Technical Memorandum

Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California

CONTENTS

FIGURES

TABLES

ACRONYMS

CFS	cubic feet per second
CVP	Central Valley Project
CWC	California Water Commission
DEW	Drier/Extreme Warming
DWR	California Department of Water Resources
GSA	Groundwater Sustainability Agency
Friant	Friant Water Authority
Friant Contractors	Friant Division long-term contract holders
PEIS/R	Program Environmental Impact Statement/Report
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RWA	Recovered Water Account
SGMA	Sustainable Groundwater Management Act
SJRRP	San Joaquin River Restoration Program
SJRRS	San Joaquin River Restoration Settlement
SWP	State Water Project
TAF	thousand acre-feet
TM	Technical Memorandum
WMW	Wetter, Moderate Warming
WSIP	Water Supply Investment Program

This page left blank intentionally.

BACKGROUND

The Friant Water Authority (Friant) was approached by several Groundwater Sustainability Agencies (GSAs) for information about future water supply availability from the Central Valley Project (CVP) Friant Division. Those GSAs include the following, who were subsequently engaged during the development of analysis to meet their request:

- Mid-Kaweah GSA, represented by Paul Hendrix
- White Wolf Sub-basin GSA, represented by Jeevan Muhar
- Kern Groundwater Authority, represented by Terry Erlewine

This Technical Memorandum (TM) was prepared for use by those GSAs and others, in accordance with the expectations set by the Friant Board of Directors in their 2016 Strategic Plan to provide "accurate and up-to-date data needed to manage water supplies through modeling and data collection."

This TM presents five scenarios that were intended to represent a range of potential water supply conditions for the Friant Division through the end of the century, all of which were assembled from existing studies that were recently conducted using the CalSim-II computer model. These scenarios were assembled from pre-existing model runs and analysis and have been compiled and reviewed by Friant for use or consideration in plans developed by GSAs that receive Friant Contract surface water deliveries. The selected scenarios are summarized below and organized by their identification name in the accompanying "Summary_FutureFriantSupplies_Final" spreadsheet file.

1. **Model Run 2015.c (''2015.c'')** was designed to represent current conditions, where implementation of the San Joaquin River Restoration Settlement (SJRRS) is limited by downstream capacity limitations and the climate and hydrology are assumed to be most similar to historical hydrologic conditions.

2. **''2030.c''** was designed to represent near future climate conditions centered around 2030 and uses California Department of Water Resources (DWR's) central tendency climate projection. This scenario assumes implementation of the SJRRS, as described in the Reclamation's Funding Constrained Framework for Implementing the SJRRS (SJRRP, 2018).

3. **''2070.c''** was designed to represent far-future climate conditions centered around 2070 and uses DWR's central tendency climate projection. This scenario assumes implementation of the SJRRS, as described in the Reclamation's Funding Constrained Framework for Implementing the SJRRS (SJRRP, 2018).

4. **''DEW.c''** was included in this TM for completeness, as it represents an extreme climate condition (being: Drier/Extreme Warming, "DEW") that was produced by DWR for planning studies. The DEW scenario was developed by DWR as a means of bracketing the range of potential future climate conditions by 2070, which are highly uncertain. This scenario was modeled with implementation of the SJRRS, as described in the Reclamation's Funding Constrained Framework for Implementing the SJRRS (SJRRP, 2018).

5. **''WMW.c''** was included in this TM for completeness, as it represents an extreme climate condition (being: Wetter/Moderate Warming, "WMW") that was produced by DWR for planning studies. The WMW scenario was developed by DWR as a means of bracketing the range of potential future climate conditions by 2070, which are highly uncertain. This scenario was modeled with implementation of the SJRRS, as described in the Reclamation's Funding Constrained Framework for Implementing the SJRRS (SJRRP, 2018).

For questions, clarifications, or suggestions that will improve this TM or its application with the implementation of the Sustainable Groundwater Management Act (SGMA) for planning purposes, please contact Jeff Payne, Director of Water Policy at jpayne@friantwater.org

STUDY SETTING

The Friant Division includes storage for waters of the San Joaquin River at Friant Dam (Millerton Lake), as well as conveyance and delivery facilities through the Friant-Kern and Madera canals that deliver water to 32 Friant Division long-term contract holders (Friant Contractors) and other water users. Figure 1 shows the location of the Friant Contractors in the San Joaquin Valley. Friant Contractors all have access to waters of the San Joaquin River through their contracts with Reclamation. However, most Friant Contractors have other supplies that include groundwater and surface water supplies that are local to their geography.

Combined, the facilities of the Friant Division span over 180 miles, crossing seven rivers, and conveying water between 16 GSAs as shown in Figure 2. All the basins connected by the Friant Division and its facilities are considered by DWR to be “critically overdrafted” and therefore are each a “high priority” for the implementation of SGMA. Table 1 lists the Friant Contractors with lands overlapping a GSA and 2014 Friant Contractor irrigated lands. A Friant Contractor may appear in more than one GSA. The 2014 irrigated acreage was obtained from remote sensing from DWR (DWR, 2017). Friant Division M&I contractors were assumed to have no agricultural demand. Kaweah-Delta Water Conservation District agricultural demands were not estimated in this analysis. Any agricultural demand within City of Fresno is represented as part of the Fresno Irrigation District.

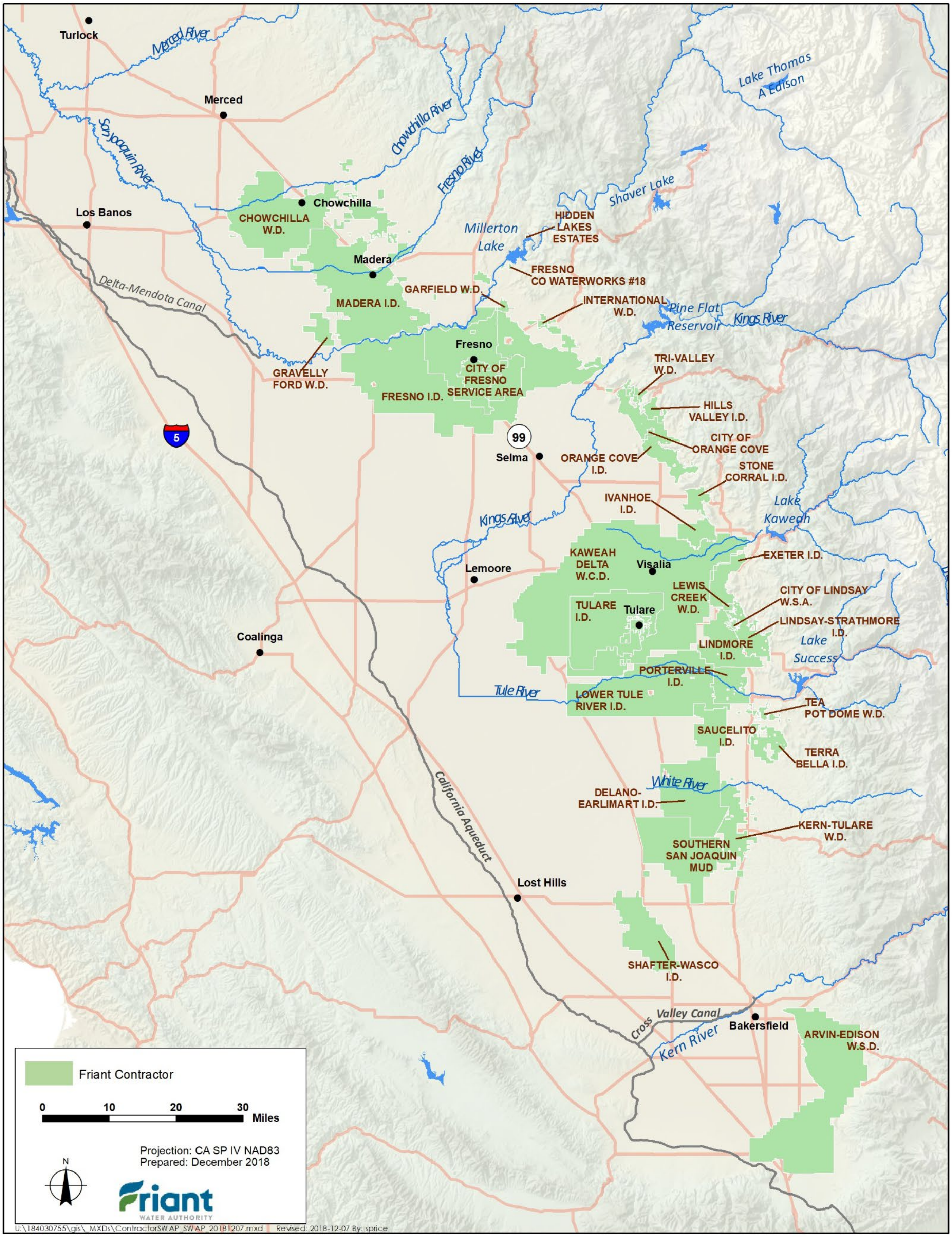

Figure 1: Location of Friant Contractors in the San Joaquin Valley

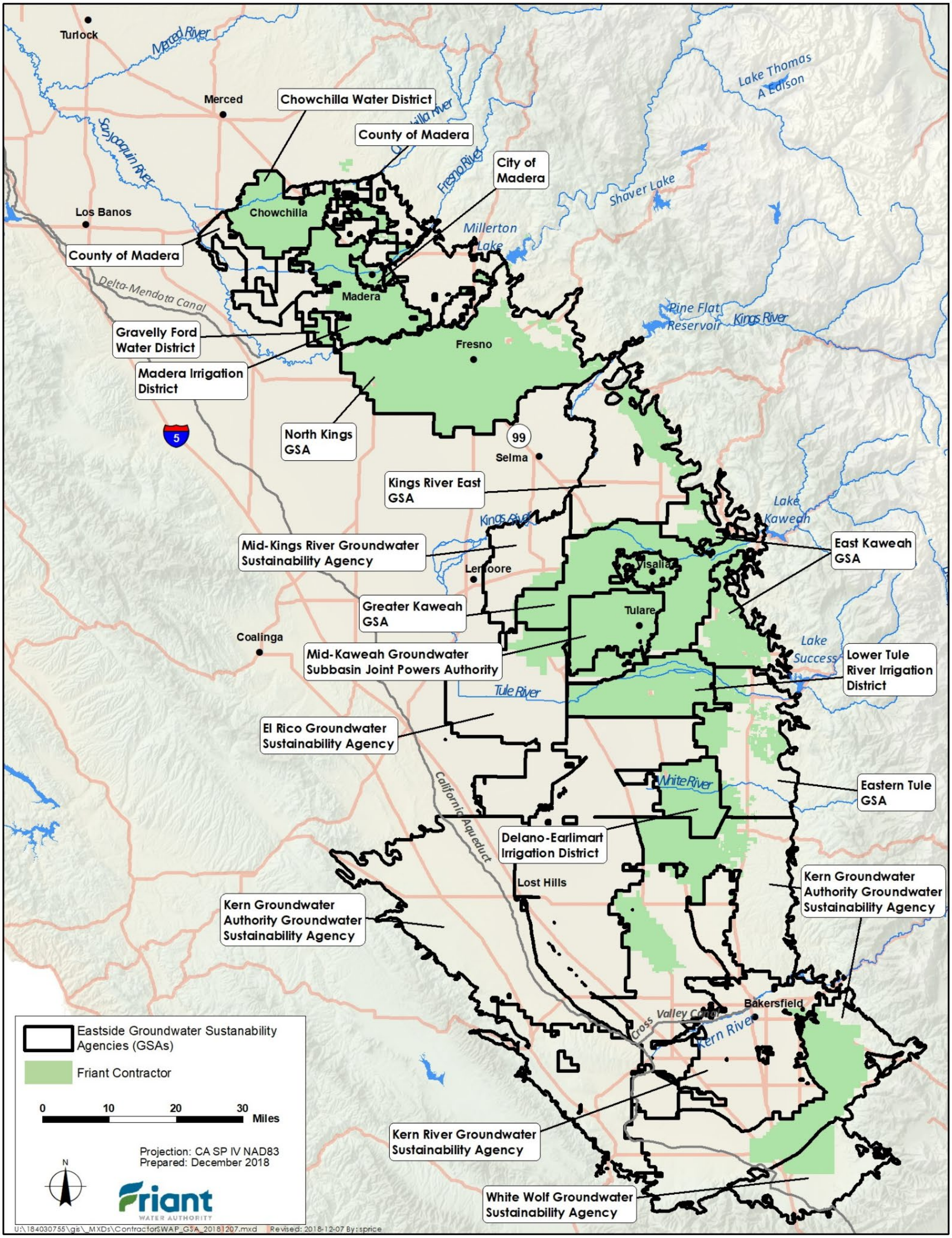

Figure 2: Location of Friant Contractors relative to GSAs

Table 1. Friant Contractors and Estimated Irrigated Acreage relative to GSAs (DWR, 2017)

GROUNDWATER SUSTAINABILITY AGENCY	FRIANT CONTRACTOR[1]	FRIANT CONTRACTOR IRRIGATED LAND[2] (ACRES)
Chowchilla Water District	Chowchilla Water District	67,170
City of Madera	Madera Irrigation District	910
County of Madera	Chowchilla Water District	30
	Madera Irrigation District	90
Gravelly Ford Water District	Gravelly Ford Water District	7,490
Madera Irrigation District	Madera Irrigation District	100,360
North Kings GSA	Fresno Irrigation District[3]	128,330
	Garfield Water District	1,160
	International Water District	540
Kings River East GSA	Hills Valley Irrigation District	2,830
	Orange Cove Irrigation District	24,360
	Tri-Valley Water District	1,040
Mid-Kings River GSA	Kaweah Delta Water Conservation District[2]	NE
East Kaweah GSA	Exeter Irrigation District	10,580
	Ivanhoe Irrigation District	9,630
	Lewis Creek Water District	1,010
	Lindmore Irrigation District	22,760
	Lindsay - Strathmore Irrigation District	10,880
	Lower Tule River Irrigation District	80
	Stone Corral Irrigation District	5,980
Greater Kaweah GSA	Exeter Irrigation District	500
	Ivanhoe Irrigation District	30
	Kaweah Delta Water Conservation District[4]	NE
	Tulare Irrigation District	60
Mid-Kaweah Groundwater Subbasin Joint Powers Authority	Tulare Irrigation District	58,160
El Rico GSA	Kaweah Delta Water Conservation District[4]	NE
Lower Tule River Irrigation District	Lower Tule River Irrigation District	80,480
	Porterville Irrigation District	70
Eastern Tule GSA	Kern - Tulare Water District	8,480
	Porterville Irrigation District	12,470
	Saucelito Irrigation District	18,060
	Tea Pot Dome Water District	3,090
	Terra Bella Irrigation District	9,110
Delano - Earlimart Irrigation District	Delano - Earlimart Irrigation District	49,960
Kern Groundwater Authority GSA	Arvin - Edison Water Storage District	84,280
	Kern-Tulare Water District	14,500
	Shafter - Wasco Irrigation District	30,190
	Southern San Joaquin Municipal Utility District	45,190
Kern River GSA	Arvin - Edison Water Storage District	190
White Wolf GSA	Arvin - Edison Water Storage District	20,830

Key:
GSA = Groundwater Sustainability Agency
NE = Not estimated
Notes:
[1]Only Friant Contractors with agricultural demands shown per GSA, Friant M&I contractors were assumed to have no agricultural demand.
[2] Irrigated lands rounded to nearest 10 acres
[3]Any agricultural lands within City of Fresno is represented as part of the Fresno Irrigation District
[4]Kaweah-Delta Water Conservation District agricultural lands were not estimated

PREVIOUS STUDIES AND REPORTS

The potential range of future Friant Division water supplies from the San Joaquin River have been studied for several recent efforts. This TM relies on computer models, assumptions, and analysis that were initially developed for and reported by the following:

- San Joaquin River Restoration Settlement, and Program (SJRRS and SJRRP)
  - Settlement Agreement (2006)
  - Program Environmental Impact Statement/Report (PEIS/R; Reclamation, 2009)
- Temperance Flat Reservoir studies, including:
  - Federal Feasibility Study (Reclamation, ongoing)
  - Application to California Proposition 1, Water Storage Investment Program (Temperance Flat Reservoir Authority, 2017)

FACTORS AFFECTING FRIANT SUPPLIES THROUGH YEAR 2100

Beyond the natural variability of annual precipitation in the headwaters of the San Joaquin River, several drivers are expected to greatly influence the water supplies of the Friant Division over the coming century. These include:

1. **Changes in the climate and hydrology**: These changes include a warming trend that is expected to reduce winter snow accumulation and hasten spring melt and runoff. Five climate conditions are considered in this report.
2. **Implementation of the SJRRS Restoration Goal:** The SJRRS Restoration Goal is currently limited in its implementation but is expected to be fully implemented by 2030, with the completion of river conveyance enhancements below Friant Dam. When completed, the impact of the SJRRS on Friant Contractor supplies will reach the extent anticipated in the SJRRS.
3. **Implementation of the SJRRS Water Management Goal**: The SJRRS Water Management Goal provides for several mechanisms to reduce or avoid water supply impacts on Friant Contractors. The water supply benefits of two SJRRS provisions are quantified in this analysis, being those described in Paragraphs 16(a) (i.e., recapture and recirculation) and 16(b) (i.e., water sold at $10 per acre foot during wet conditions).
   - Paragraph 16(a) is restricted at this time, being limited to the recapture of flows that can be released from Friant Dam. As implementation of the Restoration Goal progresses, so will recapture and recirculation.
   - Paragraph 16(b) is currently underutilized. At the time of the Settlement, a fixed $10 per acre foot price for wet year supplies was expected to stimulate investments in groundwater infiltration facilities. With subsequent water supply challenges imposed by SGMA on the Eastern San Joaquin Valley, the regional appetite for groundwater infiltration has grown dramatically. At this time, Friant Contractors anticipate considerable interest and ability to divert and infiltrate flows that may have spilled from Friant Dam under historical conditions. The upper end of implementation of 16(b) is expected to occur before 2030.
4. **Interruptions in Delta Water Supplies**: In summary, waters of the San Joaquin River have been made available to the Friant Division through both a water rights purchase and an exchange contract. The exchange contract is subject to delivery of water supplies from the Delta to the original instream water rights holders, where interruptions in Delta supplies can result in deliveries from Friant Dam to Mendota Pool that reduce water supplies to the Friant Division.

   While interruptions in Delta supplies have been experienced in recent years, this analysis does not include any related shortfalls to the Friant Division for any of the presented scenarios for several reasons. First, recent and unpublished Reclamation modeling that includes the latest adjustments to the Coordinated Operations Agreement (signed December 2018) and several other updates suggests that there would not be any shortfalls over the historical hydrology. Second, Friant staff have judged that publicly available simulations of Delta supplies and upstream reservoir operations are not realistic. Lastly, the interpretation of the exchange contract is currently being litigated and speculation on the matter by Friant could create an unnecessary distraction.

   However, a GSP that desires to apply the consequence of an interrupted Delta water supply may do so with minor modification to the results in this TM. This can be achieved by reducing Friant Division water supplies for 1977 by up to 100 percent, at the discretion of the GSP. Analysis conducted for Friant has indicated that 1977 produces conditions that are closest to those that may require releases from Friant Dam. The reader should note that the CalSim II period of analysis does not consider conditions in the recent drought, being limited to the historical period from 1921 to 2003.

INVENTORY OF MODEL SIMULATIONS PERFORMED

This report presents simulated operations that account for five climate conditions and the eventual full implementation of SJRRS Restoration and Water Management goals. Table 2 identifies 15 individual modeling runs compiled for this TM, along with the major assumptions for each.

The reader should note that each of the five climate conditions contain three model runs, denoted with a suffix of "a", "b", and "c". To calculate the Restoration Goal for each of these climate conditions, model runs "a" and "b" were conducted to create comparisons that are necessary for explaining effect of SJRRS implementation. Calculation of the Water Management Goal requires a comparison of model runs "a" to model runs "b" and "c" to represent the expected recapture and recirculation for each level of SJRRS implementation.

In all cases, the scenario with a ".c" suffix is the only model run recommended for use by GSPs. The other two simulations (".a" and ".b") are provided for reference and specifications for their simulation are documented, below.

Table 2. Fifteen model runs simulated for this Report

MODEL RUN	CLIMATE CONDITION	SJRRS SETTLEMENT		BENCHMARK CALSIM-II MODEL USED
		RESTORATION GOAL	WATER MANAGEMENT GOAL	
2015.a	2015 Conditions (historical modified for recent changes)	Pre-SJRRS	Pre-SJRRS	DWR Delivery Capability Report, 2015 climate
2015.b		Limited SJRRS	Limited Access	
2015.c			Full Access	
2030.a	Near-Future (DWR 2030 Central Tendency)	Pre-SJRRS	Pre-SJRRS	Water Commission, 2030 climate
2030.b		Full SJRRS	Limited Access	
2030.c			Full Access	
2070.a	Late-Future (DWR 2070 Central Tendency)	Pre-SJRRS	Pre-SJRRS	Water Commission, 2070 climate
2070.b		Full SJRRS	Limited Access	
2070.c			Full Access	
DEW.a	Late-Future, 2070 Drier/Extreme Warming	Pre-SJRRS	Pre-SJRRS	Water Commission, 2070 DEW climate
DEW.b		Full SJRRS	Limited Access	
DEW.c			Full Access	
WMW.a	Late-Future, 2070 Wetter/Moderate Warming	Pre-SJRRS	Pre-SJRRS	Water Commission, 2070 WMW climate
WMW.b		Full SJRRS	Limited Access	
WMW.c			Full Access	

Key:
DEW = Drier/Extreme Warming
DWR = California Department of Water Resources
SJRRS = San Joaquin River Restoration Settlement
WMW = Wetter/Moderate Warming

All simulations were performed using CalSim-II, the State of California's premiere water supply planning and analysis tool. The primary use of the CalSim model is for estimating water supply exports from the Sacramento-San Joaquin Delta for delivery to CVP and State Water Project (SWP) water users. CalSim-II simulates statewide water supply operations using a continuous 82-year hydrology, traditionally based on the period of historic records beginning October 1921 and running through September 2003.

CLIMATE CHANGES EVALUATED

The California Water Commission (CWC) Water Supply Investment Program (WSIP) developed baseline CalSim-II simulations using several levels of potential climate change to modify input hydrology of the entire system, including the San Joaquin River. These scenarios were developed using the 20 combinations of climate change models and representative concentration pathways recommended by DWR Climate Change Technical Advisory Group as being most appropriate for California water resource planning and analysis.

Further details on the specific climate change included in each of the simulations is included in the CWC WSIP Technical Reference (CWC, 2016). The resulting climate change conditions used in this analysis include:

1. **2015 Conditions:** This represents a historical hydrology modified to match climate and sea level conditions for a thirty-year period centered at 1995 (reference climate period 1981 – 2010).
2. **Near-Future 2030 Central Tendency:** This represents a 2030 future hydrology with projected climate and sea level conditions for a thirty-year period centered at 2030 (reference climate period 2016 – 2045).
3. **Late-Future 2070 Central Tendency:** This hydrology represents a 2070 future condition with projected climate and sea level conditions for a thirty-year period centered at 2070 (reference climate period 2056 – 2085).
4. **Late-Future 2070 Drier/Extreme Warming Conditions (DEW):** This hydrology represents a 2070 DEW future condition with projected climate and sea level conditions for a thirty-year period centered at 2070 (reference climate period 2056 – 2085).
5. **Late-Future 2070 Wetter/Moderate Warming Conditions (WMW):** This hydrology represents a 2070 WMW future condition with projected climate and sea level conditions for a thirty-year period centered at 2070 (reference climate period 2056 – 2085).

General advice on how to apply these climate change scenarios was provided by the CWC for use by applicants to the WSIP program. This advice can be found on-line, here:

https://cwc.ca.gov/-/media/CWC-Website/Files/Documents/2016/07_July/July2016_Agenda_Item_8_Attach_2_Updated_Climate_Change_Requirements.pdf

The seasonal timing of inflow to Millerton Lake is projected to change in response to climate change. Historical inflow to Millerton Lake generally peak during the month of June due to the delayed runoff from a large snow pack. The climate change scenarios for 2030 and 2070 are based on warmer conditions that will produce precipitation events with more rainfall and less snowpack than historically occurred, resulting in peak runoff earlier in the year. Peak runoff into Millerton Lake is projected to occur in May for the 2030 scenario, and in April for the 2070 scenario. Figure 3 shows the general trend of Millerton Lake inflow change due to climate change.

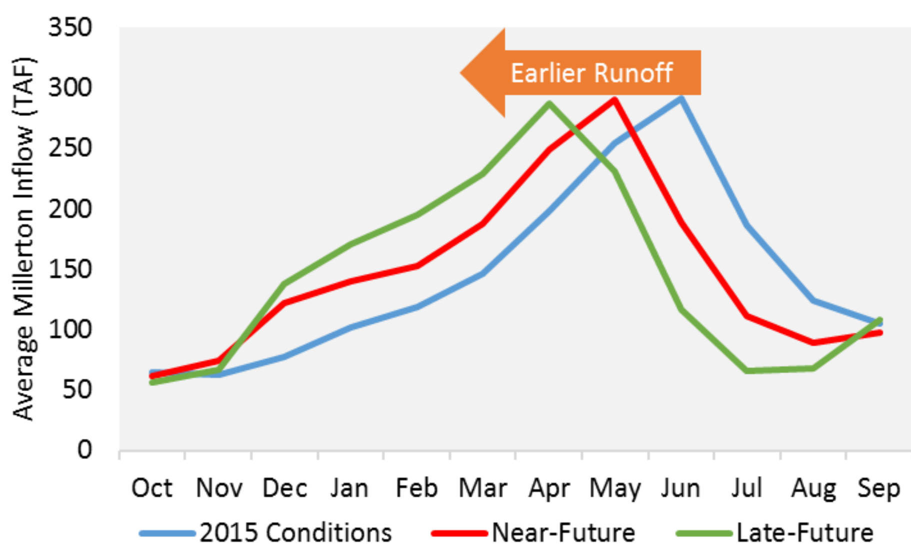

Figure 3. Millerton Lake Inflow Change Due to Climate Change

When analyzing CalSim-II outputs, the results are often summarized by water year type, which classifies groups of years with similar hydrologic characteristics. A water year starts October 1 of the preceding calendar year and ends September 30 of the current year. For example, water year 1922 starts October 1, 1921 and ends September 30, 1922. In this analysis the SJRRS water year type classification was used to summarize the estimated changes in Friant Division supplies. The SJRRS water year types are classified as follows: Wet, Normal-Wet, Normal-Dry, Dry, Critical High and Critical Low. For the CWC WSIP the SJRRP water year type classification remained unchanged between the five climate change conditions. In this TM, the SJRRS water year types were redefined based on Unimpaired Millerton Inflow (consistent with the SJRRS) from the CalSim II SV input files. This was done to update the SJRRS hydrographs to better reflect the anticipated climate change conditions. Table 3 summarizes the SJRRS water year types by climate condition. For reporting purposes, the designation of Critical water year type includes both Critical High and Critical Low SJRRS water year types.

Table 3. SJRRS Water Year Types per Climate Condition by Number of Years and Percentage of Total Years

SJRRS WATER YEAR TYPE	2015 CONDITIONS	NEAR-FUTURE, 2030	LATE-FUTURE, 2070	LATE-FUTURE, 2070 DEW	LATE-FUTURE, 2070 WMW
Wet	16 (20%)	18 (22%)	19 (23%)	21 (26%)	35 (43%)
Normal-Wet	25 (30%)	21 (26%)	20 (24%)	12 (15%)	21 (26%)
Normal-Dry	24 (29%)	25 (30%)	20 (24%)	11 (13%)	15 (18%)
Dry	12 (15%)	11 (13%)	16 (20%)	20 (24%)	9 (11%)
Critical[1]	5 (6%)	7 (9%)	7 (9%)	18 (22%)	2 (2%)
Long-Term[2]	82	82	82	82	82

Key:
DEW = Drier/Extreme Warming
DWR = California Department of Water Resources
SJRRS = San Joaquin River Restoration Settlement
WMW = Wetter/Moderate Warming
Note:
[1]For reporting purposes, the designation of Critical water year type includes both Critical High and Critical Low SJRRP water year types
[2]Long-Term average reflects the 82-year CalSim II simulation period (October 1921 thru September 2003)

SJRRS IMPLEMENTATION

Implementation of the SJRRS includes actions to meet both the Restoration and Water Management Goals. Both goals have a direct effect on Friant Division water supplies, and both are expected to change in implementation over time. As indicated in Table 2, each scenario is accompanied by two different levels of SJRRS implementation (denoted ".a" and ".b"). These model runs were conducted to allow for a comparative analysis, which is needed at this time to quantify changes in water supplies as part of the SJRRS implementation. Additionally, Friant had been asked for a representation of water supplies under current conditions, where downstream river capacities are constraining implementation of the SJRRS.

Presently, both goals are implemented in a limited manner because of capacity restrictions in the San Joaquin River below Friant Dam (which constrict releases for the Restoration Goal) and the need for further buildout of groundwater infiltration facilities to take full advantage wet year supplies, when available (for the Water Management Goals). However, Reclamation has plans for implementation that will allow for virtually all SJRRS releases to be made by 2025 (SJRRP, 2018). Further, water users throughout the Friant Division are pursuing a broad array of facilities that will enhance the ability to implement Paragraph 16(b) water supplies, when available.

Restoration Goal Implementation

Three levels of Restoration Goal implementation are considered, as follows:

1. **Pre-SJRRS:** This simulation sets the required minimum release from Millerton to the San Joaquin River to the values in the without project baseline conditions (SJRRP, 2009).

2. **Limited SJRRS:** This condition approximates current conditions, which are expected to remain limited until 2025. Simulations of this condition are based on the current channel capacity of 1,300 cubic feet per second (CFS) in Reach 2.
3. **Full SJRRS:** This condition represents the SJRRS hydrograph with capacities identified in the SJRRS Funding Constrained Framework. Under this plan, channel capacity will not exceed the identified 2025 channel capacity of 2,500 CFS in Reach 2. This hydrograph was used in the 2030, 2070, 2070 DEW, and 2070 WMW level of climate change simulations. Flow releases (Flow Schedules) for this condition were approximated with a spreadsheet developed by the SJRRP for the Framework Document (SJRRP, 2018). Table 3 shows the Full SJRRS Implementation hydrograph compared to the Funding Constrained Framework SJRRS hydrograph for the four climate change scenarios. The differences between the four climate change scenarios is due to the different number of years per SJRRS water year type, as shown in Table 3. Table 4 is not the impact of Friant Deliveries, but represents the SJRRS releases under the Funding Constrained Framework under different climate change conditions.

Table 4 Long-Term Average SJRRS Releases under Full SJRRS Implementation and the Funding Constrained Framework Four Climate Conditions

SJRRS WATER YEAR TYPE	FULL SJRRP IMPLEMENTATION (TAF/YEAR)	FUNDING CONSTRAINED FRAMEWORK			
		NEAR-FUTURE, 2030 (TAF/YEAR)	LATE-FUTURE, 2070 (TAF/YEAR)	LATE-FUTURE, 2070 DEW (TAF/YEAR)	LATE-FUTURE, 2070 WMW (TAF/YEAR)
Wet	674	633	633	628	633
Normal-Wet	474	434	433	428	432
Normal-Dry	365	365	364	363	357
Dry	302	297	296	296	300
Critical High	188	188	188	188	188
Critical Low	117	117	117	117	117
Long-Term[1]	438	417	414	376	483[2]

Key:
DEW = Drier/Extreme Warming
DWR = California Department of Water Resources
SJRRS = San Joaquin River Restoration Settlement
TAF/year = thousand acre-feet per year
WMW = Wetter/Moderate Warming
Note:
[1]Long-Term average reflects the 82-year CalSim II simulation period (October 1921 thru September 2003)
[2] The Long-Term Average SJRRS release for 2070 WMW is higher than the Full SJRRP Implementation because, as Table 3 shows, the number of Wet water years increased from 16 years (20 percent) in the 2015 Condition to 35 years (43 percent) in the 2070 WMW Condition.

The quantification of SJRRS implementation impact is performed by comparing the with and without SJRRS water supplies diverted from Friant Dam.

In the course of compiling these model runs, it was discovered that previous studies had not correctly implemented SJRRS flows under climate change. SJRRS outflow requirements at Friant Dam are determined by the total annual hydrology, which can change enough under climate conditions to alter a given year's release requirements. All scenarios and results in this report have been adjusted to correctly set SJRRS flow requirements, including under climate change.

Water Management Goal Implementation

Three levels of Water Management Goal implementation are considered, as follows:

a. **Pre-SJRRS**: This represents the without SJRRS condition.

b. **Limited Access:** This represents 16(a) supplies available to Friant Contractors as part of the SJRRS that provides for recapture and recirculation of flows released from Friant Dam for the purposes of meeting the Restoration Goal.

c. **Full Access:** This represents supplies anticipated with future ability to divert 16(a) and 16(b) supplies to Friant Contractors. 16(b) stipulates a Recovered Water Account (RWA) that represents water not required to meet SJRRS or other requirements be made available to Friant Contractors who experience a reduction in water deliveries from the implementation of the SJRRS. 16(b) water is made available to those Friant Contractors at $10 per acre-foot during wet condition.

The reader should be aware of the following assumptions regarding the presentation of SJRRS Paragraph 16(a) supplies (aka "recapture water") by this TM:

- The SJRRS and implementing documents identify several locations for recapture, however this analysis estimates recapture as the incremental improvement in total Delta Exports that result from the SJRRS. The total potential recapture could be higher if recapture is pursued on the lower San Joaquin River, before it enters the Delta.
- Volumes of Delta recapture are estimated by comparing simulated Delta exports with and without the implementation of the SJRRS. The net improvement in Delta export over the year is summed and presented as the recapture supply.
- Actual recapture will depend on future implementation decisions by both Reclamation and DWR, and the resolution of a dispute between Friant and westside CVP contractors who believe that SJRRS implementation will reduce their contract allocations. Resolution of these matters may reduce the available volumes of recaptured supply that are possible.
- Delivery of recaptured supplies to Friant Division lands from the Delta will require conveyance capacity and agreements with DWR and other agencies that are not currently well understood.
- Recapture will not be affected by implementation of the 2018 amendments to Coordinated Operations Agreement between Reclamation and DWR.
- Reclamation has been allocating recaptured supplies among Friant Contractors as if it were part of the Class 1 and Class 2 allocation at Friant Dam. Thus, all recapture is dedicated to Class 1 contract holders until the sum of Friant allocations and Recapture exceeds a 100 percent Class 1 allocation. Recapture supplies have been subdivided into in Class 1 and Class 2 quantities.
- Recapture water supply availability must be viewed as total opportunity.

The reader should be aware of the following assumptions regarding the presentation of SJRRS Paragraph 16(b) supplies (aka "$10 water" or "RWA water") by this TM:

- This analysis simulates 16(b) as an additional demand after Class 1 and Class 2 delivery allocations are met and before 215 ("Other") deliveries are made.
- This analysis simulates 16(b) delivery via the Friant Kern and Madera canals with an anticipated level of future groundwater infiltration facilities throughout the Friant Division. These facilities were contemplated as a result of SJRRS implementation, and are described by analysis in the SJRRS PEIS/R.
- The future management of 16(b) supplies cannot be fully anticipated at this time. Policy for the allocation of supplies has been in a constant state of evolution. For the purposes of this TM, a suggested allocation of 16(b) supplies among Friant Contractors is presented, based on the relative expected reduction in delivery of SJRRS on Class 1 and 2 contract supplies, by contractor.
- 16(b) water supply availability must be viewed as total opportunity.

GUIDANCE ON USE OF RESULTS

This TM provides descriptions of potential future water supplies for the Friant Division for five climate change conditions under different levels of SJRRS implementation.

The key outputs of this report are provided in tables by monthly and total volumes by contract year (which begins March 1 of the current calendar year and ends February 28 of the following year), except when noted, and summarized by SJRRS water year type classification and long-term average for each of the following:

- Millerton Lake Inflow
- Total Friant Division deliveries of:
  - Class 1
  - Class 2/Other
  - Paragraph 16(b) water (aka $10 water, or RWA water)
- Friant Dam Spill
- Potential Friant Division Delta Recapture (by year, only), for:
  - Class 1 Delta Recapture
  - Class 2 Delta Recapture
  - Total Delta Recapture

These data are provided in a spreadsheet, entitled: "Summary_FutureFriantSupplies_Final.xlsm"

Table 5 provides a portion of a tabulated output available in the spreadsheet. Tabulated information includes the average monthly and total volumes by SJRRS water year type classification and long-term average. For reporting purposes, the designation of Critical water year type includes both Critical-High and Critical-Low SJRRS water year types. Tabulated information also includes the monthly and total volumes per contract year (Mar-Feb). In the spreadsheet, the tables include the monthly and total volumes per contract year for the entire 82-year CalSim-II simulated period (October 1921 to September 2003).

Table 5. Example Output Table for Class 1 Deliveries

		Class 1 Delivery												
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
		TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF
	Wet	16.1	28.1	51.6	123.4	189.9	181.5	106.3	48.5	12.2	6.4	6.3	29.8	800.0
	Normal-Wet	26.2	46.3	75.0	149.8	189.3	165.2	84.0	28.9	4.7	4.5	4.5	21.6	800.0
	Normal-Dry	32.9	56.7	92.1	158.6	184.4	152.5	67.9	20.9	3.6	3.6	3.4	19.7	796.3
	Dry	29.7	48.8	81.7	143.9	167.1	130.5	55.8	20.9	4.7	2.3	2.3	17.3	705.1
	Critical	16.7	19.9	36.4	86.6	111.5	65.2	31.0	19.9	6.6	0.0	0.0	9.9	403.8
	Long Term	26.1	44.6	74.1	142.4	179.9	153.4	76.2	28.7	6.0	4.0	3.9	21.3	760.4
2015 SJRRP WY Type	Month Year	Mar TAF	Apr TAF	May TAF	Jun TAF	Jul TAF	Aug TAF	Sep TAF	Oct TAF	Nov TAF	Dec TAF	Jan TAF	Feb TAF	Total TAF
Normal-Wet	1921								0.0	0.0	0.0	0.0	0.0	0.0
Normal-Wet	1922	22.3	37.4	59.8	138.2	189.1	174.0	97.8	36.4	5.5	5.3	5.3	28.9	800.0
Normal-Wet	1923	25.6	42.7	64.4	146.7	187.1	170.7	95.2	33.8	4.9	4.6	4.6	19.7	800.0
Critical	1924	17.9	21.4	39.2	93.2	120.0	72.2	31.6	21.4	7.1	0.0	0.0	10.7	434.7
Normal-Dry	1925	32.8	56.4	89.7	158.4	188.2	152.0	70.7	21.0	3.9	3.9	3.3	19.7	800.0
Normal-Dry	1926	33.2	57.1	98.8	160.4	183.9	151.2	65.6	19.9	3.3	3.3	3.3	19.9	800.0
Normal-Wet	1927	25.7	47.4	80.6	151.2	191.4	163.5	79.8	26.8	4.8	4.6	4.6	19.8	800.0
Normal-Dry	1928	31.6	57.8	92.0	162.4	186.2	153.1	66.4	20.2	3.4	3.4	3.4	20.2	800.0
Dry	1929	26.8	48.2	80.3	132.2	148.5	124.8	53.0	16.1	2.7	2.7	2.7	16.1	654.0
Dry	1930	27.1	48.8	81.1	133.6	150.1	126.2	53.6	16.3	2.7	2.7	2.7	16.3	661.1
Critical	1931	12.9	15.5	28.3	67.4	86.9	52.3	22.9	15.5	5.2	0.0	0.0	7.7	314.5
Normal-Wet	1932	25.6	42.7	64.4	146.7	187.1	170.7	95.2	33.8	4.9	4.6	4.6	19.7	800.0
Normal-Dry	1933	32.8	56.4	89.7	158.4	188.2	152.0	70.7	21.0	3.9	3.9	3.3	19.7	800.0
Dry	1934	24.0	28.7	52.2	124.2	159.9	96.2	42.2	28.5	9.5	0.0	0.0	14.2	579.6
Normal-Wet	1935	28.2	47.3	80.4	150.7	190.7	162.9	79.5	26.7	4.7	4.6	4.6	19.7	800.0
Normal-Wet	1936	28.2	47.2	80.3	150.7	190.7	162.9	79.5	26.7	5.0	4.6	4.6	19.7	800.0
Normal-Wet	1937	28.7	48.0	81.6	159.5	191.1	160.7	74.5	24.0	4.0	4.0	4.0	20.0	800.0
Wet	1938	17.2	28.4	52.1	115.8	193.9	182.0	104.2	49.9	13.0	6.6	6.6	30.4	800.0

CLASS 1 AND CLASS 2 SUPPLY PROJECTIONS

While CalSim-II does produce estimated deliveries of Class 1 water supplies with some confidence, the simulated "Class 2" and "Other" model outputs have always been problematic. This is because CalSim-II approximations of wet year operations were calibrated to mimic total releases – not actual deliveries of Class 2 or (separately) Other supplies. As a result, the modeling outputs provided with this TM do not distinguish between Class 2 and Other modeling categories. These two data outputs have been grouped to describe Class 2 behavior in aggregate. Through previous modeling conducted for SJRRS implementation, Friant Division managers have found the aggregation of Class 2 and Other model outputs performs closer to actual experience with Class 2 deliveries.

CalSim-II does not determine delivery by Friant Contractor, it simulates the annual allocations and then distributes them over the year on a monthly pattern. CalSim- II does approximate the division of flows between the Madera and Friant-Kern canals, but the actual final deliveries simulated in CalSim-II are not to specific Friant contractors or physical locations. Standard practice in interpreting deliveries to Friant Contractors has been to split Class 1 and Class 2/Other deliveries among individual contractors by contract quantity. For example, a district with an 80 thousand acre-feet (TAF) Friant Division Class 1 contract (i.e., 10 percent of total Class 1) and 70 TAF of Class 2 (i.e., five percent of total Class 2), would have access to 10 percent of the Class 1 supplies and five percent of the Class 2/Other supplies in a given year. Table 6 lists the Friant Contractors corresponding Class 1 and Class 2 contract amounts by volume and percentage. These have been incorporated into the spreadsheet to facilitate use.

NOTE: The reader may note that Section 215 water supplies are not discussed. While the factors that produce "215 water" are presumed to exist in the future, the frequency and magnitude of their availability is expected to be greatly diminished by implementation of the SJRRS, which has made available water supplies to Friant Contractors through Paragraph 16(b) of the Settlement. The assumed low availability of 215 water comports with recent experience, even with partial SJRRS implementation. As a result, this analysis makes no attempt to quantify future 215 water supply availability, which may be presumed to be nearly zero for planning purposes. "16(b)" or "RWA" or "$10" water (all the same) is discussed in a later section.

Table 6. Friant Contractor Summary

FRIANT CONTRACTOR	CLASS 1 ACRE-FEET	CLASS 2 ACRE-FEET	CLASS 1 PERCENTAGE	CLASS 2/OTHER PERCENTAGE
Arvin-Edison Water Storage District	40,000	311,675	5.0%	22.2%
Chowchilla Water District	55,000	160,000	6.9%	11.4%
City of Fresno	60,000	0	7.5%	0.0%
City of Lindsay	2,500	0	0.3%	0.0%
City of Orange Cove	1,400	0	0.2%	0.0%
Delano-Earlimart Irrigation District	108,800	74,500	13.6%	5.3%
Exeter Irrigation District	11,100	19,000	1.4%	1.4%
Fresno County Water Works District No. 18	150	0	0.0%	0.0%
Fresno Irrigation District	0	75,000	0.0%	5.4%
Garfield Water District	3,500	0	0.4%	0.0%
Gravelly Ford Water District	0	14,000	0.0%	1.0%
Hills Valley Irrigation District	1,250	0	0.2%	0.0%
International Water District	1,200	0	0.2%	0.0%
Ivanhoe Irrigation District	6,500	500	0.8%	0.0%
Kaweah Delta Water Conservation District	1,200	7,400	0.2%	0.5%
Kern-Tulare Water District	0	5,000	0.0%	0.4%
Lewis Creek Water District	1,200	0	0.2%	0.0%
Lindmore Irrigation District	33,000	22,000	4.1%	1.6%
Lindsay-Strathmore Irrigation District	27,500	0	3.4%	0.0%
Lower Tule River Irrigation District	61,200	238,000	7.7%	17.0%
Madera County	200	0	0.0%	0.0%
Madera Irrigation District	85,000	186,000	10.6%	13.3%
Orange Cove Irrigation District	39,200	0	4.9%	0.0%
Porterville Irrigation District	15,000	30,000	1.9%	2.1%
Saucelito Irrigation District	21,500	32,800	2.7%	2.3%
Shafter-Wasco Irrigation District	50,000	39,600	6.3%	2.8%
Southern San Joaquin Municipal Utility District	97,000	45,000	12.1%	3.2%
Stone Corral Irrigation District	10,000	0	1.3%	0.0%
Tea Pot Dome Water District	7,200	0	0.9%	0.0%
Terra Bella Irrigation District	29,000	0	3.6%	0.0%
Tri-Valley Water District	400	0	0.1%	0.0%
Tulare Irrigation District	30,000	141,000	3.8%	10.1%
Total	800,000	1,401,475	100%	100%

SJRRS WATER SUPPLY PROJECTIONS

The SJRRS Water Management Goal creates two new categories of supplies for Friant Contractors that are described in paragraphs 16(a) and (b) of the Settlement.

Delta recapture (Paragraph 16(a) is quantified in this analysis by taking the difference in Delta Exports between the with and without SJRRS implementation and crediting the net volume of improvement to the SJRRS recapture program. This does not account for the ability to recapture water supplies on the lower San Joaquin River. Delta recapture is reported as an annual quantity to overcome limitations in the simulation of monthly operations, which are not appropriate for use as monthly recapture volumes at this time. This supply represents an upper bound for potential recapture in the Delta. Discussions between Reclamation, DWR, and

Friant are ongoing to establish the availability of this water supply through Delta pumping. At the time of this report, no processes are in place to recapture in the Delta.

In recent practice, recaptured supplies have been split between Class 1 and 2 contractors, using recapture to back-fill for water contract allocations. For this analysis, Delta recapture has been split between Class 1 and Class 2 contractors, based on recent practices by Reclamation. At the request of Friant Contractors, recapture is provided first to Class 1 water users up to the point that the combination of Friant Division deliveries and recapture equal a 100 percent Class 1 allocation. Any volumes in excess are allocated to Class 2 contractors, proportional to their Class 2 contract volumes. The spreadsheet includes summary tables of total Delta recapture, and a breakout of Class 1 and Class 2 recapture by Friant Contractor proportional to their contract amounts as shown in Table 5. Users of this data are encouraged to apply contract quantities (Table 6) to attribute allocations among Friant Contractors.

The second SJRRS water category, Paragraph 16(b) supplies, are quantified in the CalSim II model by assuming a demand for this potential supply and meeting this demand, limited by availability of flood water and channel capacity for delivery. Any remaining flood water is then assumed available for 215/other delivery in the simulation. Specific patterns for the use of this supply do not yet exist and, thus, CalSim-II makes no assertion about anything except for the expectation and potential for these supplies to be delivered.

For consistency with previous efforts to interpret the CalSim II model and its output, 16(b) supplies have been divided among Friant Contractors in proportion to their share of impact from the SJRRS that accumulates to their water supplies. The impact from the SJRRS is estimated by comparison of the total C1 and C2/Other delivery in the Pre-SJRRS and “limited” CalSim II simulations. The allocation to the individual contractors was done based on percentage of impact from the Proposed Implementation Agreement of the Friant Settlement (SJRRP, 2009) and from the percentage impact computed from the new CalSim II simulation performed for this analysis. For example, a Friant Contractor with five percent of reduction in total Class 1 and Class 2/Other is and would have access to five percent of the 16(b) supplies. Table 7 and 8 shows impact of SJRRS under the five climate change conditions and computed impacts from the Mediator’s Report for the Friant Contractors.

Table 7. Summary of Friant Contractor Impacts per Climate Change and Mediator's Report (Volume)

FRIANT CONTRACTOR	LONG-TERM AVERAGE CLASS 1 AND CLASS 2/OTHER IMPACTS					
	MEDIATOR'S REPORT	2015 CONDITION	NEAR-FUTURE, 2030	LATE-FUTURE, 2070	LATE-FUTURE, 2070 DEW	LATE-FUTURE, 2070 WMW
	TAF	TAF	TAF	TAF	TAF	TAF
Arvin-Edison Water Storage District	30.342	28.13	28.88	26.54	18.69	28.41
Chowchilla Water District	17.661	15.76	16.58	15.75	12.59	16.04
City of Fresno	3.629	2.30	3.06	3.71	5.22	2.52
City of Lindsay	0.151	0.10	0.13	0.15	0.22	0.11
City of Orange Cove	0.085	0.05	0.07	0.09	0.12	0.06
Delano-Earlimart Irrigation District	13.255	10.53	11.96	12.47	13.10	10.97
Exeter Irrigation District	2.398	2.05	2.20	2.15	1.89	2.10
Fresno County Water Works District No. 18	0.009	0.01	0.01	0.01	0.01	0.01
Fresno Irrigation District	6.719	6.40	6.46	5.79	3.66	6.43
Garfield Water District	0.212	0.13	0.18	0.22	0.30	0.15
Gravelly Ford Water District	1.254	1.19	1.21	1.08	0.68	1.20
Hills Valley Irrigation District[1]	0.000	0.00	0.00	0.00	0.00	0.00
International Water District	0.073	0.05	0.06	0.07	0.10	0.05
Ivanhoe Irrigation District	1.173	0.29	0.37	0.44	0.59	0.32
Kaweah Delta Water Conservation District[1]	0.000	0.000	0.000	0.000	0.000	0.000
Kern-Tulare Water District[1]	0.000	0.000	0.000	0.000	0.000	0.000
Lewis Creek Water District	0.088	0.05	0.06	0.07	0.10	0.05
Lindmore Irrigation District	3.967	3.14	3.58	3.74	3.94	3.28
Lindsay-Strathmore Irrigation District	1.663	1.06	1.40	1.70	2.39	1.16
Lower Tule River Irrigation District	25.024	22.66	23.62	22.16	16.94	22.99
Madera County	0.012	0.01	0.01	0.01	0.02	0.01
Madera Irrigation District	21.805	19.13	20.35	19.61	16.47	19.53
Orange Cove Irrigation District	2.371	1.50	2.00	2.42	3.41	1.65
Porterville Irrigation District	3.655	3.14	3.35	3.24	2.77	3.20
Saucelito Irrigation District	4.221	3.62	3.92	3.86	3.47	3.72
Shafter-Wasco Irrigation District	6.572	5.30	5.96	6.15	6.28	5.50
Southern San Joaquin Municipal Utility District	10.346	7.56	8.82	9.46	10.63	7.94
Stone Corral Irrigation District	0.605	0.38	0.51	0.62	0.87	0.42
Tea Pot Dome Water District	0.454	0.28	0.37	0.44	0.63	0.30
Terra Bella Irrigation District	1.754	1.11	1.48	1.79	2.52	1.22
Tri-Valley Water District[1]	0.000	0.000	0.000	0.000	0.000	0.000
Tulare Irrigation District	14.447	13.18	13.67	12.74	9.49	13.36
Total	**173.945**	**149.13**	**160.26**	**156.49**	**137.14**	**152.67**

Key:
DEW = Drier/Extreme Warming
TAF = thousand acre-feet
WMW = Wetter/Moderate Warming
Note:
[1] Friant Contractor calculated impact as zero because they do not receive a proportion of 16(b) supplies.

Table 8. Summary of Friant Contractor Impacts per Climate Change and Mediator's Report (Percentage)

FRIANT CONTRACTOR	LONG-TERM AVERAGE CLASS 1 AND CLASS 2/OTHER IMPACTS					
	MEDIATOR'S REPORT	2015 CONDITION	NEAR-FUTURE, 2030	LATE-FUTURE, 2070	LATE-FUTURE, 2070 DEW	LATE-FUTURE, 2070 WMW
	%	%	%	%	%	%
Arvin-Edison Water Storage District	17.444%	18.864%	18.020%	16.958%	13.630%	18.611%
Chowchilla Water District	10.153%	10.571%	10.347%	10.066%	9.183%	10.504%
City of Fresno	2.086%	1.544%	1.909%	2.368%	3.806%	1.653%
City of Lindsay	0.087%	0.064%	0.080%	0.099%	0.159%	0.069%
City of Orange Cove	0.049%	0.036%	0.045%	0.055%	0.089%	0.039%
Delano-Earlimart Irrigation District	7.620%	7.063%	7.464%	7.970%	9.553%	7.183%
Exeter Irrigation District	1.378%	1.373%	1.374%	1.376%	1.380%	1.373%
Fresno County Water Works District No. 18	0.005%	0.004%	0.005%	0.006%	0.010%	0.004%
Fresno Irrigation District	3.863%	4.292%	4.030%	3.701%	2.669%	4.213%
Garfield Water District	0.122%	0.090%	0.111%	0.138%	0.222%	0.096%
Gravelly Ford Water District	0.721%	0.801%	0.752%	0.691%	0.498%	0.786%
Hills Valley Irrigation District[1]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
International Water District	0.042%	0.031%	0.038%	0.047%	0.076%	0.033%
Ivanhoe Irrigation District	0.675%	0.196%	0.234%	0.281%	0.430%	0.207%
Kaweah Delta Water Conservation District[1]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Kern-Tulare Water District[1]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Lewis Creek Water District	0.050%	0.031%	0.038%	0.047%	0.076%	0.033%
Lindmore Irrigation District	2.281%	2.108%	2.232%	2.388%	2.876%	2.145%
Lindsay-Strathmore Irrigation District	0.956%	0.708%	0.875%	1.085%	1.744%	0.758%
Lower Tule River Irrigation District	14.386%	15.194%	14.736%	14.159%	12.352%	15.057%
Madera County	0.007%	0.005%	0.006%	0.008%	0.013%	0.006%
Madera Irrigation District	12.536%	12.831%	12.699%	12.532%	12.011%	12.791%
Orange Cove Irrigation District	1.363%	1.009%	1.247%	1.547%	2.486%	1.080%
Porterville Irrigation District	2.101%	2.103%	2.089%	2.072%	2.019%	2.099%
Saucelito Irrigation District	2.427%	2.430%	2.446%	2.467%	2.531%	2.435%
Shafter-Wasco Irrigation District	3.778%	3.553%	3.719%	3.927%	4.581%	3.602%
Southern San Joaquin Municipal Utility District	5.948%	5.071%	5.504%	6.048%	7.754%	5.201%
Stone Corral Irrigation District	0.348%	0.257%	0.318%	0.395%	0.634%	0.276%
Tea Pot Dome Water District	0.261%	0.185%	0.229%	0.284%	0.457%	0.198%
Terra Bella Irrigation District	1.008%	0.746%	0.923%	1.144%	1.839%	0.799%
Tri-Valley Water District[1]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Tulare Irrigation District	8.305%	8.840%	8.531%	8.141%	6.921%	8.748%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.000%**

Key:
DEW = Drier/Extreme Warming
WMW = Wetter/Moderate Warming
Note:
[1] Friant Contractor does not receive a proportion of 16(b) supplies.

REFERENCES

California Department of Water Resources. Land Use Viewer. September 2017
https://gis.water.ca.gov/app/CADWRLandUseViewer/

California Water Commission, Water Storage Investment Program, Technical Reference, November 2016
https://cwc.ca.gov/-/media/CWC-Website/Files/Documents/2017/WSIP/TechnicalReference.pdf

San Joaquin River Restoration Program, Funding Constrained Framework for Implementation, May 2018
http://www.restoresjr.net/program-releases-framework-to-guide-program-into-next-decade/

San Joaquin River Restoration Program, Programmatic Environmental Impact Statement, January 2009
https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=2940

San Joaquin River Restoration Program, Proposed Implementation Agreement of the Friant Settlement, April 2009

San Joaquin River Restoration Program Settlement Agreement, October 2009
http://www.revivethesanjoaquin.org/content/san-joaquin-river-settlement-agreement

SJRRP, *see San Joaquin River Restoration Program*