EXHIBIT F

Water Unavailability Methodology for the Delta Watershed

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1 Introduction

The Sacramento/San Joaquin Delta (Delta) watershed is currently experiencing extremely dry conditions following dry conditions in 2020. Currently, the 2021 and 2020 period is projected to be one of the driest two-year periods on record for runoff. These low runoff conditions have resulted in very low inflows to reservoirs and associated limited storage supplies for various purposes this summer and into the fall. To help address these conditions, the State Water Resources Control Board (State Water Board or Board) developed a methodology to assess water unavailability in the Delta watershed. Based on the current output of the methodology, on June 15, 2021, the State Water Board issued notices to all post-1914 appropriative water right holders in the Delta watershed indicating that water supplies are not available for their use based on the best available information (notices of water unavailability).

The Delta watershed includes supplies from both the Sacramento and San Joaquin river systems. As shown in Figure 1 below, these river systems, including their tributaries, drain water from about 40 percent of California's land area, supporting a variety of beneficial uses of water. The San Francisco Bay-Delta (Bay-Delta) is one of the most important ecosystems in California as well as the hub of California's water supply system. As the largest tidal estuary on the western coast of the Americas, it provides essential habitat to a vast array of aquatic, terrestrial, and avian wildlife in the Delta, San Francisco Bay, and near shore ocean, as well as a diverse assemblage of species upstream of the Delta. Water from the Delta provides a portion of the supplies to more than two-thirds of Californians, supports industry, and is used to irrigate millions of acres of farmland.

Given the importance of the water supplies in the Delta watershed for multiple purposes and the extreme limitations in water supplies this year, action is needed to notify water users when water supplies are not available under their priority of right. The Department of Water Resources' (DWR) State Water Project (SWP) and the U.S. Bureau of Reclamation's (Reclamation) Central Valley Project (CVP) (collectively Projects) are responsible for providing salinity control and meeting environmental flows in the Delta, as well as specific requirements for flows and temperature management on Project tributaries. Currently, many Project reservoir storage levels are at or near historical lows, creating significant concerns for salinity control, municipal water supplies (particularly from Folsom Reservoir), and temperature management and other environmental needs this year and going into next year. As a result of these concerns, the Projects have submitted, and were granted subject to terms and conditions, a

temporary urgency change petition to reduce their obligations to release water from storage to meet flow and water quality requirements in the Delta.[1]

Concerns for reservoir storage levels are compounded when diversions occur by users when supplies do not exist at their priority of right resulting in the need for additional releases of stored water from Project reservoirs in order to repel salinity intrusion from the ocean and meet other minimal needs.

Determining when water supplies are unavailable to users will be important to ensure that supplies are available to meet current water quality and flow requirements and the demands of senior water right holders. However, it may be unclear to water users when supplies are unavailable for their use because supplies are needed by downstream senior water right holders or because supplies are comprised of releases of previously stored water that is released to serve contractors or to meet water quality or flow requirements.

The State Water Board has developed a methodology for identifying when available data indicates that natural and abandoned water supplies are unavailable for direct diversion or diversion to storage for consumptive use by post-1914 appropriative water users in the Delta watershed (Delta Water Unavailability Method or Water Unavailability Methodology for short). The methodology is not intended to address other supplies of water like rediversion of previously stored water for use by Project contractors. The methodology also does not address water unavailability for non-consumptive uses of water like hydropower diversions since these supplies are returned back to the stream, though these diversions may change the timing of flows generally from the wet season to the dry season.

The methodology evaluates water supplies and demands on a monthly scale at the subwatershed and watershed scale for both the Sacramento River and San Joaquin River watersheds during the 2021 irrigation season with currently available data, reporting, and tools. The Water Unavailability Methodology improves upon methods for determining water unavailability in prior droughts, most recently in 2014 and 2015. Major improvements are described below and are focused on ensuring that demands are not overinflated in ways that would overestimate water unavailability, causing more water users to receive notices of water unavailability or resulting in those notices applying for a longer time period. Other improvements include better supply estimates. With more time, better data, and improved tools, additional improvements will be possible.

[1] The Board order conditionally approving the petition is available here: https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/docs/2021/20210601_swb_tuco.pdf

Figure 1. Delta Watershed Location

The Water Unavailability Methodology is being used to support the issuance of notices of water unavailability to post-1914 appropriative water right holders this summer. The methodology could also be refined to support determinations of water unavailability for pre-1914 appropriative and riparian water right claimants. Further development of the Water Unavailability Methodology is planned to make it appropriate for use outside of the dry season, including methods to address demands for storage during the wet season. The Water Unavailability Methodology does not apply to deliveries of previously stored water that are released for rediversion or use by a water right holder or their contractors.

This report and associated technical appendices describe the current approach and major assumptions for the Water Unavailability Methodology. Technical Appendix A describes the Water Unavailability Methodology spreadsheet, including the input data sources, computation steps, and outputs used to develop the water unavailability visualizations. Technical Appendix B describes the process used to collect and clean up the demand datasets, which are based on 2018 and 2019 data reported by water users for the Delta watershed. The technical appendices and spreadsheet are available on the State Water Board's drought webpage.

The report, technical appendices, and spreadsheet have been updated since the draft of the methodology was released on May 12, 2021, based on public comments and further evaluation by State Water Board staff. In addition, a new appendix has been added, Appendix C, which summarizes the substantive technical, factual, or legal comments that have been received to date. This report will continue to be updated, as appropriate, as the methodology is updated. All revisions will be made available on the Board's drought webpage.

Updates that have been made since the May 12, 2021 draft methodology was released include: refinement of Figure 5 (no changes to the subwatershed boundaries were made); refinements to Putah Creek supply estimates; refinement of the method for incorporating abandoned instream flows into the supply dataset; exclusion of Stony Creek abandoned flows; reassignment of certain demand to better reflect the sources of supplies for those demands; and proration of Legal Delta demands based on only connected water supplies between the two watersheds. In addition, the supply-demand comparison visualizations have also been updated with more recent supply forecasts from the sources listed in section 2.1.4.

1.1 Background

The mission of the State Water Board is: "To preserve, enhance, and restore the quality of California's water resources and drinking water for the protection of the environment, public health, and all beneficial uses, and to ensure proper water resource allocation and efficient use, for the benefit of present and future generations." The Board's critical goals of providing safe drinking water to all Californians and maintaining the quality of our waterways, in keeping with both state and federal requirements, rely on the Board's

successful administration of the water rights system. California's water rights system is one of the most complex in the nation, incorporating both riparian[2] and appropriative water rights, including appropriative rights issued under the Board's authority and those in existence prior to the inception of its predecessor-in-interest.[3]

The water right priority system, based on the "priority date" of each water right, forms the basis for determining which users may divert, and how much, when there is insufficient water in the stream for all users. Older, more senior appropriative water rights have priority over more junior appropriative water rights. Senior water right holders are more likely to receive water at times of shortage than more junior water right holders. However, once water is stored or imported, the entity that stored or imported the water has the only right to it, though others may acquire contingent junior rights to any return flows.

When the amount of water available in a surface water source is not sufficient to support the needs of existing water right holders and in-stream uses, junior appropriators must cease diversion in favor of higher-priority rights. However, it is not always clear to a junior diverter whether there is sufficient natural flow in the system to support their diversion and senior water uses and instream needs downstream. As part of administrating water rights, the State Water Board may issue notices of curtailment to water rights holders based on California's water rights priority system.

1.2 Current Conditions

After two years of low precipitation, the U.S. Drought Monitor now reports that 97 percent of California is experiencing moderate to exceptional drought, of which 79 percent is experiencing extreme to exceptional drought (USDM 2021). The U.S. Seasonal Drought Outlook, released by the Climate Prediction Center on April 15, 2021 and valid for April 15 through July 31, 2021, shows drought is likely to persist into summer in California (NOAA 2021). Within the Delta watershed, conditions have been extraordinarily dry, with Water Year (WY) 2020 ranking as the ninth driest on record and WY 2021 ranking as the fourth driest on record (DWR & Reclamation 2021). These dry

[2] Generally, a riparian water right is a right to use the natural flow of water on land contiguous to a natural water course. Riparian water rights are unquantified, allowing the diverter to take water from the natural flow of the water course for any immediate reasonable and beneficial use on the subject land. In times of shortage, all riparian rights share the shortage on a correlative basis; that is, each riparian is required to reduce its use proportionally so that the reduced supply is divided among all riparian rights.

[3] Use of water on non-riparian land or seasonal storage of water for later beneficial use requires an appropriative water right. An appropriative water right that was acquired before the Water Commission Act went into effect on December 19, 1914 is called a pre-1914 appropriative water right. Appropriative rights acquired after this date are called post-1914 appropriative water rights, and they are administered and regulated by the State Water Board.

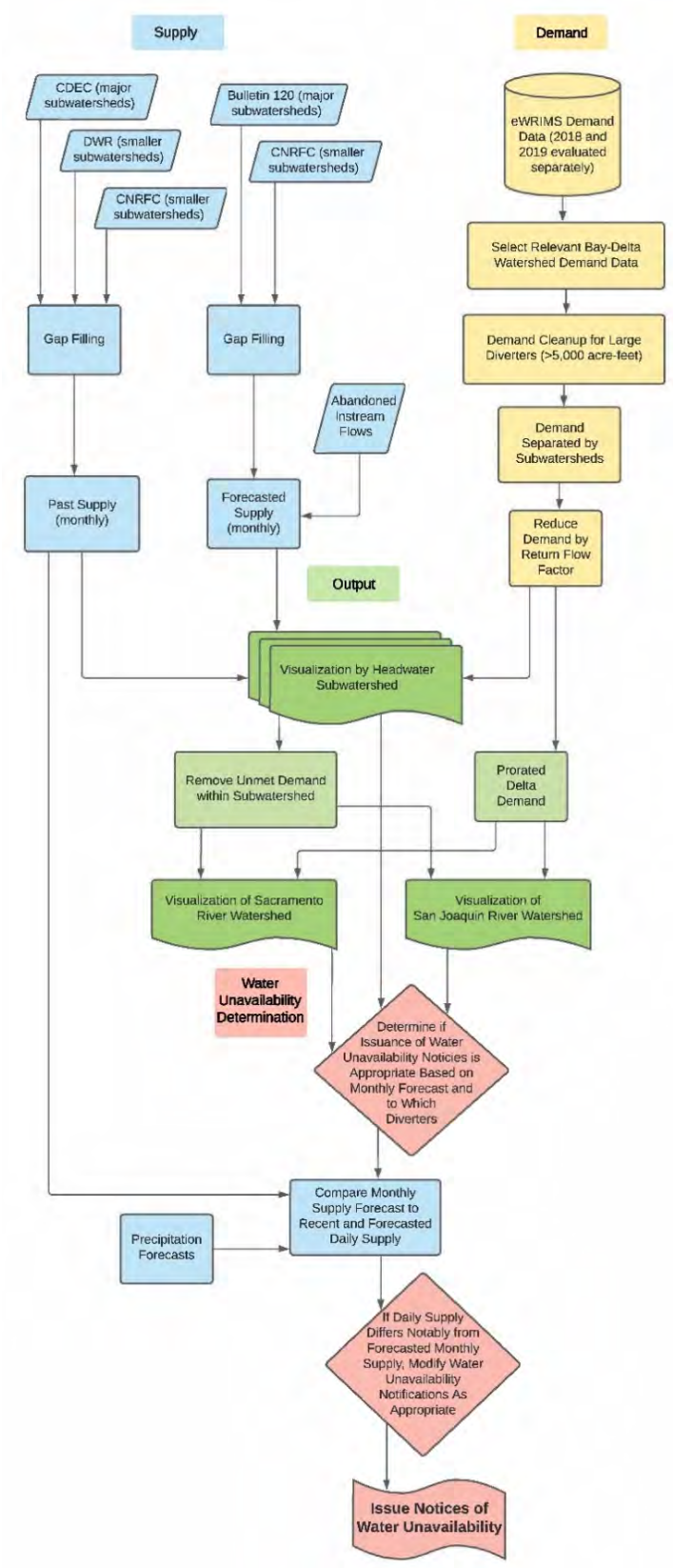
conditions have resulted in reservoir storage levels that are significantly below average (DWR 2021a; DWR 2021d). As of May 10, 2021, storage volumes in major reservoirs, including Lake Shasta, Lake Oroville, and Folsom Lake are lower than 50 percent of capacity (*Ibid*) and near 50 percent of average storage conditions (DWR 2021b).

As a result of the current dry conditions, on May 10, 2021, Governor Newson issued a drought emergency proclamation covering 41 of California's 58 counties. The proclamation orders the State Water Board and other agencies to consider a number of actions to protect water needed for health, safety, and the environment in the Delta watershed. The proclamation specifically indicates that the State Water Board shall consider emergency regulations to curtail water diversions when water is not available at water right holders' priority of right or to protect previously stored releases of water (Exec 2021). Upon finalization, this methodology may serve as the technical basis for future emergency curtailment regulations pursuant to the directives in the emergency drought proclamation.

2 Water Unavailability Methodology

The Water Unavailability Methodology compares the best available supply data for the Delta watershed to the best available estimates of demand for the same area. The methodology then compares this data for multiple areas within the Delta watershed: the Sacramento River watershed, San Joaquin River watershed, and headwater subwatersheds (see definition in section 2.3.1 below), to determine if supply may be insufficient to meet certain priorities of right. These comparisons are presented visually using interactive graphs and in spreadsheet format. The following sections describe the sources of the supply and demand data, adjustments made to the data as needed, and the resultant outputs of the comparisons. Figure 2 below shows an overview of the Water Unavailability Methodology that is covered in greater detail in the following sections.

Figure 2. Water Unavailability Methodology Flowchart



2.1 Supply

The purpose of this analysis is to account for the availability of natural and abandoned flows within the Delta watershed for diversion by water right holders under their priority of right. This analysis is not intended to account for the availability of imported supplies from other watersheds that do not contribute to available supplies for general use in the Delta watershed. Specifically, imported supplies from the Trinity River system are imported for use by Reclamation and their contractors and are not available to other users under their own water rights. The analysis is also not intended to account for releases of previously stored water for downstream delivery, use, or rediversion since those supplies are also not available to other users under their own water rights. In the case where previously stored water is released to meet instream flow requirements that apply in an upstream subwatershed, but not downstream watersheds, and the water is not released for delivery to a downstream user, these flows are considered to be abandoned and part of available supplies.

The methodology incorporates the use of past and projected future full natural flow (FNF) (or unimpaired flow) estimates (see section 2.1.4 below). FNF represents the natural water production of a river basin unaltered by upstream water diversion, storage, or import from or export to other watersheds (DWR 2015). FNF is a theoretical water supply estimate rather than a reconstruction of pre-development streamflows (DWR 2016). Though FNF values are not directly measured, the locations where they are estimated are referred to herein as “gages.”

Past FNF estimates are calculated from measured streamflows, adjusted for upstream operations by subtracting imported water and adding upstream diversions, changes in storage, and evaporative losses. The past FNF values serve two purposes: (1) to provide historical context to current water supply conditions and (2) to show water supply conditions for the current year, from January 2021 to the present. Water years in the Sacramento and San Joaquin River watersheds are categorized as Wet, Above Normal, Below Normal, Dry, and Critically Dry based on equations defined in State Water Board Decision 1641 that account for the unimpaired runoff of each water year and its preceding water year (DWR 2021c). For both the Sacramento and San Joaquin River watersheds, 2021 is considered Critically Dry (see next section).

Forecasted FNF values are calculated from snowpack measurements, estimates of water content, expected weather, rates of evaporation, ground absorption, and other factors. Because future water supply cannot be predicted with absolute certainty, a forecast provides a range of expected water supply volumes. These potential volumes are assigned probabilities that they will occur based on current conditions. Probabilities are expressed in exceedances, or the percent chance that the future FNF will exceed a given amount. For example, the 10 percent exceedance indicates wetter than average conditions where there is a 10 percent chance that the FNF volume will exceed the forecast value, and a 90 percent chance that the FNF volume will be less than this forecast value. Similarly, a 90 percent exceedance indicates drier conditions where

there is a 90 percent chance that the FNF volume will exceed the forecast value, and there is a 10 percent chance that the FNF volume will be less than this forecast value. A 50 percent exceedance indicates a 50 percent chance that the FNF volume will exceed the forecast value and a 50 percent chance that the FNF volume will be less than this forecast value (50 percent exceedance is equivalent to the median). Generally, this forecast is the middle of the range of possible FNF volumes that can be produced given current conditions. As the dry season approaches, forecasts become progressively more precise as actual events replace the variable range of potential conditions. Currently, conditions in the Delta watershed are extremely dry, tracking drier than the 99 percent exceedance.

2.1.1 **Supply Analysis**

The range of data available within the supply dataset described below allows for the comparison of historical FNF to current year estimates and forecasts. As described above, the current hydrology is tracking drier than the 99 percent exceedance forecast. For reference, both the 90 percent and 99 percent exceedances, provided in the official supply forecasts released in June 2021, are shown in Figure 3 and Figure 4 below. As indicated below, the current year supply within the Delta watershed is drier than the median critically dry year over the period of 1922 through 2019.

Figure 3. 2021 Supply Conditions Within the Sacramento River Watershed

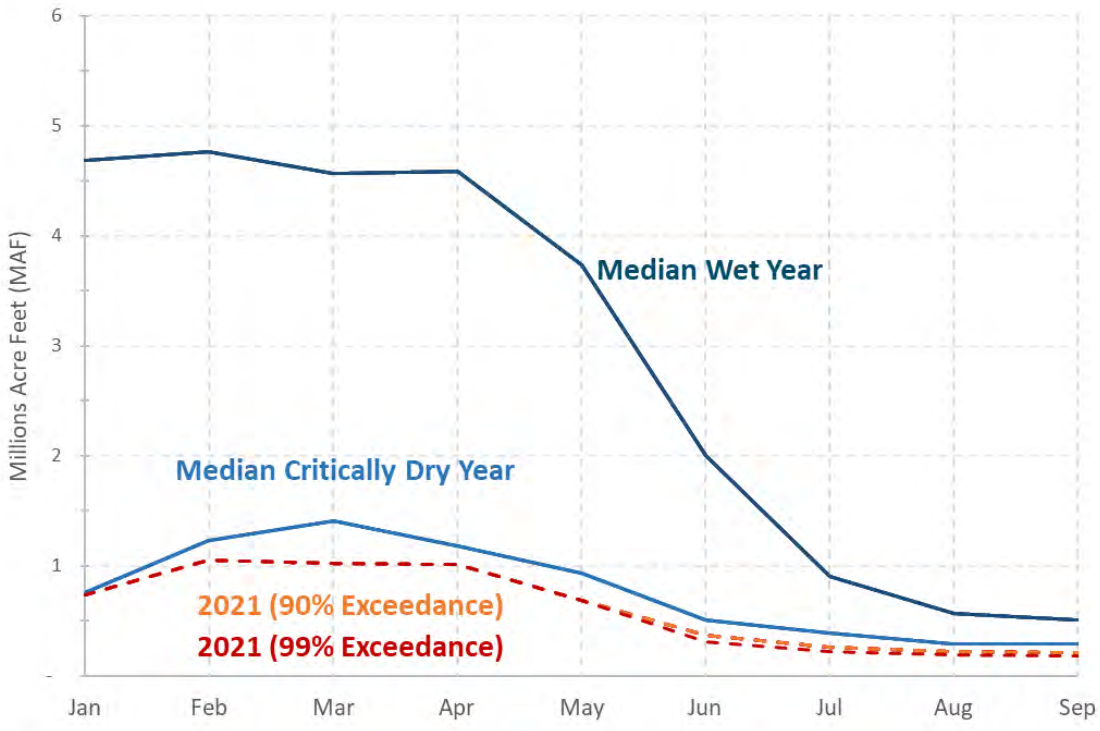
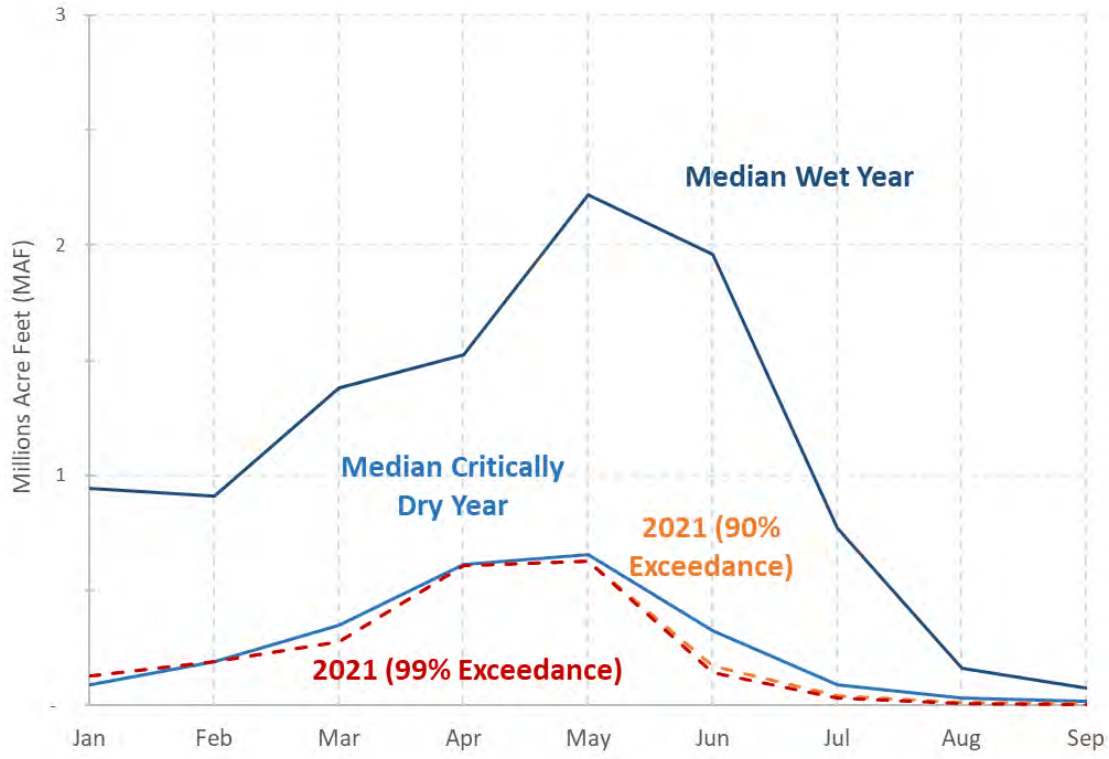


Figure 4. 2021 Supply Conditions Within the San Joaquin River Watershed



2.1.2 **Types of Water**

The water rights system is complex. In many cases during droughts, the observable water in a stream may not be available for diversion because the water: is needed to meet senior downstream demand; has been transferred for use or rediversion downstream; or is previously stored water that has been released to meet downstream demands, water quality and flow requirements, and contractual demands. This section discusses the additional complexities in determining whether water is available for diversion.

Water in a stream system may consist of a combination of “natural flows,” imported supplies, storage releases, abandoned flows, and return flows:

1. **Natural flow** – Natural flows are the natural runoff of a river basin unaltered by upstream water diversion, storage, or import from or export to other watersheds. Natural flows, quantified as FNF, are the basis of this methodology.
2. **Imported Supplies** – Imported supplies include supplies that are brought from one water supply source to another for consumptive uses or non-consumptive uses. In the Delta watershed, imported supplies are brought in from outside of the watershed from the Trinity River. These additional water supplies are not

accounted for in this analysis because these supplies do not constitute natural or abandoned flows.

3. **Previously Stored Water** – Seasonally stored water, including releases of previously stored water for downstream use, is not available for diversion or use by diverters other than the entity that stored the water, their contractors, or recipients of a transfer. Accordingly, the methodology does not account for these storage supplies.

4. **Abandoned water** – Abandoned water is water that has been used or dedicated for a specific purpose for which it is no longer needed. If it was previously diverted, the diverter lays no further claim to the water, such as is commonly the case with return flow from agricultural uses. If the water was dedicated for instream use, it becomes abandoned once it flows out of the reach for which it was dedicated. Abandoned flows are available for downstream diversion.

    a. **Abandoned instream flows** – Water for instream use may be comprised of previously stored water releases that are foreign in time or imported from another watershed or bypassed natural flow that is provided for the purposes of preserving or enhancing wetlands, protecting fish and wildlife, and/or recreation. Some instream flows that only apply to a certain reach of a stream can be considered abandoned past that reach. Instream flows that are required to meet Delta instream flow, outflows, and salinity requirements are not considered abandoned. Section 2.1.6 below describes adjustments to the supply analysis to account for certain abandoned instream flows.

    b. **Abandoned return flows** – Return flows from other uses such as irrigated agriculture or municipal water treatment plants may be discharged back to the stream system with no residual claim of control, dominion, or right of further use. In such a case, this water would be available to appropriative diverters and may be available to riparian diverters if not foreign in time or source. Section 2.2.6.1 below describes adjustments made to the demand dataset to account for return flows from use within the Delta watershed.

The Water Unavailability Methodology assumes all FNF is available for diversion. The methodology also includes assumptions for return flows and abandoned instream flows that are available for diversion. Incorporation of return flows reduces demand calculated purely on reported diversions because a component of that diversion is introduced back into the system. As a simplifying assumption, the methodology does not distinguish between the types of water available within a stream system. Additional analysis will be needed to distinguish supplies that are foreign in time or watershed and not available to riparian diverters.

2.1.3 **Subwatershed Delineation**

The supply-demand analysis begins at a “subwatershed” level. Subwatershed boundaries were defined using the U.S. Geologic Survey (USGS) Watershed Boundary Dataset (WBD) and National Hydrography Dataset (NHD), which delineate land areas draining to streams. Subwatersheds in the Delta watershed were established based on Hydrologic Unit Code level 8 watersheds (HUC8s), which represent areas of sufficient size to capture as much of the available flow as possible within the watershed given the existing network of FNF gages.

Some subwatershed boundaries were defined as a combination of multiple HUC8s due to the presence of multiple HUC8s upstream of a single FNF gage location. These subwatersheds include the Sacramento River above Bend, the Upper American River, and the Upper Feather River. Some HUC8s containing small tributaries on the valley floor were also combined into a single subwatershed due to the use of these boundaries for supply estimates produced by DWR,[4] including the Upper Sacramento River Valley, Sacramento River Valley Floor, and San Joaquin Valley Floor subwatersheds. A total of 20 Delta subwatersheds were used in the Water Unavailability Methodology: 10 each in the Sacramento and San Joaquin River watersheds (see Figure 5).

An inventory of available FNF gages from multiple sources (see section 2.1.4 below) was compared to the subwatershed boundaries, NHD stream maps, and water right points of diversion (PODs) to identify target FNF gages that are representative of water supplies and demands met by them within each subwatershed. These target FNF gages were considered during the prioritization of available supply data sources discussed in more detail in section 2.1.4 below.

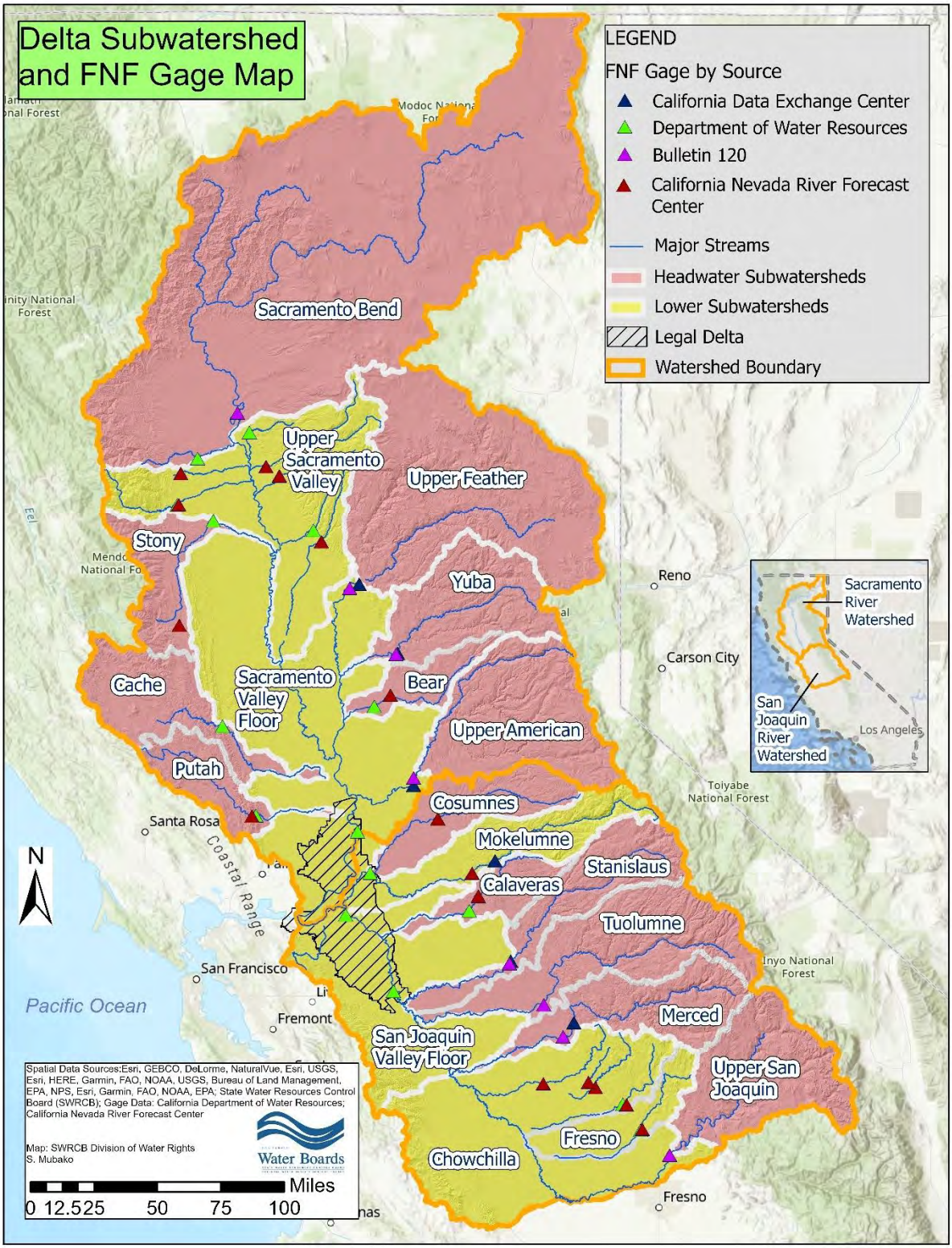
The Water Unavailability Methodology assumes that water supply data at each FNF gage shown in Figure 5 below is representative of the total FNF for the subwatershed as a whole, not only the portion of the subwatershed upstream of the location. This assumption may result in minimal underestimation of supply within certain upstream subwatersheds and minimal overestimation of supply in corresponding downstream subwatersheds. Given the broad spatial coverage of the methodology and the use of generally conservative estimates regarding supply, this assumption is not anticipated to significantly impact watershed-wide determinations of water unavailability.

Supplies and demands from the Tulare Lake watershed (including the Kings, Kern, Kaweah, and Tule Rivers) and the Panoche Creek subwatershed are not included in the Water Unavailability Methodology. Natural flows from the Tulare Lake watershed, despite not being a part of the Delta watershed, at times enter the watershed, largely from the Kings River via Fresno Slough. However, surface water contributions of the Tulare Lake region have historically been minimal and may have been significant only in wet years (DWR 2016). Natural flow would not reach the Delta watershed from the

[4] See DWR’s March 2016 Report on Unimpaired Flows in the Bay-Delta Watershed, described in section 2.1.4 below.

Tulare Lake watershed during the dry season of a critically dry year. Therefore, supplies and demands from the Tulare Lake watershed have been excluded from the methodology. In addition, the methodology excludes supply and demand from the Panoche Creek subwatershed, a relatively small tributary in the southwest corner of the San Joaquin River watershed. There is no available FNF supply data for Panoche Creek, and aerial photographs indicate that it terminates in agricultural fields west of Mendota. Therefore, it is assumed not to significantly contribute to available water supplies within the Delta watershed.

Figure 5. Delta Subwatershed and FNF Gage Map



2.1.4 **Supply Data Sources**

Because there is no single data source that provides both past and forecasted FNF estimates for the entire Delta watershed, supply data is derived from multiple sources which vary by location, timescale (i.e., historical data, including prior months of the current water year, and future forecasted data), and temporal resolution (i.e., daily or monthly). These data sources were considered hierarchically; that is, if data for a particular subwatershed was not available from the preferred data source, the next source was checked. If the data was available there, that data was incorporated into the dataset, and so on down the list.

The sources of past supply data, in order of priority of use, are:

1. The California Data Exchange Center (CDEC), which contains published FNF estimates made by water system operators within each watershed. These are primarily available for larger rivers and contain monthly data as far back as WY 1901 in some subwatersheds.
2. DWR's March 2016 Report on Unimpaired Flows in the Bay-Delta Watershed, which contains monthly FNF estimates for water years 1922 through 2014.
3. The National Oceanic and Atmospheric Administration (NOAA) National Weather Service California Nevada River Forecast Center (CNRFC) estimates of daily FNF.[5] These estimates are available for many streams beginning with WY 2013. This source was used only for streams where no other data was available.

The sources of forecasted supply data, in order of priority of use, are:

1. DWR's California Cooperative Snow Surveys Bulletin 120 Water Supply Forecast (B-120),[6] which contains monthly FNF forecasts for the current water year for only larger rivers. B-120 Water Supply Index (WSI) products include forecasts with 10, 25, 50, 75, 90, and 99 percent exceedance probabilities.

[5] CNRFC data is published on a daily scale, which is summed to generate monthly values for the purpose of this analysis. Any negative daily FNF values were replaced with zero values.

[6] Bulletin 120 (B-120) provides FNF forecasts for the state's major watersheds. It is updated monthly, around the fifth business day of each month, from February to May of each year. The FNF calculation is made using DWR's own database of diversions upstream of unimpaired flow stations. The methodology relies upon DWR's unimpaired flow calculations and did not cross-check DWR's diversion database against the Board's records of reported diversions.

2. CNRFC daily FNF forecasts.[7] This source was used only for minor tributaries. Exceedance probabilities were calculated from the available forecast data.

If data was available from multiple sources for the same subwatershed (e.g., past data from both CDEC and DWR or forecasted data from both B-120 and CNRFC), both datasets were compared for an overlapping time period to validate that there we no substantial inconsistencies between them. These comparisons did not result in any changes to the assumed hierarchy of data sources described above.

The final water supply dataset used in the Water Unavailability Methodology's supply-demand comparison consists of monthly FNF data. The use of monthly supply forecasts and demand estimates (see section 2.2 below) is assumed to negate the need to consider the water's transit time within the Delta watershed (i.e., it takes less than a month for water to flow from its headwaters to a downstream diverter).

CDEC provides both monthly and daily FNF estimates for many rivers in California. Daily FNF estimates are less accurate than monthly estimates because they are based on less data than is available at the completion of each month (DWR 2015). Therefore, daily CDEC FNF values are not used in the water unavailability graphs described in section 2.4 below. However, daily FNF estimates may be used to determine the most appropriate supply forecast (e.g., 10, 50, 90, or 99 percent exceedance probability) to use when issuing notices of water unavailability, as described below in section 3.1.1.

Table 1 and Table 2 below summarize the sources of both past and forecasted supply data for each subwatershed included in the supply dataset for the Sacramento River watershed and the San Joaquin River watershed, respectively. The source information includes the agency from which the data was obtained and the unique identifier for each FNF gage site. Past source data is broken down into the sources of monthly and daily estimates; daily sources with date ranges in Table 1 and Table 2 were summed to generate monthly past data, while those shown without date ranges were used only for periodic forecast monitoring (see section 3.1.1). The monthly past source data also includes the years for which data is available, such as WY 1906 to present. For forecasted supply data, information is provided on the resolution, frequency, and format of forecast updates. Subwatersheds where gap-filling procedures were applied (see section 2.1.5 below) are denoted with asterisks, and all gap-filled values are specifically identified as such in the supply dataset.

[7] CNRFC forecasts are presented daily in the form of 39 different FNF "traces," from which exceedance probabilities were calculated. Daily values for each probability were summed to generate monthly forecasts matching the B-120 format.

Table 1. Sacramento River Watershed Supply Data Sources

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage, Date Range if applicable)*	
Sacramento River at Bend	CDEC SBB: Sacramento River above Bend Bridge, sensor 65 (WY 1906-Present)	CDEC BND: Sacramento River at Bend Bridge, sensor 8	DWR B-120 SRWSI: Sacramento River above Bend Bridge (monthly TAF for current WY in 6 exceedances)
Stony Creek	DWR UF4: Stony Creek at Black Butte (WY 1922-2014)	CNRFC EPRC1: Little Stony Creek-East Park Reservoir (WY 2015-Present)*	CNRFC EPRC1: Little Stony Creek-East Park Reservoir (daily TCFS for next year in 39 traces)*
Cache Creek	DWR UF3: Cache Creek above Rumsey (WY 1922-2014)	*	*
Upper Feather River	CDEC FTO: Feather River at Oroville, sensor 65 (WY 1906-Present)	CDEC ORO: Oroville Dam, sensor 8	DWR B-120 SRWSI: Feather River at Oroville (monthly TAF for current WY in 6 exceedances)
Yuba River	CDEC YRS: Yuba River near Smartville, sensor 65 (WY 1901-Present)	CDEC YRS: Yuba River near Smartville, sensor 8	DWR B-120 SRSWI: Yuba River near Smartville plus Deer Creek (monthly TAF for current WY in 6 exceedances)
Bear River	DWR UF10: Bear River near Wheatland (WY 1922-2014)	*	CNRFC CFWC1: Bear River-Camp Far West (daily TCFS for next year in 39 traces)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage, Date Range if applicable)*	
Upper American River	CDEC AMF: American River at Folsom, sensor 65 (WY 1901-Present)	CDEC NAT: Lake Natoma (Nimbus Dam), sensor 8	DWR B-120 SRWSI: American River below Folsom Lake (monthly TAF for current WY in 6 exceedances)
Putah Creek	DWR UF2: Putah Creek near Winters (WY 1922-2014)	*	*
Upper Sacramento River Valley	DWR UF5: Sacramento Valley West Side Minor Streams (WY 1922-2014)	CNRFC EDCC1: Elder Creek-Paskenta + TCRC1: Thomes Creek-Paskenta (WY 2015-Present)*	CNRFC EDCC1: Elder Creek-Paskenta + TCRC1: Thomes Creek-Paskenta (daily TCFS for next year in 39 traces)*
	DWR UF7: Sacramento Valley East Side Minor Streams (WY 1922-2014)	CNRFC MLMC1: Mill Creek-Los Molinos + DCVC1: Deer Creek-Vina + BKCC1: Butte Creek-Chico (WY 2015-Present)*	CNRFC MLMC1: Mill Creek-Los Molinos + DCVC1: Deer Creek-Vina + BKCC1: Butte Creek-Chico (daily TCFS for next year in 39 traces)*
Sacramento River Valley Floor	DWR UF1: Sacramento Valley Floor (WY 1922-2014)	*	*

*Gap filling procedure used to adjust existing data or fill-in missing data (see section 2.1.5).

Table 2. San Joaquin River Watershed Supply Data Sources

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Chowchilla River	DWR UF20: Chowchilla River at Buchanan Reservoir (WY 1922-2014)	CNRFC BHNC1: Chowchilla River-Buchanan Reservoir (WY 2015-Present)	CNRFC BHNC1: Chowchilla River-Buchanan Reservoir (daily TCFS for next year in 39 traces)
Upper San Joaquin River	CDEC SJF: San Joaquin River below Friant, sensor 65 (WY 1901-Present)	CDEC SJF: San Joaquin River below Friant, sensor 8	B-120 SJWSI: San Joaquin River inflow to Millerton Lake (monthly TAF for current WY in 6 exceedances)
Fresno River	DWR UF21: Fresno River near Daulton (WY 1922-2014)	CNRFC HIDC1: Fresno River-Hensley Lake (WY 2015-Present)	CNRFC HIDC1: Fresno River-Hensley Lake (daily TCFS for next year in 39 traces)
Merced River	CDEC MRC: Merced River near Merced Falls, sensor 65 (WY 1901-Present)	CDEC EXC: New Exchequer-Lake McClure, sensor 8	B-120 SJWSI: Merced River below Merced Falls (monthly TAF for current WY in 6 exceedances)
Tuolumne River	CDEC TLG: Tuolumne River-La Grange Dam, sensor 65 (WY 1901-Present)	CDEC TLG: Tuolumne River-La Grange Dam, sensor 8	B-120 SJWSI: Tuolumne River below La Grange Reservoir (monthly TAF for current WY in 6 exceedances)
Stanislaus River	CDEC SNS: Stanislaus River-Goodwin, sensor 65 (WY 1901-Present)	CDEC GDW: Goodwin Dam, sensor 8	B-120 SJWSI: Stanislaus River below Goodwin Reservoir (monthly TAF for current WY in 6 exceedances)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Calaveras River	DWR UF15: Calaveras River at Jenny Lind (WY 1922-2014)	CNRFC NHGC1: Calaveras River-New Hogan Reservoir (WY 2015-Present) CDEC NHG: New Hogan Lake, sensor 8 (WY 2015-Present)	CNRFC NHGC1 (daily TCFS for next year in 39 traces)
Mokelumne River	CDEC MKM: Mokelumne River-Mokelumne Hill, sensor 65 (WY 1901-Present)	CDEC MKM: Mokelumne River-Mokelumne Hill, sensor 8	CNRFC CMPC1: Mokelumne River-Mokelumne Hill (daily TCFS for next year in 39 traces)
Cosumnes River	CDEC CSN: Cosumnes River at Michigan Bar, sensor 65 (WY 1908-Present)	CDEC MHB: Cosumnes River at Michigan Bar, sensor 8	CNRFC MHBC1: Cosumnes River-Michigan Bar (daily TCFS for next year in 39 traces)
San Joaquin River Valley Floor	DWR UF12: San Joaquin Valley East Side Minor Streams + UF17: San Joaquin Valley Floor + UF24: San Joaquin Valley West Side Minor Streams (WY 1922-2014)	CNRFC MPAC1: Mariposa Creek-Mariposa Reservoir + OWCC1: Owens Creek-Owens Reservoir + MEEC1: Bear Creek-McKee Road*	CNRFC MPAC1: Mariposa Creek-Mariposa Reservoir + OWCC1: Owens Creek-Owens Reservoir + MEEC1: Bear Creek-McKee Road (daily TCFS for next year in 39 traces)*

*Gap filling procedure used to adjust existing data or fill-in missing data (see section 2.1.5).

2.1.5 **Filling Supply Data Gaps**

After the compilation of supply data from the sources listed in section 2.1.4 above, data "gaps" remain for some subwatersheds in the Delta watershed. These gaps include periods of missing past or forecasted data and past or forecasted data that cover only a

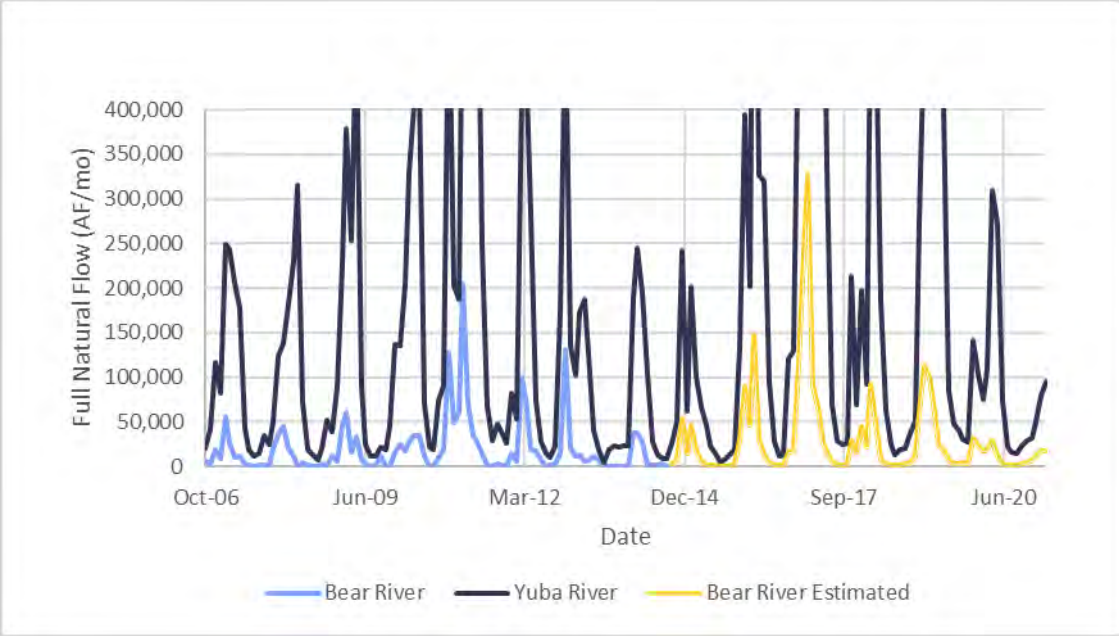
portion a subwatershed, as defined for this analysis (see section 2.1.3 above). These gaps were filled using extrapolation and augmentation processes, respectively, to create a complete supply dataset for use in the Water Unavailability Methodology. Technical Appendix A contains descriptions of specific gap-filling processes for each subwatershed where they were applied.

2.1.5.1 *Extrapolation*

To fill missing past or forecasted supply data gaps, overlapping historical data between the subwatershed with missing data ("Stream") and a nearby watershed with similar hydrology but more robust data ("River") were analyzed. The Stream:River ratio was calculated[8] for each month over this period, and outliers were removed. Then, the River FNF estimates were multiplied by the average monthly Stream:River ratio to extrapolate reasonable FNF estimates to fill the gaps in the subwatershed's dataset.

For example, February 2021 supply data for the Bear River subwatershed was not available from any of the sources listed in section 2.1.4 above. Therefore, prior February FNF estimates for the Bear River subwatershed were compared to the neighboring Yuba River and a ratio of 1:5 was calculated (Bear:Yuba). Missing February data for the Bear River subwatershed was estimated by multiplying the Yuba River subwatershed's February 2021 FNF estimate by this ratio. Figure 6 below illustrates the Bear:Yuba extrapolation for the period of WY 2014 to present.

Figure 6. Extrapolation Example: Estimation of Bear River FNF (WY 2014–present) Based on Yuba River FNF



[8] The Stream:River ratio calculation is analogous to a linear interpolation each month, with the y-intercept always set to zero.

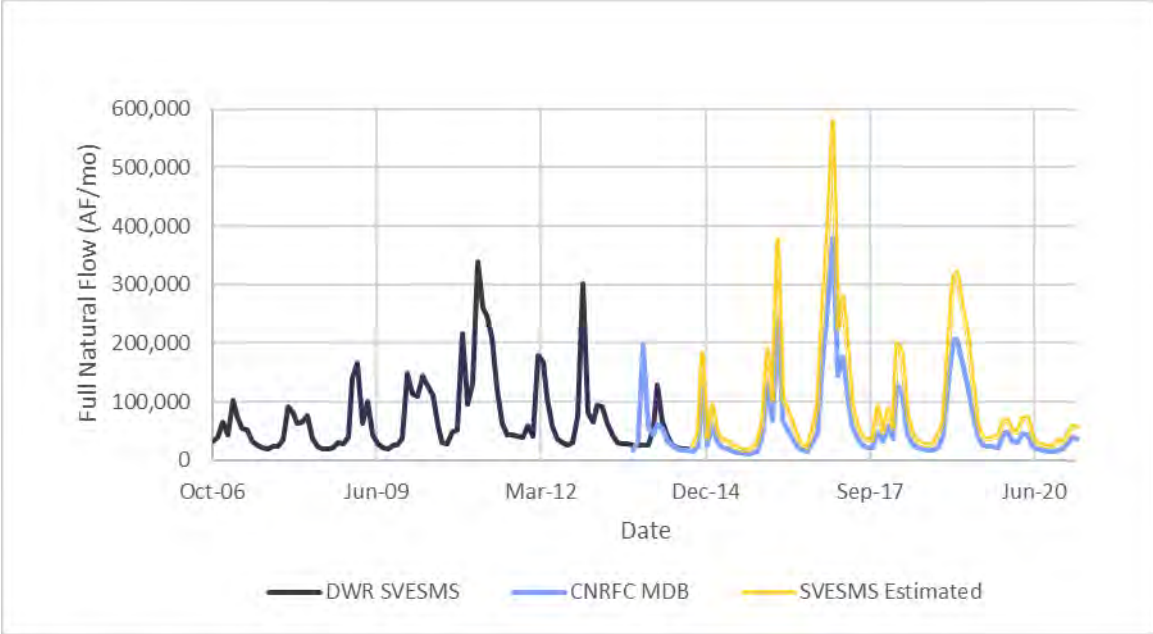
2.1.5.2 *Augmentation*

In other areas, past or forecasted data may exist but not represent the entire FNF supply of a watershed that would be expected to be available for diversion. This was the case for watersheds consisting of multiple small tributary streams, in which only some streams have available supply forecasts through CNRFC. DWR's 2016 Bay-Delta Unimpaired Flow Report includes past FNF estimates that cover all tributaries in these subwatersheds. To increase the "CNRFC" forecasts to approximate a forecast for the entire subwatershed (as the past supply estimates from "DWR" do), overlapping historical data between the two sources were analyzed. The ratio DWR:CNRFC was calculated on a monthly basis over this period, and outliers were removed.[9] Then, the past and forecasted CNRFC values were augmented by multiplying them by the monthly average DWR:CNRFC ratio to produce a reasonable FNF forecast estimate for the subwatershed.

For example, DWR's past (WY 1922–2014) unimpaired flow estimates for the Sacramento Valley East Side Minor Streams (UF7 in DWR's Report), part of the Upper Sacramento Valley subwatershed, include Antelope Creek, Mill Creek, Deer Creek, Big Chico Creek, Butte Creek, and other minor tributaries from Big Chico Creek to the Feather River (DWR 2016). CNRFC only has past (WYs 2013–present) and forecasted FNF data available for Mill, Deer, and Butte Creeks (MDB, in total). By comparing historical FNF values for a period with overlapping data (WYs 2013 and 2014), a monthly relationship ratio can be calculated. In this example, for February, the total Sacramento Valley East Side Minor Streams unimpaired flow was about 1.5 times the MDB supply. Therefore, missing February data in the Upper Sacramento Valley subwatershed would be estimated by multiplying the MDB supply by 1.5. The Upper Sacramento Valley subwatershed also includes supplies from West Side Minor Streams, which were estimated using a similar method with different DWR and CNRFC gages. Figure 7 below illustrates the DWR:CNRFC augmentation to estimate FNF for the Sacramento Valley East Side Minor Streams.

[9] Because the DWR FNF values include data for all of the CNRFC streams and additional tributaries, the value of the DWR:CNRFC ratio is always greater than one.

Figure 7. Augmentation Example: Adjusting CNRFC Data for Mill, Deer, and Butte Creeks (MDB) to Estimate FNF Within Sacramento Valley East Side Minor Streams (SVESMS), a Portion of the Upper Sacramento Valley Subwatershed, Based on DWR's FNF Estimate for SVESMS



2.1.6 **Abandoned Instream Flows**

Specific reaches of streams within the Delta watershed may be subject to minimum instream flow requirements due to water right permit/license conditions, Board orders/decisions/regulations, Federal Energy Regulatory Commission (FERC) hydropower license conditions, biological opinion requirements, or private agreements. If these instream flow requirements are met by diverters bypassing flow, these flows are already included in the FNF values. If these instream flow requirements are met via releases of stored water, these flows are not captured by the FNF calculations. Beyond the reach for which they are intended for instream use, these storage releases are available for diversion, and, therefore, may theoretically be considered alongside FNF values to more accurately represent the amount of water available for downstream diversion unless there are provisions making these flows unavailable for use.

Current data limitations prevent a precise accounting of when instream flow requirements that will be abandoned have been met by stored water. Therefore, to incorporate abandoned instream flows into the supply dataset without artificially inflating estimates of available supply by assuming all abandoned instream flows have been met by releases of stored water, the methodology uses the greater of the FNF value and the abandoned instream flow value to represent the amount of supply contribution of the subwatershed to the respective watershed-wide supply. In other words, it was assumed that if the FNF is greater than the instream flow then instream flow requirement is being met by FNF; conversely, if the instream flow is greater than the FNF then it was

assumed that the instream flow is met at least in part by storage releases which can be considered abandoned below their intended reach.

For the purposes of this analysis, all abandoned instream flows whose instream flow reach ends near the bottom of a subwatershed were considered. The methodology does not currently account for instream flows that end higher up in the subwatershed. Using data from the State Water Board's Sacramento Valley Water Allocation Model (SacWAM)[10] and Water Supply Effects (WSE) model,[11] a total of eight instream flow requirements that would produce abandoned flows were identified. These flow requirements, locations, and amounts are summarized in Table 3 and Table 4 below for the Sacramento and San Joaquin River watersheds, respectively. Water released by the Projects to meet water quality and flow requirements included in State Water Board Decision 1641 is not considered abandoned because those flows are intended to remain instream through the Delta and as outflow from the Delta.

[10] SacWAM is a hydrologic and system operations model developed by the Stockholm Environment Institute (SEI) and State Water Board using the Water Evaluation and Planning (WEAP) platform to represent the Sacramento River watershed, Delta, and eastside tributaries to the Delta (the Calaveras, Cosumnes, and Mokelumne Rivers). Information on SacWAM is available here: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/sacwam/

[11] WSE is a hydrologic and system operations model developed by the State Water Board to represent the lower San Joaquin River and its lower tributaries (the Merced, Tuolumne, and Stanislaus Rivers). Information on WSE is available here: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/2018_sed/

Table 3. Sacramento River Watershed Flows Considered to Contribute Abandoned Supplies[12]

Sub-watershed	Abandoned Instream Flow (cfs)					Notes
	May	June	July	Aug.	Sept.	
Upper North Fork Feather River	300	300	300	300	250	FERC P-2107 license (below Poe Dam)
Yuba River	500	500	250	250	250	Board Decision 1644 (at Marysville, assumes Extreme Critical year, does not include flows transferred to DWR)
Bear River	25	25	10	10	10	FERC P-2997 license (below Camp Far West Diversion Dam, does not include flows transferred to DWR)
Upper American River	425	475	425	425	350	FERC 20140820 license (South Fork below Chili Bar, assumes Dry year, includes Conditions 1 and 3) and P-2079 license (North Fork below American River Pump Station)
Putah Creek	5	5	5	5	5	2000 Putah Creek Accord (outflow to Toe Drain)
Total	**1,035**	**1,085**	**770**	**770**	**695**	

[12] Abandoned flows from Stony Creek were included in the May 12, 2021 version of the methodology but have been excluded from this updated version because, given current hydrology, any abandoned instream flow from Stony Creek is expected to seep into the underlying groundwater basin prior to reaching the Sacramento River and contributing to available downstream supplies.

Table 4. San Joaquin River Watershed Flows Considered to Contribute Abandoned Supplies

Sub-watershed	Abandoned Instream Flows (cfs)					Notes
	May	June	July	Aug.	Sept.	
Merced River	60	15	15	15	15	FERC P-2179 license (below Crocker Huffman Diversion Dam, assumes Dry year)
Tuolumne River	311	50	50	50	50	FERC P-2299 license (below La Grange Diversion Dam, assumes SJR 60-20-20 index is between 1.5 and 2.0 MAF)
Total	**371**	**65**	**65**	**65**	**65**	

For the simplicity of the analysis, the Water Unavailability Methodology does not currently account for whether the abandoned flows included in the supply dataset are foreign in either time or source and not available for use by riparian diverters since the methodology is not currently intended to be used to support notices of water unavailability to riparian users.

2.2 Demand

The Water Unavailability Methodology evaluates demands for natural and abandoned flows. It is not intended to account for demands for previously stored water, imported supplies, and contractual demands. The analysis relies on reported demand data from the State Water Board's Electronic Water Rights Information Management System (eWRIMS) computer database.[13] The eWRIMS data system contains information regarding water rights, including but not limited to:

- Water right ownership information
- Water right type (e.g., "Appropriative" or "Statements of Diversion and Use")
- Water right status (e.g., active, inactive, revoked, etc.)
- Authorized diversion seasons and volumes
- Authorized beneficial uses, including both consumptive (e.g., irrigation) and non-consumptive (e.g., hydropower generation) beneficial uses
- Spatial location of PODs,[14] including HUC8 watershed(s)

[13] A public version of the eWRIMS database is available here: https://ciwqs.waterboards.ca.gov/ciwqs/ewrims/EWPublicTerms.jsp

[14] The eWRIMS database contains a mapping application to view the spatial location of PODs.

- Electronically reported water diversion and use information, available on a monthly basis

The eWRIMS database system contains information for various water right types, including both riparian and appropriative water rights. Within the eWRIMS database system, post-1914 appropriative water rights are categorized as "Appropriative," and pre-1914 appropriative and riparian claims are categorized as "Statements of Diversion and Use." The eWRIMS database system also includes information for other minor water right types, such as water right registrations.

Currently, all diverters are required to submit annual reports of water diversion and use (annual reports) to the State Water Board electronically through the eWRIMS Report Management System (RMS). The annual reports are mandatory filings that document water diversions and uses made during each month of the previous calendar year, including monthly direct diversion volumes, monthly diversion to storage volumes, and monthly water use volumes. A separate annual report of water diversion and use is required for each water right each year; therefore, a diverter may be required to submit more than one annual report if they hold or claim more than one right. Reports for the prior calendar year are due by April 1 for appropriative water rights, stockpond certificates,[15] and registrations[16] and by July 1 for groundwater recordations and statements of water diversion and use. Diversion data contained within the annual reports forms the basis for estimates of water demand used in the Water Unavailability Methodology.

For this analysis, water demand is based on the total monthly diversion amount reported for each water right record, including monthly direct diversions and monthly diversions to storage. The demand dataset used in the Water Unavailability Methodology is specifically derived from the reported annual diversion data for calendar years 2018 and 2019, the most current years available. 2020 diversion data was not used for this analysis because the full dataset is not yet available.[17]

The methodology primarily relies on 2018 demand data, with additional data from 2019 also available for comparison purposes. 2018 was a below normal water year and is assumed to more closely resemble demands during a critically dry year than 2019, which was a wet water year. The reliance on 2018 demand data may underestimate actual demand since demands are likely to be greater during a critically dry year due to

[15] Stockpond certificates are appropriative water rights issued by the State Water Board through 1997 and are limited to diversion of 10 acre-feet (AF) or less per year.
[16] Water right registrations are appropriative water rights issued by the State Water Board through an expedited acquisition process for certain small projects first available in 1989. Water right registrations are available for small domestic use, livestock stockpond use, small irrigation use, and cannabis small irrigation use.
[17] Reporting of 2020 diversion and use information is not due for Statements of Diversion and Use (riparian and pre-1914 appropriative water right claimants) until July 1, 2021.

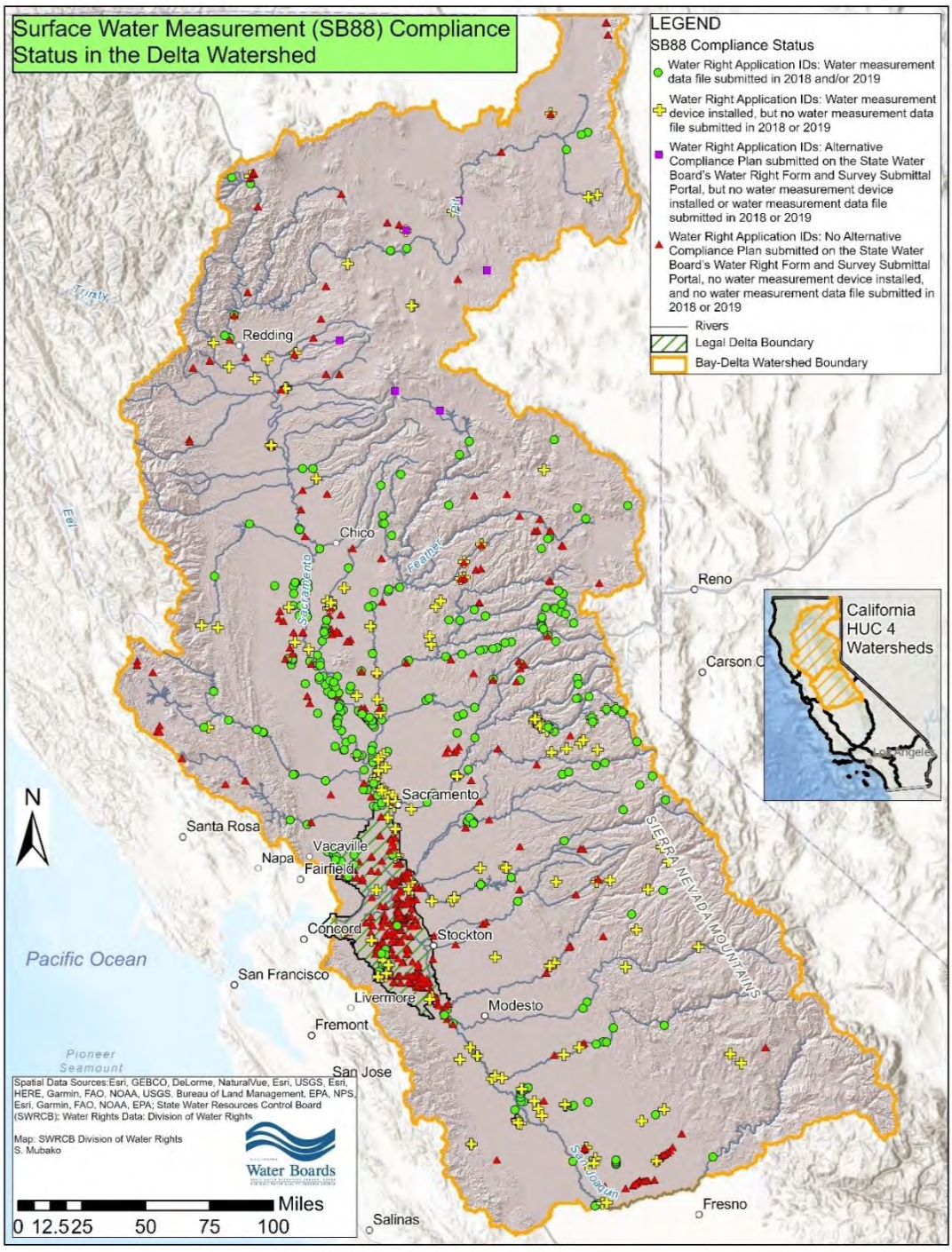
the drier soil conditions. There are also likely higher losses to evaporation and seepage in a critically dry year. Conservation activities that may be pursued this year may offset higher critical year demands to some degree, but it is assumed that using below normal year demand estimates in a critically dry year is a conservative assumption for the purposes of avoiding issuance of notices of water unavailability when they may not be warranted. While diversions during the wet season may vary significantly from year to year, demands for natural and abandoned flows during the dry season are assumed to be similar from year to year and to some degree be greater during drier years.

In addition, 2018 diversion data was used because it is the only drier year for which diversion data is available since updated water right measurement and reporting requirements went into effect with Senate Bill 88 (SB88). Pursuant to regulations implementing SB88, all water right diverters authorized to divert more than 10 AF annually from rivers, creeks, springs, or subterranean streams must comply with measurement requirements. There are three ways to achieve measurement compliance: (1) install, use, and maintain a device capable of measuring the rate of direct diversion; (2) propose an alternative compliance plan; or (3) utilize a measurement method for multiple diverters. SB88 set expectations for both the accuracy of measurement devices as well as the monitoring frequency of the device and included measurement device installation deadlines of January 1, 2018 or earlier.

Although the implementation of SB88 has increased the frequency of required reporting for many diverters and may help to improve the quality of reported diversion and use data submitted to the State Water Board, many diverters have not yet achieved full compliance with the water right measurement requirements even though the measuring device installation deadlines have now passed. For example, among the 244 largest consumptive water right records in the Delta watershed located outside of the Legal Delta, diverters installed a measuring device and submitted a measurement data file for 2018 or 2019 in accordance with SB88 for only 57 percent (140) of the records. Diverters submitted proposed Alternative Compliance Plans pursuant to SB88 for an additional 2 percent (4) of the records. Diverters installed a measuring device but failed to submit a measurement data file for 2018 or 2019 for 27 percent (65) of the records, and did not install a measuring device, submit a measurement data file for 2018 or 2019, or submit a proposed Alternative Compliance Plan for 14 percent (35) of the records. Compliance with the measurement requirements may be even lower for smaller diverters.

Figure 8 below shows the locations of the PODs associated with the largest (larger than 5,000 AF face value or 5,000 AF of reported use) consumptive water right records in the Delta watershed and displays the SB88 compliance status.

Figure 8. Delta Watershed: Surface Water Measurement (SB88) Compliance Status



As discussed in more detail below, diversion data contained within annual reports is self-reported and is not systematically verified for accuracy upon submittal. As a result, an internal review and quality control effort was conducted.

2.2.1 **Initial Selection of Water Right Records**

A subset of the water right records in the eWRIMS database for the Delta watershed were selected for use in the Water Unavailability Methodology based on several criteria:

- Spatial Location: POD(s) located within the Delta watershed[18]
- Water Right Status: Active status types only, thereby excluding inactive-type statuses (e.g., inactive, revoked, cancelled, etc.)
- Water Right Type: "Appropriative" (i.e., post-1914 appropriative, excluding registrations and stockpond certificates) and "Statement of Diversion and Use" (i.e., pre-1914 appropriative and riparian), thereby excluding minor water right types
- Beneficial Uses: All beneficial uses except exclusively non-consumptive beneficial uses

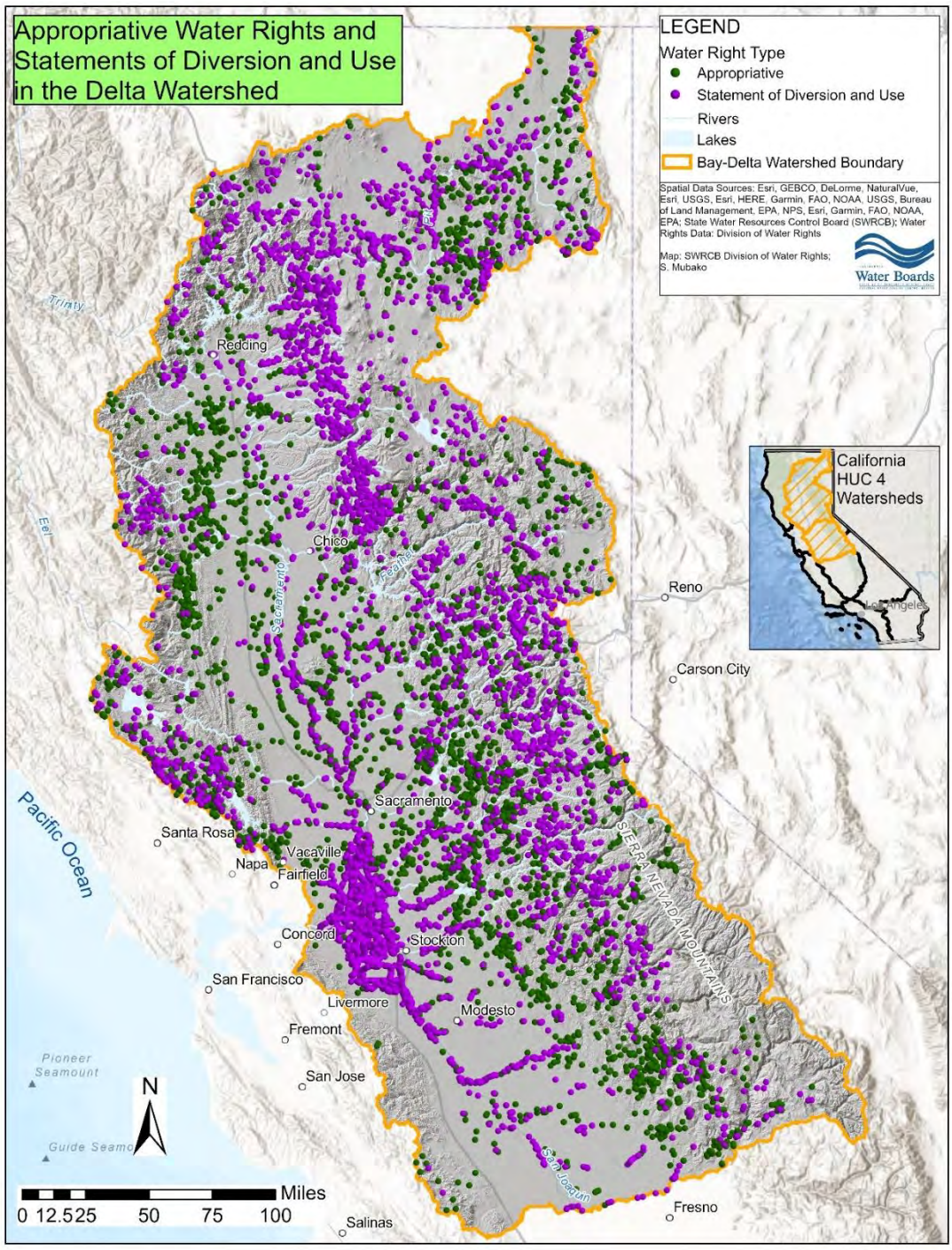
Water right records with active-type statuses were selected to best approximate current year water demand since it is unlikely that inactive-type statuses (e.g., inactive, revoked, cancelled, etc.) would be reactivated during the current year. Only water right records with "Appropriative" and "Statement of Diversion and Use" water right types were included because minor water right types, such as registrations and stockponds, were assumed to constitute a negligible amount of the water diversion and use within the Delta watershed.

Water right records identified as non-consumptive based on the beneficial use type (e.g., hydropower generation, fish and wildlife preservation and enhancement, etc.) were also excluded. Non-consumptive uses, such as for hydropower generation, may change the timing of flows but do not reduce the amount of supply available unless they result in an interbasin diversion (see section 2.2.6 below). Given the temporal resolution of the supply and demand dataset (i.e., monthly) and the lesser amount of hydropower-related storage occurring during the dry season than the wet season, the potential impact of these non-consumptive diversions on the timing of flows is not assumed to be significant.

This initial selection of water right records resulted in a demand dataset consisting of approximately 11,700 total records. Of these, approximately 5,100 were post-1914 appropriative water rights and 6,600 were statements of diversion and use. These records are shown in Figure 9 below.

[18] All PODs within the Delta watershed were selected except for those within the Panoche Creek subwatershed. As described in section 2.1.3 above, supply data is not available for this subwatershed; therefore, neither supply nor demand for this area were included in this analysis.

Figure 9. Active Consumptive Appropriative Water Rights and Statements of Diversion and Use in the Delta Watershed



2.2.2 **Initial Quality Control**

Water diversion data contained within the eWRIMS database originates from annual reports of water diversion and use electronically submitted by diverters. This self-

reported data is not systematically verified for accuracy upon receipt and contains inaccuracies, inconsistencies, and other errors. Staff conducted a quality control effort following the initial selection of water right records for the demand dataset.

The approximately 12,000 total records existing within the demand dataset after initial selection were too numerous to feasibly review in their entirety at this time. Therefore, the scope of the review was narrowed to appropriative water rights with a face value (maximum diversion amount) of 5,000 AF or greater and statements of diversion and use with reported diversions of 5,000 AF or greater in either calendar year 2018 or 2019. This produced a manageable subset of water right records to review within a limited timeframe of approximately 580 records, including approximately 360 post-1914 appropriative rights and approximately 220 riparian and pre-1914 appropriative claims. These records account for approximately 90 percent of the water diverted in the Delta watershed in 2018 and 2019 but less than 10 percent of the users.

For this narrower set of records, the 2018 and 2019 annual reports of water diversion and use associated with each record were reviewed to identify potential inaccuracies in the diversion data. During the review process, several types of data errors were identified and corrected, if the appropriate correction was discernable.[19] These corrections included:

- Correction of diversion data entry and reporting issues, such as incorrect units of measurement and decimal placement errors
- Removal of duplicate diversion values, such as the same diversions reported under multiple water right records
- Removal of non-consumptive diversions improperly appearing as consumptive
- Correction of diversion values as necessary where reported diversion exceeds the water right's face value

During the quality control process, if the appropriate correction was unclear, the affected records were flagged for potential further investigation beyond the information readily available in eWRIMS.

In addition to the records review described above, approximately 100 post-1914 appropriative rights were identified that reported diversions less than 5,000 AF but in excess of the face value of the water right. Most of these diversions are very small. Due to time constraints, these records were not investigated individually. Instead, for these rights, the reported diversion amounts within the demand dataset were updated to equal the face value of the right.

[19] Comments provided within the annual reports of water diversion and use often contained critical information to inform these corrections. For example, some diverters stated that their purpose of use is entirely non-consumptive. Others indicated that a particular diversion was fully reported under two or more separate rights, i.e., duplicated.

Except for the correction to reported diversions in excess of the face value of post-1914 rights, all water right records with a face value or reported use under 5,000 AF were included in the demand analysis without a quality control review. As mentioned above, these records constitute only about 10 percent of the total demand within the Delta watershed.

2.2.3 **Additional Quality Control**

After conducting the initial quality control review of the 2018 and 2019 annual reports for the largest diversions as discussed above, and after applying corrections to rectify errors, some diversion values remained flagged as potentially including incorrect demand information with outstanding issues that could not be resolved without further information. Examples of the issues include:

- Possible duplicate reporting of diversion volumes under multiple water right records where it was not possible to quantify the duplicate reporting amount.
- Possible overreporting of diversion volumes that could not be corrected to reflect a best estimate of the actual diversion volume based on the available information. For example, some annual reports contained information that appeared to indicate that the diversion volume was not measured and, as a result, the maximum diversion amount authorized under the permit or license had been reported.
- Apparent inclusion of both consumptive and non-consumptive uses in the reported diversion amount where it was not possible to quantify the volume of water diverted only for consumptive uses.
- Other potential data reporting issues where the appropriate correction was unclear.

In these cases, additional information may be needed to determine the appropriate correction or resolve other reporting-related issues. State Water Board staff has contacted numerous water right holders or their agents to gather this information. Diversion volumes within the demand dataset were updated according to the responses provided. However, it was not feasible to contact all water right holders or agents in all cases where a potential reporting related error was identified or a correction applied to a diversion value. Efforts were prioritized to contact water right holders or agents based on several factors, including reported diversion size and relative level of uncertainty regarding potential reporting-related inaccuracies. In addition, some water right holders and agents did not provide responses to inquiries regarding potential reporting related errors. In the absence of additional information provided by the water right holder or agent, best estimates of the actual diversion values were used based on information contained within the annual report of water diversion and use and supplemental information available within the eWRIMS database.

Further refinements to the demand dataset used in the Water Unavailability Methodology may occur. Diverters who are aware of reporting issues, including, but not

limited to, the items discussed above, should contact the State Water Board at Bay-Delta@waterboards.ca.gov.

In addition, the quality-controlled 2018 and 2019 demand datasets were compared to FNF for each of these years, respectively, at the subwatershed (see section 2.1.3 above), Sacramento River watershed, and San Joaquin River watershed scales to assess the reasonableness of the demand datasets. The demand datasets used in the Water Unavailability Methodology represent the State Water Board's current best estimate of demand for these years based on the available information.

2.2.4 **Demand Aggregation by Subwatershed**

The Water Unavailability Methodology requires that both the supply and demand data be aggregated to a common spatial resolution for comparison purposes. The supply data is generally only available at the HUC8 watershed scale or larger, while the demand data includes both the HUC8 watershed and the precise spatial location (latitude and longitude) for each POD. For the purposes of this analysis, demand values within the demand dataset were aggregated at the same subwatershed scale as the supply values within the supply dataset (see section 2.1.3 above). The subwatershed assignments of specific PODs, such as those located near Folsom, Oroville, and Friant Dams, were reassigned on a case-by-case basis within the demand dataset to better fit the demand to the subwatershed from which it draws supply.

All of the PODs of most water right records are geographically located within a single subwatershed. In these instances, all of the demand associated with these rights is attributed to that subwatershed. Fifty-five water right records in the Delta watershed have PODs that span multiple subwatersheds. Nine of these are Project diversions, which frequently have PODs upstream of the Delta at the major storage reservoirs, downstream on Delta tributaries, and within the Delta itself. As described in section 2.2.5 below, the Water Unavailability Methodology treats these diversions differently because of the unique circumstances of the Projects' diversions. For the 31 remaining non-Project diversions that have PODs within multiple subwatersheds, the total reported diversion for each water right record was split among the applicable subwatersheds based on the proportion of the total PODs located within each subwatershed. For example, if a water right record had 3 associated PODs, one of which was located within the Sacramento Bend subwatershed and 2 within the Upper Sacramento Valley subwatershed, one-third of the total demand for the water right would be attributed to the Sacramento Bend subwatershed and two-thirds to the Upper Sacramento Valley subwatershed. An apportionment of demand based on the amount diverted at each POD is not possible at this time because water diversion and use information is typically reported by water right and not for individual PODs.

2.2.5 **Project Demands**

The Projects divert and store water for use by contractors both within and outside of the Delta watershed. These contractors include contractors that do not have their own

basis of right and contractors that have their own bases of water right that may also receive supplemental contract supplies (referred to as settlement contractors). Settlement contractors entered into contracts with the Projects to resolve water right disputes related to construction of the Projects. These contracts are not synonymous with the underlying rights but are instead negotiated agreements. The Projects contractors that do not have their own water rights include CVP service contractors and SWP Table A contractors. CVP service contracts and SWP Table A contracts include contracts for use within the Delta watershed and use outside of the Delta watershed. Diversions by the Projects for uses outside of the Delta watershed are subject to area of origin protection pursuant to the Water Code.[20] This protection prohibits the Projects from diverting for purposes of exporting natural and abandoned flows needed for uses within the Delta watershed.

In recognition of area of origin protection, Project diversions were assumed to have the lowest priority date. While some of the Projects' diversions serve inbasin purposes that are not subject to area of origin protection, this summer all of these uses are expected to be met with previously stored water due to the lack of significant inflow and other Project obligations. In addition to recognizing area of origin protection, identifying Project diversions as junior to other diversions ensures that any duplicate reporting between the Projects and their various settlement contractors that have their own underlying water rights or claims of right does not inflate demands in a manner that materially affects the analysis. The exception to this approach is for New Melones Project water rights. Since New Melones water is not authorized for export out of the Delta watershed, these demands are assumed to be met in accordance with the original priority date of the rights.

Generally, the Projects will not be diverting water and will be releasing previously stored water under conditions when notices of water unavailability would be issued. The responsibility to meet water quality and flow requirements effectively results in curtailment of Project water rights without any further action. Accordingly, while notices of water unavailability may still be issued to the Projects, such notices are unlikely to have a material effect during the summer. The State Water Board will reevaluate the possibility for watershed specific issues that may arise during the wet season related to these assumptions prior to application of this methodology beyond the dry season.

2.2.5.1 *Trinity River Imports*

Several consumptive water rights associated with the CVP Trinity River Division (A005628, A015374, A015375, A016767, and A017374) have PODs within the Delta watershed but the diverted water originates from the Trinity River watershed. These water rights and correlating diversion data were removed from the Delta consumptive diversion dataset for analysis because the water associated with these diversions is imported to the Delta watershed and does not impact supply forecasting for the

[20] Wat. Code, §§ 11128, 11460.

watershed. Diversion data for these out of basin water rights was transferred to a list of determined non-consumptive beneficial use(s) water rights for the Delta watershed.

2.2.5.2 ***Settlement Contractor Demands***

As discussed above, there are various water users in the Delta watershed that have settlement contracts with DWR and Reclamation that provide a contractual entitlement to a certain supply to these users. These contracts are intended to satisfy these users' underlying rights and to provide supplemental supplies. Because these users have their own water rights or claims of right for which they likely report use and contractual supplies for which DWR and Reclamation report use, there may be overlapping reporting of demands. For purposes of this analysis, it is assumed that most settlement contractors, with the exception of the Exchange Contractors on the San Joaquin River (see below discussion), have demands for natural and abandoned flows in accordance with their water use reports and that these users will take water pursuant to their senior water rights first if it is available. The fact that the supply may not be available at the senior priority of right or claim of right is not assumed to diminish the demand. Accordingly, settlement contractors may receive notices of water unavailability under their own water rights and would then need to rely upon contractual supplies to the extent those supplies are available.

Sacramento River and Feather River Settlement Contractor Demands

As a result of the very dry hydrologic conditions this year, allocations to Sacramento River and Feather River settlement contractors under their contracts have been reduced to approximately 75 and 50 percent, respectively. However, these reductions are not assumed under this analysis because the contracts are not synonymous with the underlying right or claim. For example, Sacramento River settlement contract amounts total 2.1 million acre-feet (MAF) but reported use under these contractors' underlying water right claims is closer to 1.4 to 1.6 MAF (which is close to 75 percent of the contract amount). Also, these groups of users have different priorities of rights and include a combination of pre-1914 and post-1914 rights (e.g., over 600 thousand acre-feet of Sacramento River settlement contractors' reported use in 2018 occurred under post-1914 claims of right). Accordingly, determining which rights to reduce demands for is not clear. The State Water Board plans to continue to coordinate with DWR, Reclamation, and the settlement contractors on these issues.

Exchange Contractors

The Exchange Contractors receive replacement supplies exported from the Delta in exchange for use of water from the San Joaquin River under the Exchange Contractors' underlying rights as part of settlement contracts related to the development of the Friant Project by Reclamation. Accordingly, all of the Exchange Contractor demands are assumed to be met with previously stored CVP supplies since the Exchange Contractors do not use water from the San Joaquin River under their underlying water right claims unless they are shorted supplies under their Exchange Contracts. This

year, shortages to Exchange Contractors are not currently expected. If there are shortages, the methodology could be adjusted to account for those shortages and the resulting demand for San Joaquin River water under the Exchange Contractors' claimed water rights.

2.2.6 Abandoned Flows and Interbasin Diversions (Yuba-Bear and Drum-Spaulding)

Non-consumptive uses are generally not included in demand estimates under the methodology. However, the May 12, 2021 draft methodology identified that adjustments were planned to be made to account for the interbasin diversions that occur from the Yuba River watershed to the Bear and American Rivers as part of highly complex hydroelectric project operations under Pacific Gas and Electric Company's (PG&E) Upper Drum-Spaulding Hydroelectric Project and Lower Drum Hydroelectric Project and Nevada Irrigation District's (NID) Yuba-Bear Hydroelectric Project. Under Upper Drum-Spaulding and Yuba-Bear hydroelectric project operations, water is exported from the Yuba River watershed to the Bear River via the South Yuba Canal and the Drum Canal.

Since May 12, 2021, adjustments to the demand dataset to account for interbasin diversions between the Yuba River watershed and Bear River watershed were considered. However, a review of information contained within the applicable PG&E and NID water right records indicated that diversions through the South Yuba Canal and Drum Canal are already reported under water right records located in the Yuba River subwatershed. In addition, it appears that previously stored water accounts for a large portion of the water transferred from the Yuba River to the Bear River during the summer months. Therefore, adjustments were not applied to account for the interbasin diversions. Adjustments related to diversions to storage during the wet season may be considered at a later date.

2.2.6.1 *Return Flow Estimates*

In recognition that only a portion of consumptive-use diversions are actually consumptively used due to return flows from irrigation and to a lesser extent municipal uses, a return flow factor was applied to diversion values within the demand dataset. Return flows are waters that are diverted and returned to the river as part of agricultural and urban uses. Agricultural return flows include operational spills from canals, flow through and draining of rice paddies, and drainage from other agricultural fields. The volume of return flows from agriculture varies based on type of use, crop type, location, soils, and season. Urban return flows are primarily comprised of treated effluent from wastewater treatment plants.

Out of the hundreds of return flow sources in the Delta watershed, the rates and volumes of most are unknown and only a handful have streamflow gages. Rates of return flow can be estimated using models developed to simulate the surface and groundwater hydrology. Models that have been developed for the Delta watershed include SacWAM, CalSim, C2VSIM, and regional water budgets developed by DWR.

Of these models, CalSim 3 is the most complete hydrologic simulation model of the Sacramento and San Joaquin River watersheds. CalSim 3 return flow rates were compared with SacWAM and the results show similar trends for the Sacramento River watershed. SacWAM provides detailed representations of the hydrologic processes including return flows in the Sacramento River watershed but does not include a representation of the San Joaquin River watershed. DWR's surface-groundwater model, C2VSIM fine grid, may provide useful information on return flows with future calibration efforts, but at this time the surface hydrology does not correspond well with observed data during dry periods. DWR's regional water budgets may also provide useful estimates of return flows in the future, but at this time they are not available.

CalSim 3 includes simulations for the 1922–2015 period. For the purpose of estimating return flows, results for water year 2014 were analyzed because it is a recent year out of the period of simulation that has hydrology that most closely matches the forecast for 2021. The CalSim 3 results, summarized in Table 5 and Table 6 below, show an increasing return flow as a percent of diversion after May continuing throughout the remainder of the irrigation season in the Sacramento River watershed and generally lower and more constant return flows in the San Joaquin River watershed. The increasing proportion of return flow in the Sacramento River watershed is primarily due to decreased diversions in August and September while return flows are maintained primarily due to rice operations. Urban return flows remain relatively constant throughout the irrigation season. In the San Joaquin River watershed, agricultural and urban return flows remain relatively constant throughout the summer.

Table 5. CalSim 3 Results of Monthly Diversions and Return Flows for Sacramento River Watershed, May–September 2014

Month	Diversions (TAF)	Return (TAF)	Percent Return
May	829	320	39%
June	845	161	19%
July	875	184	21%
August	660	187	28%
September	339	324	96%
Annual Average	**4,990**	**2,093**	**42%**

Table 6. CalSim 3 Results of Monthly Diversions and Return Flows for San Joaquin River Watershed, May–September 2014

Month	Diversions (TAF)	Return (TAF)	Percent Return
May	313	75	24%
June	362	76	21%
July	403	85	21%
August	331	68	21%
September	216	54	25%
Annual Average	**2,566**	**605**	**24%**

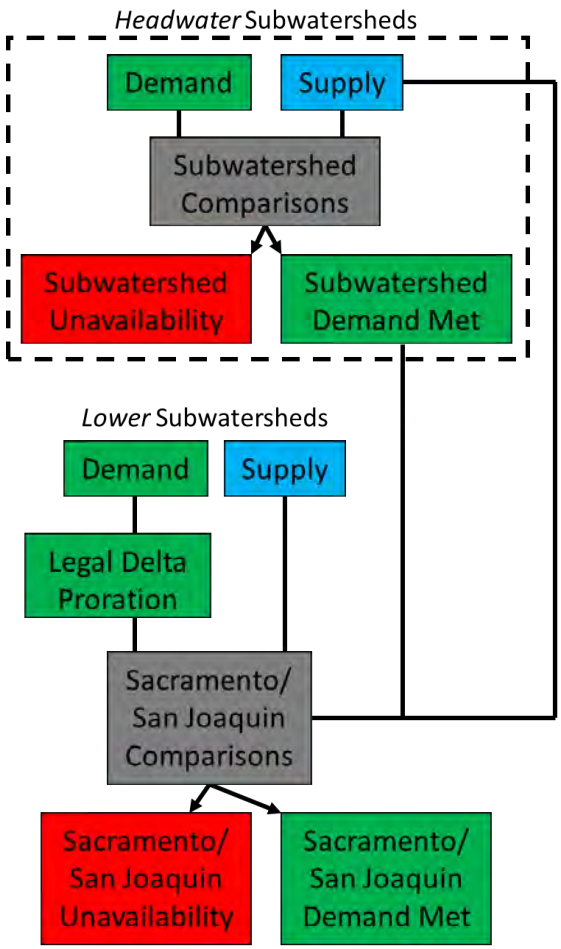
Spatially, most diversions and return flows occur in the Sacramento and San Joaquin Valley regions. Accordingly, return flow factors were only applied to demands in the Sacramento Bend, Upper Sacramento Valley, Sacramento River Valley Floor, and San Joaquin River Valley Floor subwatersheds.

2.3 Adjustments to the Supply and Demand Datasets

2.3.1 Elimination of Unmet Demand

A significant improvement over the water unavailability methodology used in the previous drought is the implementation of a more granular analysis, evaluating the supply and demand on both a subwatershed level (e.g., a single tributary like the Feather River) and watershed-wide level (the Sacramento and San Joaquin River watersheds). The watershed-wide analysis also includes water rights that divert from within the Legal Delta (see section 2.3.3 below). This allows for water unavailability to be determined based on physical supplies within a headwater stream and for the accounting of senior demands that may have priority to divert that supply further downstream. Supply and demand are compared at a subwatershed level for those subwatersheds that are not downstream of any other subwatershed. Demands within these “headwater” subwatersheds can only be met by supply originating within the subwatershed itself. Figure 10 below is a schematic showing how this analysis was performed using the supply and demand data previously described.

Figure 10. Schematic of Supply and Demand Analysis at the Subwatershed and Watershed Levels



As shown in Figure 10, supply and demand are first compared within the headwater subwatersheds. While supplies from the headwater subwatersheds are considered available to meet downstream demands in the larger Sacramento or San Joaquin River watershed analyses, only headwater subwatershed demand that is able to be met by the available supply in the headwater subwatershed is considered in the watershed analysis.

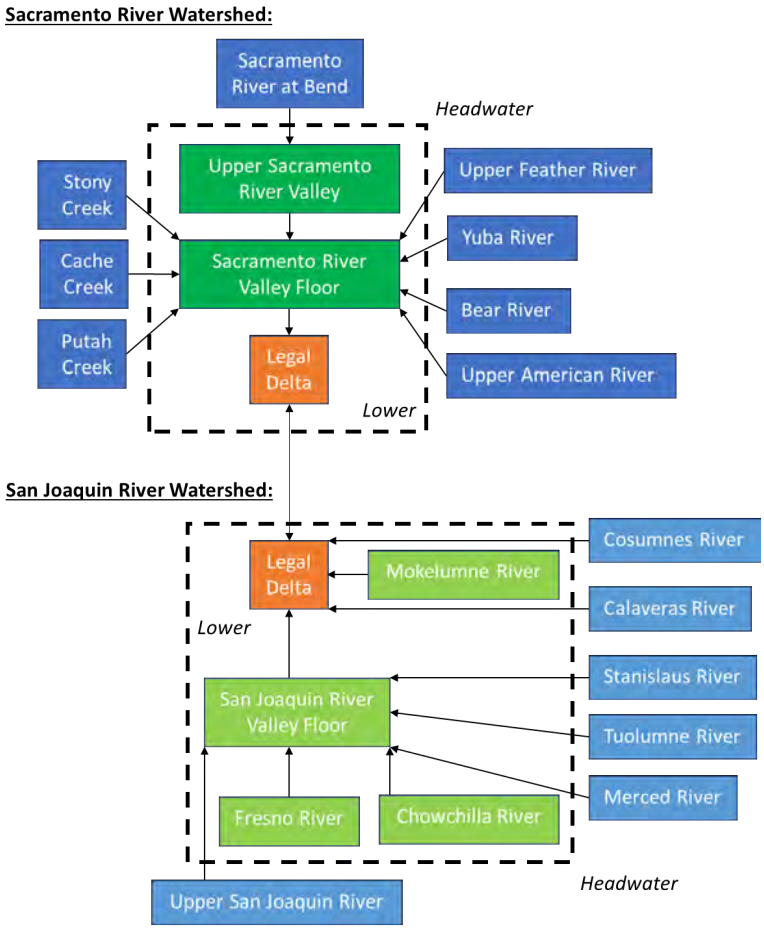
The headwater subwatersheds in the Sacramento River watershed include the Sacramento River and tributaries above Bend, Stony Creek, Cache Creek, Putah Creek, the Upper Feather River above Oroville Dam, Yuba River, Bear River, and the Upper American River above Folsom Dam (see Figure 5). The headwater subwatersheds in the San Joaquin River watershed are the Upper San Joaquin River above Friant Dam, Merced River, Tuolumne River, Stanislaus River, Calaveras River, and the Cosumnes River. Figure 11 below shows a schematic of the subwatersheds previously mapped in Figure 5. A small number of rights in the headwater Putah Creek, Stanislaus River, Calaveras River, and Cosumnes River subwatersheds which lie within

the Legal Delta were excluded from the headwater subwatershed analysis and included only in the Sacramento and San Joaquin watershed-wide analyses, as they have access to water from both the Sacramento and San Joaquin Rivers (see section 2.3.3 below).

Lower subwatersheds are defined as such because they contain demands that can be met by supplies from outside tributaries (the headwater subwatersheds). The Upper Sacramento River Valley and Sacramento River Valley floor subwatersheds are considered lower watersheds because demands within them may be met from the mainstem of the Sacramento River flowing in from the Sacramento River at Bend. Similarly, the San Joaquin River Valley Floor includes demands on the mainstem of the San Joaquin River that can be met by inflow from the Stanislaus, Tuolumne, Merced, and Upper San Joaquin River subwatersheds.

Additional subwatersheds in the San Joaquin River watershed were classified as lower subwatersheds because their boundaries, based on HUC8 watersheds mapped in the USGS NHD (see section 2.1.3 above), contain demands that are not met from supplies within the subwatershed. These consist of the Chowchilla River (which includes minor east side tributaries and the mainstem of the San Joaquin River from Friant Dam to the confluence with the Merced River), Fresno River (which includes diversion points on the Eastside Bypass that are supplied by San Joaquin River flood flows), and the Mokelumne River (which includes demands on the mainstem of the San Joaquin River within the Legal Delta) subwatersheds. The Legal Delta is not a distinct subwatershed; it is a category of rights within several subwatersheds which have access to water from both the Sacramento and San Joaquin Rivers (see section 2.3.3 below).

Figure 11. Subwatersheds Schematic



Diverters within the headwater subwatersheds whose demand cannot be physically met by the supply available within those subwatersheds may receive notices of water unavailability based on the headwater subwatershed-level analysis. In addition, if demand in a headwater subwatershed exceeds the available supply, the excess demand is eliminated from the larger watershed-wide analysis. As a result, demand that cannot be met by physically available supplies is not "charged against" supplies from elsewhere in the Delta watershed.

The evaluation of water availability at the headwater subwatershed scale is only part of the evaluation of water availability. Water availability must also be evaluated at the overall Sacramento and San Joaquin River watershed scale. Though water may be physically available within a headwater subwatershed, it may be needed to meet the demand of senior users downstream that may have the right to some of the water originating in the headwater subwatershed. This broader availability is shown in the watershed-wide analysis.

2.3.2 **Elimination of Supply and Demand in Disconnected Headwater Subwatersheds**

The Water Unavailability Methodology is not currently intended to determine water unavailability for pre-1914 appropriative and riparian claimants, including relative availability between those uses. If the headwater subwatershed analysis indicates that the total demands of riparian and pre-1914 claimants exceed the available supply in a particular headwater subwatershed, that headwater subwatershed's supplies and demands are removed from the watershed-wide analysis for that month. In other words, it is assumed that the given stream would not have continuity with the larger Delta watershed due to fulfillment of the local senior water right demands.

2.3.3 **Proration of Legal Delta Demands**

Diverters in the Legal Delta (defined by the 1959 Delta Protection Act) may have access to water supplies from both the Sacramento and San Joaquin River watersheds. To account for this, demands within the Legal Delta were divided between the two watersheds based on the monthly proportion of connected supply available (see 2.3.22.3.2 above) from each watershed. For example, if the Sacramento River watershed contributes 80 percent of the connected supply within the Delta watershed for a given month, 80 percent of Legal Delta demand is charged against Sacramento River watershed supply for that month and 20 percent is charged against San Joaquin River watershed supply. Monthly supply ratios for Sacramento and San Joaquin River watersheds were calculated based on data for 2021; for past months of 2021 these months' FNF values were used. For present or future months, the exceedance forecast selected for use in determining water unavailability for each watershed (see 3.1.1 below) was used for the proration. The proration of Legal Delta demands is only applicable to the assessment of water unavailability at a watershed-wide scale and does not impact the assessment of water unavailability at the headwater subwatershed scale.

Diverters within the Legal Delta will only receive notices of water unavailability if both the Sacramento River watershed analysis and the San Joaquin River watershed analysis show that water will be unavailable at their priority of right. The hydrology of the Legal Delta is complex. This proration method offers a simplified and generous assessment of water availability in the Legal Delta in this critically dry period.

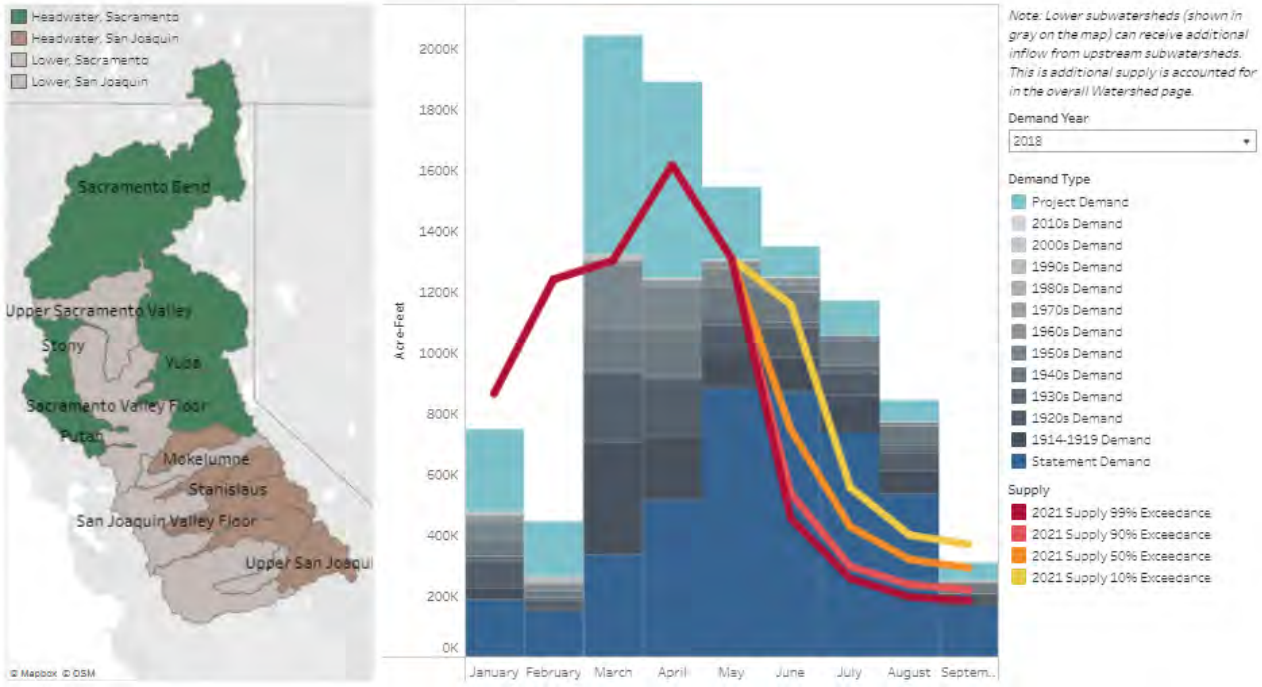
2.4 Water Unavailability Visualizations

The Water Unavailability Methodology includes two major types of water unavailability visualizations: the headwater subwatershed visualizations (14 in total) and the watershed-wide visualizations,[21] consisting of one for the Sacramento River watershed and one for the San Joaquin River watershed. Samples of these graphs are provided below as Figures 11, 12, and 13. Each graph displays demand data from both the 2018

[21] Supply and demand within the watershed-wide analyses is adjusted as described in section 2.3 above.

and 2019 demand datasets. The demands are sorted by water right priority, with riparian and pre-1914 demand combined into the "statement demand" category at the base of the graph, post-1914 appropriative rights grouped by decade and stacked above statement demand, and Project demands stacked at the top (see section 2.2.5 above). The subwatershed visualization displays four water supply scenarios: the 10 percent, 50 percent, 90 percent, and 99 percent FNF exceedance forecasts, representing optimistic, neutral, pessimistic, and extremely pessimistic forecasts, respectively. Because conditions in the Delta watershed are currently extremely dry, the adjustments to the supply and demand datasets described in section 2.3 above were done using the 90 percent FNF exceedance forecast.[22] As a result, the watershed-wide visualizations display a single supply scenario, the adjusted 90 percent exceedance forecast.

Figure 12. Sample Headwater Subwatershed Water Unavailability Visualization (Yuba River)



[22] Section 3.1.1 below describes how daily FNF may be used to determine which FNF exceedance forecast most closely represents actual conditions.

Figure 13. Sample Sacramento River Watershed Water Unavailability Visualization

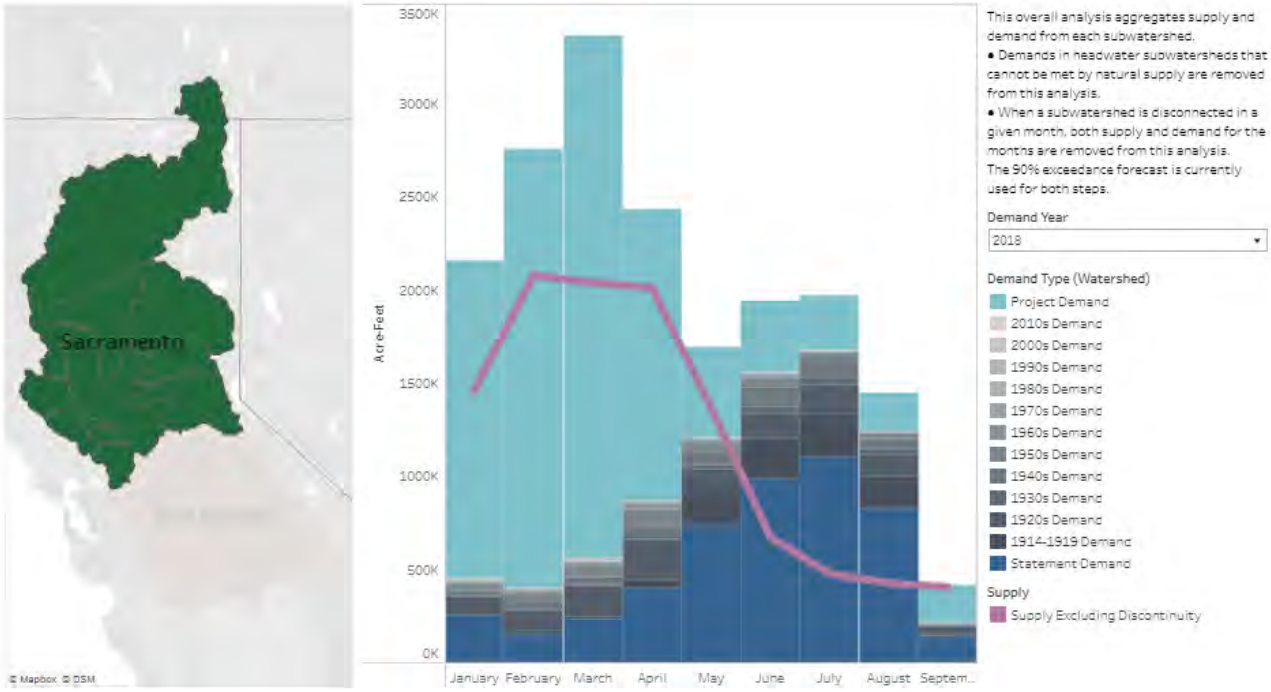
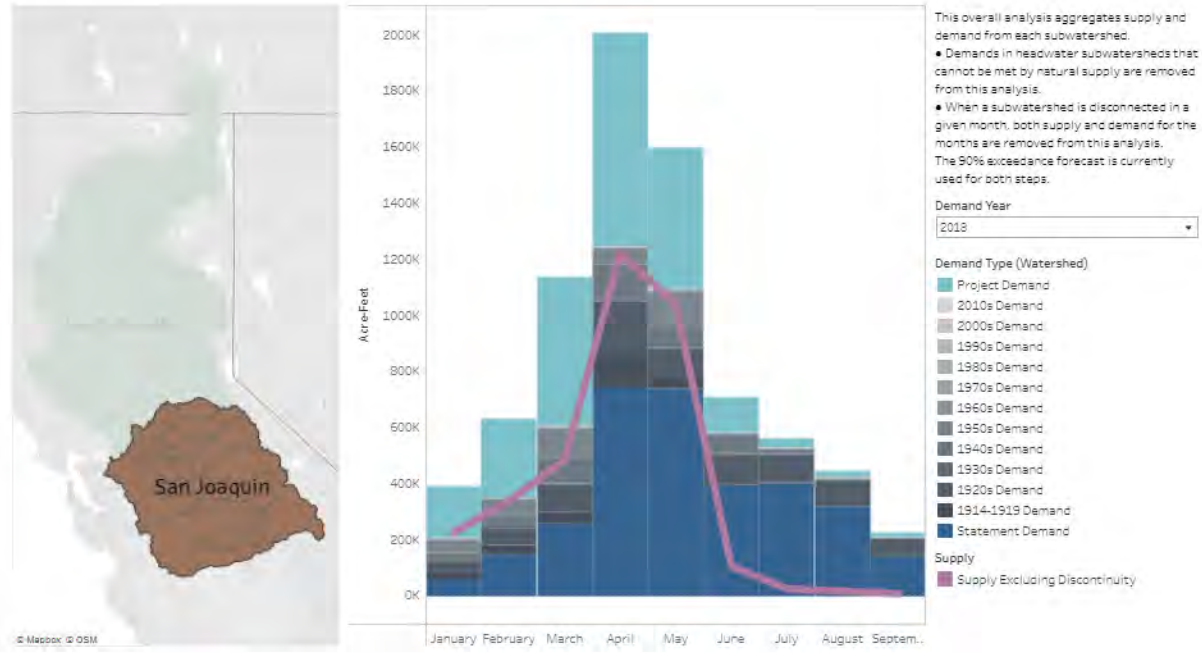


Figure 14. Sample San Joaquin River Watershed Water Unavailability Visualization



The visualizations have been made available to the public on the Board's drought webpage using the Tableau interactive platform and will be updated monthly to reflect current supply conditions. Visitors to the site are able to toggle between the 2018 and

2019 demand datasets. As discussed above, the 2018 demand dataset is planned to be used to assess if insufficient supply is available to meet certain priorities of post-1914 appropriative rights (i.e., the post-1914 priorities of right positioned above the applicable supply line(s) in the visualizations). Section 3.1 below describes the proposed process for issuing notices of water unavailability to diverters.

3 Implementation

3.1 Issuance of Notices of Water Unavailability

The Water Unavailability Methodology is being used to determine when there is insufficient supply to meet post-1914 appropriative diverters' priorities of right within the Delta watershed based on the best available information, either at the scale of a headwater subwatershed or the wider Sacramento or San Joaquin River watersheds. Based on the current output of the methodology, on June 15, 2021, the State Water Board issued notices of water unavailability (also referred to simply as "notices") to all post-1914 appropriative water right holders in the Delta watershed indicating that water supplies are not available for their use. Notices are not directives to stop diverting and are different from curtailment orders. Rather, they inform affected diverters that water is expected to be unavailable for their diversion in a future time frame. These notices also play an important policy and public relations role by offering the opportunity for voluntary compliance prior to formal enforcement action by the Board. Diverting unavailable water can result in penalties for injuring more senior water right holders and public trust resources. As discussed above, this methodology may serve as the technical basis for future emergency regulations and associated curtailment orders.

Currently, the methodology does not assess issues of water unavailability by priority for riparian or pre-1914 appropriative claimants. Given current projected severe limitations in water availability, the methodology may be updated to address water unavailability issues for these claimants. As discussed above, diverters in the Legal Delta will only receive notices of water unavailability if supply is unavailable to them from both the Sacramento and the San Joaquin Rivers, the issuance of which will be coordinated with the Office of the Delta Watermaster. In addition, implementation of this methodology will operate separately from issuance of curtailment notices pursuant to standard water right Term 91, which has been in effect since April 29, 2021, and is likely to be in effect until significant precipitation occurs.

3.1.1 Exceedance Forecast Selection

The methodology requires the selection of an appropriate future supply forecast (e.g., 10 percent, 50 percent, 90 percent, and 99 percent exceedance forecasts) for use in determining which diverters should receive notices of water unavailability. To account for the potential variability of daily water supply and the degree of uncertainty inherent in

monthly forecasts, cumulative daily FNF estimates[23] for the current month (sourced from CDEC and CNRFC[24]) will be compared to the most recent monthly supply forecasts. This will provide an indication of which forecast is likely to be the most accurate predictor of actual conditions for that month. For example, if the cumulative daily FNF tracks close to the 90 percent monthly supply forecast, the 90 percent supply forecast may be used to determine the priority at which notices should be issued. If the daily cumulative FNF exceeds the 90 percent supply forecast only part way through the month, the 50 percent supply forecast may be used. In addition, the State Water Board will continually evaluate the need to discontinue notices of water unavailability based on forecasted or actual precipitation that does, or is expected to, result in a measurable increase to available supplies.[25]

Different exceedance forecasts may be used between the Sacramento River watershed and the San Joaquin River watershed, if appropriate. The exceedance forecast selected for the watershed-wide analyses will also be used for that watershed's headwater subwatershed analyses. For example, if the 90 percent exceedance forecast is determined to be the most likely to accurately predict conditions in the Sacramento River watershed, it will be used for the Sacramento River watershed-wide analysis as well as each of the headwater subwatershed analyses for that watershed.

3.2 Water Quality and Public Trust Resources

The Water Unavailability Methodology does not account for any of the following: (a) water needs for public trust resources; (b) natural instream losses and evaporation; or (c) non-agricultural consumptive uses in the Delta (e.g., open water evaporation, riparian vegetation, etc.).[26] Currently, notices of water unavailability are not proposed to be issued to make water available for the environment, only to make water available for senior water right holders and claimants and to prevent the unlawful diversion of storage releases which are intended to meet water quality and flow requirements or contract demands. The methodology does not affect other obligations that water users may have for meeting flow and other requirements.

[23] The daily FNFs are valuable for the purpose of this check but are not suitable to replace past or forecasted monthly FNF values because they are based on fewer data points than are available at the end of each month and due to the lag time between upstream operations and their effect on downstream flow measurements.
[24] Occasionally, CDEC or CNRFC may report negative daily FNFs. These values are replaced with zero values before doing any further calculations.
[25] Significant precipitation events are unlikely to occur during the summer irrigation season.
[26] For context, the State Water Board's 1977 Drought Report Appendix, Table 14 estimated that non-agricultural consumptive water use in the Delta was as high as 74,560 AF in June 1977.

3.3 Communication and Public Engagement Strategy

State Water Board staff has engaged with a number of water users on issues related to the development of the Water Unavailability Methodology. In addition, a public workshop regarding the May 12, 2021 draft version of the methodology was held on May 21, 2021, during which numerous parties provided oral comment. Numerous written comments on the draft methodology were also timely received by the May 25, 2021 deadline. Modifications to the methodology appropriate for use of the methodology in determining water unavailability for post-1914 water right holders in the Delta watershed this summer for the purpose of issuing notices of water unavailability have been made and are described in this document as well as its technical appendices.

The State Water Board will continue to regularly update the information used to determine water unavailability in the methodology as new data becomes available, and regular updates regarding issues related to water unavailability will be provided to the public during Board meetings. At least monthly updates will also be provided on the Board's drought webpage, including updated supply-demand graphs. If daily cumulative FNF significantly exceeds the forecasted monthly supply used in the methodology, the webpage may be updated more frequently to communicate the potentially changed conditions to diverters.

This methodology does not represent a static assessment of how the State Water Board will determine water unavailability within the Delta watershed. The methodology may change as the season progresses and based on new information and refined analyses as appropriate. This methodology is a first step toward refining the Board's process for issuing notices of water unavailability, which includes refinements upon the 2014 and 2015 methodology that were feasible given existing time and data constraints. Additional refinements to the methodology would be required to implement it for pre-1914 appropriative and riparian claimants and for use during the upcoming wet season.

4 Areas of Potential Refinement

4.1 Near-Term Opportunities

4.1.1 Supply

California water supply data is generated by agencies other than the State Water Board and is, therefore, subject to the data quality assurance programs and improvements of those agencies. In the near-term, the State Water Board will continue to focus refinement efforts on improvements to the preparation of supply data for use in water unavailability analyses. These improvements relate to analysis repeatability, automation of the data preparation process, and data documentation. Within the next

few years, the Board may further improve the preparation of supply data via the implementation of additional data validation methods, refinement of the process to identify and fill data gaps, and incorporation of new supply data as it becomes available. The Board may also alter assumptions of the analysis to reflect increased understanding of groundwater interactions, riparian evapotranspiration, and evaporative losses.

4.1.2 **Demand**

The State Water Board will continue to refine the demand dataset used in the Water Unavailability Methodology as appropriate by streamlining existing processes and improving demand estimates and accounting. This includes the identification of additional data entry errors, estimation of demand values where necessary and feasible, and additional data quality control methods. Refinement of the representation of non-consumptive uses will also be evaluated. The Board will also continue ongoing work with diverters to improve water accounting by minimizing instances of duplicate reporting, identifying incorrectly reported re-diversions, refining estimates of return flows from larger scale diverters such as those diverting more than 100,000 AF per year, and increasing compliance with the regulations that resulted from SB88. The Board may also consider specific demand issues within the Delta for lands below sea level.

Assessing the validity of reported demand data beyond previously described issues is beyond the scope of the current methodology as it will require more time than is presently available and the acquisition of new data resources. Over the next few years, the State Water Board plans to develop cross-validation methods using other datasets such as aerial imagery, OpenET, and land use datasets to assess the validity of reported demand values. The Board may also refine the subwatershed determination method (see section 2.2.4 above) by developing more accurate estimates of proportional demand for water rights that have PODs located in more than one subwatershed. In addition, the Board may use the historical demand record to develop statistical and predictive approaches to identify outliers in the demand dataset and, in conjunction with outside datasets, develop higher temporal resolution for demand estimates.

4.2 Longer-Term Opportunities

In the next several years as part of larger efforts, the State Water Board will work toward developing a data management plan for the demand dataset. The plan's primary functions will be to formalize quality assurance measures, improve data intake processes, and publish the dataset in accordance with Assembly Bill 1755 and the State Water Board's Open Data Resolution to the extent feasible. During the plan development, the Board will expand upon existing data validation efforts using land use based demand estimates, and collaborate with other agencies or organizations to identify where the installation of telemetered diversion gages are needed to enable the validation of demand data to an acceptable level of accuracy. The Board may also look

to refine internal and external accounting methods for contracted water, water transfers, and other issues.

Ultimately, the demand data is most limited by the number of required or available telemetered demand gages and the relatively infrequent manual reporting requirements. These spatial and temporal limitations prevent the State Water Board from conducting a finer scale analysis and responding in real time to limited water availability. New requirements for reporting demands and transitioning to land based demand estimates could improve the spatial and temporal coverage of water demand data in California and improve the Board's ability to effectively monitor and manage water supplies.

In the long-term, the Board is also planning to evaluate the use of more sophisticated dynamic evaluation tools capable of addressing the complexities of water unavailability issues in the Delta watershed and other areas of the state with greater spatial and temporal resolution. To be effective, however, these tools are dependent on adequate quality data.

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Technical Appendix A

Technical Appendix A: Methodology Spreadsheet Description is available on the drought webpage at https://www.waterboards.ca.gov/drought/drought_tools_methods/delta_method.html.

Technical Appendix B

Technical Appendix B: Demand Dataset Description and Preparation is available on the drought webpage at https://www.waterboards.ca.gov/drought/drought_tools_methods/delta_method.html.

Appendix C

Appendix C: Summary of Public Comments is available on the drought webpage at https://www.waterboards.ca.gov/drought/drought_tools_methods/delta_method.html.