span. The average leave behind recharge rate for both phases combined is estimated to be approximately 1,850 acre-feet per year.

Specifically, groundwater level results from a 50-year project operational scenario of leave behind recharge are compared to groundwater levels for a 50-year period without project leave behind. The difference between these "with project" and "without project" scenarios is the groundwater level benefit of the project.

3 NUMERICAL MODEL

The United States Geological Survey (USGS) numerical groundwater flow model MODFLOW (Harbaugh, 2005)[3], one of the most widely-used and accepted groundwater flow models in the world, is used for the 50-year transient[4] analysis of the proposed project. The numerical approach afforded by MODFLOW is selected over an analytical approach (e.g., Mahdavi, 2015)[5] given its ability to more readily simulate the temporally- and spatially-variant properties and processes associated with the proposed project.

3.1 CONCEPTUAL MODEL

The conceptual model, which is based on our understanding of the hydrogeology of the study area and of the proposed project, provides the framework for the numerical model. TH&Co developed a hydrogeologic conceptual model for the nearby Kern Water Bank and Pioneer Project that provided the framework for an actively-maintained regional-scale calibrated numerical model that also includes the Study Area (TH&Co, 2011)[6]. Given that this analysis is limited to a comparison of "with project" and "without project" scenarios, several components of the regional-scale conceptual model which apply equally to both scenarios are not considered (i.e., precipitation, evapotranspiration, pumping for municipal, agricultural and private use and associated return flows, other recharge basins, and any other inflows and outflows not associated with the proposed project). The components of the regional-scale conceptual model applicable to this analysis are as follows:

- Geology: The Study Area is in the eastern portion of the Tulare Basin on the flat distal portions of the alluvial fan deposited by the Kern River. The land surface elevation of the Study Area is approximately 300 feet above mean sea level (ft amsl). The geologic units considered in this analysis are the 'Younger Alluvium and Flood Plain Deposits' and the 'Older Alluvium'. The Younger Alluvium and Flood Plain Deposits are Recent

3 Harbaugh, A.W., 2005, *MODFLOW-2005, The U.S. Geological Survey modular ground-water model - the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16*.

4 The term 'transient' as used here implies that the stresses on the groundwater system change over time, which in turn cause groundwater elevations to change over time.

5 Mahdavi, A., 2015. *Transient-State Analytical Solution for Groundwater Recharge in Anisotropic Sloping Aquifer*. Water Resources Management, 29:3735–3748. May.

6 TH&Co, 2011. *Hydrogeological Impact Evaluation Related to Operation of the Kern Water Bank and Pioneer Project*. December 5th.

(Holocene) sediments deposited in, and adjacent to, active stream and river channels and in the areas of historical lakebeds and form the ground surface. River channel sediments are predominantly sand and gravel whereas the Flood plain deposits contain a higher percentage of silt and clay. The thickness of the Younger Alluvium is approximately 150 feet thick in the Study Area. The Older Alluvium consists of Pleistocene (2 million to 10,000 years before present) sediments composed of unconsolidated alluvial fan deposits and stream and terrace deposits. Because it is difficult to distinguish between the 'Younger Alluvium and Flood Plain Deposits' and 'Older Alluvium', they are grouped together as 'Quaternary Alluvium'.

- Hydrogeology: The aquifer system in the Study Area is characterized by lenticular sand and gravel deposits of varying thickness and lateral extent that are separated by less permeable deposits of silt and clay. In the Study Area, the saturated sediments are likely unconfined and modeled as such; however, given the highly stratified nature of the sediments in the subsurface and aquifer test results, it appears that the aquifer likely becomes more confined with depth.
- Groundwater Recharge: Recharge of the groundwater system within the Study Area occurs through both natural and artificial mechanisms. Natural recharge occurs through subsurface underflow from upgradient areas and infiltration of streamflow within the Kern River channel. Areal recharge due to infiltration of precipitation in areas outside the Kern River channel is comparatively small. The Kern River is the primary natural surface water feature in the southern Tulare Basin and the Study Area (see **Figure 1**) and is used as a conveyance mechanism to transfer water from various upstream imported sources to downstream recharge projects. Artificial recharge occurs as managed recharge in the spreading basins associated with these projects, infiltration losses in unlined canals, return flow from agricultural irrigation, return flow associated with municipal and industrial water use in urban areas, and return flow from individual septic systems in unsewered areas. Recharge facilities that influence the Study Area include the KWB, the Pioneer Project, the 2800 Acres, the Berrenda Mesa Project, the West Kern Water District/Buena Vista Water Storage District (WKWD/BVWSD Recharge Basins, and the RRBWSD Recharge Basins). The basins have historically received imported water from the State Water Project via the California Aqueduct, imported water from the Central Valley Project (CVP) via the Friant-Kern Canal, and natural storm water flow from the Kern River. Of course, given the objective of this analysis, 'leave behind' water associated with artificial recharge via the Phase I and Phase II projects are critical components of the conceptual model.

3.2 Model Domain and Model Grid, Boundary Conditions, Initial Conditions, and Aquifer Parameters

This section presents the overall model design and input parameters. The input values used to simulate the proposed project recharge were presented in **Section 2**.

3.2.1 Model Domain and Model Grid

The basis of the numerical method coded into MODFLOW-2005 is the subdivision (discretization) of the model domain into rectangular prismatic cells, resulting in a model 'grid'. The Study Area coincides with the model domain, the areal extent of which is shown on **Figure 2**. The model extends vertically from the ground surface to a depth ranging from approximately 620 feet in the south to approximately 710 feet in the north. The thicknesses used for this single-layered model (**Figure 3**) are based on the model layering used in the multilayered regional-scale numerical model with consideration given to the head boundary conditions discussed below. In plan-view, the Study Area was subdivided into 50 rows and 70 columns consisting of uniform (square) cells dimensioned 1,000 feet by 1,000 feet. The model grid is shown in **Figure 4**.

3.2.2 Boundary Conditions

The boundary conditions used in the model include both head and flux boundaries and initial conditions.

3.2.2.1 Head boundaries

Time-variant head boundaries are prescribed in the southern and northern portions of the model domain to simulate the generally northwesterly flow of groundwater within the Study Area (**Figure 5**). The head boundaries are based on three wells in the southern (upgradient) portion and six wells in the northern (downgradient) portion for which extensive groundwater elevation records are available. For the upgradient boundary, which is strongly influenced by the ongoing recharge projects near the Kern River described earlier, the cyclical trend observed between 2004 and 2017 is repeated into the future to define this boundary throughout the 50-year simulation period. For the northern boundary, the decreasing trend observed between 2004 and 2017 is extrapolated for the first 20 years of the simulation and thereafter, based on the 20-year compliance period mandated by the Sustainable Groundwater Management Act for areas to the north/northwest of the Study Area, is maintained at a constant value for the final 30 years of the simulation based on the extrapolated values calculated for Year 20.

The MODFLOW input 'package' used to simulate the head boundaries is the time-variant specified head (CHD) package.

3.2.2.2 Flux Boundaries

The flux boundaries are prescribed in the two proposed project areas (Phase I and Phase II) to simulate proposed recharge. Infiltration from the Goose Lake Slough is comparatively negligible and is therefore not considered in this analysis. Twenty-seven cells are used for the Phase I and Phase II project areas to approximate the 640-acre extent of each area. As such, the Phase I and Phase II project areas are both conservatively modeled at approximately 620 acres.[7] The locations of the flux boundaries are shown in **Figure 5**.

The MODFLOW input package used to simulate the flux boundaries is the recharge (RCH) package.

3.2.3 Initial Conditions

Initial conditions are the initial groundwater elevations which the transient 50-year model uses to begin its numerical calculations. As such, the initial conditions are effectively a boundary condition in time. To ensure that the response of groundwater elevations throughout the model domain is due solely to the simulated stresses and not errors in the initial head configuration (i.e., the initial conditions) that may not be a valid solution to the numerical model, initial conditions were established by repeated transient simulations with no flux boundaries until the simulated

[7] Using 28 cells to simulate the two project areas would have slightly overestimated their respective areas at 643 acres.

heads showed no appreciable change over time early in the simulation (e.g., the first 30 days). That is, the initial conditions for the model are based on a valid steady-state solution for the numerical model (Reilly and Harbaugh, 2004)[8].

3.2.4 Aquifer Parameters

Hydraulic conductivity and specific yield values for the model are those in the corresponding layer in TH&Co's existing regional-scale model. The distributions of these spatially-variant parameters are shown on **Figure 6** and **Figure 7**, respectively.

4 MODEL RESULTS

The model results are presented in terms of the difference between simulated groundwater elevations (i.e., "mounding") and simulated water budgets for the "with project" and "without project" scenarios. A quality check is also presented.

4.1 Model-Predicted Groundwater Elevations

Model-predicted groundwater elevations from two model 'observation wells' centered within the Phase I project (P1-A and P1-B) and one centered within the Phase II project (P2-A), as shown on **Figure 5**, are used for the analysis. The model-predicted groundwater elevations for the "with project" and "without project" scenarios are shown along with land surface elevations for each project area on **Figure 8a** and **Figure 8b**. The differences between these two scenarios are more clearly shown on **Figure 9a** and **Figure 9b**.[9] As shown on these figures, the approximate maximum change (increase) in groundwater elevations due to leave behind recharge occurs during Year 16 of the 50-year simulation and are as follows:

- Phase I Area: ~1.75 feet; and
- Phase II Area: ~2 feet.

The spatial distribution of the maximum mounding associated with the projects is shown on **Figure 10**.

4.2 Water Budget

The model water budget consists of the following three components:

1. Groundwater inflow and outflow ("underflow"), both of which are driven by the time-variant constant head boundaries;
2. Recharge (inflow only), which is driven by the recharge flux boundaries prescribed for each project area; and
3. the change in storage resulting from the underflow and recharge.

These components for the "with project" and "without project" are listed in **Table 2**. The effect of mounding, which decreases the hydraulic gradient south (upgradient) of the projects and increases it north (downgradient) of the projects, is reflected in the lower "Constant Head In" value and higher "Constant Head Out" value associated with the "with project" scenario. The "Recharge In" and "Recharge Out" values are self-evident for both scenarios. The total model-

[8] Reilly, T.E. and A.W. Harbaugh, 2004. *Guidelines for Evaluating Ground-Water Flow Models*. U.S. Geological Survey Scientific Investigations Report 2004-5038, 30 pp.

[9] Because the numerical model only considers saturated zone flow and does not considered unsaturated zone flow, the recharge is assumed to instantaneously reach the water table.

predicted recharge associated with 'leave behind' water over the 50-year simulation for both project areas is approximately 16,200 acre-feet. As there are two project areas and nine simulated recharge events, the average simulated recharge rate for each project area is approximately 900 acre-feet per year. Therefore, the total simulated recharge rate for both projects is approximately 1,800 acre-feet per year.

4.3 QUALITY CHECK

The "with project" and "without project" models ran within minutes with no convergence problems using industry-standard head and flow closure criteria of 0.01 feet and 864 ft^3/day, respectively. The maximum absolute percent discrepancy[10] for the "with project" and "without project" scenarios based on cumulative volumes was zero percent whereas for volumetric rates it was 0.01 percent. Both values are well within industry standards.

An analytical model that predicts mounding (Hantush, 1967)[11] for a single recharge project as provided by the USGS (Carleton, 2010)[12] gives an average mounding elevation for each project of approximately 1.5 feet based on input values used in the numerical model. The 1.5-foot value is in reasonable agreement with those obtained using the numerical model, especially when the combined effect ('superposition') of mounding predicted using the numerical model as shown on **Figure 10** is considered.

5 CONCLUSION

Based on the analysis presented here, the proposed project will result in measurable increases in groundwater elevations and therefore a groundwater level benefit.

6 REFERENCES

Carleton, G.B., 2010. *Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins*. U.S. Geological Survey Scientific Investigations Report 2010-5102, 64 pp.

Dee Jaspar & Associates, Inc. (DJ&A), 2017. *Kern Fan Groundwater Storage Project, Draft Concept Study*. August 10th.

Hantush, M.S., 1967. *Growth and Decay of Groundwater Mounds in Response to Uniform Percolation*. Water Resources Research, v.3, p. 227–234.

Harbaugh, A.W., 2005, *MODFLOW-2005, The U.S. Geological Survey modular ground-water model - the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16*.

Mahdavi, A., 2015. *Transient-State Analytical Solution for Groundwater Recharge in Anisotropic Sloping Aquifer*. Water Resources Management, 29:3735–3748. May.

[10] Discrepancies arise due to the iterative procedure in the numerical model and are generally minimized using sufficiently small head and flow closure criteria.
[11] Hantush, M.S., 1967. *Growth and Decay of Groundwater Mounds in Response to Uniform Percolation*. Water Resources Research, v.3, p. 227–234.
[12] Carleton, G.B., 2010. *Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins*. U.S. Geological Survey Scientific Investigations Report 2010-5102, 64 pp.

Reilly, T.E. and A.W. Harbaugh, 2004. *Guidelines for Evaluating Ground-Water Flow Models*. U.S. Geological Survey Scientific Investigations Report 2004-5038, 30 pp.

Thomas Harder & Company, Inc. (TH&Co), 2011. *Hydrogeological Impact Evaluation Related to Operation of the Kern Water Bank and Pioneer Project*. December 5th.

TABLES

Historical Recharge Rates and Calculated 'Leave Behind' Recharge Rates

	Actual Historical Recharge (acre-feet per year)			Calculated 'Leave Behind' Recharge (acre-feet per year)			
Year	ENV	IRWD	Rosedale	ENV	IRWD	Rosedale	Total
1922	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0
1936	5,964	8,946	8,946	388	805	358	1,551
1937	5,964	9,014	8,879	388	811	355	1,554
1938	11,351	17,330	16,725	738	1,560	669	2,966
1939	0	0	0	0	0	0	0
1940	0	0	0	0	0	0	0
1941	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0
1943	9,272	7,570	7,016	603	681	281	1,565
1944	0	0	0	0	0	0	0
1945	8,464	7,429	7,964	550	669	319	1,537
1946	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0
1951	73	130	133	5	12	5	22
1952	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0
1956	11,544	17,316	17,316	750	1,558	693	3,001
1957	0	0	0	0	0	0	0
1958	5,772	8,826	8,490	375	794	340	1,509
1959	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0
1969	20,157	13,054	12,195	1,310	1,175	488	2,973
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0

Historical Recharge Rates and Calculated 'Leave Behind' Recharge Rates

	Actual Historical Recharge (acre-feet per year)			Calculated 'Leave Behind' Recharge (acre-feet per year)			
Year	ENV	IRWD	Rosedale	ENV	IRWD	Rosedale	Total
1972	0	0	0	0	0	0	0
1973	5,957	4,184	3,299	387	377	132	896
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	7,726	20,081	19,907	502	1,807	796	3,106
1979	0	0	0	0	0	0	0
1980	8,213	21,962	20,562	534	1,977	822	3,333
1981	0	0	0	0	0	0	0
1982	544	1,763	1,078	35	159	43	237
1983	76	304	119	5	27	5	37
1984	1	7	1	0	1	0	1
1985	0	0	0	0	0	0	0
1986	13,745	0	0	893	0	0	893
1987	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0

Number of Recharge Years (over entire 82-year record) => 16
Average Recharge Rate during Recharge Years over entire 82-year record (acre-feet per year) => 1574

Number of Recharge Years (over first 50 years of 82-year record) => 9
Average Recharge Rate during Recharge Years over first 50 years of 82-year record (acre-feet per year) => 1853

Model-Predicted Water Budget

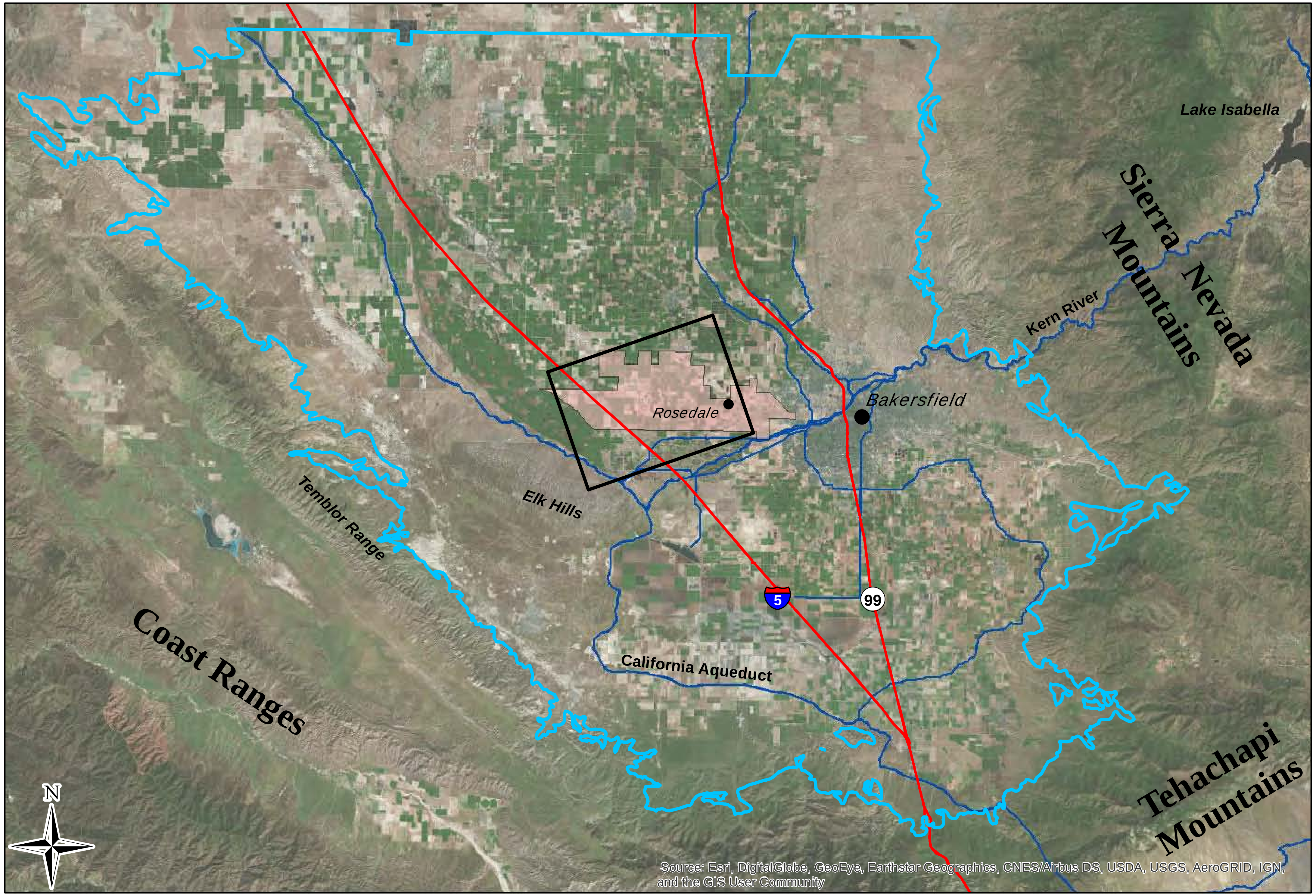
Component	"With Project" (acre-ft)	"Without Project" (acre-ft)	Difference (acre-ft)
Constant Head In	6,196,235	6,200,989	-4,754
Constant Head Out	6,875,078	6,864,254	10,825
Recharge In	16,213	0	16,213
Recharge Out	0	0	0
Storage In	4,741,121	4,739,241	1,880
Storage Out	4,078,243	4,075,752	2,491

FIGURES

Irvine Ranch Water District

Kern Fan Groundwater Storage Project

22-Feb-18



0 5 10 20 Miles

NAD 83 State Plane CA Zone 5

Map Features

- Tulare Basin
- Study Area
- Highways
- Rosedale-Rio Bravo Water Storage District
- Water Courses

Basemap Source: www.esri.com

Regional Setting

Thomas Harder & Co.
Groundwater Consulting

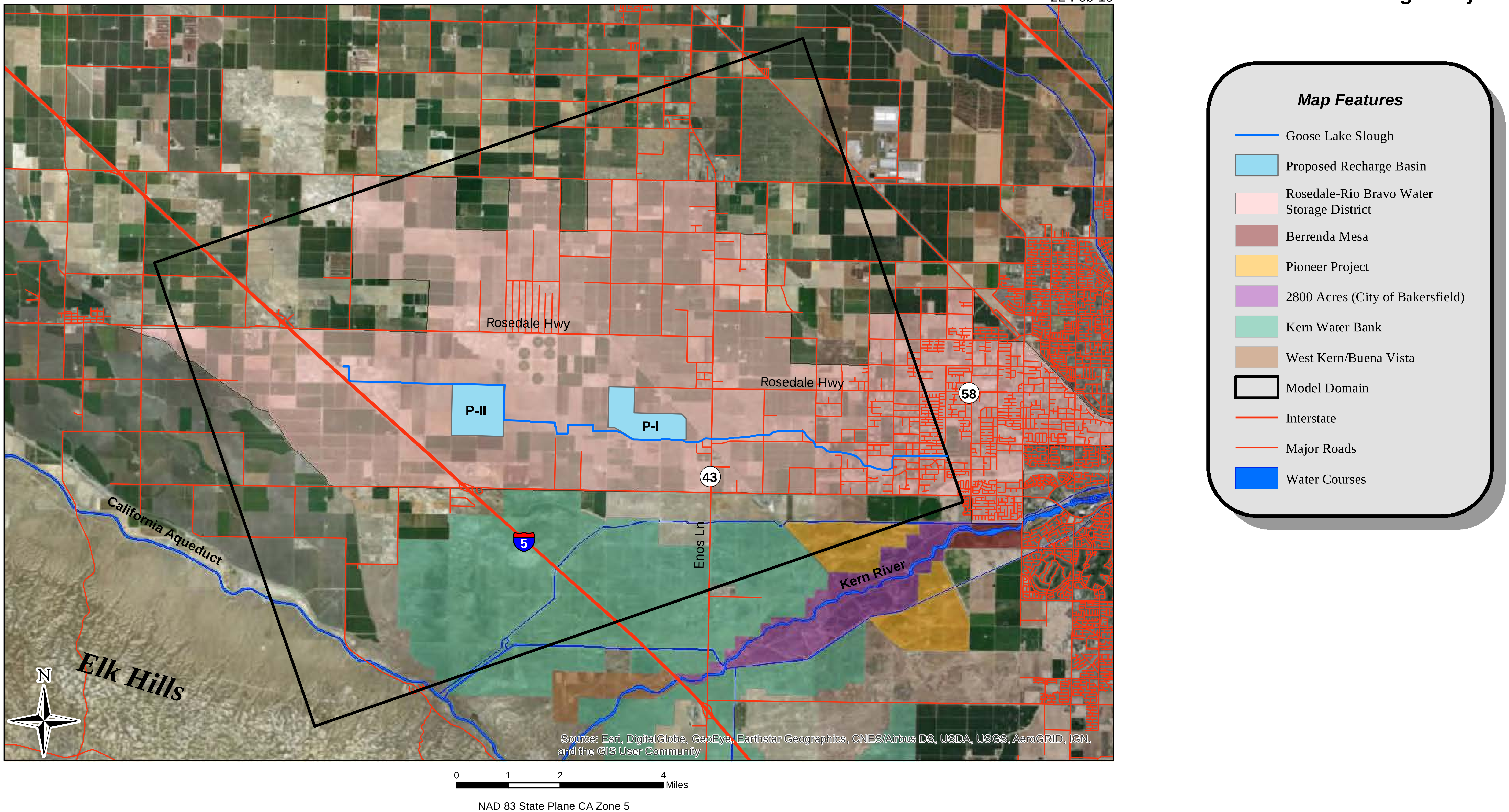
Regional Map

Figure 1

Irvine Ranch Water District

22-Feb-18

Kern Fan Groundwater Storage Project



Thomas Harder & Co.
Groundwater Consulting

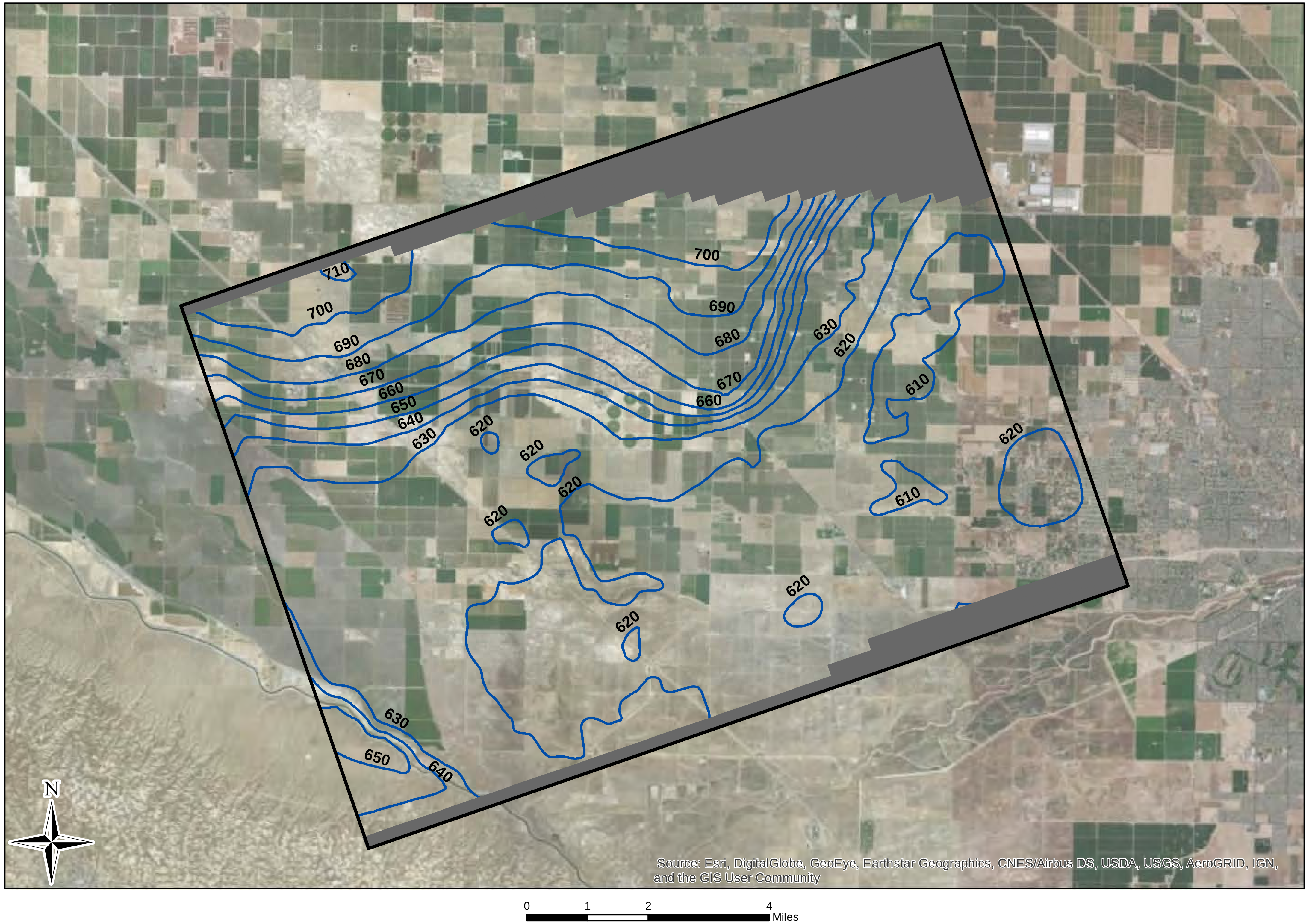
Study Area

Figure 2

Irvine Ranch Water District

22-Feb-18

Kern Fan Groundwater Storage Project



NAD 83 State Plane CA Zone 5

Map Features

- Layer Thickness Contour (ft)
- No Flow Zone
- Model Domain

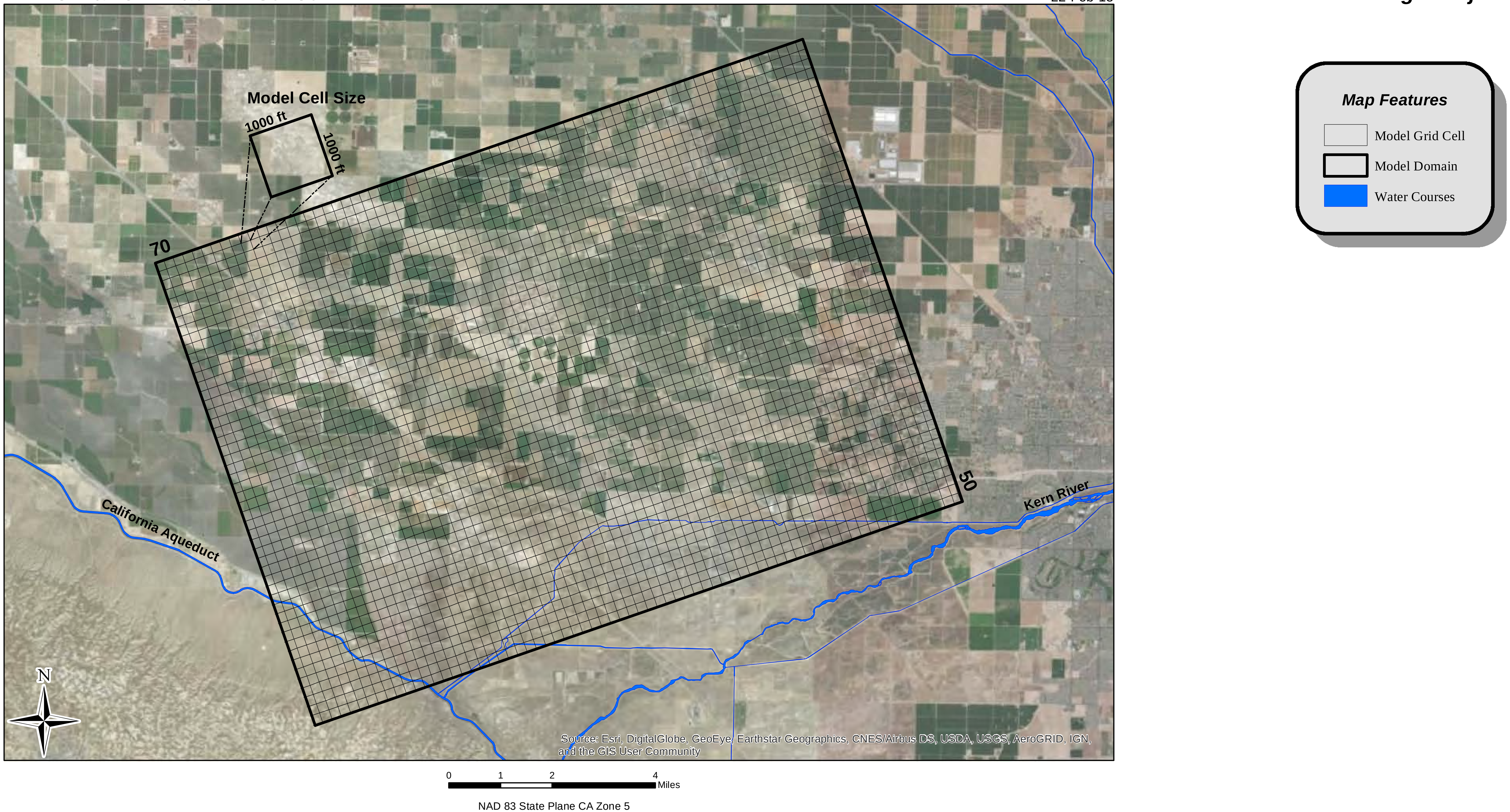
Thomas Harder & Co.
Groundwater Consulting

Layer Thickness

Figure 3

22-Feb-18

Kern Fan Groundwater Storage Project



Thomas Harder & Co.
Groundwater Consulting

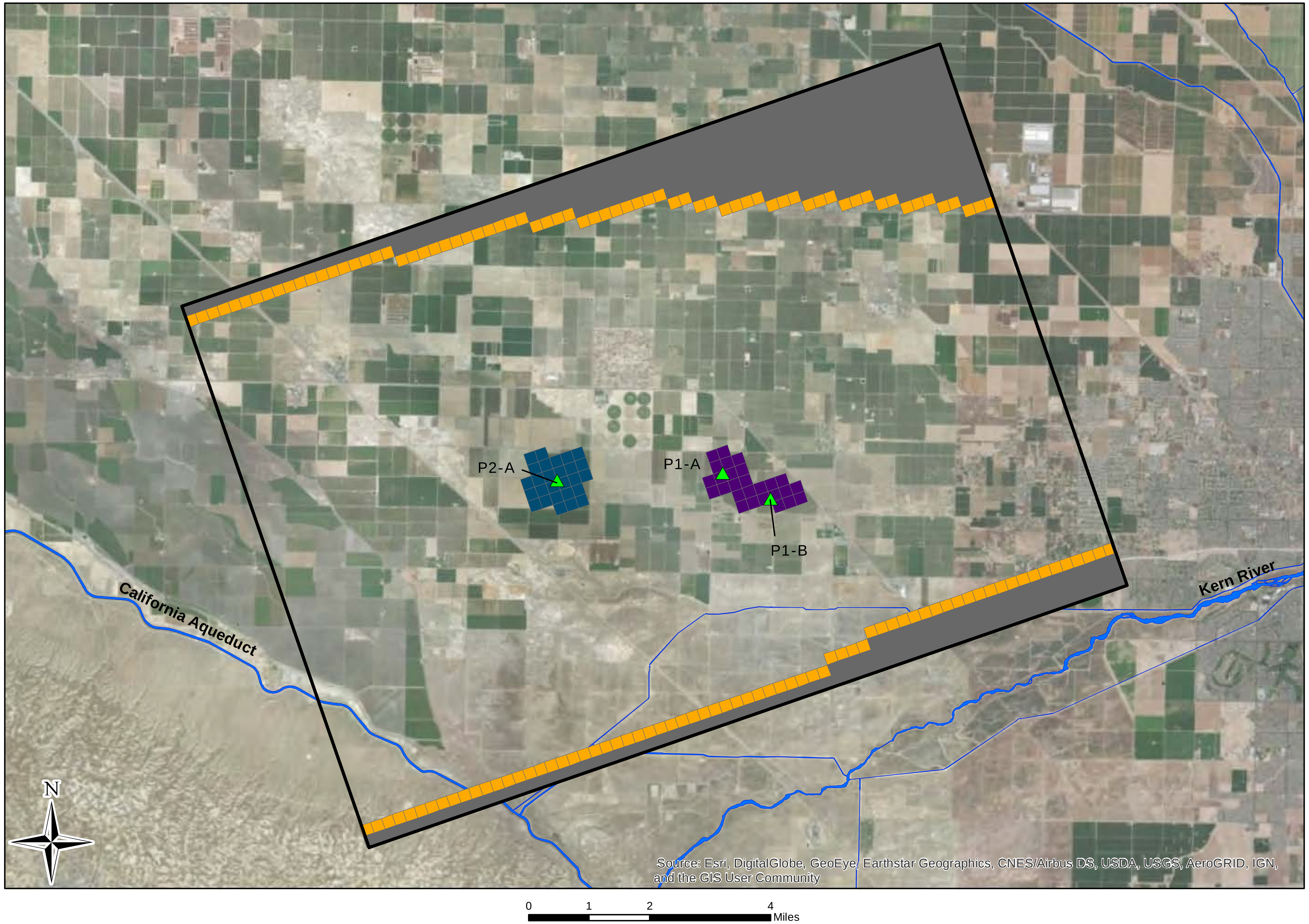
Model Grid

Figure 4

Irvine Ranch Water District

22-Feb-18

Kern Fan Groundwater Storage Project



NAD 83 State Plane CA Zone 5

Map Features

- Observation Well
- Specified Head Cell (Head Boundary)
- P-I Basin (Flux Boundary)
- P-II Basin (Flux Boundary)
- No Flow Zone (Flux Boundary)
- Model Domain
- Water Courses

Thomas Harder & Co.
Groundwater Consulting

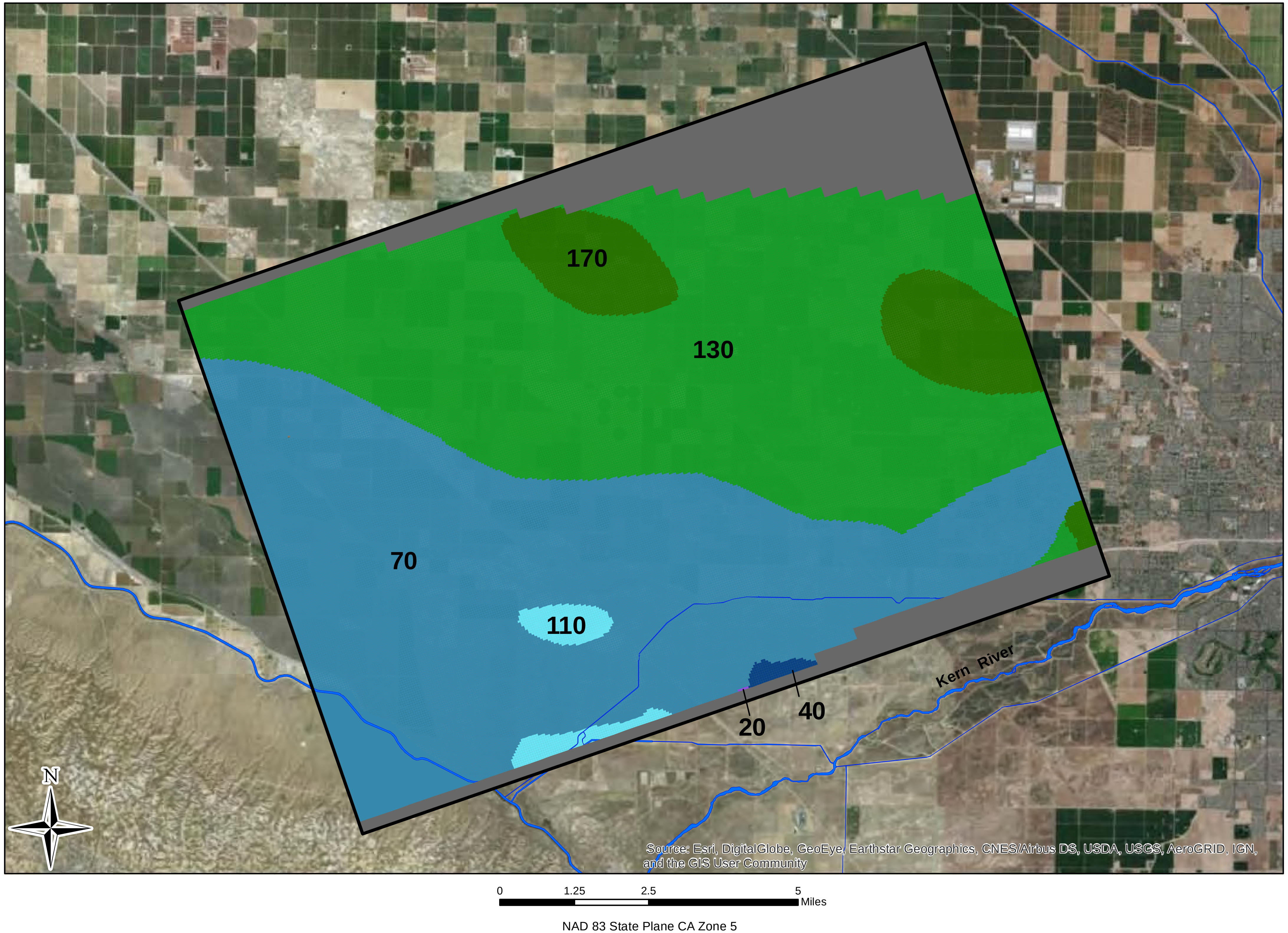
Head and Flux Boundaries

Figure 5

Irvine Ranch Water District

Kern Fan Groundwater Storage Project

22-Feb-18



Map Features

Hydraulic Conductivity (ft/day)

- 20, 1
- 40, 1
- 70, 1
- 110, 1
- 130, 1
- 170, 3.3
- 170, 4.5
- No Flow Zone
- Model Domain
- Water Course

Thomas Harder & Co.
Groundwater Consulting

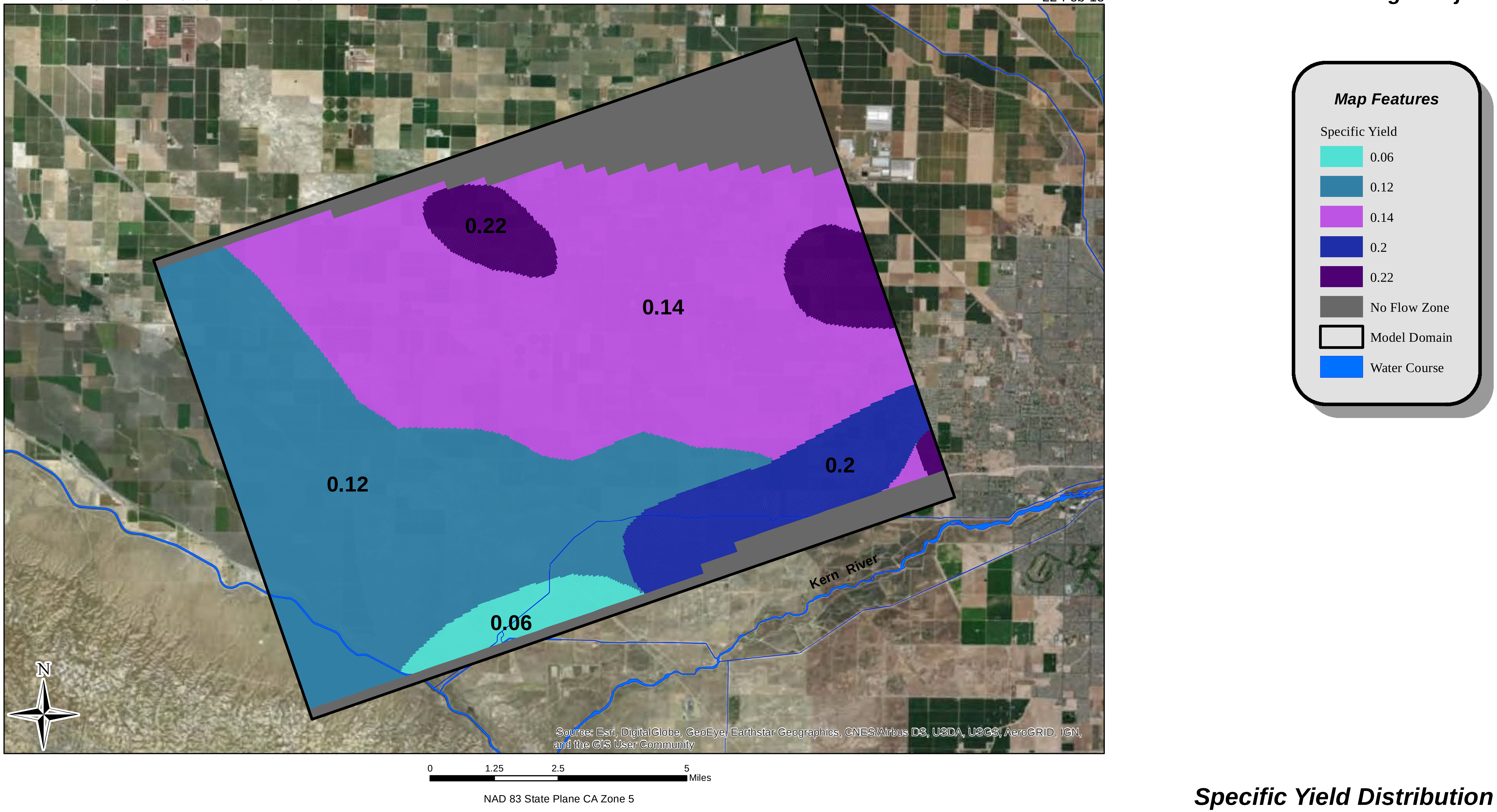
Hydraulic Conductivity Distribution

Figure 6

Kern Fan Groundwater Storage Project

Irvine Ranch Water District

22-Feb-18



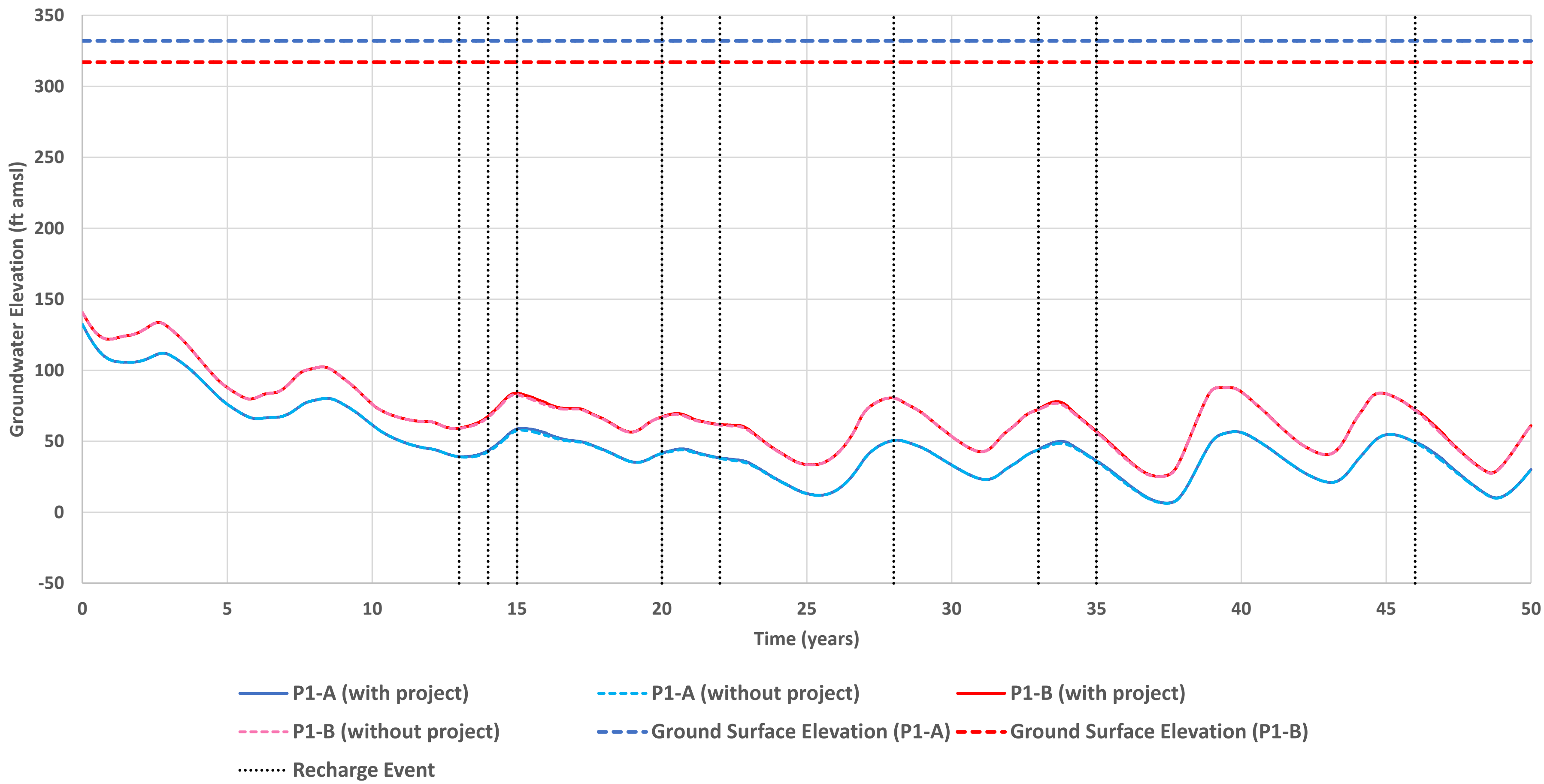
Thomas Harder & Co.
Groundwater Consulting

Specific Yield Distribution

Figure 7

Irvine Ranch Water District
Kern Fan Groundwater Storage Project

Figure 8a
Model-Predicted Groundwater Elevations
Phase I Area



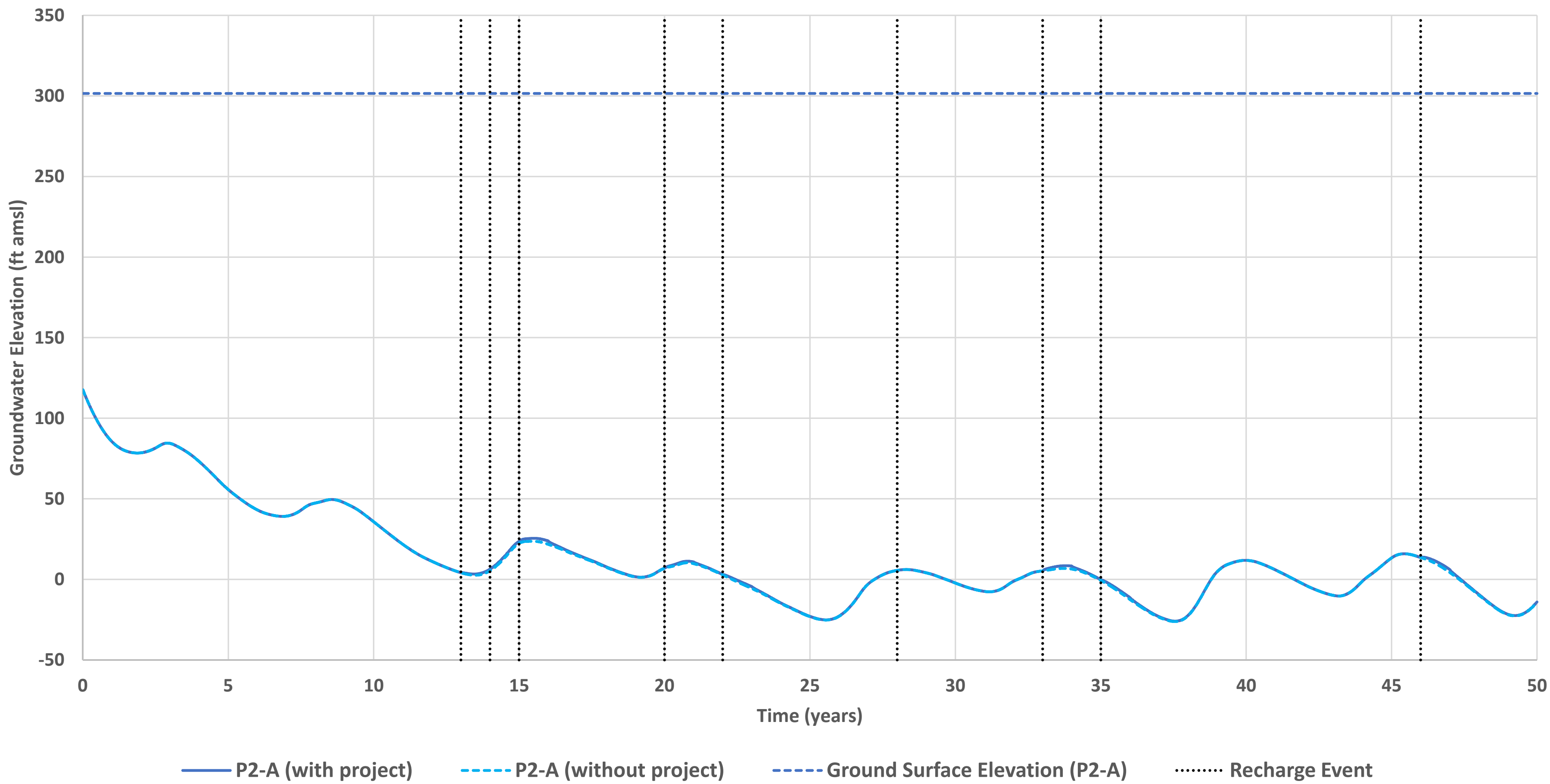
Thomas Harder & Co.
Groundwater Consulting

2/23/2018
Hydrographs.xlsx | Phase I

Figure 8b

Irvine Ranch Water District
Kern Fan Groundwater Storage Project

Model-Predicted Groundwater Elevations
Phase II Area

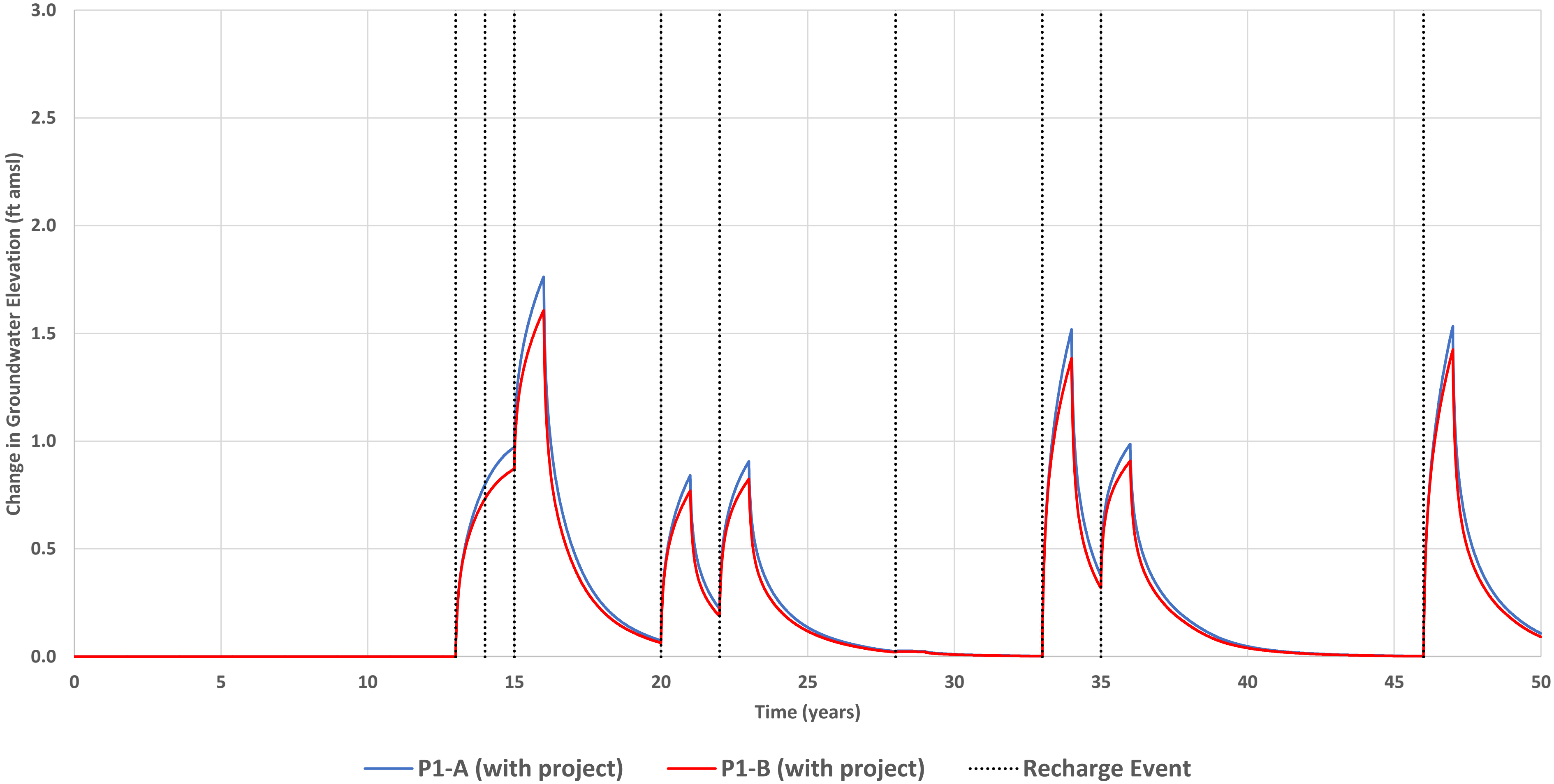


Thomas Harder & Co.
Groundwater Consulting

2/23/2018
Hydrographs.xlsx | Phase II

Irvine Ranch Water District
Kern Fan Groundwater Storage Project

Figure 9a
Change in Model-Predicted Groundwater Elevations
Phase I Area

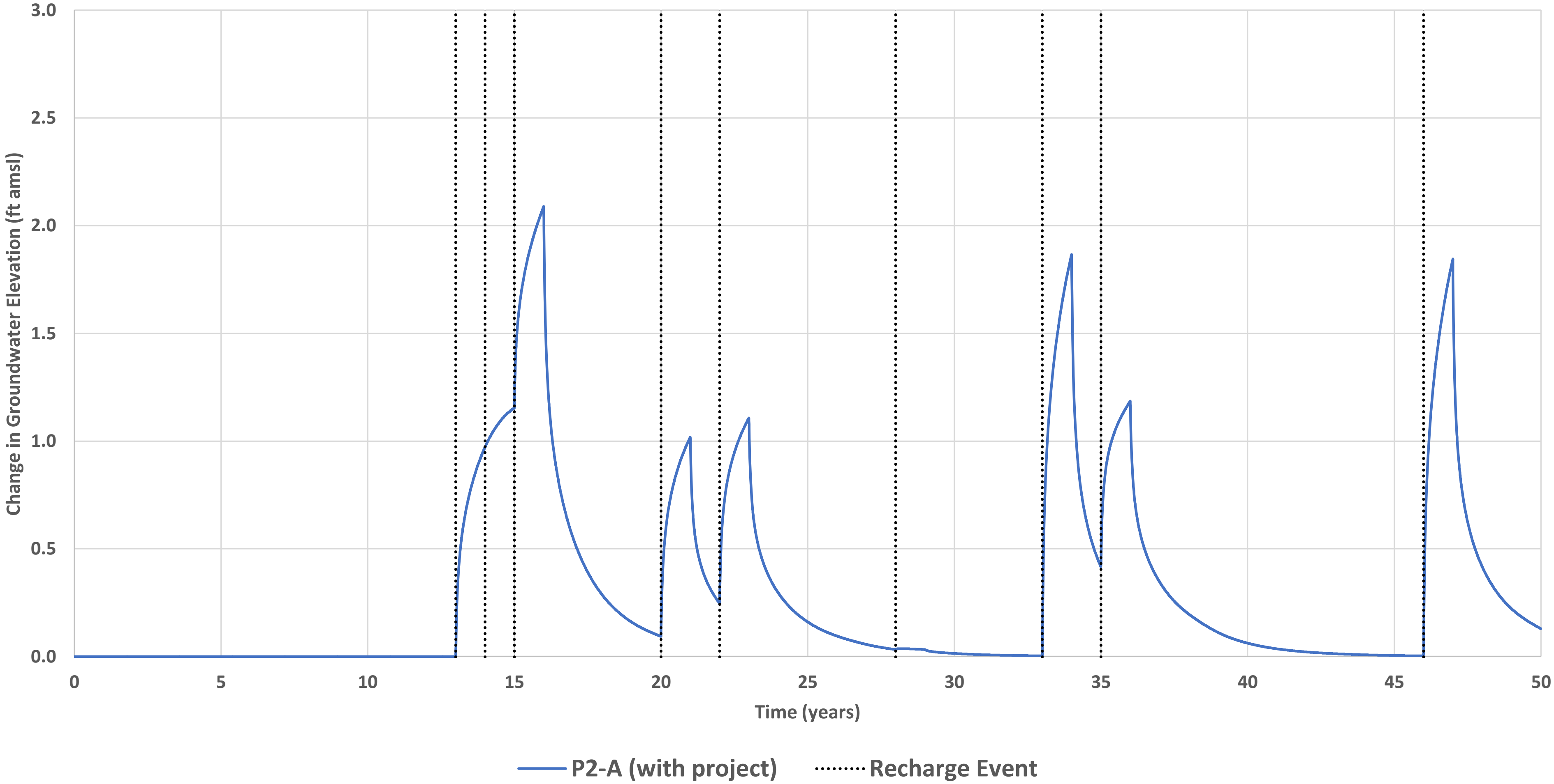


Thomas Harder & Co.
Groundwater Consulting

2/23/2018
Hydrographs | Phase I

Figure 9b
Change in Model-Predicted
Groundwater Elevations
Phase II Area

Irvine Ranch Water District
Kern Fan Groundwater Storage Project



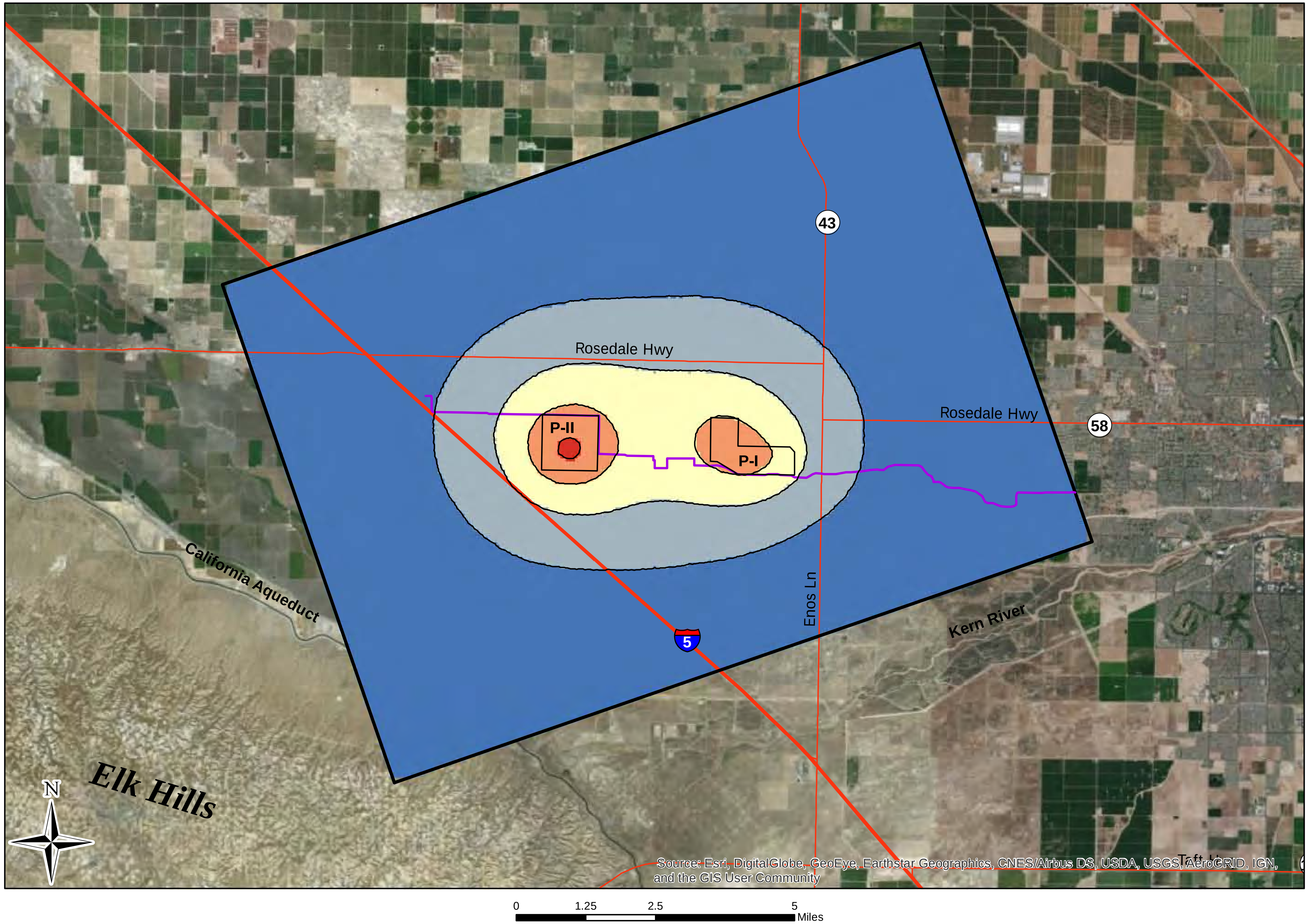
Thomas Harder & Co.
Groundwater Consulting

2/23/2018
Hydrographs | Phase II

Kern Fan Groundwater Storage Project

Irvine Ranch Water District

22-Feb-18



Map Features

- Goose Lake Slough
- Proposed Recharge Basin
- Model Domain
- Interstate
- Major Roads
- Water Courses

Difference in Head (ft)

- 0 - 0.5
- 0.51 - 1
- 1.1 - 1.5
- 1.6 - 2
- 2.1 - 2.5

Thomas Harder & Co.
Groundwater Consulting

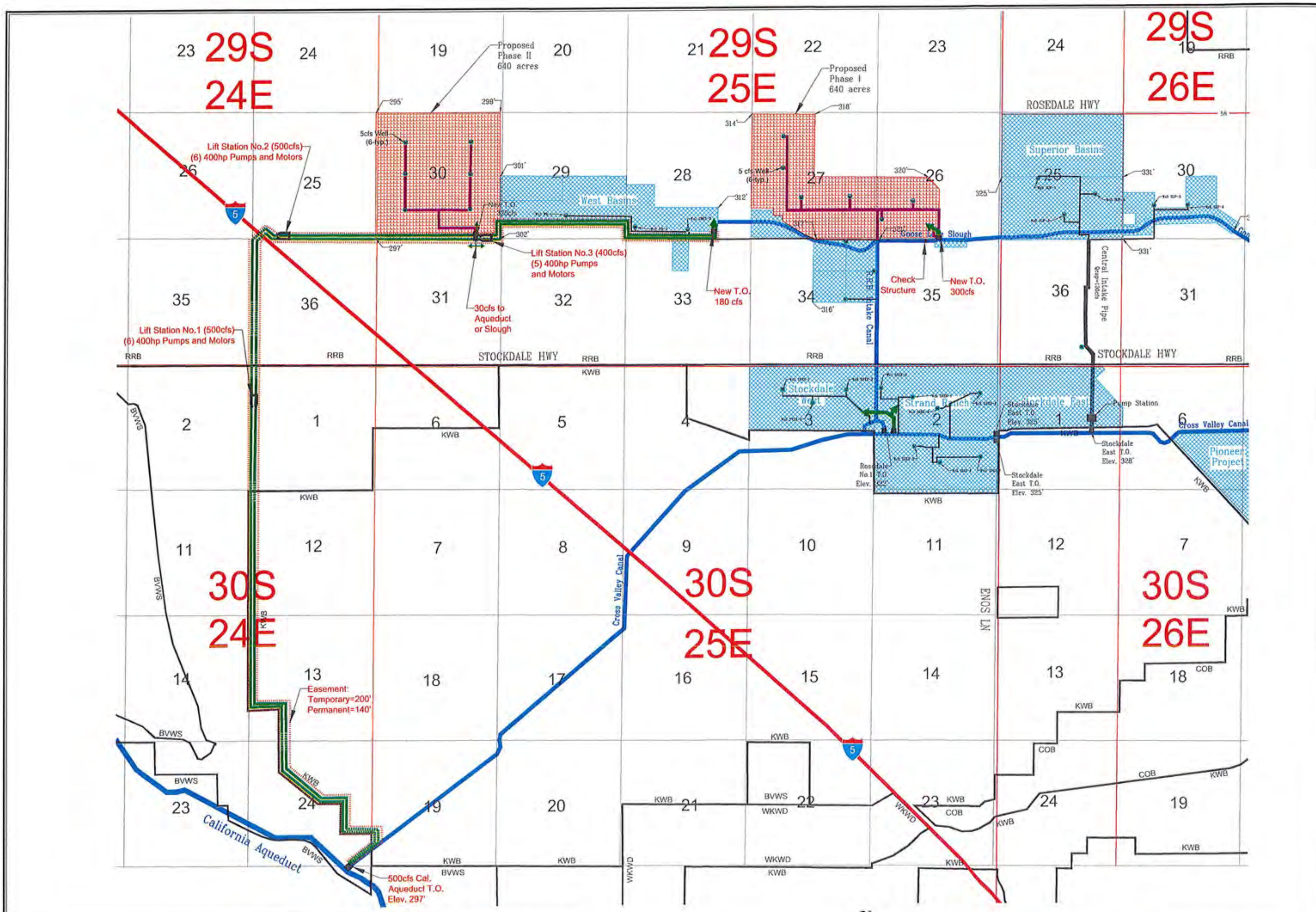
Difference Map

Figure 10

ATTACHMENT A

Project Concept Map

(from Dee Jasper & Associates, Inc., 2017)



Kern Fan Groundwater Storage Project Feasibility Study Map

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

APPENDIX D:

CRAMER FISH SCIENCES TECHNICAL MEMORANDUM

Chinook Salmon Benefits from Kern Fan Groundwater Storage Project

FEBRUARY 22, 2018

CRAMER FISH SCIENCES®
An Employee Owned Consulting Company

Brad Cavallo
Principal Scientist
13300 New Airport Rd, Suite 102
Auburn, CA 95602
bcavallo@fishsciences.net

February 22nd, 2018

TECHNICAL MEMORANDUM

Subject: Chinook Salmon Benefits from Kern Fan Groundwater Storage Project

Prepared for: Irvine Ranch Water District

Prepared by: Brad Cavallo, Dr. Steven Zeug and Dr. Myfanwy Johnston.

This technical memorandum provides a description of methodology, assumptions and results for an assessment of Spring-run and Winter-run Chinook ecosystem benefits resulting from the Kern Fan Groundwater Storage Project (Project).

1. Project operations for ecosystem benefits

The WSIP identifies sixteen priorities for ecosystem benefits. Cramer Fish Sciences (CFS) consulted with MBK Engineers and Irvine Ranch Water District to recommend how 18 thousand acre-feet (TAF) of additional water supply made available by the proposed Project could be used to provide the greatest benefit to ecosystem priorities and relative environmental value criteria (Revs). CFS recommended a pulse released from Lake Oroville in the month of April. CALSIM analysis provided by MBK Engineers indicated the Project could, with 1922-2003 hydrology under the WSIP 2030 future condition, provide for seven April flow pulses (of 18 TAF) in dry or critically dry years. Under the WSIP 2070 future condition, the Project can provide for five April flow pulses (of 18 TAF) in dry or critically dry years.

CFS recommended and assumed the 18TAF would be applied as a 3.75 day, 2,400cfs increase in Feather River flows released from the Thermalito Afterbay Outlet (TAO). Releasing this water from the TAO is important because the Feather River downstream of TAO has no ramping criteria for flows greater than 2,500 cfs (NMFS 2016a).

2. Methods for quantifying ecosystem benefits

Two ecosystem priorities are the primary beneficiaries of an April flow pulse on the Feather River. Ecosystem Priority 2 (P2) calls for “flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids. April is a period of “high” relative abundance for downstream migration and rearing of juvenile spring Chinook and juvenile steelhead in the Feather River and in the Sacramento downstream of Verona (NMFS 2016a). Also in April, juvenile winter-run Chinook are at “low” abundance in the Sacramento River downstream of Verona (NMFS 2016a).

Ecosystem Priority 12 (P12) calls for enhanced “access to fish spawning, rearing, and holding habitat by eliminating barriers to migration”. Upstream migration of adult green sturgeon in the Feather River is “high” for the month of April and upstream passage for green sturgeon appears to be positively influenced by river flow (NMFS 2016a).

Though April flow pulses are expected to benefit multiple fish species and life stages, our quantitative analysis focuses on assessing benefits (or impacts) to outmigrating juvenile spring-run Chinook and winter-run Chinook salmon.

Feather River Analyses

The Feather River hosts natural and hatchery origin spring-run Chinook. NMFS considers both in-river and hatchery spawning Feather River spring-run Chinook salmon to be part of the listed CV spring-run Chinook salmon ESU (NMFS 2016b). NMFS, in their most recent five-year review of CV spring-run, assigned a recovery priority for spring-run Chinook salmon in the Feather River of 5 (with 1 being the highest priority, 12 being the lowest priority) (NMFS 2016b). These determinations are based upon the evolutionary legacy the Feather River spring-run stock represents, because the stock continues to exhibit a CV spring-run Chinook salmon migration timing, and because of habitat and management improvements required as part of the Oroville Facilities FERC Relicensing Settlement Agreement.

Name	Value	Description	Source
SmH	2 million	Annual spring-run hatchery smolts released at Gridley.	FRH Spring Chinook HGMP
SmN	2 million	Annual natural origin spring-run juvenile production reaching apprxoimately Gridley on the Feather River.	Natural origin spring-run Chinook are produced on the Feather River, but abundance is uncertain. This value is approximated based on likely in-river spawning coupled with expected enhancements identified in the FRH Spring Chinook HGMP and FERC Reclicensing Biological Opinion (NMFS 2016a)
MIGm	0.62	Fraction of natural smolts emigrating in April	NMFS (2016a)
MIGp	0.125	Fraction of days in month with flow pulse	Duration of flow pulse (3.75 days) divided by 30
relm	0.5	Fraction of FRH smolts released in April	FRH Spring Chinook HGMP
relf	0.5	Fraction of FRH smolt release which be coordinated to coincide with flow pulse	Jason Kindopp (CDWR), personal communication
B0	-2.1	Smolt survival in the Feather River (untransformed value)	See text
B1	1.47	Flow survival effect (untransformed value)	NMFS (2017), Table B1. See text for more details.
Qm	variable	Standardized Feather River flow by month	CALSIM output
SmS	3.2 million	Annual natural origin spring-run smolts from the Sacramento River basin excluding the Feather River basin (estimated from spawning escapement, fecundity, egg-fry survival data)	See Table 2
SmW	2.1 million	Annual winter-run smolts from the Sacramento River (estimated from spawning escapement, fecundity, egg-fry survival data)	See Table 2
Sa	0.0144	Mean survival rate for smolts to return as adults	Zeug et al. (2012). See text for more details.
Sa max	0.0192	Maximum survival rate for smolts to return as adults	Zeug et al. (2012). See text for more details.
Sa min	0.0096	Miimum survival rate for smolts to return as adults	Zeug et al. (2012). See text for more details.

Table 1. Values, descriptions and sources for inputs and parameters used for the quantification of Project ecosystem benefits.

There are two components of the Feather River spring-run Chinook salmon analysis: 1) smolts released by FRH, and 2) juvenile spring-run Chinook salmon naturally produced in the Feather River. FRH annually produces 2 million spring-run Chinook smolts released into the Feather River. Natural origin spring-run Chinook are certainly produced in the Feather River, but their abundance is currently unknown (NMFS 2016a). Given expected habitat enhancements of the Feather River and the requirement to segregate spring and fall-run in the immediate future (see NMFS 2016a), we conservatively assume an average of 2 million natural origin spring-run smolts will be produced naturally by the Feather River by the time the Project is completed. Additionally, we assume all FRH spring-run Chinook releases will occur at Gridley. Though future FRH release locations are unknown, the California Hatchery Scientific Review Group has recommended all hatchery production be released as close to the source hatchery as possible (CA HSRG 2012). Given this recommendation and concerns abut straying Feather River Hatchery spring-run

Chinook (see NMFS 2016a), future spring-run Chinook releases downstream of the Yuba River confluence (e.g. Boyd's Pump) are unlikely.

Other data and sources used to evaluate effects of the proposed Project on the survival of Feather River spring-run Chinook salmon are summarized in Table 1. Related source flow data and calculations are shown in the Excel spreadsheet "FR_analysis_v3".

The monthly number of FRH produced spring-run smolts entering the Sacramento River (Sm_{FRH}) from the Feather River is estimated by

(eq1) $$Sm_H * rel_m * relf * surv_m$$

and the monthly number of natural origin spring-run smolts entering the Sacramento River from the Feather River (Sm_{FRW})is estimated by

(eq2) $$Sm_N * MIG_m * MIG_p * surv_m.$$

Survival for both hatchery and natural origin smolts are modeled as a function of monthly Feather River flows

(eq3) $$logit(surv_m) = B0 + B1 * Q_m$$

where B0 and B1 are model parameters (Table 1), and where Q_m is monthly Feather River flows standardized relative to all monthly Feather River flow observations (provided by CALSIM). Monthly flow data (1922 through 2003) representing four future conditions (WISP 2030, WISP 2030, WF_Base and WF) and two scenarios (Project and no project) were provided by MBK Engineers (see MBK 2018). A total of eight different CALSIM scenarios were analyzed.

	Sacramento Basin Spring-run		***Winter-run***	
Data Type	**Reference**	**Data**	**Reference**	**Data**
Total In-river Escapement	GrandTab (March 2010), 10 yr Avg	8,924	GrandTab (March 2010), 10 yr Avg	7,634
Pre-spawning mortality	Garman & McReynolds 2005-08	5.53%	Poytress & Carillo 2010	5%
Percent Female	Garman & McReynolds 2005-08	55%	Killam 2009	54%
Fecundity	DWR 2009	5300	Poytress & Carillo 2010	3859
Egg to Fry Survival	Poytress & Carillo 2010	33%	Poytress & Carillo 2010	33%
Fry to Delta Survival	USFWS, unpublished data	53%	USFWS, unpublished data	53%
Total Juveniles Reaching Delta		**4,200,000**		**2,600,000**
Percent smolts entering delta	USFWS Sacramento Trawls	86%	USFWS Sacramento Trawls	82%
Total Smolts Reaching Delta		**3,600,000**		**2,100,000**

Table 2. Values, descriptions and data sources used to estimate average Sacramento River basin spring-run and winter-run Chinook smolt production reaching the Delta (i.e. inputs for the Delta Passage Model).

The flow survival relationship (eq3) was developed by the NMFS Southwest Fishery Science Center as part of a life cycle modeling effort for winter-run Chinook salmon (NMFS 2017). The NMFS LCM is under continuous development, but the model (including this flow-survival function) were used in the NMFS Biological Opinion for California Water Fix (http://www.westcoast.fisheries.noaa.gov/central_valley/CAWaterFix.html). Of course, survival differences between the Sacramento and the Feather River are likely to occur. To address these expected differences, we utilized available Feather River spring-run Chinook acoustic tagging data to estimate B0, but relied upon the estimate of B1 from NMFS (2017). Survival per river kilometer data from Figure 2-30 (NMFS 2016a) were converted to a reach-specific survival estimate of 0.11, representing survival from Gridley to the confluence with the Sacramento River. Transforming 0.11 as necessary for the logit scale shown in eq3 yields a value of -2.1 for B0. The resulting relationship between Feather River flow and spring-run Chinook survival is depicted in Figure 1. Ideally, a Feather River flow-survival relationship would be based solely upon observations from the Feather River. However, since few observations of Feather River survival were available, we combined available Feather River information with findings from the NMFS winter-run Chinook life cycle modeling effort. Though there is uncertainty about the Feather River flow-survival relationship depicted in Figure 1, scientific literature from Central Valley tributaries affirms a positive relationship between Feather River flow and juvenile salmon survival is likely. Investigations into the relationship between river discharge and juvenile salmon survival in the Central Valley have primarily focused on the Sacramento-San Joaquin Delta and several studies have reported significant positive relationships (Newman 2003, Perry 2010). Less attention has been focused on the Feather River or other upstream tributaries. However, there are multiple lines of evidence to suggest a positive flow-survival relationship operates in the Feather River. Within the Central Valley, Zeug et al. (2014) reported a significant positive relationship between river discharge (and discharge variability) and survival for juvenile Chinook salmon in the Stanislaus River. Additionally, Perry et al. (*In press*) found that survival increased in delta reaches when high levels of discharge resulted in a switch from bi-directional to unidirectional flow. A positive flow survival relationship for Chinook salmon during spring in the Snake River was reported by Smith et al. (2003). However, flow was correlated with turbidity and temperature complicating attempts to separate out effects. Regardless of the causal mechanism it is clear that increases in flow result in more favorable conditions for juvenile Chinook survival during migration.

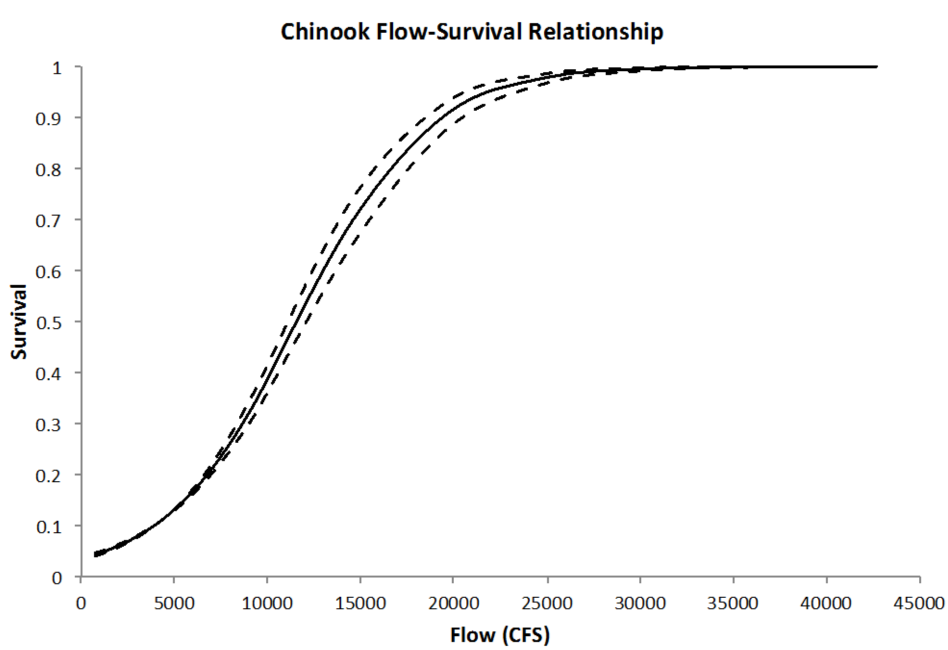


Figure 1. Estimated flow-survival relationship for juvenile Feather River spring-run Chinook salmon. Dashed lines indicate standard deviation associated with parameter B1 as estimated by NMFS (2017).

Flow pulses produced by the Project occurred exclusively in dry years, with Feather River base flows at less than 3,000cfs. The estimated survival under these conditions occurs at the left side of the curve depicted in Figure 1. On average, we estimate Project flow pulses improve survival relative to the base flow condition by approximately 4.6%

Date	Survvial w/o Pulse	Survvial w/ Pulse	Difference
04/30/1939	0.052	0.097	0.046
04/30/1944	0.060	0.112	0.052
04/30/1960	0.074	0.137	0.063
04/30/1976	0.046	0.088	0.042
04/30/1981	0.046	0.088	0.042
04/30/1985	0.046	0.088	0.042
04/30/1988	0.043	0.082	0.039
		Average:	**0.046**

Table 3. Estimated survival rates for Feather River Chinook salmon with and without the 2,400cfs flow pulse provided by the Project. Source data and calculations visible in the Excel spreadsheet "FR_analysis_v3".

Delta Analyses

Survival rates for Feather River spring-run Chinook, Sacramento River basin spring-run Chinook, and Sacramento River winter-run Chinook from Verona (Sacramento River) to San Francisco Bay were estimated for each flow scenario (with and without the proposed project) using the Delta Passage Model (DPM).

Sm_{FRH} and Sm_{FRW} provided inputs to the Delta Passage Model (DPM) representing Feather River Hatchery origin spring-run Chinook and Feather River natural origin spring-run Chinook, respectively. The number of spring-run (Sm_{SSRC}) and winter-run (Sm_{SWRC}) Chinook smolts entering from the Sacramento River basin are indicated in Table 2. DPM produced annual survival rates for winter and spring Chinook (weighted by monthly emigration timing) are shown in the Excel spreadsheet "Smolt_Surv_to_Bay_V2". A detailed description of the DPM is provided below.

The DPM simulates migration of Chinook salmon smolts entering the Sacramento River at Verona and estimates survival to Chipps Island. The DPM uses available time-series data and values taken from empirical studies or other sources to parameterize model relationships and inform uncertainty, thereby using the greatest amount of data available to dynamically simulate responses of smolt survival to changes in water management. Although the DPM is based primarily on studies of late fall–run Chinook salmon, it is applied here for winter-run and spring-run by adjusting emigration timing and assuming that all migrating Chinook salmon smolts will respond similarly to Delta conditions. The DPM results presented here reflect the current version of the model, which continues to be reviewed and refined, and for which a sensitivity analysis has been completed to examine various aspects of uncertainty related to the model's inputs and parameters.

Although studies have shown considerable variation in emigrant size, with Central Valley Chinook salmon migrating as fry, parr, or smolts (Brandes and McLain 2001; Williams 2001), the DPM relies predominantly on data from acoustic-tagging studies of large (>140 mm) smolts, and therefore should be applied cautiously to pre-smolt migrants. Salmon juveniles less than 80 mm are more likely to exhibit rearing behavior in the Delta (Moyle 2002) and thus likely will be represented poorly by the DPM. It has been assumed that the downstream emigration of fry, when spawning grounds are well upstream, is probably a dispersal mechanism that helps distribute fry among suitable rearing habitats. However, even when rearing habitat does not appear to be a limiting factor, downstream movement of fry still may be observed, suggesting that fry emigration is a viable alternative life-history strategy (Healey 1980; Healey and Jordan 1982; Miller et al. 2010). Unfortunately, survival data are lacking for small (fry-sized) juvenile emigrants because of the difficulty of tagging such small individuals. Therefore, the DPM should be viewed as a smolt survival model only, with its survival relationships generally having been derived from larger smolts (>140 mm), with the fate of pre-smolt emigrants not incorporated into model results.

The DPM has undergone substantial revisions based on comments received through the preliminary proposal anadromous team meetings and in particular through feedback received during a workshop held on August 24, 2010, a 2-day workshop held June 23–24, 2011, and various meetings of a workgroup consisting of agency biologists and consultants. This comparison of survival among Project and baseline alternatives uses the most recent version of the DPM as of July 2015 with several additional modifications described below. The DPM is viewed as a simulation framework that can be changed as more data or new hypotheses regarding smolt migration and survival become available. The results are based on these revisions.

Survival and abundance estimates generated by the DPM are not intended to predict future observed survival. Instead, the DPM provides a simulation tool that compares the effects of different water management options on smolt migration survival, with accompanying estimates of uncertainty. The DPM was used to evaluate overall through-Delta survival for baseline and Project scenarios using CALSIM flow data as inputs for Sacramento River and Delta water conditions. The DPM produced annual survival rates weighted by monthly emigration timing for spring-run and winter-run Chinook salmon.

Model Overview

The DPM is based on a detailed accounting of migratory pathways and reach-specific mortality as Chinook salmon smolts travel through a simplified network of reaches and junctions (Figure 2). The biological functionality of the DPM is based on the foundation provided by Perry et al. (2010) as well as other acoustic tagging–based studies (San Joaquin River Group Authority 2008, 2010; Holbrook et al. 2009) and coded wire tag (CWT)–based studies (Newman and Brandes 2010; Newman 2008). Uncertainty is explicitly modeled in the DPM by incorporating environmental stochasticity and estimation error whenever available.

The major model functions in the DPM are as follows.

1. Delta Entry Timing, which models the temporal distribution of smolts entering the Sacramento River at Verona for each race of Chinook salmon.
2. Fish Behavior at Junctions, which models fish movement as they approach river junctions.
3. Migration Speed, which models reach-specific smolt migration speed and travel time.
4. Route-Specific Survival, which models route-specific survival response to non-flow factors.
5. Flow-Dependent Survival, which models reach-specific survival response to flow.
6. Export-Dependent Survival, which models survival response to water export levels in the Interior Delta reach.

Functional relationships are described in detail in the *Model Functions* section below.

Model Time Step

The DPM operates on a daily time step using simulated flow data and Delta exports as model inputs. The DPM does not attempt to represent sub-daily flows or diel salmon smolt behavior in response to the interaction of tides, flows, and specific channel features. The DPM is intended to represent the net outcome of migration and mortality occurring over one day, not three-dimensional movements occurring over minutes or hours (e.g., Blake and Horn 2003).

Spatial Framework

The DPM version used for this Project is composed of eight reaches and two junctions (Figure 2; Table 4) selected to represent primary salmonid migration corridors where high-quality data were available for fish and hydrodynamics. For simplification, Sutter Slough and Steamboat Slough are combined as the reach SS; and Georgiana Slough, the Delta Cross Channel (DCC), and the forks of the Mokelumne River to which the DCC leads are combined as Geo/DCC. The Geo/DCC reach can be entered by Sacramento Chinook salmon runs through the combined junction of Georgiana Slough and DCC (Junction C). The Interior Delta reach can only be entered from Geo/DCC. Because of the lack of data informing specific routes through the Interior Delta, or tributary-specific survival, the entire Interior Delta region is treated as a single model reach. The four distributary junctions (channel splits) depicted in the DPM are (A) Sacramento River at Fremont Weir (not used for this Project), (B) Sacramento River at head of Sutter and Steamboat Sloughs, (C) Sacramento River at the combined junction with Georgiana Slough and DCC, and (D) San Joaquin River at the head of Old River (not used for this Project). The proportion of fish entering Yolo was set to zero for this Project because the confluence of the Feather River is downstream of this junction. Additionally, survival was not estimated for San Joaquin or Mokelumne rivers because the proposed Project would not affect these systems.

Table 4. Description of Modeled Reaches and Junctions in the Delta Passage Model

Reach/ Junction	Description	Reach Length (km)
Sac1	Sacramento River from Freeport to junction with Sutter/Steamboat Sloughs	19.33
Sac2	Sacramento River from Sutter/Steamboat Sloughs junction to junction with Delta Cross Channel/Georgiana Slough	10.78
Sac3	Sacramento River from Delta Cross Channel junction to Rio Vista, California	22.37
Sac4	Sacramento River from Rio Vista, California to Chipps Island	23.98
Verona	Fremont Weir to Freeport	57
SS	Combined reach of Sutter Slough and Steamboat Slough ending at Rio Vista, California	26.72
Geo/DCC	Combined reach of Georgiana Slough, Delta Cross Channel, and South and North Forks of the Mokelumne River ending at confluence with the San Joaquin River in the Interior Delta	25.59
Interior Delta	Begins at end of reach Geo/DCC, San Joaquin River via Junction D, or Old River via Junction D, and ends at Chipps Island	NA[a]

Reach/ Junction	**Description**	**Reach Length (km)**
B	Combined junction of Sutter Slough and Steamboat Slough with the Sacramento River	NA
C	Combined junction of the Delta Cross Channel and Georgiana Slough with the Sacramento River	NA
[a] Reach length for the Interior Delta is undefined because salmon can take multiple pathways. Also, timing through the Interior Delta does not affect Delta survival because there are no Delta reaches located downstream of the Interior Delta.		

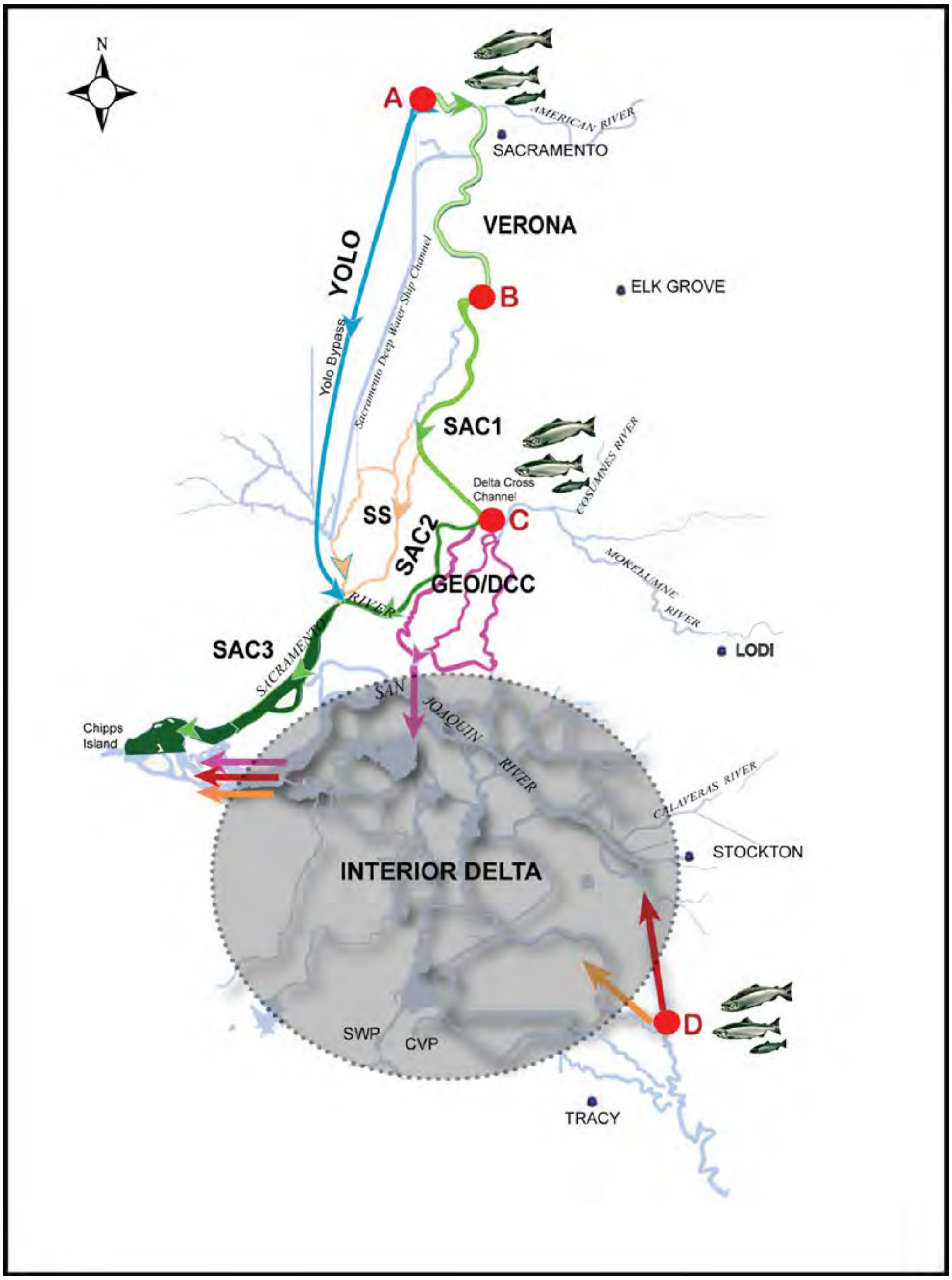


Figure 2. Map of the Sacramento–San Joaquin River Delta Showing the Modeled Reaches and Junctions of the Delta applied in the Delta Passage Model. Bold headings label modeled reaches, and red circles indicate model junctions. Salmonid icons indicate locations where smolts enter the Delta in the DPM. The Yolo reach and junction was not included in this analysis. Smolts enter the Interior Delta from the Geo/DCC reach or from Junction D via Old River or from the San Joaquin River. The San Joaquin and Mokelumne rivers were not modeled in the current Project because the proposed Project would not affect flow in those systems. Because of the lack of data informing specific routes through the Interior Delta, and tributary-specific survival, the entire Interior Delta region is treated as a single model reach.

Flow Input Data

Water movement through the Delta as input to the DPM is derived from monthly (tidally averaged) flow output produced by CALSIM-II. The nodes in CALSIM II that were used to provide flow for specific reaches in the DPM are shown in Table 5.

Table 5. Delta Passage Model Reaches and Associated Output Locations from CALSIM II.

DPM Reach or Model Component	CALSIM Node
Sac1	C169
Sac2	C400
Sac3	C401A
Sac4	C402A
Verona	NA
SS	-1811.574+(Sac1*0.3608831)
Geo/DCC	C401B
South Delta Export Flow	Delta Exports

Model Functions

Delta Entry Timing

Recent sampling data on Delta entry timing of emigrating juvenile smolts for three Central Valley Chinook salmon runs were used to inform the daily proportion of juveniles entering the Delta for each run (Table 6). Because the DPM models the survival of smolt-sized juvenile salmon, pre-smolts were removed from catch data before creating entry timing distributions. The lower 95th percentile of the range of salmon fork lengths visually identified as smolts by the USFWS in Sacramento trawls was used to determine the lower length cutoff for smolts. A lower fork length cutoff of 70 mm for smolts was applied, and all catch data of fish smaller than 70 mm were eliminated. To isolate wild production, all fish identified as having an adipose-fin clip (hatchery production) were eliminated, recognizing that most of the fall-run hatchery fish released upstream of Sacramento are not marked. Daily catch data for each brood year were divided by total annual catch to determine the daily proportion of smolts entering the Delta for each brood year. Sampling was not conducted daily at most stations and catch was not expanded for fish caught but not measured. Finally, the daily proportions for all brood years were plotted for each race, and a normal distribution was visually approximated to obtain the daily proportion of smolts entering the DPM for each run (Figure 3). Because a bi-modal distribution appeared evident for winter-run entry timing, a generic probability density function was fit to the winter-run daily proportion data using the package "sm" in R software (R Core Team 2012). The R fitting procedure estimated the best-fit probability distribution of the daily proportion of fish entering the DPM for winter-run. Timing of Delta entry was backed up to Verona for each run based on estimates of travel time in the reach between Verona and Sacramento calculated from acoustic tag data (Michel 2010).

Table 6. Sampling Gear Used to Create Juvenile Delta Entry Timing Distributions for Each Central Valley Run of Chinook Salmon

Chinook Salmon Run	Gear	Agency	Brood Years

Sacramento River Winter Run	Trawls at Sacramento	USFWS	1995–2009
Sacramento River Spring Run	Trawls at Sacramento	USFWS	1995–2005
Sacramento River Fall Run	Trawls at Sacramento	USFWS	1995–2005

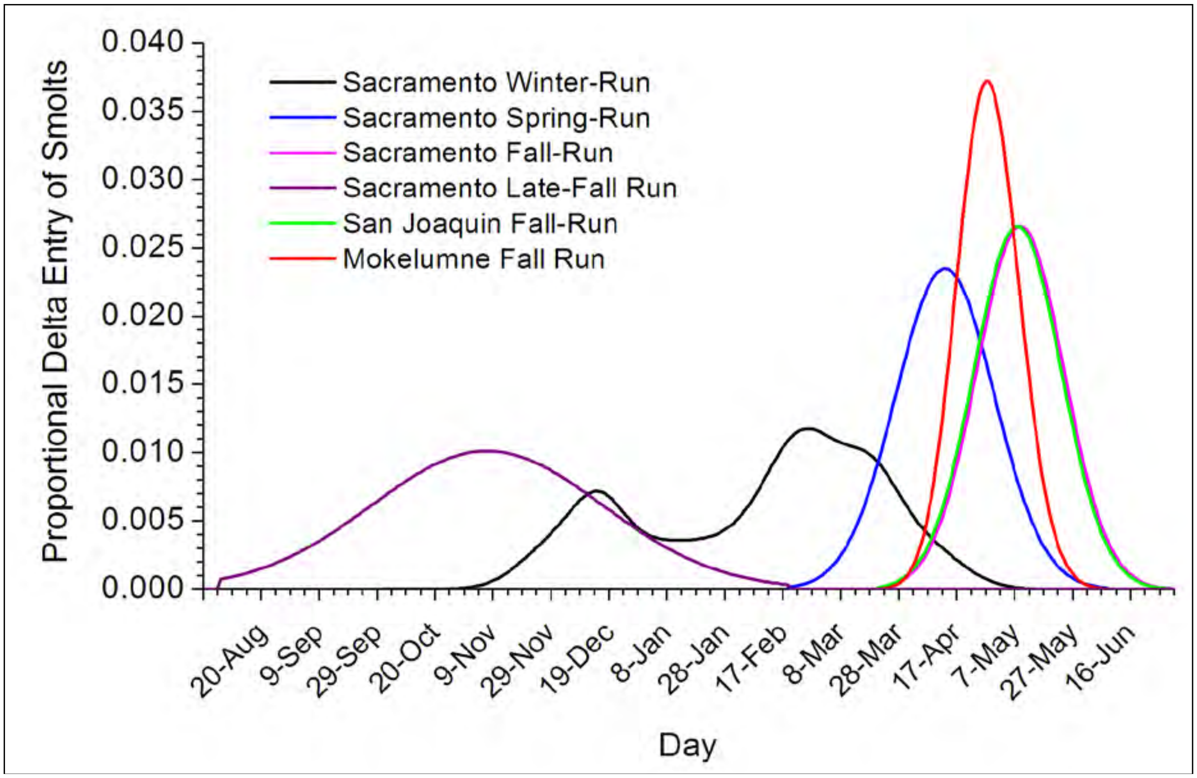


Figure 3. Delta Entry Distributions for Chinook Salmon Smolts Applied in the Delta Passage Model for Sacramento River Winter-Run, Sacramento River Spring-Run, Sacramento River Fall-Run, Sacramento River Late Fall–Run, San Joaquin River Fall-Run, and Mokelumne River Fall-Run Chinook Salmon. For this Project, only spring-winter and fall run in the Sacramento River were modeled.

Migration Speed

The DPM assumes a net daily movement of smolts in the downstream direction. The rate of smolt movement in the DPM affects the timing of arrival at Delta junctions and reaches, which can affect route selection and survival as flow conditions or water project operations change.
Smolt movement in all reaches except the Interior Delta is a function of reach-specific length and migration speed as observed from acoustic-tagging results. Reach-specific length (kilometers [km]) (Table 4) is divided by reach migration speed (km/day) the day smolts enter the reach to calculate the number of days smolts will take to travel through the reach.

For north Delta reaches Verona, Sac1, Sac2, SS, and Geo/DCC, mean migration speed through the reach is predicted as a function of flow. Many studies have found a positive relationship between juvenile Chinook salmon migration rate and flow in the Columbia River Basin (Raymond 1968; Berggren and Filardo 1993; Schreck et al. 1994), with Berggren and Filardo (1993) finding a logarithmic relationship for Snake River yearling Chinook salmon. Ordinary least squares regression was used to test for a logarithmic relationship between reach-specific migration speed (km/day) and average daily reach-specific flow (cubic meters per second [m^3/sec]) for the first day smolts entered a particular reach for reaches where acoustic-tagging data was available (Sac1, Sac2, Sac3, Sac4, Geo/DCC, and SS):

$$Speed = \beta_0 \ln(flow) + \beta_1;$$

Where β_0 is the slope parameter and β_1 is the intercept.

Individual smolt reach-specific travel times were calculated from detection histories of releases of acoustically-tagged smolts conducted in December and January for three consecutive winters (2006/2007, 2007/2008, and 2008/2009) (Perry 2010). Reach-specific migration speed (km/day) for each smolt was calculated by dividing reach length by travel days (Table 7). Flow data was queried from the DWR's California Data Exchange website (<http://cdec.water.ca.gov/>).

Table 7. Reach-Specific Migration Speed and Sample Size of Acoustically-Tagged Smolts Released during December and January for Three Consecutive Winters (2006/2007, 2007/2008, and 2008/2009)

Reach	Gauging Station ID	Release Dates	Sample Size	Speed (km/day)			
				Avg	Min	Max	SD
Sac1	FPT	12/05/06–12/06/06, 1/17/07–1/18/07, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	452	13.32	0.54	41.04	9.29
Sac2	SDC	1/17/07–1/18/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	294	9.29	0.34	10.78	3.09
Sac3	GES	12/05/06–12/06/06, 1/17/07–1/18/07, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	102	9.24	0.37	22.37	7.33
Sac4	GES[a]	12/05/06–12/06/06, 1/17/07–1/18/07, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	62	8.60	0.36	23.98	6.79
Geo/DCC	GSS	12/05/06–12/06/06, 1/17/07–1/18/07, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	86	14.20	0.34	25.59	8.66
SS	FPT-SDC[b]	12/05/06–12/06/06, 12/04/07–12/07/07, 1/15/08–1/18/08, 11/30/08–12/06/08, 1/13/09–1/19/09	30	9.41	0.56	26.72	7.42

[a] Sac3 flow is used for Sac4 because no flow gauging station is available for Sac4.
[b] SS flow is calculated by subtracting Sac2 flow (SDC) from Sac1 flow (FPT).

Migration speed was significantly related to flow for reaches Sac1 (df = 450, F = 164.36, P < 0.001), Sac2 (df = 292, F = 4.17, P = 0.042), and Geo/DCC (df = 84, F = 13.74, P <0.001). Migration speed increased as flow increased for all three reaches (Figure 4). Therefore, for reaches Sac1, Sac2, and Geo/DCC, the regression coefficients shown in Table 8 are used to calculate the expected average migration rate given the input flow for the reach and the associated standard error of the regressions is used to inform a normal probability distribution that is sampled from the day smolts enter the reach to determine their migration speed throughout the reach. The minimum migration speed for each reach is set at the minimum reach-specific migration speed observed from the acoustic-tagging data (Table 7). The flow-migration rate relationship that was used for Sac1 also was applied for the Verona reach.

Table 8. Sample Size and Slope (β0) and Intercept (β1) Parameter Estimates with Associated Standard Error (in Parenthesis) for the Relationship between Migration Speed and Flow for Reaches Sac1, Sac2, and Geo/DCC.

Reach	N	β_0	β_1
Sac1	452	21.34 (1.66)	-105.98 (9.31)
Sac2	294	3.25 (1.59)	-8.00 (8.46)
Geo/DCC	86	11.08 (2.99)	-33.52 (12.90)

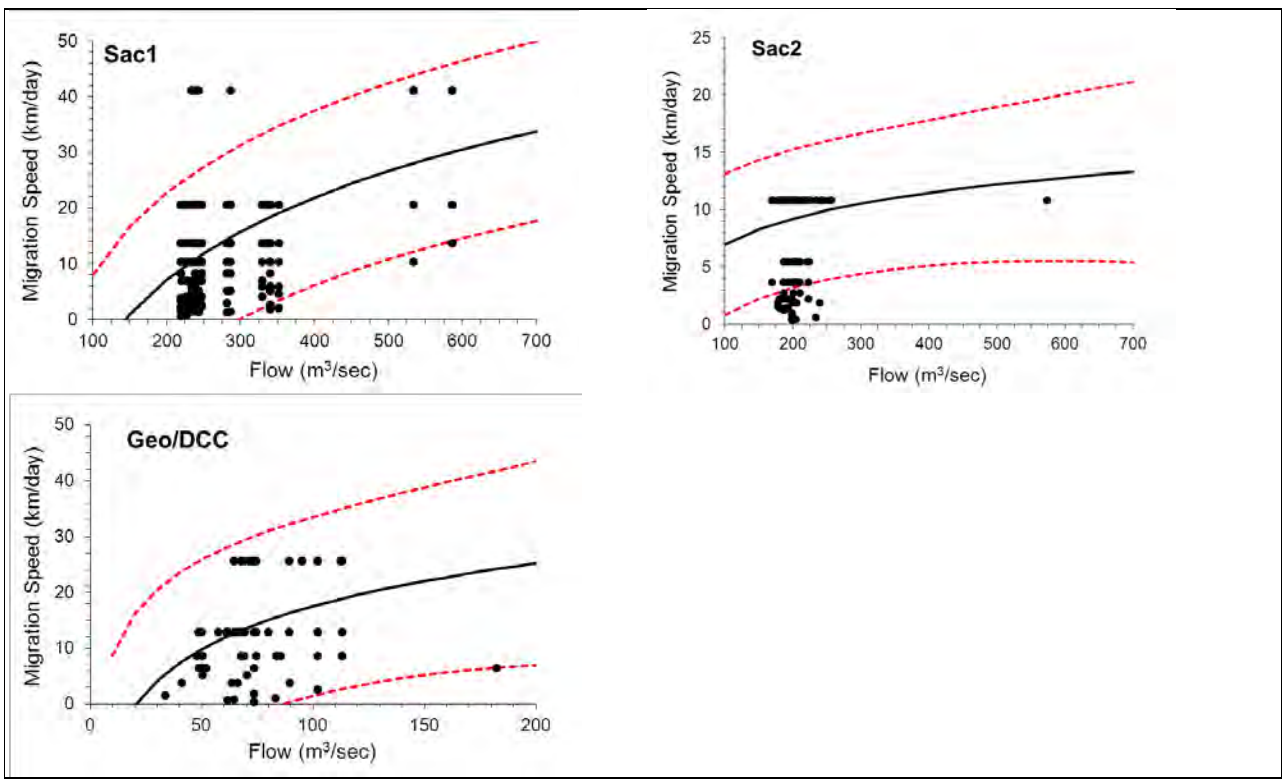


Figure 4. Reach-Specific Migration Speed (km/day) as a Function of Flow (m3/sec) Applied in Reaches Sac1, Sac2, and Geo/DCC. Circles are observed migration speeds of acoustically-tagged smolts from acoustic-tagging studies from Perry (2010), solid lines are predicted mean reach survival curves, and dotted lines are 95% prediction intervals used to inform uncertainty.

No significant relationship between migration speed and flow was found for reaches Sac3 (df = 100, F = 1.13, P =0.29), Sac4 (df = 60, F = 0.33, P = 0.57), and SS (df = 28, F = 0.86, P = 0.36).

Therefore, for these reaches the observed mean migration speed and associated standard deviation (Table 7) is used to inform a normal probability distribution that is sampled from the day smolts enter the reach to determine their migration speed throughout the reach. As applied for reaches Sac1, Sac2, and Geo/DCC, the minimum migration speed for reaches Sac3, Sac4, and SS is set at the minimum reach-specific migration speed observed from the acoustic-tagging data (Table 7).

The travel time of smolts migrating through the Interior Delta in the DPM is informed by observed mean travel time (7.95 days) and associated standard deviation (6.74) from North Delta acoustic-tagging studies (Perry 2010). However, the timing of smolt passage through the Interior Delta does not affect Delta survival because there are no Delta reaches located downstream of the Interior Delta.

Fish Behavior at Junctions (Channel Splits)

Perry et al. (2010) found that acoustically-tagged smolts arriving at Delta junctions exhibited inconsistent movement patterns in relation to the flow being diverted. For Junction B (Sacramento River-Sutter/Steamboat Sloughs), Perry et al. (2010) found that smolts consistently entered downstream reaches in proportion to the flow being diverted. Therefore, smolts arriving at Junction B in the model move proportionally with flow. For Junction C (Sacramento River–Georgiana Slough/DCC), Perry (2010) found a linear, nonproportional relationship between flow and fish movement. His relationship for Junction C was applied in the DPM:

$$y = 0.22 + 0.47x;$$

where y is the proportion of fish diverted into Geo/DCC and x is the proportion of flow diverted into Geo/DCC (Figure 5).

In the DPM, this linear function is applied to predict the daily proportion of fish movement into Geo/DCC as a function of the proportion of flow into Geo/DCC.

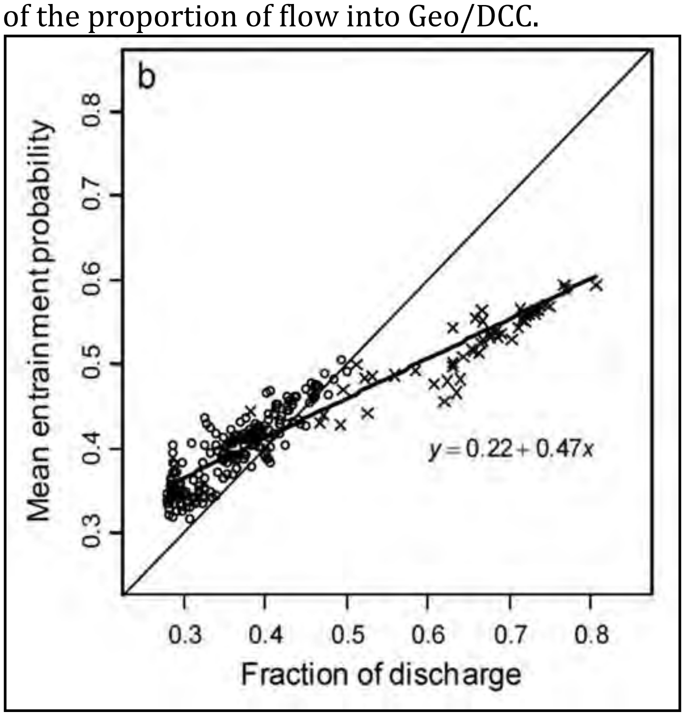


Figure 5. Figure from Perry (2010) Depicting the Mean Entrainment Probability (Proportion of Fish Being Diverted into Reach Geo/DCC) as a Function of Fraction of Discharge (Proportion of Flow Entering Reach Geo/DCC). Circles Depict DCC Gates Closed, Crosses Depict DCC Gates Open.

Route-Specific Survival

Survival through a given route (individual reach or several reaches combined) is calculated and applied the first day smolts enter the reach. For reaches where literature showed support for reach-level responses to environmental variables, survival is influenced by flow (Sac1, Sac2, Sac3 and Sac4 combined, SS and Sac 4 combined, Interior Delta via San Joaquin River, and Interior Delta via Old River) or south Delta water exports (Interior Delta via Geo/DCC). For these reaches, daily flow or exports occurring the day of reach entry are used to predict reach survival during the entire migration period through the reach (Table 9). For Geo/DCC, reach survival is assumed to be unaffected by Delta conditions and is informed by the mean and standard deviation of survival from acoustic-tagging studies.

Table 9. Route-Specific Survival and Parameters Defining Functional Relationships or Probability Distributions for Each Chinook Salmon Run and Methods Section Where Relationship is Described.

Route	Chinook Salmon Run	Survival	Methods Section Description
Verona	All Sacramento runs	0.931 (0.02)	This section
Sac1	All Sacramento runs	Function of flow	Flow-Dependent Survival
Sac2	All Sacramento runs	Function of flow	Flow-Dependent Survival
Sac3 and Sac4 combined	All Sacramento runs	Function of flow	Flow-Dependent Survival
SS and Sac4 combined	All Sacramento runs	Function of flow	Flow-Dependent Survival
Geo/DCC	All Sacramento runs	0.65 (0.126)	This section
Interior Delta	All Sacramento runs	Function of exports	Export-Dependent Survival

For reach Geo/DCC, no empirical data were available to support a relationship between survival and Delta flow conditions (channel flow, exports). Therefore, for these reaches mean reach survival is used along with reach-specific standard deviation to define a normal probability distribution that is sampled from when smolts enter the reach to determine reach survival (Table 9).

Mean reach survival and associated standard deviation for Geo/DCC are informed by survival data from smolt acoustic-tagging studies from Perry (2010). Smolts migrating down the Sacramento River during the acoustic-tagging studies could enter the DCC or Georgiana Slough when the DCC was open (December releases), therefore, group survivals for both routes are used to inform the mean survival and associated standard deviation for the Geo/DCC reach for Sacramento River runs (Table 10).

Mean survival and associated standard deviation for the Verona reach between Fremont Weir and Yolo Bypass were derived from the 2007–2009 acoustic-tag study reported by Michel (2010), who did not find a flow-survival relationship for that reach.

Table 10. Individual Release-Group Survival Estimates, Release Dates, Data Sources, and Associated Calculations Used to Inform Reach-Specific Mean Survivals and Standard Deviations Used in the Delta Passage Model for Reaches Where Survival Is Uninfluenced by Delta Conditions.

DPM Reach	Survival	Release Dates	Survival Calculation	Mean	Standard Deviation
Geo/DCC via Sacramento River	0.648	12/05/06	S_{D1}	0.559	0.194
	0.600	12/04/07–12/06/07	$S_{D1,SAC}*S_{D2}$		
	0.762	1/15/08–1/17/08	$S_{D1,SAC}*S_{D2}$		
	0.774	11/31/08–12/06/08	$S_{D1,SAC}*S_{D2}$		
	0.467	1/13/08–1/19/09	$S_{D1,SAC}*S_{D2}$		
	0.648	12/05/06	$S_{C1}* S_{C2}$		
	0.286	12/04/07–12/06/07	S_{C1}		
	0.286	11/31/08–12/06/08	S_{C1}		
Source: Perry 2010.					

Flow-Dependent Survival

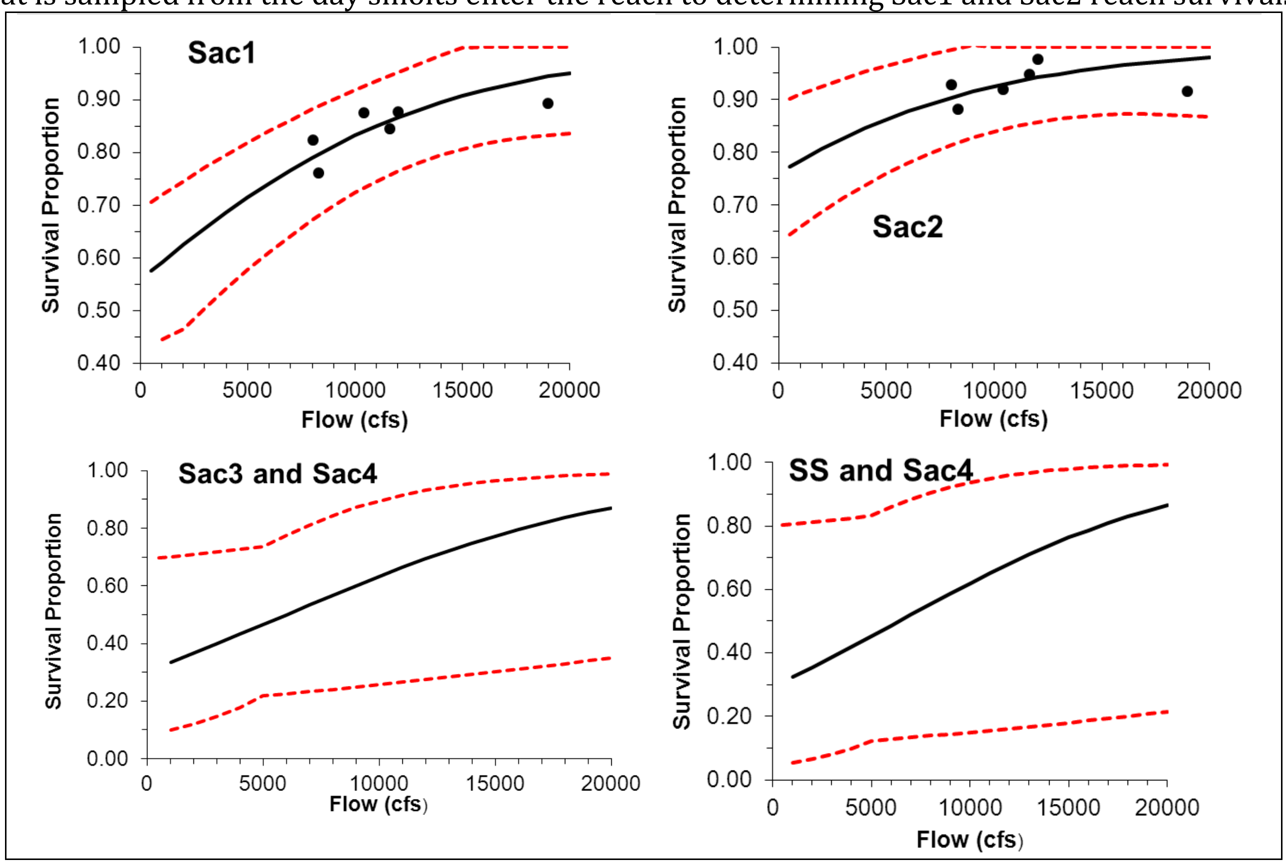
For reaches Sac1, Sac2, Sac3 and Sac4 combined and SS and Sac4 combined, flow values on the day of route entry are used to predict route survival. Perry (2010) evaluated the relationship between survival among acoustically-tagged Sacramento River smolts and Sacramento River flow measured below Georgiana Slough (DPM reach Sac3) and found a significant relationship between survival and flow during the migration period for smolts that migrated through Sutter and Steamboat Sloughs to Chipps Island (Sutter and Steamboat route; SS and Sac4 combined) and smolts that migrated from the junction with Georgiana Slough to Chipps Island (Sacramento River route; Sac3 and Sac4 combined). Therefore, for route Sac3 and Sac4 combined and route SS and Sac4 combined, the logit survival function from Perry (2010) was used to predict mean reach survival (*S*) from reach flow (*flow*):

$$S = \frac{e^{(\beta_0 + \beta_1 flow)}}{1 + e^{(\beta_0 + \beta_1 flow)}}$$

where β_0 (SS and Sac4 = -0.175, Sac3 and Sac4 = -0.121) is the reach coefficient and β_1 (0.26) is the flow coefficient, and *flow* is average Sacramento River flow in reach Sac3 during the experiment standardized to a mean of 0 and standard deviation of 1.

Perry (2010) estimated the global flow coefficient for the Sutter Steamboat route and Sacramento River route as 0.52. For the Sac3 and Sac4 combined route and the SS and Sac4 combined route, mean survival and associated standard error predicted from each flow-survival relationship is used to inform a normal probability distribution that is sampled from the day smolts enter the route to determine their route survival.

With a flow-survival relationship appearing evident for group survival data of acoustically-tagged smolts in reaches Sac1 and Sac2, Perry's (2010) relationship was applied to Sac1 and Sac2 while adjusting for the mean reach-specific survivals for Sac1 and Sac2 observed during the acoustic-tagging studies (Figure 6; Table 11). The flow coefficient was held constant at 0.52 and the residual sum of squares of the logit model was minimized about the observed Sac1 and Sac2 group survivals, respectively, while varying the reach coefficient. The resulting reach coefficients for Sac1 and Sac2 were 1.27 and 2.16, respectively. Mean survival and associated standard error predicted from the flow-survival relationship is used to inform a normal probability distribution that is sampled from the day smolts enter the reach to determining Sac1 and Sac2 reach survival.



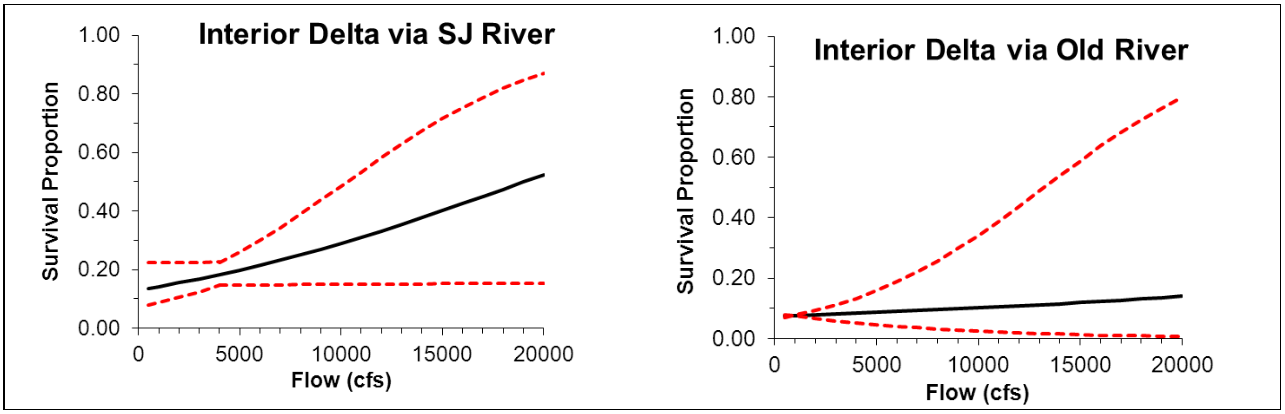


Figure 6. Route Survival as a Function of Flow Applied in Reaches Sac1, Sac2, Sac3 and Sac4 combined, SS and Sac4 combined, Interior Delta via the San Joaquin River, and Interior Delta via Old River For Sac1, Sac2, Sac3, and Sac4, circles are observed group survivals from acoustic-tagging studies from Perry (2010). Raw data are not available from Newman (2010) for Interior Delta via San Joaquin River and Interior Delta via Old River from Newman (2010). Solid lines are predicted mean route survival curves, and dotted lines are 95% confidence bands used to inform uncertainty. Survival of smolts through the Interior Delta via the San Joaquin and Old River were not modeled in the current Project.

Table 11. Group Survival Estimates of Acoustically-Tagged Chinook Salmon Smolts from Perry (2010) and Associated Calculations Used to Inform Flow-Dependent Survival Relationships for Reaches Sac1 and Sac2.

DPM Reach	Survival	Release Dates	Source	Survival Calculation
Sac1	0.844	12/5/06	Perry 2010	S_{A1} *S_{A2}
Sac1	0.876	1/17/07	Perry 2010	S_{A1} *S_{A2}
Sac1	0.874	12/4/07-12/6/07	Perry 2010	S_{A1} *S_{A2}
Sac1	0.892	1/15/08-1/17/08	Perry 2010	S_{A1} *S_{A2}
Sac1	0.822	11/31/08-12/06/08	Perry 2010	S_{A1} *S_{A2}
Sac1	0.760	1/13/09-1/19/09	Perry 2010	S_{A1} *S_{A2}
Sac2	0.947	12/5/06	Perry 2010	S_{A3}
Sac2	0.976	1/17/07	Perry 2010	S_{A3}
Sac2	0.919	12/4/07-12/6/07	Perry 2010	S_{A3}
Sac2	0.915	1/15/08-1/17/08	Perry 2010	S_{A3}
Sac2	0.928	11/31/08-12/06/08	Perry 2010	S_{A3}
Sac2	0.881	1/13/09-1/19/09	Perry 2010	S_{A3}

Exports are standardized as described for flow. Uncertainty in these parameters is accounted for by using model-averaged estimates for the intercept, flow coefficient and export coefficient. The model-averaged estimates and their standard deviations are used to define a normal probability distribution that is resampled each day in the model. San Joaquin River flows downstream of the head of Old River that were modeled by Newman (2010) ranged from -49 cfs to 10,756 cfs, with a median of 3,180 cfs. Exports modeled by Newman (2010) ranged from 805 cfs to 10,295 cfs, with a median of 2,238 cfs.

Export-Dependent Survival

As migratory juvenile salmon enter the Interior Delta from Geo/DCC for Sacramento races they transition to an area strongly influenced by tides and where south Delta water exports may influence survival. The export–survival relationship described by Newman and Brandes (2010) was applied as follows:

$$\theta = 0.5948 * e^{(-0.000065*Total\_Exports)};$$

where θ is the ratio of survival between coded wire tagged smolts released into Georgiana Slough and smolts released into the Sacramento River and Total_Exports is the flow of water (cfs) pumped from the Delta from the State and Federal facilities.

θ is a ratio and ranges from just under 0.6 at zero south Delta exports to ~0.27 at 12,000-cfs south Delta exports (Figure 7).

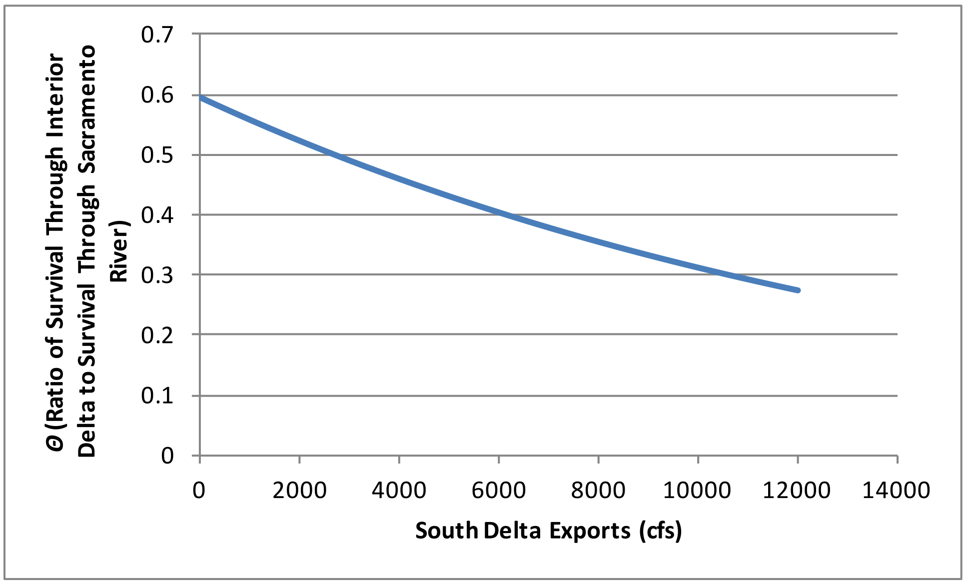


Figure 7. Relationship between θ (Ratio of Survival through the Interior Delta to Survival through Sacramento River) and South Delta Export Flows. Source: Newman and Brandes 2010.

θ was converted from a ratio into a value of survival through the Interior Delta using the equation:

$$S_{ID} = \frac{\theta}{S_{Geo/DCC}} * (S_{Sac3} * S_{Sac4});$$

where S_{ID} is survival through the Interior Delta, θ is the ratio of survival between Georgiana Slough and Sacramento River smolt releases, $S_{Geo/DCC}$ is the survival of smolts in the Georgiana Slough/Delta Cross Channel reach, $S_{Sac3} * S_{Sac4}$ is the combined survival in reaches Sac 3 and Sac 4 (Figure 8).

Uncertainty is represented in this relationship by using the estimated value of θ and the standard error of the equation to define a normal distribution bounded by the 95% prediction interval of the model that is then re-sampled each day to determine the value of θ.

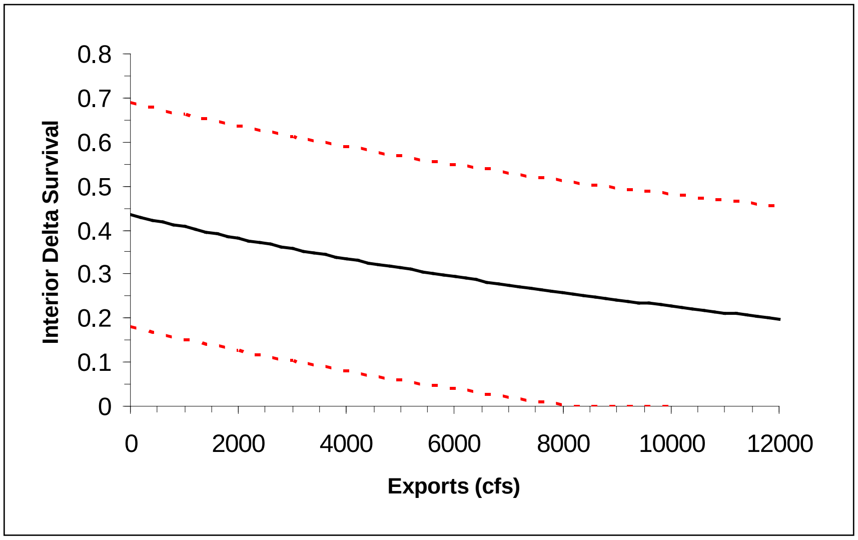


Figure 8. Interior Delta Survival as a Function of Delta Exports (Newman and Brandes 2010) as Applied for Sacramento Races of Chinook Salmon Smolts Migrating through the Interior Delta via Reach Geo/DCCSurvival values in reaches Sac3, Sac4, and Geo/DCC were held at mean values observed during acoustic-tag studies (Perry 2010) to depict export effect on Interior Delta survival in this plot. Dashed lines are 95% prediction bands used to inform uncertainty in the relationship.

Bay Smolt to Adult Returns

Total annual adult returns of spring-run Chinook salmon were calculated as

$$(Sm_{FRH}+Sm_{FRW}+Sm_{SSRC})*S_{DPM\_SRC} * S_a$$

and total annual adult returns of winter-run Chinook salmon were calculated as

$$Sm_{SWRC}*S_{DPM\_WRC} * S_a$$

Where…
S_{DPM_SRC} is the DPM-based estimate of survival for spring-run Chinook smolts to Delta exit;

S_{DPM_WRC} is the DPM-based estimate of survival for winter-run Chinook smolts to Delta exit; and where S_a is survival rate for smolts exiting the Delta to return as adults.

As discussed by Zeug et al. (2012), O'Farrell et al. (2012), Winship et al. (2014), Araujo et al. (2015), and others, smolt to adult survival is a function of factors including age and year specific natural mortality, age and year specific harvest mortality, and age at maturity. Since variation in these factors would not be influenced by the Project, we simplified by assuming all salmon matured at age-3 and that no harvest occurred until age-3. With these assumptions, smolt to adult mortality (S_a) was calculated as

$$M_2 * M_W * H_3$$

where M_2 is the survival of smolts to age-2, where M_w is overwinter survival of age-2 fish and where H_3 represents the fraction of fish surviving harvest and returning to spawn. Based upon Zeug et al. (2012) we fixed parameter values at 0.64 for M_w and at 0.75 for H_3. Since smolt to adult mortality is known to vary widely from year-to-year and among salmon populations (see Bradford et al. 1995), consistent with Zeug et al. (2012) we allowed M_2 to vary from a mean of 0.03, to a maximum value of 0.04 and to a minimum value of 0.02. The resulting range of values for S_a are shown in Table 2 and also reflected in the summary of results shown in Table 12. The estimated range for S_a are consistent with findings reported by Bradford et al. (1995), Araujo et al. (2015), Winship et al. (2014), O'Farrell et al. (2012), and are therefore considered appropriate for their application to evaluating the proposed Project.

3. Results from quantitative analysis

MBK (2018) describes water project operations, river flows and water supply results associated with the Project. Using these same simulated flows and water project operations, our analysis shows substantial net benefits to spring-run and winter-run Chinook (Table 12). The range of estimates shown in Table 12 demonstrated the influence of parameter uncertainty on estimated benefits. Though the magnitude of benefits are variable, our quantitative analyses demonstrates a consistent, strongly positive effect on adult abundance for spring-run and winter-run Chinook salmon.

Table 12. Estimated net change in adult Chinook salmon resulting from 50 years of proposed Project operations under four future conditions relative to no project.

	Spring-run		Winter-run	
Future Condition	Mean	Range	Mean	Range
2030	1011	(674-1348)	109	(73-145)
2070	715	(476-953)	73	(48-97)
WF_Base	672	(448-896)	53	(36-71)
WF	1044	(696-1392)	74	(50-99)

As expected, benefits for Chinook salmon occur in years when the Project allows for a Feather River flow pulse. In most years, Chinook salmon are not affected positively or negatively by the Project. For spring-run Chinook, we estimate from 121 to 354 additional adult Chinook would result from each of the seven Project flow pulses occurring in the 2030 future condition (Figure 9). The 2070 future condition allowed for five Project flow pulses producing from 168 to 375 additional spring-run adults for each flow pulse event (Figure 9).

Reductions in estimated annual adult Chinook occur in some years as a result of increased Delta diversions associated with the Project, but these losses are outweighed by much larger benefits which accumulate across all years (Table 12).

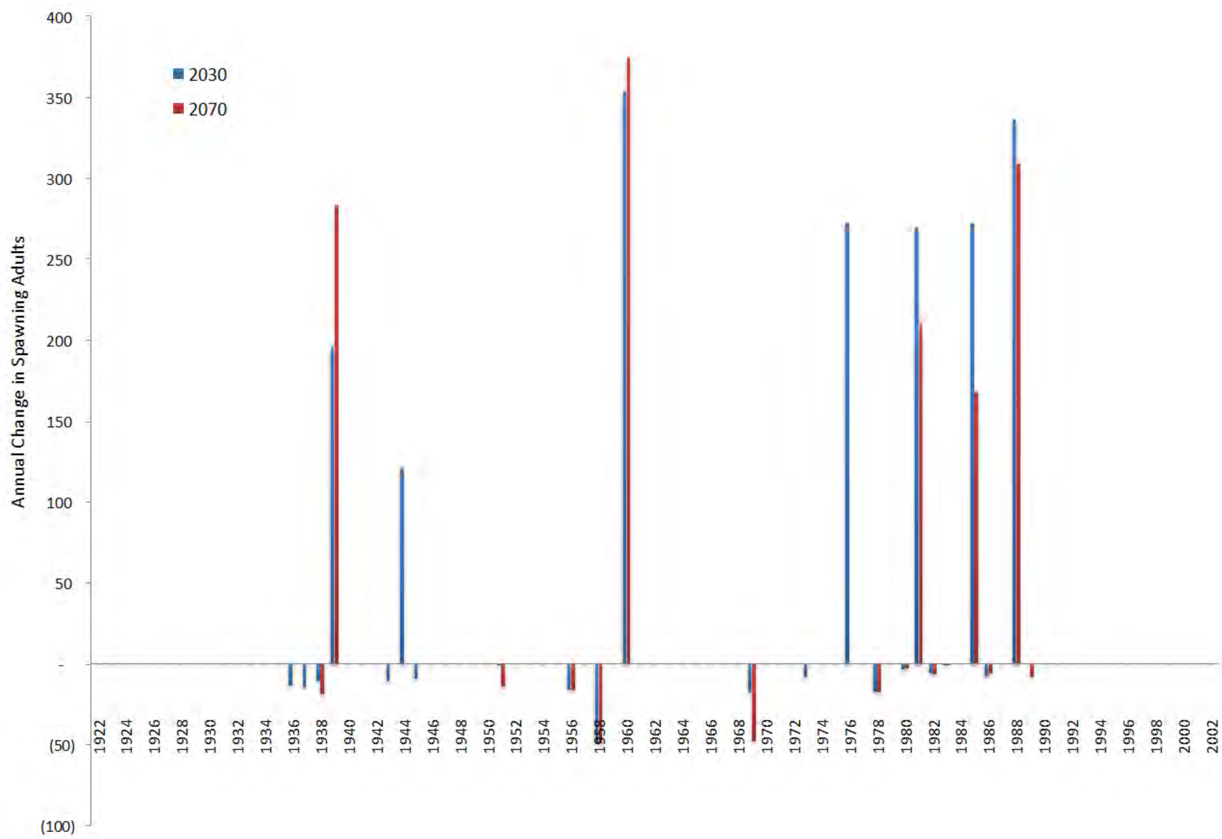


Figure 9. Annual change in adult spring-run Chinook spawners returns associated with the under 2030 and 2070 future conditions.

Benefits from the Project are also apparent for winter-run Chinook salmon. Though winter-run Chinook salmon are not present in the Feather River, the flow pulse originating from the Feather River reaches the Sacramento River and provides benefits from Verona to Delta exit. In most years, winter-run Chinook salmon are not affected positively or negatively by the Project. Benefits ranging from 26 to 57 additional adult Chinook winter-run occur with the seven Project flow pulses associated with the 2030 condition, and with the five Project flow pulses for the 2070 condition (Figure 10). Most winter-run Chinook smolts emigrate through Delta prior to April and are thus are sometimes exposed to increased winter exports associated with the Project (MBK 2018). As with spring-run Chinook, Delta losses for winter-run Chinook occur but are outweighed by larger benefits which accumulate across all years (Table 12).

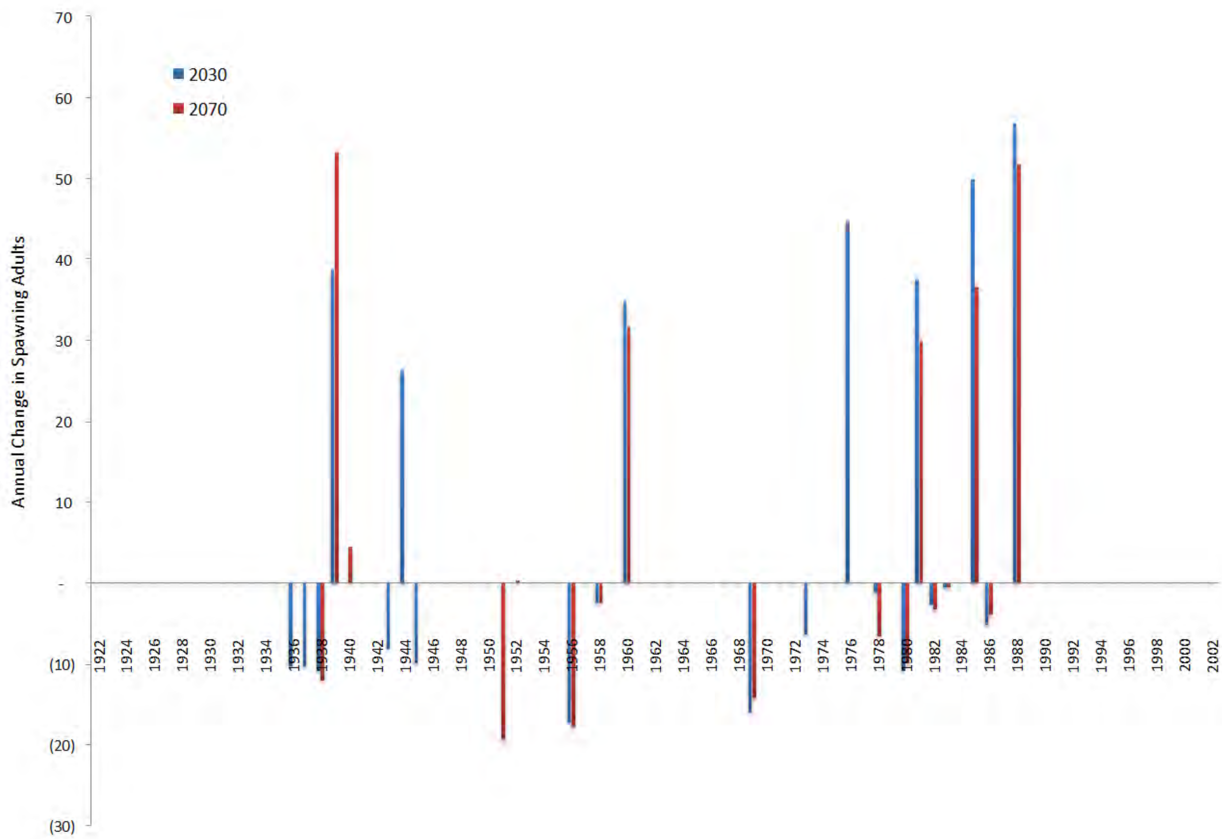


Figure 10. Annual change in adult winter-run Chinook spawning returns associated with the Project under 2030 and 2070 future conditions.

It is important to note that these abundance estimates do not represent a prediction of future spawning escapements. Rather these results reflect a comparison between water project operations using historic hydrologic conditions. The DPM and smolt-to-adult survival (S_a) components of the model analysis represent some major sources of uncertainty, but no practical modeling effort can adequately represent future real-world variation introduced by factors such as changing climate, changing habitat, changing harvest management, changing hatchery management, and shifting ocean productivity. Our modeling application here is consistent with other analytical efforts providing a standardized basis for comparing outcomes between alternative water management while controlling for unknown or uncontrollable future variation in environmental conditions.

Literature cited

Araujo, H.A., et al. 2015. Modeling population responses of Chinook and coho salmon to suspended sediment using a life history approach. Theoretical Population Biology Vol. 6, May. DOI: 10.1016/j.tpb.2015.04.003

Berggren, T. J., and M. J. Filardo. 1993. An Analysis of Variables Influencing the Migration of Juvenile Salmonids in the Columbia River Basin. North American Journal of Fisheries Management 13(1):48–63.

Blake, A. and M. J. Horn. 2003. Acoustic Tracking of Juvenile Chinook Salmon Movement in the Vicinity of the Delta Cross Channel, Sacramento River, California – 2001 Study Results. Prepared for U.S. Geological Survey and SRI International.

Brandes, P. L. and J. S. McLain. 2001. Juvenile Chinook Salmon Abundance, Disribution, and Survival in the Sacramento–San Joaquin Estuary. Pages 39-137 in R. Brown (ed.). Contributions to the Biology of Central Valley Salmonids, Fish Bulletin 179, Volume 2. Sacramento, CA: California Department of Fish and Game.

Bradford, M.J., 1995. Comparative review of Pacific salmon survival rates. Can. J. Fish. Aquat. Sci. 52, 1327–1338.

California Hatchery Scientific Review Group (CA HSRG). 2012. California Hatchery Review Project, Coleman Steelhead Program Report June 2012. http://cahatcheryreview.com/reports/

California Water Fix (CWF). 2016. Appendix 5.D, Quantitative methods and detailed results for effects analysis of Chinook salmon, Central Valley steelhead, green sturgeon and killer whale. Available: http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/CAWaterFix/app_5.d_methods.pdf

Healey, M. C. 1980. Utilization of the Nanaimo River Estuary by Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*). U.S. National Marine Fisheries Service Fishery Bulletin 77:653–668.

Healey, M. C. and F. P. Jordan. 1982. Observations on Juvenile Chum and Chinook and Spawning Chinook in the Nanaimo River, British Columbia, during 1975-1981. *Canada Manuscript Report of Fisheries and Aquatic Sciences* 1659:4.

Holbrook, C. M., R. W. Perry, and N. S. Adams. 2009. Distribution and Joint Fish-Tag Survival of Juvenile Chinook Salmon Migrating through the Sacramento-San Joaquin River Delta, California, 2008. Open-file report 2009-1204. U.S. Geological Survey, Reston, VA.

Michel, C. J. 2010. *River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (Oncorhynchus tshawytscha) Smolts and the Influence of Environment.* Master's thesis. University of California, Santa Cruz. Santa Cruz, CA.

MBK Engineers. 2018. Technical Memorandum: Analysis of Kern Fan Groundwater Storage Project for Water Storage Investment Program. February 16, 2018.

Miller, J. A., A. Gray, and J. Merz. 2010. Quantifying the Contribution of Juvenile Migratory Phenotypes in a Population of Chinook Salmon *Oncorhynchus tshawytscha*. *Marine Ecology Progress Series* 408:227–240.

Moyle, P. B. 2002. *Inland Fishes of California*, Revised and Expanded. Berkeley: University of California Press.

National Marine Fisheries Service (NMFS). 2017. Model description for the Sacramento River Winter-run Chinook Salmon Life Cycle Model. May 9, 2017.

National Marine Fisheries Service (NMFS). 2016a. Endangered species act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fisheries Conservation and Management Act essential fish habitat response and Fish and Wildlife Coordination Act recommendations for relicensing the Oroville Facilities Hydroelectric Project, Butte County, CA. National Marine Fisheries Service, West Coast Region.

National Marine Fisheries Service (NMFS). 2016b. 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit. National Marine Fisheries Service, West Coast Region.

Newman, K. B. 2008. *An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies.* U.S. Fish and Wildlife Service, Stockton, CA. Available: http://www.science.calwater.ca.gov/pdf/psp/PSP_2004_final/PSP_CalFed_FWS_salmon_studies_final_033108.pdf .

Newman, K. B., and P. L. Brandes. 2010. Hierarchical modeling of juvenile Chinook salmon survival as a function of Sacramento-San Joaquin Delta water exports. North American Journal of Fisheries Management 30:157–169.

O'Farrell, M. R., M. S. Mohr, A. M. Grover, and W. H. Satterthwaite. 2012. Sacramento River winter Chinook cohort reconstruction: analysis of ocean fishery impacts. NOAA Technical Memorandum NOAAXTMXNMFSX SWFSCX491.

Perry, R. W. 2010. Survival and Migratory Dynamics of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin River Delta. PhD dissertation. University of Washington, Seattle.

Perry, R. W. 2010. Survival and Migration Dynamics of Juvenile Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento-San Joaquin River Delta. Ph.D. Dissertation. University of Washington, Seattle, WA.

Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A. P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta. *North American Journal of Fisheries Management* 30(1):142–156.

Perry RW, Pope AC, Romine JG, Brandes PL, Burau JR, Blake AR, Ammann AJ, Michel CJ. *In press*. Flow-mediated effects on travel time, routing and survival of juvenile Chinook salmon in a spatially complex, tidally forced river delta. Canadian Journal of Fisheries and Aquatic Sciences.

R Core Team. 2012. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Available: <http://www.R-project.org>.

Raymond, H. L. 1968. Migration Rates of Yearling Chinook Salmon in Relation to Flows and Impoundments in the Columbia and Snake Rivers. Transactions of the American Fisheries Society 97:356–359.

San Joaquin River Group Authority. 2008. 2007 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January. Prepared by San Joaquin River Group Authority, Davis, CA. Prepared for California Water Resource Control Board in compliance with D-1641. Sacramento, CA. Available: <http://www.sjrg.org/technicalreport/>.

San Joaquin River Group Authority. 2010. 2009 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January. Prepared by San Joaquin River Group Authority, Davis, CA. Prepared for California Water Resource Control Board in compliance with D-1641. Sacramento, CA. Available: <http://www.sjrg.org/technicalreport/>.

Schreck, C. B., J. C. Snelling, R. E. Ewing, C. S. Bradford, L. E. Davis, and C. H. Slater. 1994. Migratory Characteristics of Juvenile Spring Chinook Salmon in the Willamette River. Completion Report. Bonneville Power Administration.

Smith SG, Muir WD, Hockersmith EE, Zabel RW. 2003. Influence of river conditions on survival and travel time of Snake River subyearling fall Chinook salmon. North American Journal of Fisheries Management 23:939-961.

Williams, J. G. 2001. Chinook Salmon in the Lower American River, California's Largest Urban Stream. Pages 1–37 in R. Brown (ed.). Contributions to the Biology of Anadromous Salmonids of the Central Valley, California. *Fish Bulletin* 179:2. Sacramento: California Department of Fish and Game.

Winship, A.J., M.R. O'Farrell and M.S. Mohr. 2014. Fishery and hatchery effects on an endangered salmon population with low productivity. Transactions of the American Fisheries Society, 143(4):957X 971.

Zeug, S.C., P.S. Bergman, B.J. Cavallo, and K.S. Jones. 2012. Application of a life cycle simulation model to evaluate impacts of water management and conservation actions on an endangered population of Chinook salmon. Environmental Modeling and Assessment. 13 p.

Zeug SC, Sellheim K, Watry C, Wikert JD, Merz J. 2014. Response of juvenile Chinook salmon to managed flow: lessons learned from a population at the southern extent of their range in North America. Fisheries Management and Ecology 21:155-168.

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

APPENDIX E:

M.CUBED TECHNICAL MEMORANDUM

Estimate of Benefits from the Kern Fan Groundwater Storage Project

FEBRUARY 23, 2018

M.CUBED
POLICY ANALYSIS FOR THE PUBLIC AND PRIVATE SECTORS

February 23, 2018

To: **Fiona Sanchez, Irvine Ranch Water District**

From: **Richard McCann, Partner**

RE: **Estimate of Benefits from the Kern Fan Groundwater Storage Project**

Introduction

This technical memo outlines the data and methodological approach for calculating the economic benefits of Irvine Ranch Water District's (IRWD) and Rosedale Rio Bravo Water Storage District's (Rosedale) proposed Kern Fan Groundwater Storage Project in support of a grant application for the Water Storage Investment Program (WSIP). **It includes specific responses to concerns raised by the California Water Commission in its Economic Review and a description of all adjustments made to the analysis in response to Commission comments.**

Overview

The Kern Fan Integrated Groundwater Storage Project (Project) will provide ecosystem benefits for the Delta and its tributaries and other benefits by recharging and storing up to 100,000 acre-feet (AF) of unallocated State Water Project (SWP) Article 21 water in the Kern County groundwater basin for subsequent extraction and recovery to offset SWP Table A demands during periods of need. Deliveries of unallocated Article 21 water would be made on behalf of Irvine Ranch Water District (IRWD) as a landowner in Dudley Ridge Water District (DRWD) and Rosedale as a sub-unit of the Kern County Water Agency. During droughts or times of need when surface supplies are reduced, stored groundwater will be recovered from the Project via 12 new extraction wells and conveyed to points of use in DRWD, IRWD and Rosedale's service areas. Approximately 25% of the stored water would be held as SWP system water that would be used for ecosystem benefit purposes. This 25% of the water would be made available for ecosystem benefits through operational exchanges, which would be facilitated through a Coordinated Operating Agreement that would be executed between the project partners and Department of Water Resources (DWR). The project will provide several public and non-public benefits, including water supply, groundwater improvement, environmental benefits, and emergency response benefits. Based on guidelines provided in the California Water Commission's WSIP Technical Reference (TR) and project information provided by IRWD, Cramer Fish Sciences and MBK Engineers, M.Cubed completed estimates of the economic benefits in these four benefit categories. Estimates of the net present value (NPV) of total benefits in 2015 dollars are outlined in Table 1.

Table 1. Summary of Benefit Estimates

Category	Type of Benefit	NPV of Benefits (2015$ millions)
Non-public Benefits	Water Supply Benefits	$50.4
	Groundwater	$3.5
Public Benefits	Environmental Benefits—Salmon recovery	$30.8
	Environmental Benefits—Incidental Wetland Habitat	$98.2
	Emergency Response—Extended drought	$18.6
	Emergency Response—Delta failure	$28.5
Total Benefits		$230.0

Project benefits are expected to begin in 2026 and continue throughout the 50-year life of the project, through 2075. We calculate net present value at the project start in 2026. The net present value calculation uses a discount rate of 3.5%, as directed in the WSIP TR.

Benefits

Non-Public Benefits--Water Supply

Water Supply benefits are non-public benefits that will accrue to IRWD, Rosedale, and Dudley Ridge, and their service area customers. According to updated modeling results from MBK Engineers, non-public benefit water supply from the project is less than originally estimated. Originally, the project was expected to provide an expected value of 4,500 acre-feet of additional water supply in the 2030 future condition, and 4,100 acre-feet in the 2070 future condition. **Under the revised model, the project will provide 2,700 acre-feet of water in the 2030 future condition and 3,000 acre-feet in the 2070 future condition.** Approximately three-quarters of the total water supply will be available to Rosedale and Dudley Ridge for agricultural use, and the remaining one-quarter will be available to IRWD under both future conditions.

We use the alternative cost approach to estimate the water supply benefits of the project. The water supply benefit is divided between agricultural (75%) and urban uses (25%), which face different alternative costs of water. We use the Delta Export unit value provided in the TR as the value of an alternative water supply for Rosedale and Dudley Ridge. Delta export values are provided for 2030 and 2045, which we re-weight according to the water year types during which IRWD and Rosedale are expected to recover stored groundwater according to MBK Engineers. These weights are available for 2030 and 2070. We therefore use water cost anchor points of 2030, 2045, and 2070—2030 unit values weighted at 2030 recovery levels, 2045 unit values weighted at 2030 recovery levels and 2045 unit values weighted at 2070 recovery levels. We interpolate between these points to find unit values for 2026 to 2075, according to the methodology laid out in the TR. **The Commission review noted on page 5 that a conveyance cost, initially not included in this analysis, should be added to Delta Export unit values. To address this oversight, we use data provided by Dudley Ridge, which includes monthly conveyance cost data from 2001 to 2017.[1] We convert this data to 2015 dollars and find an average of $17.10. We use this value, based on a complete record of actual data as the conveyance cost, rather than the $12.07 conveyance cost suggested by the Commission review, which relies on a single year of data.**

[1] Data from Dudley Ridge WD included the Appeal Supplement.

For IRWD, the alternative supply cost is the Tier 1 untreated rate from Metropolitan Water District of Southern California (MWDSC), which was $676 per AF in 2015. **The Commission review found this value appropriate but raised some questions about the basis for escalating this rate over time. We adjust the MWDSC rate throughout the analysis so that only the Tier 1 rate and no other charges and penalties are escalated over time. As an escalation rate, the original analysis assumed that MWDSC rates would increase in line with Delta Export unit values, however, the Commission review claimed that this approach was not appropriate, noting on page 5 of its review that the analysis did not provide sufficient rationale and documentation. For a more appropriate escalation rate, we use MWDSC's forecast of Tier 1 prices as found in their Ten-Year Financial Forecast provided at a 2/9/2016 MWDSC Board Meeting.[2] According to the forecast of Full Service Untreated Tier 1 water, prices are projected to increase by an average of 5.6% from 2016 to 2026. Over the same period, average CPI inflation is projected to be 2.3%, resulting in an average real price increase of 3.3%. We apply this rate of increase to MWDSC Tier 1 rates over the life of the project. We consider documentation provided by MWDSC on their expected price increases to be sufficient rationale and documentation of urban price escalation.**

Applying the 3.5% discount rate to the stream of alternative water supply costs, we arrive at the total net present value of non-public water supply benefits of **$50.4 million**.

Non-Public Benefits--Groundwater

To evaluate the groundwater benefit, we use the alternative cost approach to estimate how much it would cost to purchase the same volume of water for groundwater recharge in Kern County as that provided by the project.

According to groundwater policy in Kern County, a portion of banked groundwater is not recovered by the banking entity and remains in the ground to bolster local groundwater levels. **For this project groundwater basin leave-behind percentages vary depending on the water supply account. For the accounts, 9% of water in the urban account and 4% of water in the agricultural account are considered to be left to help recharge local basins, according to groundwater modeling assumptions used by MBK Engineers. These numbers are also consistent with an existing Memorandum of Understanding (MOU) between Rosedale and other Kern Fan banking entities. For the environmental account, we apply an average of these two rates, or 6.5%. Based on these values, we find a weighted average leave-behind rate of 6.56% in 2030 and 6.5% in 2070 and use these shares to calculate the total groundwater level benefit.**

As in the Non-Public Water Supply benefit above, we also added SWP conveyance costs to Delta Export costs, as outlined by the Commission in response to the initial groundwater benefit on page 7 of their Economics Review. We use the same conveyance cost of $17.10 in 2015 dollars based on 2001-2017 conveyance cost data provided by Dudley Ridge. For the purpose of recharging groundwater, we consider the alternative cost to be the Delta Export costs provided in the WSIP TR. We weight those costs according to water year type frequency according to the San Joaquin River Water Year Index to arrive at 2030 and 2070 future condition values. Interpolating between these points, we find a net present value of **$3.5 million** at the project start, in 2015 dollars.

Public Benefits--Environmental—Salmon Recovery

We use the benefit value for two runs of Chinook salmon provided in the WSIP TR to calculate the environmental benefit of salmon recovery based on a willingness-to-pay valuation.

The project will create increased environmental flows in dry and critical years by offsetting State Water Project Table A water demands and making that water available for instream flows from Lake Oroville, along the Feather and Sacramento Rivers, and in the Delta estuary. Based on water modelling carried out

[2] Board meeting minutes with forecast summary included in the Appeal Supplement.

by MBK Engineers, Cramer Fish Sciences recommended pulse flows on the Feather River to maximize benefits to Winter and Spring run Chinook Salmon, and Steelhead Trout (which are considered separately in the supplemental section at the end of this Technical Appendix). **In the initial analysis, the total number of pulse flows was reduced to account for water used in a Delta Emergency. However, under the updated water modeling using the November 2, 2016 CalSim II model and revised spreadsheet model, MBK Engineers found that there would be sufficient water to meet a Delta emergency response without adversely affecting pulse flows for environmental benefit. Therefore, in this updated analysis there are a total of 7 pulse flows available.** Cramer Fish Sciences modeled the number of fish that would be restored in the 2030 and 2070 future conditions. We calculate the annual expected number of additional winter-run and spring-run Chinook for 2030 and 2070, and interpolate between the two points, and extrapolate backwards to 2026. The WSIP TR recommends a benefit of $100,000 per fish per year for winter and spring-run Chinook. We apply this value to the stream of future additional Chinook to calculate a net present value of **$48.9 million**.

We also used the alternative cost approach to calculate the environmental benefit of Salmon recovery. This approach is based on the cost of procuring a similar volume of water in dry and critical years for environmental flows. **The initial analysis assumed that the project participants would need to purchase water at the urban supply price to exchange for environmental water north of the Delta. California Water Commission reviewers took issue with this approach in its economic review. We adjusted this methodology to use Sacramento Valley unit values from the TR, as suggested on page 3 of the Commission's review, weighted by the years in which pulse flows would be available from the project.**

However, while we rely on the Commission's assessment that voluntary water transfers in the Sacramento Valley could be used to provide the same timing and amount of water as provided by the Kern Fan Project, there remains significant uncertainty as to whether 18,000 acre-feet of water would be available in any given critically dry year. In addition, there is an issue of timing, since the water year type is not known with any certainty until March,[3] but pulse flows would provide the greatest benefit in April or May. Meanwhile farmers in the Sacramento Valley who would be making water available to transfer through fallowing would need to make their planting decisions in February and would incur losses if they make the decision to instead fallow land in the spring. Farmers would need to be compensated for this uncertainty in their planting decisions or would need to plant lower-value crops that require less initial investment. In fact, one of the main benefits of a storage project like the Kern Fan Project is that it provides certainty that water would be available for the environment in dry and critical years, and at any time in the spring when it would be most beneficial.

To provide these flows in April and May of a Dry or Critically Dry year with a similar amount of certainty, an option agreement would need to be in place with suppliers in the Sacramento Valley. Options have been used for larger-scale Sacramento Valley water transfers at least four times—1995, 2003, 2005, and 2008. Without an option agreement already in place, there would not be sufficient time to reach an agreement in March, or if there was, there is a real possibility that farmers would need to be compensated for sunk costs in their initial planting. The options provide a similar guarantee as storage that water supply can be called every year on relatively short notice, given that the conditions driving that decision cannot be known until shortly before the call is made. Options payments take these uncertainties into account.

We rely on several historical options contracts in the Sacramento Valley to estimate an appropriate option payment. There are four well-documented option contracts that have been used to account for the uncertainty of water transfers from the Sacramento Valley since 1995. For all of these transfers the option payment ranged from $3.50 to $10.00 per acre-foot paid every year whether the water was called or not, for the option of calling on water by February 15 of each year, before farmers have made

---

[3] Based on DWR's updated Water Supply Index at http://cdec.water.ca.gov/water_supply.html.

investments in their fields.[4] The two more recent transfers, which took place in 2005 and 2008 include an additional option payment of $20.00 and $40.00 per acre-foot respectively, which allows the buyer to extend the call date from February 15 to May 2. This extra payment compensates farmers for any losses from initial planting. Since pulse flows provided by this project would be made available in April and May, this extension would be necessary to create an equal amount of certainty that flows would actually be available. We therefore use an average of the $30.00 option from the GCID, et al-MWDSC transfer in 2005 and the $50.00 option from the Butte Water District-SDCWA transfer in the 2008 contract, both converted to 2015 dollars, or $46.24 as the appropriate option value. We apply this payment to the full pulse flow volume for every year, independent of water year type, since it would have to be paid for the life of the project to deliver an equivalent benefit. We use the **Sacramento Valley unit values from the TR**, weighted for the hydrologic year types (dry and critical) when environmental pulses are expected to take place as the actual cost of transferred water. Using the alternative cost approach, we find a benefit of **$30.8 million**.

According to the TR, the lesser value from the willingness-to-pay approach and the alternative cost approach should be used as the final benefit calculation. We use the lesser benefit estimate of $30.8 million from the alternative cost approach as the final benefit number.

Supplemental Benefits from Steelhead Trout Recovery

The initial analysis did not quantify benefits to Steelhead Trout due to lack of sufficient information, however, Cramer Fish Sciences noted that steelhead smolts from the Feather River will also benefit from the pulse flows (Application IRWD_Tab4_Attach 1_Priority 2_FINAL.pdf). Although it is not a topic brought up in the Commission's review, changes to the water model, and particularly the greater volume of water available for environmental benefits make Steelhead worth considering in this version. While the Commission's review was clear that only those topics raised in the initial review should be addressed in applicants' additional information, it is not possible to change one part of the modelling without affecting many other areas. Since Steelhead Trout are now a significant benefit, we consider them here in a supplemental section. See the supplemental section at the end of this Technical Appendix for a full description of the benefit to Steelhead Trout. Note however, that the benefits detailed above are independent of the Steelhead benefit.

Public Benefits--Environmental—Incidental Wetland Habitat

The water storage project will provide incidental wetland habitat for migratory birds during the years that the Kern Fan Project takes and recharges Article 21 water into storage. During those years, the 1,280 acres that comprise the project will be inundated with water to percolate into the groundwater basin. The ponds will provide temporary habitat to migratory bird species along the Pacific Flyway.

To estimate the benefits associated with this habitat, we used the alternative cost approach. **In our initial analysis we assumed that the project participants would need to purchase the land outright to create wetlands. The Commission disagreed with this assumption, stating on page 4 of the Economic Review that it is not necessary to purchase the land outright and that instead land could be flooded that is already dedicated to groundwater recharge, or a limited easement could be acquired at a lower cost.**

It is not appropriate to use a short-term easement or land lease for this use, because it would require significant construction and changes to the land use to create a recharge basin or a free-standing wetland. Orchards and irrigated agriculture using water-efficient modern methods are not appropriate

---

[4] In 1995, the State Drought Water Bank paid water districts $3.50 per AF to call water at $40 per AF. In 2003, MWDSC established a transfer option agreement with Glenn-Colusa Irrigation District, of which about half of the 60.000 AF under option was called. In 2005 MWDSC signed a contract with Glenn-Colusa ID for just over 100,000 af. In 2008, San Diego County Water Agency agreed to an option with Butte Water District and Sutter Extension Water District. The documentation for the latter three agreements are included in the Appeal Supplement.

for temporary wetlands, nor are petroleum-production lands, because of existing infrastructure. Additionally, because agricultural land requires preparation such as berm construction to be ready for inundation as wetlands. The land preparation must be completed before it is possible to know whether the water supply will be available in January, and therefore the land cannot be used for any agricultural activity other than grazing. Annual conversion costs are likely to make any other agricultural use uneconomic. Thus, costs must reflect a long-term easement.

It is also not feasible to use existing recharge basins to provide the same benefit as flooding in wet years under the project. Existing recharge basins are already in use during periods when Article 21 water is available. The Commission suggests on page 4 of its review that the inundation could take place in any 24 months.[5] However, this is not the case. First, the wetland benefit is particular to winter and spring months when migratory birds would be present. And second, existing water banking recharge basins would typically be in use during other months recharging sources of water other than Article 21 water during years of normal hydrology. During dry and critical dry years when surface water is reduced, water banking entities are typically recovering previously stored water. Operationally, when water banking entities are recovering water through extraction wells they would not also be delivering water for recharge. They would use the surface recharge water in-lieu of groundwater. During dry years, the recharge basins would typically be dry and used for livestock grazing. As a result, during dry and critical years, there would not be water delivered to the basins for recharge.[6]

Regardless of these feasibility issues, we did estimate the potential benefits of creating wetlands on leased agricultural land, which the project's assessors confirmed is the only land available within 5-10 miles of the California Aqueduct. The Commission's review did not specify in which years the alternative wetlands would be created except to note that inundation would not necessarily need to occur during the same years and months that the Kern Fan project would take flows. On this basis, we assume that the 21 months of recharge (from MBK Engineers revised modeling from CalSim II) take place in the first 7 years of the project (i.e., 3 months over 7 years totaling 21 months). We use only winter months so that the benefits to migratory birds will be similar to those created by the project. We assume that the entire 220,000 AF that would be recharged over the course of the project would be recharged instead over these 21 months, an average of 31,429 AF per year. As the cost of water, we use the weighted average cost of Delta export water across all water year types plus conveyance. As the cost of land, we use the cost of leasing agricultural land in Kern County, according to the project participants' assessor, or $300 per acre, deflated to 2015 dollars. We also include the costs of constructing berms and conveyance from the canal as a minimal representation of preparing wetlands, as well as removal costs to restore land to conditions for agricultural use, including leveling, berm and rip rap removal. We have not included any additional costs that are required to restore wetland conditions on land previously used for agriculture. Using this approach, the total benefits are $111.8 million.

Based on the feasibility concerns with the above approach, we also estimated the cost of an alternative dedicated wetlands that delivers benefits in the same years as Kern Fan and requires construction of infrastructure to deliver water from the California Aqueduct to the wetland site. To estimate the land value, we use the cost of a permanent easement rather than outright purchase in response to Commission feedback. Based on the Project cost estimates (other than land purchase) in the Application (Tab 6-A8_IRWD_Total Project Cost_FINAL.pfd), the cost of a long-term easement, suitable for constructing water conveyance facilities on would cost $10,750 per acre in 2017, or $10,199 in 2015 dollars. We use the same costs to move water from the aqueduct as in the above approach, which includes, a canal connection to the California Aqueduct, a conveyance canal to the site, canal siphons, and lift stations in addition to significant earthwork and interbasin structures to keep water in the basins. We assume that the Kern Fan project would be farther from the California Aqueduct than any

---

[5] We have updated this to 21 months to correspond with updated model results.

other option (approximately 10 miles as identified in the Application), so the expected cost would be for a canal of half the length used in project cost estimates and do not include any costs associated with recharge and recovery. Similar to the first approach, we include the costs of restoring the land to its pre-wetland condition at the end of the project, based on a subset of costs from the original Application. For this approach, since the alternative project would only take Article 21 water in wet years, we use the Delta Export unit value for wet years provided in the WSIP TR, which ranges from $204 in 2030 to $414 in 2045. We interpolate between these values and leave prices beyond 2045 at $414 to be conservative. **The Commission Review also pointed out that conveyance costs should be included along with the Delta Export unit value throughout the various benefits. Therefore, to these unit values we also add the Dudley Ridge SWP conveyance cost from the period from 2001 to 2017, $17.10 per acre-foot. Taking the net present value of this stream of benefits results in a total benefit of $98.2 million at the project start.**

We consider the second approach to be more appropriate as well as least cost at $98.2 million.

Public Benefits--Emergency Response—Extended Drought

A major benefit of the project is that it provides water to IRWD, Rosedale, and Dudley Ridge in the event of extreme drought, when other water resources are at their most expensive. Groundwater stored as part of the project will be available to call on during a drought emergency or as an alternative supply in the case of a local supply outage. The WSIP TR outlines that emergency response benefits should be monetized using avoided costs or alternative costs. Here we use the alternative cost approach. According to the WSIP TR an emergency is defined as a critical year that occurs in the 3rd or later year of consecutive drought.

The new water modeling results show a slight increase in the available drought emergency supply. In the original analysis, drought emergency supplies of 4,500 and 4,100 acre-feet were used to calculate benefits under the 2030 and 2070 future conditions, respectively. With updated modelling, available drought emergency supply is estimated to be 4,750 in both the 2030 and 2070 future conditions. Using these values, interpolating between them, and extrapolating to the beginning of the project in 2026, we arrive at the volume of water supply available for emergency response in each year of the project life.

Alternative costs are based on the lowest cost alternative agricultural water for Rosedale and Dudley Ridge, and urban water for IRWD. The Economic Review raised concerns with both values. On the agriculture side, the analysis initially used $800 per acre-foot, as a typical price paid for an acre-foot of water during the recent multi-year drought according to Rosedale. Prices for agricultural water have reached as high as $2,000 in the Central Valley in the recent drought.[7] **However, the Commission's Economic Review argues on page 5 of its review that because the $800 price represents a single observation it is not justified and recommends using the Delta Export value in a critical year as the value of water.**

We do not find evidence that the $360 unit value for Delta exports in a critical year is an accurate value for water in a drought emergency. Per the WSIP TR, water for emergency response extended drought is defined as a critical year that occurs in the 3rd of later year of consecutive drought. The CWC reviewers confirmed in our Economics Review meeting that the unit values provided in the TR do not include water prices specific to the 3rd year or later of an extended drought. Instead, TR unit values are only appropriate for single dry and critically dry years. Page 5-16 of the TR states that the provided unit values" may be too low and may not be appropriate", "especially under shortage conditions." Since a

[7] Lisa Kreiger, "California drought: High-bidding farmers battle in water auctions," San Jose Mercury News, http://www.mercurynews.com/2014/07/19/california-drought-high-bidding-farmers-battle-in-water-auctions/, July 19, 2014.

drought emergency counts as shortage conditions, we consider that the TR unit values are inappropriate for this benefit.

Instead, we rely on data provided by Dudley Ridge on the water offers it received from 2014 through 2016, as a documented source of the price that agricultural users in Kern County are willing to pay during an extended drought period.[8] There are only two cases of extended drought in the hydrologic record-- 1987-1992 drought and the recent 2012-2016 drought. Since water transfer data is only available for the most recent drought, we consider that 21 observations over three years at the end of the worst drought in California history to be sufficient basis for a drought emergency benefit. The average of these offers in 2015 dollars is $925 per acre-foot.[9] The Economic Review also noted that conveyance cost should be included in the agricultural valuation. We include the SWP conveyance cost of $17.10 per acre-foot based on 2001-2017 monthly data from Dudley Ridge.

For the urban supply, the alternative source is imported water from MWDSC. However, in addition to the normal Tier 1 rate of $676 per acre-foot, IRWD would have to pay a $1,480 per acre-foot penalty for exceeding their allocation in an emergency scenario, bringing the total cost to $2,156 per acre-foot. The Commission agreed with this alternative valuation in its Economics Review. **However, it raised concerns on page 5 about how this price was escalated over time, pointing out that there is no justification for escalating an M&I rate at the same rate as TR values that are escalated to account for the effects of SGMA. To address these comments, as outlined above in the section on Water Supply Benefits, in this analysis we use 10-year projected escalation in Metropolitan's Tier 1 rate, net of CPI inflation over the same period, based on price projections provided by Metropolitan to its board in 2016. We apply this escalation rate, 3.3% to the Tier 1 rate only, and do not escalate the $1,480 penalty or any other additional charges to the Metropolitan rate.** To be conservative we apply this 2015 rate to emergency water supplies for years from the start of the project through 2030.

Applying the agricultural emergency supply rate to the 75% of the emergency water supply available to Rosedale and Dudley Ridge and the urban emergency rate to the 25% of the emergency water supply available to IRWD, we arrive at annual emergency supply alternative costs. However, according to historical hydrologic year data provided by MBK Engineers, a critical year in the 3rd year or later of a multi-year drought has only occurred in 6 of the 82 years on record-- a 7% probability of occurrence. We apply this probability to the entire stream of alternative costs and take the net present value at the project start to arrive at a benefit of **$18.6 million**.

Public Benefits--Emergency Response—Delta Failure

A separate emergency response benefit of the project is the emergency water supply it can provide in the event of a levee failure in the Delta that curtails water project deliveries. We analyze this benefit using an alternative cost approach.

The WSIP TR explains that an emergency response to Delta Failure should be assumed to occur once, 30 years into the project operation period—2056 for this project. According to the updated analysis carried out by MBK Engineers, according to historical hydrology, the project is likely to have 23,500 acre-feet of water available for emergency response after 30 years of operation.

In the event of interrupted flows through the Delta, IRWD's alternative supply will be water purchases from MWDSC. We therefore use MWDSC's Tier 1 rate of $676 per acre-foot in addition to a $2,960 penalty for water use over 115% of IRWD's allocation. **The CWC reviewers, on page 6 of its Economics Review agreed that these values were appropriate. In the original analysis, we escalated these costs in step**

---

[8] Data from Dudley Ridge available in "Other Supporting Documentation Uploaded" section of the Appeal letter.

[9] As a confirmation, Buena Vista Water Storage District also held an auction in which the median value paid by buyers was $1,200 per AF. Because these are cleared market prices rather than offers, we did not average the two data sources. The BVWSD data is included in the Appeal Supplement.

with the Delta Export unit values in the TR. However, the Commission's review found this inappropriate and removed the escalation factor. In this analysis, as outlined in previous sections, we instead use an escalation factor based on Metropolitan's projected rates increases over a 10-year period, as presented to the MWDSC Board in 2016.[10] To be consistent with other benefits, we escalate only the Tier 1 rate at the projected rate increase based on MWDSC's estimates for 2016-2026. The $2,960 penalty and all other charges are not escalated. To be conservative, we use current water costs in the year 2030 and escalate costs after that point. As with other benefits, we apply the urban rate to the approximately 25% of the emergency supply that would go to urban users.

In the original analysis we also assumed that the alternative cost of water to agricultural users in Rosedale and Dudley Ridge would be the urban rate because agricultural users would need to outbid urban suppliers for available agricultural water. However, the Economics Review found on page 6 that the original analysis did not justify that agricultural users would be willing to pay the urban emergency rate. Instead, they suggest using the Delta Export unit value of $1,056 per acre-foot plus a conveyance fee of $12.07. However, we contend that it is not reasonable to apply a Delta Export value in a scenario when the Delta cannot be used to convey water south to agricultural users in the San Joaquin Valley—that option is foreclosed by definition. In addition, page 5-16 of the TR states that "the unit values may be too low and another method may be appropriate", "especially under shortage conditions." A Delta failure represents extreme shortage conditions under which the unit values would be inappropriate.

To address this, we use a different approach to value the agricultural benefit. As a unit value, we use the median offer price provided by Dudley Ridge for the 2014-2016 period of $925 per acre-foot on the presumption that a Delta emergency would be interpreted as equivalent to an extended drought due to the uncertainty about when exports would be resumed. Agricultural users have demonstrated that they are willing to pay this amount in times of a "normal" extended drought. We believe that a Delta outage, however, will represent unprecedented shortage conditions south of the Delta. Under such conditions, the only alternative supply available to agricultural users is groundwater. Presumably pumps would be turned on "24/7" to replace lost surface supplies in the San Joaquin Valley. To adjust for the overdraft of groundwater during an unprecedented drought we assume that under SGMA users would be required to recharge some portion of the overdraft in subsequent years. To account for this cost, we add to the agricultural value 50% of the average Delta Export value to purchase replacement water in subsequent years. While we do not have any certainty about what this recharge requirement will be in the future, we do know that the actual value of water under these emergency conditions will be greater than those for a normal drought period, that agricultural users in the Central Valley rely heavily on groundwater in times of project supply shortages, and the SGMA will require groundwater basins to reach sustainable yields by the time we assume the Delta Outage occurs. Therefore, some assumption is necessary. Because this type of emergency is unprecedented in California it is impossible to document actual costs or demonstrate actual willingness to pay under similar conditions. Therefore, we believe that the value in an extended drought plus the 50% payback assumption is a conservative estimate of the true value of water under a Delta emergency.

Multiplying 25% of the 23,500 acre-feet emergency supply by the urban emergency water rate and 75% of the supply by the agricultural rate in 2056, we arrive at a total benefit estimate. The net present value of this benefit in 2026 is **$28.5 million**.

MBK Engineers also explored how using the Delta Emergency supplies 30 years into the project life would affect other project benefits. In their initial analysis they found that the only impact is that environmental pulse flows north of the Delta would be reduced from 6 pulses over the life of the project, to 5. **However, in updated model results, they find that the 23,500 acre-feet of water is available for Delta emergency response without impacting other project supply accounts.**

[10] Summary forecast included in Appeal Supplement

Supplemental Benefits

Steelhead Trout

Steelhead Trout were not considered in the initial economic analysis, which focused only on Spring- and Winter-run Chinook Salmon. While the Commission, was clear that no new topics should be introduced in the revised analysis, we find that Steelhead are worth considering as the pulse flows produced from the Project is expected to provide significant environmental benefits to the juvenile Steelhead under the new water modelling results.

According to modelling carried out by Cramer Fish Sciences, environmental pulse flows provided by the project would results in the survival of 95 additional steelhead trout under the 2030 future condition, and 62 trout under the 2070 future condition. Valuing these fish at the $100,000 per fish as provided in the TR results in a benefit of $4.0 million over the life of the project.

Considering this benefit along with the Salmon benefits outlined in this memo, we find a total environmental benefit of $42.9 million using the willingness to pay approach.

Appeal Supplement

1. Dudley Ridge Water District: Historical Summary of Monthly Variable OMP&R Charges 2001-2007
2. Metropolitan Water District of Southern California: Ten-Year Financial Forecast
3. Woods Institute for the Environment, Stanford University: Option Contracts in Practice: Contractual and Institutional Design for California Water Transfers
4. Dudley Ridge Water District: Summary of Water Offers 2014-2016
5. Buena Vista Water Storage District 2014 Water Auction
6. Email from Alliance Ag Services: Least Cost Alternative - Lease for Wetland Creation

1. Dudley Ridge Water District

Historical Summary of Monthly Variable OMP&R Charges 2001-2017

This data set, provided by Dudley Ridge Water District, includes historical variable O&M Power and Variable Transmission Charges for its State Water Project deliveries from January, 2001 to November, 2017.

Dudley Ridge Water District

Historical Summary of Monthly Variable OMP&R Charges

Date	Variable O&M Power	Variable Transmission	Combined
Jan-01			7.1440
Aug-01			16.2300
Jan-02			10.9770
Sep-02			9.1470
Nov-02			0.0000
Jan-03			8.8990
May-03			11.5740
Nov-03			0.0000
Jan-04			11.9440
Sep-04			6.7380
Jan-05	14.3808	1.0483	15.4291
Aug-05	8.0215	1.0483	9.0698
Jan-06	16.1636	1.0479	17.2115
Apr-06	13.9914	1.0479	15.0393
Aug-06	5.9124	1.0479	6.9603
Jan-07	14.4038	1.0471	15.4509
Jul-07	15.2260	1.0471	16.2731
Nov-07	0.0000	1.0471	1.0471
Jan-08	16.1888	1.0499	17.2387
Oct-08	13.6919	1.5324	15.2243
Nov-08	0.0000	1.5324	1.5324
Jan-09	16.5418	1.5686	18.1104
May-09	15.4501	1.5686	17.0187
Jan-10	15.5920	1.5436	17.1356
Jul-10	17.4581	1.5436	19.0017
Oct-10	0.0000	1.5436	1.5436
Jan-11	15.5833	1.5387	17.1220
Mar-11	15.7393	1.5387	17.2780
Dec-11	0.0000	1.5387	1.5387
Jan-12	18.9980	0.6860	19.6840
Dec-12	0.0000	0.6860	0.6860
Jan-13	21.7846	0.6860	22.4706
Jun-13	21.7846	0.0000	21.7846
Jan-14	29.9709	0.6463	30.6172
Jul-14	29.9709	0.0000	29.9709
Jan-15	30.7143	0.6461	31.3604
Jun-15	29.0862	0.0000	29.0862
Jan-16	33.4407	0.0000	33.4407
May-16	23.2156	0.0000	23.2156
Nov-16	0.0000	0.0000	0.0000
Jan-17	22.8849	0.0000	22.8849
May-17	20.8960	0.0000	20.8960
Nov-17	0.0000	0.0000	0.0000

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES
Post Office Box 942836
Sacramento, California 94236-0001

STATE WATER RESOURCES DEVELOPMENT SYSTEM

INVOICE FOR

DUDLEY RIDGE WATER DISTRICT

OFF-AQUEDUCT POWER FACILITIES
MINIMUM OMP&R COMPONENT OF THE TRANSPORTATION CHARGE
IN 2015

Mr. Joe MacIlvaine, President
Dudley Ridge Water District
286 West Cromwell Avenue
Fresno, California 93711-6162

Invoice No: 15-008-O-(Revised)

Date: July 1, 2015

Contract No: 160250

[in dollars]

Due on or Before	Debt Service	Cover	Maintenance	RG4 Separation	Amount
January 1	$1,375	$344	$8	$2,932	$4,659
February 1	1,375	344	8	2,932	4,659
March 1	1,375	344	8	2,932	4,659
April 1	1,375	344	8	2,932	4,659
May 1	1,375	344	8	2,932	4,659
June 1	1,375	344	8	2,932	4,659
July 1	969	242	0	4,957	6,168
August 1	969	242	(1)	4,957	6,167
September 1	969	242	(1)	4,957	6,167
October 1	969	242	(1)	4,957	6,167
November 1	969	242	(1)	4,957	6,167
December 1	969	242	(1)	4,956	6,166
Total:	$14,064	$3,516	$43	$47,333	$64,956

TERMS: As provided under Article 32 (b) of the contract, interest shall accrue at the Pooled Money Investment Fund Rate per month on delinquency payment if the delinquency continues for more than 30 days.

Attachment 1-1

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

State Water Resources Development System

ESTIMATED VARIABLE O.M.P.R. COMPONENT
CHARGES FOR WATER DELIVERIES DURING

Calendar Year 2015
For

DUDLEY RIDGE WATER DISTRICT

WATER DELIVERIES		VARIABLE O.M.P.&R. COMPONENT TRANSPORTATION CHARGE	
DESCRIPTION (1)	ACRE-FEET (2)	UNIT CHARGE 1/ (3)	AMOUNT (4)
Scheduled	30,215	23.30344640	704,114
		Sub total	704,114
Net adjustment per redetermination of pre-2015 charges 2/			(109,538)
Estimated Year 2015 Replacement Accounting System (RAS) Charges 2/			0
Prior years RAS over and under adjustments 2/			(104,348)
Total Estimated 2015 Charges			490,228

1/ Derived by dividing column (4) by column (2).
2/ Will be applied 1/12 monthly to the actual 2015 water delivery billings.

DWR 2868 (rev. 6/86)

Attachment 5
Revised November 30, 2014

2. Metropolitan Water District of Southern California:

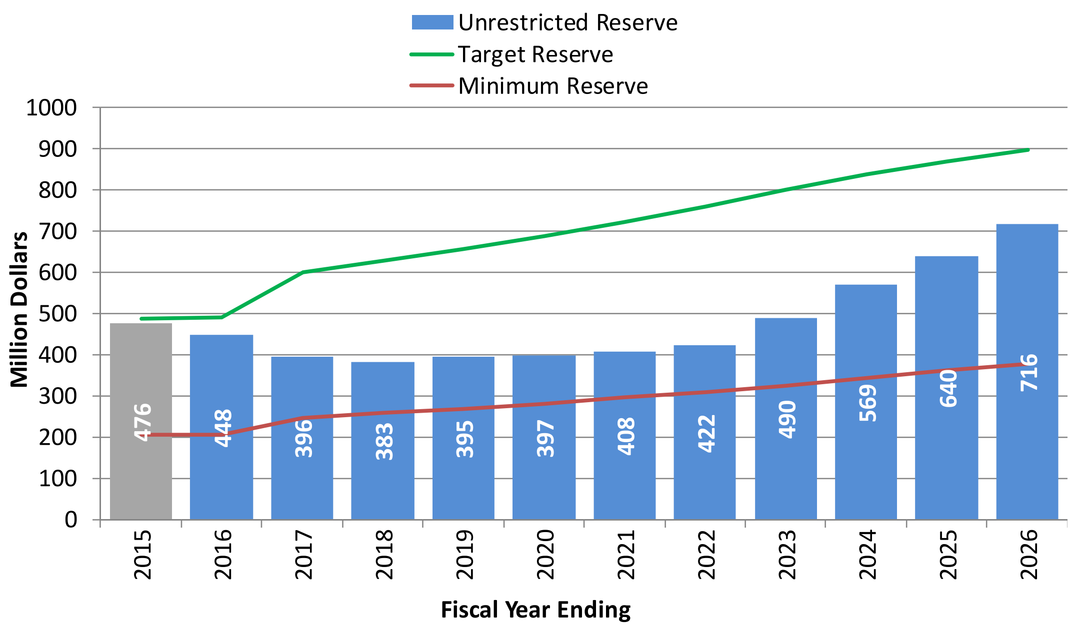
Ten-Year Financial Forecast

This report was presented to the Metropolitan Board on 2/9/2016. The table on page 4 of this report includes a forecast of Tier 1 rates for the period from 2016 to 2026.

TEN-YEAR FINANCIAL FORECAST

The ability to ensure a reliable supply of high quality water for Metropolitan's 26 member agencies depends on Metropolitan's ongoing ability to fund operations and maintenance, maintain and augment local and imported water supplies, fund replacements and refurbishment of existing infrastructure, and invest in system improvements. This ten-year plan builds on the biennial budget to support long range resource, capital investment and operational planning. As such, it includes a forecast of future costs and the revenues necessary to support operations and investments in infrastructure and resources that are derived from Metropolitan's planning processes while conforming to Metropolitan's financial policies. These financial policies, which address reserve levels, financial indicators, and capital funding strategies, ensure sound financial management and fiscal stability for Metropolitan.

Projected Financial Indicators



Ave Rate Increase	**1.5%**	**1.5%**	**4.0%**	**4.0%**	**4.5%**	**4.5%**	**4.5%**	**4.5%**	**4.5%**	**4.5%**	**4.5%**	**4.5%**
Sales, MAF	**1.90**	**1.63**	**1.70**	**1.70**	**1.75**	**1.75**	**1.75**	**1.75**	**1.80**	**1.80**	**1.80**	**1.80**
Rev. Bond Cvg	**2.7**	**1.5**	**1.6**	**1.6**	**1.7**	**1.8**	**1.9**	**2.0**	**2.3**	**2.4**	**2.6**	**2.7**
Fixed Chg Cvg	**2.4**	**1.3**	**1.3**	**1.3**	**1.4**	**1.4**	**1.4**	**1.4**	**1.5**	**1.5**	**1.5**	**1.5**
PAYGO, $M	**210**	**99**	**120**	**120**	**120**	**120**	**120**	**123**	**127**	**130**	**133**	**137**

The figure above summarizes the financial metrics of the ten-year financial forecast. Metropolitan projects that the fixed charge coverage ratio will meet the board-established targets throughout the ten-year period. Revenue bond coverage will meet target in FY 2021/22. Reserve levels will be above minimums as established by board policy; PAYGo expenditures are set at a level that is consistent with the board policy adopted in 2014 that PAYGo expenditures would be funded from revenues, with the proposed amount set at

60 percent of the Capital Investment Plan (CIP); and projected rate increases are adequate to cover costs with moderated changes from one year to another.

The estimated overall rate increases result from increasing investments for the State Water Project (SWP) and the California Water Fix, investments in reliability through conservation and local resources, investments to maintain the conveyance and distribution system, and increasing operating and maintenance costs. Annual expenditures are expected to increase from $1.7 billion in FY 2016/17 to $2.4 billion by FY 2025/26, or an annual average increase of about 4.0 percent. Metropolitan's share of the costs for the California Water Fix is expected to increase to about $246 million by FY 2025/26. During this same period, capital investments are expected to be about $2.1 billion. To finance these capital investments, the ten-year forecast anticipates funding $1.2 billion of the CIP from water sales revenues, or PAYGo. The balance of the CIP, or $0.9 billion, would be financed by issuing revenue bond debt, either fixed or variable.

Planning is necessary for Metropolitan to successfully fund the many investments necessary to meet the challenges facing the region over the next ten years with manageable rate increases. Among the more significant challenges are:

- Investing in the elements of the 2015 IRP Update to ensure reliable water supplies for Metropolitan's service area and preparing for uncertainty.
- Continuing to provide supply reliability through a diversified portfolio of actions to stabilize and maintain imported supplies.
- Meeting future growth through increased water conservation and the development of new local supplies, while protecting existing supplies, to achieve higher retail water use efficiency, in compliance with state policy.
- Pursuing a comprehensive transfer and exchange strategy.
- Building storage in wet and normal years to manage risks and drought.
- Funding an estimated $2.1 billion capital program that provides projects meeting water quality, reliability, stewardship and information technology directives.

ASSUMPTIONS FOR THE TEN-YEAR FORECAST

The following table summarizes key assumptions that underlie the ten-year forecast.

Fiscal Year Ending	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Sales, MAF	1.70	1.70	1.75	1.75	1.75	1.75	1.80	1.80	1.80	1.80
CRA diversions, MAF	1.01	1.04	1.06	1.08	1.07	1.06	1.06	1.06	1.06	1.04
SWP allocation, %	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
CIP, $M	200	200	200	200	200	205	211	217	222	228
PAYGO, $M	120	120	120	120	120	123	127	130	133	137
Conservation, $M	27	32	38	38	38	38	38	38	38	38
CA Water Fix, $M	-	-	20	38	63	96	133	169	206	246
Inflation, %	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%
Interest on investments, %	1.25%	1.30%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%
Interest rate, fixed bonds, %	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%
Interest rate, variable bonds, %	0.45%	0.80%	1.20%	1.20%	1.20%	1.20%	1.20%	1.20%	1.20%	1.20%

Metropolitan's principal sources of water supplies are the SWP and the Colorado River. Metropolitan receives water delivered from the SWP under State Water Contract (SWC) provisions, including contracted supplies, use of carryover storage in San Luis Reservoir, and surplus supplies. Metropolitan holds rights to a basic apportionment of Colorado River water and has priority rights to an additional amount depending on availability of surplus supplies. The Supply Programs supplement these SWP and Colorado River supplies. The SWP and Colorado River sources derive from two different hydrologic regions, which have helped buffer shortages. The ten-year forecast assumes an average hydrology on both regions. Together with Metropolitan's Supply Programs, dry periods in either region can be managed.

The CIP has been further reduced from prior forecasts to maintain affordability throughout the ten-year period, reduce debt service, and provide headroom to absorb the additional costs of the California Water Fix. CIP projects have been carefully reviewed, scored and ranked to ensure that only the projects necessary to deliver water reliably and safely while meeting all regulatory requirements are included.

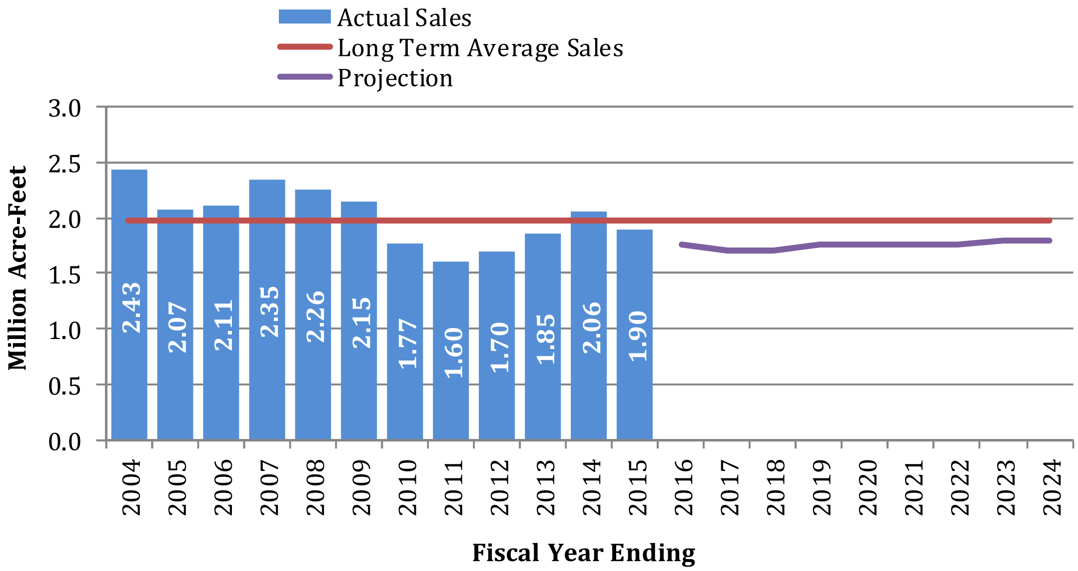
The inflation factor is based on forecasts by economists and is applied to Metropolitan's O&M expenses, including labor, chemicals, and other O&M expenses. The interest rate applicable to Metropolitan's investment portfolio is based on an analysis of the current forward curve for investments over a ten-year period. This interest rate forecast informs the interest rate applicable to variable rate bonds. The interest rate for fixed rate bonds is also based on forecasts.

WATER SALES FORECAST

Water sales revenue provides approximately 80 percent of the revenues necessary to support Metropolitan's capital and operating costs. The 2015 IRP Update provides the basis for the water sales forecast over the ten years. It is expected that demand for Metropolitan supplies will remain relatively flat over the ten-year period, from 1.70 million acre-feet in 2016/17 to 1.85 million acre-feet by 2025/26. This forecast includes the San Diego County Water Authority exchange agreement (exchange agreement) water deliveries. The 2015 IRP Update contemplates continued investment in local resources and retail and regional conservation measures to meet state policy regarding water use efficiency. By 2025/26, conservation and water efficiency initiatives will result in a further reduction of regional water use by an estimated 163,000 acre-feet, which reflect efforts to meet state policy to reduce per capita retail water use by 20 percent by 2020. Local resource augmentation will result in approximately 157,000 acre-feet of additional local supply, including production already anticipated from existing programs. These local supplies and increased conservation and water use efficiency reduce the need to import water and reduce expected water sales by Metropolitan.

The figure below shows historic and forecast water sales, including the exchange agreement water. Long-term, Metropolitan's sales have averaged just under 2.0 million acre-feet. As noted above, expected sales are forecast to be below this average at 1.85 million acre-feet by 2025/26. Under changed economic, climatic and hydrologic conditions, sales over the next ten years could range between 1.5 million acre-feet and 2.0 million acre-feet 80 percent of the time.

Water Sales, MAF



SOURCES OF FUNDS

Revenues

Through 2025/26, receipts from rates and charges, which include the RTS, Capacity Charge and water sales revenues, collected from the member agencies will account for approximately 92 percent of total revenues. Total revenues are projected to increase from about $1.6 billion in 2016/17 to $2.5 billion in 2025/26. This increase is almost entirely attributed to increases in water rates and charges.

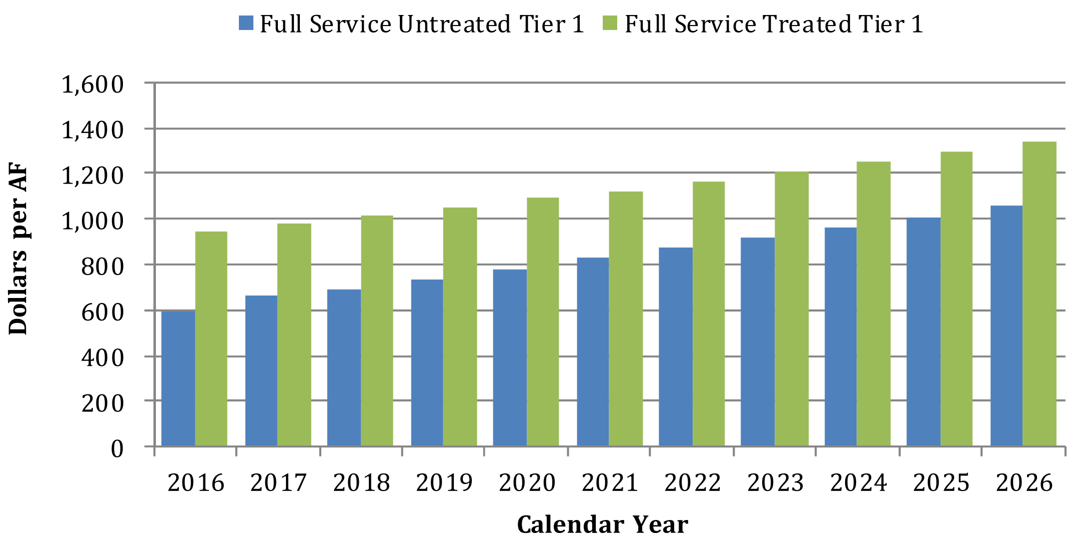
Water Rates and Charges

The table below shows the estimated unbundled water rates and charges under the current rate structure. Components of the rate structure may increase at different rates depending on the costs recovered. The full-service treated Tier 1 water rate is estimated to be approximately $1,344 per acre-foot by January 1, 2026, compared to $942 per acre-foot on January 1, 2016, an average increase of 3.6 percent per year over the ten-year period.

Rates & Charges Effective January 1st	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Tier 1 Supply Rate ($/AF)	$156	$201	$209	$214	$226	$238	$245	$250	$261	$273	$285
Tier 2 Supply Rate ($/AF)	$290	$295	$295	$295	$295	$295	$295	$295	$295	$295	$295
System Access Rate ($/AF)	$259	$289	$299	$320	$335	$358	$383	$412	$440	$469	$499
Water Stewardship Rate ($/AF)	$41	$52	$55	$59	$60	$61	$61	$62	$62	$62	$62
System Power Rate ($/AF)	$138	$124	$132	$145	$162	$178	$187	$193	$198	$204	$210
Full Service Untreated Volumetric Cost ($/AF)											
Tier 1	$594	$666	$695	$738	$783	$835	$876	$917	$961	$1,008	$1,056
Tier 2	$728	$760	$781	$819	$852	$892	$926	$962	$995	$1,030	$1,066
Treatment Surcharge ($/AF)	$348	$313	$320	$315	$309	$288	$288	$288	$288	$288	$288
Full Service Treated Volumetric Cost ($/AF)											
Tier 1	$942	$979	$1,015	$1,053	$1,092	$1,123	$1,164	$1,205	$1,249	$1,296	$1,344
Tier 2	$1,076	$1,073	$1,101	$1,134	$1,161	$1,180	$1,214	$1,250	$1,283	$1,318	$1,354
Readiness-to-Serve Charge ($M)	$153	$135	$140	$143	$148	$156	$168	$182	$196	$211	$228
Capacity Charge ($/cfs)	$10,900	$8,000	$8,700	$9,000	$9,300	$9,700	$10,000	$10,500	$11,100	$11,100	$11,300

The following figure shows the volumetric cost per acre-foot for Tier 1 Full Service untreated water and Tier 1 Full Service treated water. A proposal will be presented to the Board for consideration to address fixed cost recovery of Treatment costs which are currently recovered through a volumetric rate.

Volumetric Cost, $ AF



Property tax revenue is expected to increase from $98.3 million in FY 2016/17 to $120.1 million in FY 2025/26. This projection assumes the Board maintains the ad valorem tax rate at .0035 percent of assessed valuations, by suspending the limit under MWD Act Section 124.5, and assessed value increases by 2.5 percent per year. By FY 2025/26 almost all of the revenues are used to pay SWP costs, which would include Metropolitan's share of the California Water Fix costs.

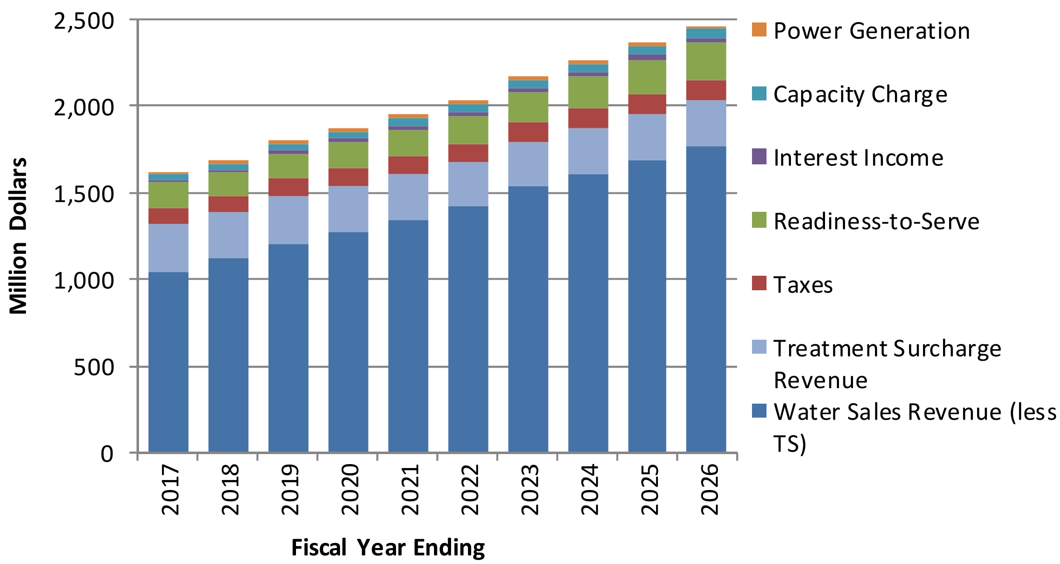
Power sales from Metropolitan's hydroelectric power recovery plants are projected to average about $18.5 million per year over this ten-year period. Metropolitan has 16 small hydroelectric plants on its distribution system. The combined generating capacity of these plants is approximately 122 MW. These revenues are dependent on the amount of water that flows through Metropolitan's distribution system and the price paid. Power from some of the plants is sold under existing contracts that are priced significantly higher compared to the prices currently being offered for renewable power.

Benefits from the hydroelectric plants' environmental attributes including the Renewable Energy Credits (RECs) are included in the existing contracts and for the Etiwanda Power Plant. Renewable Portfolio standard (RPS) California Energy Commission certification for the DVL units was received in 2009; the associated RECs are sold on an unbundled basis.

Interest income is projected to increase from $13.6 million in FY 2016/17 to $28.3 million in FY 2025/26 as a result of increased balances and higher average returns of 1.25 percent to 1.7 percent from FY 2016/17 to FY 2025/26. Metropolitan earns interest on invested fund balances and uses this income to reduce the costs that must be recovered through rates and charges. These invested funds also act as a partial hedge against changes in interest rates on Metropolitan's variable rate debt obligations. Interest income will vary over the ten-year forecast period as interest rates and cash balances available for investments will fluctuate. Miscellaneous income includes items like leases and late fees and is forecasted to increase from $12.0 million in FY 2016/17 to $15 million in FY 2025/26.

Forecasted revenues by major category are shown in the figure below.

Revenue Forecast, $ millions



Other Funding Sources

Other sources of funds include withdrawals from bond construction funds, Refurbishment and Replacement (R&R) Fund, General Fund, Water Stewardship Fund (WSF), Treatment Surcharge Stabilization Fund (TSSF), Water Rate Stabilization Fund (WRSF), Revenue Remainder Fund, and working capital borrowing.

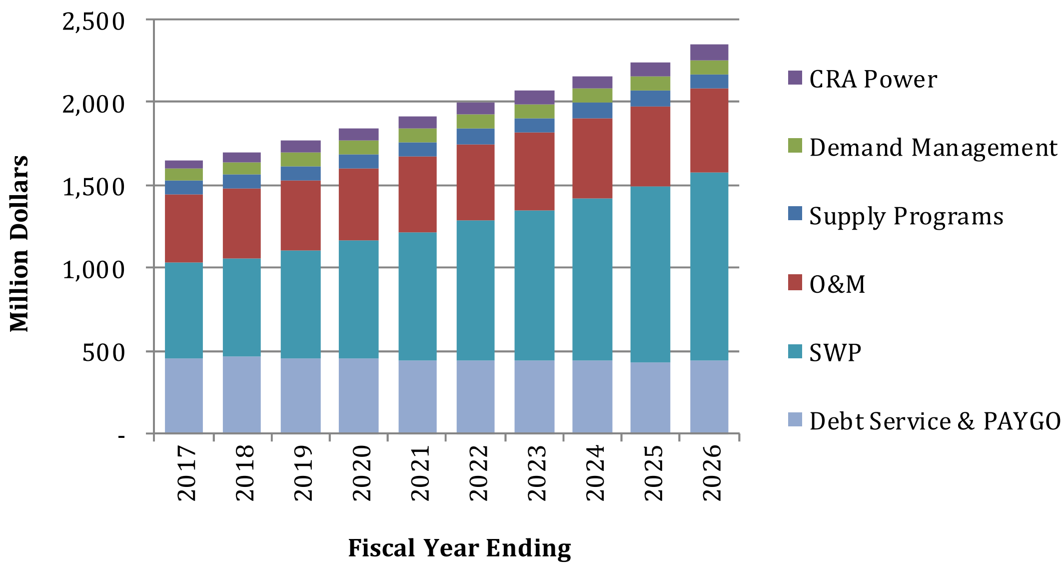
USES OF FUNDS

Over the next ten years, total annual expenditures are projected to range from $1.7 billion to $2.4 billion.

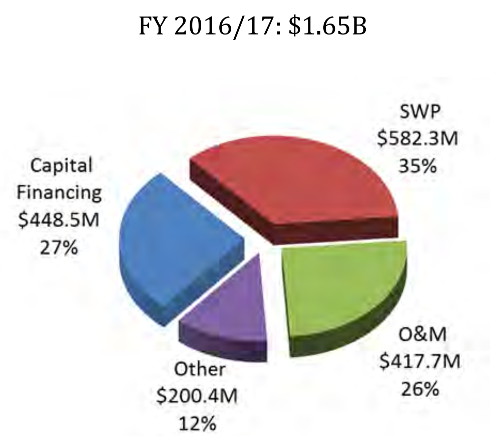
Expenses

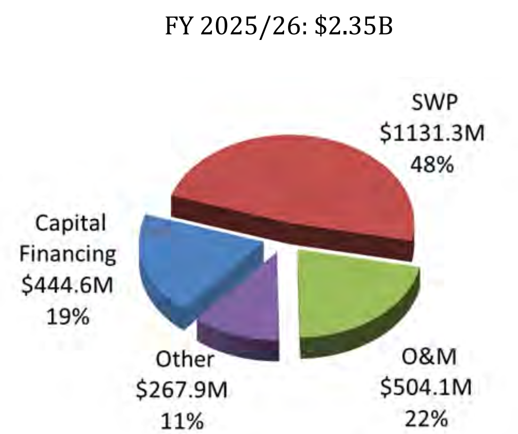
Expenses are grouped into six major categories: SWP, O&M, demand management programs, CRA power costs, supply programs, and capital financing. The first figure below illustrates the general trends in expenses over the ten-year period from FY 2016/17 to FY 2025/26. The second figure following shows the comparison of FY 2016/17 to FY 2025/26 in terms of the contribution of expenses to the total.

Expenditure Forecast, $ millions



Expenditure Forecast, Contribution by Major Area





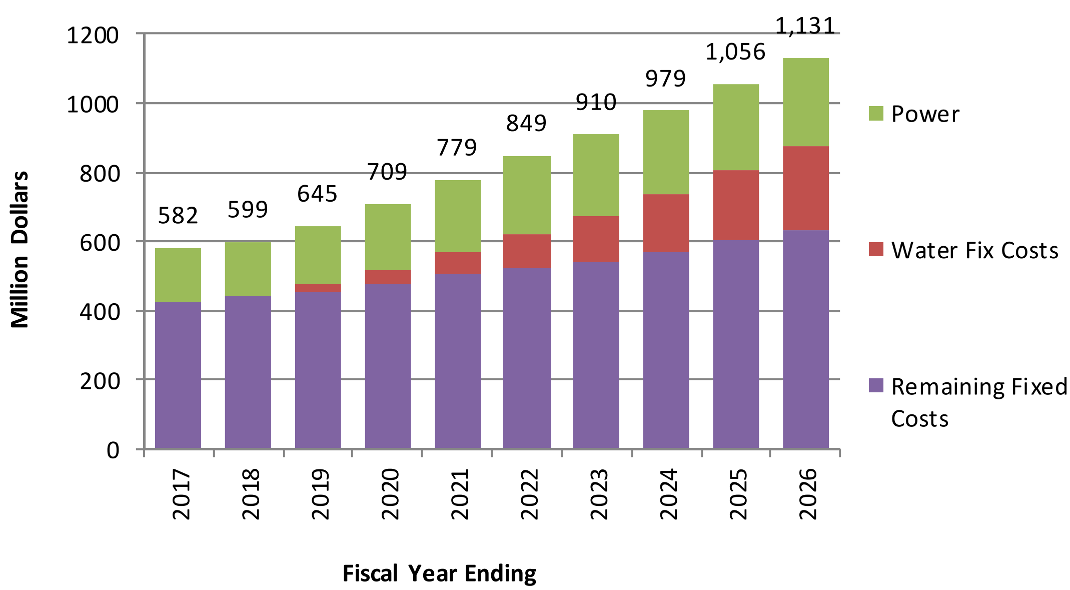
State Water Project

Metropolitan is one of 29 agencies that contract with the State of California for service from the SWP. Metropolitan is obligated to pay its share of the capital and minimum operations, maintenance, power, and replacement charges of the SWP regardless of the amount of water actually received. In addition, Metropolitan pays the power costs to convey the water. The ten-year forecast assumes that SWC annual costs, including power, will increase from $582 million in FY 2016/17 to $1,131 million in 2015/26, as shown in the figure below. SWC costs account for 35 percent of Metropolitan's expenditures in FY 2016/17, growing to 47 percent in FY 2025/26, primarily due to the California Water Fix costs. These costs account for $246 million in FY 2025/26. Water supply benefits from the California Water Fix are realized outside the ten-year period of the forecast, as are operations, maintenance and energy costs. The remainder of the fixed costs is based upon information provided by the Department of Water Resources, and is associated with Transportation Capital and Minimum Operations & Maintenance, and the Delta Water Supply Capital and Minimum Operations & Maintenance. Variable SWP power costs are projected to gradually increase over the ten-year period.

Power costs will vary depending on the price of electricity, total system deliveries, storage operations, and the amount of water pumped on the SWP. SWP variable power costs are projected to increase about 6.2 percent per year over the ten-year forecast period. Increasing costs affecting the SWP include the cost of emissions allowances, adding renewable energy to the SWP power portfolio, and using the California Independent System Operator grid to transmit power from generation sources to the SWP load locations. The SWP owns generating resources, including the Hyatt complex, recovery generation units on the Aqueduct, and a contract for power from the Kings River Conservation District's Pine Flat generating facility. The SWP is a participant in the Lodi Energy Center, a natural gas-fired combined cycle generating facility located in Lodi, California, and operated by the Northern California Power Agency. The SWP has acquired renewable resources. Additional resources necessary to meet the balance of the project's energy requirements are obtained from the wholesale energy market, which exposes the SWP to wholesale energy market price volatility. Net flows through the SWP that incur power are expected to average about 1.0 MAF per year.

The total SWC costs are shown in the figure below. The SWP is described under the General District Requirements section of the Biennial Budget.

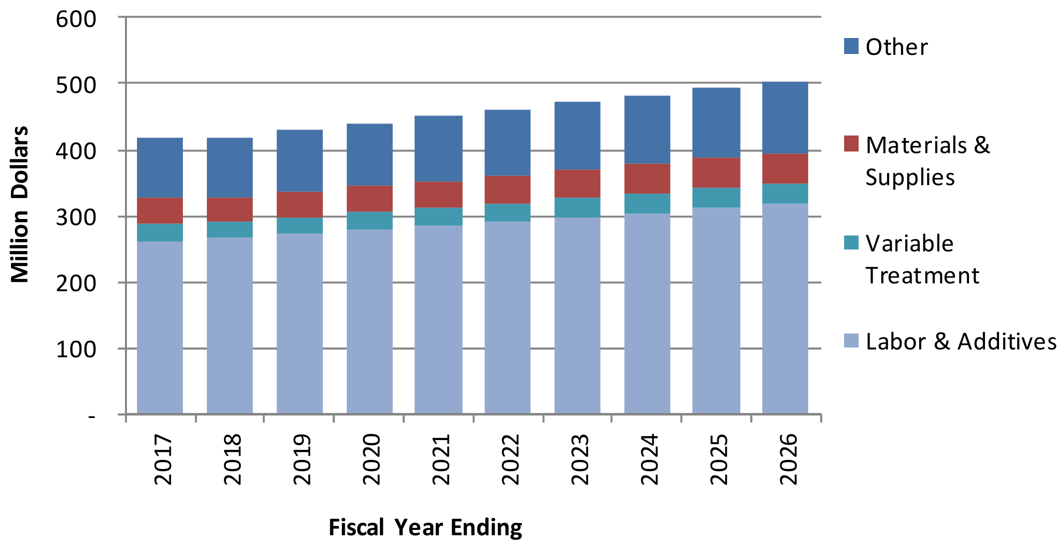
SWP Forecast, $ millions



Operations and Maintenance

O&M costs in FY 2025/26 are projected to be $504 million. This represents an average annual increase of 2.1 percent from FY 2016/17. During this time frame, inflation is assumed to be 2.25 percent. The ten-year forecast assumes Metropolitan continues to fully fund the annual required contribution to meet future retiree medical costs (Other Post-Employment Benefits, or OPEB) and retirement benefits.

Figure 14. O&M Forecast, $ millions



Demand Management

Demand management costs include funding for the Local Resource Programs (LRP) and the Conservation Credit Program (CCP) and are projected to increase from $75.1million in FY 2016/17 to $84.5 million in FY 2025/26. The LRP costs are projected to be fairly flat over the ten-year period at about $45.0 million per year. As the yield from existing LRP projects receiving incentives decreases, new projects are expected to receive funding. The CCP costs are projected to increase from $27.0 million in FY 2016/17 to $38 million in FY 2018/19, and remain flat through the remainder of the ten-year period. This program provides continued funding of residential, commercial, and outdoor conservation programs.

Demand Management programs are described under the General District Requirements section of the Biennial Budget.

CRA Power Costs

CRA Power costs are projected to increase from $46.6 million in FY 2016/17 to $89.7 million in FY 2025/26. Power costs will vary depending on the price of electricity, Metropolitan's resource portfolio to meet electricity needs, storage operations, and the amount of water pumped on the CRA. Due to the expiration of the SCE Service and Interchange Agreement, Metropolitan will be buying more supplemental power and will have exposure to market prices.

Power costs are described under the General District Requirements section of the Biennial Budget. Colorado River diversions are expected to average about 1.0 MAF over the ten-year period, slightly more than deliveries as water is stored.

Supply Programs

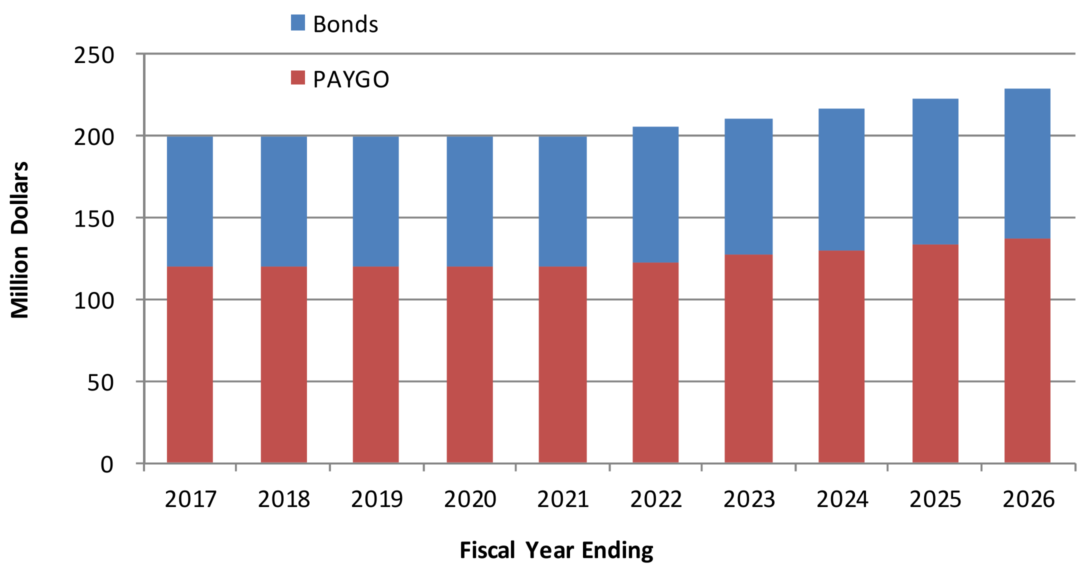
Supply programs increase slightly over the ten-year period from $78.7 million in FY 2016/17 to $93.7 million in FY 2025/26. The estimates represent expenditures for expected conditions. If extreme weather conditions are experienced, these cost estimates could be much higher or lower. If higher than normal demand is coupled with lower than normal supply, supply program costs could be significantly higher.

A description of Metropolitan's Supply Programs is provided under the General District Requirements section of the Biennial Budget.

Capital Investment Plan

The ten-year projected CIP through FY 2025/26 is estimated at $2.1 billion. The CIP continues to reflect the deferral of facility expansion projects. The CIP focuses on projects that enhance reliability while focusing on necessary refurbishment and replacement of aging infrastructure. The following figure shows the funding source for the ten-year CIP.

CIP Ten-Year Forecast and Funding Sources, $ millions



Capital Financing Options

The CIP will be funded from a combination of bond proceeds and operating revenues. In order to mitigate increases in water rates, provide financial flexibility, and support Metropolitan's high credit ratings including maintaining revenue bond debt service and fixed charge coverage ratios, it is proposed that 60 percent of the CIP be funded from current revenues, or PAYGo. This level of PAYGo funding is appropriate given that a significant portion of future CIP projects has been identified as R&R projects. This level of PAYGo also ensures that Metropolitan meets its coverage targets by generating a margin of revenues over operating and debt expenditures. The additional revenue required to meet Metropolitan's revenue bond debt service coverage target of 2.0 times and fixed charge coverage of 1.2 times is available to fund the CIP. PAYGo funding throughout the ten-year horizon of the planning period ensures that current customers are always contributing funds towards the capital investments they are benefiting from, and not deferring these costs entirely to future generations of ratepayers.

Bond funded expenditures will include a combination of variable and fixed rate debt. Debt has been structured to mitigate near-term rate impacts and smooth out long-term debt service. The principal advantage of variable rate debt is the opportunity for a lower interest cost. Normally, short-term interest rates are lower than long-term interest rates for debt of comparable credit quality. If interest rates remain constant, Metropolitan will generally have significantly lower interest costs on variable rate debt than on fixed rate debt, even after remarketing and liquidity facility costs. Also, if interest rates decline, Metropolitan will benefit from lower interest costs without the necessity or cost of a refunding. If interest rates rise, variable rates could stay lower than the fixed rate originally avoided, and the longer the variable rate debt is outstanding at favorable spreads, the higher the break-even point becomes on fixed rate debt. Variable rate debt is used to mitigate interest costs over the long term, and provides a natural hedge against changes in investment earnings: when interest rates are high, interest costs on variable rate debt is higher but so are earnings from Metropolitan's investment portfolio. When interest rates are low, interest earnings are lower, but so are variable rate interest costs.

Fixed rate debt holders generally require some form of "call protection." Typically, fixed rate bonds are only redeemable a given number of years after their issuance and if the issuer pays a prepayment premium. Because the interest rate on variable rate debt is periodically reset, call protection is not important to variable rate debt holders. Variable rate debt, therefore, may generally be prepaid without premium on any date on which the interest rate is changed or on any interest payment date.

However, variable rate debt does have risks. These risks include:

- Rising interest rates. Because future interest rates are unknown, the costs of capital improvements financed with variable rate debt are more difficult to estimate for revenue planning purposes. Significant interest rate increases could cause financial stress.
- Liquidity facility renewal risk. Variable rate debt normally requires a liquidity facility to protect the investors and issuers against "puts" of a large portion or all of the debt on a single day. Liquidity facilities generally do not cover the full term of the debt. If an issuer's credit declines or the liquidity facility capacity is not available, the issuer runs the risk of not being able to obtain an extension or renewal of the expiring liquidity facility. In that event, the issuer may have to retire the debt or convert it to fixed rate debt.

In the last several years, Metropolitan has issued self-liquidity debt. Metropolitan is irrevocably committed to purchase all self-liquidity bonds tendered pursuant to any optional or mandatory tender to the extent that remarketing proceeds are insufficient and no standby bond purchase agreement or other liquidity facility is in effect. Metropolitan's obligation to pay the purchase price of any tendered self-liquidity bonds is an unsecured, special limited obligation of Metropolitan payable from net operating revenues. In addition, Metropolitan's investment policy permits it to purchase tendered self-liquidity bonds as an investment for its investment portfolio. So, while Metropolitan is only obligated to purchase tendered self-liquidity bonds from net operating revenues, it may use the cash and investments in its investment portfolio to purchase tendered self-liquidity bonds. Metropolitan has not secured any liquidity facility or letter of credit to pay the purchase price of any tendered self-liquidity bonds; however, Metropolitan has entered into revolving credit agreements with which it may make borrowings for the purpose of paying the purchase price of self-liquidity bonds.

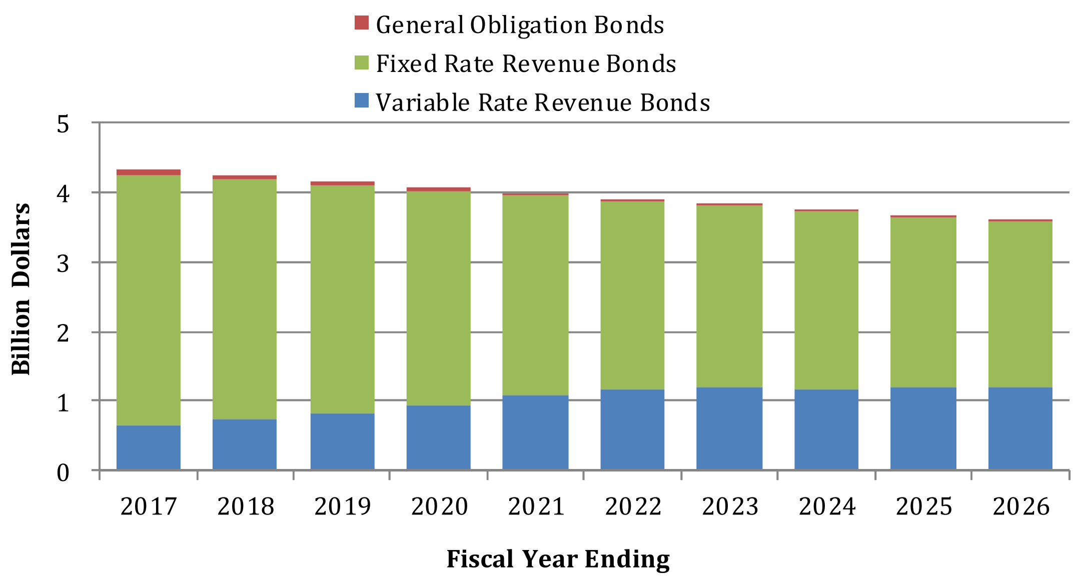
Sales of variable rate debt issues are more complex than fixed rate debt issues. Larger issuers often issue a portion of their debt as variable rate debt. Also, if construction costs are uncertain a borrower can use variable rate debt initially and convert to fixed rate debt in the amount needed after construction is completed.

Debt Financing

It is anticipated that there will be about $2.1 billion of capital expenditures over the ten-year period. Of this, $0.9 billion, or 40 percent of future capital expenditures, are anticipated to be funded by debt proceeds. Outstanding bond debt, including revenue and GO bonds, as of December 31, 2015 is $4.35 billion. The net assets of Metropolitan at June 30, 2015 were $6.9 billion. Metropolitan may not have outstanding revenue bond debt in amounts greater than 100 percent of its equity. As of June 30, 2015, the debt to equity ratio was 63 percent.

Total outstanding debt is illustrated below. Total outstanding debt is estimated to be $3.6 billion by FY 2025/26.

Outstanding Debt, $ billions

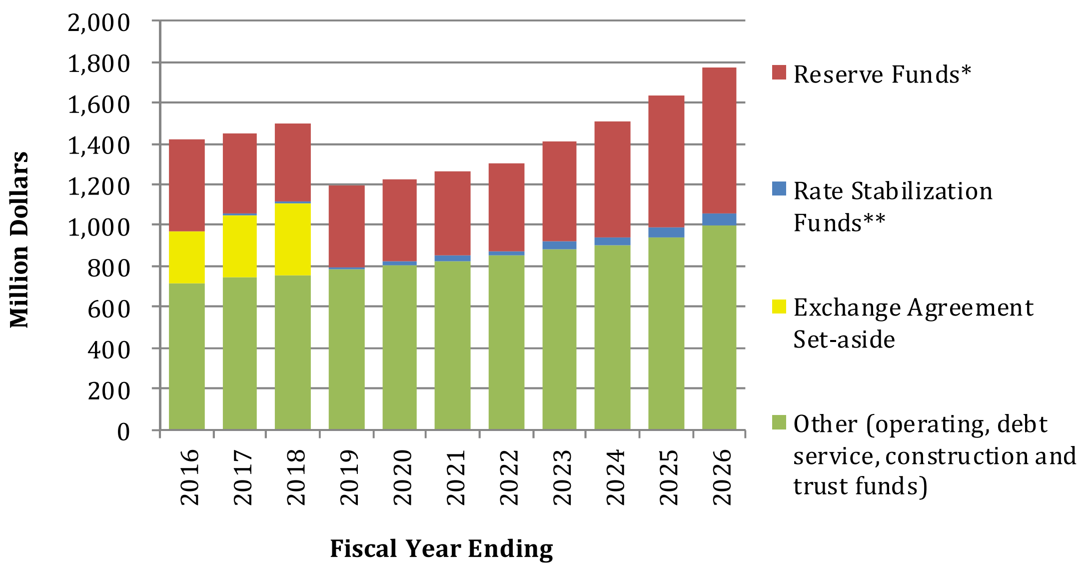


Metropolitan's variable rate debt as a percentage of total revenue bond debt is projected to increase to 31 percent over this time period as fixed rate debt is retired and new variable rate debt is issued. The appropriate amount of variable rate debt will continue to be monitored and adjusted depending on market rates, financing needs, available short-term investments, and fund levels in the investment portfolio with which variable interest rate exposure can be hedged. GO bond debt will decrease as voter approved indebtedness matures.

FUND BALANCES AND RESERVES

As shown in the figure below, over the next ten years total fund balances are projected to increase to $1.8 billion in FY 2025/26. The Exchange Agreement Set-aside designated fund is no longer needed after 2018 by which time all appeals in the SDCWA litigation are expected to be decided.

End of Year Fund Balances, $ millions



* Includes Water Rate Stabilization Fund and Revenue Remainder Fund. Working capital borrowings have been used, in part, to replace revenues that have been deposited to the Exchange Agreement Set-aside Designated Fund.

** Includes Water Stewardship Fund and Treatment Surcharge Stabilization Fund.

FINANCIAL RATIOS

Revenue bond debt service coverage is one primary indicator of credit quality, and is calculated by dividing net operating revenues by debt service. Revenue bond debt service coverage measures the amount that net operating revenues exceed or "cover" debt service payments over a period of time. Higher coverage levels are preferred since they indicate a greater margin of protection for bondholders. For example, a municipality with 2.0 times debt service coverage has twice the net operating revenues required to meet debt service payments. The ten-year forecast projects that Metropolitan's revenue bond coverage ratio achieves 2.0 times during the last half of the period. Metropolitan's minimum coverage policy is vital to continued strong credit ratings and low cost bond funding.

In addition to revenue bond debt service coverage, Metropolitan also measures total coverage of all fixed obligations after payment of operating expenditures. This additional measure is used primarily because of Metropolitan's recurring capital costs for the State Water Contract. Rating agencies expect that a financially sound utility consistently demonstrate an ability to fund all recurring costs, whether they are operating expenditures, debt service payments or other contractual payments. The ten-year forecast projects that Metropolitan's fixed charge coverage ratio is at least 1.2 times over the ten-year period. These levels help maintain strong credit ratings and access to the capital markets at low cost, and provides PAYGo funding for the CIP.

Ten-Year Financial Forecast, Sources and Uses of Funds, $ millions

Fiscal Year Ending	2017 Budget	2018 Budget	2019 Forecast	2020 Forecast	2021 Forecast	2022 Forecast	2023 Forecast	2024 Forecast	2025 Forecast	2026 Forecast
SOURCES OF FUNDS										
Revenues										
Taxes	98.3	100.5	102.8	105.1	107.4	109.8	112.3	114.8	117.4	120.1
Interest Income	13.6	12.4	19.1	19.8	20.5	21.1	22.3	24.1	26.1	28.3
Hydro Power	15.3	21.6	22.2	22.7	22.4	21.8	23.1	23.3	21.8	22.3
Fixed Charges (RTS & Capacity Charge)	182.3	172.7	178.8	184.0	192.0	203.5	218.2	234.5	250.3	266.7
Treatment Surcharge Revenue*	272.9	261.3	275.6	273.1	261.9	251.2	259.0	258.1	257.3	256.6
Water Sales Revenue (less TS)	1,032.3	1,114.2	1,197.7	1,259.9	1,335.5	1,413.3	1,528.1	1,601.8	1,679.5	1,760.7
Miscellaneous Revenue	12.0	12.1	12.4	12.8	13.3	13.7	14.0	14.3	14.6	15.0
Bond Proceeds	89.6	79.7	79.7	79.7	79.7	79.7	89.4	79.4	89.4	109.2
Working Capital Borrowing	46.6	47.4	-	-	-	-	-	-	-	-
Sub-total Revenues	**1,763.0**	**1,822.0**	**1,888.3**	**1,957.3**	**2,032.6**	**2,114.1**	**2,266.3**	**2,350.3**	**2,456.3**	**2,578.9**
Fund Withdrawals										
R&R and General Fund	120.0	120.0	120.0	120.0	120.0	123.0	127.0	130.0	133.0	137.0
Bond Funds for Construction	-	0.3	0.3	0.3	0.3	2.8	-	7.2	0.1	-
Treatment Surcharge Stabilization Fund*	-	3.2	-	-	-	6.3	-	-	-	4.0
Decrease in Rate Stabilization Fund	94.2	23.0	-	9.8	2.9	-	-	-	-	-
Sub-total Fund Withdrawals	**214.2**	**146.5**	**120.3**	**130.1**	**123.2**	**132.0**	**127.0**	**137.2**	**133.1**	**141.0**
TOTAL SOURCES OF FUNDS	**1,977.2**	**1,968.5**	**2,008.6**	**2,087.4**	**2,155.8**	**2,246.1**	**2,393.3**	**2,487.5**	**2,589.4**	**2,719.9**
Fiscal Year Sales & Exchange (MAF)	**1.68**	**1.70**	**1.74**	**1.76**	**1.75**	**1.75**	**1.79**	**1.80**	**1.80**	**1.80**

Totals may not foot due to rounding.
* Not affected by treatment rate structure

Fiscal Year Ending	2017 Budget	2018 Budget	2019 Forecast	2020 Forecast	2021 Forecast	2022 Forecast	2023 Forecast	2024 Forecast	2025 Forecast	2026 Forecast
USES OF FUNDS										
Expenses										
State Water Contract	582.3	599.4	645.5	708.8	778.6	849.2	910.3	978.5	1,056.2	1,131.3
Supply Programs	78.7	81.7	83.8	84.4	84.8	87.8	89.6	91.6	93.7	93.7
Colorado River Power	46.6	54.4	64.6	70.1	74.0	76.5	78.8	83.0	85.7	89.7
Debt Service	328.5	344.1	338.4	334.4	320.5	317.4	308.5	311.9	298.1	307.6
Demand Management	75.1	75.9	82.0	84.5	84.5	84.5	84.5	84.5	84.5	84.5
Departmental O&M	358.6	358.1	366.1	374.4	382.8	391.4	400.2	409.3	418.5	428.0
Treatment Chemicals, Solids & Power	24.3	24.6	26.5	27.3	27.9	28.4	30.0	30.6	31.1	31.8
Other O&M	34.7	37.1	37.9	38.7	39.6	40.5	41.4	42.4	43.3	44.3
Sub-total Expenses	**1,528.8**	**1,575.3**	**1,644.7**	**1,722.5**	**1,792.6**	**1,875.8**	**1,943.3**	**2,031.8**	**2,111.3**	**2,210.9**
Capital Investment Plan	200.0	200.0	200.0	200.0	200.0	205.4	210.9	216.6	222.5	228.5
Fund Deposits										
R&R and General Fund	120.0	120.0	120.0	120.0	120.0	123.0	127.0	130.0	133.0	137.0
Revenue Bond Construction	9.6	-	-	-	-	-	5.4	-	-	17.7
Water Stewardship Fund	-	-	-	0.8	2.4	3.4	6.9	8.4	7.3	7.7
Exchange Agreement Set-aside	46.6	47.4	-	-	-	-	-	-	-	-
Treatment Surcharge Stabilization Fund*	6.7	-	10.6	9.9	2.3	-	1.2	1.8	0.2	-
Interest for Construction & Trust Funds	0.3	0.4	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.9
Increase in Required Reserves	65.1	25.4	32.7	33.6	38.0	37.8	46.1	37.7	62.8	55.6
Increase in Water Rate Stabilization Fund	-	-	0.0	-	-	0.2	51.8	60.5	51.6	61.5
Sub-total Fund Deposits	**248.4**	**193.2**	**163.9**	**164.9**	**163.2**	**164.9**	**239.0**	**239.1**	**255.7**	**280.5**
TOTAL USES OF FUNDS	**1,977.2**	**1,968.5**	**2,008.6**	**2,087.4**	**2,155.8**	**2,246.1**	**2,393.3**	**2,487.5**	**2,589.4**	**2,719.9**

Totals may not foot due to rounding.
* Not affected by treatment rate structure

Ten-Year Financial Forecast, Coverage Ratios and Fund Balances, $ millions

Fiscal Year Ending	2017 Budget	2018 Budget	2019 Forecast	2020 Forecast	2021 Forecast	2022 Forecast	2023 Forecast	2024 Forecast	2025 Forecast	2026 Forecast
RATIOS										
Fixed Charge Coverage	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
Revenue Bond Coverage	1.6	1.6	1.7	1.8	1.9	2.0	2.3	2.4	2.6	2.7
Var. Rate Debt as % of Rev. Bond Debt	15%	18%	20%	23%	27%	30%	31%	32%	33%	33%
RESTRICTED FUNDS EOY balance										
General Fund	109.0	109.0	109.0	109.0	109.0	109.0	109.0	109.0	109.0	109.0
Other	637.2	652.6	673.9	695.3	719.7	741.8	778.0	790.4	834.7	894.1
Sub-total Restricted Funds	746.2	761.6	782.9	804.3	828.7	850.8	887.0	899.4	943.7	1,003.1
UNRESTRICTED FUNDS EOY balance										
Reserve Funds (1)	395.9	383.1	394.7	397.3	408.3	422.0	489.8	569.1	639.8	716.2
Treatment Surcharge Stabilization Fund	6.7	3.4	14.0	23.9	26.1	19.9	21.0	22.9	23.1	19.1
Water Stewardship Fund	-	-	-	0.8	3.2	6.6	13.5	21.8	29.1	36.9
R&R Fund	-	-	-	-	-	-	-	-	-	-
General Fund	-	-	-	-	-	-	-	-	-	-
Exchange Agreement Set-aside	303.5	350.9	-	-	-	-	-	-	-	-
Sub-total Unrestricted Funds	706.1	737.4	408.7	422.0	437.7	448.5	524.3	613.8	692.1	772.1
TOTAL FUNDS	**1,452.3**	**1,499.0**	**1,191.6**	**1,226.4**	**1,266.4**	**1,299.2**	**1,411.3**	**1,513.2**	**1,635.8**	**1,775.2**

Totals may not foot due to rounding.
(1) includes Water Rate Stabilization Fund and Revenue Remainder Fund.

3. Woods Institute for the Environment, Stanford University: Option Contracts in Practice: Contractual and Institutional Design for California Water Transfers

This policy brief, published by the Woods Institute in October, 2008, gives a detailed history of options contracts and their use in California, including the terms and prices of every contract in place by 2008.

WOODS INSTITUTE FOR THE ENVIRONMENT STANFORD UNIVERSITY

POLICY BRIEF 10/2008

Option Contracts in Practice: Contractual and Institutional Design for California Water Transfers

By Claire D. Tomkins, Thomas A. Weber, David L. Freyberg, James L. Sweeney, and Barton H. Thompson

Executive Summary

In 2003, the Metropolitan Water District of Southern California (MWD) introduced option contracting in the California water market, signing 11 contracts with Sacramento Valley agricultural water districts for access to a total of 146,230 acre-feet (af) of water. The option contracts gave MWD the right, but not the obligation, to purchase water several months in the future. Contracting was repeated with three of the larger agricultural districts in 2005, for a supply of just over 100,000 af. In March of 2008, the San Diego County Water Authority entered the option market. Option contracting could prove an important aspect of water market development, facilitating temporary transfers of water at a time when the state's supply is under increasing pressure and demand continues to grow.

A look at past contracting suggests that gains associated with individual trades have been significant, leading to an increase in joint payoffs to the seller and buyer of 70-85%. Expected losses from urban water shortages in the MWD service area were estimated at $49M in 2003 and decreased to $18M under contracting. The magnitude of the total gains from trade in 2003 and 2005 is estimated at between $29M and $34M.[1] Future contract design should address the following points: (1) inefficiencies in the current price structure, (2) flexibility with regard to renegotiation, and (3) policies for community mitigation. Past contract prices have been structured as two volumetric charges: a base price, or reservation fee, and an exercise price to be paid if delivery is taken at a future date. Levying a volumetric reservation fee can lead the buyer to purchase an inefficiently small number of options. A change in the price structure, introducing a non-volumetric contracting fee can remedy this. Renegotiation clauses can aid efficiency by allowing one party to effectively buy out the other if its valuations for water rise significantly. Finally, the administration and effective use of community mitigation funds, which have become a standard element of contracts, requires review.

Institutions designed to support option trading in the water market need to address two existing barriers to trade: (1) *matching* (where potential buyers and sellers pair up), and (2) *access to infrastructure*. The matching phase is currently complicated by the lack of a centralized system for signaling willingness to trade. An online marketplace to connect buyers and sellers could help address the matching barrier. Online platforms have been successfully instituted in a number of markets, including timber, electricity, and e-commerce. Infrastructure access is another barrier. Under the current system, the Department of Water Resources controls the critical north-south infrastructure and grants priority access to State Water Project contractors based on their size. Infrastructure rights cannot be freely bought or traded. For smaller parties or non-contractors there is a considerable risk that infrastructure will be unavailable for delivery at a given date. A system of tradable infrastructure rights would help address this issue. Preapproved block permits for infrastructure rights, issued by region and auctioned off sequentially to qualified districts within the region, would establish such a system. Block permits have the advantages of repeatability (they can be reissued) and adjustability in the face of changing ambient conditions. o

Policy Insights

1. Standardized option agreements are an important step in the transition from nonmarket relational contracting, in which select parties draft custom contracts, to an active market for standardized contracts. The drafting of standardized contracts should consider a new price structure, implementing a fixed contracting fee in place of the current volumetric (per acre-foot) reservation charge, and clauses both to allow renegotiation and to address the appropriate use of mitigation funds.

An option contract specifies two prices – an option price and a strike price – and an exercise date, on which the buyer decides whether or not to take delivery of the contracted water (sometimes referred to as *calling* or *exercising* the option). The strike price is that which the buyer will pay per acre-foot (af) of water if he elects to exercise the option, e.g., the price per af of water taken on delivery. There is also an upfront charge (or reservation fee) paid by the buyer in order to secure the right to exercise the contract at a future date. The terms of option agreements signed to date in the water market have varied, typically involving detailed operational provisions and differing prices. The contracts signed by MWD in 2003 have served as a template of sorts. Contracting remains, nonetheless, essentially a nonmarket transaction characterized by time spent in the matching, valuation, and negotiation phases. To the extent that standard agreements can be drafted and implemented, water transfers will come to resemble *market transactions* rather than nonmarket transactions. The drafting of standard agreements raises a number of issues, including that of price structure.

Past contract prices have been structured as volumetric charges. There is an initial per-af reservation charge for the water under contract and an exercise price to be paid per af of water taken on delivery at a future date (the exercise date). Given that the buyer may not exercise all, or even any, of the options that he holds, the reservation charge induces him to hold a conservative number of options. This is inefficient from an economic standpoint.[2] Rather, the buyer should be able to hold as many options as he would conceivably need at the exercise date. Maximum flexibility is economically efficient, as long as the seller's opportunity cost of providing this flexibility vanishes. The latter holds true, at least approximately, in the California water market. A fixed contracting fee would remove the incentive to under-contract while still allowing the seller to levy an upfront payment. As the seller can still extract a profit through the upfront fee, he faces no disincentive to switch pricing schemes. Charges for a number of services are structured this way, including billing for water, telephone, and electricity service. There is an upfront fee (sometimes referred to as a connection fee) to establish service. The volumetric charge is based on actual usage. This prevents under-usage.

2. Observed trends in the contract market include rising contract prices, additional buyer activity, and one-year durations. The latter will no longer be possible under more stringent environmental review guidelines, necessitating a shift in the market.

In five years, water option prices have risen from \$10/af base and \$90/af strike (in 2003) to \$50/af base and \$200/af strike (in 2008). One interpretation of the price hike is an increase in seller bargaining power possibly due to (1) a heightened awareness (among sellers) of the high cost of urban water shortage and (2) the presence of more stringent buyer competition. One result of the higher prices is a more even distribution of gains from trade between sellers and buyers. A look at past contracts suggests that prices may have been highly favorable to buyers. The increase in buyer activity suggests the viability of one-year water transfer contracts as an approach to covering short-term water shortages. These transfers currently enjoy an expedited environmental review. A full review under the California Environmental Quality Assurance (CEQA), which generally takes in excess of six months, is required for long-term water transfers. If required for short-term transfers, it would render such contracting infeasible: the time required for review would exceed the time horizon of the water transfer. A lawsuit filed this past year in the Butte County Superior Court by Butte Environmental Counsel against Richvale Irrigation District seeks to eliminate expedited environmental review for short-term transfers. In the event of a decision in favor of Butte, a shift from one-year to multi-year option contracting would be required to keep the contract market alive. This may prompt new contract structures, e.g., flexible multi-year agreements.

The development of a flexible contract structure, under which two parties interested in trade can secure environmental review and approval for a multi-year period *without being locked into the terms of trade for each year*, would offer several advantages. First, it would encourage buyers and sellers to preemptively establish channels for trade. This increases the overall likelihood of a successful future transfer by ensuring completion of the matching phase in advance. Second, it would reduce the transaction cost associated with contract ratification. In effect, the two parties would be free to engage in repeated contracting upon receipt of an initial favorable environmental review. There is one example to date of a multi-year (35-year) option contract, signed between MWD and the Palo Verde Irrigation District (PVID) in 2003, granting MWD the right to call up to 100,000 af a year.

3. Preallocated block permits for infrastructure access would facilitate option trading by creating a system of tradable, or auctionable, conveyance rights. A central clearinghouse for matching buyers and sellers would further support market development.

Preallocated block permits have been used to establish markets for emissions trading of nitrogen oxide and sulfur dioxide in the United States, and carbon dioxide in Europe. A well-defined emissions right specifies a quantity, location, and time horizon. The block permit standardizes these features. Sulfur dioxide emissions permits, for example, are defined as a ton of SO_2 per annum anywhere in the U.S. Permits are issued by a government body to all stakeholders based on set criteria, such as size of operations or number of constituents. In the case of sulfur dioxide permits, grants were made to electricity utilities by the U.S. Environmental Protection Agency (EPA) and based on historical emissions.

In the California water market, block permits for infrastructure would need to specify a volume of water (total af) transferrable within a specific time window, possibly ranging from several days to months. Under such a system, permits are tradable, or auctionable. Preallocation of permits would allow parties arranging future transfers, e.g., under option contracts, to secure infrastructure access in advance. Under the current priority-based system, parties with low-priority access wishing to trade are unlikely to be able to do so. Transfer permits issued at the regional level could be auctioned off sequentially to qualifying water districts, e.g., those within the region. Once allocated, permits could then be traded through a central clearinghouse (online marketplace).

Prices and Terms from the 2003, 2005, and 2008 Contracts

Option contracts have been signed in the California water market in 2003, 2005, and 2008. The contracts are typically signed in the early spring before hydrologic conditions for the year are known. MWD actively pursued contracts in 2003 following a two-year dry spell, during which storage levels had been drawn down. MWD did not actively pursue contracts in 2004. The agency did sign contracts in 2005, with dry conditions having persisted in 2004. The 2005 options were not called, as spring rains alleviated dry conditions. The dry conditions in 2007 and 2008 made option contracts appealing to MWD, but negotiations in 2008 fell through. SDCWA signed two contracts in 2008.

Past option contracts have specified, in addition to prices, a number of trade-related conditions. There are fees for conveying water on state-owned infrastructure, which the contracts signed to date specify will be paid by the buyer. There are also losses associated with using natural channels for conveyance (referred to as “carriage losses”), which the contracts again stipulate are to be borne by the buyer. These losses can represent up to 20% of the total volume transferred. In addition, San Diego County Water Authority assesses a 50% probability that infrastructure will be unavailable for conveyance: with limited pumping capacity at the south-Delta outtakes for conveyance of water north-south, transfers may be delayed or blocked. The contracts designate that the risk of non-conveyance is to be assumed by the buyer. Both parties agree, however, to work together to achieve a storage solution (with the U.S. Bureau of Reclamation (USBR)) such that water can be transferred at a later date. Environmental review costs incurred under CEQA are to be shared. The manner in which water is to be made available for transfer *and* the community-wide impacts of the transfer are dealt with explicitly in the contract. Crop acreage is to be fallowed upon call of an option. The buyer agrees to pay a mitigation fee in excess of the strike price per acre-foot (af) of water called, with the total fees paid comprising a mitigation fund to be disbursed at the seller’s discretion.[3]

The first option contracts were initiated by MWD and signed in 2003, with 11 irrigation districts in the Sacramento Valley. MWD again entered into option agreements in 2005. MWD held options for 146,230 af and 112,495 af of water, respectively, in the two years – an amount totaling approximately 5% of MWD’s average annual deliveries (of 2.4 maf). The contracts were structured similarly, with the largest contract signed between MWD and the Glenn-Colusa Irrigation District (GCID), the biggest irrigation district in Glenn and Colusa counties, and one of the bigger statewide districts. The base price was $10/af and the strike price was $90/af, for up to 60,000 af of water. MWD paid a non-refundable $600,000 upfront. The option was indexed to the hydrologic conditions, a proxy for the value of water at the future date: if 2003 was designated a “critical” water year in accordance with an established index (the 40-30-30 Sacramento Valley Index), the strike price was to be incremented by

$25/af to $115/af. The contract specified that if the water was not made available by GCID at the time of exercise, MWD would receive a full refund plus interest. The option was set to expire on February 15, on which date MWD called all of the options. A $5/af mitigation payment was issued (and, in fact, requested) by MWD to "be deposited by GCID into a restricted interest bearing account to be administered and utilized by GCID for the purpose of monitoring and mitigating any and all adverse impacts, environmental and other associated with the GCID water transfers." The contract also asserted the following: "… GCID contends that there are no third party economic impacts…associated with its transfer of pre-1914 water rights water." A relatively small quantity of the total acreage in GCID was fallowed to supply the water. This policy of restricted fallowing is encouraged by the state's water code. Under the Water Code, fallowing of acreage in excess of 20% of a district's total landholdings requires public review.

There were several amendments to the MWD-GCID 2005 contract. Most notably the call date was pushed back from February 15 to April 1 and an extension clause was added, whereby the option could be extended from April 1 to May 2 for an additional option payment of $20/af. The clause also specified that the extension be for no less than 40,000 af, where the total number of options held amounted to 80,000 af of water. The hydrologic indexing was removed from the contract, and the new strike price of $115/af reflected an increase of $25/af. The initial fee remained at $10/af. The payout structure associated with the extendable option was slightly more complex: the total payment (option fee plus strike) was set at $125/af with an additional payment of $10/af (total $135/af) if the option had been extended after April 1 but called before April 16, and an additional payment of $20/af (total $145/af) if the option had been extended after April 1 and was called between April 16 and May 2. Hence, for an option called before April 1, the strike price would be $115/af – the $125/af minus the upfront fee of $10/af, with no extension fee.

In 2008, the San Diego County Water Authority (SDCWA) signed option contracts with two northern irrigation districts, the Butte Water District and Sutter Extension Water District. These contracts specified the same base fee of $10/af, with an extension clause for $40/af. The exercise price increased significantly to $200/af.[4] San Diego paid the $50/af reservation fee per option (the $10/af base plus the $40/af extension fee) and ultimately exercised all of the options. The general terms of the contract closely match those of the MWD contracts, specifying that the buyer bear both the cost and losses associated with conveyance, as well as the risk of non-conveyance (with cooperation to secure north-of-Delta storage as an alternative to immediate conveyance). In two departures from the MWD contracts, the SDCWA contracts designate that the buyer pay all environmental permitting costs and forego the community mitigation fee. Significant detail regarding the actual crop fallowing or crop-shifting practices (to make water available for transfer) was omitted and payment details were simplified. The SDCWA contracts are a streamlined version of the MWD contracts.

Magnitude and Distribution of Welfare Gains from Contracting

Both parties have stood to gain from entering into option agreements. Both the magnitude and the distribution of the gains to each side are an important consideration from a societal perspective and may impact parties' willingness to trade in the future.

Generally, the economic gains from contracting depend on two key uncertain factors: (1) the seller's *opportunity cost* of water and (2) the buyer's *potential shortage cost* of water. If the seller elects not to transfer water, the alternative use of the water is application to a crop such as rice. The opportunity cost of transferred water is the profit expected from the sale of the rice. The buyer's potential shortage cost of water depends on the potential magnitude of the shortage, e.g., how many acre-feet of residential demand an urban water agency must fulfill, as well the cost of either meeting this demand or declaring a shortage. For an urban water agency in Southern California, for instance, projected shortages could range from zero to 100,000 af in a given year at a cost of $1,347 af, where the latter is the penalty rate for additional supply (from MWD).

Under current assessments of the shortage cost for water in Southern California ($1,347/af) and historical commodity prices for rice, buyers have appropriated a disproportionately large share of the gains from trade. Over 90% of the total gains from trade accrued to the buyers in 2003 and 2005. Contract prices rose in 2008, resulting in a more even distribution of the gains from trade, with the seller's share increasing to 30%. If the upward trend continues, it will likely result in a more even distribution of gains from trade.

Table 1 reports estimates of the seller's and buyer's valuations without contracting, where the buyer's payoff is negative, reflecting the anticipated shortage cost of water. These are reported as the seller's and buyer's reserve values. The payoffs under contracting are also estimated. The magnitudes of anticipated losses from water shortage without contracting are estimated at $49M and $43M in 2003 and 2005, respectively. Contracting reduces the anticipated losses to approximately $18M in 2003 and $17M in 2005. The social welfare gains from contracting are $34M and $29M. The smaller welfare gains in 2008 owe to the reduced size of the contracts that year: approximately one-fifth the quantity of water was transferred.

The estimates in Table 1 are sensitive to a number of assumptions, notably those regarding the shortage cost of water, the commodity prices for the seller's crop, and the seller's and buyer's actual valuations.[5] The terms of the past contracts reveal neither expectations regarding the shortage cost of water nor expectations regarding commodity prices in the years that they were signed. The proxy for the shortage cost of water

	2003	2005	2008
Seller's Reserve ($M)	6	9	4
Buyer's Reserve ($M)	(49)	(43)	(8)
Seller Payoff ($M)	9	12	5
Buyer Payoff ($M)	(18)	(17)	(5)
Welfare Gain ($M)	34	29	5

Table 1. Estimated Welfare Gain Under Contracting

assumed here is the aforementioned penalty rate charged by MWD (to SDCWA, for instance) for supply in excess of the base contracted amount. If the shortage cost of water were in reality lower than that estimate, then the reduction in the buyer's averted shortage cost would yield a more even distribution of the gains. The shortage cost of water may be lower than the MWD penalty rate if, for example, lower-cost supplemental water sources or rationing are viable alternatives. Lower-cost supplemental groundwater may be made available via groundwater pumping, desalination or reuse technologies, or through other water transfer arrangements.

Key Contract Parameters

Option contracts are a form of coinsurance, where the value from contracting is derived from the ability of the buyer and the seller to share risk. The buyer faces a potential costly supply shortage, the magnitude of which depends on the future level of demand as well as the assessed cost of not meeting that demand. The future level of demand depends on a number of parameters, including climatic conditions, and remains uncertain. The seller, a farmer, faces an uncertain price on the commodity market for a crop under cultivation. The future price of the crop determines his opportunity cost of transferring water. These two key uncertainties – future commodity prices and potential urban water shortages – are critical to contract valuation and pricing. Both vary interannually.

There exist reasonably accurate data on historical commodity prices.[6] The validity of historical data is, however, called into question by sudden and sharp price movements, as observed in 2007-2008 on the commodity exchange, with soybean, rice, and wheat prices hitting historical highs. For the purposes of contract-design, there are quotes openly available throughout the year for futures on all major commodities. In contrast, there are very limited data on the actual cost of urban water shortage for users in Southern California. The cost of a secondary supply serves as a proxy for the cost of shortage when the utility intends to cover any unmet demand. A 1993 survey by CIC, Inc., an economic consulting firm hired by SDCWA to assess water outage costs under earthquake scenarios, suggested shortage costs run as high as $5,000/af.[8]

Price per cwt	13.5-19	($/cwt)
Subsidy per cwt	2	($/cwt)
Yield per acre	71.5	(cwt)
Revenue per acre	858-1,753	($)
Average cost per acre	832.77	($/acre)
Profit per acre	133.25-525.73	($/acre)
Water use per acre	3.3	(af/acre)
Profit per af of applied water	40-159	($/af)

Table 2. Rice Production Data (Per hundred-weight, or cwt) [7]

Table 2 reports production data for rice used to calculate the farmer's opportunity cost of transferred water. The consumptive use of water per cultivated acre of rice, for example, is 3.3 af of water. Only water consumptively used is eligible for transfer, where *consumptive use* is defined as the quantity absorbed by the plant or evaporated from the plant or soil surface.

Assessing the buyer's potential shortage cost of water requires an estimate of the potential magnitude of the shortage, and then the associated cost of shortage. A distribution of potential future shortages can be estimated based on historical deliveries, firm supply, and projected demand scenarios. The supply is comprised of both available storage water and annual flows into the system.

Design of Standardized Contracts

The issuance of standardized contracts reduces both the uncertainty and the overhead associated with contract negotiation. Drafting such contracts raises a number of questions. *What price structure should be adopted? Also, what contractual clauses are desirable?* And, *how should contracting costs, including, environmental review cost and conveyance, be allocated?*

An efficient two-part price structure implements (1) a fixed fee for contracting and (2) a strike price equal to the seller's opportunity cost plus the marginal cost of conveyance. As discussed, past contracts have implemented a volumetric price structure, charging a per-option (per-af) reservation fee and exercise fee, or strike price. In general, this price structure results in the buyer holding too few options from a social welfare perspective. By charging a fixed fee for contracting in place of the volumetric reservation charge, the seller still collects an upfront payment but does not bias the buyer's decision.

Contracting incurs both fixed costs and marginal costs. The cost of undergoing environmental review is a fixed cost and can be allocated to the buyer through the fixed contracting fee. The conveyance charge for moving water on state-owned infrastructure is a marginal cost and should be rolled into the strike price.

A second issue is the design of standardized option clauses to address renegotiation and community mitigation funds. Renegotiation clauses have not been standard to date but would help ensure that delivery on contracts is avoided when uneconomical. If the buyer must take physical delivery of the water to which he has a contractual right, as opposed to reselling it or keeping it, there is a potential efficiency loss. Delivery of goods under contract is rare in financial markets, where the contracted good is (re)sold to the party with the highest value at the exercise date, often through an external spot market, and money changes hands. There is no spot market for water as yet in California. In its absence, the renegotiation clause encourages the buyer and seller to fully consider the alternative to delivery, e.g., that of resale to the seller. It may also encourage sellers to look for outside buyers in the intervening period.

An alternative to the renegotiation clause is a strike price indexed to the seller's market conditions. Specifically, the price is indexed to the seller's profit from crop cultivation as a function of the prevailing commodity prices. This ensures that the buyer only exercises options up to the point where the value of water in an urban setting exceeds that for agricultural applications. Historical prices for crops such as rice have remained significantly below estimates of the urban shortage cost of water. However, the record high prices for commodities this past year, in the face of global crop failures and rising demand, call this assumption into question and make indexing even more appropriate.

The issuance and use of a community mitigation fund is a third issue in contract design. Mitigation funds have become a standard element of contractual water transfers. The funds have been established in recognition of negative community-wide impacts due to fallowing programs associated with water transfers, including reduced farm employment and farming-related equipment sales. Size and designation of mitigation funds have varied considerably; a generally-accepted fair and successful precedent has yet to be established. Funds that are structured to disburse individual compensation, such as that established under the Imperial Irrigation District (IID) transfer with the San Diego County Water Authority (SDCWA), generate concerns akin to those facing the welfare systems – namely that dependencies will be encouraged and a precedent for high levels of compensation will be established. At the same time, such programs may be necessary to provide assistance during a transitional period. Funds that are either tied to community development and aimed at diversifying the local economy or, alternatively, set aside for active water management programs, may prove more sustainable.[9]

The viability of temporary water transfers as a mechanism for covering supply shortages hinges on their continued acceptance by farming communities. Water rights sales, or permanent transfers, have met with considerable institutional resistance by farming communities in the past. Although water transfers at the district level typically require approval only by the irrigation or water district board, community sentiment is likely to be fully taken into account. For instance, the GCID board of directors, elected by proportional vote based on landholdings in the irrigation district, ultimately made the contracting decisions in the MWD-GCID transfer. However, the board would have been aware of both the possibility of organized community resistance to prevent future water sales and its accountability to its constituents. The careful design of mitigation funds can help win this approval and also ensure that temporary transfers don't threaten the sustainability of agricultural practices in the future.

An alternative to the establishment of mitigation fees would be the introduction of contractual clauses specifying retainers, or side payments, for community farming enterprises and laborers. The advantage of retainers is a guarantee that the infrastructure, e.g., operation of the mills and marketers, vital to farming activity remains solvent. Closure of these enterprises due to low volume over a period of successive years would be disruptive to future farming practices. In years when transfers are not desirable, e.g., when crop prices are high or water supply is plentiful, farms must remain operable. Given that transfers under fallowing are currently restricted to a less than 20% of a districts total cultivated acreage, the fluctuation in crop volume due to transfers may not be great enough to threaten local business. There is a natural fluctuation in annual volumes due to favorable/unfavorable growing conditions, for which the system is already attuned. As with individual payments from a central mitigation fund, the question arises as to whom exactly qualifies for a retainer fee. Also at issue is the appropriate fee level.

Design of Institutions to Support Contractual Water Transfers

High search costs and limited infrastructure access pose serious barriers to the formation of a more active contracting market. A centralized clearinghouse to match buyers and sellers would reduce search costs. The Drought Water Purchase Program operated by the DWR in dry years is a model of this concept. DWR purchases water from willing sellers, typically agricultural districts, and then makes the water available to interested buyers, typically urban water districts. The limited operation of the market – in select dry years – curtails the ability of buyers to tailor their water management programs. Such management might, for instance, require transfers during non-drought years to replenish storage. There are hundreds of water districts in California, each potentially with an incentive to become involved with water transfers. Under the current system, these districts have limited ability to initiate trade. An online marketplace could effectively match willing buyers and sellers. Online platforms have been vetted in a number of sectors, including popular commerce (eBay), timber (eTimber), and electricity (APX). Timber auctions match logging companies and mills. Auctions can be initiated by either side at any point – buyers initiate reverse auctions or sellers initiate forward auctions.[10] Similarly, in online electricity markets, wholesale and commercial electricity buyers and sellers are matched anonymously based on bids and offers, with each party specifying a reserve price which it will not go above (or below).

DWR's existing role as market-maker is a natural one in light of its control of the major north-south water artery, the State Water Project. Water sold through the Drought Water Purchase Program can be conveyed on state infrastructure under DWR's first-priority rights. Opening the market, as proposed under the adoption of an online trading platform, first requires that infrastructure rights be accessible. Otherwise market participation will be restricted to several large players with high-priority rights. Under a system of tradable, or auctionable, conveyance permits, parties wishing to arrange water transfers could simultaneously set transfer contracts and bid on conveyance rights. Preallocated block permits would accomplish this and have the advantages of repeatability and adjustability, where permits can simply be reissued or adjusted by a proportionality factor, to account for changes in ambient conditions and new claims.

The initial allocation of block permits – with each block consisting of a standardized volume, location (access and delivery point), and time window – for infrastructure access could be granted at a regional level. Block size would be on the order of 10,000 af. The location would be tied to a capacity-constrained point, e.g., a pumping facility. The time window for the permit may range from a few days to a few months. Adjustments to block size could then be tied to ambient conditions, such as minimum flow levels. The final distribution of rights between individual districts wishing to engage in trade could then be decided through sequential auctions of the allotted regional blocks, with all districts within the initial region as qualifying auction participants. A double auction would be conducted through the central (online) clearinghouse, in which the holders of block permits (essentially infrastructure rights) and buyers wishing to transfer water submit electronic bids. If the permits are adjustable, e.g., can be uniformly decremented or even nullified due to legal restrictions on conveyance, possibly under environmental statute, then the infrastructure risk remains. This notwithstanding, the issuance of defined permits reduces the uncertainty and creates the *possibility* of trade and hence active contacting.

A remaining issue for legislative review, is that of subsidies. The current structuring of subsidies under the Farm Bill is such that farmers are paid a subsidy per cwt for a given crop. In years that land is not cultivated, the subsidy is foregone. The subsidy distorts the value of water by assigning additional value to it when used to grow crops as opposed to used for urban use or transfers. This subsidy deserves review, keeping in mind that a simple transfer of the subsidy from crop cultivation to general water use (including transfers) may have the undesirable impact of increasing wasteful use.

Temporary water transfers could come to play an important role in managing the state's water supply uncertainty. These short-term transfers have the advantages of flexibility, allowing parties to adjust to changing yearly conditions, and low transaction cost. Further reliance on option agreements as a water supply management tool, however, requires institutions to support trade. A centralized clearinghouse and standardized contracts to further reduce transaction cost – in particular matching and negotiation costs – as well as the introduction of tradable infrastructure permits, would support an active market-based system for water transfers. The design of these institutions in California will be of interest to the worldwide community, which also faces water supply pressure in the form of population growth, economic expansion, global climate change, and concern about environmental degradation. o

Notes

1. Tomkins, C.D., Weber, T.A. (2008) "Option Contracting in the California Water Market," Technical Report #2008-10-09, Department of Management Science and Engineering, Stanford University, Stanford, CA.

2. Ibid, p. 14.

3. Metropolitan Water District (2003) "Option and Short-term Water Purchase and Sale Agreement Between Glenn-Colusa Irrigation District and the Metropolitan Water District of Southern California," MWD, Sacramento, CA. Also, MWD (2005) "Option and Short-term Water Purchase and Sale Agreement Between Glenn-Colusa Irrigation District, Dudley Ridge Water District, Kern County Water Agency, and Metropolitan Water District of Southern California and Palmdale Water District," MWD, Sacramento, CA.

4. San Diego County Water Authority (SDCWA) (2008), "Memorandum of Understanding between Butte Water District and San Diego County Water Authority for Transfer of Water," SDCWA, San Diego, CA. Also, San Diego County Water Authority (SDCWA) (2008), "Memorandum of Understanding between Sutter Extension Water District and San Diego County Water Authority for Transfer of Water," SDCWA, San Diego, CA.

5. The technical assumption is that the seller maximizes expected value.

6. See for instance the Food and Agricultural Organization of the United Nations (FAO). [http://faostat.fao.org/]

7. Rice prices as quoted by the Farm Service Agency (FAS). *Interview with Don Perez of FSA, Glenn Colusa County, December 27, 2007.* Data on the cost of rice production from USDA, Research Team, *Rice Briefing*; data on the yield per acre of cultivated rice from *Feed Grains Database*:[http://www.ers.usda.gov]. Consumptive use of water for rice is approximately 3.3 af per acre according to the California Department of Water Resources (2007). Application is actually 5.89 af.

8. CIC Research, Inc., (1993) "The Economic Impact on San Diego County of Three Levels of Water Delivery: 80, 60, or 40 Percent Occurring for Two Months or Six Months, Phase II," CIC Research Inc., San Diego, CA.

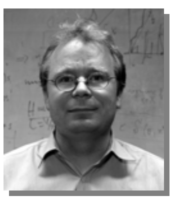
9. Hanak, E. (2003) "Who Should be Allowed to Sell Water in California? Third-Party Issues and the Water Market," Public Policy Institute of California, San Francisco, CA.

10. Hanak, ibid., p. 95.

Authors

Claire D. Tomkins recently completed her PhD in Management Science and Engineering at Stanford. Her doctoral thesis is entitled "Pricing and Allocation of Water Resources."
ctomkins@stanford.edu

James L. Sweeney is a Professor of Management Science and Engineering and Director of the Precourt Institute for Energy Efficiency and a Senior Fellow at the Stanford Institute for Economic Policy Research and the Hoover Institution.
jim.sweeney@stanford.edu



Thomas A. Weber is an Assistant Professor of Management Science and Engineering at Stanford University. His research is concerned with the economics of information and uncertainty.
webert@stanford.edu

Barton H. Thompson is the Robert E. Paradise Professor of Natural Resources Law and the current director of the Woods Institute for the Environment at Stanford University.
buzzt@stanford.edu

David L. Freyberg is an Associate Professor of Civil and Environmental Engineering, member of the Environmental Fluid Mechanics and Hydrology program, and a Woods Institute for the Environment Fellow by courtesy at Stanford.
freyberg@stanford.edu

Acknowledgements

The authors are grateful to the numerous individuals in the California water community who shared their expertise and their data, including Bob Campbell and Gordon Hess at SDCWA, Steve Hirsch at MWD, Tim Quinn at the Association of California Water Agencies, Paul Mendoza at the DWR, Ellen Hanak at the Public Policy Institute of California, and Gary Liebcap at U.C. Santa Cruz. Funding for this research was in part provided by Woods Institute EVP grant 1094280-1-WAKAB.

4. Dudley Ridge Water District:

Summary of Water Offers 2014-2016

This data set, provided by Dudley Ridge Water District provides a summary of the water transfer offers it received from 2014 through 2016, including their price, along with carriage losses, water source, and owner, where available.

SUMMARY OF WATER OFFERS 2014-2016

Date of Offer	Owner	Amount Available(AF)	Water Source	Cost ($/AF)	Carriage Loss	Cost with Carriage Loss	Additional Delivery Costs
3/4/2014	Semitropic Water Storage District	6,000	San Luis/KWB	$ 1,200			$20/af (if from San Luis) $85/af (if from KWB)
4/2/2014	DWR		SWP	$ 300	30%	$ 430	
4/2/2014	DWR		SWP	$ 300	50%	$ 600	
4/2/2014	DWR		SWP	$ 400	30%	$ 570	
4/2/2014	DWR		SWP	$ 400	50%	$ 800	
11/24/2014	*Seller not specidifed in offer	359 - 2,500		$ 1,050			
2/18/2015	Dry Year Water Purchase Program		NOD	$ 700	15%	$ 824	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 700	30%	$ 1,000	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 800	15%	$ 941	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 800	30%	$ 1,143	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 900	15%	$ 1,059	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 900	30%	$ 1,286	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 1,000	15%	$ 1,176	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 1,000	30%	$ 1,429	
3/4/2015	Dry Year Water Purchase Program	130,000	NOD	$ 700	20%	$ 875	
3/4/2015	Dry Year Water Purchase Program	130,000	NOD	$ 700	30%	$ 1,000	
3/25/2015	Dry Year Water Purchase Program	30,000	NOD	$ 665			
10/28/2015	Westside Water District	300		$ 925			Water Toll would be added
2/25/2016	Dry Year Water Purchase Program		NOD	$ 550	20%	$ 688	$36 (Water Toll rate)
2/25/2016	Dry Year Water Purchase Program			$ 550	30%	$ 786	$36 (Water Toll rate)
6/21/2016	Sites (offer in todays dollars)			$ 1,000			
8/18/2016	Rosedale	5,000		$ 800			

Kellie Welch - 2014 Dry Year Transfer Program Update - REMINDER

From:	"Rick Besecker" <rbesecker@ppeng.com>
To:	<AndrewE@paramountfarming.com>, "Austin Ewell" <austin@ewellgroup.com>, ...
Date:	1/8/2014 4:14 PM
Subject:	2014 Dry Year Transfer Program Update - REMINDER
Attachments:	DYTP Requests.pdf

All,

The SWC Buyer group met to discuss the sellers' pricing justification, the buyers' pricing sensitivities and our counter offer to the sellers. This year, the SWCs hired M^3 to do an economic analysis on 2014 rice prices. As a result, rice prices were estimated at $145/AF. SWC added $20/AF to get to the $165/AF NOD in our initial offer to the sellers. However, the sellers stated that they want to move away from rice economics. They said in past years, rice prices have been higher. Plus, the sellers noted that DYTP water went for $275/AF NOD in 2009 while going into year three of a drought. Therefore, they want $300/AF NOD.

In regards to litigation, there is rumor that the environmentalists are watching the 2014 transfers very closely and have asked the sellers to notify them of any CEQA that is drafted. Thus said, this is the sellers' justification as to why they want the buyers to take on 100% of the liability. The sellers' general thoughts are that they might as well just plant rice instead of getting sued. Additionally, the SWC General Counsel noted that since we have been doing a lot of NOD transfers lately, this could be viewed as a long-term transfer program, thus opening up more potential for litigation.

After discussion amongst the SWC buyer group, the following terms were agreed upon to go back as a counter offer to the sellers.

- $250/AF NOD
- CEQA/Admin $35K
- Litigation $50K then 50/50 split
- Crop idling call date April 18 (DWR operations capacity study out ~Apr. 16)

Additionally, it was emphasized by all the importance of coordinating with the CVP on the price/terms and offer schedule. The CVP's goal is to counter offer their sellers before Christmas. Therefore, the SWC buyers will do the same.

<u>Other</u>

- Most of the M&I SWCs on the call and Oak Flat WD said that they would not purchase at $300/AF NOD. MWD's pricing threshold is currently at $250/AF NOD. I relayed that DRWD has landowners dropping out at $225-$250/AF, but <u>may</u> still have some demand at $300/AF.
- It is estimated that there could potentially be 100-150 TAF (140 TAF fallow + 10 TAF GW sub) made available by 5-8 sellers. Please see attached DYTP Requests for potential allocations of up to 150 TAF (note that the quantities will change once the buyer pool is finalized).
- The negotiated DYTP water cost will most likely drive the 2014 Yuba C4 water price.
- 2014 Yuba water estimate ~80 TAF total (all components), split 50/50 with SLDMWA.

Please submit your 2014 Dry Year water transfer requests by water type (GW substitution, fallowing, or both) by Friday Jan 10. I will invoice you for the $5/AF SWC administration fee deposit on Monday.

Please don't hesitate to call if you have any questions.

Thanks,

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
2505 Alluvial Avenue
Clovis, CA 93611-9166
Phone: (559) 326-1100 Ext. 312
Fax: (559) 326-1090
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

Kellie Welch - Potential water supply

From: "Rick Besecker" <rbesecker@ppeng.com>
To: <AndrewE@paramountfarming.com>, "Austin Ewell" <austin@ewellgroup.com>, ...
Date: 3/4/2014 4:50 PM
Subject: Potential water supply

Water Users:

Semitropic Water Storage District has up to 6,000 AF available for purchase. A portion of the water is in San Luis Reservoir (SLR) and the remainder would be pumped from the Kern Water Bank. Purchase price is $1,200/AF plus delivery costs of about $20/AF if from SLR, and potentially $85/AF if from KWB.

Please contact me or Dale before **3:00 PM Wednesday** if you have interest in this water.

Rick Besecker

Dudley Ridge Water District

c/o Provost & Pritchard Consulting Group

2505 Alluvial Avenue

Clovis, CA 93611-9166

Phone: (559) 326-1100 Ext. 312

Fax: (559) 326-1090

E-mail: rbesecker@ppeng.com

Website: www.ppeng.com

Kellie Welch - Water Purchases for North of Delta Water - RESPONSE REQUESTED BY 3:30 THURSDAY

From: "Dale Melville" <dmelville@ppeng.com>
To: <rpm@mccarthyfarms.com>, "Ana Mojica" <anam@paramountfarming.com>, "Andr...
Date: 4/2/2014 10:16 AM
Subject: Water Purchases for North of Delta Water - RESPONSE REQUESTED BY 3:30 THURSDAY
Cc: "Rick Besecker" <rbesecker@ppeng.com>, "Tom Glover" <tglover@ppeng.com>

All,

GOOD NEWS:

- The recent storms may be enough to allow the 50% cuts to Feather River contractors to be eliminated. If their full allocation is restored, they will be able to sell water this year via fallowing (larger amounts) and groundwater substitution (smaller amounts).
- MWDSC has dropped out of the program, so most of any water made available would go to KCWA (half) along with DRWD and a few other small districts.
- DWR has stated that carriage losses will be less than 50% this year.

BAD NEWS:

- Rice prices are high this year. Price for water North of Delta (NOD) could be $400/af (vs pricing discussions earlier this year at $275/af)
  - worst case, at 50% losses, equates to $800/af plus water toll charges to you.
  - Best case, at 30% losses, equates to $570/af plus water toll charges to you.

REQUEST:

- To provide DRWD's input on a SWP Buyers call tomorrow at 4:00, we need to know what quantity of water you would be interested in purchasing under each of the following conditions. **Please return via email to Rick no later than 3:30 tomorrow (Thursday, 4/3/14).** This is not binding, but the SWP negotiators need this information in meeting with Sellers in the next few days.
  - Quantity at $300/af and 30% carriage losses = $430/af wet water: ______________ AF
  - Quantity at $300/af and 50% carriage losses = $600/af wet water: ______________ AF
  - Quantity at $400/af and 30% carriage losses = $570/af wet water: ______________ AF
  - Quantity at $400/af and 50% carriage losses = $800/af wet water: ______________ AF

Thanks....this will help in the negotiations; we can do some interpolation for intermediate numbers. We'll also be pushing for a final call date (final quantity based on the negotiated price) to be in early-mid May when deposits will need to be made.

Dale K. Melville, Manager-Engineer
Dudley Ridge Water District
286 W. Cromwell Avenue
Fresno, CA 93711-6162
Phone: (559) 449-2700 x102
Fax: (559) 449-2715
Cell: (559) 355-5880

DUDLEY RIDGE WATER DISTRICT

286 W. CROMWELL AVENUE
FRESNO, CALIFORNIA 93711-6162

PHONE (559) 449-2700
FAX (559) 449-2715

July 1, 2014

PO#
520595
(1 of 2)

Irvine Ranch Water District
craig@irwd.com

INVOICE — Invoice Number: 14137WT

This invoice is for supplemental water purchases incorrectly billed on the previous Water Toll invoice.

Acre-Feet	Description	$/Acre-Foot	Total
30	Westside Districts Water Purchase	840.90	25,227.00
-29	Less Previously Paid	290.72	-8,430.88
30	Westside Districts Water Delivery	30.00	900.00
-29	Less Previously Paid	30.00	-870.00

RECEIVED
JUL 29 2014
PURCHASING

1010.000.1610.142120

TOTAL AMOUNT DUE AND PAYABLE BY 8/1/14	$16,826.12

Delinquent Water Toll Charges shall be subject to a 5% penalty charge on the amount delinquent and interest charges on the amount delinquent at a rate of 1 1/2% per month from and after the delinquent date until the delinquency, penalties, and interest are paid in full. The District shall have the right to terminate deliveries of water to any land within the District which is delinquent in this charge

*Note - Invoice 14137WT $16,826.12 - Invoice 14073YE2 (2,647.18) = $14,178.94 Amt of full pmt

Kellie Welch - 2015 water available

From: Rick Besecker <rbesecker@ppeng.com>
To: Ana Mojica <AnaM@paramountfarming.com>, Andrew Edstrom <AndrewE@paramoun...
Date: 11/24/2014 1:51 PM
Subject: 2015 water available

Water Users:

We have received an offer for a minimum of 359 AF up to a maximum of 2,500 AF available for $1,050/AF, deliverable in 2015. Please email myself or Dale by Monday, December 1 if you have interest in this supply.

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
286 W. Cromwell Avenue
Fresno, CA 93711-6162
Phone: (559) 449-2700
Fax: (559) 449-2715
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

From: Rick Besecker <rbesecker@ppeng.com>
To: Ana Mojica <AnaM@paramountfarming.com>, Andrew Edstrom <AndrewE@paramoun...
Date: 2/18/2015 11:21 AM
Subject: 2015 DYTP Requests

Water Users,
Negotiations for the 2015 Dry Year Water Purchase Program are underway, and we've been asked to provide our potential level of interest at various purchase prices. Please indicate your potential level of participation below and email back to me ASAP.

NOD Purchase Price	Cost with 15% Carriage Loss	Cost with 30% Carriage Loss	NOD Purchase Amount
$700	$824	$1,000	
800	941	1,143	
900	1,059	1,286	
1,000	1,176	1,429	

Note that this is only for initial planning purposes—we will be asking for firmer commitments once the program details (price, volume, etc.) are finalized.

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
2505 Alluvial Avenue
Clovis, CA 93611-9166
Phone: (559) 326-1100 Ext. 312
Fax: (559) 326-1090
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

Kellie Welch - 2016 Dry Year Transfer Program

From: Rick Besecker <rbesecker@ppeng.com>
To: Ana Mojica <Ana.Mojica@wonderful.com>, Andrew Edstrom <Andrew.Edstrom@wo...
Date: 2/25/2016 1:17 PM
Subject: 2016 Dry Year Transfer Program

Water Users,

We have been working with other SWP Contractors to develop the 2016 Dry Year Transfer Program. The term sheets went out to potential sellers today with an initial offer of $550/AF. Estimated losses transferring the water through the delta will probably range between 20%-30%. With estimated losses of 30% the cost of this water in the California Aqueduct is about $786/AF (about $688/AF with a 20% loss) plus our water toll rate (currently $36/AF).

We must submit our request to participate in the 2016 Program by March 4, 2016 along with a $5/AF deposit based on our north of delta request. By April 15, 2016 we must submit the first 50% of the purchase price. The second 50% will be due June 1, 2016.

As in past years DWR will plan to move the 2016 Dry Year Water thru the delta during the July – September period. DWR staff currently estimates capacity will be available to move the water. DWR will be providing updated capacity estimates later this month. Delivery of the Dry Year water will be subject to delta pumping restrictions.

If you are interested in participating in the 2016 Dry Year Transfer Program we need your north of delta request along with a $5/AF deposit by 12 noon March 2, 2016. Early in April we will email invoices for the first 50% of the water purchase based on preliminary estimates of the District's share of the program. Those payments will be due by 12 noon April 13, 2016. The remaining 50% plus DWR delivery charges will be due by May 27, 2016.

If you have questions feel free to either send me an email or give me a call.

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
286 W. Cromwell Avenue
Fresno, CA 93711-6162
Phone: (559) 449-2700
Fax: (559) 449-2715
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

Kellie Welch

From:	Rick Besecker <rbesecker@ppeng.com>
To:	Ana Mojica <AnaM@paramountfarming.com>, Andrew Edstrom <AndrewE@paramoun...
Date:	3/4/2015 11:34 AM
Attachments:	15 DYTP.pdf

Water Users,
We have been working with other SWP Contractors to develop a 2015 Dry Year Transfer Program. We encountered additional challenges this year as a result of increased water broker activity in the Feather River service area. The Broker activity also drove the price of water up. However, we anticipate a maximum of 130,000 AF of water will be offered to the SWP Contractor group at a north of delta price of $700/AF. Estimated losses transferring the water thru the delta will probably range between 20%-30%. With estimated losses of 30% the cost of this water in the California Aqueduct is about $1,000/AF (about $875/AF with 20% loss) plus our water toll rate (currently $23/AF).
We must submit our request to participate in the 2015 Program by March 11th along with a $5/AF deposit based on our north of delta request. By March 25th we must submit the first 50% of the purchase price. The second 50% will be due May 5th.

Metropolitan WD has indicated it will participate in the 2015 Program—this will significantly reduce our allocation of the available water. Based on the this year's interested contractors, we estimate the District's share of this year's program to be up to 1,900 AF north of the delta. The attached table illustrates projected water availability.
As in past years DWR will plan to move the 2015 Dry Year Water thru the delta during the July – September period. DWR staff currently estimates capacity will be available to move the water. DWR will be providing updated capacity estimates later this month. Delivery of the Dry Year water will be subject to delta pumping restrictions.
If you are interested in participating in the 2015 Dry Year Transfer Program we need your north of delta request along with a $5/AF deposit by 12 noon March 11th. Early the week of March 16th we will email invoices for the first 50% of the water purchase ($350/AF north of delta) based on preliminary estimates of the District's share of the program. Those payments will be due by 12 noon March 25th. The remaining 50% plus DWR delivery charges will be due by May 5th.
If you have questions feel free to either send me an email or give me a call.

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
2505 Alluvial Avenue
Clovis, CA 93611-9166
Phone: (559) 326-1100 Ext. 312
Fax: (559) 326-1090
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

Kellie Welch - DYTP Allocation

From: Rick Besecker <rbesecker@ppeng.com>
To: Ana Mojica <AnaM@paramountfarming.com>, Andrew Edstrom <AndrewE@paramoun...
Date: 3/17/2015 11:01 AM
Subject: DYTP Allocation

The district was allocated 1,561 AF of water through the Dry Year Transfer Program. The breakdown among landowners is as follows:

Paramount 811 AF
Sandridge 551 AF
Kings 107 AF
Utica 70 AF
Sibley 7 AF
Jackson 15 AF

Invoices for the purchase price ($700/AF) are going in the mail (and emailed) today—**they are due on Monday, March 23**.

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
286 W. Cromwell Avenue
Fresno, CA 93711-6162
Phone: (559) 449-2700
Fax: (559) 449-2715
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

Kellie Welch - Water Operations Call

From: Rick Besecker <rbesecker@ppeng.com>
To: Ana Mojica <AnaM@paramountfarming.com>, Andrew Edstrom <AndrewE@paramoun...
Date: 3/25/2015 12:09 PM
Subject: Water Operations Call
Cc: Phillip Nixon <pnixon@lhwd.org>, "'ghammett@belridgewsd.com'" <ghammett@...

Water Users,

Just finished today's water operations call with DWR—here is the bad news:

- Statewide snowpack is at 9% of the April 1 average—this is the lowest on record. Temperatures are expected to rise this weekend, effectively melting the remaining snow. The 30-day precipitation forecast is non-committal, but April has produced significant rain events in the past.
- Allocation studies support 21% (at the most likely 99% exceedence) to 25% (at least likely 50% exceedence).
- Deliveries to Feather River Service Area Contractors will likely be curtailed—while this won't impact the 2015 allocation it will reduce carryover storage in Oroville, and is likely to impact (reduce or eliminate) water available to the Dry Year Transfer Program.
- There is plenty of capacity in July through September to move non-Project water.
- There will be no Yuba Accord surface water available in 2015. Up to 30,000 AF of groundwater substitution water could be made available at $665/AF (north of the Delta).
- The dry conditions could result in additional losses for the Dry Year Transfer Program, but the contractors will push to delay imposing in 2015.

Let's hope for some April showers—every little bit will help.

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
286 W. Cromwell Avenue
Fresno, CA 93711-6162
Phone: (559) 449-2700
Fax: (559) 449-2715
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

Kellie Welch - End of year water supply

From: Rick Besecker <rbesecker@ppeng.com>
To: Ana Mojica <Ana.Mojica@wonderful.com>, Andrew Edstrom <Andrew.Edstrom@wo...
Date: 10/28/2015 3:24 PM
Subject: End of year water supply

Water Users,
We have a potential new supply of up to 300 AF available through the Westside Districts for $925/AF (plus our water toll). Water would be available mid- to late-November and can be delivered by the end of December. Please respond by end of week if you would like to purchase your allocated portion (or are not interested).

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
286 W. Cromwell Avenue
Fresno, CA 93711-6162
Phone: (559) 449-2700
Fax: (559) 449-2715
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

Kellie Welch - Need for Additional Water in DRWD

From:	Dale Melville <dmelville@ppeng.com>
To:	"Kimberly.Brown@wonderful.com" <Kimberly.Brown@wonderful.com>, "JTVidovi...
Date:	6/21/2016 10:54 AM
Subject:	Need for Additional Water in DRWD
Cc:	"heather@deanzaproperties.com" <heather@deanzaproperties.com>, "BillPhil...
Attachments:	4.5-Overview(vA).pdf; SWC-Sites_Reservoir_Exportable_Releases_051616.pdf

All,

Given the state of the SWP water supply (average 60% allocation, and trending downward), DRWD continues to look at short-term and long-term water supplies to supplement the SWP water. For the past eight years, DRWD has been procuring supplemental water supplies in concert with the "Westside 5" (DRWD and four Westside districts in Kern County) and we continue to investigate other opportunities to increase DRWD's supply and/or reliability. Currently, a potential opportunity for supplemental water is the proposed Sites Reservoir, which the Board will be discussing at its July 13 meeting.

Sites Reservoir could provide additional dry year supplies to districts south of the Delta during times when pumping capacity is available (currently, typically at less than 50% allocations). Cost of the water is estimated to be near $1,000/af of yield. I have attached a recent Overview of the Sites project (prepared by the Sites Project Authority) and an analysis of yield from Sites that could be exported South of the Delta (prepared by the State Water Contractors); although review of these two documents are not critical to address the information I am requesting below, they do provide the most current information on the Sites project. The last slide on the SWC presentation indicates water costs at $969/af (at 3% interest) and $1,344/af (at 5.7%, the rate being assumed for the CA WaterFix....i.e., 'tunnels"). For such large public projects under current conditions, the lower rate is more appropriate. The unit costs from the SWC presentation are for North of the Delta (and carriage losses across the Delta are typically 25%+/-); however, the SWC analyst and general manager are convinced that there are ample opportunities to coordinate Sites releases with the SWP and CVP reservoirs to produce sufficient water savings that would exceed the Delta carriage losses. Thus, for purposes of this email, it is assumed that additional water supply savings would off-set the Delta losses and the cost to DRWD growers would be ~$1,000/af. It is also important to note that operations of the Sites project is at least 10 years away; the unit cost of ~$1,000/af is in today's dollars.

REQUEST FROM DRWD WATER USERS:
To assist the Board in their review of what, if any, level of participation DRWD may want to request in the initial phase of the Sites project, please provide to me no later than Monday, July 11, a preliminary (non-binding) estimate of the quantity of water your operation may be interested in at a cost of ~$1,000/af. Please indicate the quantity either as an average annual supply and/or as a dry year supply.

This request will also assist DRWD in evaluating other water supply opportunities through our arrangement with the Westside 5. Thx.

Dale K. Melville, PE
Manager-Engineer
Dudley Ridge Water District
286 W. Cromwell Ave.
Fresno, CA 93711-6162
559-449-2700 x102
559-449-2715 fax
559-355-5880 cell

Kellie Welch - Supplemental Water

From: Rick Besecker <rbesecker@ppeng.com>
To: Ana Mojica <Ana.Mojica@wonderful.com>, Austin Ewell <austin@ewellgroup.c...
Date: 8/18/2016 8:34 AM
Subject: Supplemental Water

Water Users:

Rosedale-Rio Bravo WSD has up to 5,000 AF of water available for purchase this year through the Westside Districts for $800/AF. Please respond by Friday, August 26 if you are interested.

Rick Besecker
Dudley Ridge Water District
c/o Provost & Pritchard Consulting Group
286 W. Cromwell Avenue
Fresno, CA 93711-6162
Phone: (559) 449-2700
Fax: (559) 449-2715
E-mail: rbesecker@ppeng.com
Website: www.ppeng.com

5. Buena Vista Water Storage District Water Auction 2014:

This data set, provided by Rosedale provides documentation of Buena Vista Water Storage District auction of water in 2014 which the median value buyers paid was $1,200 per AF.

ADMINISTRATIVE REPORT

Meeting Date: February 19, 2014

Agenda Section: Consent Calendar
Item: 8b

TO: **Board of Directors**

FROM: **Maurice Etchechury**

DATE: **February 11, 2014**

SUBJECT: **Water Sales Update**

RECOMMENDATION: Ratify Water Sales in the amount of 12,206 Acre-Feet

On January 15, 2014 the BOD approved the sale of 12,000 AF of water. Bids were received on February 5, 2014. The bid results are attached. Over 63,000 AF were requested at prices exceeding the minimum bid. During the bid process the State reduced the allocation on the SWP to zero. This combined with the BV's bid created a bit of media circus. The district staff countered charges of "Price Gouging" and others with the message of assisting others in need and the need for action to reign in the subversion of the intended operations of the SWP by environmental regulation.

The process was also muddled by the fact that the KCWA revealed that a substantial portion of the "Carryover Water," that local districts use as insurance in times like this, was trapped north of the Delta in Oroville Dam. Staff had to get a handle on DWR and KCWA accounting so that any sales made would actually be water that could be delivered. To make a very long a tedious story short the problem was alleviated by the largest buyers of the water notifying BV that they were willing to accept the water "In System" not in Kern County. This is a risk on their part and just underscores the seriousness of the drought, the need for a transfer facility across the delta and the adverse effects "Environmental Regulations" have on the operation of the project. This should not be taken as an endorsement of the delta tunnels known as BDCP.

The water BV is selling is characterized as follows:

Carryover	10,839*
Backup	1,367
2013 State Water	12,206

*This water is comprised of the following:

2013 BV Table A	1,368
2013 BV/KD Exchange	3,613
2013 BV/CWD Exchange	5,858
Total	10,839

Staff increased the sale amount to 12,206 from 12,000. The board should ratify this action. This is so that BV can zero out this account as of 1/1/14 and start fresh.

The proceeds from this sale is $13.96mm.

Of the 12,206, 600 AF is being sold to Harris Ranch in Mettler via Arvin Edison/Wheeler Ridge. Harris Ranch will be responsible for coordinating the wheeling from Tupman. The other 11,606 will be sold through Belridge, Berrenda Mesa and Lost Hills (WS3). They are going to take the water "In the system."

The allocation of the 11,606 AF to the WS3 is; Brenda Mesa 2.15%, Belridge 88.37% and Lost Hills 9.48%.

	Bidder	Price $	Quantity AF	Total $	Calculated Total
		TOTAL	-		
1	Harris Ranch-Mettler	$ 1,350.00	300	$ 405,000	$ 405,000
2	Starrh&Starrh	$ 1,250.00	1,000	$ 1,250,000	$ 1,250,000
3	Cal Heavy Oil	$ 1,207.00	350	$ 422,450	$ 422,450
4	Starrh&Starrh	$ 1,200.00	1,000	$ 1,200,000	$ 1,200,000
5	Primex	$ 1,200.00	1,100	$ 1,320,000	$ 1,320,000
6	Harris Ranch-Mettler	$ 1,200.00	300	$ 360,000	$ 360,000
7	Horizon Nut	$ 1,175.00	250	$ 293,750	$ 293,750
8	Starrh&Starrh	$ 1,150.00	1,000	$ 1,150,000	$ 1,150,000
9a	Starrh&Starrh	$ 1,100.00	600	$ 1,100,000	$ 660,000
10a	Paramount Farming	$ 1,100.00	6,100	$ 11,000,000	$ 6,710,000
		TOTAL	**12,000**	**TOTAL**	**$ 13,771,200**
9b	Starrh&Starrh	$ 1,100.00	400	$ 1,100,000	$ 440,000
10b	Paramount Farming	$ 1,100.00	3,900	$ 11,000,000	$ 4,290,000
11	Starrh&Starrh	$ 1,050.00	1,000	$ 1,050,000	$ 1,050,000
12	Stiefvater Orchards	$ 1,030.00	2,000	$ 2,060,000	$ 2,060,000
13	Webster Pistachios	$ 1,011.00	400	$ 404,400	$ 404,400
14	Cal Heavy Oil	$ 1,007.00	300	$ 302,100	$ 302,100
15	Elex Farm	$ 1,000.00	250	$ 250,000	$ 250,000
16	Harris Ranch-Mettler	$ 1,000.00	300	$ 300,000	$ 300,000
17	Chapparel Industries	$ 1,000.00	750	$ 750,000	$ 750,000

18	Wheeler Ridge-Maricopa	$ 1,000.00	3,000	$ 3,000,000	$ 3,000,000
19	Harris Ranch-Mettler	$ 950.00	300	$ 285,000	$ 285,000
20	Rod Stiefvater	$ 915.00	250	$ 228,750	$ 228,750
21	Sandridge	$ 900.00	1,000	$ 900,000	$ 900,000
22	Munger Bros	$ 900.00	1,500	$ 1,350,000	$ 1,350,000
23	Cawelo	$ 900.00	400	$ 360,000	$ 360,000
24	Rod Stiefvater	$ 865.00	250	$ 216,250	$ 216,250
25	Amin Orchard	$ 850.00	1,200	$ 1,020,000	$ 1,020,000
26	Rudy Hernandez	$ 850.00	400	$ 340,000	$ 340,000
26	Sandridge	$ 825.00	1,000	$ 825,000	$ 825,000
27	Rod Stiefvater	$ 815.00	250	$ 203,750	$ 203,750
27	John Antongiavanni Jr.	$ 808.00	350	$ 282,800	$ 282,800
28	Cal Heavy Oil	$ 807.00	300	$ 242,100	$ 242,100
29	Kern Tulare	$ 802.00	3,000	$ 2,406,000	$ 2,406,000
30	S&H Ranch	$ 800.00	250	$ 200,000	$ 200,000
31	Grimmway Farms	$ 800.00	1,100	$ 880,000	$ 880,000
32	Global Ag Properties	$ 800.00	3,000	$ 2,400,000	$ 2,400,000
33	S&H Ranch	$ 800.00	250	$ 200,000	$ 200,000
34	Wheeler Ridge-Maricopa	$ 800.00	2,000	$ 1,600,000	$ 1,600,000
35	Rod Stiefvater	$ 765.00	250	$ 191,250	$ 191,250
36	CAPS	$ 750.00	500	$ 350,000	$ 375,000
37	Elex Farm	$ 750.00	250	$ 187,500	$ 187,500
38	Cal Pistachio	$ 750.00	250	$ 187,500	$ 187,500
39	Chapparel Industries	$ 750.00	750	$ 562,500	$ 562,500
40	Sandridge	$ 750.00	1,000	$ 750,000	$ 750,000

41	Royal Farming	$	750.00	1,000	$	750,000	$	750,000
42	Virve Almonds	$	750.00	800	$	600,000	$	600,000
43	Rudy Hernandez	$	750.00	300	$	225,000	$	225,000
44	Rudy Hernandez	$	725.00	250	$	181,250	$	181,250
45	Rainbow Orchards VI	$	700.00	400	$	280,000	$	280,000
46	Sunnyview Vineyards	$	677.00	1,000	$	677,000	$	677,000
47	Cawelo	$	675.00	3,000	$	2,025,000	$	2,025,000
48	Cawelo	$	675.00	1,000	$	675,000	$	675,000
49	Kern Westside	$	650.00	12,000	$	7,800,000	$	7,800,000
	TOTAL ACRE-FEET BID			**63,850**	**$**	**49,598,150.00**		

6. Alliance Ag Services Email

Re: Lease Cost Alternative lease land for wetland creation

Kellie Welch - Least Cost Alternative

From: Mike Ming <mming@allianceappr.com>
To: "'Kellie Welch (Welch@irwd.com)'" <Welch@irwd.com>
Date: 2/23/2018 8:54 AM
Subject: Least Cost Alternative

The least cost alternative would incorporate a 7-year lease. The lease rate would begin at $300.00 per acre per year and escalate 2.50% each year of the lease.

Lands in the general area lease for 3-5 years so a seven year lease is not abnormal.

The availability of land could vary depending on large land owner and their respective growing seasons and cropping patterns.

Land that is available within 5 miles of the Aqueduct in Kern County is either farmland or already habitat. Any lease would also have a restoration clause. This would make sure the lands are returned to pre-lease condition.
I hope this answers the question.

Mike

Michael G. Ming, Broker
Alliance Ag Services, LLC
CalBRE #0951819
5401 Business Park South
Suite 122
Bakersfield, CA 93309

Agricultural Brokerage and Consulting

Local Knowledge - Global Reach

(661) 631-0391 Kern County
(661) 631-0392 Facsimile

(559) 408-5975 Central San Joaquin Valley

(805) 979-9495 Central Coast

ALLIANCE
AG SERVICES

www.allianceagservices.com

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

1. MBK SPREADSHEET MODEL

NOT INCLUDED IN THIS COPY

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

2. CRAMER FISH SCIENCES MODELS

2a. Feather River Analysis- Spreadsheet

2b. Smolt Survival to Bay Analysis- Spreadsheet

2c. Delta Passage Model- Player Version

NOT INCLUDED IN THIS COPY

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

3. M.CUBED SPREADSHEET QUANTIFICATION SUPPORT

M.Cubed Spreadsheet quantification support originally submitted as Tab 6 Attachment 5

Tab6-A5_IRWD_WSIP_Econ Benefits_081117_FINAL.xlsx

Worksheets included in workbook:

1. Summary of Total Benefits
2. Annual Benefits
3. Physical and Economic Summary
4. TR
5. Water Supply Changes
6. Groundwater RecharSPREADHSge
7. Recharge Events
8. Salmonid Survival
9. Conveyance Cost
10. Wetland Construction
11. Option values
12. Extended Drought Water Values
13. SJR WY index
14. Drought Frequency
15. MWD Escalation
16. CA DOF CPI

SUPPORTING DOCUMENTATION:
M.CUBED SPREADSHEET QUANTIFICATION SUPPORT
WORKSHEET 1: SUMMARY OF TOTAL BENEFITS

Summary of Benefits **NPV in 2026 of benefits @ 3.5% discount**

		primary approach (2015 $)		secondary approach (2015 $)		ORIGINAL primary approach (2015 $)
Non-public Benefits						
	Water Supply Benefits	$ 50,440,996	(alternative cost)			$ 47,745,447
	Groundwater	$ 3,485,796	(alternative cost)			$ 4,296,189
Public Benefits						
	Environmental Benefits--Salmon	$ 30,828,335	(alternative cost)	$ 48,920,533	(willingness to pay)	$ 20,978,395
	Environmental Benefits--Incidental wetland habitat	$ 98,248,070	(alternative cost)	$111,761,600	(alternative cost)	$ 39,796,319
	Emergency Response--Extended drought	$ 18,570,140	(alternative cost)			$ 5,062,067
	Emergency Response--Delta failure	$ 28,452,182	(alternative cost)			$ 59,924,484
	TOTAL Public Benefits	**$ 176,098,728**				$ 125,761,264
	Total All Benefits	**$ 230,025,520**				

Environmental Benefit--Salmon--Willingness to pay approach #1

	Additional Spring-run Chinook over 50-year period	Additional Winter-run Chinook over 50-year period	value of winter-run and spring-run Chinook (2015 $)	NPV Total benefit (2015 $)
2030	1011	109	$ 100,000	**$48,920,533**
2070	715	73		

Updated inputs and results in response to Economic Review

project life year	year		EV [Additional Spring-run Chinook]	EV [Additional Winter-run Chinook]	EV[Total additional fish]	Total environmental benefit ($)
	2015					
	2016					
	2017					
	2018					
	2019	*Phase I starts*				
	2020					
	2021				0	$ -
	2022				0	$ -
	2023				0	$ -
	2024	*Ph I ends, Ph II starts*			0	$ -
	2025	*Ph II ends*			0	$ -
1	2026	*project starts 1/1/26*	21	2	23	$ 2,306,400
2	2027		21	2	23	$ 2,289,800
3	2028		21	2	23	$ 2,273,200
4	2029		20	2	23	$ 2,256,600
5	2030		20	2	22	$ 2,240,000
6	2031		20	2	22	$ 2,223,400
7	2032		20	2	22	$ 2,206,800
8	2033		20	2	22	$ 2,190,200
9	2034		20	2	22	$ 2,173,600
10	2035		19	2	22	$ 2,157,000
11	2036		19	2	21	$ 2,140,400
12	2037		19	2	21	$ 2,123,800
13	2038		19	2	21	$ 2,107,200
14	2039		19	2	21	$ 2,090,600
15	2040		19	2	21	$ 2,074,000
16	2041		19	2	21	$ 2,057,400
17	2042		18	2	20	$ 2,040,800
18	2043		18	2	20	$ 2,024,200
19	2044		18	2	20	$ 2,007,600
20	2045		18	2	20	$ 1,991,000
21	2046		18	2	20	$ 1,974,400
22	2047		18	2	20	$ 1,957,800
23	2048		18	2	19	$ 1,941,200
24	2049		17	2	19	$ 1,924,600
25	2050		17	2	19	$ 1,908,000
26	2051		17	2	19	$ 1,891,400
27	2052		17	2	19	$ 1,874,800
28	2053		17	2	19	$ 1,858,200
29	2054		17	2	18	$ 1,841,600
30	2055		17	2	18	$ 1,825,000
31	2056		16	2	18	$ 1,808,400
32	2057		16	2	18	$ 1,791,800
33	2058		16	2	18	$ 1,775,200
34	2059		16	2	18	$ 1,758,600
35	2060		16	2	17	$ 1,742,000
36	2061		16	2	17	$ 1,725,400
37	2062		15	2	17	$ 1,708,800
38	2063		15	2	17	$ 1,692,200
39	2064		15	2	17	$ 1,675,600
40	2065		15	2	17	$ 1,659,000
41	2066		15	2	16	$ 1,642,400
42	2067		15	2	16	$ 1,625,800
43	2068		15	1	16	$ 1,609,200.00
44	2069		14	1	16	$ 1,592,600
45	2070		14	1	16	$ 1,576,000
46	2071		14	1	16	$ 1,576,000
47	2072		14	1	16	$ 1,576,000
48	2073		14	1	16	$ 1,576,000
49	2074		14	1	16	$ 1,576,000
50	2075		14	1	16	$ 1,576,000

	2030			2070		
	With Project	Without Project	ferer	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]						
4. Annual Economic Bene	$ 2,240,000	0	##	$ 1,576,000	0	$ 1,576,000

Environmental Benefit--Salmon--Alternative cost approach #2

	environmental flows, expected value, all years (AF)		2030--Sac Valley cost of water (2015$)	2045--Sac Valley cost of water (2015 $)	weights based on project env supply--	Option value per AF	NPV Total benefit (2015 $)	
2030	1,500	wet	$ 145	$ 150	0%	$46.24	$30,828,335	2030
2070	1,300	above normal	$ 191	$ 198	0%			2070
		below normal	$ 255	$ 264	0%			2030 share
	Volume of each pulse flow (AF)	dry	$ 275	$ 283	63%			2070 share
	18,000	critical	$ 345	$ 354	38%			

EV [Environmental flows due to project) (AF)	water unit cost based on Sac Valley unit values in dry and crit years (2015 $)		option volume	option price (2015 $)	Total supply benefit--avoided cost (2015 $)
	$ 293				
	$ 293				
	$ 294				
	$ 295				
	$ 295				
	$ 296				
	$ 296				
	$ 297				
	$ 297				
	$ 298				
	$ 298				
1,500	$ 299		18,000	$ 46	$ 1,280,908.79
1,500	$ 300		18,000	$ 46	$ 1,281,746.29
1,500	$ 300		18,000	$ 46	$ 1,282,583.79
1,500	$ 301		18,000	$ 46	$ 1,283,421.29
1,500	$ 301		18,000	$ 46	$ 1,284,258.79
1,495	$ 302		18,000	$ 46	$ 1,283,587.25
1,490	$ 302		18,000	$ 46	$ 1,282,910.12
1,485	$ 303		18,000	$ 46	$ 1,282,227.41
1,480	$ 303		18,000	$ 46	$ 1,281,539.12
1,475	$ 304		18,000	$ 46	$ 1,280,845.25
1,470	$ 305		18,000	$ 46	$ 1,280,145.79
1,465	$ 305		18,000	$ 46	$ 1,279,440.75
1,460	$ 306		18,000	$ 46	$ 1,278,730.12
1,455	$ 306		18,000	$ 46	$ 1,278,013.91
1,450	$ 307		18,000	$ 46	$ 1,277,292.12
1,445	$ 307		18,000	$ 46	$ 1,276,564.75
1,440	$ 308		18,000	$ 46	$ 1,275,831.79
1,435	$ 309		18,000	$ 46	$ 1,275,093.25
1,430	$ 309		18,000	$ 46	$ 1,274,349.12
1,425	$ 310		18,000	$ 46	$ 1,273,599.41
1,420	$ 310		18,000	$ 46	$ 1,272,051.29
1,415	$ 310		18,000	$ 46	$ 1,270,503.16
1,410	$ 310		18,000	$ 46	$ 1,268,955.04
1,405	$ 310		18,000	$ 46	$ 1,267,406.91
1,400	$ 310		18,000	$ 46	$ 1,265,858.79
1,395	$ 310		18,000	$ 46	$ 1,264,310.66
1,390	$ 310		18,000	$ 46	$ 1,262,762.54
1,385	$ 310		18,000	$ 46	$ 1,261,214.41
1,380	$ 310		18,000	$ 46	$ 1,259,666.29
1,375	$ 310		18,000	$ 46	$ 1,258,118.16
1,370	$ 310		18,000	$ 46	$ 1,256,570.04
1,365	$ 310		18,000	$ 46	$ 1,255,021.91
1,360	$ 310		18,000	$ 46	$ 1,253,473.79
1,355	$ 310		18,000	$ 46	$ 1,251,925.66
1,350	$ 310		18,000	$ 46	$ 1,250,377.54
1,345	$ 310		18,000	$ 46	$ 1,248,829.41
1,340	$ 310		18,000	$ 46	$ 1,247,281.29
1,335	$ 310		18,000	$ 46	$ 1,245,733.16
1,330	$ 310		18,000	$ 46	$ 1,244,185.04
1,325	$ 310		18,000	$ 46	$ 1,242,636.91
1,320	$ 310		18,000	$ 46	$ 1,241,088.79
1,315	$ 310		18,000	$ 46	$ 1,239,540.66
1,310	$ 310		18,000	$ 46	$ 1,237,992.54
1,305	$ 310		18,000	$ 46	$ 1,236,444.41
1300	$ 310		18,000	$ 46	$ 1,234,896.29
1300	$ 310		18,000	$ 46	$ 1,234,896.29
1300	$ 310		18,000	$ 46	$ 1,234,896.29
1300	$ 310		18,000	$ 46	$ 1,234,896.29
1300	$ 310		18,000	$ 46	$ 1,234,896.29
1300	$ 310		18,000	$ 46	$ 1,234,896.29

2030		
With Project	Without Project	Difference
$ 1,284,259	0	$ 1,284,259

2070		
With Project	Without Project	Difference
$ 1,234,896	0	$ 1,234,896

Water Supply Benefit (non-public)--alternative cost approach

Annual Expected Water Supply (urban)	Annual Expected Water Supply (agriculture)	rate of change between 2030 and 2045 (ratio)		2030--Delta Export cost of water ($/AF)	2045--Delta Export cost of water ($/AF)	water year weights--SJ WY Index	adjusted weights based on project supply--2030	adjusted weights based on project supply--2070	NPV Total benefit (2015 $)
650.00	2050	102%	wet	$ 205	$ 414	29%	0%	0%	**$50,440,996**
750.00	2250	103%	above normal	$ 256	$ 519	20%	6%	7%	
24%	76%	137%	below normal	$ 267	$ 633	16%	6%	11%	
25%	75%	136%	dry	$ 285	$ 674	16%	44%	55%	
portion of water on non-emergency supply	100%	193%	critical	$ 360	$ 1,056	20%	44%	20%	

weighted average change in water cost from 2030 to 2045	131%	Additional Conveyance cost	$ 17

Annual expected water supply (AF) (Agriculture)	Delta export values weighted by project supply year types (2015 $) (applied share of supply to Ag agencies)	Conveyance cost	Annual expected water supply (AF) (Urban)	Met tier 1 rates, inflated at Met projected escalation (2015 $) (applied to urban share)	Total supply benefit--avoided cost (2015 $)
1,811	$ 178	$ 17	561	$ 874	$ 842,916
1,816	$ 212	$ 17	566	$ 900	$ 925,038
1,821	$ 246	$ 17	571	$ 926	$ 1,008,243
1,826	$ 281	$ 17	576	$ 954	$ 1,092,561
1,831	$ 315	$ 17	580.55	$ 982	$ 1,178,022
1,836	$ 349	$ 17	586	$ 1,011	$ 1,264,657
1,841	$ 383	$ 17	591	$ 1,042	$ 1,352,498
1,846	$ 418	$ 17	596	$ 1,073	$ 1,441,579
1,851	$ 452	$ 17	601	$ 1,105	$ 1,531,934
1,856	$ 486	$ 17	606	$ 1,139	$ 1,623,600
1,861	$ 520	$ 17	610	$ 1,173	$ 1,716,615
1,866	$ 555	$ 17	615	$ 1,209	$ 1,811,016
1,871	$ 589	$ 17	620	$ 1,246	$ 1,906,845
1,876	$ 623	$ 17	625	$ 1,284	$ 2,004,143
1,881	$ 658	$ 17	630	$ 1,323	$ 2,102,954
1,886	$ 692	$ 17	635	$ 1,363	$ 2,203,322
1,891	$ 726	$ 17	640	$ 1,405	$ 2,305,296
1,896	$ 760	$ 17	645	$ 1,449	$ 2,408,923
1,901	$ 795	$ 17	650	$ 1,493	$ 2,514,253
1,906	$ 829	$ 17	655	$ 1,540	$ 2,621,340
1,911	$ 823	$ 17	660	$ 1,540	$ 2,622,933
1,916	$ 818	$ 17	665	$ 1,540	$ 2,624,471
1,921	$ 813	$ 17	670	$ 1,540	$ 2,625,956
1,926	$ 807	$ 17	675	$ 1,540	$ 2,627,387
1,931	$ 802	$ 17	680	$ 1,540	$ 2,628,764
1,936	$ 796	$ 17	685	$ 1,540	$ 2,630,087
1,941	$ 791	$ 17	690	$ 1,540	$ 2,631,357
1,946	$ 786	$ 17	695	$ 1,540	$ 2,632,572
1,951	$ 780	$ 17	700	$ 1,540	$ 2,633,733
1,956	$ 775	$ 17	705	$ 1,540	$ 2,634,841
1,961	$ 769	$ 17	710	$ 1,540	$ 2,635,895
1,966	$ 764	$ 17	715	$ 1,540	$ 2,636,894
1,971	$ 759	$ 17	720	$ 1,540	$ 2,637,840
1,976	$ 753	$ 17	725	$ 1,540	$ 2,638,732
1,981	$ 748	$ 17	730	$ 1,540	$ 2,639,570
1,986	$ 743	$ 17	735	$ 1,540	$ 2,640,355
1,991	$ 737	$ 17	740	$ 1,540	$ 2,641,085
1,996	$ 732	$ 17	745	$ 1,540	$ 2,641,761
2,001	$ 726	$ 17	750	$ 1,540	$ 2,642,384
2,006	$ 721	$ 17	755	$ 1,540	$ 2,642,952
2,011	$ 716	$ 17	760	$ 1,540	$ 2,643,467
2,016	$ 710	$ 17	765	$ 1,540	$ 2,643,928
2,021	$ 705	$ 17	770	$ 1,540	$ 2,644,335
2,026	$ 699	$ 17	775	$ 1,540	$ 2,644,688
2,031	$ 694	$ 17	677	$ 1,540	$ 2,485,886
2,031	$ 694	$ 17	2,031	$ 1,540	$ 4,570,049
2,031	$ 694	$ 17	2,031	$ 1,540	$ 4,570,049
2,031	$ 694	$ 17	2,031	$ 1,540	$ 4,570,049
2,031	$ 694	$ 17	2,031	$ 1,540	$ 4,570,049
2,031	$ 694	$ 17	2,031	$ 1,540	$ 4,570,049

2030			2070		
With Project	Without Project	Difference	With Project	Without Project	Difference
$ 1,178,022	0	$ 1,178,022	$ 2,485,886	0	$ 2,485,886

Groundwater Recharge Benefits (non-public)--alternative cost approach

	Annual Expected Recharge	weighted average leave-behind percentage	Total groundwater recharge benefit supply	(Urban)	(Agriculture)	NPV Total benefit (2015 $)
2030	4400	6.56%	289	69.5	219.0	**$3,485,796**
2070	4500	6.50%	293	73.1	219.4	

Additional Conveyance cost	$ 17.10

Annual expected groundwater recharge (AF)	Delta Export value, averaged across all WY types (2015 $)	Conveyance cost	Total GW benefit--avoided cost (2015 $)
288.1	$ 170	$ 17	$ 53,782
288.2	$ 194	$ 17	$ 60,871
288.3	$ 219	$ 17	$ 67,965
288.4	$ 243	$ 17	$ 75,063
288.5	$ 268	$ 17	$ 82,167
288.6	$ 292	$ 17	$ 89,276
288.7	$ 317	$ 17	$ 96,389
288.8	$ 341	$ 17	$ 103,507
288.9	$ 366	$ 17	$ 110,631
289.0	$ 390	$ 17	$ 117,759
289.1	$ 415	$ 17	$ 124,892
289.2	$ 439	$ 17	$ 132,030
289.3	$ 464	$ 17	$ 139,173
289.4	$ 489	$ 17	$ 146,321
289.5	$ 513	$ 17	$ 153,473
289.6	$ 538	$ 17	$ 160,631
289.7	$ 562	$ 17	$ 167,794
289.8	$ 587	$ 17	$ 174,961
289.9	$ 611	$ 17	$ 182,133
290.0	$ 636	$ 17	$ 189,311
290.1	$ 636	$ 17	$ 189,376
290.2	$ 636	$ 17	$ 189,441
290.3	$ 636	$ 17	$ 189,506
290.4	$ 636	$ 17	$ 189,572
290.5	$ 636	$ 17	$ 189,637
290.6	$ 636	$ 17	$ 189,702
290.7	$ 636	$ 17	$ 189,768
290.8	$ 636	$ 17	$ 189,833
290.9	$ 636	$ 17	$ 189,898
291.0	$ 636	$ 17	$ 189,963
291.1	$ 636	$ 17	$ 190,029
291.2	$ 636	$ 17	$ 190,094
291.3	$ 636	$ 17	$ 190,159
291.4	$ 636	$ 17	$ 190,225
291.5	$ 636	$ 17	$ 190,290
291.6	$ 636	$ 17	$ 190,355
291.7	$ 636	$ 17	$ 190,420
291.8	$ 636	$ 17	$ 190,486
291.9	$ 636	$ 17	$ 190,551
292.0	$ 636	$ 17	$ 190,616
292.1	$ 636	$ 17	$ 190,681
292.2	$ 636	$ 17	$ 190,747
292.3	$ 636	$ 17	$ 190,812
292.4	$ 636	$ 17	$ 190,877
292.5	$ 636	$ 17	$ 190,943
292.5	$ 636	$ 17	$ 190,943
292.5	$ 636	$ 17	$ 190,943
292.5	$ 636	$ 17	$ 190,943
292.5	$ 636	$ 17	$ 190,943
292.5	$ 636	$ 17	$ 190,943

2030				2070		
With Project	Without Project	Difference		With Project	Without Project	Difference
$ 82,167	0	$ 82,167		$ 190,943	0	$ 190,943

Emergency Response (Public Benefit)--Extended drought--alternative cost approach

	MWDSC water rates (2015$/AF) (2030)
full service Tier 1 rate	$ 582.00
DWR variable OMPR Compo	$ 23.30
Actual PG&E pumping cost	$ 71.06
Total	$ 676.36

	Average available drought supply		Met Water Shortage Allocation penalty ($/ AF)	NPV Total benefit (2015 $)
2030	4,750	water use 100-115% of allocation	$ 1,480	**$18,570,140**
2070	4,750	water use over 115% of allocation	$ 2,960	

Additional Conveyance cost	$ 17.10

median offer price in extended drought	2045_inflated at Delta Export rate
$ 925	$ 2,713

MWD untreated Tier 1 escalation factor net of inflation	3.30%

Pr(critical year in 3rd or greater year of consecutive drought)	7%

unit values based on Met tier 1 rates, inflated at Met projected escalation (2015 $)	Annual expected emergency GW supply (AF)_ALL	Median Offer price, escalated at Delta Export unit value rate (2015 $)_AGRICULTURE	Conveyance cost	Met Tier 1 plus shortage allocation penalty (2015 $)_URBAN	Total drought benefit--avoided cost (2015 $)
$ 676					
$ 696					
$ 715					
$ 736					
$ 757					
$ 779					
$ 802					
$ 825					
$ 849					
$ 874	4,750	$ 925	$ 17	$ 2,353.99	$ 450,117
$ 900	4,750	$ 925	$ 17	$ 2,379.73	$ 452,353
$ 926	4,750	$ 925	$ 17	$ 2,406.32	$ 454,664
$ 954	4,750	$ 925	$ 17	$ 2,433.79	$ 457,050
$ 982	4,750	$ 925	$ 17	$ 2,462.16	$ 459,516
$ 1,011	4,750	$ 1,044	$ 17	$ 2,491.47	$ 493,141
$ 1,042	4,750	$ 1,163	$ 17	$ 2,521.75	$ 526,849
$ 1,073	4,750	$ 1,283	$ 17	$ 2,553.03	$ 560,645
$ 1,105	4,750	$ 1,402	$ 17	$ 2,585.35	$ 594,530
$ 1,139	4,750	$ 1,521	$ 17	$ 2,618.73	$ 628,508
$ 1,173	4,750	$ 1,640	$ 17	$ 2,653.21	$ 662,582
$ 1,209	4,750	$ 1,760	$ 17	$ 2,688.83	$ 696,755
$ 1,246	4,750	$ 1,879	$ 17	$ 2,725.62	$ 731,030
$ 1,284	4,750	$ 1,998	$ 17	$ 2,763.63	$ 765,410
$ 1,323	4,750	$ 2,117	$ 17	$ 2,802.90	$ 799,900
$ 1,363	4,750	$ 2,236	$ 17	$ 2,843.46	$ 834,502
$ 1,405	4,750	$ 2,356	$ 17	$ 2,885.36	$ 869,220
$ 1,449	4,750	$ 2,475	$ 17	$ 2,928.64	$ 904,059
$ 1,493	4,750	$ 2,594	$ 17	$ 2,973.36	$ 939,022
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,540	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113
$ 1,539.55	4,750	$ 2,713	$ 17	$ 3,019.55	$ 974,113

2030					2070			
With Project			Without Project	Difference	With Project		Without Project	Difference
$ 459,516			0	$ 459,516	$ 974,113		0	$ 974,113

Emergency Response (Public Benefit)--Delta Failure--alternative cost approach

Water supplies available at 30 years into project life (AF)		NPV Total benefit (2015 $)
23,500	(most expensive critical year unit values	**$28,452,182**

% of GW payback required for SGMA
50%

	Water supplies available at assumed Delta failure (AF)_ALL	Median offer price plus share of replacement water at Delta Export value_AGRICULTURE 25%	Met Tier 1 with Penalty _URBAN 25%	Total Delta failure benefit (2015 $)
				0
				0
				0
				0
1200		$ 1,058.85	$ 3,942	0
1200		$ 1,190	$ 3,971	0
		$ 1,322	$ 4,002	0
		$ 1,453	$ 4,033	0
		$ 1,585	$ 4,065	0
		$ 1,716	$ 4,099	0
		$ 1,848	$ 4,133	0
		$ 1,979	$ 4,169	0
		$ 2,111	$ 4,206	0
		$ 2,242	$ 4,244	0
		$ 2,374	$ 4,283	0
		$ 2,505	$ 4,323	0
		$ 2,637	$ 4,365	0
		$ 2,768	$ 4,409	0
		$ 2,900	$ 4,453	0
		$ 3,031.18	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
	23,500	$ 3,031	$ 4,500	$ 79,859,405
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
2771.754298		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0
		$ 3,031	$ 4,500	0

2030			2070		
With Project	Without Project	Difference	With Project	Without Project	Difference
$ -	0	$ -	$ -	0	$ -

Environmental Benefit--Wetland Habitat--alternative cost approach #1--permanent easement, inundation takes place in same timeline as project inundation, wet years only

Acres of land inundated as seasonal wetland (acres)	Value of permanent easement (2017 $/Acre)	Value of permanent easement (2015 $/Acre)
1,280	$ 10,750	$ 10,199.47

	2017 $	2015 $
Wetland constru	$ 50,848,680	$ 48,244,606
Restoration Cost	$ 770,400	$ 726,309

NPV Total benefit (2015 $)
$ **98,248,070**

	2030	2070
Total Project recharge	4,400	4,500
total months of inundation	21	20
total volume of recharge		222,525.00

Additional Conveyance cost	$ 17.10

Acres of land inundated as seasonal wetland (acres)	permanent easement value of land ($/Acre)	volume of water created by project, used to flood project land (AF)	Cost of delta export water in wet years (2015 $)	Conveyance	Construction costs at beginning and end of project	Value of seasonal wetland in inundation years
1,280	$ 10,199	4,390	$ 149.27	$ 17.10	$ 48,244,606	$ 62,030,276
1,280	0	4,393	$ 163.20	$ 17.10	$ -	$ 791,968
1,280		4,395	$ 177.13	$ 17.10	$ -	$ 853,656
1,280		4,398	$ 191.07	$ 17.10	$ -	$ 915,413
1,280		4,400	$ 205.00	$ 17.10	$ -	$ 977,240
1,280		4,403	$ 218.93	$ 17.10	$ -	$ 1,039,137
1,280		4,405	$ 232.87	$ 17.10	$ -	$ 1,101,104
1,280		4,408	$ 246.80	$ 17.10	$ -	$ 1,163,140
1,280		4,410	$ 260.73	$ 17.10	$ -	$ 1,225,245
1,280		4,413	$ 274.67	$ 17.10	$ -	$ 1,287,421
1,280		4,415	$ 288.60	$ 17.10	$ -	$ 1,349,666
1,280		4,418	$ 302.53	$ 17.10	$ -	$ 1,411,981
1,280		4,420	$ 316.47	$ 17.10	$ -	$ 1,474,365
1,280		4,423	$ 330.40	$ 17.10	$ -	$ 1,536,819
1,280		4,425	$ 344.33	$ 17.10	$ -	$ 1,599,343
1,280		4,428	$ 358.27	$ 17.10	$ -	$ 1,661,936
1,280		4,430	$ 372.20	$ 17.10	$ -	$ 1,724,599
1,280		4,433	$ 386.13	$ 17.10	$ -	$ 1,787,332
1,280		4,435	$ 400.07	$ 17.10	$ -	$ 1,850,135
1,280		4,438	$ 414	$ 17.10	$ -	$ 1,913,007
1,280		4,440	$ 414	$ 17.10	$ -	$ 1,914,084
1,280		4,443	$ 414	$ 17.10	$ -	$ 1,915,162
1,280		4,445	$ 414	$ 17.10	$ -	$ 1,916,240
1,280		4,448	$ 414	$ 17.10	$ -	$ 1,917,318
1,280		4,450	$ 414	$ 17.10	$ -	$ 1,918,395
1,280		4,453	$ 414	$ 17.10	$ -	$ 1,919,473
1,280		4,455	$ 414	$ 17.10	$ -	$ 1,920,551
1,280		4,458	$ 414	$ 17.10	$ -	$ 1,921,629
1,280		4,460	$ 414	$ 17.10	$ -	$ 1,922,706
1,280		4,463	$ 414	$ 17.10	$ -	$ 1,923,784
1,280		4,465	$ 414	$ 17.10	$ -	$ 1,924,862
1,280		4,468	$ 414	$ 17.10	$ -	$ 1,925,940
1,280		4,470	$ 414	$ 17.10	$ -	$ 1,927,017
1,280		4,473	$ 414	$ 17.10	$ -	$ 1,928,095
1,280		4,475	$ 414	$ 17.10	$ -	$ 1,929,173
1,280		4,478	$ 414	$ 17.10	$ -	$ 1,930,251
1,280		4,480	$ 414	$ 17.10	$ -	$ 1,931,328
1,280		4,483	$ 414	$ 17.10	$ -	$ 1,932,406
1,280		4,485	$ 414	$ 17.10	$ -	$ 1,933,484
1,280		4,488	$ 414	$ 17.10	$ -	$ 1,934,562
1,280		4,490	$ 414	$ 17.10	$ -	$ 1,935,639
1,280		4,493	$ 414	$ 17.10	$ -	$ 1,936,717
1,280		4,495	$ 414	$ 17.10	$ -	$ 1,937,795
1,280		4,498	$ 414	$ 17.10	$ -	$ 1,938,873
1,280		4,500	$ 414	$ 17.10	$ -	$ 1,939,950
1,280		4,500	$ 414	$ 17.10	$ -	$ 1,939,950
1,280		4,500	$ 414	$ 17.10	$ -	$ 1,939,950
1,280		4,500	$ 414	$ 17.10	$ -	$ 1,939,950
1,280		4,500	$ 414	$ 17.10	$ -	$ 1,939,950
1,280		4,500	$ 414	$ 17.10	$ 770,400.00	$ 2,710,350

2030			2070			
With Project	Without Project	Difference	With Project	Without Project		Difference
$ 977,240	0	$ 977,240	$ 1,939,950	0		$ 1,939,950

Environmental Benefit--Wetland Habitat--alternative cost approach #2 (Commission recommended)--temporary land cost, inundation can take place in another 21 months, any 7 years, 3 winter months per year

Acres of land inundated as seasonal wetland (acres)	Agricultural lease in Kern County (2017 $/Acre)	Agricultural lease in Kern County (2015 $/Acre)
1,280	$ 300	$ 284.64

	2017 $	2015 $
Wetland constru	$ 50,848,680	$ 48,244,606
Restoration Cost	$ 770,400	$ 726,309

NPV Total benefit (2015 $)
$111,761,600

	2030	2070
Total expected annual Project recharge	4,400	4,500
Total project recharge over 50	220,000	225,000
total months of inundation	21	20

Additional Conveyance cost	$ 17.10
total volume of recharge	220,000.00

Acres of land inundated as seasonal wetland (acres)	temporary easement value of land ($/Acre)	volume of water created by project, used to flood project land (AF)	Cost of delta export water in wet years (2015 $)	Conveyance	Construction costs at beginning and end of project	Value of seasonal wetland in inundation years
1,280	$ 285	31,428.57	$ 294.48	$ 17.10	$ 48,244,606	$ 58,401,397
1,280	$ 285	31,428.57	$ 287.79	$ 17.10	$ -	$ 9,946,449
1,280	$ 285	31,428.57	$ 281.09	$ 17.10	$ -	$ 9,736,108
1,280	$ 285	31,428.57	$ 274.40	$ 17.10	$ -	$ 9,525,766
1,280	$ 285	31,428.57	$ 267.71	$ 17.10	$ -	$ 9,315,425
1,280	$ 285	31,428.57	$ 292.24	$ 17.10	$ -	$ 10,086,447
1,280	$ 285	31,428.57	$ 316.77	$ 17.10	$ 770,400.00	$ 11,627,869
1,280			$ 341.30	$ 17.10	$ -	$ -
1,280			$ 365.84	$ 17.10	$ -	$ -
1,280			$ 390.37	$ 17.10	$ -	$ -
1,280			$ 414.90	$ 17.10	$ -	$ -
1,280			$ 439.43	$ 17.10	$ -	$ -
1,280			$ 463.97	$ 17.10	$ -	$ -
1,280			$ 488.50	$ 17.10	$ -	$ -
1,280			$ 513.03	$ 17.10	$ -	$ -
1,280			$ 537.57	$ 17.10	$ -	$ -
1,280			$ 562.10	$ 17.10	$ -	$ -
1,280			$ 586.63	$ 17.10	$ -	$ -
1,280			$ 611.16	$ 17.10	$ -	$ -
1,280			$ 636	$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -
1,280				$ 17.10	$ -	$ -

2030			2070			
With Project	Without Project	Difference	With Project	Without Project		Difference
$ 9,315,425	0	$ 9,315,425	$ -	0		$ -

Physical and Economic Benefits Summary

November 2016

Part 1. Physical and Economic Benefits. Repeat this block for each category of public or non-public benefit quantified

Enter Benefit Category here [1]	Non-Public Benefit						
Repeat Rows 1 through 4 for every quantified physical benefit in this benefit category							
1. Physical Benefit Name: Water Supply Benefits				Notes: 2/3 of non-ecosystem water allocated to water supply. Weighted by hydrology and costs of water for ag and urban. See Benefit Calculation Tab Attachment 3 and Attachment 5 for detail.			
2. Physical Benefit Measurement Units: Acre-Feet				Notes:			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		3015	0	3015	2747	0	2747
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 1,178,022	$ -	$ 1,178,022	$ 2,485,886	$ -	$ 2,485,886
1. Physical Benefit Name: Groundwater Level Improvement				Notes:			
2. Physical Benefit Measurement Units: Acre-Feet				Notes:			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		385.7	0	385.7	351.4	0	351.4
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 82,167	$ -	$ 82,167	$ 190,943	$ -	$ 190,943
5. Total Annual Monetized Benefit for the Category (sum of all row 4s.)		$ 1,260,189	$ -	$ 1,260,189	$ 2,676,829	$ -	$ 2,676,829

Enter Benefit Category here [1]	Ecosystem Benefit						
Repeat Rows 1 through 4 for every quantified physical benefit in this benefit category							
1. Physical Benefit Name:Ecosystem				Notes:			
2. Physical Benefit Measurement Units: Number of Salmon Surviving to Adulthood				Notes: Spring Run Chinook and Winter Run Chinook over 50 year period. See Physical Public Benefit Tab Attachment 2 and Benefit Calculation Tab Attachment 3 and Attachment 5 for details.			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		545	0	545	460	0	460
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 1,284,259	$ -	$ 1,284,259	$ 1,234,896	$ -	$ 1,234,896
1. Physical Benefit Name: Incidental wetland habitat				Notes:			
2. Physical Benefit Measurement Units: Acres				Notes: Probability of incidental wetland 20% over 50 year period			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		1280	0	1280	1280	0	1280
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 977,240	$ -	$ 977,240	$ 1,939,950	$ -	$ 1,939,950
5. Total Annual Monetized Benefit for the Category (sum of all row 4s.)		$ 2,261,499	$ -	$ 2,261,499	$ 3,174,847	$ -	$ 3,174,847

Enter Benefit Category here [1]	Emergency Response						
Repeat Rows 1 through 4 for every quantified physical benefit in this benefit category							
1. Physical Benefit Name: Extended Drought				Notes:			
2. Physical Benefit Measurement Units: Acre-Feet				Notes: 1/3 of non-ecosystem water allocated to emergency drought water supply. Weighted by hydrology and costs of water for ag and urban, and incorporates 7% probability of extended drought. See Benefit Calculation Tab Attachment 3 and Attachment 5 for detail.			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		1485	0	1485	1353	0	1353
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 459,516	$ -	$ 459,516	$ 974,113	$ -	$ 974,113
1. Physical Benefit Name: Delta Failure				Notes: WSIP Technical Guidance stated that Delta Failure should be assumed to occur once, 30 years into project period - 2056 for this project. The equivalent alternative cost-based benefit in 2070 that would yield the same NPV as an event in 2056 is given below.			
2. Physical Benefit Measurement Units: Acre-Feet				Notes:			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		20000	0	20000	20000	0	20000
4. Annual Economic Benefit, 2015 $ Million/Yr					#REF!	$ -	#REF!
5. Total Annual Monetized Benefit for the Category (sum of all row 4s.)		$ 459,516	$ -	$ 459,516	#REF!	$ -	#REF!

[1] Enter one of these benefits: Ecosystem, Water Quality, Flood Control, Emergency Response, Recreation, or Non-public benefit

[2] Net of any non-mitigated physical effects

Part 2. Total Economic Net Benefits and Allocated Cost by Benefit Category in 2015 $ Million

Sum of annual economic net benefits by type	Enter Page Number from Application	Ecosystem	Water Quality	Flood Control	Emergency Response	Recreation	Total Public Benefits	Non-Public Benefits	Total public and non-public benefits[1]
Sum of 2030 benefits from Part 1, Row 5		$ 2,261,499			$ 459,516		$ 2,721,015	$ 1,260,189	$ 3,981,204
Sum of 2070 benefits from Part 1, Row 5		$ 3,174,847			#REF!		#REF!	$ 2,676,829	#REF!
Present Value of Benefits over Planning Horizon using 3.5% Discount Rate		$129,076,406			$ 47,022,322		$ 176,098,728	$ 53,926,792	$ 230,025,520
Present Value of Total Project Costs Allocated to each Benefit Category									
Capital Costs Allocated to Each Benefit Category									
Total Requested Program Cost Share									

[1] Present value of total public and non-public benefits, total project costs, and total Program funding request must match numbers in Part 3

Part 3. Present Value of Project Costs, Cost-Effectiveness Measure, and Public Benefit Ratio, Million 2015 $ Present Value

	Enter Page Number of Application	2015 $ Million Present Value
Project Costs		
Capital costs as defined in Program regulations		
Interest during construction		
Replacement costs		
Future environmental mitigation or compliance obligation costs		
Operations, maintenance and repair (OM&R) costs		
Other costs (describe)		
Present Value of Total Project Costs[1]		
Present Value of Cost of Least-Cost Alternative that Provides the Same Total Physical Benefits		$ 176,098,728
Present Value of All Public and Non-public Benefits[1]		$ 230,025,520
Ratio of Present Value of Total Monetized Net Benefits to the Total Project Costs		
Present Value of Public Benefits[1]		$ 176,098,728
Total Requested Program Cost Share[1]		
Public Benefit Ratio: Ratio of Present Value of Monetized Net Public Benefits to the Total Requested Program Cost Share		

[1] Must match numbers in Part 2

WSIP Grant BCA_Technical Reference
Ch 5 input variables

Planning horizon	project life, or 100 years, whichever is less	constant 2015 dollars
Discount rate	3.50%	

Unit Values of Water for WSIP

2030 conditions (2015 dollars)

Water Year Type (Sacramento Valley 40-30-30 or San Joaquin Valley 60-20-20 Index)	Sacramento Valley (in $/AF of consumptive use)	Delta Export (in $/AF of applied water)	Eastside San Joaquin Basin (in $/AF of consumptive use)	Friant Service Area (in $/AF of consumptive use)
Wet	$ 145	$ 205	$ 106	$ 200
Above Normal	$ 191	$ 256	$ 133	$ 251
Below Normal	$ 255	$ 267	$ 189	$ 261
Dry	$ 275	$ 285	$ 201	$ 278
Critical	$ 345	$ 360	$ 375	$ 324

2045 and later conditions with SGMA (2015 dollars)

Water Year Type (Sacramento Valley 40-30-30 or San Joaquin Valley 60-20-20 Index)	Sacramento Valley (in $/AF of consumptive use)	Delta Export (in $/AF of applied water)	Eastside San Joaquin Basin (in $/AF of consumptive use)	Friant Service Area (in $/AF of consumptive use)
Wet	$ 150	$ 414	$ 309	$ 256
Above Normal	$ 198	$ 519	$ 388	$ 321
Below Normal	$ 264	$ 633	$ 437	$ 461
Dry	$ 283	$ 674	$ 466	$ 512
Critical	$ 354	$ 1,056	$ 728	$ 1,105

Applicants may also use their own unit values or other benefit methods if careful explanation and justification are provided. If using the unit values in Table 5-5, values between 2030 and 2045 shall be developed by interpolation. The unit values shall not be increased past 2045 unless applicants provide justification based on independently published information.

fall-run Chinook salmon in CA (for non-listed salmon species)	$ 2,500	economic value per adult fish entering fresh water	Layton, et al., 1999
winter-run Chinook salmon, spring-run Chinook salmon, Central Valley steelhead trout	$ 100,000		Based on 2 studies

Incremental water supply changes from the Kern Fan Project

2030 Water supply impacts						Adjusted water year weights based on water supply			Adjusted water year weights based on eco water impacts	
Year Type	Recharge (TAF)	# of pulses (years)	Eco. Water Supply (TAF)	IRWD Water Supply (TAF)	RRBWSD Water Supply (TAF)	water year type frequency based on SJRiver Index	Expected value of additional water supplies	adjusted water year weights based on project supplies	Expected value of additional eco water supply	adjusted water year weights based on project supplies
Wet	7	0	0	0	0	29%	0.000	0%	0	0%
Above Normal	9	0	0	1	0	20%	0.195	6%	0	0%
Below Normal	5	0	0	1	0	16%	0.159	6%	0	0%
Dry	0	5	5	2	4	16%	0.951	44%	4.756	63%
Critical	0	2	3	4	4	20%	1.561	44%	4.683	38%
All years	4.4	7	1.5	1.3	1.4		2.866		9.439	

2070 Water supply impacts										
Year Type	Recharge (TAF)	# of pulses (years)	Eco. Water Supply (TAF)	IRWD Water Supply (TAF)	RRBWSD Water Supply (TAF)					
Wet	9	0	0	0	0	29%	0.000	0%	0.000	0%
Above Normal	11	0	0	1	0	20%	0.195	7%	0.000	0%
Below Normal	0	0	0	1	1	16%	0.317	11%	0.000	0%
Dry	0	4	5	4	6	16%	1.585	55%	7.927	93%
Critical	0	1	1	2	1	20%	0.585	20%	0.585	7%
All years	4.5	5	1.3	1.5	1.5		2.683		8.512	

Source: MBK Engineering

Groundwater Recharge Benefits (non-public) -- Alternative cost approach

Average Annual Supplies (From MBK Model)

Future Condition	Environmental (AF)	Urban (AF)	Agriculture (AF)	Annual Expected Recharge (AF)
2030	1,300	1,600	1,500	4,400
2070	1,100	1,700	1,700	4,500
Groundwater basin leave-behind percentages:	*6.5%*	*9.0%*	*4.0%*	

Weighted average leave-behind percentage
6.56%
6.50%

Average Annual Expected Groundwater Supplies (Leave-behind Percentages Supplied)

Future Condition	Environmental (AF)	Urban (AF)	Agriculture (AF)	Annual Expected Recharge (AF)
2030	85	144	60	289
2070	72	153	68	293

Kern Fan Recharge Events
Summary

	Year Type Occurance (Years)	Number of Recharge Events for Year Type (Years)	Avg Recharge Time during Years that Recharge Events Occur (Months)
Wet Year	26	8	1.375
Above Normal	12	4	1.75
Below Normal	14	3	1
Dry	18	0	#DIV/0!
Critical	12	0	#DIV/0!

Assumptions	
Recharge Ponds (acres):	1200
Rate- Month 1 (ft/day)	0.70
Rate- Month 2 (ft/day)	0.65
Rate- Month 3 (ft/day)	0.60

		WSIP 2030		WSIP 2070	
Sacramento Valley Year Type	Water Year	Water Recharged (TAF)	Approximate Recharge Time (Months)	Water Recharged (TAF)	Approximate Recharge Time (Months)
Cumulative Total		**361**	**21**	**367**	**20**
Above Normal	1922	0	0	0	0
Above Normal	1928	0	0	0	0
Above Normal	1940	0	0	0	0
Above Normal	1951	0	1	45	2
Above Normal	1954	0	0	0	0
Above Normal	1957	0	0	0	0
Above Normal	1973	13	1	0	0
Above Normal	1978	48	2	48	2
Above Normal	1980	51	3	44	3
Above Normal	1993	0	0	0	0
Above Normal	2000	0	0	0	0
Above Normal	2003	0	0	0	0
Below Normal	1923	0	0	0	0
Below Normal	1935	0	0	0	0
Below Normal	1936	24	1	0	0
Below Normal	1937	24	1	0	0
Below Normal	1945	24	1	0	0
Below Normal	1946	0	0	0	0
Below Normal	1948	0	0	0	0
Below Normal	1950	0	0	0	0
Below Normal	1959	0	0	0	0
Below Normal	1962	0	0	0	0
Below Normal	1966	0	0	0	0
Below Normal	1968	0	0	0	0
Below Normal	1972	0	0	0	0
Below Normal	1979	0	0	0	0
Critical	1924	0	0	0	0
Critical	1929	0	0	0	0
Critical	1931	0	0	0	0
Critical	1933	0	0	0	0
Critical	1934	0	0	0	0
Critical	1976	0	0	0	0
Critical	1977	0	0	0	0
Critical	1988	0	0	0	0
Critical	1990	0	0	0	0
Critical	1991	0	0	0	0
Critical	1992	0	0	0	0
Critical	1994	0	0	0	0
Dry	1925	0	0	0	0
Dry	1926	0	0	0	0
Dry	1930	0	0	0	0
Dry	1932	0	0	0	0
Dry	1939	0	0	0	0
Dry	1944	0	0	0	0
Dry	1947	0	0	0	0
Dry	1949	0	0	0	0
Dry	1955	0	0	0	0
Dry	1960	0	0	0	0
Dry	1961	0	0	0	0
Dry	1964	0	0	0	0
Dry	1981	0	0	0	0
Dry	1985	0	0	0	0
Dry	1987	0	0	0	0
Dry	1989	0	0	0	0
Dry	2001	0	0	0	0
Dry	2002	0	0	0	0
Wet	1927	0	0	0	0
Wet	1938	45	2	69	3
Wet	1941	0	0	0	0
Wet	1942	0	0	0	0
Wet	1943	24	1	0	0
Wet	1952	-24	0	0	0
Wet	1953	0	0	0	0
Wet	1956	46	2	46	2
Wet	1958	23	1	23	1
Wet	1963	0	0	0	0
Wet	1965	0	0	0	0
Wet	1967	0	0	0	0
Wet	1969	45	2	59	3
Wet	1970	0	0	0	0
Wet	1971	0	0	0	0
Wet	1974	0	0	0	0
Wet	1975	0	0	0	0
Wet	1982	3	1	16	1
Wet	1983	0	1	2	2
Wet	1984	0	0	0	0
Wet	1986	14	1	14	1
Wet	1995	0	0	0	0
Wet	1996	0	0	0	0
Wet	1997	0	0	0	0
Wet	1998	0	0	0	0
Wet	1999	0	0	0	0

Additional Adult Chinook from 50 years of Project Operations

Smolt to Adult Return Rate

	Spring-Run	Winter-run	Steelhead
2030	1011	109	95
2070	715	73	62

results as of 2/21/18

Source: Cramer Fish Sciences

SWP historic conveyance costs to DRWD

		Conveyance cost (nominal)	Conveyance cost (2015$)
Average		$ 15.59	$ **17.10**

Mo.	Yr.	Nominal $	Real 2015 $
Jan	2001	$ 7.14	$ 9.82
Aug	2001	$ 16.23	$ 22.30
Jan	2002	$ 10.98	$ 14.72
Sep	2002	$ 9.15	$ 12.27
Nov	2002		
Jan	2003	$ 8.90	$ 11.67
May	2003	$ 11.57	$ 15.17
Nov	2003		
Jan	2004	$ 11.94	$ 15.26
Sep	2004	$ 6.74	$ 8.61
Jan	2005	$ 15.43	$ 19.01
Aug	2005	$ 9.07	$ 11.18
Jan	2006	$ 17.21	$ 20.41
Apr	2006	$ 15.04	$ 17.84
Aug	2006	$ 6.96	$ 8.25
Jan	2007	$ 15.45	$ 17.74
Jul	2007	$ 16.27	$ 18.68
Nov	2007	$ 1.05	$ 1.20
Jan	2008	$ 17.24	$ 19.14
Oct	2008	$ 15.22	$ 16.91
Nov	2008	$ 1.53	$ 1.70
Jan	2009	$ 18.11	$ 20.17
May	2009	$ 17.02	$ 18.96
Jan	2010	$ 17.14	$ 18.85
Jul	2010	$ 19.00	$ 20.90
Oct	2010	$ 1.54	$ 1.70
Jan	2011	$ 17.12	$ 18.35
Mar	2011	$ 17.28	$ 18.52
Dec	2011	$ 1.54	$ 1.65
Jan	2012	$ 19.68	$ 20.63
Dec	2012	$ 0.69	$ 0.72
Jan	2013	$ 22.47	$ 23.22
Jun	2013	$ 21.78	$ 22.51
Jan	2014	$ 30.62	$ 31.06
Jul	2014	$ 29.97	$ 30.41
Jan	2015	$ 31.36	$ 31.36
Jun	2015	$ 29.09	$ 29.09
Jan	2016	$ 33.44	$ 32.70
May	2016	$ 23.22	$ 22.70
Nov	2016		
Jan	2017	$ 22.88	$ 21.71
May	2017	$ 20.90	$ 19.83
Nov	2017		

Dudley Ridge Water District

Historical Summary of Monthly Variable OMP&R Charges

Date	Variable O&M Power	Variable Transmission	Combined
Jan-01			7.1440
Aug-01			16.2300
Jan-02			10.9770
Sep-02			9.1470
Nov-02			0.0000
Jan-03			8.8990
May-03			11.5740
Nov-03			0.0000
Jan-04			11.9440
Sep-04			6.7380
Jan-05	14.3808	1.0483	15.4291
Aug-05	8.0215	1.0483	9.0698
Jan-06	16.1636	1.0479	17.2115
Apr-06	13.9914	1.0479	15.0393
Aug-06	5.9124	1.0479	6.9603
Jan-07	14.4038	1.0471	15.4509
Jul-07	15.2260	1.0471	16.2731
Nov-07	0.0000	1.0471	1.0471
Jan-08	16.1888	1.0499	17.2387
Oct-08	13.6919	1.5324	15.2243
Nov-08	0.0000	1.5324	1.5324
Jan-09	16.5418	1.5686	18.1104
May-09	15.4501	1.5686	17.0187
Jan-10	15.5920	1.5436	17.1356
Jul-10	17.4581	1.5436	19.0017
Oct-10	0.0000	1.5436	1.5436
Jan-11	15.5833	1.5387	17.1220
Mar-11	15.7393	1.5387	17.2780
Dec-11	0.0000	1.5387	1.5387
Jan-12	18.9980	0.6860	19.6840
Dec-12	0.0000	0.6860	0.6860
Jan-13	21.7846	0.6860	22.4706
Jun-13	21.7846	0.0000	21.7846
Jan-14	29.9709	0.6463	30.6172
Jul-14	29.9709	0.0000	29.9709
Jan-15	30.7143	0.6461	31.3604
Jun-15	29.0862	0.0000	29.0862
Jan-16	33.4407	0.0000	33.4407
May-16	23.2156	0.0000	23.2156
Nov-16	0.0000	0.0000	0.0000
Jan-17	22.8849	0.0000	22.8849
May-17	20.8960	0.0000	20.8960
Nov-17	0.0000	0.0000	0.0000

Wetland Construction Estimate

Item No.	Item Description	Unit	Quantity	Unit Cost	Extended Cost	Phase
1	Mobilization, Demobilization, & Cleanup	LS	1	$ 910,000	$ 910,000	1
2	Canal Connection to California Aqueduct	LS	1	$ 1,185,000	$ 1,185,000	1
3	Conveyance Canal	LS	1	$ 9,112,500	$ 9,112,500	1
4	Canal Siphons	LS	1	$ 11,040,000	$ 11,040,000	1
5	Lift Stations	LS	1	$ 8,005,000	$ 8,005,000	1
6	Turnout, Earthwork, and Interbasin Structures	LS	1	$ 6,490,400	$ 6,490,400	1
				Contract Cost	**$ 36,742,900**	
				20% Construction Contingency	$ 7,348,580	
				Wetland Basin Permanent Easement - 1280 acres		$ 16,960,000
				Conveyance Canal - Temporary Easement	$ 438,750	
				Conveyance Canal - Permanent Easement	$ 881,500	
				Aqueduct R/W & Compliance	$ 25,000	
				Habitat Credit Purchase	$ 1,600,000	
				Field Cost	**$ 47,036,730**	
				Non-Contract Costs	$ 3,811,950	
				Total Construction Cost	**$ 50,848,680**	

			acres	cost/acre	total cost
Permanent Easement	*AC*	*165*		**$ 10,750**	*$ 1,773,750*
Temporary Easement	*AC*	*235*		**$ 3,750**	*$ 881,250*

Wetland Removal Cost Estimate

1	Removal of Rip Rap at Interbasin Structures	24	EA	$ 3,600	$ 86,400
2	Removal of Interbasin Structures and Cutoff Walls	24	EA	$ 8,500	$ 204,000
3	Removal of Rip Rap at Discharge from Canal	1	LS	$ 10,000	$ 10,000
4	Removal of a Portion of Discharge Pipe from Canal	1	LS	$ 10,000	$ 10,000
5	Clear and Grub Site	1	LS	$ 60,000	$ 60,000
6	Removal of Embankments	1	LS	$ 350,000	$ 350,000
7	Leveling Site	1	LS	$ 50,000	$ 50,000
				Total Removal Cost	**$ 770,400**

Source: Irvine Ranch Water District - Feasibility Level Cost Estimate (Class 4)

Sacramento Valley Water Transfer Option Prices

	Option (nominal)	Extension* (nominal)	Total reservation fee (nominal)	Option (2015$)	Purchase (nominal)	critical year premium
1995	$ 3.50	$ -	$ 3.50	$ 5.67	$ 40.00	
2003	$ 10.00	$ -	$ 10.00	$ 13.11	$ 90.00	$ 25.00
2005	$ 10.00	$ 20.00	$ 30.00	$ 36.96	$ 115.00	
2008	$ 10.00	$ 40.00	$ 50.00	$ 55.52	$ 200.00	
				$ 46.24		

Note: *moves call date from Feb 15 to May 2

Source: Option prices for 2005 and 2008 transactions:
https://woods.stanford.edu/sites/default/files/files/200810-Policy-Brief-2-Option-Contracts.pdf

Source
Drought Water Bank and various Sac Valley agencies
2003 Met agreement with 11 Sac Valley agencies
2005 Met agreement with 11 Sac Valley agencies
2008 SDCWA agreement with Butte and Sutter WDs
Average of 2005, 2008 option values, including extension values

Dudley Ridge--SUMMARY OF WATER OFFERS 2014-2016

Date of Offer	Owner	Amount Available(AF)	Water Source	Cost ($/AF)	Carriage Loss	Cost with Carriage Loss	Additional Delivery Costs
3/4/2014	Semitropic Water Storage District	6,000	San Luis/KWB	$ 1,200		$ 1,200	$20/af (if from San Luis) $85/af (if from KWB)
4/2/2014	DWR		SWP	$ 300	30%	$ 430	
4/2/2014	DWR		SWP	$ 300	50%	$ 600	
4/2/2014	DWR		SWP	$ 400	30%	$ 570	
4/2/2014	DWR		SWP	$ 400	50%	$ 800	
11/24/2014	*Seller not specidifed in offer	359 - 2,500		$ 1,050		$ 1,050	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 700	15%	$ 824	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 700	30%	$ 1,000	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 800	15%	$ 941	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 800	30%	$ 1,143	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 900	15%	$ 1,059	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 900	30%	$ 1,286	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 1,000	15%	$ 1,176	
2/18/2015	Dry Year Water Purchase Program		NOD	$ 1,000	30%	$ 1,429	
3/4/2015	Dry Year Water Purchase Program	130,000	NOD	$ 700	20%	$ 875	
3/4/2015	Dry Year Water Purchase Program	130,000	NOD	$ 700	30%	$ 1,000	
3/25/2015	Dry Year Water Purchase Program	30,000	NOD	$ 665		$ 665	
10/28/2015	Westside Water District	300		$ 925		$ 925	Water Toll would be added
2/25/2016	Dry Year Water Purchase Program		NOD	$ 550	20%	$ 688	$36 (Water Toll rate)
2/25/2016	Dry Year Water Purchase Program			$ 550	30%	$ 786	$36 (Water Toll rate)
8/18/2016	Rosedale	5,000		$ 800		$ 800	
				median--all:		$ 925	
				median--South of Delta only		**$ 925**	

Bid results from a 2014 auction of 12,000 AF of water by Buena Vista Water District

	Bidder	Quantity AF	Price
1	Harris Ranch-Mettler	300	1,350
2	Starrh&Starrh	1000	1,250
3	Cal Heavy Oil	350	1,207
4	Starrh&Starrh	1000	1,200
5	Primex	1100	1,200
6	Harris Ranch-Mettler	300	1,200
7	Horizon Nut	250	1,175
8	Starrh&Starrh	1000	1,150
9a	Starrh&Starrh	600	1,100
10a	Paramount Farming	6100	1,100
		median--all	**$ 1,200**

deleted offer: Sites not yet constructed so left out of calculation

6/21/2016	Sites (offer in todays dollars)	$ 1,000	$ 1,000

San Joaquin River Index

Year	SJ River WY Index	Water Year Type	Year Type	# of Years	%
1906	11.76	W	W	24	29.3%
1907	14.07	W	AN	16	19.5%
1908	7.73	D	BN	13	15.9%
1909	12.1	W	D	13	15.9%
1910	9.38	AN	C	16	19.5%
1911	11.74	W			
1912	6.71	BN	110 year avg	8.06	
1913	6.24	C			
1914	10.92	W			
1915	10.99	W			
1916	10.83	W			
1917	8.83	W			
1918	6.19	BN			
1919	7	BN			
1920	5.15	BN			
1921	9.2	AN			
1922	8.97	W			
1923	7.06	AN			
1924	3.87	C			
1925	6.39	BN			
1926	5.75	D			
1927	9.52	AN			
1928	8.27	BN			
1929	5.22	C			
1930	5.9	C			
1931	3.66	C			
1932	5.48	AN			
1933	4.63	D			
1934	4.07	C			
1935	6.98	AN			
1936	7.75	AN			
1937	6.87	W			
1938	12.62	W			
1939	5.58	D			
1940	8.88	AN			
1941	11.47	W			
1942	11.27	W			
1943	9.77	W			
1944	6.35	BN			
1945	6.8	AN			
1946	7.7	AN			
1947	5.61	D			
1948	7.12	BN			
1949	6.09	BN			
1950	6.62	BN			
1951	9.18	AN			
1952	12.38	W			
1953	9.55	BN			
1954	8.51	BN			
1955	6.14	D			
1956	11.38	W			
1957	7.83	BN			
1958	12.16	W			
1959	6.75	D			
1960	6.2	C			
1961	5.68	C			
1962	6.65	BN			
1963	9.63	AN			
1964	6.41	D			
1965	10.15	W			
1966	7.16	BN			
1967	10.2	W			
1968	7.24	D			

orig data

1906 12.57 12.92 26.71 11.76 W 2.53 9.24 12.43 6.70 W
1907 18.96 13.45 33.70 14.07 W 3.67 7.61 11.82 6.20 W
1908 8.29 5.60 14.77 7.73 BN 0.98 2.17 3.32 2.40 D
1909 20.61 8.98 30.68 12.10 W 2.85 5.91 8.97 4.59 W
1910 13.12 6.11 20.12 9.38 W 2.87 3.62 6.64 3.65 AN
1911 12.27 13.12 26.38 11.74 W 3.63 7.52 11.48 5.97 W
1912 4.84 5.65 11.41 6.71 BN 0.54 2.57 3.21 2.55 BN
1913 5.72 6.29 12.85 6.24 D 0.44 2.34 3.00 2.00 C
1914 16.72 10.08 27.81 10.92 W 2.72 5.67 8.69 4.35 W
1915 11.41 11.42 23.86 10.99 W 1.29 4.95 6.40 4.10 W
1916 14.25 8.89 24.14 10.83 W 2.67 5.50 8.38 4.65 W
1917 7.25 9.14 17.26 8.83 AN 1.66 4.84 6.66 4.13 W
1918 5.27 4.89 10.99 6.19 D 1.07 3.40 4.59 3.08 BN
1919 8.12 6.77 15.66 7.00 BN 1.06 2.99 4.09 2.62 BN
1920 3.63 4.91 9.20 5.15 C 0.72 3.29 4.09 2.64 BN
1921 15.47 7.52 23.80 9.20 AN 1.97 3.84 5.90 3.23 AN
1922 6.63 10.57 17.98 8.97 AN 1.51 5.99 7.68 4.54 W
1923 6.21 6.27 13.21 7.06 BN 1.39 3.95 5.51 3.55 AN
1924 3.27 1.94 5.74 3.87 C 0.45 1.03 1.50 1.42 C
1925 8.76 6.51 15.99 6.39 D 1.45 3.93 5.51 2.93 BN
1926 6.37 4.79 11.76 5.75 D 0.89 2.56 3.49 2.30 D
1927 14.34 8.75 23.83 9.52 W 1.80 4.56 6.50 3.56 AN
1928 10.24 5.86 16.76 8.27 AN 1.69 2.64 4.37 2.63 BN
1929 4.00 3.84 8.40 5.22 C 0.52 2.29 2.84 2.00 C
1930 8.24 4.65 13.52 5.90 D 0.76 2.44 3.25 2.02 C
1931 3.52 2.09 6.10 3.66 C 0.46 1.18 1.66 1.20 C
1932 6.28 6.24 13.12 5.48 D 1.79 4.69 6.63 3.41 AN
1933 3.73 4.66 8.94 4.63 C 0.49 2.77 3.34 2.44 D
1934 5.68 2.45 8.63 4.07 C 0.98 1.26 2.28 1.44 C
1935 6.27 9.69 16.59 6.98 BN 1.26 5.03 6.41 3.56 AN
1936 10.32 6.41 17.35 7.75 BN 2.00 4.38 6.49 3.74 AN
1937 5.50 7.24 13.33 6.87 BN 1.78 4.66 6.53 3.90 W
1938 17.96 12.93 31.83 12.62 W 3.58 7.33 11.24 5.89 W
1939 4.56 3.04 8.18 5.58 D 1.00 1.83 2.90 2.20 D
1940 14.78 6.93 22.43 8.88 AN 2.49 4.04 6.59 3.36 AN
1941 16.32 9.77 27.08 11.47 W 2.22 5.51 7.93 4.43 W
1942 14.33 9.93 25.24 11.27 W 1.93 5.28 7.38 4.44 W
1943 13.37 6.90 21.13 9.77 W 2.86 4.28 7.28 4.03 W
1944 4.81 4.93 10.43 6.35 D 0.87 2.97 3.92 2.76 BN
1945 8.42 5.92 15.06 6.80 BN 2.07 4.37 6.60 3.59 AN
1946 10.89 5.97 17.62 7.70 BN 1.99 3.65 5.73 3.30 AN
1947 5.90 3.83 10.39 5.61 D 1.26 2.12 3.42 2.18 D
1948 5.39 9.55 15.75 7.12 BN 0.56 3.58 4.21 2.70 BN
1949 5.73 5.59 11.97 6.09 D 0.62 3.12 3.79 2.53 BN
1950 7.01 6.72 14.44 6.62 BN 1.02 3.57 4.65 2.85 BN
1951 16.77 5.42 22.95 9.18 AN 4.35 2.83 7.25 3.14 AN
1952 13.86 13.68 28.60 12.38 W 2.18 6.84 9.30 5.17 W
1953 10.84 8.26 20.09 9.55 W 1.07 3.18 4.35 3.03 BN
1954 9.74 6.81 17.43 8.51 AN 1.10 3.16 4.30 2.72 BN
1955 5.19 5.07 10.98 6.14 D 0.78 2.67 3.50 2.30 D
1956 20.32 8.60 29.89 11.38 W 4.14 5.29 9.67 4.46 W
1957 7.72 6.29 14.89 7.83 AN 1.02 3.19 4.29 3.01 BN
1958 16.37 12.24 29.71 12.16 W 1.67 6.40 8.36 4.77 W
1959 7.40 3.84 12.05 6.75 BN 0.98 1.85 2.98 2.21 D
1960 7.72 4.65 13.06 6.20 D 0.85 2.07 2.96 1.85 C
1961 6.87 4.39 11.97 5.68 D 0.54 1.50 2.10 1.38 C
1962 8.17 6.23 15.11 6.65 BN 1.26 4.24 5.61 3.07 BN
1963 12.01 10.09 22.99 9.63 W 1.68 4.37 6.24 3.57 AN
1964 5.90 4.37 10.92 6.41 D 0.93 2.14 3.14 2.19 D
1965 16.59 8.13 25.64 10.15 W 3.20 4.55 8.13 3.81 W
1966 7.42 4.84 12.95 7.16 BN 1.49 2.42 3.98 2.51 BN
1967 12.14 11.01 24.06 10.20 W 2.46 7.09 9.98 5.25 W
1968 8.66 4.12 13.64 7.24 BN 1.02 1.85 2.94 2.21 D

1969	11.05	W
1970	10.4	AN
1971	10.37	BN
1972	7.29	D
1973	8.58	AN
1974	12.99	W
1975	9.35	W
1976	5.29	C
1977	3.11	C
1978	8.65	W
1979	6.67	AN
1980	9.04	W
1981	6.21	D
1982	12.76	W
1983	15.29	W
1984	10	AN
1985	6.47	D
1986	9.96	W
1987	5.86	C
1988	4.65	C
1989	6.13	C
1990	4.81	C
1991	4.21	C
1992	4.06	C
1993	8.54	W
1994	5.02	C
1995	12.89	W
1996	10.26	W
1997	10.82	W
1998	13.31	W
1999	9.8	AN
2000	8.94	AN
2001	5.76	D
2002	6.35	D
2003	8.21	BN
2004	7.51	D
2005	8.49	W
2006	13.2	W
2007	6.19	C
2008	5.16	C
2009	5.78	BN
2010	7.08	AN
2011	10.54	W
2012	6.89	D
2013	5.83	C
2014	4.07	C
2015	4.01	C

1969 15.33 10.68 26.98 11.05 W 3.84 8.14 12.29 6.09 W
1970 18.87 4.35 24.06 10.40 W 2.55 2.96 5.61 3.18 AN
1971 12.71 8.90 22.57 10.37 W 1.56 3.23 4.91 2.89 BN
1972 7.61 5.02 13.43 7.29 BN 1.25 2.22 3.57 2.16 D
1973 12.80 6.38 20.05 8.58 AN 1.87 4.48 6.47 3.50 AN
1974 21.69 9.78 32.50 12.99 W 2.43 4.53 7.12 3.90 W
1975 9.24 8.95 19.23 9.35 W 1.37 4.65 6.18 3.85 W
1976 4.63 2.75 8.20 5.29 C 0.78 1.07 1.97 1.57 C
1977 2.49 1.93 5.12 3.11 C 0.22 0.80 1.05 0.84 C
1978 14.90 8.12 23.92 8.65 AN 2.57 6.50 9.65 4.58 W
1979 6.06 5.64 12.41 6.67 BN 1.87 3.99 5.98 3.67 AN
1980 15.49 6.00 22.33 9.04 AN 3.74 5.41 9.47 4.73 W
1981 6.81 3.63 11.10 6.21 D 0.85 2.29 3.22 2.44 D
1982 20.56 11.82 33.41 12.76 W 3.78 7.00 11.41 5.45 W
1983 22.75 13.66 37.68 15.29 W 5.42 8.73 15.01 7.22 W
1984 15.98 5.52 22.35 10.00 W 3.51 3.48 7.13 3.69 AN
1985 6.24 4.00 11.04 6.47 D 1.11 2.41 3.60 2.40 D
1986 19.45 5.45 25.83 9.96 W 4.36 4.92 9.50 4.31 W
1987 5.85 2.80 9.27 5.86 D 0.55 1.48 2.08 1.86 C
1988 5.78 2.90 9.23 4.65 C 0.86 1.55 2.48 1.48 C
1989 9.03 5.07 14.82 6.13 D 1.07 2.42 3.56 1.96 C
1990 4.94 3.72 9.26 4.81 C 0.83 1.59 2.46 1.51 C
1991 3.90 4.01 8.44 4.21 C 0.56 2.57 3.20 1.96 C
1992 5.41 2.93 8.87 4.06 C 0.86 1.66 2.58 1.56 C
1993 12.44 8.98 22.21 8.54 AN 2.49 5.65 8.38 4.20 W
1994 4.55 2.73 7.81 5.02 C 0.66 1.80 2.54 2.05 C
1995 19.83 13.60 34.55 12.89 W 3.67 8.01 12.32 5.95 W
1996 13.05 8.37 22.29 10.26 W 2.57 4.51 7.22 4.12 W
1997 20.22 4.39 25.42 10.82 W 5.75 3.59 9.51 4.13 W
1998 17.65 12.54 31.40 13.31 W 2.82 7.11 10.43 5.65 W
1999 12.97 7.26 21.19 9.80 W 1.90 3.85 5.91 3.59 AN
2000 12.06 5.96 18.90 8.94 AN 1.98 3.78 5.90 3.38 AN
2001 5.64 3.46 9.81 5.76 D 0.92 2.23 3.18 2.20 D
2002 9.32 4.57 14.60 6.35 D 1.27 2.75 4.06 2.34 D
2003 10.71 7.74 19.31 8.21 AN 1.25 3.49 4.87 2.81 BN
2004 10.95 4.40 16.04 7.51 BN 1.51 2.25 3.81 2.21 D
2005 8.40 9.28 18.55 8.49 AN 2.73 6.28 9.21 4.75 W
2006 18.06 13.09 32.09 13.20 W 2.86 7.37 10.44 5.90 W
2007 6.59 3.04 10.28 6.19 D 0.99 1.46 2.51 1.97 C
2008 5.90 3.82 10.28 5.16 C 0.99 2.45 3.49 2.06 C
2009 7.05 5.30 13.02 5.78 D 1.51 3.35 4.94 2.72 BN
2010 7.45 7.78 16.01 7.08 BN 1.43 4.53 6.08 3.55 AN
2011 12.68 11.53 25.21 10.54 W 3.68 6.90 10.99 5.58 W
2012 5.69 5.46 11.84 6.89 BN 0.83 1.86 2.76 2.18 D
2013 8.52 3.01 12.19 5.83 D 1.33 1.67 3.05 1.71 C
2014 4.29 2.59 7.46 4.07 C 0.46 1.21 1.72 1.16 C
2015 6.95 1.77 9.27 4.01 C 0.66 0.74 1.43 0.81 C

http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST

Summary

Year Type	WSIP 2030 Recharge (TAF/year)	WSIP 2070 Recharge (TAF/year)
Wet	7	9
Above Normal	9	11
Below Normal	5	0
Dry	0	0
Critical	0	0
All Years	4.4	4.5

number of times 3rd or higher year of drought occurs	6
Probability of 3rd or higher year of drought occuring in period of record	**7%**

Sacramento Valley Year Type	Water Year	Recharge (TAF/year) WSIP 2030	Recharge (TAF/year) WSIP 2070	Year of emergency drought conditions (criical year 3rd or later year of multi-year drought)
Above Normal	1922	0	0	
Below Normal	1923	0	0	
Critical	1924	0	0	0
Dry	1925	0	0	0
Dry	1926	0	0	0
Wet	1927	0	0	
Above Normal	1928	0	0	
Critical	1929	0	0	0
Dry	1930	0	0	0
Critical	1931	0	0	1
Dry	1932	0	0	0
Critical	1933	0	0	1
Critical	1934	0	0	1
Below Normal	1935	0	0	
Below Normal	1936	24	0	
Below Normal	1937	24	0	
Wet	1938	45	69	
Dry	1939	0	0	0
Above Normal	1940	0	0	
Wet	1941	0	0	
Wet	1942	0	0	
Wet	1943	24	0	
Dry	1944	0	0	0
Below Normal	1945	24	0	
Below Normal	1946	0	0	
Dry	1947	0	0	0
Below Normal	1948	0	0	
Dry	1949	0	0	0
Below Normal	1950	0	0	
Above Normal	1951	0	45	
Wet	1952	0	0	
Wet	1953	0	0	
Above Normal	1954	0	0	
Dry	1955	0	0	0
Wet	1956	46	46	
Above Normal	1957	0	0	
Wet	1958	23	23	
Below Normal	1959	0	0	
Dry	1960	0	0	0
Dry	1961	0	0	0
Below Normal	1962	0	0	
Wet	1963	0	0	
Dry	1964	0	0	0
Wet	1965	0	0	
Below Normal	1966	0	0	
Wet	1967	0	0	
Below Normal	1968	0	0	
Wet	1969	45	59	
Wet	1970	0	0	
Wet	1971	0	0	
Below Normal	1972	0	0	
Above Normal	1973	13	0	
Wet	1974	0	0	
Wet	1975	0	0	
Critical	1976	0	0	0
Critical	1977	0	0	0
Above Normal	1978	48	48	
Below Normal	1979	0	0	
Above Normal	1980	51	44	
Dry	1981	0	0	0
Wet	1982	3	16	
Wet	1983	0	2	
Wet	1984	0	0	
Dry	1985	0	0	0
Wet	1986	14	14	
Dry	1987	0	0	0
Critical	1988	0	0	0
Dry	1989	0	0	0
Critical	1990	0	0	1
Critical	1991	0	0	1
Critical	1992	0	0	1
Above Normal	1993	0	0	
Critical	1994	0	0	0
Wet	1995	0	0	
Wet	1996	0	0	
Wet	1997	0	0	
Wet	1998	0	0	
Wet	1999	0	0	
Above Normal	2000	0	0	
Dry	2001	0	0	
Dry	2002	0	0	
Above Normal	2003	0	0	

Provided by MBK Engineers 2/20/2018

WORKSHEET 15: MWD ESCALATION

MWDSC Wholesale Water Rates

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	average change over period 2004-2015	average CPI inflation over same period	real increase in Met water rate
Tier 1 Supply	73	73	73	73	73	73	109	101	104	106	140	148	158														
escalation		0.0%	0.0%	0.0%	0.0%	0.0%	49.3%	-7.3%	3.0%	1.9%	32.1%	5.7%	6.8%												7.6%		
Full Service Untreated Vol. Cost--Tier 1	326	326	331	331	331	351	412	484	527	560	593	593	582	594	666	695	738	783	835	876	917	961	1008	1056	2004-2015 avg	inflation	net increase
escalation		0.0%	1.5%	0.0%	0.0%	6.0%	17.4%	17.5%	8.9%	6.3%	5.9%	0.0%	-1.9%	2.1%	12.1%	4.4%	6.2%	6.1%	6.6%	4.9%	4.7%	4.8%	4.9%	4.8%	5.1%	2.3%	2.8%
																									2016-2026 avg		2016-2026 avg, net of inflation
Full Service Treated Vol. Cost	408	418	443	453	478	508	579	701	744	794	847	890	923												**5.6%**		**3.3%**
escalation		2.5%	6.0%	2.3%	5.5%	6.3%	14.0%	21.1%	6.1%	6.7%	6.7%	5.1%	3.7%												7.2%		

Source: MWDSC Board Minutes

Source: CA DOF http://www.dof.ca.gov/Forecasting/Economics/Indicators/Inflation/

CONSUMER PRICE INDICES, UNITED STATES AND CALIFORNIA
CALENDAR YEAR AVERAGES, (1982-84=100)

	United States		California	
	Index	% change	Index	% change
All Urban Consumers				
1970	38.8	--	37.9	--
1971	40.5	4.4	39.3	3.7
1972	41.8	3.2	40.6	3.3
1973	44.4	6.2	43.0	5.9
1974	49.3	11.0	47.4	10.2
1975	53.8	9.1	52.3	10.3
1976	56.9	5.8	55.6	6.3
1977	60.6	6.5	59.5	7.0
1978	65.2	7.6	64.4	8.2
1979	72.6	11.3	71.3	10.7
1980	82.4	13.5	82.4	15.6
1981	90.9	10.3	91.4	10.9
1982	96.5	6.2	97.3	6.5
1983	99.6	3.2	98.9	1.6
1984	103.9	4.3	103.8	5.0
1985	107.6	3.6	108.6	4.6
1986	109.6	1.9	112.0	3.1
1987	113.6	3.6	116.5	4.0
1988	118.3	4.1	121.9	4.6
1989	124.0	4.8	128.0	5.0
1990	130.7	5.4	135.0	5.5
1991	136.2	4.2	140.6	4.1
1992	140.3	3.0	145.6	3.6
1993	144.5	3.0	149.4	2.6
1994	148.2	2.6	151.5	1.4
1995	152.4	2.8	154.0	1.7
1996	156.9	3.0	157.1	2.0
1997	160.5	2.3	160.5	2.2
1998	163.0	1.6	163.7 r/	2.0
1999	166.6	2.2	168.5	2.9
2000	172.2	3.4	174.8	3.7
2001	177.1	2.8	181.7	3.9
2002	179.9	1.6	186.1	2.4
2003	184.0	2.3	190.4	2.3
2004	188.9	2.7	195.4	2.6
2005	195.3	3.4	202.6	3.7
2006	201.6	3.2	210.5	3.9
2007	207.342	2.8	217.424	3.3
2008	215.303	3.8	224.807	3.4
2009	214.537	-0.4	224.110	-0.3
2010	218.056	1.6	226.919	1.3
2011	224.939	3.2	232.931	2.6
2012	229.594	2.1	238.155	2.2
2013	232.957	1.5	241.623	1.5
2014	236.736	1.6	246.055	1.8
2015	237.017	0.1	249.636	1.5
2016	240.007	1.3	255.329	2.3
2017 f/	245.567	2.3	263.110	3.0

Average inflation 2004-2015
2.29

CONSUMER PRICE INDICES, UNITED STATES AND CALIFORNIA
CALENDAR YEAR AVERAGES, (1982-84=100)

	United States		California		
	Index	% change	Index		% change
2018 f/	251.228	2.3	270.829		2.9
2019 f/	256.884	2.3	278.662		2.9
2020 f/	262.449	2.2	286.627		2.9
Urban Wage Earners and Clerical Workers					
1970	39.0	--	38.2		--
1971	40.7	4.4	39.6		3.7
1972	42.1	3.4	40.9		3.3
1973	44.7	6.2	43.3		5.9
1974	49.6	11.0	47.7		10.2
1975	54.1	9.1	52.6		10.3
1976	57.2	5.7	55.9		6.3
1977	60.9	6.5	59.9		7.2
1978	65.6	7.7	64.7		8.0
1979	73.1	11.4	72.1		11.4
1980	82.9	13.4	83.6		16.0
1981	91.4	10.3	92.7		10.9
1982	96.9	6.0	98.5		6.3
1983	99.8	3.0	99.0		0.5
1984	103.3	3.5	102.5		3.5
1985	106.9	3.5	106.7		4.1
1986	108.6	1.6	109.6		2.7
1987	112.5	3.6	113.9		3.9
1988	117.0	4.0	118.9		4.4
1989	122.6	4.8	124.9		5.0
1990	129.0	5.2	131.5		5.3
1991	134.3	4.1	136.7		4.0
1992	138.2	2.9	141.4		3.4
1993	142.1	2.8	144.7		2.3
1994	145.6	2.5	146.6		1.3
1995	149.8	2.8	149.1		1.7
1996	154.1	2.9	152.0		1.9
1997	157.6	2.3	155.0		1.9
1998	159.7	1.3	157.6	r/	1.7
1999	163.2	2.2	162.2		2.9
2000	168.9	3.5	168.1		3.6
2001	173.5	2.7	174.7		3.9
2002	175.9	1.4	179.0		2.5
2003	179.8	2.2	183.8		2.7
2004	184.5	2.6	188.9		2.8
2005	191.0	3.5	195.9		3.7
2006	197.1	3.2	203.3		3.8
2007	202.767	2.9	209.876		3.2
2008	211.053	4.1	217.648		3.7
2009	209.630	-0.7	216.293		-0.6
2010	213.967	2.1	219.714		1.6
2011	221.575	3.6	226.364		3.0
2012	226.229	2.1	231.611		2.3
2013	229.324	1.4	234.948		1.4
2014	232.771	1.5	238.960		1.7

CONSUMER PRICE INDICES, UNITED STATES AND CALIFORNIA
CALENDAR YEAR AVERAGES, (1982-84=100)

	United States		California	
	Index	% change	Index	% change
2015	231.810	-0.4	241.618	1.1
2016	234.076	1.0	246.195	1.9
2017 f/	239.591	2.4	253.647	3.0
2018 f/	245.259	2.4	261.314	3.0
2019 f/	250.829	2.3	268.969	2.9
2020 f/	256.342	2.2	276.777	2.9

f/ May Revision Forecast, April 2017

NOTE: Beginning with the January 2007 data, indices published by the Bureau of Labor Statistics will be rounded to three decimal places
The California indices conform to this change.

r/ CA CPI revised by DIR

All Urban Consumers: Includes, in addition to wage earners and clerical workers, groups such as professional, managerial, and technical workers, the self-employed, short-term workers, the unemployed, and retirees, and others not in the labor force.

San Francisco CMSA: Includes the counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, & Sonoma

Los Angeles CMSA: Includes the counties of Los Angeles, Orange, Riverside, San Bernardino, & Ventura

California: Weighted average of San Francisco CMSA, Los Angeles CMSA and (from 1965-1986) San Diego indices.

Sources:

San Francisco CMSA, Los Angeles CMSA and San Diego county, United States -- US Bureau of Labor Statistics (BLS)

California -- Calculated by the CA Department of Finance using a formula developed by the CA Dept. of Industrial Relations (DIR)

Forecasts -- CA Department of Finance (percent changes calculated from unrounded data)

Updated: May 11, 2017 Filename: bbcycpi

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

4. BENEFIT AND COST ANALYSIS SPREADSHEETS

Benefit and Cost Analysis Spreadsheets originally submitted as Tab 6 Attachment 9

Tab6-A9-A10_IRWD_Benefit-Cost_Analysis_Cost_Allocation.xlsx

Worksheets included in workbook:

1. Benefit Ratios
2. Cost Allocation
3. Dashboard
4. DJA O&M PV
5. DJA Replacement PV
6. DJA O&M Cost Estimate
7. DJA O&M Const Cost Estimate
8. WSIP 2030 MBK Operations
9. WSIP 2070 MBK Operations

BENEFIT RATIOS

Key Data from Other Worksheets

$171,321,859	Project capital cost
$16,029,044	PV of O&M(@2030)
$16,253,055	PV of O&M (@2070)
$10,476,475	PV of replacement
$197,827,378	*Total Project Cost*

Benefit Type	**Future Conditions** *2030 w/Climate Change*	*2070 w/Climate Change*
Non-Public		
Water Supply Benefits	$50,440,995.78	~~$47,745,446.54~~
Groundwater	$3,485,795.79	~~$4,296,188.77~~
Subtotal	$53,926,791.56	~~$52,041,635.31~~
Public		
Ecosystem Benefit - Salmon	$30,828,335.40	~~$20,978,395.07~~
Ecosystem Benefit - Wetlands	$98,248,070.23	~~$39,796,318.99~~
Emergency Response - Extended Drought	$18,570,140.39	~~$5,062,066.79~~
Emergency Response - Delta Failure	$28,452,181.95	~~$59,924,483.60~~
Subtotal	$176,098,727.97	~~$125,761,264.45~~
Total Benefits	**$230,025,519.54**	**~~$177,802,899.77~~**
Public Benefit Ratio	**2.056**	**~~1.47~~**
Benefit-Cost Ratio	**1.16**	**~~0.90~~**

Note on O&M Values: Due to changes resulting from revised CalSimII model runs and the associated Kern Fan operational model developed by MBK, the model-predicted operations of the project changed slightly. This has resulted in a change to the present value of O&M costs for both the 2030 and 2070 scenarios. Previously reported O&M values were $18,809,076 for the 2030 scenario and $17,993,034 for the 2070 scenario.; these costs have decreased to $16,024,969 and $16,264,914, respectively.

COST ALLOCATION

Cost Shares

$85,660,930	WSIP funds requested
$42,830,465	Portion funded by IRWD
$42,830,465	Portion funded by RRBWSD

	Beneficiary		
	State of California	*IRWD*	*RRBWSD*
Public Benefits			
Ecosystem	$129,076,406	$0	$0
Emergency Response	$47,022,322	$0	$0
Non-Public Benefits			
Water Supply	$0	$25,220,498	$25,220,498
Groundwater	$0	$1,742,898	$1,742,898
Total Benefits	**$176,098,728**	**$26,963,396**	**$26,963,396**
Cost Share Category			
Ecosystem	$42,830,465	$0	$0
Emergency Response	$42,830,465	$0	$0
Water Supply	$0	$40,061,929	$40,061,929
Groundwater	$0	$2,768,536	$2,768,536
Total Cost Share	**$85,660,930**	**$42,830,465**	**$42,830,465**
Benefit to Cost Share Ratio*	**2.06**	**0.63**	**0.63**

*While the benefit to cost share ratio for IRWD and RRBWSD is below 1.0, IRWD and RRBWSD additionally plan to utilize their share of the project facilites for other future groundwater storage and recovery programs. This would result in an increased benefit to IRWD and RRBWSD in excess of the benefits demonstrated for the Kern Fan Groundwater Storage Project, as discussed in application Tab 3, Question 6 (project affect on groundwater basins).

KERN FAN GROUNDWATER STORAGE PROJECT - ECONOMIC ANALYSIS

Planning level estimate of costs and benefits

Key Parameters

50	Project operations horizon/period *(years)*
2021	Construction start year
2025	Construction complete year
2024	Phase 1 online year
2025	Phase 2 online year
2075	Operations horizon end year
$171,321,859	Estimated capital cost *(dollars)*
$85,660,930	Estimated grant funding amount *(dollars)*
$42,830,465	Estimated IRWD capital contribution *(dollars)*
$42,830,465	Estimated RRBWSD capital contribution *(dollars)*
3.5%	Discount rate *(CA cost of borrowing from CWC Technical Reference Appendix G; aligns well with IRWD cost of capital @3.47%)*
2.0%	Bakersfield long term land value appreciation rate (per Mike Ming, ARA FRICS)

PHASE I WELL FIELD O&M COSTS

Year Type	*Monthly Cost*	*Annual Cost*
Dry Year (Pumping Wells)	$153,216.67	$1,838,600.00
Wet Year (Recharging Water)	$10,816.67	$129,800.00
Idle Year	$5,916.67	$71,000.00

PHASE I CANAL O&M COSTS

Year Type	*Monthly Cost*	*Annual Cost*
Dry Year (Pumping Wells)	$9,658.33	$115,900.00
Wet Year (Recharging Water)	$668,697.90	$8,024,374.86
Idle Year	$5,758.33	$69,100.00

PHASE I GOOSE LAKE SLOUGH TURNOUT O&M COSTS

Year Type	*Monthly Cost*	*Annual Cost*
Dry Year (Pumping Wells)	$1,852.78	$22,233.33
Wet Year (Recharging Water)	$64,052.78	$768,633.33
Idle Year	$1,352.78	$16,233.33

PHASE II WELL FIELD O&M COSTS

Year Type	*Monthly Cost*	*Annual Cost*
Dry Year (Pumping Wells)	$153,216.67	$1,838,600.00
Wet Year (Recharging Water)	$10,816.67	$129,800.00
Idle Year	$5,916.67	$71,000.00

DURATION OF OPERATIONS

Year Type	*2030 Conditions**	*2070 Conditions**
Dry Year (Pumping Wells)	6.36	6.52
Wet Year (Recharging Water)	1.65	1.68
Idle Year	73.99	73.81

*The values utilized for duration of operations for both the 2030 and 2070 condition were adjusted to reflect full years of operations. The data was adjusted from partial-year operations data provided by MBK Engineers. Since the modeled operations from MBK were over a 82 year hydrology, the proportions of idle, dry, and wet years were used to calculate a a weighted average annual O&M cost. This annual value was applied to the 50 years of expected operations to determine an appropriate present value of O&M costs.

WEIGHTED AVERAGE OF O&M COSTS

Year Type	*Total Cost*	*2030 Conditions*	*2070 Conditions*
Dry Year (Pumping Wells)	$3,815,333.33	6.36	6.52
Wet Year (Recharging Water)	$9,052,608.19	1.65	1.68
Idle Year	$227,333.33	73.99	73.81

2030 Condition Weighted Average Annual O&M:	$683,377.61
2070 Condition Weighted Average Annual O&M:	$692,928.02

O&M COSTS ESCALATED

Operations Year	*Calendar Year*	*Annual O&M Cost (@2030)*	*Annual O&M Cost (@2070)*
-	2015	-	-
-	2016	-	-
-	2017	-	-
-	2018	-	-
-	2019	$0.00	$0.00
-	2020	$0.00	$0.00
-	2021	$0.00	$0.00
-	2022	$0.00	$0.00
-	2023	$0.00	$0.00
-	2024	$0.00	$0.00
-	2025	$0.00	$0.00
1	2026	$683,377.61	$692,928.02
2	2027	$683,377.61	$692,928.02
3	2028	$683,377.61	$692,928.02
4	2029	$683,377.61	$692,928.02
5	2030	$683,377.61	$692,928.02
6	2031	$683,377.61	$692,928.02
7	2032	$683,377.61	$692,928.02
8	2033	$683,377.61	$692,928.02
9	2034	$683,377.61	$692,928.02
10	2035	$683,377.61	$692,928.02
11	2036	$683,377.61	$692,928.02
12	2037	$683,377.61	$692,928.02
13	2038	$683,377.61	$692,928.02
14	2039	$683,377.61	$692,928.02
15	2040	$683,377.61	$692,928.02
16	2041	$683,377.61	$692,928.02
17	2042	$683,377.61	$692,928.02
18	2043	$683,377.61	$692,928.02
19	2044	$683,377.61	$692,928.02
20	2045	$683,377.61	$692,928.02
21	2046	$683,377.61	$692,928.02
22	2047	$683,377.61	$692,928.02
23	2048	$683,377.61	$692,928.02
24	2049	$683,377.61	$692,928.02
25	2050	$683,377.61	$692,928.02
26	2051	$683,377.61	$692,928.02
27	2052	$683,377.61	$692,928.02
28	2053	$683,377.61	$692,928.02
29	2054	$683,377.61	$692,928.02
30	2055	$683,377.61	$692,928.02
31	2056	$683,377.61	$692,928.02
32	2057	$683,377.61	$692,928.02
33	2058	$683,377.61	$692,928.02
34	2059	$683,377.61	$692,928.02
35	2060	$683,377.61	$692,928.02
36	2061	$683,377.61	$692,928.02
37	2062	$683,377.61	$692,928.02
38	2063	$683,377.61	$692,928.02
39	2064	$683,377.61	$692,928.02
40	2065	$683,377.61	$692,928.02
41	2066	$683,377.61	$692,928.02
42	2067	$683,377.61	$692,928.02
43	2068	$683,377.61	$692,928.02
44	2069	$683,377.61	$692,928.02
45	2070	$683,377.61	$692,928.02
46	2071	$683,377.61	$692,928.02
47	2072	$683,377.61	$692,928.02
48	2073	$683,377.61	$692,928.02
49	2074	$683,377.61	$692,928.02
50	2075	$683,377.61	$692,928.02
	NPV of O&M->	**$16,029,043.97**	**$16,253,054.75**

ANNUALIZED REPLACEMENT COST ESTIMATES FROM DJA REPORT

Description	*Annualized Cost*
Canal Replacement	$30,500.00
Lift Station Replacement	$276,813.00
Aqueduct Turnout Replacement	$4,130.00
Phase II Turnout Replacement	$4,130.00
West Basin Turnout Replacement	$6,070.00
Phase I Well Site Replacement	$51,204.00
Goose Lake Slough Turnout Replacement	$22,600.00
Phase II Well Site Replacement	$51,204.00
Total Estimated Annual Replacement->	$446,651.00

RECPLACEMENT COSTS PV CALCULATION

Operations Year	*Calendar Year*	*Replacement Cost*
-	2015	-
-	2016	-
-	2017	-
-	2018	-
-	2019	$0.00
-	2020	$0.00
-	2021	$0.00
-	2022	$0.00
-	2023	$0.00
-	2024	$0.00
-	2025	$0.00
1	2026	$446,651.00
2	2027	$446,651.00
3	2028	$446,651.00
4	2029	$446,651.00
5	2030	$446,651.00
6	2031	$446,651.00
7	2032	$446,651.00
8	2033	$446,651.00
9	2034	$446,651.00
10	2035	$446,651.00
11	2036	$446,651.00
12	2037	$446,651.00
13	2038	$446,651.00
14	2039	$446,651.00
15	2040	$446,651.00
16	2041	$446,651.00
17	2042	$446,651.00
18	2043	$446,651.00
19	2044	$446,651.00
20	2045	$446,651.00
21	2046	$446,651.00
22	2047	$446,651.00
23	2048	$446,651.00
24	2049	$446,651.00
25	2050	$446,651.00
26	2051	$446,651.00
27	2052	$446,651.00
28	2053	$446,651.00
29	2054	$446,651.00
30	2055	$446,651.00
31	2056	$446,651.00
32	2057	$446,651.00
33	2058	$446,651.00
34	2059	$446,651.00
35	2060	$446,651.00
36	2061	$446,651.00
37	2062	$446,651.00
38	2063	$446,651.00
39	2064	$446,651.00
40	2065	$446,651.00
41	2066	$446,651.00
42	2067	$446,651.00
43	2068	$446,651.00
44	2069	$446,651.00
45	2070	$446,651.00
46	2071	$446,651.00
47	2072	$446,651.00
48	2073	$446,651.00
49	2074	$446,651.00
50	2075	$446,651.00
	NPV of Replacement->	**$10,476,475.18**

Irvine Ranch Water District

Operation & Maintenance Cost Estimate

Phase I Well Field Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	Monthly RRBWSD Recovery Charge[5]	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost if Utilized for 12 Months[6]	Average Cost per Ac-Ft[7]	
Dry Year (Pumping Wells)	$ 8,000.00	$ 144,900.00	$ 316.67	$ -	$ -	$ 153,216.67	$ 1,838,600.00	$ 73.54	95%
Wet Year (Recharging Wat	$ 9,000.00	$ 1,500.00	$ 316.67	$ -	$ -	$ 10,816.67	$ 88,150.00	$ 1.76	14%
Idle Year	$ 4,100.00	$ 1,500.00	$ 316.67	$ -	$ -	$ 5,916.67	$ 71,000.00		25%

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent
2. Cost includes one additional piece of equipment for property
3. Monthly PG&E cost to operate(6) 400 hp wells
4. Average monthly cost for cellular service to (6) Mission Units
5. Assumed 35 cfs flow rate for a 30 day month for a total of 2,083 ac-ft of water recovered per month or 25,000 ac-ft/yr
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 3.5 months of recharging 56,250 ac-ft and 8.5 months a
7. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Phase I Canal Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	Monthly RRBWSD Recovery Charge	DWR Conveyance Cost[5]	Total Monthly Cost	Total Annual Cost[6]	Average Cost per Ac-Ft[7]	
Dry Year (Pumping Wells)	$ 8,000.00	$ 1,500.00	$ 158.33	$ -	$ -	$ 9,658.33	$ 115,900.00	$ 4.64	16%
Wet Year (Recharging Wat	$ 9,000.00	$ 197,486.00	$ 158.33	$ -	$ 462,053.57	$ 668,697.90	$ 2,389,388.50	$ 23.89	30%
Idle Year	$ 4,100.00	$ 1,500.00	$ 158.33	$ -	$ -	$ 5,758.33	$ 69,100.00		26%

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent
2. Cost includes one additional piece of equipment for canal
3. Monthly PG&E cost to operate (18) 300 hp lift pumps moving 500 cfs, Total 112,500 ac-ft / year
4. Average monthly cost for cellular service to (3) Mission Units
5. Article 21 water cost estimated at $23.00/AF for 112,500 ac-ft, however 37.5% of DWR water is already in the IRWD
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 3.5 months of conveying up to 112,500 ac-ft and 8.5 mc
7. Dry year conveying 25,000 ac-ft to aqueduct and a wet year recharging 112,500 ac-ft.

Phase I Goose Lake Slough Turnout Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[3]	Monthly RRBWSD Recovery Charge	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost[4]	Average Cost per Ac-Ft[5]
Dry Year (Pumping Wells)	$ 1,500.00	$ 300.00	$ 52.78	$ -	$ -	$ 1,852.78	$ 22,233.33	$ 0.89
Wet Year (Recharging Wat	$ 4,000.00	$ 60,000.00	$ 52.78	$ -	$ -	$ 64,052.78	$ 235,683.33	$ 4.71
Idle Year	$ 1,000.00	$ 300.00	$ 52.78	$ -	$ -	$ 1,352.78	$ 16,233.33	

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent
2. Monthly PG&E cost to operate (4) 300 hp lift pumps moving 240 cfs, Total 50,000 ac-ft / year
3. Average monthly cost for cellular service to (1) Mission Units
4. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 3.5 months of recharging 556,250 ac-ft and 8.5 months
5. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Phase II Well Field Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	Monthly RRBWSD Recovery Charge[5]	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost if Utilized for 12 Months[6]	Average Cost per Ac-Ft[7]
Dry Year (Pumping Wells)	$ 8,000.00	$ 144,900.00	$ 316.67	$ -	$ -	$ 153,216.67	$ 1,838,600.00	$ 73.54
Wet Year (Recharging Wat	$ 9,000.00	$ 1,500.00	$ 316.67	$ -	$ -	$ 10,816.67	$ 88,150.00	$ 1.76
Idle Year	$ 4,100.00	$ 1,500.00	$ 316.67	$ -	$ -	$ 5,916.67	$ 71,000.00	

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent
2. Cost includes one additional piece of equipment for property
3. Monthly PG&E cost to operate(6) 400 hp wells
4. Average monthly cost for cellular service to (6) Mission Units
5. Assumed 35 cfs flow rate for a 30 day month for a total of 2,083 ac-ft of water recovered per month or 25,000 ac-ft/yr
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 3.5 months of recharging 56,250 ac-ft and 8.5 months a
7. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Irvine Ranch Water District

Canal Alignment along KWB to West Basins

Item No.	Item Description	Unit	Quantity	Unit Cost	Extended Cost	Phase	Year
1	Mobilization, Demobilization, & Cleanup	LS	1	$ 1,820,000.00	$ 1,820,000.00	1	2021
2	Aqueduct Cofferdam & Dewatering	LS	1	$ 250,000.00	$ 250,000.00	1	2022
3	Aqueduct Turnout Excavation	LS	1	$ 55,000.00	$ 55,000.00	1	2022
4	Aqueduct Reinforced Concrete Structure	LS	1	$ 200,000.00	$ 200,000.00	1	2022
5	Aqueduct Backfill and Compaction	LS	1	$ 50,000.00	$ 50,000.00	1	2022
6	Aqueduct Miscellaneous Steel	LS	1	$ 55,000.00	$ 55,000.00	1	2022
7	Aqueduct Metering	EA	2	$ 90,000.00	$ 180,000.00	1	2022
8	Aqueduct Slide Gate & Actuator	EA	2	$ 37,500.00	$ 75,000.00	1	2022
9	Aqueduct Electrical, Controls, & Lighting	LS	1	$ 300,000.00	$ 300,000.00	1	2022
10	Aqueduct Liner Repair	LS	1	$ 20,000.00	$ 20,000.00	1	2022
11	Canal Earthwork	CY	1,650,000	$ 10.00	$ 16,500,000.00	1	2022
12	Concrete Canal Lining	SF	2,640,000	$ 6.00	$ 15,840,000.00	1	2022
13	Canal Appurtenances	LS	1	$ 250,000.00	$ 250,000.00	1	2022
14	Canal Fencing	LF	110,000	$ 7.50	$ 825,000.00	1	2022
15	Levee Road Aggregate Base Ground Cover	LS	1	$ 650,000.00	$ 650,000.00	1	2022
16	East Canal Crossing Siphon & Appurtenances	LS	1	$ 1,000,000.00	$ 1,000,000.00	1	2022
17	Main Canal Crossing Siphon & Appurtenances	LS	1	$ 500,000.00	$ 500,000.00	1	2022
18	WKWD Pipeline Crossing Siphon & Appurtenances	LS	1	$ 250,000.00	$ 250,000.00	1	2022
19	Stockdale Hwy Crossing Siphon & Appurtenances	LS	1	$ 1,000,000.00	$ 1,000,000.00	1	2022
20	I-5 Crossing Siphon & Appurtenances	LS	1	$ 1,500,000.00	$ 1,500,000.00	1	2022
21	Farm Road Siphon & Appurtenances	EA	3	$ 600,000.00	$ 1,800,000.00	1	2022
22	84" Siphon Piping	LF	10,720	$ 1,500.00	$ 16,080,000.00	1	2022
23	Lift Station Excavation	LS	3	$ 60,000.00	$ 180,000.00	1	2023
24	Lift Station Reinforced Concrete Structure	LS	3	$ 650,000.00	$ 1,950,000.00	1	2023
25	Lift Station Pumps - 67 cfs to 83 cfs	EA	18	$ 150,000.00	$ 2,700,000.00	1	2023
26	Lift Station Motors - 300 hp to 400 hp	EA	18	$ 95,000.00	$ 1,710,000.00	1	2023
27	Lift Station Discharge Piping & Appurtenances	LS	3	$ 750,000.00	$ 2,250,000.00	1	2023
28	Lift Station VFD's	EA	18	$ 50,000.00	$ 900,000.00	1	2023
29	Lift Station Electrical, Controls, & Lighting	LS	3	$ 500,000.00	$ 1,500,000.00	1	2023
30	Lift Station Backfill & Compaction	LS	3	$ 65,000.00	$ 195,000.00	1	2023
31	Lift Station Slide Gates	EA	3	$ 37,500.00	$ 112,500.00	1	2023
32	Lift Station Miscellaneous Steel	LS	3	$ 80,000.00	$ 240,000.00	1	2023
33	Lift Station Site Fencing	LS	1	$ 135,000.00	$ 135,000.00	1	2023
34	Lift Station Ground Cover	LS	1	$ 45,000.00	$ 45,000.00	1	2023
35	West Basins Turnout Structure Excavation	LS	1	$ 50,000.00	$ 50,000.00	1	2024
36	West Basins Turnout Reinforced Concrete Structure	LS	1	$ 200,000.00	$ 200,000.00	1	2024
37	West Basins Structure Backfill & Compaction	LS	1	$ 50,000.00	$ 50,000.00	1	2024
38	West Basins Turnout Miscellaneous Steel	LS	1	$ 35,000.00	$ 35,000.00	1	2024
39	West Basins Metering	EA	3	$ 90,000.00	$ 270,000.00	1	2024
40	West Basins Turnout Slide Gate	EA	3	$ 55,000.00	$ 165,000.00	1	2024
41	West Basins Turnout Electrical	LS	1	$ 150,000.00	$ 150,000.00	1	2024
42	Phase II 640 Acres Turnout Structure Excavation	LS	1	$ 55,000.00	$ 55,000.00	2	2024
43	Phase II 640 Acres Turnout Reinforced Concrete Structure	LS	1	$ 150,000.00	$ 150,000.00	2	2024
44	Phase II 640 Acres Structure Backfill & Compaction	LS	1	$ 50,000.00	$ 50,000.00	2	2024
45	Phase II 640 Acres Turnout Miscellaneous Steel	LS	1	$ 40,000.00	$ 40,000.00	2	2024

46	Phase II 640 Acres Metering	EA	2	$ 90,000.00	$ 180,000.00	2	2024
47	Phase II 640 Acres Turnout Slide Gate	EA	2	$ 37,500.00	$ 75,000.00	2	2024
48	Phase II 640 Acres Turnout Electrical	LS	1	$ 150,000.00	$ 150,000.00	2	2024
49	Phase II 640 Acres Earthwork and Interbasin Structures	LS	1	$ 2,895,200.00	$ 2,895,200.00	2	2023
50	Phase II 640 Acres Well Drilling, Construction, & Development	EA	6	$ 798,901.00	$ 4,793,406.00	2	2023
51	Phase II 640 Acres Well Equipping with Pumps, Motors, Discharge Piping, & Electrical	EA	6	$ 777,333.67	$ 4,664,002.00	2	2024
52	Phase II 640 Acres Well Recovery Pipeline - 16" C905 PVC	LF	2800	$ 70.00	$ 196,000.00	2	2024
53	Phase II 640 Acres Well Recovery Pipeline - 24" C905 PVC	LF	5500	$ 130.00	$ 715,000.00	2	2024
54	Phase II 640 Acres Well Recovery Pipeline - 36" C905 PVC	LF	4200	$ 180.00	$ 756,000.00	2	2024
55	Goose Lake Slough Turnout Structure Excavation	LS	1	$ 60,000.00	$ 60,000.00	1	2023
56	Goose Lake Slough Turnout Reinforced Concrete Structure	LS	1	$ 650,000.00	$ 650,000.00	1	2023
57	Goose Lake Slough Turnout Backfill & Compaction	LS	1	$ 60,000.00	$ 60,000.00	1	2023
58	Goose Lake Slough Turnout Miscellaneous Steel	LS	1	$ 80,000.00	$ 80,000.00	1	2023
59	Goose Lake Slough Lift Station Pumps - 60 cfs	EA	4	$ 140,000.00	$ 560,000.00	1	2023
60	Goose Lake Slough Lift Station Motors - 300 hp	EA	4	$ 85,000.00	$ 340,000.00	1	2023
61	Goose Lake Slough Lift Station Discharge Piping & Appurtenances	LS	1	$ 600,000.00	$ 600,000.00	1	2023
62	Goose Lake Slough Metering	EA	2	$ 90,000.00	$ 180,000.00	1	2023
63	Goose Lake Slough Turnout Slide Gate	EA	1	$ 37,500.00	$ 37,500.00	1	2023
64	Goose Lake Slough Turnout Electrical	LS	1	$ 500,000.00	$ 500,000.00	1	2023
65	Phase 1 640 Acres Conveyance Pipelines	LF	200	$ 1,500.00	$ 300,000.00	1	2023
66	Phase 1 640 Acres Discharge Structure	LS	1	$ 55,000.00	$ 55,000.00	1	2023
67	Goose Lake Slough Check Structure - Earthwork	LS	1	$ 35,000.00	$ 35,000.00	1	2023
68	Goose Lake Slough Check Structure - Reinforced Concrete	LS	1	$ 200,000.00	$ 200,000.00	1	2023
69	Goose Lake Slough Check Structure - Rip-Rap	LS	1	$ 30,000.00	$ 30,000.00	1	2023
70	Goose Lake Slough Check Structure - Appurtenances, Weir Boards	LS	1	$ 25,000.00	$ 25,000.00	1	2023
71	RRB Intake Canal Interconnection	LS	1	$ 250,000.00	$ 250,000.00	1	2023
72	Phase 1 640 Acres Earthwork and Interbasin Structures	LS	1	$ 2,895,200.00	$ 2,895,200.00	1	2022
73	Phase 1 640 Acres Well Drilling, Construction, & Development	EA	6	$ 798,901.00	$ 4,793,406.00	1	2022
74	Phase 1 640 Acres Well Equipping with Pumps, Motors, Discharge Piping, & Electrical	EA	6	$ 777,333.67	$ 4,664,002.00	1	2022
75	Phase 1 640 Acres Well Recovery Pipeline - 16" C905 PVC	LF	1350	$ 70.00	$ 94,500.00	1	2022
76	Phase 1 640 Acres Well Recovery Pipeline - 24" C905 PVC	LF	4200	$ 130.00	$ 546,000.00	1	2022
77	Phase 1 640 Acres Well Recovery Pipeline - 30" C905 PVC	LF	2800	$ 130.00	$ 364,000.00	1	2022
78	Phase 1 640 Acres Well Recovery Pipeline - 36" C905 PVC	LF	2800	$ 180.00	$ 504,000.00	1	2022
79	SCADA Communication & Appurtenances	LS	1	$ 300,000.00	$ 300,000.00	1	2022
	Contract Cost:				*$ 104,880,716.00*		
	20% Construction Contingency:				*$ 20,976,143.20*		2021
	Property Acquisition - 640 acres	*AC*	*640*	*$ 26,500.00*	*$ 16,960,000.00*		2019
	Property Acquisition - 640 acres	*AC*	*640*	*$ 21,500.00*	*$ 13,760,000.00*		2019
	Temporary Easement	*AC*	*235*	*$ 3,750.00*	*$ 881,250.00*		2020
	Permanent Easement	*AC*	*165*	*$ 10,750.00*	*$ 1,773,750.00*		2020
	Aqueduct R/W & Compliance	*LS*	*1*	*$ 25,000.00*	*$ 25,000.00*		2020
	Habitat Credit Purchase	*AC*	*200*	*$ 16,000.00*	*$ 3,200,000.00*		2020
	Field Cost:				*$ 162,456,859.20*		
	Non-Contract Costs:				*$ 8,865,000.00*		2019
	Total Construction Cost:				***$171,321,859.20***		

Summary	WSIP 2030 SCENARIO					
	ENV		IRWD		ROSEDALE	
Year Type	Recharge (TAF/year)	Recovery (TAF/year)	Recharge (TAF/year)	Recovery (TAF/year)	Recharge (TAF/year)	Recovery (TAF/year)
Wet	2	0	2	0	2	0
Above Normal	2	0	4	1	4	0
Below Normal	1	0	2	1	2	0
Dry	0	3	0	2	0	4
Critical	0	2	0	4	0	4
All Years	1.3	1.0	1.6	1.3	1.5	1.4
Model Column:	W	Z	AB	AE	AG	AJ

		ENV		IRWD		ROSEDALE					
Sacramento Valley Year Type	Water Year	Recharge (TAF/year)	Recovery (TAF/year)	Recharge (TAF/year)	Recovery (TAF/year)	Recharge (TAF/year)	Recovery (TAF/year)		**Recharge Years of Operation**		**Recovery Years of Operation**
Above Normal	1922	0.00	0.00	0.00	0.00	0.00	0.00				
Below Normal	1923	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1924	0.00	0.00	0.00	0.00	0.00	0.00				
Dry	1925	0.00	0.00	0.00	0.00	0.00	0.00				
Dry	1926	0.00	0.00	0.00	0.00	0.00	0.00				
Wet	1927	0.00	0.00	0.00	0.00	0.00	0.00				
Above Normal	1928	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1929	0.00	0.00	0.00	0.00	0.00	0.00				
Dry	1930	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1931	0.00	0.00	0.00	0.00	0.00	0.00				
Dry	1932	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1933	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1934	0.00	0.00	0.00	0.00	0.00	0.00				
Below Normal	1935	0.00	0.00	0.00	0.00	0.00	0.00				
Below Normal	1936	5.96	0.00	8.95	0.00	8.95	0.00	23.86	0.11		
Below Normal	1937	5.96	0.00	9.01	0.00	8.88	0.00	23.86	0.11		
Wet	1938	11.35	0.00	17.33	0.00	16.72	0.00	45.41	0.21		
Dry	1939	0.00	13.75	0.00	2.50	0.00	7.50	0.00	0.00	23.75	0.50
Above Normal	1940	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	5.00	0.10
Wet	1941	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1942	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1943	9.27	0.00	7.57	0.00	7.02	0.00	23.86	0.11	0.00	0.00
Dry	1944	0.00	13.75	0.00	5.00	0.00	15.00	0.00	0.00	33.75	0.71
Below Normal	1945	8.46	0.00	7.43	7.50	7.96	0.00	23.86	0.11	7.50	0.16
Below Normal	1946	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1947	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1948	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1949	0.00	0.00	0.00	7.50	0.00	15.00	0.00	0.00	22.50	0.47
Below Normal	1950	0.00	0.00	0.00	7.50	0.00	0.00	0.00	0.00	7.50	0.16
Above Normal	1951	0.07	0.00	0.13	0.00	0.13	0.00	0.34	0.00	0.00	0.00
Wet	1952	-8.46	0.00	-7.85	0.00	-7.20	0.00	-23.51	-0.11	0.00	0.00
Wet	1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1955	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1956	11.54	0.00	17.32	0.00	17.32	0.00	46.18	0.21	0.00	0.00
Above Normal	1957	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1958	5.77	0.00	8.83	0.00	8.49	0.00	23.09	0.11	0.00	0.00
Below Normal	1959	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1960	0.00	13.75	0.00	0.00	0.00	0.00	0.00	0.00	13.75	0.29
Dry	1961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1962	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1965	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1966	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1967	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1969	20.16	0.00	13.05	0.00	12.20	0.00	45.41	0.21	0.00	0.00
Wet	1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1971	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	1973	5.96	0.00	4.18	0.00	3.30	0.00	13.44	0.06	0.00	0.00
Wet	1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical	1976	0.00	13.75	0.00	2.50	0.00	7.50	0.00	0.00	23.75	0.50
Critical	1977	0.00	0.00	0.00	31.25	0.00	29.67	0.00	0.00	60.92	1.27
Above Normal	1978	7.73	0.00	20.08	3.12	19.91	0.00	47.71	0.22	3.12	0.07

Below Normal	1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	1980	8.21	0.00	21.96	0.00	20.56	0.00	50.74	0.23	0.00	0.00
Dry	1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1982	0.54	0.00	1.76	0.00	1.08	0.00	3.38	0.02	0.00	0.00
Wet	1983	0.08	0.00	0.30	0.00	0.12	0.00	0.50	0.00	0.00	0.00
Wet	1984	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Dry	1985	0.00	13.75	0.00	0.00	0.00	0.00	0.00	0.00	13.75	0.29
Wet	1986	13.75	0.00	0.00	0.00	0.00	0.00	13.75	0.06	0.00	0.00
Dry	1987	0.00	0.00	0.00	18.75	0.00	30.00	0.00	0.00	48.75	1.02
Critical	1988	0.00	13.75	0.00	16.25	0.00	7.50	0.00	0.00	37.50	0.78
Dry	1989	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	2.50	0.05
Critical	1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical	1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical	1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical	1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
									1.65		**6.36**

Summary — WSIP 2070 SCENARIO

Year Type	ENV Recharge (TAF/year)	ENV Recovery (TAF/year)	IRWD Recharge (TAF/year)	IRWD Recovery (TAF/year)	ROSEDALE Recharge (TAF/year)	ROSEDALE Recovery (TAF/year)
Wet	3	0	3	0	3	0
Above Normal	2	0	5	1	5	0
Below Normal	0	0	0	1	0	1
Dry	0	3	0	4	0	6
Critical	0	1	0	2	0	1
All Years	1.1	0.8	1.7	1.5	1.7	1.5
Model Column:	W	Z	AB	AE	AG	AJ

Sacramento Valley Year Type	Water Year	ENV Recharge (TAF/year)	ENV Recovery (TAF/year)	IRWD Recharge (TAF/year)	IRWD Recovery (TAF/year)	ROSEDALE Recharge (TAF/year)	ROSEDALE Recovery (TAF/year)		**Recharge Years of Operation**		**Recovery Years of Operation**
Above Normal	1922	0	0	0	0	0	0				
Below Normal	1923	0	0	0	0	0	0				
Critical	1924	0	0	0	0	0	0				
Dry	1925	0	0	0	0	0	0				
Dry	1926	0	0	0	0	0	0				
Wet	1927	0	0	0	0	0	0				
Above Normal	1928	0	0	0	0	0	0				
Critical	1929	0	0	0	0	0	0				
Dry	1930	0	0	0	0	0	0				
Critical	1931	0	0	0	0	0	0				
Dry	1932	0	0	0	0	0	0				
Critical	1933	0	0	0	0	0	0				
Critical	1934	0	0	0	0	0	0				
Below Normal	1935	0	0	0	0	0	0				
Below Normal	1936	0	0	0	0	0	0	0.00	0.00		
Below Normal	1937	0	0	0	0	0	0	0.00	0.00		
Wet	1938	17	0	26	0	26	0	69.26	0.32		
Dry	1939	0	14	0	5	0	15	0.00	0.00	33.75	0.71
Above Normal	1940	0	0	0	8	0	0	0.00	0.00	7.50	0.16
Wet	1941	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1942	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1943	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1944	0	0	0	10	0	8	0.00	0.00	17.94	0.38
Below Normal	1945	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1946	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1947	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1948	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1949	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1950	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1951	11	0	17	0	17	0	45.41	0.21	0.00	0.00
Wet	1952	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1953	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1954	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1955	0	0	0	15	0	16	0.00	0.00	30.22	0.63
Wet	1956	7	0	19	0	19	0	46.18	0.21	0.00	0.00
Above Normal	1957	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1958	4	0	10	0	9	0	23.09	0.11	0.00	0.00
Below Normal	1959	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1960	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1961	0	14	0	5	0	15	0.00	0.00	33.75	0.71
Below Normal	1962	0	0	0	8	0	0	0.00	0.00	7.50	0.16
Wet	1963	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1964	0	0	0	12	0	11	0.00	0.00	23.51	0.49
Wet	1965	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1966	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1967	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1968	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1969	11	0	24	0	23	0	58.57	0.27	0.00	0.00
Wet	1970	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1971	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1972	0	0	0	3	0	8	0.00	0.00	10.00	0.21
Above Normal	1973	0	0	0	5	0	0	0.00	0.00	5.00	0.10
Wet	1974	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1975	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1976	0	0	0	13	0	14	0.00	0.00	26.22	0.55
Critical	1977	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1978	5	0	22	0	21	0	47.71	0.22	0.00	0.00

Below Normal	1979	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1980	4	0	21	0	19	0	44.47	0.20	0.00	0.00
Dry	1981	0	14	0	0	0	0	0.00	0.00	13.75	0.29
Wet	1982	14	0	1	0	1	0	16.35	0.07	0.00	0.00
Wet	1983	2	0	0	0	0	0	2.32	0.01	0.00	0.00
Wet	1984	0	0	0	0	0	0	0.03	0.00	0.00	0.00
Dry	1985	0	14	0	0	0	0	0.00	0.00	13.75	0.29
Wet	1986	14	0	0	0	0	0	13.75	0.06	0.00	0.00
Dry	1987	0	0	0	26	0	37	0.00	0.00	63.75	1.33
Critical	1988	0	14	0	11	0	0	0.00	0.00	25.00	0.52
Dry	1989	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1990	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1991	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1992	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1993	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1994	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1995	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1996	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1997	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1998	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1999	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	2000	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	2001	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	2002	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	2003	0	0	0	0	0	0	0.00	0.00	0.00	0.00
									1.68		**6.52**

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

5. PHYSICAL AND ECONOMIC SUMMARY TABLES

Revised - Previously Sumitted as Tab 6-A11_IRWD_Physical and Economic Benefits Summary Tables_FINAL.xlsx

Physical and Economic Benefits Summary

November 2016

Part 1. Physical and Economic Benefits. Repeat this block for each category of public or non-public benefit quantified							
Enter Benefit Category here [1]	Non-Public Benefit						
Repeat Rows 1 through 4 for every quantified physical benefit in this benefit category							
1. Physical Benefit Name: Water Supply Benefits				Notes: 2/3 of non-ecosystem water allocated to water supply. Weighted by hydrology and costs of water for ag and urban. See Benefit Calculation Tab Attachment 3 and Attachment 5 for detail.			
2. Physical Benefit Measurement Units: Acre-Feet				Notes:			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		3015	0	3015	2747	0	2747
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 1,178,022	$ -	$ 1,178,022	$ 2,485,886	$ -	$ 2,485,886
1. Physical Benefit Name: Groundwater Level Improvement				Notes:			
2. Physical Benefit Measurement Units: Acre-Feet				Notes:			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		385.7	0	385.7	351.4	0	351.4
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 82,167	$ -	$ 82,167	$ 190,943	$ -	$ 190,943
5. Total Annual Monetized Benefit for the Category (sum of all row 4s.)		$ 1,260,189	$ -	$ 1,260,189	$ 2,676,829	$ -	$ 2,676,829

Enter Benefit Category here [1]	Ecosystem Benefit						
Repeat Rows 1 through 4 for every quantified physical benefit in this benefit category							
1. Physical Benefit Name:Ecosystem				Notes:			
2. Physical Benefit Measurement Units: Number of Salmon Surviving to Adulthood				Notes: Spring Run Chinook and Winter Run Chinook over 50 year period. See Physical Public Benefit Tab Attachment 2 and Benefit Calculation Tab Attachment 3 and Attachment 5 for details.			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		545	0	545	460	0	460
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 1,284,259	$ -	$ 1,284,259	$ 1,234,896	$ -	$ 1,234,896
1. Physical Benefit Name: Incidental wetland habitat				Notes:			
2. Physical Benefit Measurement Units: Acres				Notes: Probability of incidental wetland 20% over 50 year period			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		1280	0	1280	1280	0	1280
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 977,240	$ -	$ 977,240	$ 1,939,950	$ -	$ 1,939,950
5. Total Annual Monetized Benefit for the Category (sum of all row 4s.)		$ 2,261,499	$ -	$ 2,261,499	$ 3,174,847	$ -	$ 3,174,847

Enter Benefit Category here [1]	Emergency Response						
Repeat Rows 1 through 4 for every quantified physical benefit in this benefit category							
1. Physical Benefit Name: Extended Drought				Notes:			
2. Physical Benefit Measurement Units: Acre-Feet				Notes: 1/3 of non-ecosystem water allocated to emergency drought water supply. Weighted by hydrology and costs of water for ag and urban, and incorporates 7% probability of extended drought. See Benefit Calculation Tab Attachment 3 and Attachment 5 for detail.			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		1485	0	1485	1353	0	1353
4. Annual Economic Benefit, 2015 $ Million/Yr		$ 459,516	$ -	$ 459,516	$ 974,113	$ -	$ 974,113
1. Physical Benefit Name: Delta Failure				Notes: WSIP Technical Guidance stated that Delta Failure should be assumed to occur once, 30 years into project period - 2056 for this project. The equivalent alternative cost-based benefit in 2070 that would yield the same NPV as an event in 2056 is given below.			
2. Physical Benefit Measurement Units: Acre-Feet				Notes:			
		2030			2070		
	Enter Page Number from Application	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]		20000	0	20000	20000	0	20000
4. Annual Economic Benefit, 2015 $ Million/Yr					#REF!	$ -	#REF!
5. Total Annual Monetized Benefit for the Category (sum of all row 4s.)		$ 459,516	$ -	$ 459,516	#REF!	$ -	#REF!

[1] Enter one of these benefits: Ecosystem, Water Quality, Flood Control, Emergency Response, Recreation, or Non-public benefit

[2] Net of any non-mitigated physical effects

Part 2. Total Economic Net Benefits and Allocated Cost by Benefit Category in 2015 $ Million

Sum of annual economic net benefits by type	Enter Page Number from Application	Ecosystem	Water Quality	Flood Control	Emergency Response	Recreation	Total Public Benefits	Non-Public Benefits	Total public and non-public benefits[1]
Sum of 2030 benefits from Part 1, Row 5		$ 2,261,499			$ 459,516		$ 2,721,015	$ 1,260,189	$ 3,981,204
Sum of 2070 benefits from Part 1, Row 5		$ 3,174,847			#REF!		#REF!	$ 2,676,829	#REF!
Present Value of Benefits over Planning Horizon using 3.5% Discount Rate		$129,076,406			$ 47,022,322		$ 176,098,728	$ 53,926,792	$ 230,025,520
Present Value of Total Project Costs Allocated to each Benefit Category									
Capital Costs Allocated to Each Benefit Category									
Total Requested Program Cost Share									

[1] Present value of total public and non-public benefits, total project costs, and total Program funding request must match numbers in Part 3

Part 3. Present Value of Project Costs, Cost-Effectiveness Measure, and Public Benefit Ratio, Million 2015 $ Present Value

	Enter Page Number of Application	2015 $ Million Present Value
Project Costs		
Capital costs as defined in Program regulations		
Interest during construction		
Replacement costs		
Future environmental mitigation or compliance obligation costs		
Operations, maintenance and repair (OM&R) costs		
Other costs (describe)		
Present Value of Total Project Costs[1]		
Present Value of Cost of Least-Cost Alternative that Provides the Same Total Physical Benefits		$ 176,098,728
Present Value of All Public and Non-public Benefits[1]		$ 230,025,520
Ratio of Present Value of Total Monetized Net Benefits to the Total Project Costs		
Present Value of Public Benefits[1]		$ 176,098,728
Total Requested Program Cost Share[1]		
Public Benefit Ratio: Ratio of Present Value of Monetized Net Public Benefits to the Total Requested Program Cost Share		

[1] Must match numbers in Part 2

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

6. ECOSYSTEM PRIORITY WORKSHEET—GENERAL INFORMATION

General Info: Ecosystem Priorities and Relative Environmental Value Criteria	
Ecosystem Priorities	
P 1	Provide cold water at times and locations to increase the survival of salmonid eggs and fry.
P 2	Provide flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids.
P 3	Maintain flows and appropriate ramping rates at times and locations that will minimize dewatering of salmonid redds and prevent stranding of juvenile salmonids in side channel habitat
P 4	Improve ecosystem water quality
P 5	Provide flows that increase dissolved oxygen and lower water temperatures to support anadromous fish passage
P 6	Increase attraction flows during upstream migration to reduce straying of anadromous species into non-natal tributaries
P 7	Increase Delta outflow to provide low salinity habitat for Delta smelt, longfin smelt, and other estuarine fishes in the Delta, Suisun Bay, and Suisun Marsh
P 8	Maintain or restore groundwater and surface water interconnection to support instream benefits and groundwater dependent ecosystems.
P 9	Enhance flow regimes or groundwater conditions to improve the quantity and quality of riparian and floodplain habitats for aquatic and terrestrial species.
P 10	Enhance the frequency, magnitude, and duration of floodplain inundation to enhance primary and secondary productivity and the growth and survival of fish
P 11	Enhance the temporal and spatial distribution and diversity of habitats to support all life stages of fish and wildlife species
P 12	Enhance access to fish spawning, rearing, and holding habitat by eliminating barriers to migration
P 13	Remediate unscreened or poorly screened diversions to reduce entrainment of fish
P 14	Provide water to enhance seasonal wetlands, permanent wetlands, and riparian habitat for aquatic and terrestrial species on State and Federal wildlife refuges and on other public and private lands
P 15	Develop and implement invasive species management plans utilizing techniques that are supported by best available science to enhance habitat and increase the survival of native species
P 16	Enhance habitat for native species that have commercial, recreational, scientific, or educational uses
Relative Environmental Value Criteria (REVs)	
REV 1	Number of different ecosystem priorities, for which corresponding public benefits are, provided by the project.
REV 2	Magnitude of ecosystem improvements.
REV 3	Spatial and temporal scale of ecosystem improvements.
REV 4	Inclusion of an adaptive management and monitoring program that includes measurable objectives, performance measures, thresholds, and triggers for managing ecosystem benefits.
REV 5	Immediacy of ecosystem improvement actions and realization of benefits
REV 6	Duration of ecosystem improvements.
REV 7	Consistency with species recovery plans and strategies, initiatives, and conservation plans
REV 8	Location of ecosystem improvements and connectivity to areas already being protected or managed for conservation values
REV 9	Efficient use of water to achieve multiple ecosystem benefits
REV 10	Resilience of ecosystem improvements to the effects of changing environmental conditions, including hydrologic variability and climate change.

Project Information

Project Name

Kern Fan Groundwater Storage Project (Kern Fan Project or Project)

Project Description (Summary)

The Kern Fan Groundwater Storage Project (Kern Fan Project or Project) will be operated to provide both public and non-public benefits by recharging and storing State Water Project (SWP) unallocated Article 21 water in the Kern County Subbasin of the San Joaquin Valley Groundwater Basin in wet years and extracting water when needed in dry years to provide ecosystem, emergency supply, and water supply benefits. The Unallocated Article 21 water supplies recharged and stored in the Kern Fan Project will be allocated to the Project beneficiaries as follows:

25% to the Public or Ecosystem account
37.5% to the IRWD/DRWD account
37.5% to the Rosedale account

MBK Engineers' analysis simulated water stored in each of the three accounts. Project recharge rates are simulated as a function of recharge in preceding months based on IRWD and Rosedale's experience and assumptions made in the Draft Concept Study (Dee Jaspar & Associates, 2017). Approximately 25 percent of the stored water would be held as SWP system water that would be used for ecosystem benefits purposes. This 25 percent of the water would be made available for ecosystem benefits through 1-for-1 exchanges that would occur when the water is extracted from the ground. The 1-for-1 exchanges would result in Table A water that is held in Lake Oroville, being reclassified as SWP system water and the SWP system water being extracted from the ground, being reclassified as Table A water. The Table A water would be used to meet DRWD and Rosedale SWP Table A demands either directly or through operational exchanges. The SWP system water left in Oroville Reservoir would then be used to provide short-term ecosystem pulse flows to generate ecosystem benefits by improving habitat for fish in the Feather and Sacramento Rivers and Delta. The 1-for-1 exchanges would result in the water extracted from the ground and used by DRWD and Rosedale being classified as Table A water and the water left in Oroville Reservoir for use in providing ecosystem benefits being classified as SWP system water.

Identify the current conditions date (i.e., year) that will be used within the application.

2030

Ecosystem improvement application instructions:

To complete the ecosystem improvement section of the Water Storage Investment Program application review the 16 ecosystem priorities listed above, determine which priorities will be addressed by your project's ecosystem improvements, and answer all questions for each priority you will address. In addition to answering the priority-specific questions, answer the general questions listed on this worksheet which apply to all priorities addressed by your project. The final relative environmental value of each project will be based on a technical review of each ecosystem priority using relative environmental criteria (REV) 2-10 and the total number of priorities claimed by a project (REV 1).

For the purpose of this application the Current Conditions date will be based on the existing conditions of an applicant's CEQA document. If specific data requested in this application is not available in the CEQA document, the applicant will use the demarcation date of the existing conditions in the CEQA document. An applicant must use the demarcation date of the existing conditions from their CEQA document consistently within the application when identifying current conditions.

REV 1: Number of ecosystem priorities targeted by the project

Briefly explain which ecosystem priorities will be met by this project.

The Kern Fan Project will meet ecosystem priorities 2, 12, and 14. Approximately 25 percent of the water stored in the Project is designated for the ecosystem account which would be held as SWP system water to be used for ecosystem benefits purposes when needed. Operation of the Project will be coordinated with that of the SWP to enable the DWR to release pulses of water from Oroville Reservoir when water is needed for fish spawning, rearing, and migration. The pulse flows (Ecosystem Pulses) will provide measurable improvements to environmental habitat in the Feather River downstream of Oroville Dam, and in the Sacramento River, from its confluence with the Feather River through the Delta thus meeting the criteria for WSIP Ecosystem Priorities 2 and 12 benefits. The Kern Fan Project is also expected to provide intermittent wetland habitat along the recharge basins where marsh-like environments are established during recharge periods and create ideal habitat for waterfowl, shorebirds, raptors, and other native and migrating birds thus meeting the criteria for WSIP Ecosystem Priority 14. These conditions are expected to exist whenever recharge activity occurs on the Project sites.

REV 4: Inclusion of an adaptive management and monitoring program that includes measurable objectives, performance measures, thresholds, and triggers to achieve ecosystem benefits.

Describe the process through which an adaptive management and monitoring program will be developed for approval by the responsible agency.

IRWD and Rosedale will work with the CDFW to develop an adaptive management and monitoring program that meets the requirements of the program regulations.

Describe the framework you will use to develop measurable objectives, performance measures, thresholds, and triggers for your adaptive management and monitoring program.

IRWD and Rosedale will consult with the appropriate agencies to develop relevant measurable objectives for each of the three ecosystem priorities that the project will address. As suggested by Cramer Fish Sciences, a relevant performance metric for Priority 2 may be an observed flow-survival relationship consistent with the predicted flow-survival relationship described by National Marine Fisheries Service (NMFS). IRWD and Rosedale may participate in and support flow-survival studies relevant to evaluating performance of the flow pulses in achieving expected ecosystem benefits.

Performance measures associated with Priority 12 would be developed upon new information becoming available to quantify expected benefits. IRWD and Rosedale may also participate in and support monitoring programs which assess flow effects on green sturgeon passage on the Feather River.

Performance measures associated with Priority 14 would be developed to be consistent with local and regional conservation plans such as the Central Valley Joint Venture Implementation Plan. Benefits associated with this priority would be monitored by conducting bird surveys during the years in which recharge activity occurs.

How will operational decisions be made if physical parameters and biological responses fall outside the range of anticipated benefits?

Should the physical parameters and biological responses fall outside the range of anticipated benefits, IRWD and Rosedale will work with the appropriate agencies to determine a solution that restores the anticipated amount of ecosystem benefits without infringing upon other expected benefits such as emergency response and water supply.

What funding sources and financial commitments do you intend to utilize for the formation and implementation of an adaptive management and monitoring program over the duration of the claimed benefits?

Should the Kern Fan Project be awarded Prop 1 WSIP funding, IRWD and Rosedale will move forward in developing an adaptive management and monitoring program that meets the requirements of the program regulations. It is expected that the development of the plan would be jointly funded through IRWD and Rosedale's respective annual operating budgets. (See under **Feasibility and Implementation Risk Tab, Attachment 1** – Financial Feasibility). The implementation of the adaptive management plan over the duration of the claimed benefits would also be funded through IRWD and Rosedale's respective annual operating budgets.

Explain what environmental uncertainties are relevant to your claimed benefit(s) and will be included in your adaptive management and monitoring program (i.e. climate change, sea level rise, earthquakes, variation in snow pack, forest fires, landslides/erosion etc.).

Environmental uncertainties relevant to the benefits provided by the Project include climate change, variation in snow pack and periods of multi-year drought because the project benefits depend on unallocated Article 21 water supply available for recharge and storage in the project. MBK Engineers performed uncertainty analyses related to the potential future (WSIP 2070) climate change, including Project performance during critical droughts and the California WaterFix. This uncertainty analysis is included in the MBK Engineers Technical Memorandum and associated model, August, 2017. (See under the **Feasibility and Implementation Risk Tab, Attachment 1** – Technical Feasibility (MBK Engineers Report 2017). Results from the uncertainty analyses would be taken into consideration upon development of the adaptive management and monitoring program for the project.

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

REV 9: Efficient use of water to achieve multiple ecosystem benefits

Will the same unit of water benefit multiple priorities? If so, explain which priorities will benefit, and the anticipated differences in project water availability between priorities.

Water that accrues in the ecosystem account will provide benefit for the ecosystem priority 2 and ecosystem priority 12. When water is physically recharged into the groundwater basin at the project sites it will provide a temporary wetland habitat benefit for birds (ecosystem priority 14). When an ecosystem pulse is made and a 1-for-1 exchange occurs, the water extracted from the ground and used by DRWD and Rosedale is classified as Table A water and the water left in Oroville Reservoir for use in releasing the ecosystem pulse is reclassified as SWP system water. SWP system water released as part of an ecosystem pulse then provides increased flows in the Feather River which results in benefits for ecosystem priority 2 and ecosystem priority 12.

How will hydrologic connections among priorities be measured and guaranteed?

Hydrologic connections among priorities will be measured and guaranteed through implementation of the adaptive management and monitoring plan.

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

7. ECOSYSTEM PRIORITY 2 WORKSHEET

Priority 2: Provide flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids.

Species Information

What salmonid species are you targeting?

Juvenile Central Valley spring-run Chinook salmon are the primary target of the spring flow pulse provided by the proposed project. April represents the peak month for outmigration of juvenile spring-run Chinook from the Feather and Sacramento River basins.

Winter-run Chinook juveniles in the Sacramento River downstream of Verona (the confluence with the Feather River) will also benefit from the flow pulse provided by the proposed project.

Steelhead smolts emigrating from the Feather and Sacramento River basins will also benefit, but insufficient data are available to quantify these benefits.

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the flow related habitat needs of each species are described.

The basis for expected flow-related benefits are described and source-referenced in the Cramer Fish Sciences Technical Memorandum (CFS 2017) See also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) in WSIP funding application.
Also see NMFS (2016a) and NMFS (2017) referenced in CSF 2017 report.

See Revised CFS Technical Memorandum and models provided as part of the Appeal.

REV 2: Magnitude of ecosystem improvements

What is the expected magnitude of the ecosystem improvement that will address this priority? Magnitude should be expressed as: a) the change from current conditions without the project to current conditions with the project, and b) the change from 2030 conditions without the project to 2030 conditions with the project. How did you estimate this value?
If the ecosystem improvement will benefit multiple salmonid species or runs, provide the magnitude of the ecosystem improvement for each species or run separately.

In 2030 conditions, the project provides for seven~~six~~ additional April, Feather River flow pulses over 82 years of simulated hydrology (MBK 2017). Over fifty years of operations with the project (2030 conditions) these April flow pulses are expected to provide a net benefit of 1011 ~~586~~ (range of 674-1348) additional ADULT Central Valley spring-run Chinook salmon and 109~~41~~ (range of 73-145) additional ADULT Sacramento River winter-run Chinook salmon.

In the 2070 condition, the project provides for five additional April, Feather River flow pulses over 82 years of simulated hydrology (MBK 2017). Over fifty years of operations (2070 conditions) these April flow pulses are ~~s~~ expected to provide a net benefit of 715 (range of 476-953) ~~428~~ additional ADULT Central Valley spring-run Chinook salmon and ~~32~~73 (range of 48-97) additional ADULT Sacramento River winter-run Chinook salmon.

Methods used to assess and quantify these methods are described in the Cramer Fish Sciences Technical Memorandum See **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) in WSIP funding application.

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models provided as part of the Appeal.

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the magnitude of the ecosystem improvement is described and quantified.

The basis for expected flow-related benefits are described and source-referenced in the Cramer Fish Sciences Technical Memorandum. See **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) in WSIP funding application.
Also see NMFS (2016a) and NMFS (2017) referenced in CSF 2017 report.

See Revised CFS Technical Memorandum and models provided as part of the Appeal.

REV 3: Spatial and temporal scale of ecosystem improvements.
What is the geographical extent (e.g. river miles, acres) of the ecosystem improvement that will address this priority?
Flow pulses associated with the project will effect approximately 60 river miles of the Feather River (from the Thermalito Afterbay Outlet to Verona) and 67 river miles of the Sacramento River (from Verona to Rio Vista).
Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) where the geographical extent of the ecosystem improvement is documented or mapped.
https://www.sacramentoriver.org/sac_river_atlas.php http://www.water.ca.gov/orovillerelicensing/docs/wg_study_reports_and_docs/EWG/sp-g2_interim_report_part_c%20.pdf
When during the year will the project provide flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids? How are flows likely to vary with hydrologic conditions (i.e. among water year types) a) under current conditions with and without the project, and b) in 2030 with and without the project? If the ecosystem improvement will benefit multiple salmonid species or runs, provide the timing of ecosystem improvements for each species or run separately.
The flow pulse will occur in the month of April. With 2030 conditions, over 82 years of historic hydrologies the flow pulse occurs seven~~six~~ times. Five times in dry water years and twice~~once~~ in an extremely dry water year. Since flow pulses occur in years with generally low river flows (without the project), greater benefits are achieved for target salmonids (the assumed flow-survival relationship is non-linear, see **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) for more information). See Revised CFS Technical Memorandum and models provided as part of the Appeal.
Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the timing of ecosystem improvements that address this priority are described and quantified.
See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report), and see also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report. See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal. See Revised CFS Technical Memorandum and models provided as part of the Appeal.
REV 4: Inclusion of an adaptive management and monitoring program that includes measurable objectives, performance measures, thresholds, and triggers to achieve ecosystem benefits.
Provide additional information on how this ecosystem improvement will be incorporated into the adaptive management and monitoring program. If available, provide examples of objectives, performance measures, thresholds, or triggers that could be used to manage benefits associated with this priority.
Natural resource management entities (DWR, NMFS, CDFW, USFWS, USBR) regularly conduct survival studies on outmigration of juvenile Chinook salmon and steelhead. A relevant performance metric for the proposed project would be an observed flow-survival relationships consistent with the predicted flow-survival relationships described by NMFS (2017) and utilized in the project analysis (CFS 2017). New information on the patterns of flow-survival or emigration timing for spring-run and winter-run Chinook juveniles may suggest changes in the timing or magnitude of flow pulses provided by the project. See **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) in WSIP funding application. IRWD will participate in and support flow-survival studies relevant to evaluating performance of the flow pulses in achieving expected ecosystem benefits. See Revised CFS Technical Memorandum and models provided as part of the Appeal.
REV 5: Immediacy of ecosystem improvement actions and realization of benefits
Immediacy of ecosystem improvement: Number of months from grant encumbrance until the proposed ecosystem improvement is completed (i.e. the expected timeframe until the improvement is implemented or construction is completed).
The project will require 3 years and 6 months for construction and is expected to begin storing water available for flow pulses by the year 2025. The year in which the first flow pulse will be delivered is dependent on future hydrologies and cannot be predicted in advance.

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the immediacy timeframe is described and quantified.

See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report), and see also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report.

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models provided as part of the Appeal.

Realization of ecosystem improvement: Number of months from the time the ecosystem improvement is completed (i.e. project is implemented or construction is complete), until the benefit associated with this priority can be observed (i.e. when measurable improvements can be observed and quantified)

Analysis conducted by MBK indicates 7~~6~~ flow pulses will occur with the project over 82 years of historic hydrologies (2030 conditions). If we assume each historic water year is an independent event, then there is 8.5~~7.3~~% probability of a project flow pulse occurring in any year after the project is fully operated. ~~There is a greater than 50% probability of at least one project related flow pulse occurring within ten years of the project operating.~~ See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report).

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the realization timeframe is described and quantified.

See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report),

REV 6: Duration of ecosystem improvements

How long (number of years) after realization (as calculated under REV 5 above) is the ecosystem improvement expected to address this priority? Maximum is 100 years. Explain how this value was determined and whether the magnitude of the ecosystem improvement is anticipated to change over time.

After realization, a minimum of 13~~8~~,860~~000~~ AF of groundwater will need to accrue in the Ecosystem Benefits account in order to make a flow pulse. Assuming historic hydrologies and each water year occurs as independent event, flow pulses associated with the project are expected to occur with an annual probability of 8.5~~7.3~~%. The ecosystem improvement will address this priority whenever a flow pulse occurs.

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the duration of the ecosystem improvement is described and quantified.

See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report). Also see the Operations Plan located in the **Benefit Calculation, Monetization, Resiliency Tab, Attachment 2.**

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal

REV 7: Consistency with species recovery plans and strategies, initiatives, and conservation plans

Does the ecosystem improvement meet any goals or objectives established in existing species recovery plans, initiatives, or conservation plans including but not limited to the NOAA Fisheries Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead; State Wildlife Action Plan; Central Valley Joint Venture Implementation Plan, San Joaquin County Multi-Species Habitat Conservation Plan and Open Space Plan, Draft Solano Multi-Species Habitat Conservation Plan, East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan, Draft Recovery Plan for the Giant Garter Snake, and California Water Action Plan? If so which goals, objectives, or actions will be met? Why?

Yes. Flow pulses to improve rearing and outmigration survival of winter-run Chinook salmon, spring-run Chinook salmon and steelhead are identified in the NMFS recovery plan for the species. Specifically, Actions IDs SFB-1.3, DEL-1.1, DEL-1.3, and FER-1.10 from the 2014 NMFS recovery plan. In addition, the Biological Opinion for operation the Oroville Facilities (NMFS 2016) specifically calls for evaluation of Feather River flow pulses to benefit spring-run Chinook, steelhead and green sturgeon.

See Revised CFS Technical Memorandum and models provided as part of the Appeal.
Additional locations in the application, supporting documentation or attachments (page number, table number, other) where the consistency with goals, objectives, or actions from recovery plans, initiative, or conservation plans are discussed.
See Cramer Fish Sciences Report under file name IRWD_Tab 4-A2-CFS_TechMemo_Final.docx included in the **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2.** See Revised CFS Technical Memorandum and models provided as part of the Appeal.
REV 8: Location of ecosystem improvements and connectivity to areas already being protected or managed for conservation values
Provide a map that shows the extent of the ecosystem improvement that will address this priority (e.g. river miles that meet the temperature benefits). Provide additional instructions or clarification to reviewers who will be viewing this map (i.e. describe the color and/or label that identifies the spatial extent of the ecosystem improvement). If available, also submit supporting electronic files such as a .kmz file or ArcGIS layer associated with the maps provided.
The ecosystem benefits associated with the project will occur within the active channel of the Feather River. A map of the Feather River is included in under **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2,** see IRWD_FeatherRiverMap.pdf.
Explain why this location was selected. How is the location beneficial to the targeted species in the context of local environmental conditions and the target species' needs?
The Feather River was selected because of its function as a corridor of water conveyance for the State Water Project and because the Feather River hosts in-river and hatchery spawning; Feather River spring-run Chinook salmon both part of the listed CV spring-run Chinook salmon ESU (NMFS 2016b). NMFS, in their most recent five-year review of CV spring-run, assigned a recovery priority for spring-run Chinook salmon in the Feather River of 5 (with 1 being the highest priority, 12 being the lowest priority) (NMFS 2016b). These determinations are based upon the evolutionary legacy the Feather River spring-run stock represents, because the stock continues to exhibit a CV spring-run Chinook salmon migration timing, and because of habitat and management improvements required as part of the Oroville Facilities FERC Relicensing Settlement Agreement. Project flow pulses originating in the Feather River affect the Sacramento River downstream of Verona and thereby benefit spring-Chinook, winter Chinook and steelhead originating from points upstream in the Sacramento River basin. See Cramer Fish Sciences Report included in **Physical Public Benefits Tab, Ecosystem Benefits Section, Attachment 2** – CFS 2017 report for references cited above. See Revised CFS Technical Memorandum and models provided as part of the Appeal.
Is the ecosystem improvement location adjacent to, or near, other areas already being protected or managed for conservation values? Explain the proximity of the ecosystem improvement to other areas already being protected or managed for conservation values and any hydrologic connectivity that may occur between these locations.
The Feather and Sacramento River corridors are adjacent to numerous habitat features managed for conservation of anadromous salmonids and other species. For example, existing or future floodplain enhancements on the Feather and Sacramento River could benefit from project flow pulses if those flow pulses helped to extend or achieve floodplain inundation in conjunction with flow pulse events originating from other water sources. The flow pulses provided by the project are not expected to appreciably inundate floodplain features alone, but could compliment other such efforts.
Are the flows provided physically accessible by the targeted species in all year types? If not, explain barriers that may exist between the targeted species and ecosystem improvements.
Yes. The Feather and Sacramento Rivers are essential migratory corridors for juvenile salmonids in April of all water year types.
Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe and quantify the spatial extent of the ecosystem improvement, the proximity of the ecosystem improvement to other areas already being protected or managed for conservation value, and the degree to which hydrologic connections (if any) occur between the ecosystem improvement and areas already being protected or managed for conservation value.
None that can be specifically identified and quantified.

REV 9: Efficient use of water to achieve multiple ecosystem benefits

How will water provided to address this priority be managed? Explain design efficiencies and operational strategies intended to maximize the efficiency of water allocated to ecosystem improvements that address this priority.

Ecosystem benefits for this priority are achieved when a flow pulse is released. In the years when flow pulses are released, Delta carriage water costs are reduced because project water was exported during periods of Delta surplus with no carriage water cost and stored in the export service area. The model used to calculate these benefits assumes 20 percent carriage water and the 3 percent conveyance loss can be saved when extracting water from the project for delivery within the export service area instead of meeting those demands from Oroville Reservoir.

Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe the design efficiencies and operational strategies used to maximize water efficiency under this priority.

For a description and details on design efficiencies and operational strategies to maximize water efficiency, see page 6 of the MBK Engineers' Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report)., and see also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report.
See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models provided as part of the Appeal.

REV 10: Resilience of ecosystem improvements to the effects of changing environmental conditions, including hydrologic variability and climate change.

Which environmental uncertainties associated with this priority were considered in the project siting, design, and operation? How were these uncertainties incorporated into project siting, design, or operation? Examples of environmental uncertainties include, but are not limited to: sea level rise, temperature changes, changes in precipitation, landslides, erosion, earthquakes, wildfires, drought events, and flooding events.

MBK Engineers (MBK) performed uncertainty analyses related to potential climate change, the California Water Fix, and the project's performance during drought. Using the results from these uncertainty analyses, CFS determined the change in winter-run and spring-run adult Chinook salmon over fifty years of project operations. Under 2070 climate change conditions, the project provided a net benefit of 715~~428~~ (range of 476-953) spring-run Chinook and 73~~32~~ (range of 48-97) winter-run Chinook. Under the California Water Fix future condition the project provided a net benefit of 1044~~452~~ (range of 696-1392) spring-run Chinook, ~~and~~ net benefit ~~loss~~ of 74 (range of 50-99)~~34~~ winter-run Chinook. ~~The reason for net loss of winter-run Chinook is because North Delta diversions associated with the California Water Fix more directly impact winter-run Chinook smolts than do South Delta exports.~~ Further information on the uncertainty analyses preformed can be found in the MBK Engineers' and the CFS reports under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report) and also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report.
See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models provided as part of the Appeal.

Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe and quantify the environmental uncertainties considered in the project siting, design, and operation.

See MBK Engineers and Cramer Fish Sciences reports under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report), and also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report.
See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models provided as part of the Appeal.

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

8. ECOSYSTEM PRIORITY 14 WORKSHEET

Priority 14: Provide water to enhance seasonal wetlands, permanent wetlands, and riparian habitat for aquatic and terrestrial species on State and Federal wildlife refuges and on other public and private lands
REV 2: Magnitude of ecosystem improvements
What is the expected magnitude of the ecosystem improvement that will address this priority? Magnitude should be expressed as: a) the change from current conditions without the project to current conditions with the project, and b) the change from 2030 conditions without the project to 2030 conditions with the project. How did you estimate this value?
In 2030 conditions over a 50 year operating period, it is expected that the project would provide temporary wetland habitat to migratory birds for an average duration of approximately 1.5 months during years in which recharge activity occurs. This incidental benefit occurs whenever water is being recharged onto the project sites. The availability of temporary habitat was then determined by the availability of water supply for the project.
Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the magnitude of the ecosystem improvement is described and quantified.
See 'IRWD_Priority14' file under the **Physical Public Benefits Tab, Ecosystem Benefits Section, Attachment 2.** See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.
REV 3: Spatial and temporal scale of ecosystem improvements.
What is the geographical extent (e.g. river miles, acres) of the ecosystem improvement that will address this priority?
The project would provide water to approximately 1,200 acres of recharge ponds located on two separate project sites. The temporary wetland area would be the area of the recharge ponds.
Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) where the geographical extent of the ecosystem improvement is documented or mapped.
Location of the proposed project facilities that demonstrates the extent of the temporary wetland area is located in **Feasibility and Implementation Risk Tab, Attachment 1** – Appendix A (Dee Jaspar & Associates Draft Concept Study, 2017).
When during the year will water be provided for seasonal wetlands, permanent wetlands, and riparian habitat? How are seasonal wetlands, permanent wetlands, and riparian habitat likely to vary with hydrologic conditions (i.e. among water year types) a) under current conditions with and without the project, and b) in 2030 with and without the project?
Water is estimated to be recharged on the project sites and will provide temporary wetland habitat during the winter months of wet, above normal and below normal water years when recharge activity occurs. Under 2030 conditions during wet years when recharge activity occurs, the project can be expected to provide approximately 1.44 months of temporary wetland habitat. Under these conditions during above normal years approximately 2 months of temporary habitat can be expected and during below normal years approximately 1 month of temporary habitat can be expected.
Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the timing of water releases for seasonal wetlands, permanent wetlands, or riparian habitat improvements are described and quantified.
See 'IRWD_Priority14' file under the **Physical Public Benefits Tab, Ecosystem Benefits Section, Attachment 2**. See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.
REV 4: Inclusion of an adaptive management and monitoring program that includes measurable objectives, performance measures, thresholds, and triggers to achieve ecosystem benefits.
Provide additional information on how this ecosystem improvement will be incorporated into the adaptive management and monitoring program. If available, provide examples of objectives, performance measures, thresholds, or triggers that could be used to manage benefits associated with this priority.
IRWD and Rosedale will work with the CDFW to develop an adaptive management and monitoring program that meets the requirements of the program regulations. In order to measure performance of the public benefit provided by the project, IRWD and Rosedale intend to conduct bird surveys during the years in which recharge activity occurs. In addition, IRWD and Rosedale may coordinate monitoring programs with other local agencies near the project site that currently manage wetland habitats.
REV 5: Immediacy of ecosystem improvement actions and realization of benefits
Immediacy of ecosystem improvement: Number of months from grant encumbrance until the proposed ecosystem improvement is completed (i.e. the expected timeframe until the improvement is implemented or construction is completed).

The project will require approximately 3 years and 6 months for construction to be completed and is expected to be able to begin to store water by the year 2025. The year in which the unallocated Article 21 water is first delivered to the recharge ponds is dependent upon future hydrologies and cannot be predicted in advance.
Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the immediacy timeframe is described and quantified.
Project schedule is located in the **Feasibility and Implementation Tab, Attachment 3.**
Realization of ecosystem improvement: Number of months from the time the ecosystem improvement is completed (i.e. project is implemented or construction is complete), until the benefit associated with this priority can be observed (i.e. when measurable improvements can be observed and quantified)
Construction of the project is expected to be completed in 2025. Water will be recharged into the ponds as soon as unallocated Article 21 water supply becomes available for the project. The temporary wetland habitat will be available for migratory birds and other water fowl when water is recharged into the ponds.
Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the realization timeframe is described and quantified.
Project schedule is located in the **Feasibility and Implementation Tab, Attachment 3**.
REV 6: Duration of ecosystem improvements
How long (number of years) after realization (as calculated under REV 5 above) is the ecosystem improvement expected to address this priority? Maximum is 100 years. Explain how this value was determined and whether the magnitude of the ecosystem improvement is anticipated to change over time.
After realization of this improvement, the project is expected to provide temporary wetland habitat to migratory birds whenever recharge activity occurs on the project sites. Over an 82 year simulation period using historical hydrology, the project was expected to have a total of 21~~3~~ months of recharge under 2030 conditions. Using historical hydrology, it was determined that the project would have 1 to 3 months of temporary habitat during years in which recharge activity occurs depending on the year type. Duration of recharge was determined using the approximate area of recharge basins (1,200 acres), recharge rate of land (0.7 ft/day), and amount of water recharged per event.
Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the duration of the ecosystem improvement is described and quantified.
See 'IRWD_Priority14' file under the **Physical Public Benefits Tab, Ecosystem Benefits Section, Attachment 2.** See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.
REV 7: Consistency with species recovery plans and strategies, initiatives, and conservation plans
Does the ecosystem improvement meet any goals or objectives established in existing species recovery plans, initiatives, or conservation plans including but not limited to the NOAA Fisheries Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead; State Wildlife Action Plan; Central Valley Joint Venture Implementation Plan, San Joaquin County Multi-Species Habitat Conservation Plan and Open Space Plan, Draft Solano Multi-Species Habitat Conservation Plan, East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan, Draft Recovery Plan for the Giant Garter Snake, and California Water Action Plan? If so which goals, objectives, or actions will be met? Why?
As identified in the Stockdale Integrated Banking Project Final EIR, the tricolored blackbird is considered to have a high potential to occur near the project site. The open water canals and agricultural fields on and near the proposed project sites can support the species. The tricolored blackbird is not a focal species in the Central Valley Joint Venture Implementation Plan however the Central Valley Joint Venture Implementation Plan states that it is a partner in the conservation of the tricolored blackbird species. In addition, the tricolored blackbirds are the focus of conservation efforts supported by partners of the Central Valley Joint Venture.
Additional locations in the application, supporting documentation or attachments (page number, table number, other) where the consistency with goals, objectives, or actions from recovery plans, initiative, or conservation plans are discussed.
Further information can be found in the Environmental Setting section of the Stockdale Integrated Banking Project Final EIR. See link to Final EIR located in the **Feasibility and Implementation Risk Tab, Attachment 4.**

REV 8: Location of ecosystem improvements and connectivity to areas already being protected or managed for conservation values
Provide a map that shows the extent of the ecosystem improvement that will address this priority (e.g. river miles that meet the temperature benefits). Provide additional instructions or clarification to reviewers who will be viewing this map (i.e. describe the color and/or label that identifies the spatial extent of the ecosystem improvement). If available, also submit supporting electronic files such as a .kmz file or ArcGIS layer associated with the maps provided.
The temporary wetland habitat expected to be made available from the project will be within the recharge basins that will be constructed on two project sites, totally approximately 1,200 acres. A map showing the location of the proposed project sites is located in the **Feasibility and Implementation Risk Tab, Attachment 1** – Appendix A (Dee Jaspar & Associates Draft Concept Study, 2017).
Explain why this location was selected. How does this location enhance seasonal wetlands, permanent wetlands, and riparian habitat for aquatic and terrestrial species in the context of local environmental conditions?
The temporary wetland habitat expected to be made available from the project is an incidental benefit that occurs as result of normal project recharge operations during wet, above normal, and below normal water years. The two project sites were selected due to their soils properties and expected infiltration rates. The two project sites are also ideal within proximity to current water banking projects owned by IRWD and Rosedale as well as located within the additional site radius boundary identified in the Stockdale Project Final EIR (located in the **Feasibility and Implementation Risk Tab, Attachment 4**). The project's location is in the vicinity of properties managed by the Kern Water Bank Authority where several species of birds have been surveyed. The temporary habitat provided by the project would augment existing habitat to these birds.
Is the ecosystem improvement location adjacent to, within, or near, other areas already being protected or managed for conservation values? Explain the proximity of the ecosystem improvement to other areas already being protected or managed for conservation values and any hydrologic connectivity that may occur between these locations.
The proposed properties for the project are located within approximately 2 miles of the northern boundary of the Kern Water Bank. The Kern Water Bank property is a State and Federally designated habitat for sensitive and endangered native plant and animal species. 3,267 acres of the Kern Water Bank are designated as a Conservation Bank for projects located within the Kern Water Bank Authority Permit Area in the southern San Joaquin Valley. The Kern Fan project will recharge water through shallow ponds into the same underground aquifer that the Kern Water Bank recharges water into.
Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe and quantify the spatial extent of the ecosystem improvement, the proximity of the ecosystem improvement to other areas already being protected or managed for conservation value, and the degree to which hydrologic connections (if any) occur between the ecosystem improvement and areas already being protected or managed for conservation value.
A map showing the vicinity of the project to the Kern Water Bank is shown as Figure 3.4-2 in the Stockdale Project Final EIR. A link to the Final EIR is located in the **Feasibility and Implementation Risk Tab, Attachment 4.**
REV 9: Efficient use of water to achieve multiple ecosystem benefits
How will water provided to address this priority be managed? Explain design efficiencies and operational strategies intended to maximize the efficiency of water allocated to ecosystem improvements that address this priority.
Unallocated Article 21 water is the supply anticipated for this project and provides an incidental benefit when recharged into the filtration ponds located on the project properties. Therefore any water supply acquired for this project will not only provide water supply benefits, emergency supply benefits, and benefits to winter and spring-run chinook salmon but will at the same time provide temporary habitat to migratory bird species when being recharged.
Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe the design efficiencies and operational strategies used to maximize water efficiency under this priority.
Further information on how the project will be operated is located in the **Benefit Calculation, Monetization, Resiliency Tab, Attachment 2** (Preliminary Operations Plan).
REV 10: Resilience of ecosystem improvements to the effects of changing environmental conditions, including hydrologic variability and climate change.
Which environmental uncertainties associated with this priority were considered in the project siting, design, and operation? How were these uncertainties incorporated into project siting, design, or operation? Examples of environmental uncertainties

include, but are not limited to: sea level rise, temperature changes, changes in precipitation, landslides, erosion, earthquakes, wildfires, drought events, and flooding events.
The availability of temporary wetland habitat provided by the project is directly related to the amount of water recharged onto the project site. Therefore any uncertainty associated with providing this ecosystem improvement is a result of decrease in the project's overall water supply. MBK Engineers performed uncertainty analyses related to potential climate change, the California Water Fix, and the project's performance during drought. MBK Engineers determined that under 2070 climate change conditions the project's average annual recharge is increased ~~reduced~~ by 1~~4~~00 AF. The availability of temporary habitat over fifty years of project operations then decreases by approximately 1 month. However with the California Water Fix, MBK determined the project's average annual recharge increases by 2,300~~5,500~~ AF thereby significantly increasing the availability of temporary habitat. See **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report), See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.
Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe and quantify the environmental uncertainties considered in the project siting, design, and operation.
More information on uncertainty analyses performed for the project can be found in the **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report). See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

9. THOMAS HARDER & CO. ANALYTICAL MODEL FOR GROUNDWATER LEVEL BENEFITS

NOT INCLUDED IN THIS COPY

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

10. SUPPLEMENTAL INFORMATION RELATED TO OTHER BENEFITS NOT QUANTIFIED

Supplemental information related to other benefits not quantified

10a. Cramer Fish Sciences Technical Memorandum: Steelhead Benefits

10b. M.Cubed Spreadsheet quantification support for Steelhead Benefits

-Supplemental Benefits worksheet

-Input from Cramer Fish worksheet

-Input from TR worksheet

10c. Supplemental Ecosystem Priority 2 Worksheet Revised for Steelhead Benefits

10d. Benefit and Cost Analysis Spreadsheets updated to include Steelhead Benefits:

-Benefit Ratios worksheet

-Cost Allocation worksheet

-Dashboard worksheet

-DJA O&M PV worksheet

-DJA Replacement PV worksheet

-DJA O&M Cost Estimate worksheet

-DJA Const Cost Estimate worksheet

-WSIP 2030 MBK Operations worksheet

-WSIP 2070 MBK Operations worksheet

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

10. SUPPLEMENTAL INFORMATION RELATED TO OTHER BENEFITS NOT QUANTIFIED

A. CRAMER FISH SCIENCES TECHNICAL MEMORANDUM: STEELHEAD BENEFITS

Brad Cavallo
Principal Scientist
13300 New Airport Rd, Suite 102
Auburn, CA 95602
bcavallo@fishsciences.net

February 22nd, 2018

TECHNICAL MEMORANDUM

Subject: Steelhead Benefits from Kern Fan Groundwater Storage Project

Prepared for: Irvine Ranch Water District

Prepared by: Brad Cavallo, Dr. Steven Zeug and Dr. Myfanwy Johnston.

This technical memorandum provides a description of methodology, assumptions and results for an assessment of Steelhead ecosystem benefits resulting from the Kern Fan Groundwater Storage Project (Project).

1. Project operations for ecosystem benefits

The WSIP identifies sixteen priorities for ecosystem benefits. Cramer Fish Sciences (CFS) consulted with MBK Engineers and Irvine Ranch Water District to recommend how 18 thousand acre-feet (TAF) of additional water supply made available by proposed Project could be used to provide the greatest benefit to ecosystem priorities and relative environmental value criteria (Revs). CFS recommended a pulse released from Lake Oroville in the month of April. CALSIM analysis provided by MBK Engineers indicated the Project could, with 1922-2003 hydrology under the WSIP 2030 future condition, provide for seven April flow pulses (of 18 TAF) in dry or critically dry years. Under the WSIP 2070 future condition, the Project can provide for five April flow pulses (of 18 TAF) in dry or critically dry years.

CFS recommended and assumed the 18TAF would be applied as a 3.75 day, 2,400cfs increase in Feather River flows released from the Thermalito Afterbay Outlet (TAO). Releasing this water from the TAO is important because the Feather River downstream of TAO has no ramping criteria for flows greater than 2,500 cfs (NMFS 2016a).

2. Methods for quantifying ecosystem benefits

Two ecosystem priorities are the primary beneficiaries of an April flow pulse on the Feather River. Ecosystem Priority 2 (P2) calls for "flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids. April is a period of "high" relative abundance for downstream migration and rearing of juvenile steelhead in the Feather River (NMFS 2016a).

Though April flow pulses are expected to benefit multiple fish species and life stages, our quantitative analysis here focuses on assessing benefits to outmigrating steelhead smolts originating from the Feather River Hatchery.

River and Delta Analysis

Feather River natural and hatchery produced steelhead are designated as part of the California Central Valley (CCF) Distinct Population Segment (NMFS 2016b). Though natural origin CCV steelhead smolts occur in the Feather River, information on their abundance and emigration timing is highly uncertain (NMFS 2016b). In contrast, annual production of steelhead smolts by Feather River Hatchery (FRH) is well understood. FRH annually releases roughly 450,000 yearling CCV steelhead. FRH steelhead are released into the Feather River in late winter/early spring. For purposes of this analysis we assume all FRH steelhead releases will occur at Boyd's Pump. Boyd's pump is appropriate because it is a commonly used release site, and because it is the only Feather River location where releases have been intensively studied via acoustic tagging. Though future FRH release locations are unknown, the California Hatchery Scientific Review Group has recommended all hatchery production be released as close to the source hatchery as possible (CA HSRG 2012). Boyd's pump would appear the most downstream location that may satisfy CA HSRG recommendations. If future releases are instead made at locations upstream of Boyd's Pump, then this analysis would be underestimating (rather than overestimating) survival benefits associated with a flow pulse.

Table 1. Values, descriptions and sources for inputs and parameters used for the quantification of Project ecosystem benefits.

Name	Value	Description	Source
St FRH	450,000	Annual FRH steelhead production.	NMFS 2016(a)
relf	0.25	Fraction of FRH steelhead smolts expected to be coordinated to coincide with flow pulse	NA
B0	-0.85	FRH steelhead survival to the Golden Gate (log base e scale)	See text
B1	1.47	Flow survival effect (log base e scale)	NMFS (2017), Table B1. See text for more details.
Qm	variable	Standardized Feather River flow by month	CALSIM output
Sa	0.0144	Mean survival rate for smolts to return as adults	Zeug et al. (2012). See text for more details.
Sa max	0.0192	Maximum survival rate for smolts to return as adults	Zeug et al. (2012). See text for more details.
Sa min	0.0096	Miimum survival rate for smolts to return as adults	Zeug et al. (2012). See text for more details.

Other data and sources used to evaluate effects of the proposed Project on the survival of Feather River steelhead are summarized in Table 1. Related source flow data and calculations are shown in the Excel spreadsheet "FR_analysis_steelhead".

The annual number of FRH steelhead smolts reaching the Golden Gate Bridge entering the (St_B) is estimated by

(eq1) $$St_{FRH} * relf * surv_m$$

where survival for hatchery steelhead ($surv_m$) is modeled as a function of monthly Feather River flows

(eq2) $$logit(surv_m) = B0 + B1 * Q_m$$

where B0 and B1 are model parameters (Table 1), and where Q_m is monthly Feather River flows standardized relative to all monthly Feather River flow observations (provided by CALSIM). Monthly flow data (1922 through 2003) representing four future conditions (WISP 2030, WISP 2030, WF_Base and WF) and two scenarios (Project and no project) were provided by MBK Engineers (see MBK 2018). A total of eight different CALSIM scenarios were analyzed.

The flow survival relationship (eq2) was developed by the NMFS Southwest Fishery Science Center as part of a life cycle modeling effort for winter-run Chinook salmon (NMFS 2017). The NMFS LCM is under continuous development, but the model (including this flow-survival function) were used in the NMFS Biological Opinion for California Water Fix (http://www.westcoast.fisheries.noaa.gov/central_valley/CAWaterFix.html). Of course, survival differences between the Sacramento-Feather Rivers and between winter-run Chinook and steelhead are expected. To address these expected differences, we utilized available steelhead acoustic tagging data to estimate B0, but relied upon the estimate of B1 from NMFS (2017). We utilized FRH steelhead survival estimates provided by Kurth and Hampton (2017) who estimated an average survival rate of 0.30 from Boyd's Pump to Verona (Feather River confluence with the Sacramento River). Zeug et al. (2016) estimated survival of 0.45 for acoustically tagged hatchery steelhead smolts from the Sacramento River to the Golden Gate Bridge. The combined survival for these two reaches is 0.13 (i.e. 0.30*0.45) representing survival from Boyd's Pump on the Feather River to ocean entry at the Golden Gate Bridge. Transforming 0.13 as necessary for the logit scale shown in eq2 yields a value of -0.85 for B0 (see Table 1). The resulting relationship between Feather River flow and steelhead survival is depicted in Figure 1. It is important to note that this relationship assumes the Feather River flow pulse provides benefits in both the Sacramento and Feather River, but also does not credit (or discount) the effects of Sacramento River flow changes- effectively assuming Sacramento River flows during FRH steelhead emigration are effectively neutral between Project and Non-Project conditions. CALSIM results reported by MBK indicate this is a reasonable assumption. The Delta Passage Model (DPM) was used to assess Delta effects for spring-run and winter-run Chinook salmon, but was not used for steelhead because of insufficient information from Delta acoustic tagging studies for this species.

Ideally, a Feather River flow-survival relationship would be based solely upon observations from the Feather River. However, since few observations of Feather River survival were available, we combined available Feather River information with findings from the NMFS winter-run Chinook life cycle modeling effort. Though there is uncertainty about the Feather River flow-survival relationship depicted in Figure 1, scientific literature Central Valley tributaries affirms a positive relationship between Feather River flow and juvenile salmon survival is likely. Investigations into the relationship between river discharge and juvenile salmon survival in the Central Valley have primarily focused on the Sacramento-San Joaquin Delta and several studies have reported significant positive relationships (Newman 2003, Perry 2010). Less attention has been focused on the Feather River or other upstream tributaries. However, there are multiple lines of evidence to suggest a positive flow-survival relationship operates in the Feather River. Within the Central Valley, Zeug et al. (2014) reported a significant positive relationship between river discharge (and discharge variability) and survival for juvenile Chinook salmon in the Stanislaus River. Additionally, Perry et al. (*In press*) found that survival increased in delta reaches when high levels of discharge resulted in a switch from bi-directional to unidirectional flow. A positive flow survival relationship for Chinook salmon during spring in the Snake River was reported by Smith et al. (2003). However, flow was correlated with turbidity and temperature complicating attempts to separate out effects. Regardless of the causal mechanism it is clear that increases in flow result in more favorable conditions for juvenile Chinook survival during migration.

Flow pulses produced by the Project occurred exclusively in dry years, with Feather River base flows at less than 3,000cfs. The estimated survival under these conditions occurs at the left side of the curve depicted in Figure 1.

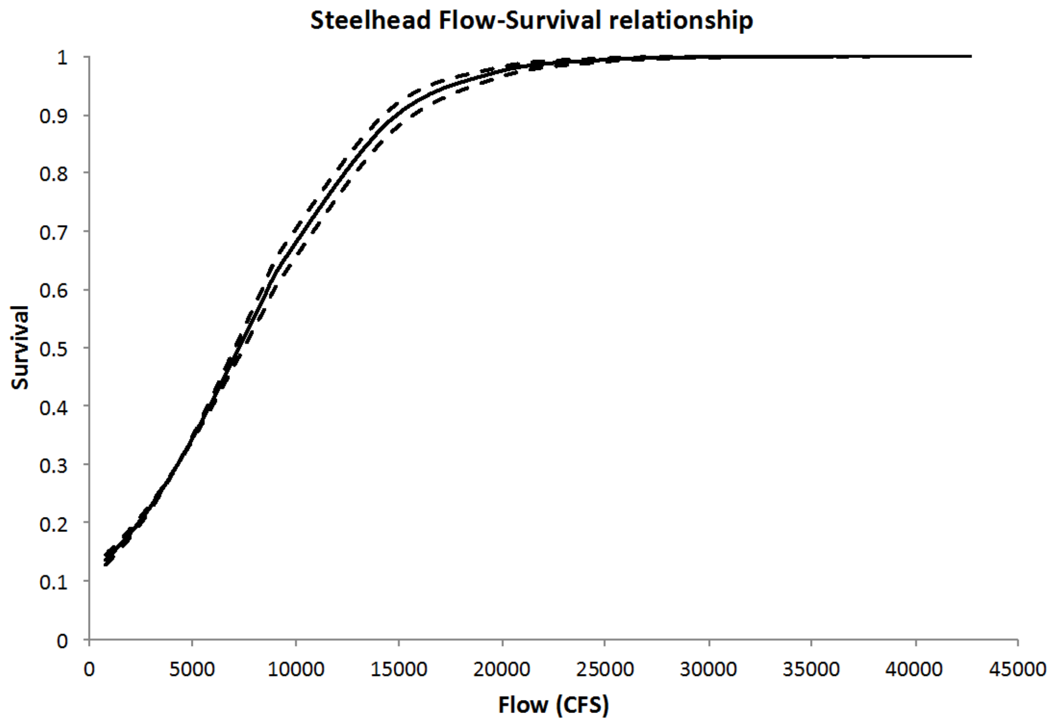


Figure 1. Estimated flow-survival relationship for juvenile Feather River Hatchery steelhead. Plotted flows are for the Feather River only- Sacramento River flows are not included in this relationship. Dashed lines indicate standard deviation associated with parameter B1 as estimated by NMFS (2017).

Bay Smolt to Adult Returns

Total annual adult returns of steelhead were calculated as

$$St_B * S_a$$

where S_a is survival rate for steelhead smolts from Bay exit to return as adults.

Survival probabilities for smolts returning to freshwater as adults are relatively well understood for Chinook salmon (see Zeug et al. 2012, Araujo et al. 2015, Winship et al. 2014, O'Farrell et al. 2012), but are less documented for steelhead. Unlike salmon, steelhead are iteroparous spawners and exhibit other complex life histories which complicate estimation of survival from ocean entry to adult return. Given the lack of steelhead specific estimates, we rely upon available Chinook salmon information.

For Chinook salmon, smolt to adult survival is a function of factors including age and year specific natural mortality, age and year specific harvest mortality, and age at maturity. Since variation in these factors would not be influenced by the Project, we simplified by assuming all steelhead matured at age-3 and that no harvest occurred until age-3. With these assumptions, smolt to adult mortality (S_a) was calculated as

$$M_2 * M_W * H_3$$

where M_2 is the survival of smolts to age-2, where M_w is overwinter survival of age-2 fish and where H_3 represents the fraction of fish surviving harvest and returning to spawn. Based upon Zeug et al. (2012) we fixed parameter values at 0.64 for M_w and at 0.75 for H_3. Since smolt to adult mortality is known to vary widely from year-to-year and among salmon populations (see Bradford et al. 1995), consistent with Zeug et al. (2012) we allowed M_2 to vary from a mean of 0.03, to a maximum value of 0.04 and to a minimum value of 0.02. The resulting range of values for S_a are shown in Table 1 and also reflected in the summary of results shown in Table 2.

3. Results from quantitative analysis

MBK (2018) describes water project operations, river flows and water supply results associated with the Project. Using these same simulated flows and water project operations, our analysis shows a substantnial net benefits to Central Valley steelhead (Table 2). The range of estimates shown in Table 2 demonstrate the influence of parameter uncertainty on estimated benefits. Though the magnitude of benefits are variable, our quantitative analyses demonstrates a consistent, positive effect on adult abundance of the CCV steelhead DSP.

Table 2. Estimated net change in adult CCV steelhead resulting from 50 years of proposed Project operations under four future conditions relative to no project.

Change in Adult Steelhead Abundance from 50 years with Project

Future Condition	Mean	Range
2030	95	(63-127)
2070	62	(42-83)
WF_Base	69	(46-92)
WF	130	(87-174)

It is important to note that these abundance estimates do not represent a prediction of future steelhead spawning abundance. Rather, these results reflect a comparison between water project operations using historic hydrologic conditions. The smolt-to-adult survival (S_a) component of the model analysis represent some major sources of uncertainty, but no practical modeling effort can adequately represent future real-world variation introduced by factors such as changing climate, changing habitat, changing harvest management, changing hatchery management, and shifting ocean productivity. Our modeling application here is consistent with other analytical efforts providing a standardized basis for comparing outcomes between alternative water management while controlling for unknown or uncontrollable future variation in environmental conditions.

Literature cited

Araujo, H.A., et al. 2015. Modeling population responses of Chinook and coho salmon to suspended sediment using a life history approach. Theoretical Population Biology Vol. 6, May. DOI: 10.1016/j.tpb.2015.04.003

Berggren, T. J., and M. J. Filardo. 1993. An Analysis of Variables Influencing the Migration of Juvenile Salmonids in the Columbia River Basin. North American Journal of Fisheries Management 13(1):48–63.

Blake, A. and M. J. Horn. 2003. Acoustic Tracking of Juvenile Chinook Salmon Movement in the Vicinity of the Delta Cross Channel, Sacramento River, California – 2001 Study Results. Prepared for U.S. Geological Survey and SRI International.

Brandes, P. L. and J. S. McLain. 2001. Juvenile Chinook Salmon Abundance, Disribution, and Survival in the Sacramento–San Joaquin Estuary. Pages 39-137 in R. Brown (ed.). Contributions to the Biology of Central Valley Salmonids, Fish Bulletin 179, Volume 2. Sacramento, CA: California Department of Fish and Game.

Bradford, M.J., 1995. Comparative review of Pacific salmon survival rates. Can. J. Fish. Aquat. Sci. 52, 1327–1338.

California Hatchery Scientific Review Group (CA HSRG). 2012. California Hatchery Review Project, Coleman Steelhead Program Report June 2012. http://cahatcheryreview.com/reports/

California Water Fix (CWF). 2016. Appendix 5.D, Quantitative methods and detailed results for effects analysis of Chinook salmon, Central Valley steelhead, green sturgeon and killer whale. Available: http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/CAWaterFix/app_5.d_methods.pdf

Healey, M. C. 1980. Utilization of the Nanaimo River Estuary by Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*). U.S. National Marine Fisheries Service Fishery Bulletin 77:653–668.

Healey, M. C. and F. P. Jordan. 1982. Observations on Juvenile Chum and Chinook and Spawning Chinook in the Nanaimo River, British Columbia, during 1975-1981. *Canada Manuscript Report of Fisheries and Aquatic Sciences* 1659:4.

Holbrook, C. M., R. W. Perry, and N. S. Adams. 2009. Distribution and Joint Fish-Tag Survival of Juvenile Chinook Salmon Migrating through the Sacramento-San Joaquin River Delta, California, 2008. Open-file report 2009-1204. U.S. Geological Survey, Reston, VA.

Kurth, R. and A. Hampton 2017. The effect of release strategy on apparent survival of Feather River Hatchery steelhead smolts. Informing Delta Management Using Biotelemetry Symposium. November 9, 2017 University of California Davis.

Michel, C. J. 2010. *River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (Oncorhynchus tshawytscha) Smolts and the Influence of Environment.* Master's thesis. University of California, Santa Cruz. Santa Cruz, CA.

Miller, J. A., A. Gray, and J. Merz. 2010. Quantifying the Contribution of Juvenile Migratory Phenotypes in a Population of Chinook Salmon *Oncorhynchus tshawytscha*. *Marine Ecology Progress Series* 408:227–240.

Moyle, P. B. 2002. *Inland Fishes of California*, Revised and Expanded. Berkeley: University of California Press.

National Marine Fisheries Service (NMFS). 2017. Model description for the Sacramento River Winter-run Chinook Salmon Life Cycle Model. May 9, 2017.

National Marine Fisheries Service (NMFS). 2016a. Endangered species act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fisheries Conservation and Management Act essential fish habitat response and Fish and Wildlife Coordination Act recommendations for relicensing the Oroville Facilities Hydroelectric Project, Butte County, CA. National Marine Fisheries Service, West Coast Region.

National Marine Fisheries Service (NMFS). 2016b. 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit. National Marine Fisheries Service, West Coast Region.

Newman, K. B. 2008. *An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies.* U.S. Fish and Wildlife Service, Stockton, CA. Available: http://www.science.calwater.ca.gov/pdf/psp/PSP_2004_final/PSP_CalFed_FWS_salmon_studies_final_033108.pdf .

Newman, K. B., and P. L. Brandes. 2010. Hierarchical modeling of juvenile Chinook salmon survival as a function of Sacramento-San Joaquin Delta water exports. North American Journal of Fisheries Management 30:157–169.

O'Farrell, M. R., M. S. Mohr, A. M. Grover, and W. H. Satterthwaite. 2012. Sacramento River winter Chinook cohort reconstruction: analysis of ocean fishery impacts. NOAA Technical Memorandum NOAAXTMXNMFSX SWFSCX491.

Perry, R. W. 2010. Survival and Migratory Dynamics of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin River Delta. PhD dissertation. University of Washington, Seattle.

Perry, R. W. 2010. Survival and Migration Dynamics of Juvenile Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento-San Joaquin River Delta. Ph.D. Dissertation. University of Washington, Seattle, WA.

Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A. P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta. *North American Journal of Fisheries Management* 30(1):142–156.

Perry RW, Pope AC, Romine JG, Brandes PL, Burau JR, Blake AR, Ammann AJ, Michel CJ. *In press*. Flow-mediated effects on travel time, routing and survival of juvenile Chinook salmon in a spatially complex, tidally forced river delta. Canadian Journal of Fisheries and Aquatic Sciences.

R Core Team. 2012. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Available: <http://www.R-project.org>.

Raymond, H. L. 1968. Migration Rates of Yearling Chinook Salmon in Relation to Flows and Impoundments in the Columbia and Snake Rivers. Transactions of the American Fisheries Society 97:356–359.

San Joaquin River Group Authority. 2008. 2007 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January. Prepared by San Joaquin River Group Authority, Davis, CA. Prepared for California Water Resource Control Board in compliance with D-1641. Sacramento, CA. Available: <http://www.sjrg.org/technicalreport/>.

San Joaquin River Group Authority. 2010. 2009 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January. Prepared by San Joaquin River Group Authority, Davis, CA. Prepared for California Water Resource Control Board in compliance with D-1641. Sacramento, CA. Available: <http://www.sjrg.org/technicalreport/>.

Schreck, C. B., J. C. Snelling, R. E. Ewing, C. S. Bradford, L. E. Davis, and C. H. Slater. 1994. Migratory Characteristics of Juvenile Spring Chinook Salmon in the Willamette River. Completion Report. Bonneville Power Administration.

Smith SG, Muir WD, Hockersmith EE, Zabel RW. 2003. Influence of river conditions on survival and travel time of Snake River subyearling fall Chinook salmon. North American Journal of Fisheries Management 23:939-961.

Williams, J. G. 2001. Chinook Salmon in the Lower American River, California's Largest Urban Stream. Pages 1–37 in R. Brown (ed.). Contributions to the Biology of Anadromous Salmonids of the Central Valley, California. *Fish Bulletin* 179:2. Sacramento: California Department of Fish and Game.

Winship, A.J., M.R. O'Farrell and M.S. Mohr. 2014. Fishery and hatchery effects on an endangered salmon population with low productivity. Transactions of the American Fisheries Society, 143(4):957X 971.

Zeug, S.C., P.S. Bergman, B.J. Cavallo, and K.S. Jones. 2012. Application of a life cycle simulation model to evaluate impacts of water management and conservation actions on an endangered population of Chinook salmon. Environmental Modeling and Assessment. 13 p.

Zeug SC, Sellheim K, Watry C, Wikert JD, Merz J. 2014. Response of juvenile Chinook salmon to managed flow: lessons learned from a population at the southern extent of their range in North America. Fisheries Management and Ecology 21:155-168.

Zeug SC, Brodsky, A, and J. Nelson. 2016. Comparative survival of Coleman National Fish Hatchery-origin and Nimbus Hatchery-origin steelhead juveniles during outmigration. Fisheries Report for U.S. Bureau of Reclamation, Bay-Delta Office. November 29, 2016.

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

10. SUPPLEMENTAL INFORMATION RELATED TO OTHER BENEFITS NOT QUANTIFIED

B. M.CUBED SPREADSHEET QUANTIFICATION SUPPORT FOR STEELHEAD BENEFITS

Environmental Benefit--Steelhead Trout--Willingness to pay approach #1

	Additional Steelhead Trout	value of winter-run and spring-run Chinook (2015 $)	NPV Total benefit (2015 $)
2030	95	$ 100,000	$4,058,737.27
2070	62		
	Total:	78	

year		EV[Additional Steelhead Trout]	expected additional spring winter-run Chinook	Total environmental benefit ($)
2015				
2016				
2017				
2018				
2019	Phase I starts			
2020				
2021			0	$ -
2022			0	$ -
2023			0	$ -
2024	Ph I ends, Ph II starts		0	$ -
2025	Ph II ends		0	$ -
2026	project life begins Jan 1	2	2	$ 194,750
2027		2	2	$ 190,000
2028		2	2	$ 190,000
2029		2	2	$ 190,000
2030		2	2	$ 190,000
2031		2	2	$ 188,350
2032		2	2	$ 186,700
2033		2	2	$ 185,050
2034		2	2	$ 183,400
2035		2	2	$ 181,750
2036		2	2	$ 180,100
2037		2	2	$ 178,450
2038		2	2	$ 176,800
2039		2	2	$ 175,150
2040		2	2	$ 173,500
2041		2	2	$ 171,850
2042		2	2	$ 170,200
2043		2	2	$ 168,550
2044		2	2	$ 166,900
2045		2	2	$ 165,250
2046		2	2	$ 163,600
2047		2	2	$ 161,950
2048		2	2	$ 160,300
2049		2	2	$ 158,650
2050		2	2	$ 157,000
2051		2	2	$ 155,350
2052		2	2	$ 153,700
2053		2	2	$ 152,050
2054		2	2	$ 150,400
2055		1	1	$ 148,750
2056		1	1	$ 147,100
2057		1	1	$ 145,450
2058		1	1	$ 143,800
2059		1	1	$ 142,150
2060		1	1	$ 140,500
2061		1	1	$ 138,850
2062		1	1	$ 137,200
2063		1	1	$ 135,550
2064		1	1	$ 133,900
2065		1	1	$ 132,250
2066		1	1	$ 130,600
2067		1	1	$ 128,950
2068		1	1	$ 127,300.00
2069		1	1	$ 125,650
2070		1	1	$ 124,000
2071		1	1	$ 124,000
2072		1	1	$ 124,000
2073		1	1	$ 124,000
2074		1	1	$ 124,000
2075		1	1	$ 124,000

	2030			2070		
	With Project	Without Project	Difference	With Project	Without Project	Difference
3. Net Physical Benefit Measurement[2]						
4. Annual Economic Be	$ 190,000	0	$ 190,000	$ 124,000	0	$ 124,000

Additional Adult Chinook from 50 years of Project Operations
Smolt to Adult Return Rate

	Spring-Run	Winter-run	Steelhead
2030	1011	109	95
2070	715	73	62
	all 81 years		
2030	950		

results as of 2/21/18

2045 and later conditions with SGMA (2015 dollars)

Water Year Type (Sacramento Valley 40-30-30 or San Joaquin Valley 60-20-20 Index)	Sacramento Valley (in $/AF of consumptive use)	Delta Export (in $/AF of applied water)	Eastside San Joaquin Basin (in $/AF of consumptive use)	Friant Service Area (in $/AF of consumptive use)
Wet	$ 150	$ 414	$ 309	$ 256
Above Normal	$ 198	$ 519	$ 388	$ 321
Below Normal	$ 264	$ 633	$ 437	$ 461
Dry	$ 283	$ 674	$ 466	$ 512
Critical	$ 354	$ 1,056	$ 728	$ 1,105

fall-run Chinook salmon in CA (for non-listed salmon species)	$ 2,500	economic value per adult fish entering fresh water	Layton, et al., 1999
winter-run Chinook salmon, spring-run Chinook salmon, Central Valley steelhead trout	$ 100,000.00		Based on 2 studies

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

10. SUPPLEMENTAL INFORMATION RELATED TO OTHER BENEFITS NOT QUANTIFIED

C. SUPPLEMENTAL ECOSYSTEM PRIORITY 2 WORKSHEET REVISED FOR STEELHEAD BENEFITS

Priority 2: Provide flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids.

Species Information

What salmonid species are you targeting?

Juvenile Central Valley spring-run Chinook salmon are the primary target of the spring flow pulse provided by the proposed project. April represents the peak month for outmigration of juvenile spring-run Chinook from the Feather and Sacramento River basins.

Winter-run Chinook juveniles and juvenile steelhead in the Sacramento River downstream of Verona (the confluence with the Feather River) will also benefit from the flow pulse provided by the proposed project.

~~Steelhead smolts emigrating from the Feather and Sacramento River basins will also benefit, but insufficient data are available to quantify these benefits.~~

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the flow related habitat needs of each species are described.

The basis for expected flow-related benefits are described and source-referenced in the Cramer Fish Sciences Technical Memorandum (CFS 2017) See also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) in WSIP funding application.
Also see NMFS (2016a) and NMFS (2017) referenced in CSF 2017 report.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

REV 2: Magnitude of ecosystem improvements

What is the expected magnitude of the ecosystem improvement that will address this priority? Magnitude should be expressed as: a) the change from current conditions without the project to current conditions with the project, and b) the change from 2030 conditions without the project to 2030 conditions with the project. How did you estimate this value?
If the ecosystem improvement will benefit multiple salmonid species or runs, provide the magnitude of the ecosystem improvement for each species or run separately.

In 2030 conditions, the project provides for seven~~six~~ additional April, Feather River flow pulses over 82 years of simulated hydrology (MBK 2017). Over fifty years of operations with the project (2030 conditions) these April flow pulses are expected to provide a net benefit of 1011 ~~586~~ (range of 674-1348) additional ADULT Central Valley spring-run Chinook salmon and 109~~41~~ (range of 73-145) additional ADULT Sacramento River winter-run Chinook salmon. Additionally, the flow pulses are expected to provide an estimated net increase of 95 (range of 63-127) additional ADULT steelhead trout.

In the 2070 condition, the project provides for five additional April, Feather River flow pulses over 82 years of simulated hydrology (MBK 2017). Over fifty years of operations (2070 conditions) these April flow pulses are ~~s~~ expected to provide a net benefit of 715 (range of 476-953) ~~428~~ additional ADULT Central Valley spring-run Chinook salmon and ~~32~~73 (range of 48-97) additional ADULT Sacramento River winter-run Chinook salmon. Additionally, the flow pulses in 2070 are expected to provide an estimated net increase of 62 (range of 42-83) additional ADULT steelhead trout.

Methods used to assess and quantify these methods are described in the Cramer Fish Sciences Technical Memorandum See **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) in WSIP funding application.

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the magnitude of the ecosystem improvement is described and quantified.

The basis for expected flow-related benefits are described and source-referenced in the Cramer Fish Sciences Technical Memorandum. See **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) in WSIP funding application.
Also see NMFS (2016a) and NMFS (2017) referenced in CSF 2017 report.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

REV 3: Spatial and temporal scale of ecosystem improvements.

What is the geographical extent (e.g. river miles, acres) of the ecosystem improvement that will address this priority?

Flow pulses associated with the project will effect approximately 60 river miles of the Feather River (from the Thermalito Afterbay Outlet to Verona) and 67 river miles of the Sacramento River (from Verona to Rio Vista).

Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) where the geographical extent of the ecosystem improvement is documented or mapped.

https://www.sacramentoriver.org/sac_river_atlas.php
http://www.water.ca.gov/orovillerelicensing/docs/wg_study_reports_and_docs/EWG/sp-g2_interim_report_part_c%20.pdf

When during the year will the project provide flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids? How are flows likely to vary with hydrologic conditions (i.e. among water year types) a) under current conditions with and without the project, and b) in 2030 with and without the project?
If the ecosystem improvement will benefit multiple salmonid species or runs, provide the timing of ecosystem improvements for each species or run separately.

The flow pulse will occur in the month of April. With 2030 conditions, over 82 years of historic hydrologies the flow pulse occurs seven~~six~~ times. Five times in dry water years and twice~~once~~ in an extremely dry water year. Since flow pulses occur in years with generally low river flows (without the project), greater benefits are achieved for target salmonids (the assumed flow-survival relationship is non-linear, see **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) for more information).
See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the timing of ecosystem improvements that address this priority are described and quantified.

See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report), and see also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report.
See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

REV 4: Inclusion of an adaptive management and monitoring program that includes measurable objectives, performance measures, thresholds, and triggers to achieve ecosystem benefits.

Provide additional information on how this ecosystem improvement will be incorporated into the adaptive management and monitoring program. If available, provide examples of objectives, performance measures, thresholds, or triggers that could be used to manage benefits associated with this priority.

Natural resource management entities (DWR, NMFS, CDFW, USFWS, USBR) regularly conduct survival studies on outmigration of juvenile Chinook salmon and steelhead. A relevant performance metric for the proposed project would be an observed flow-survival relationships consistent with the predicted flow-survival relationships described by NMFS (2017) and utilized in the project analysis (CFS 2017). New information on the patterns of flow-survival or emigration timing for spring-run and winter-run Chinook juveniles may suggest changes in the timing or magnitude of flow pulses provided by the project. See **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** (CFS 2017 report) in WSIP funding application.

IRWD will participate in and support flow-survival studies relevant to evaluating performance of the flow pulses in achieving expected ecosystem benefits.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

REV 5: Immediacy of ecosystem improvement actions and realization of benefits

Immediacy of ecosystem improvement: Number of months from grant encumbrance until the proposed ecosystem improvement is completed (i.e. the expected timeframe until the improvement is implemented or construction is completed).

The project will require 3 years and 6 months for construction and is expected to begin storing water available for flow pulses by the year 2025. The year in which the first flow pulse will be delivered is dependent on future hydrologies and cannot be predicted in advance.

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the immediacy timeframe is described and quantified.

See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report), and see also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report.

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

Realization of ecosystem improvement: Number of months from the time the ecosystem improvement is completed (i.e. project is implemented or construction is complete), until the benefit associated with this priority can be observed (i.e. when measurable improvements can be observed and quantified)

Analysis conducted by MBK indicates 7~~6~~ flow pulses will occur with the project over 82 years of historic hydrologies (2030 conditions). If we assume each historic water year is an independent event, then there is 8.5~~7.3~~% probability of a project flow pulse occurring in any year after the project is fully operated. ~~There is a greater than 50% probability of at least one project related flow pulse occurring within ten years of the project operating.~~ See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report).

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the realization timeframe is described and quantified.

See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report),

REV 6: Duration of ecosystem improvements

How long (number of years) after realization (as calculated under REV 5 above) is the ecosystem improvement expected to address this priority? Maximum is 100 years. Explain how this value was determined and whether the magnitude of the ecosystem improvement is anticipated to change over time.

After realization, a minimum of 13~~8~~,860~~000~~ AF of groundwater will need to accrue in the Ecosystem Benefits account in order to make a flow pulse. Assuming historic hydrologies and each water year occurs as independent event, flow pulses associated with the project are expected to occur with an annual probability of 8.5~~7.3~~%. The ecosystem improvement will address this priority whenever a flow pulse occurs.

Additional locations in the application, supporting documentation or attachments (document name, page number, table number, other) where the duration of the ecosystem improvement is described and quantified.

See MBK Engineer's Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report). Also see the Operations Plan located in the **Benefit Calculation, Monetization, Resiliency Tab, Attachment 2.**

See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal

REV 7: Consistency with species recovery plans and strategies, initiatives, and conservation plans

Does the ecosystem improvement meet any goals or objectives established in existing species recovery plans, initiatives, or conservation plans including but not limited to the NOAA Fisheries Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead; State Wildlife Action Plan; Central Valley Joint

Venture Implementation Plan, San Joaquin County Multi-Species Habitat Conservation Plan and Open Space Plan, Draft Solano Multi-Species Habitat Conservation Plan, East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan, Draft Recovery Plan for the Giant Garter Snake, and California Water Action Plan? If so which goals, objectives, or actions will be met? Why?

Yes. Flow pulses to improve rearing and outmigration survival of winter-run Chinook salmon, spring-run Chinook salmon and steelhead are identified in the NMFS recovery plan for the species. Specifically, Actions IDs SFB-1.3, DEL-1.1, DEL-1.3, and FER-1.10 from the 2014 NMFS recovery plan. In addition, the Biological Opinion for operation the Oroville Facilities (NMFS 2016) specifically calls for evaluation of Feather River flow pulses to benefit spring-run Chinook, steelhead and green sturgeon.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

Additional locations in the application, supporting documentation or attachments (page number, table number, other) where the consistency with goals, objectives, or actions from recovery plans, initiative, or conservation plans are discussed.

See Cramer Fish Sciences Report under file name IRWD_Tab 4-A2-CFS_TechMemo_Final.docx included in the **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2.**

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

REV 8: Location of ecosystem improvements and connectivity to areas already being protected or managed for conservation values

Provide a map that shows the extent of the ecosystem improvement that will address this priority (e.g. river miles that meet the temperature benefits). Provide additional instructions or clarification to reviewers who will be viewing this map (i.e. describe the color and/or label that identifies the spatial extent of the ecosystem improvement). If available, also submit supporting electronic files such as a .kmz file or ArcGIS layer associated with the maps provided.

The ecosystem benefits associated with the project will occur within the active channel of the Feather River. A map of the Feather River is included in under **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2,** see IRWD_FeatherRiverMap.pdf.

Explain why this location was selected. How is the location beneficial to the targeted species in the context of local environmental conditions and the target species' needs?

The Feather River was selected because of its function as a corridor of water conveyance for the State Water Project and because the Feather River hosts in-river and hatchery spawning; Feather River spring-run Chinook salmon both part of the listed CV spring-run Chinook salmon ESU (NMFS 2016b). NMFS, in their most recent five-year review of CV spring-run, assigned a recovery priority for spring-run Chinook salmon in the Feather River of 5 (with 1 being the highest priority, 12 being the lowest priority) (NMFS 2016b). These determinations are based upon the evolutionary legacy the Feather River spring-run stock represents, because the stock continues to exhibit a CV spring-run Chinook salmon migration timing, and because of habitat and management improvements required as part of the Oroville Facilities FERC Relicensing Settlement Agreement.

Project flow pulses originating in the Feather River affect the Sacramento River downstream of Verona and thereby benefit spring-Chinook, winter Chinook and steelhead originating from points upstream in the Sacramento River basin.

Per CFS, though natural origin of steelhead smolts occur in the Feather River, information on their abundance and emigration timing is highly uncertain (NMFS 2016b). In contrast, annual production of steelhead smolts by Feather River Hatchery (FRH) is well understood. FRH steelhead are released into the Feather River in late winter/early spring. CFS assumed all FRH steelhead releases occur at Boyd's Pump for survival benefits associated with the pulse flow.

See Cramer Fish Sciences Report included in **Physical Public Benefits Tab, Ecosystem Benefits Section, Attachment 2** – CFS 2017 report for references cited above.
See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

Is the ecosystem improvement location adjacent to, or near, other areas already being protected or managed for conservation values? Explain the proximity of the ecosystem improvement to other areas already being protected or managed for conservation values and any hydrologic connectivity that may occur between these locations.

The Feather and Sacramento River corridors are adjacent to numerous habitat features managed for conservation of anadromous salmonids and other species. For example, existing or future floodplain enhancements on the Feather and Sacramento River could benefit from project flow pulses if those flow pulses helped to extend or achieve floodplain inundation in conjunction with flow pulse events originating from other water sources. The flow pulses provided by the project are not expected to appreciably inundate floodplain features alone, but could compliment other such efforts.

Are the flows provided physically accessible by the targeted species in all year types? If not, explain barriers that may exist between the targeted species and ecosystem improvements.

Yes. The Feather and Sacramento Rivers are essential migratory corridors for juvenile salmonids in April of all water year types.

Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe and quantify the spatial extent of the ecosystem improvement, the proximity of the ecosystem improvement to other areas already being protected or managed for conservation value, and the degree to which hydrologic connections (if any) occur between the ecosystem improvement and areas already being protected or managed for conservation value.

None that can be specifically identified and quantified.

REV 9: Efficient use of water to achieve multiple ecosystem benefits

How will water provided to address this priority be managed? Explain design efficiencies and operational strategies intended to maximize the efficiency of water allocated to ecosystem improvements that address this priority.

Ecosystem benefits for this priority are achieved when a flow pulse is released. In the years when flow pulses are released, Delta carriage water costs are reduced because project water was exported during periods of Delta surplus with no carriage water cost and stored in the export service area. The model used to calculate these benefits assumes 20 percent carriage water and the 3 percent conveyance loss can be saved when extracting water from the project for delivery within the export service area instead of meeting those demands from Oroville Reservoir.

Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe the design efficiencies and operational strategies used to maximize water efficiency under this priority.

For a description and details on design efficiencies and operational strategies to maximize water efficiency, see page 6 of the MBK Engineers' Report included under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report)., and see also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report.
See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

REV 10: Resilience of ecosystem improvements to the effects of changing environmental conditions, including hydrologic variability and climate change.

Which environmental uncertainties associated with this priority were considered in the project siting, design, and operation? How were these uncertainties incorporated into project siting, design, or operation? Examples of environmental uncertainties include, but are not limited to: sea level rise, temperature changes, changes in precipitation, landslides, erosion, earthquakes, wildfires, drought events, and flooding events.

MBK Engineers (MBK) performed uncertainty analyses related to potential climate change, the California Water Fix, and the project's performance during drought. Using the results from these uncertainty analyses, CFS determined the change in winter-run and spring-run adult Chinook salmon over fifty years of project operations. Under 2070 climate change conditions, the project provided a net benefit of 715~~428~~ (range of 476-953) spring-run Chinook and 73~~32~~ (range of 48-97) winter-run Chinook, and a net benefit of 62 (range of 42-83) steelhead under 2070 climate change conditions. Under the California Water Fix future condition the project provided a net benefit of 1044~~452~~ (range of 696-1392) spring-run Chinook,~~ and~~ net benefit ~~loss~~ of 74 (range of 50-99)~~34~~ winter-run Chinook, and a net benefit of 130 (range of 87-174) steelhead. ~~The reason for net loss of winter-run Chinook is because North Delta diversions associated with the California Water Fix more directly impact winter-run Chinook smolts than do South Delta exports.~~ Further information on the uncertainty analyses preformed can be found in the MBK Engineers' and the CFS reports under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report) and also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report.
See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal.

See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

Additional locations in the application, supporting documentation or attachments (document name, page number, figure name or number, other) that describe and quantify the environmental uncertainties considered in the project siting, design, and operation.
See MBK Engineers and Cramer Fish Sciences reports under **Feasibility and Implementation Risk Tab, Attachment 1 -** Technical Feasibility (MBK Engineers, 2017 report), and also **Physical Public Benefits Tab, Ecosystem Benefits, Attachment 2** – CFS 2017 report. See Revised MBK Engineers Technical Memorandum and spreadsheets provided as part of the Appeal. See Revised CFS Technical Memorandum and models and Supplemental Technical Memorandum on Steelhead Benefits provided as part of the Appeal.

Public Benefit Ratio Appeal of

Water Storage Investment Program Public Benefit Ratio Review for

The Kern Fan Groundwater Storage Project

SUPPORTING DOCUMENTATION:

10. SUPPLEMENTAL INFORMATION RELATED TO OTHER BENEFITS NOT QUANTIFIED

D. BENEFIT AND COST ANALYSIS SPREADSHEETS UPDATED TO INCLUDE STEELHEAD BENEFITS

BENEFIT RATIOS

Key Data from Other Worksheets

$171,321,859	Project capital cost
$16,029,044	PV of O&M(@2030)
$16,253,055	PV of O&M (@2070)
$10,476,475	PV of replacement
$197,827,378	*Total Project Cost*

	Future Conditions	
Benefit Type	*2030 w/Climate Change*	*2070 w/Climate Change*
Non-Public		
Water Supply Benefits	$50,440,995.78	~~$47,745,446.54~~
Groundwater	$3,485,795.79	~~$4,296,188.77~~
Subtotal	$53,926,791.56	~~$52,041,635.31~~
Public		
Ecosystem Benefit - Salmon/Steelhead	$34,887,072.67	~~$20,978,395.07~~
Ecosystem Benefit - Wetlands	$98,248,070.23	~~$39,796,318.99~~
Emergency Response - Extended Drought	$18,570,140.39	~~$5,062,066.79~~
Emergency Response - Delta Failure	$28,452,181.95	~~$59,924,483.60~~
Subtotal	$180,157,465.25	~~$125,761,264.45~~
Total Benefits	**$234,084,256.81**	**~~$177,802,899.77~~**
Public Benefit Ratio	**2.103**	**~~1.47~~**
Benefit-Cost Ratio	**1.18**	**~~0.90~~**

Note on O&M Values: Due to changes resulting from revised CalSimII model runs and the associated Kern Fan operational model developed by MBK, the model-predicted operations of the project changed slightly. This has resulted in a change to the present value of O&M costs for both the 2030 and 2070 scenarios. Previously reported O&M values were $18,809,076 for the 2030 scenario and $17,993,034 for the 2070 scenario.; these costs have decreased to $16,024,969 and $16,264,914, respectively.

COST ALLOCATION

Cost Shares

$85,660,930	WSIP funds requested
$42,830,465	Portion funded by IRWD
$42,830,465	Portion funded by RRBWSD

	Beneficiary		
	State of California	*IRWD*	*RRBWSD*
Public Benefits			
Ecosystem	$133,135,143	$0	$0
Emergency Response	$47,022,322	$0	$0
Non-Public Benefits			
Water Supply	$0	$25,220,498	$25,220,498
Groundwater	$0	$1,742,898	$1,742,898
Total Benefits	**$180,157,465**	**$26,963,396**	**$26,963,396**
Cost Share Category			
Ecosystem	$42,830,465	$0	$0
Emergency Response	$42,830,465	$0	$0
Water Supply	$0	$40,061,929	$40,061,929
Groundwater	$0	$2,768,536	$2,768,536
Total Cost Share	**$85,660,930**	**$42,830,465**	**$42,830,465**
Benefit to Cost Share Ratio*	**2.10**	**0.63**	**0.63**

*While the benefit to cost share ratio for IRWD and RRBWSD is below 1.0, IRWD and RRBWSD additionally plan to utilize their share of the project facilites for other future groundwater storage and recovery programs. This would result in an increased benefit to IRWD and RRBWSD in excess of the benefits demonstrated for the Kern Fan Groundwater Storage Project, as discussed in application Tab 3, Question 6 (project affect on groundwater basins).

KERN FAN GROUNDWATER STORAGE PROJECT - ECONOMIC ANALYSIS

Planning level estimate of costs and benefits

Key Parameters

50	Project operations horizon/period *(years)*
2021	Construction start year
2025	Construction complete year
2024	Phase 1 online year
2025	Phase 2 online year
2075	Operations horizon end year
$171,321,859	Estimated capital cost *(dollars)*
$85,660,930	Estimated grant funding amount *(dollars)*
$42,830,465	Estimated IRWD capital contribution *(dollars)*
$42,830,465	Estimated RRBWSD capital contribution *(dollars)*
3.5%	Discount rate *(CA cost of borrowing from CWC Technical Reference Appendix G;*
2.0%	Bakersfield long term land value appreciation rate (per Mike Ming, ARA FRICS)

PHASE I WELL FIELD O&M COSTS

Year Type	*Monthly Cost*	*Annual Cost*
Dry Year (Pumping Wells)	$153,216.67	$1,838,600.00
Wet Year (Recharging Water)	$10,816.67	$129,800.00
Idle Year	$5,916.67	$71,000.00

PHASE I CANAL O&M COSTS

Year Type	*Monthly Cost*	*Annual Cost*
Dry Year (Pumping Wells)	$9,658.33	$115,900.00
Wet Year (Recharging Water)	$668,697.90	$8,024,374.86
Idle Year	$5,758.33	$69,100.00

PHASE I GOOSE LAKE SLOUGH TURNOUT O&M COSTS

Year Type	*Monthly Cost*	*Annual Cost*
Dry Year (Pumping Wells)	$1,852.78	$22,233.33
Wet Year (Recharging Water)	$64,052.78	$768,633.33
Idle Year	$1,352.78	$16,233.33

PHASE II WELL FIELD O&M COSTS

Year Type	*Monthly Cost*	*Annual Cost*
Dry Year (Pumping Wells)	$153,216.67	$1,838,600.00
Wet Year (Recharging Water)	$10,816.67	$129,800.00
Idle Year	$5,916.67	$71,000.00

DURATION OF OPERATIONS

Year Type	*2030 Conditions**	*2070 Conditions**
Dry Year (Pumping Wells)	6.36	6.52
Wet Year (Recharging Water)	1.65	1.68
Idle Year	73.99	73.81

*The values utilized for duration of operations for both the 2030 and 2070 condition were adjusted to reflect full years of operations. The data was adjusted from partial-year operations data provided by MBK Engineers. Since the modeled operations from MBK were over a 82 year hydrology, the proportions of idle, dry, and wet years were used to calculate a a weighted average annual O&M cost. This annual value was applied to the 50 years of expected operations to determine an appropriate present value of O&M costs.

WEIGHTED AVERAGE OF O&M COSTS

Year Type	*Total Cost*	*2030 Conditions*	*2070 Conditions*
Dry Year (Pumping Wells)	$3,815,333.33	6.36	6.52
Wet Year (Recharging Water)	$9,052,608.19	1.65	1.68
Idle Year	$227,333.33	73.99	73.81

2030 Condition Weighted Average Annual O&M: $683,377.61
2070 Condition Weighted Average Annual O&M: $692,928.02

O&M COSTS ESCALATED

Operations Year	*Calendar Year*	*Annual O&M Cost (@2030)*	*Annual O&M Cost (@2070)*
-	2015	-	-
-	2016	-	-
-	2017	-	-
-	2018	-	-
-	2019	$0.00	$0.00
-	2020	$0.00	$0.00
-	2021	$0.00	$0.00
-	2022	$0.00	$0.00
-	2023	$0.00	$0.00
-	2024	$0.00	$0.00
-	2025	$0.00	$0.00
1	2026	$683,377.61	$692,928.02
2	2027	$683,377.61	$692,928.02
3	2028	$683,377.61	$692,928.02
4	2029	$683,377.61	$692,928.02
5	2030	$683,377.61	$692,928.02
6	2031	$683,377.61	$692,928.02
7	2032	$683,377.61	$692,928.02
8	2033	$683,377.61	$692,928.02
9	2034	$683,377.61	$692,928.02
10	2035	$683,377.61	$692,928.02
11	2036	$683,377.61	$692,928.02
12	2037	$683,377.61	$692,928.02
13	2038	$683,377.61	$692,928.02
14	2039	$683,377.61	$692,928.02
15	2040	$683,377.61	$692,928.02
16	2041	$683,377.61	$692,928.02
17	2042	$683,377.61	$692,928.02
18	2043	$683,377.61	$692,928.02
19	2044	$683,377.61	$692,928.02
20	2045	$683,377.61	$692,928.02
21	2046	$683,377.61	$692,928.02
22	2047	$683,377.61	$692,928.02
23	2048	$683,377.61	$692,928.02
24	2049	$683,377.61	$692,928.02
25	2050	$683,377.61	$692,928.02
26	2051	$683,377.61	$692,928.02
27	2052	$683,377.61	$692,928.02
28	2053	$683,377.61	$692,928.02
29	2054	$683,377.61	$692,928.02
30	2055	$683,377.61	$692,928.02
31	2056	$683,377.61	$692,928.02
32	2057	$683,377.61	$692,928.02
33	2058	$683,377.61	$692,928.02
34	2059	$683,377.61	$692,928.02
35	2060	$683,377.61	$692,928.02
36	2061	$683,377.61	$692,928.02
37	2062	$683,377.61	$692,928.02
38	2063	$683,377.61	$692,928.02
39	2064	$683,377.61	$692,928.02
40	2065	$683,377.61	$692,928.02
41	2066	$683,377.61	$692,928.02
42	2067	$683,377.61	$692,928.02
43	2068	$683,377.61	$692,928.02
44	2069	$683,377.61	$692,928.02
45	2070	$683,377.61	$692,928.02
46	2071	$683,377.61	$692,928.02
47	2072	$683,377.61	$692,928.02
48	2073	$683,377.61	$692,928.02
49	2074	$683,377.61	$692,928.02
50	2075	$683,377.61	$692,928.02
	NPV of O&M->	**$16,029,043.97**	**$16,253,054.75**

ANNUALIZED REPLACEMENT COST ESTIMATES FROM DJA REPORT

Description	*Annualized Cost*
Canal Replacement	$30,500.00
Lift Station Replacement	$276,813.00
Aqueduct Turnout Replacement	$4,130.00
Phase II Turnout Replacement	$4,130.00
West Basin Turnout Replacement	$6,070.00
Phase I Well Site Replacement	$51,204.00
Goose Lake Slough Turnout Replacement	$22,600.00
Phase II Well Site Replacement	$51,204.00
Total Estimated Annual Replacement->	$446,651.00

RECPLACEMENT COSTS PV CALCULATION

Operations Year	*Calendar Year*	*Replacement Cost*
-	2015	-
-	2016	-
-	2017	-
-	2018	-
-	2019	$0.00
-	2020	$0.00
-	2021	$0.00
-	2022	$0.00
-	2023	$0.00
-	2024	$0.00
-	2025	$0.00
1	2026	$446,651.00
2	2027	$446,651.00
3	2028	$446,651.00
4	2029	$446,651.00
5	2030	$446,651.00
6	2031	$446,651.00
7	2032	$446,651.00
8	2033	$446,651.00
9	2034	$446,651.00
10	2035	$446,651.00
11	2036	$446,651.00
12	2037	$446,651.00
13	2038	$446,651.00
14	2039	$446,651.00
15	2040	$446,651.00
16	2041	$446,651.00
17	2042	$446,651.00
18	2043	$446,651.00
19	2044	$446,651.00
20	2045	$446,651.00
21	2046	$446,651.00
22	2047	$446,651.00
23	2048	$446,651.00
24	2049	$446,651.00
25	2050	$446,651.00
26	2051	$446,651.00
27	2052	$446,651.00
28	2053	$446,651.00
29	2054	$446,651.00
30	2055	$446,651.00
31	2056	$446,651.00
32	2057	$446,651.00
33	2058	$446,651.00
34	2059	$446,651.00
35	2060	$446,651.00
36	2061	$446,651.00
37	2062	$446,651.00
38	2063	$446,651.00
39	2064	$446,651.00
40	2065	$446,651.00
41	2066	$446,651.00
42	2067	$446,651.00
43	2068	$446,651.00
44	2069	$446,651.00
45	2070	$446,651.00
46	2071	$446,651.00
47	2072	$446,651.00
48	2073	$446,651.00
49	2074	$446,651.00
50	2075	$446,651.00
	NPV of Replacement->	**$10,476,475.18**

WORKSHEET 6: DJA O&M COST ESTIMATE

Irvine Ranch Water District

Operation & Maintenance Cost Estimate

Phase I Well Field Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	Monthly RRBWSD Recovery Charge[5]	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost if Utilized for 12 Months[6]	Average Cost per Ac-Ft[7]	
Dry Year (Pumping Wells)	$ 8,000.00	$ 144,900.00	$ 316.67	$ -	$ -	$ 153,216.67	$ 1,838,600.00	$ 73.54	95%
Wet Year (Recharging Wat	$ 9,000.00	$ 1,500.00	$ 316.67	$ -	$ -	$ 10,816.67	$ 88,150.00	$ 1.76	14%
Idle Year	$ 4,100.00	$ 1,500.00	$ 316.67	$ -	$ -	$ 5,916.67	$ 71,000.00		25%

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent
2. Cost includes one additional piece of equipment for property
3. Monthly PG&E cost to operate(6) 400 hp wells
4. Average monthly cost for cellular service to (6) Mission Units
5. Assumed 35 cfs flow rate for a 30 day month for a total of 2,083 ac-ft of water recovered per month or 25,000 ac-ft/yr
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 3.5 months of recharging 56,250 ac-ft and 8.5 months at idle costs.
7. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Phase I Canal Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	Monthly RRBWSD Recovery Charge	DWR Conveyance Cost[5]	Total Monthly Cost	Total Annual Cost[6]	Average Cost per Ac-Ft[7]	
Dry Year (Pumping Wells)	$ 8,000.00	$ 1,500.00	$ 158.33	$ -	$ -	$ 9,658.33	$ 115,900.00	$ 4.64	16%
Wet Year (Recharging Wat	$ 9,000.00	$ 197,486.00	$ 158.33	$ -	$ 462,053.57	$ 668,697.90	$ 2,389,388.50	$ 23.89	30%
Idle Year	$ 4,100.00	$ 1,500.00	$ 158.33	$ -	$ -	$ 5,758.33	$ 69,100.00		26%

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent
2. Cost includes one additional piece of equipment for canal
3. Monthly PG&E cost to operate (18) 300 hp lift pumps moving 500 cfs, Total 112,500 ac-ft / year
4. Average monthly cost for cellular service to (3) Mission Units
5. Article 21 water cost estimated at $23.00/AF for 112,500 ac-ft, however 37.5% of DWR water is already in the IRWD
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 3.5 months of conveying up to 112,500 ac-ft and 8.5 months at idle costs.
7. Dry year conveying 25,000 ac-ft to aqueduct and a wet year recharging 112,500 ac-ft.

Phase I Goose Lake Slough Turnout Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[3]	Monthly RRBWSD Recovery Charge	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost[4]	Average Cost per Ac-Ft[5]
Dry Year (Pumping Wells)	$ 1,500.00	$ 300.00	$ 52.78	$ -	$ -	$ 1,852.78	$ 22,233.33	$ 0.89
Wet Year (Recharging Wat	$ 4,000.00	$ 60,000.00	$ 52.78	$ -	$ -	$ 64,052.78	$ 235,683.33	$ 4.71
Idle Year	$ 1,000.00	$ 300.00	$ 52.78	$ -	$ -	$ 1,352.78	$ 16,233.33	

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent
2. Monthly PG&E cost to operate (4) 300 hp lift pumps moving 240 cfs, Total 50,000 ac-ft / year
3. Average monthly cost for cellular service to (1) Mission Units
4. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 3.5 months of recharging 556,250 ac-ft and 8.5 months at idle costs.
5. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Phase II Well Field Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	Monthly RRBWSD Recovery Charge[5]	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost if Utilized for 12 Months[6]	Average Cost per Ac-Ft[7]
Dry Year (Pumping Wells)	$ 8,000.00	$ 144,900.00	$ 316.67	$ -	$ -	$ 153,216.67	$ 1,838,600.00	$ 73.54
Wet Year (Recharging Wat	$ 9,000.00	$ 1,500.00	$ 316.67	$ -	$ -	$ 10,816.67	$ 88,150.00	$ 1.76
Idle Year	$ 4,100.00	$ 1,500.00	$ 316.67	$ -	$ -	$ 5,916.67	$ 71,000.00	

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent
2. Cost includes one additional piece of equipment for property
3. Monthly PG&E cost to operate(6) 400 hp wells
4. Average monthly cost for cellular service to (6) Mission Units
5. Assumed 35 cfs flow rate for a 30 day month for a total of 2,083 ac-ft of water recovered per month or 25,000 ac-ft/yr
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 3.5 months of recharging 56,250 ac-ft and 8.5 months at idle costs.
7. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Irvine Ranch Water District

Canal Alignment along KWB to West Basins

Item No.	Item Description	Unit	Quantity	Unit Cost	Extended Cost	Phase	Year
1	Mobilization, Demobilization, & Cleanup	LS	1	$ 1,820,000.00	$ 1,820,000.00	1	2021
2	Aqueduct Cofferdam & Dewatering	LS	1	$ 250,000.00	$ 250,000.00	1	2022
3	Aqueduct Turnout Excavation	LS	1	$ 55,000.00	$ 55,000.00	1	2022
4	Aqueduct Reinforced Concrete Structure	LS	1	$ 200,000.00	$ 200,000.00	1	2022
5	Aqueduct Backfill and Compaction	LS	1	$ 50,000.00	$ 50,000.00	1	2022
6	Aqueduct Miscellaneous Steel	LS	1	$ 55,000.00	$ 55,000.00	1	2022
7	Aqueduct Metering	EA	2	$ 90,000.00	$ 180,000.00	1	2022
8	Aqueduct Slide Gate & Actuator	EA	2	$ 37,500.00	$ 75,000.00	1	2022
9	Aqueduct Electrical, Controls, & Lighting	LS	1	$ 300,000.00	$ 300,000.00	1	2022
10	Aqueduct Liner Repair	LS	1	$ 20,000.00	$ 20,000.00	1	2022
11	Canal Earthwork	CY	1,650,000	$ 10.00	$ 16,500,000.00	1	2022
12	Concrete Canal Lining	SF	2,640,000	$ 6.00	$ 15,840,000.00	1	2022
13	Canal Appurtenances	LS	1	$ 250,000.00	$ 250,000.00	1	2022
14	Canal Fencing	LF	110,000	$ 7.50	$ 825,000.00	1	2022
15	Levee Road Aggregate Base Ground Cover	LS	1	$ 650,000.00	$ 650,000.00	1	2022
16	East Canal Crossing Siphon & Appurtenances	LS	1	$ 1,000,000.00	$ 1,000,000.00	1	2022
17	Main Canal Crossing Siphon & Appurtenances	LS	1	$ 500,000.00	$ 500,000.00	1	2022
18	WKWD Pipeline Crossing Siphon & Appurtenances	LS	1	$ 250,000.00	$ 250,000.00	1	2022
19	Stockdale Hwy Crossing Siphon & Appurtenances	LS	1	$ 1,000,000.00	$ 1,000,000.00	1	2022
20	I-5 Crossing Siphon & Appurtenances	LS	1	$ 1,500,000.00	$ 1,500,000.00	1	2022
21	Farm Road Siphon & Appurtenances	EA	3	$ 600,000.00	$ 1,800,000.00	1	2022
22	84" Siphon Piping	LF	10,720	$ 1,500.00	$ 16,080,000.00	1	2022
23	Lift Station Excavation	LS	3	$ 60,000.00	$ 180,000.00	1	2023
24	Lift Station Reinforced Concrete Structure	LS	3	$ 650,000.00	$ 1,950,000.00	1	2023
25	Lift Station Pumps - 67 cfs to 83 cfs	EA	18	$ 150,000.00	$ 2,700,000.00	1	2023
26	Lift Station Motors - 300 hp to 400 hp	EA	18	$ 95,000.00	$ 1,710,000.00	1	2023
27	Lift Station Discharge Piping & Appurtenances	LS	3	$ 750,000.00	$ 2,250,000.00	1	2023
28	Lift Station VFD's	EA	18	$ 50,000.00	$ 900,000.00	1	2023
29	Lift Station Electrical, Controls, & Lighting	LS	3	$ 500,000.00	$ 1,500,000.00	1	2023
30	Lift Station Backfill & Compaction	LS	3	$ 65,000.00	$ 195,000.00	1	2023
31	Lift Station Slide Gates	EA	3	$ 37,500.00	$ 112,500.00	1	2023
32	Lift Station Miscellaneous Steel	LS	3	$ 80,000.00	$ 240,000.00	1	2023
33	Lift Station Site Fencing	LS	1	$ 135,000.00	$ 135,000.00	1	2023
34	Lift Station Ground Cover	LS	1	$ 45,000.00	$ 45,000.00	1	2023
35	West Basins Turnout Structure Excavation	LS	1	$ 50,000.00	$ 50,000.00	1	2024
36	West Basins Turnout Reinforced Concrete Structure	LS	1	$ 200,000.00	$ 200,000.00	1	2024
37	West Basins Structure Backfill & Compaction	LS	1	$ 50,000.00	$ 50,000.00	1	2024
38	West Basins Turnout Miscellaneous Steel	LS	1	$ 35,000.00	$ 35,000.00	1	2024
39	West Basins Metering	EA	3	$ 90,000.00	$ 270,000.00	1	2024
40	West Basins Turnout Slide Gate	EA	3	$ 55,000.00	$ 165,000.00	1	2024
41	West Basins Turnout Electrical	LS	1	$ 150,000.00	$ 150,000.00	1	2024
42	Phase II 640 Acres Turnout Structure Excavation	LS	1	$ 55,000.00	$ 55,000.00	2	2024
43	Phase II 640 Acres Turnout Reinforced Concrete Structure	LS	1	$ 150,000.00	$ 150,000.00	2	2024
44	Phase II 640 Acres Structure Backfill & Compaction	LS	1	$ 50,000.00	$ 50,000.00	2	2024
45	Phase II 640 Acres Turnout Miscellaneous Steel	LS	1	$ 40,000.00	$ 40,000.00	2	2024
46	Phase II 640 Acres Metering	EA	2	$ 90,000.00	$ 180,000.00	2	2024
47	Phase II 640 Acres Turnout Slide Gate	EA	2	$ 37,500.00	$ 75,000.00	2	2024
48	Phase II 640 Acres Turnout Electrical	LS	1	$ 150,000.00	$ 150,000.00	2	2024

49	Phase II 640 Acres Earthwork and Interbasin Structures	LS	1	$ 2,895,200.00	$ 2,895,200.00	2	2023
50	Phase II 640 Acres Well Drilling, Construction, & Development	EA	6	$ 798,901.00	$ 4,793,406.00	2	2023
51	Phase II 640 Acres Well Equipping with Pumps, Motors, Discharge Piping, & Electrical	EA	6	$ 777,333.67	$ 4,664,002.00	2	2024
52	Phase II 640 Acres Well Recovery Pipeline - 16" C905 PVC	LF	2800	$ 70.00	$ 196,000.00	2	2024
53	Phase II 640 Acres Well Recovery Pipeline - 24" C905 PVC	LF	5500	$ 130.00	$ 715,000.00	2	2024
54	Phase II 640 Acres Well Recovery Pipeline - 36" C905 PVC	LF	4200	$ 180.00	$ 756,000.00	2	2024
55	Goose Lake Slough Turnout Structure Excavation	LS	1	$ 60,000.00	$ 60,000.00	1	2023
56	Goose Lake Slough Turnout Reinforced Concrete Structure	LS	1	$ 650,000.00	$ 650,000.00	1	2023
57	Goose Lake Slough Turnout Backfill & Compaction	LS	1	$ 60,000.00	$ 60,000.00	1	2023
58	Goose Lake Slough Turnout Miscellaneous Steel	LS	1	$ 80,000.00	$ 80,000.00	1	2023
59	Goose Lake Slough Lift Station Pumps - 60 cfs	EA	4	$ 140,000.00	$ 560,000.00	1	2023
60	Goose Lake Slough Lift Station Motors - 300 hp	EA	4	$ 85,000.00	$ 340,000.00	1	2023
61	Goose Lake Slough Lift Station Discharge Piping & Appurtenances	LS	1	$ 600,000.00	$ 600,000.00	1	2023
62	Goose Lake Slough Metering	EA	2	$ 90,000.00	$ 180,000.00	1	2023
63	Goose Lake Slough Turnout Slide Gate	EA	1	$ 37,500.00	$ 37,500.00	1	2023
64	Goose Lake Slough Turnout Electrical	LS	1	$ 500,000.00	$ 500,000.00	1	2023
65	Phase 1 640 Acres Conveyance Pipelines	LF	200	$ 1,500.00	$ 300,000.00	1	2023
66	Phase 1 640 Acres Discharge Structure	LS	1	$ 55,000.00	$ 55,000.00	1	2023
67	Goose Lake Slough Check Structure - Earthwork	LS	1	$ 35,000.00	$ 35,000.00	1	2023
68	Goose Lake Slough Check Structure - Reinforced Concrete	LS	1	$ 200,000.00	$ 200,000.00	1	2023
69	Goose Lake Slough Check Structure - Rip-Rap	LS	1	$ 30,000.00	$ 30,000.00	1	2023
70	Goose Lake Slough Check Structure - Appurtenances, Weir Boards	LS	1	$ 25,000.00	$ 25,000.00	1	2023
71	RRB Intake Canal Interconnection	LS	1	$ 250,000.00	$ 250,000.00	1	2023
72	Phase 1 640 Acres Earthwork and Interbasin Structures	LS	1	$ 2,895,200.00	$ 2,895,200.00	1	2022
73	Phase 1 640 Acres Well Drilling, Construction, & Development	EA	6	$ 798,901.00	$ 4,793,406.00	1	2022
74	Phase 1 640 Acres Well Equipping with Pumps, Motors, Discharge Piping, & Electrical	EA	6	$ 777,333.67	$ 4,664,002.00	1	2022
75	Phase 1 640 Acres Well Recovery Pipeline - 16" C905 PVC	LF	1350	$ 70.00	$ 94,500.00	1	2022
76	Phase 1 640 Acres Well Recovery Pipeline - 24" C905 PVC	LF	4200	$ 130.00	$ 546,000.00	1	2022
77	Phase 1 640 Acres Well Recovery Pipeline - 30" C905 PVC	LF	2800	$ 130.00	$ 364,000.00	1	2022
78	Phase 1 640 Acres Well Recovery Pipeline - 36" C905 PVC	LF	2800	$ 180.00	$ 504,000.00	1	2022
79	SCADA Communication & Appurtenances	LS	1	$ 300,000.00	$ 300,000.00	1	2022
	Contract Cost:				*$ 104,880,716.00*		
	20% Construction Contingency:				*$ 20,976,143.20*		2021
	Property Acquisition - 640 acres	*AC*	*640*	*$ 26,500.00*	*$ 16,960,000.00*		2019
	Property Acquisition - 640 acres	*AC*	*640*	*$ 21,500.00*	*$ 13,760,000.00*		2019
	Temporary Easement	*AC*	*235*	*$ 3,750.00*	*$ 881,250.00*		2020
	Permanent Easement	*AC*	*165*	*$ 10,750.00*	*$ 1,773,750.00*		2020
	Aqueduct R/W & Compliance	*LS*	*1*	*$ 25,000.00*	*$ 25,000.00*		2020
	Habitat Credit Purchase	*AC*	*200*	*$ 16,000.00*	*$ 3,200,000.00*		2020
	Field Cost:				*$ 162,456,859.20*		
	Non-Contract Costs:				*$ 8,865,000.00*		2019
	Total Construction Cost:				***$171,321,859.20***		

Summary — WSIP 2030 SCENARIO

Year Type	ENV Recharge (TAF/year)	ENV Recovery (TAF/year)	IRWD Recharge (TAF/year)	IRWD Recovery (TAF/year)	ROSEDALE Recharge (TAF/year)	ROSEDALE Recovery (TAF/year)
Wet	2	0	2	0	2	0
Above Normal	2	0	4	1	4	0
Below Normal	1	0	2	1	2	0
Dry	0	3	0	2	0	4
Critical	0	2	0	4	0	4
All Years	1.3	1.0	1.6	1.3	1.5	1.4
Model Column:	W	Z	AB	AE	AG	AJ

Sacramento Valley Year Type	Water Year	ENV Recharge (TAF/year)	ENV Recovery (TAF/year)	IRWD Recharge (TAF/year)	IRWD Recovery (TAF/year)	ROSEDALE Recharge (TAF/year)	ROSEDALE Recovery (TAF/year)		**Recharge Years of Operation**		**Recovery Years of Operation**
Above Normal	1922	0.00	0.00	0.00	0.00	0.00	0.00				
Below Normal	1923	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1924	0.00	0.00	0.00	0.00	0.00	0.00				
Dry	1925	0.00	0.00	0.00	0.00	0.00	0.00				
Dry	1926	0.00	0.00	0.00	0.00	0.00	0.00				
Wet	1927	0.00	0.00	0.00	0.00	0.00	0.00				
Above Normal	1928	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1929	0.00	0.00	0.00	0.00	0.00	0.00				
Dry	1930	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1931	0.00	0.00	0.00	0.00	0.00	0.00				
Dry	1932	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1933	0.00	0.00	0.00	0.00	0.00	0.00				
Critical	1934	0.00	0.00	0.00	0.00	0.00	0.00				
Below Normal	1935	0.00	0.00	0.00	0.00	0.00	0.00				
Below Normal	1936	5.96	0.00	8.95	0.00	8.95	0.00	23.86	0.11		
Below Normal	1937	5.96	0.00	9.01	0.00	8.88	0.00	23.86	0.11		
Wet	1938	11.35	0.00	17.33	0.00	16.72	0.00	45.41	0.21		
Dry	1939	0.00	13.75	0.00	2.50	0.00	7.50	0.00	0.00	23.75	0.50
Above Normal	1940	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	5.00	0.10
Wet	1941	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1942	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1943	9.27	0.00	7.57	0.00	7.02	0.00	23.86	0.11	0.00	0.00
Dry	1944	0.00	13.75	0.00	5.00	0.00	15.00	0.00	0.00	33.75	0.71
Below Normal	1945	8.46	0.00	7.43	7.50	7.96	0.00	23.86	0.11	7.50	0.16
Below Normal	1946	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1947	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1948	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1949	0.00	0.00	0.00	7.50	0.00	15.00	0.00	0.00	22.50	0.47
Below Normal	1950	0.00	0.00	0.00	7.50	0.00	0.00	0.00	0.00	7.50	0.16
Above Normal	1951	0.07	0.00	0.13	0.00	0.13	0.00	0.34	0.00	0.00	0.00
Wet	1952	-8.46	0.00	-7.85	0.00	-7.20	0.00	-23.51	-0.11	0.00	0.00
Wet	1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1955	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1956	11.54	0.00	17.32	0.00	17.32	0.00	46.18	0.21	0.00	0.00
Above Normal	1957	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1958	5.77	0.00	8.83	0.00	8.49	0.00	23.09	0.11	0.00	0.00
Below Normal	1959	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1960	0.00	13.75	0.00	0.00	0.00	0.00	0.00	0.00	13.75	0.29
Dry	1961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1962	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	1964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1965	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1966	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1967	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1969	20.16	0.00	13.05	0.00	12.20	0.00	45.41	0.21	0.00	0.00
Wet	1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1971	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Below Normal	1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	1973	5.96	0.00	4.18	0.00	3.30	0.00	13.44	0.06	0.00	0.00
Wet	1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical	1976	0.00	13.75	0.00	2.50	0.00	7.50	0.00	0.00	23.75	0.50
Critical	1977	0.00	0.00	0.00	31.25	0.00	29.67	0.00	0.00	60.92	1.27
Above Normal	1978	7.73	0.00	20.08	3.12	19.91	0.00	47.71	0.22	3.12	0.07
Below Normal	1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	1980	8.21	0.00	21.96	0.00	20.56	0.00	50.74	0.23	0.00	0.00

Dry	1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1982	0.54	0.00	1.76	0.00	1.08	0.00	3.38	0.02	0.00	0.00
Wet	1983	0.08	0.00	0.30	0.00	0.12	0.00	0.50	0.00	0.00	0.00
Wet	1984	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Dry	1985	0.00	13.75	0.00	0.00	0.00	0.00	0.00	0.00	13.75	0.29
Wet	1986	13.75	0.00	0.00	0.00	0.00	0.00	13.75	0.06	0.00	0.00
Dry	1987	0.00	0.00	0.00	18.75	0.00	30.00	0.00	0.00	48.75	1.02
Critical	1988	0.00	13.75	0.00	16.25	0.00	7.50	0.00	0.00	37.50	0.78
Dry	1989	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	2.50	0.05
Critical	1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical	1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical	1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical	1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet	1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry	2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Above Normal	2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
									1.65		**6.36**

Summary

	WSIP 2070 SCENARIO					
	ENV		IRWD		ROSEDALE	
Year Type	Recharge (TAF/year)	Recovery (TAF/year)	Recharge (TAF/year)	Recovery (TAF/year)	Recharge (TAF/year)	Recovery (TAF/year)
Wet	3	0	3	0	3	0
Above Normal	2	0	5	1	5	0
Below Normal	0	0	0	1	0	1
Dry	0	3	0	4	0	6
Critical	0	1	0	2	0	1
All Years	1.1	0.8	1.7	1.5	1.7	1.5
Model Column:	W	Z	AB	AE	AG	AJ

		ENV		IRWD		ROSEDALE					
Sacramento Valley Year Type	Water Year	Recharge (TAF/year)	Recovery (TAF/year)	Recharge (TAF/year)	Recovery (TAF/year)	Recharge (TAF/year)	Recovery (TAF/year)		**Recharge Years of Operation**		**Recovery Years of Operation**
Above Normal	1922	0	0	0	0	0	0				
Below Normal	1923	0	0	0	0	0	0				
Critical	1924	0	0	0	0	0	0				
Dry	1925	0	0	0	0	0	0				
Dry	1926	0	0	0	0	0	0				
Wet	1927	0	0	0	0	0	0				
Above Normal	1928	0	0	0	0	0	0				
Critical	1929	0	0	0	0	0	0				
Dry	1930	0	0	0	0	0	0				
Critical	1931	0	0	0	0	0	0				
Dry	1932	0	0	0	0	0	0				
Critical	1933	0	0	0	0	0	0				
Critical	1934	0	0	0	0	0	0				
Below Normal	1935	0	0	0	0	0	0				
Below Normal	1936	0	0	0	0	0	0	0.00	0.00		
Below Normal	1937	0	0	0	0	0	0	0.00	0.00		
Wet	1938	17	0	26	0	26	0	69.26	0.32		
Dry	1939	0	14	0	5	0	15	0.00	0.00	33.75	0.71
Above Normal	1940	0	0	0	8	0	0	0.00	0.00	7.50	0.16
Wet	1941	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1942	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1943	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1944	0	0	0	10	0	8	0.00	0.00	17.94	0.38
Below Normal	1945	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1946	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1947	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1948	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1949	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1950	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1951	11	0	17	0	17	0	45.41	0.21	0.00	0.00
Wet	1952	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1953	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1954	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1955	0	0	0	15	0	16	0.00	0.00	30.22	0.63
Wet	1956	7	0	19	0	19	0	46.18	0.21	0.00	0.00
Above Normal	1957	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1958	4	0	10	0	9	0	23.09	0.11	0.00	0.00
Below Normal	1959	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1960	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1961	0	14	0	5	0	15	0.00	0.00	33.75	0.71
Below Normal	1962	0	0	0	8	0	0	0.00	0.00	7.50	0.16
Wet	1963	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	1964	0	0	0	12	0	11	0.00	0.00	23.51	0.49
Wet	1965	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1966	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1967	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1968	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1969	11	0	24	0	23	0	58.57	0.27	0.00	0.00
Wet	1970	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1971	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Below Normal	1972	0	0	0	3	0	8	0.00	0.00	10.00	0.21
Above Normal	1973	0	0	0	5	0	0	0.00	0.00	5.00	0.10
Wet	1974	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1975	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1976	0	0	0	13	0	14	0.00	0.00	26.22	0.55
Critical	1977	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1978	5	0	22	0	21	0	47.71	0.22	0.00	0.00
Below Normal	1979	0	0	0	0	0	0	0.00	0.00	0.00	0.00

Above Normal	1980	4	0	21	0	19	0	44.47	0.20	0.00	0.00
Dry	1981	0	14	0	0	0	0	0.00	0.00	13.75	0.29
Wet	1982	14	0	1	0	1	0	16.35	0.07	0.00	0.00
Wet	1983	2	0	0	0	0	0	2.32	0.01	0.00	0.00
Wet	1984	0	0	0	0	0	0	0.03	0.00	0.00	0.00
Dry	1985	0	14	0	0	0	0	0.00	0.00	13.75	0.29
Wet	1986	14	0	0	0	0	0	13.75	0.06	0.00	0.00
Dry	1987	0	0	0	26	0	37	0.00	0.00	63.75	1.33
Critical	1988	0	14	0	11	0	0	0.00	0.00	25.00	0.52
Dry	1989	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1990	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1991	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1992	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	1993	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Critical	1994	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1995	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1996	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1997	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1998	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Wet	1999	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	2000	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	2001	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Dry	2002	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Above Normal	2003	0	0	0	0	0	0	0.00	0.00	0.00	0.00
									1.68		**6.52**