Water Unavailability Methodology for the Delta Watershed

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1 Introduction

California and the Sacramento-San Joaquin Delta (Delta) watershed have experienced extremely dry conditions over the last three years. Statewide, water years 2020, 2021, and 2022 were the driest three-year period on record, resulting in very low runoff. These low runoff conditions resulted in very low inflows to reservoirs and associated limited storage supplies for various purposes. To help address limitations in water supplies, the State Water Resources Control Board (State Water Board or Board) developed a methodology to assess water unavailability in the Delta watershed. This report describes that methodology of identifying when available data indicates that natural and abandoned water supplies are unavailable for diversion by water right holders and claimants in the Delta watershed under their priority of right (Delta Water Unavailability Methodology or Water Unavailability Methodology for short).

This report has been updated regularly since the initial draft was released for public review on May 12, 2021. The July 23, 2021, version of this report was incorporated by reference into the emergency regulations that became effective August 19, 2021 (see section 1.3 below). The version of the report dated June 27, 2022, was incorporated by reference into the revised and renewed emergency regulation that became effective August 12, 2022. Most of the revisions to the report did not reflect changes to the methodology that was described in the July 23, 2021, report, but some relatively minor refinements to the methodology have been made. These minor refinements include:

- Exclusion of the Goose Lake subwatershed due to disconnection from the lower watersheds such that curtailing diversions would not make water available to serve senior downstream water rights or claims.
- Adjustment of subwatershed boundary delineation for certain subwatersheds previously representing headwater and valley floor portions of the larger watershed.
- Allocation of abandoned instream flows to non-riparian water right holders and claimants only.
- Application of return flow factors to direct diversion demand only.
- Use of appropriate timesteps in between monthly and weekly to determine curtailments in response to precipitation and runoff events.
- Curtailment of non-riparian rights only when no water is available at the diverter's priority of right.
- Exclusion from curtailment of rights and claims in a headwater subwatershed based on the watershed-scale unavailability analysis if that subwatershed is assumed to be disconnected from the Delta watershed (i.e., local riparian

demands exceed supply). Abandoned instream flows from the subwatershed may still contribute to watershed-scale supply if they are not diverted by local demands.

- Explanation that return flow factors may be applied to both valley floor regions and headwater subwatersheds.

This report documents the following additional refinements to the methodology since the June 27, 2022 version of the report:

- Application of a refined watershed analysis that better accounts for the connectivity of tributary streams within the Delta watershed, such that a given demand is only charged against the supply available from all subwatersheds upstream of the demand rather than charging it against all of the supply available in the larger (Sacramento River or San Joaquin River) watershed.
- The reversion of four water rights associated with the Friant Division of the Central Valley Project to their original priority dates.

The most recent two refinements were discussed in a workshop conducted by State Water Board staff on November 9, 2022. The spatial refinements of the methodology served to improve the accuracy of the methodology in certain portions of the watershed, while the temporal refinement has enabled the temporary suspension of curtailments for a greater number of diverters during sub-monthly precipitation and runoff events.

Updates to the report introduced in this January 2023 version are summarized in section 1.6 below. Previous updates to this report are summarized within the introductory sections of those versions of the report, which are available on the Delta Drought webpage.

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[1] and appropriative

[1] Generally, a riparian water right is a right to use the natural flow of water on land contiguous to a natural water course and does not include a right to divert water that is foreign in time or source. 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

water rights, including appropriative rights issued under the Board's authority and those in existence prior to the inception of its predecessor-in-interest.[2]

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 three years of low precipitation and despite a wet start to the 2023 water year, the U.S. Drought Monitor reports that much of the Central Valley remains in severe drought, with 95 percent of the state experiencing moderate to extreme drought (USDM 2022). The U.S. Seasonal Drought Outlook, released by the Climate Prediction Center on December 31, 2022, and valid through March 31, 2023, shows drought has improved slightly but remains throughout most of California (NOAA 2022). Within the Delta watershed, conditions have been extraordinarily dry, with Water Years (WY) 2020, 2021, and 2022 ranking as the driest three-year period on record based on precipitation (DWR 2022a; DWR 2022b; DWR 2022c; DWR 2022d). These dry conditions have resulted in below average reservoir storage levels in the Delta watershed (DWR 2022e).

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.

[2] Use of water on non-riparian land or seasonal storage of water for later beneficial use requires an appropriative water right. Appropriative water right holders can divert available supplies that are foreign in time or source. An appropriative water right that was initiated before the Water Commission Act went into effect on December 19, 1914, is called a pre-1914 appropriative water right, even if subsequently perfected. Appropriative rights initiated and acquired after this date are called post-1914 appropriative water rights, and they are administered and regulated by the State Water Board.

1.3 Emergency Proclamation and Regulations

As a result of the dry conditions in the spring of 2021, on May 10, 2021, Governor Newsom issued a drought emergency proclamation covering 41 of California's 58 counties (Exec 2021a). On July 8, 2021, the Governor expanded the emergency declaration to 9 additional counties (Exec 2021b) and called on Californians to reduce their water use by 15 percent compared to 2020 levels (Exec 2021c). On October 19, 2021, the Governor further expanded the emergency declaration to cover the entire state and urged Californians to increase their water conservation efforts as urban water conservation to date had fallen significantly short of the 15 percent goal (Exec 2021d).

The May 10 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 (Exec 2021a). 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 (*Ibid*). On August 3, 2021, the Board adopted emergency regulations that authorize the use of this methodology as the technical basis for curtailment orders issued pursuant to the directives in the emergency drought proclamation. On August 19, 2021, the Office of Administrative Law approved the regulations, which became effective upon filing with the Secretary of State on the same day.

On January 4, 2022, the State Water Board also adopted an emergency regulation to supplement voluntary water conservation. The regulation went into effect on January 18, 2022, and is effective for up to one year unless readopted. An executive order issued March 28, 2022, further directed the State Water Board to consider adopting emergency regulations in support of urban water conservation that would require urban water suppliers to implement certain water shortage response actions. Following this, the State Water Board adopted a second emergency water conservation regulation on May 24, 2022. The regulation went into effect on June 10, 2022, and is effective for up to one year unless readopted (Exec 2022).

On July 20, 2022, the State Water Board approved the revision and renewal of the Emergency Curtailment Regulation to Protect Water Supplies in the Sacramento-San Joaquin Delta Watershed (emergency regulation[3]). On August 12, 2022, the Office of Administrative Law approved the renewed emergency regulation, which became effective upon filing with the Secretary of State on the same day.

[3] The 2021 emergency regulation and the 2022 revision and renewal of the emergency regulation are collectively referred to as the emergency regulation or emergency regulations hereafter, unless the year is specifically referred to.

1.4 Purpose of the Water Unavailability Methodology

The San Francisco Bay-Delta (Bay-Delta) watershed includes supplies from both the Sacramento and San Joaquin river systems and their tributaries. As shown in Figure 1 below, water from about 40 percent of California's land area drains to the Bay-Delta, supporting a variety of beneficial uses of water. The 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 Legal Delta. Water from the Delta watershed 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 on water supplies this year, action is needed to determine when water supplies are not available under water right holders' or claimants' priorities 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 Project or 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 below average, creating significant concerns for salinity control, municipal water supplies, temperature management, and other environmental needs this year and next year if dry conditions continue. As a result of these concerns, the Projects submitted a request for, and were granted subject to terms and conditions, a temporary urgency change petition (TUCP) in water year 2021[4] and 2022[5] for April through June to reduce their obligations to release water from storage to meet flow and water quality requirements in the Delta. In water year 2021, over 2 million acre-feet of Supplemental Project Water was released from Project reservoirs to maintain water quality and meet outflow requirements in the Delta (SWRCB 2021). 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 to repel salinity intrusion from the ocean and meet other minimal needs.

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

[5] The Board order conditionally approving the 2022 petition is available at: https://www.waterboards.ca.gov/drought/tucp/docs/2022/20220404_tuco_swrcb.pdf

Figure 1. Delta Watershed Location

Determining when water supplies are unavailable to users is 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 users when water is unavailable for their use because supplies are needed by downstream senior water right holders or because streamflows are comprised of previously stored water that has been released to serve contractors or to meet water quality or flow requirements.

The State Water Board has developed the Water Unavailability Methodology to identify when available data indicates that natural and abandoned water supplies are unavailable for direct diversion or diversion to storage for consumptive use by water right holders and claimants in the Delta watershed under their priorities of right. The methodology is not intended to address other supplies of water, such as rediversion of previously stored water for use by Project contractors. The methodology also does not address water unavailability for non-consumptive uses of water, such as direct diversion for hydropower production when these supplies are returned back to the source stream. However, since wet season diversions to storage for later production of hydropower may change the timing of flows and affect the availability of water for other users, the methodology does consider these demands when determining water unavailability during the wet season.

The methodology evaluates water supplies and demands at the subwatershed and watershed scale for both the Sacramento River and San Joaquin River watersheds with currently available data, reporting, and tools. The methodology utilizes the best currently available data on supplies and demands, which may include use of past and projected demand data submitted in response to the August 20, 2021, curtailment and reporting orders and future orders. The Water Unavailability Methodology improves upon methods used for determining water unavailability in prior droughts, most recently in 2014 and 2015. Major improvements 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 curtailment orders or resulting in those notices or orders applying for a longer time period. Other improvements include spatial disaggregation of supply and demands by location and better supply estimates and forecasting. With more time, better data, and improved tools, additional improvements will be possible.

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, computational steps, and outputs used to develop the water unavailability visualizations. Technical Appendix B describes the process used to collect and quality control the demand datasets. Appendix C summarizes the substantive technical, factual, or legal comments regarding the Water Unavailability Methodology that were received prior to the release of the July 23, 2021, version of the report that was incorporated by reference into the emergency regulation, as well as any relevant

sections of the report where those comments have been addressed. Technical Appendix D was included to respond to comments received regarding the hydrologic complexities of the Legal Delta and to provide additional explanation regarding the assumptions used in the methodology with regard to freshwater supplies in the Legal Delta and the exclusion of tidal inflows as a source of supply. As described further below, Technical Appendix A and Technical Appendix D have been updated in this January 2023 version of the report. The technical appendices and spreadsheet are available on the State Water Board's Delta Water Unavailability Methodology webpage.

The Board intends to update the methodology as needed to administer the water rights priority system using the best available information. Due to the uncertainties that exist in determining water unavailability in the Delta watershed, conservative assumptions are used within the methodology itself and will also be used in the methodology's implementation. This report will continue to be updated, as appropriate, as the methodology is updated. All revisions will be made available on the Board's Delta Water Unavailability Methodology webpage.

1.5 Curtailment Orders

Pursuant to the emergency regulation and based on the output of the methodology, on August 20, 2021, the Board issued curtailment and reporting orders to water right holders and claimants throughout the Delta watershed. In addition to imposing curtailments, the initial orders imposed reporting requirements on all water right holders and claimants in the Delta watershed and directed diverters to subscribe to the Board's Delta Drought email distribution list or visit the Delta Drought webpage to view the Delta Watershed Curtailment Status List (Curtailment Status List) for updates regarding these and future curtailment orders. Because the emergency regulation was renewed prior to its expiration, the State Water Board continues to rely on the initial curtailment and reporting orders. Updates to the curtailment status of all water right holders and claimants within the Delta watershed have been made available on the Delta Drought webpage and sent to the Board's Delta Drought email subscription list on at least a weekly basis since August 20, 2021, unless a longer update period was noted in both methods of communication.[6] Current curtailment statuses within the watershed will continue to be updated on a weekly basis and more frequently if warranted due to precipitation and runoff forecasts. Additional information related to the Delta curtailment regulation and curtailment and reporting orders can be found on the Board's Delta Drought webpage.

[6] During periods of temporary suspension of all Delta watershed curtailments, updates may be provided on a less frequent basis as conditions warrant.

1.6 Current Updates to the Water Unavailability Methodology Report

This January 2023 update to the report considers information and input provided during the November 9, 2022, staff workshop and corresponding written comment period ending November 16, 2022, regarding recent and proposed updates to the methodology. In particular, this report update describes:

- Refinement of the watershed-scale analyses to better account for the connectivity of tributary streams within the Delta watershed, such that a given demand is only charged against the supply available from subwatersheds upstream of the demand rather than charging it against all of the supply available in the larger (Sacramento River or San Joaquin River) watershed (see section 2.3).
- Adjustment of the demand dataset to change the assumed priority dates of water rights held by Reclamation for the Friant Division of the Central Valley Project to reflect the dates when the underlying applications to appropriate water were filed (see section 2.2.9).
- Completion of quality control review of the 2018 demand dataset to include all water rights and claims that have a face value or recent annual reported diversion volume of 1,000 AF or greater, as well as refinements to enhanced reporting requirements to further refine the demand dataset and reduce the reporting burden for larger diverters (see sections 2.2.3 and 2.2.4).

The State Water Board received additional comments during the November 9, 2022, workshop and comment period that do not warrant changes to the methodology at this time. State Water Board staff plan to hold a workshop in early 2023 regarding additional potential refinements to the methodology report and Technical Appendix D. Technical Appendix D has been updated alongside this report only to note the future discussion. This update to the methodology report is also accompanied by updates to Technical Appendix A.

The focus of this report is factual and technical, not legal. Legal arguments made in petitions for reconsideration were addressed as appropriate in the order responding to petitions for reconsideration of the curtailment and reporting orders, State Water Board Order WR 2022-0147-EXEC, rather than this report. On September 15, 2022, the State Water Board received an additional petition for reconsideration from the Central Delta Water Agency and South Delta Water Agency, which will be considered and addressed in an order on reconsideration.

2 Water Unavailability Methodology

The Water Unavailability Methodology incorporates the best available supply data for the Delta watershed with the best available estimates of demand for the same area. The methodology 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.

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 forecasted 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 in the methodology: (1) to provide historical context to current water supply conditions and (2) to show water supply conditions for the current water year. 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 (D1641) that account for the unimpaired runoff of each water year and its preceding water year (DWR 2021a). For both the Sacramento and San Joaquin River

watersheds, 2021 was considered Critically Dry, and Water Year 2022 is expected to receive the same classification for both watersheds once finalized this spring. As of January 1, 2023, median 2023 forecasts for the Sacramento River and San Joaquin River watersheds are both Below Normal (DWR 2022f).

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

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. Conditions for water year 2023 to date, as well as recent 10%, 50%, and 90% exceedance forecasts (dated January 10, 2023, from the California Nevada River Forecast Center), are shown in Figure 2 and Figure 3 below. As indicated below, water year 2021 supply conditions were generally near or below median historical critical conditions (based on data for water years 1922-2021). While water year 2022 supply conditions began above median conditions for a wet year, they dropped to just above median critical conditions later in the summer. Conditions for water year 2023 in January may be wetter than median wet year conditions, though considerable uncertainly (several million acre-feet per month) exists in the forecasting of conditions several months out. While it is possible that spring and summer 2023 conditions will remain wet, conditions in water year 2022 began similarly wet before very dry conditions persisted later in the year.

Figure 2. Water Year 2023 Supply Conditions in the Sacramento River Watershed

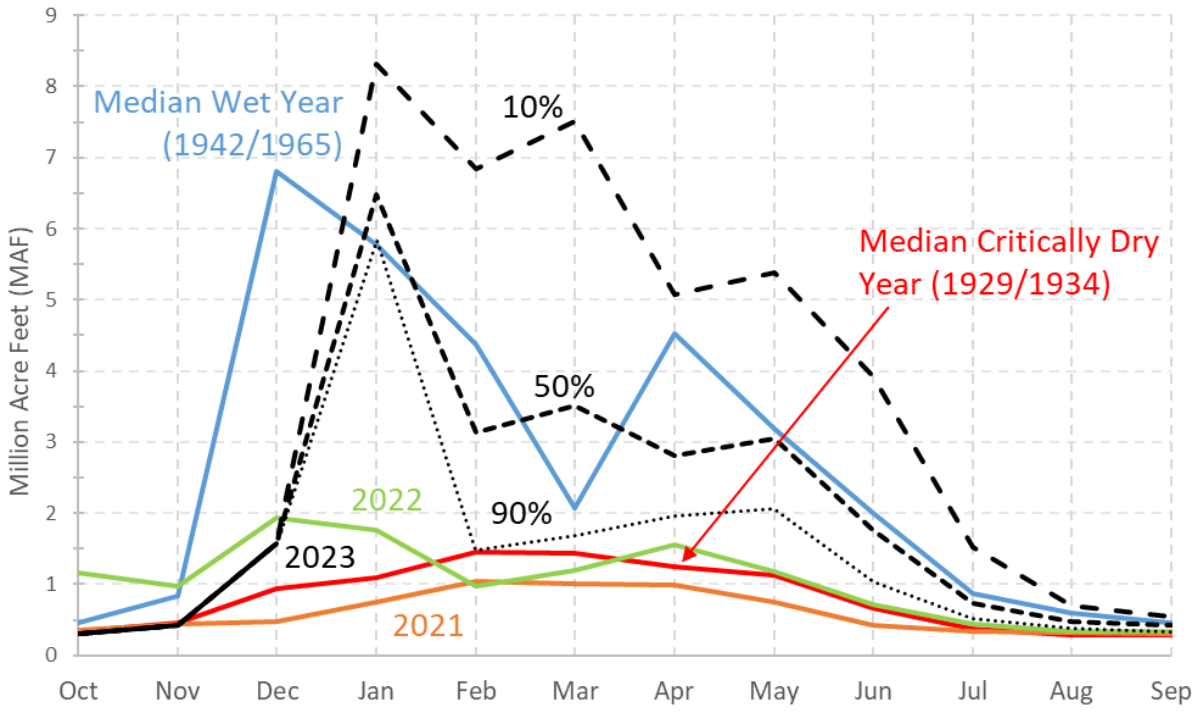
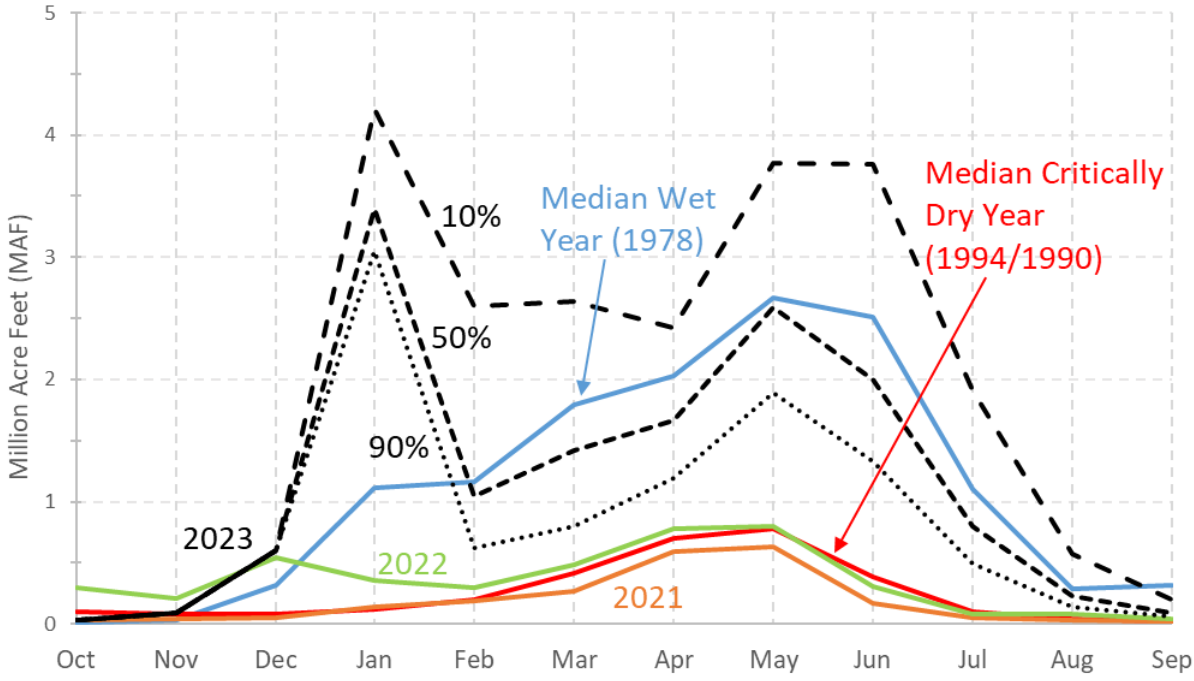


Figure 3. Water Year 2023 Supply Conditions in the San Joaquin River Watershed



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, or contractual demands. This section discusses the additional complexities in determining whether water is unavailable 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 supply in 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. Other projects may import water to one subwatershed from another, entirely within the Delta watershed (e.g., the Yuba-Bear and Drum-Spaulding projects, see section 2.2.10 below). 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, 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 2.2.11 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. Return flows are incorporated by reducing demands for direct diversion 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 except with regard to abandoned instream flows, as described in section 2.1.6 below. Additional analysis would be needed to distinguish supplies originating from abandoned returned flows that are foreign in time or watershed and are therefore 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. Geological Survey (USGS) Watershed Boundary Dataset (WBD) and National Hydrography Dataset (NHD), which delineate land areas draining to streams. Subwatersheds in the Delta watershed were primarily delineated 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 at Bend Bridge, 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 locations of supply estimates produced by DWR,[7] including the Upper Sacramento River Valley, Sacramento River Valley Floor, and San Joaquin River Valley Floor subwatersheds. Due to the presence of some demands not met by local supplies within their HUC8 boundaries, the Mokelumne, Chowchilla, Fresno, and Calaveras River subwatersheds were instead delineated as a combination of smaller Hydrologic Unit Code level 10 (HUC10) watersheds and stream buffers (see section 2.3.1). A total of 20 subwatersheds are used in the Water Unavailability Methodology: 10 each in the Sacramento and San Joaquin River watersheds (see Figure 4). Consistent with the

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

USGS WBD, the methodology assumes that the Cosumnes, Mokelumne, and Calaveras Rivers are part of the San Joaquin River watershed.

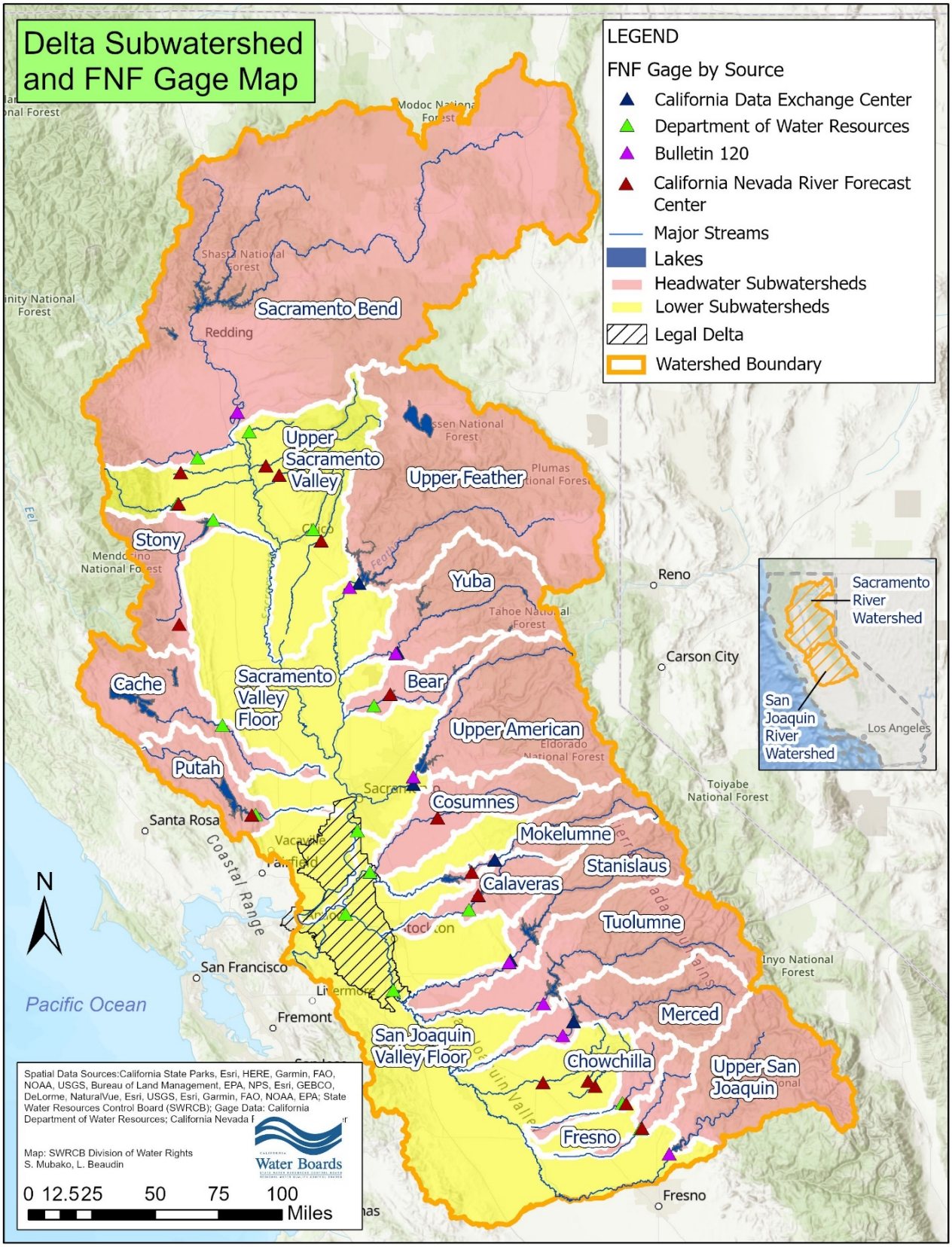
An inventory of available FNF gages from multiple sources (see section 2.1.4 below) was compared to the subwatershed boundaries, NHD stream maps, and water right points of diversion (PODs) to identify target FNF gages that are representative of water supplies and demands met by them within each subwatershed. These target FNF gages and available supply data sources are 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 4 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-scale determinations of water unavailability.

Supplies and demands from the Goose Lake, Panoche Creek, and Tulare Lake (including the Kings, Kern, Kaweah, and Tule Rivers) drainages are not included in the Water Unavailability Methodology. Goose Lake, located on the border of California and Oregon, is expected to only overflow into the North Fork of the Pit River during very wet conditions. Therefore, the methodology excludes supply and demand that occurs within the boundaries of the Goose Lake HUC8. The methodology also excludes supply and demand within the Panoche Creek HUC8, 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 imagery indicates that it terminates in agricultural fields west of Mendota, so it is assumed not to significantly contribute to available water supplies within the Delta watershed.

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 Tulare Lake watershed during the dry season of a critically dry year. Similarly, during the wet season it is unlikely that natural flow from the Tulare Lake watershed would reach the Delta watershed as long as shortage conditions persist in the Delta watershed. Therefore, supplies and demands from the Tulare Lake watershed have been excluded from the methodology.

Figure 4. 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). The sources of past supply data include:

1. The California Data Exchange Center (CDEC), which contains published FNF estimates made by water system operators within each watershed.[8] 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.[9] 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 include:

1. DWR's California Cooperative Snow Surveys Bulletin 120 Water Supply Forecast (B-120),[10] 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% exceedance probabilities, while B-120 Distribution (DIST) products include only 50% exceedance forecasts.
2. CNRFC ensemble forecasts,[11] which contain daily FNF forecasts for the next 365 days, are available for both major and minor tributaries. Exceedance probabilities are calculated from the available forecast data.

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[8] CDEC provides both monthly and daily FNF estimates for many rivers in California. These 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 water unavailability analyses.
[9] CNRFC data is published on a daily scale, which is summed to generate values over longer periods for the purpose of this analysis. Any negative daily FNF values are included as-is in the sums, but final calculated values may never be less than zero.
[10] B-120 provides monthly FNF forecasts for the state's major watersheds, which are prorated to convert to shorter timesteps as necessary. B-120 WSI products are updated monthly from December to May of each year, while B-120 DIST forecasts are updated weekly from February through early June. B-120 FNF calculations are made using DWR's own database of diversions upstream of unimpaired flow stations, which were not cross-checked against the Board's records of reported diversions.
[11] CNRFC forecasts are presented in the form of 42 different daily FNF "traces." These daily values are summed over longer timesteps and exceedances are calculated from the resulting forecasts.

Initially, the methodology used the B-120 forecast for streams where that data is available. However, given that CNRFC forecasts may better reflect expected hydrologic conditions over the short-term (7 to 14 days), CNRFC data has been relied on more recently. Curtailment status updates specify which water supply dataset and forecast exceedance are used to make curtailment decisions in order to disclose the technical basis of water supply assumptions to water right holders and the public.

The use of primarily monthly (shorter time steps have been used for curtailment suspensions) supply forecasts and demand estimates (see section 2.2 below) for curtailments 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). For the purposes of short-term considerations of curtailment suspensions due to precipitation and runoff events, sub-monthly (e.g., weekly) data are be considered to ensure that curtailments are suspended on a timestep commensurate with available supplies. Water unavailability analyses for the purpose of issuing curtailments in the Legal Delta are not performed on a timestep any shorter than 30 days (i.e., monthly).

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 is 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 are summed to generate monthly past data. The monthly past source data also includes the years for which data is available (e.g., 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.

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 Bridge	CDEC SBB: Sacramento River above Bend Bridge, sensor 65 (WY 1906-Present)	CNRFC BDBC1: Sacramento River-Bend Bridge (WY 2013-Present) CDEC BND: Sacramento River at Bend Bridge, sensor 8	DWR B-120 SRWSI and DIST: Sacramento River above Bend Bridge (monthly TAF for current WY in 6 exceedances) CNRFC BDBC1: Sacramento River-Bend Bridge (daily TCFS for next year in 42 traces)
Stony Creek	DWR UF4: Stony Creek at Black Butte (WY 1922-2014)	CNRFC EPRC1: Little Stony Creek-East Park Reservoir (WY 2013-Present)*	CNRFC EPRC1: Little Stony Creek-East Park Reservoir (daily TCFS for next year in 42 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)	CNRFC ORDC1: Feather River- Lake Oroville (WY 2013-Present) CDEC ORO: Oroville Dam, sensor 8	DWR B-120 SRWSI and DIST: Feather River at Oroville (monthly TAF for current WY in 6 exceedances) CNRFC ORDC1: Feather River- Lake Oroville (daily TCFS for next year in 42 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)*	
Yuba River	CDEC YRS: Yuba River near Smartville, sensor 65 (WY 1901-Present)	CNRFC HLEC1: Yuba River-Englebright Reservoir (WY 2013-Present) CDEC YRS: Yuba River near Smartville, sensor 8	DWR B-120 SRSWI and DIST: Yuba River near Smartville plus Deer Creek (monthly TAF for current WY in 6 exceedances) CNRFC HLEC1: Yuba River-Englebright Reservoir (daily TCFS for next year in 42 traces)
Bear River	DWR UF10: Bear River near Wheatland (WY 1922-2014)	*	*
Upper American River	CDEC AMF: American River at Folsom, sensor 65 (WY 1901-Present)	CNRFC FOLC1: American River-Folsom Lake (WY 2013-Present) CDEC NAT: Lake Natoma (Nimbus Dam), sensor 8	DWR B-120 SRWSI and DIST: American River below Folsom Lake (monthly TAF for current WY in 6 exceedances) CNRFC FOLC1: American River-Folsom Lake (daily TCFS for next year in 42 traces)
Putah Creek	DWR UF2: Putah Creek near Winters (WY 1922-2014)	*	*

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 Sacramento River Valley	DWR UF5: Sacramento Valley West Side Minor Streams (WY 1922-2014)	CNRFC EDCC1: Elder Creek-Paskenta + TCRC1: Thomes Creek-Paskenta (WY 2013-Present)*	CNRFC EDCC1: Elder Creek-Paskenta + TCRC1: Thomes Creek-Paskenta (daily TCFS for next year in 42 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 2013-Present)*	CNRFC MLMC1: Mill Creek-Los Molinos + DCVC1: Deer Creek-Vina + BKCC1: Butte Creek-Chico (daily TCFS for next year in 42 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 2013-Present)	CNRFC BHNC1: Chowchilla River-Buchanan Reservoir (daily TCFS for next year in 42 traces)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Upper San Joaquin River	CDEC SJF: San Joaquin River below Friant, sensor 65 (WY 1901-Present)	CNRFC FRAC1: San Joaquin River-Millerton Reservoir (WY 2013-Present) CDEC SJF: San Joaquin River below Friant, sensor 8	B-120 SJWSI and DIST: San Joaquin River inflow to Millerton Lake (monthly TAF for current WY in 6 exceedances) CNRFC FRAC1: San Joaquin River-Millerton Reservoir (daily TCFS for next year in 42 traces)
Fresno River	DWR UF21: Fresno River near Daulton (WY 1922-2014)	CNRFC HIDC1: Fresno River-Hensley Lake (WY 2013-Present)	CNRFC HIDC1: Fresno River-Hensley Lake (daily TCFS for next year in 42 traces)
Merced River	CDEC MRC: Merced River near Merced Falls, sensor 65 (WY 1901-Present)	CNRFC EXQC1: Merced River-Exchequer Reservoir (WY 2013-Present) CDEC EXC: New Exchequer-Lake McClure, sensor 8	B-120 SJWSI and DIST: Merced River below Merced Falls (monthly TAF for current WY in 6 exceedances) CNRFC EXQC1: Merced River-Exchequer Reservoir (daily TCFS for next year in 42 traces)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Tuolumne River	CDEC TLG: Tuolumne River-La Grange Dam, sensor 65 (WY 1901-Present)	CNRFC NDPC1: Tuolumne River-New Don Pedro Reservoir (WY 2013-Present) CDEC TLG: Tuolumne River-La Grange Dam, sensor 8	B-120 SJWSI and DIST: Tuolumne River below La Grange Reservoir (monthly TAF for current WY in 6 exceedances) CNRFC NDPC1: Tuolumne River-New Don Pedro Reservoir (daily TCFS for next year in 42 traces)
Stanislaus River	CDEC SNS: Stanislaus River-Goodwin, sensor 65 (WY 1901-Present)	CNRFC NMSC1: Stanislaus River-New Melones Reservoir (WY 2013-Present) CDEC GDW: Goodwin Dam, sensor 8	B-120 SJWSI and DIST: Stanislaus River below Goodwin Reservoir (monthly TAF for current WY in 6 exceedances) CNRFC NMSC1: Stanislaus River-New Melones Reservoir (daily TCFS for next year in 42 traces)
Calaveras River	DWR UF15: Calaveras River at Jenny Lind (WY 1922-2014)	CNRFC NHGC1: Calaveras River-New Hogan Reservoir (WY 2013-Present) CDEC NHG: New Hogan Lake, sensor 8	CNRFC NHGC1: Calaveras River-New Hogan Reservoir (daily TCFS for next year in 42 traces)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Mokelumne River	CDEC MKM: Mokelumne River-Mokelumne Hill, sensor 65 (WY 1901-Present)	CNRFC CMPC1: Mokelumne River-Mokelumne Hill (WY 2013-Present) CDEC MKM: Mokelumne River-Mokelumne Hill, sensor 8	B-120 DIST: Mokelumne River below Pardee Reservoir (monthly TAF for current WY for 50% exceedance) CNRFC CMPC1: Mokelumne River-Mokelumne Hill (daily TCFS for next year in 42 traces)
Cosumnes River	CDEC CSN: Cosumnes River at Michigan Bar, sensor 65 (WY 1908-Present)	CNRFC MHBC1: Cosumnes River-Michigan Bar (WY 2013-Present) CDEC MHB: Cosumnes River at Michigan Bar, sensor 8	B-120 DIST: Cosumnes River at Michigan Bar (monthly TAF for current WY for 50% exceedance) CNRFC MHBC1: Cosumnes River-Michigan Bar (daily TCFS for next year in 42 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 (WY 2013-Present)*	CNRFC MPAC1: Mariposa Creek-Mariposa Reservoir + OWCC1: Owens Creek-Owens Reservoir + MEEC1: Bear Creek-McKee Road (daily TCFS for next year in 42 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 of a subwatershed, as defined for this analysis (see section 2.1.3 above). These gaps are 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.

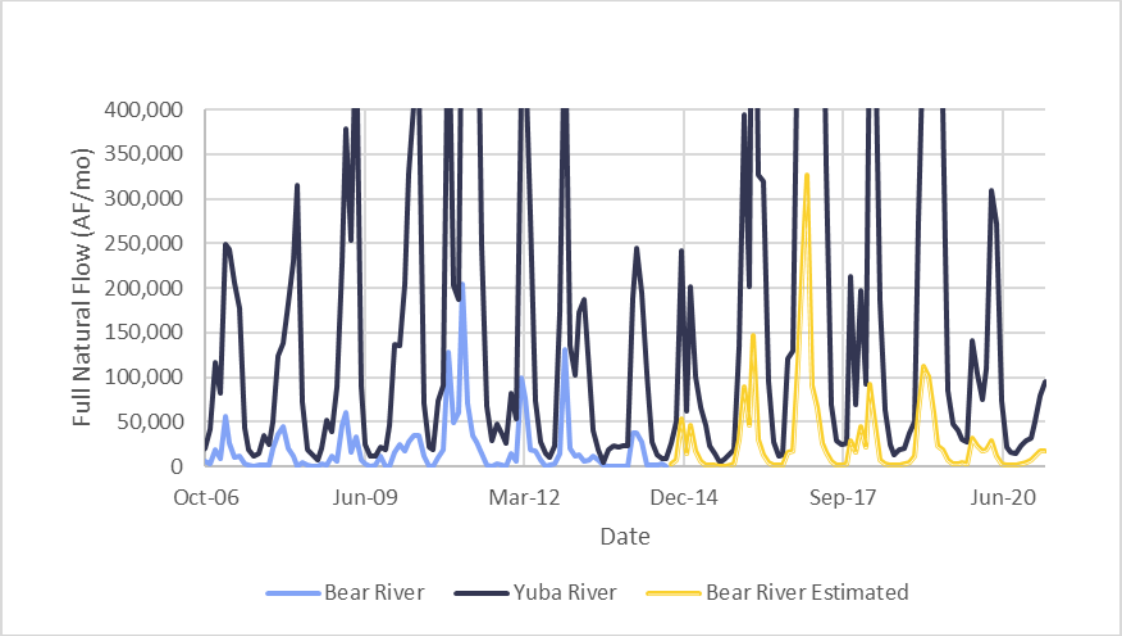
2.1.5.1 ***Extrapolation***

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[12] for each month over this period, and outliers outside three standard deviations from the overall mean were removed. Finally, River FNF estimates are 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 is 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 (Bear:Yuba) was calculated. 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 5 below illustrates the Bear:Yuba extrapolation for the period of WY 2014 to 2020.

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

Figure 5. Extrapolation Example: Estimation of Bear River FNF (WY 2014–2020) Based on Yuba River FNF



2.1.5.2 *Augmentation*

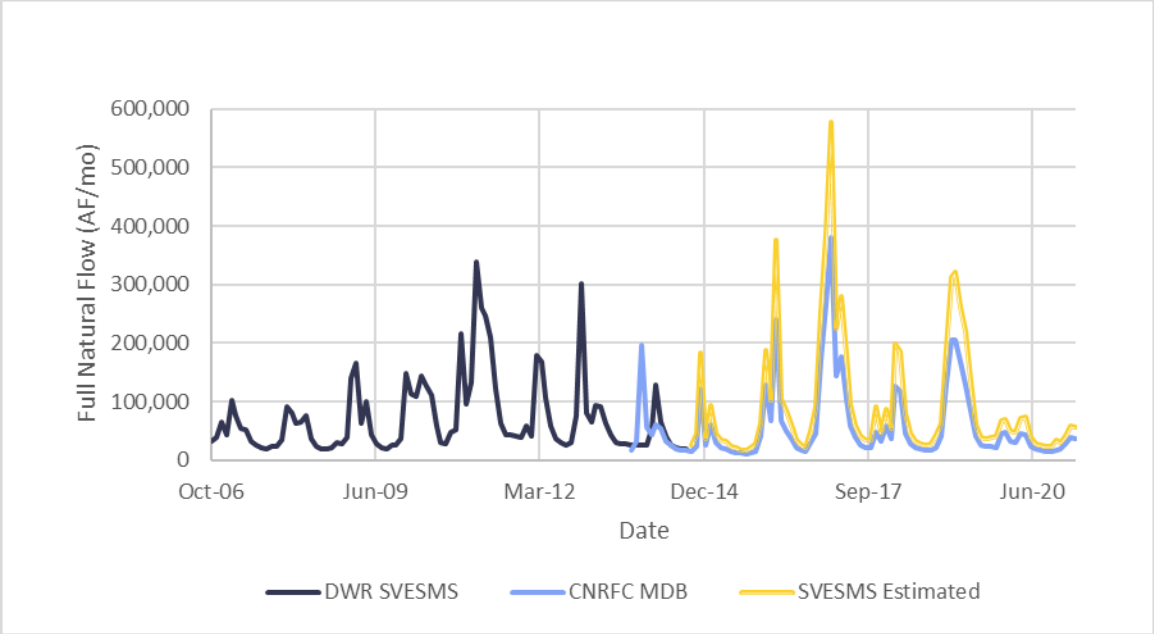
In other areas, past or forecasted data may exist but not represent the entire FNF supply of a watershed that would be expected to be available for diversion. This is the case for watersheds consisting of multiple small tributary streams in which only some streams have available supply forecasts through 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 outside three standard deviations from the overall mean were removed.[13] Finally, past and forecasted CNRFC values are 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 (SVESMS, known as 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 (WY 2013-present) and forecasted FNF data available for Mill, Deer, and Butte Creeks (MDB, in

[13] 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. This ratio calculation is analogous to a linear interpolation each month, with the y-intercept always set to zero.

total). By comparing historical FNF values for a period with overlapping data (WYs 2013 and 2014), a monthly relationship ratio was 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 6 below illustrates the SVESMS:MDB augmentation to estimate FNF for the Sacramento Valley East Side Minor Streams for the period of WY 2014 to 2020.

Figure 6. 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 (WY 2014–2020)



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 natural flow, these flows are already included in FNF values. If these instream flow requirements are met via releases of stored water, these flows are not captured by 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 each subwatershed in the watershed-scale analysis. In other words, it is assumed that if the FNF is greater than the instream flow requirement then the instream flow requirement is being met by FNF; conversely, if the instream flow requirement is greater than the FNF then it is assumed that the instream flow requirement is met at least in part by storage releases which can be considered abandoned below their intended reach.

For the purpose of this analysis, all abandoned instream flows whose intended reach ends near the bottom of a subwatershed were considered. If two instream flow requirements exist in series in a watershed, it is possible that the same water could be used to meet both requirements. To avoid double counting of additional supplies, the methodology does not include instream flows that end higher up in the subwatershed. Using data from the State Water Board's Sacramento Valley Water Allocation Model (SacWAM)[14] and Water Supply Effects (WSE) model,[15] a total of seven 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 to meet water quality and flow requirements included in State Water Board D1641 is not considered abandoned because those flows, including releases from Shasta, Folsom, and Oroville Reservoirs, are intended to remain instream to meet D1641 requirements. Releases from New Melones Reservoir to meet San Joaquin River flow requirements at Vernalis that are intended to contribute to Delta outflows, New Melones releases that are intended to contribute to meeting salinity requirements on the San Joaquin River and in the Legal Delta, and releases from Camanche Reservoir on the Mokelumne

[14] 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, Legal Delta, and eastside tributaries to the Legal Delta (the Calaveras, Cosumnes, and Mokelumne Rivers). Information on SacWAM is available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/sacwam/

[15] 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 at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/2018_sed/

River pursuant to D1641 that are intended to contribute to Delta outflows are also not considered abandoned for the purpose of evaluating water unavailability.

Table 3. Sacramento River Watershed Flows Considered to Contribute Abandoned Supplies[16]

Subwatershed		Upper Feather River[a]	Yuba River[b]	Bear River[c]	Upper American River[d]	Putah Creek[e]	*Total*
Abandoned Instream Flow (cfs)	**Jan.**	180	400	10	246	5	*841*
	Feb.	225	400	10	246	5	*886*
	Mar.	300	400	10	246	5	*961*
	Apr.	300	433	25	287	5	*1050*
	May	300	500	25	350	5	*1,180*
	Jun.	300	500	25	425	5	*1,255*
	Jul.	300	250	10	425	5	*990*
	Aug.	300	250	10	420	5	*985*
	Sep.	250	250	10	325	5	*840*
	Oct.	180	400	10	251	5	*846*
	Nov.	180	400	10	246	5	*841*
	Dec.	180	400	10	246	12	*848*

[a] Upper Feather River flow requirements are based on FERC project P-2107 license conditions for Upper North Fork Feather River flows below Poe Dam.
[b] Yuba River flow requirements are based on State Water Board Decision 1644 requirements at Marysville (assuming an Extreme Critical water year and not including flows transferred to DWR).
[c] Bear River flow requirements are based on FERC P-2997 license conditions for flow below Camp Far West Diversion Dam (not including flows transferred to DWR).
[d] Upper American River flow requirements are based on FERC P-2155 license conditions for South Fork American River flows below Chili Bar (assuming a Dry year and including Conditions 1 and 3) and P-2079 requirements for flows on the North Fork American River below the American River Pump Station.
[e] Putah Creek flow requirements are based on the 2000 Putah Creek Accord's requirements for outflow to the Toe Drain.

[16] 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

Subwatershed		Merced River[a]	Tuolumne River[b]	*Total*
Abandoned Instream Flow (cfs)	**Jan.**	60	150	*210*
	Feb.	60	150	*210*
	Mar.	60	150	*210*
	Apr.	60	245	*305*
	May	60	311	*371*
	Jun.	15	50	*65*
	Jul.	15	50	*65*
	Aug.	15	50	*65*
	Sep.	15	50	*65*
	Oct.	38	125	*163*
	Nov.	75	150	*225*
	Dec.	75	150	*225*

[a] Merced River flow requirements are based on FERC project P-2179 license conditions for flows below Crocker Huffman Diversion Dam (assuming a Dry year).
[b] Tuolumne River flows are based on FERC P-2299 license requirements for flow below La Grange Diversion Dam (assuming the San Joaquin River 60-20-20 index is between 1.5 and 2.0 million acre-feet (MAF) from May-September or less than 1.5 MAF from October-April).

Instream flow requirements are often based on a given water year type and are therefore subject to change. Generally, the requirements listed in Table 3 and Table 4 assume dry or critical conditions, resulting in the lowest possible flow requirements. Different flow requirements may be used in the methodology if appropriate due to varying hydrologic conditions during the applicable time period.

To account for the limitation on riparian rights to the diversion of only natural flow and not flow that is foreign in either time or source, the Water Unavailability Methodology allocates any portion of the incorporated instream flow requirements in excess of the FNF to only non-riparian diverters.

2.2 Demand

The Water Unavailability Methodology evaluates demands for natural and abandoned flows by basis of water right. It is not intended to account for demands for previously stored water, imported supplies, and contractual demands. The analysis to date has relied on reported demand data from the State Water Board's Electronic Water Rights Information Management System (eWRIMS) computer database.[17] Since November

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

2022 the Methodology has also utilized projected demand data reported by larger users pursuant to the emergency regulation (see section 2.2.4). Projections of demands during the wet season may be more accurate than historical diversion data for purposes of estimating demands, particularly for storage which historically occurred when flows were present and do not necessarily reflect demands that would exist this year.

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 "Statement of Diversion and Use")
- Water right claim type for Statements of Diversion and Use (e.g., "Riparian," "Pre-1914," etc.) as reported in the diverter's Initial Statement of Water Diversion and Use and annual Supplemental 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,[18] including HUC8 watersheds
- 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 other claims of right, which mainly consist of 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 whose diversion and use is not reported by a watermaster[19] are required to submit annual reports of water diversion and use (annual reports) to the

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

[19] Watermasters are empowered to ensure water is allocated according to established water rights as determined by court adjudications or agreements (DWR 2021b). Some watermasters report the diversion and use of water within their areas of oversight to the Board via means other than the eWRIMS Report Management System. This data is not

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 2021 diversion information were due by April 1, 2022 for appropriative water rights, stockpond certificates,[20] and registrations[21] and by July 1, 2022 for statements of water diversion and use. Annual reporting periods and deadlines for 2022 and future years will change pursuant to Senate Bill 155, signed into law on September 23, 2021.[22] Diversion data contained within annual reports form the basis for estimates of water demand used in the Water Unavailability Methodology. Water right holders and claimants that divert water under Statements of Diversion and Use also provide information about the water right claim type (e.g., riparian, pre-1914 appropriative, etc.) in annual reports.

For this analysis, water demand is primarily based on the total monthly diversion amount reported for each water right record, including monthly direct diversions and monthly diversions to storage from reported annual diversion data. Data from calendar

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currently incorporated into the eWRIMS database except to the extent that individual diverters may have also mistakenly reported their diversions to the Board via the eWRIMS Report Management System. As a result, diversions in watermaster service areas are generally not included in the methodology's demand dataset and did not receive the August 20, 2021, curtailment and reporting orders or prior notices of water unavailability. Initial investigations suggest that a total of ten such watermaster service areas covering at least 16 different adjudications are located in the Delta watershed and overseen by DWR and Modoc County. From the standpoint of diverters included in the methodology, the omission of watermaster service areas results in an underestimation of watershed demands that may result in less curtailments. In the future, data from watermaster reports may be incorporated into the demand dataset and water rights within these watermaster service areas may be issued curtailment orders.

[20] 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.

[21] Water right registrations are appropriative water rights issued by the State Water Board through an expedited acquisition process for certain small projects, which first became available in 1989. Water right registrations are available for small domestic use, livestock stockpond use, small irrigation use, and cannabis small irrigation use.

[22] Senate Bill 155 changes the reporting period for all water rights and claims from the calendar year to the water year (October 1 through September 30) and consolidates the reporting deadlines into a single date for all water rights and claims. To transition to this new system, water diversion and use reporting for January 1 through September 30, 2021, was due for all diverters on April 1, 2022. Thereafter, diversion and use reporting for each water year will be due on February 1 of the subsequent year (e.g., water diversion and use reporting for October 1, 2021, through September 30, 2022, will be due by February 1, 2023).

year 2018, the most recent drier year (below normal) for which quality-controlled demand data is available, is used, except in cases where reliable updated information is available. Reliable demand projections may include data submitted as part of the enhanced reporting requirements under the emergency regulation and other sources. Staff have completed updates to the enhanced reporting processes that allows water right holders and claimants whose rights or claims have a face value or reported diversions in 2018 or 2019 of over 1,000 AF per year to identify if updates should be made to the demand assumptions used in the Methodology. This change is expected to reduce the burden of completing the enhanced demand reporting and increase compliance such that the data is usable in the Methodology.

In addition to historical use and enhanced reporting data, other reliable sources have been and will continue to be relied upon to adjust demand assumptions as appropriate. As the result of historic dry conditions, low storage conditions in Shasta Reservoir, and the need to maintain water in storage for temperature control and minimal protection of endangered species and critical water supplies, Reclamation implemented extraordinary water supply reductions in contractual supplies for the Sacramento River Settlement Contractors (SRSC) in 2022. DWR also implemented substantial reductions in contractual supplies for Feather River Contractors (FRC) in recognition of the extremely dry conditions. Reclamation and DWR may also implement similar measures in 2023 if drought conditions persist. These reductions in contractual supplies affect diversions under the contractors' underlying water rights, as well as supplemental stored water supplies provided to these contractors under water rights held by Reclamation and DWR. Although natural and abandoned flows may be adequate to satisfy the contractors' underlying water rights early in the irrigation season, natural and abandoned flows will decrease as the season progresses, and the contractors must schedule their diversions based on the amount of supplemental stored water that will be available during the entire irrigation season in consideration of the need to maintain storage for critical purposes this year and next. Based on conditions last summer, demand data was adjusted to account for these reductions in diversions.

The 2022 emergency regulation includes provisions that allow for demands by these users not to be reduced on the basis that the reductions in diversions under the contractors' underlying rights are intended to preserve limited reservoir storage in upstream reservoirs to satisfy the contractors' reduced allocations and meet water quality and other critical needs as part of an operations plan for the Projects, not to make water available to more junior water right holders. The regulation includes a determination that, given these circumstances and the need to maintain storage for critical purposes, it would be unreasonable for reduced diversions by the SRSC and FRC to make water available to more junior water right holders and claimants. Any water unused by the SRSC and the FRC due to a reduction in their contractual supplies is needed to remain instream to allow Reclamation and DWR to conserve limited cold-water pools, improve water quality, protect carryover storage, or ensure minimum health and safety water supplies in accordance with their operations plan. The emergency

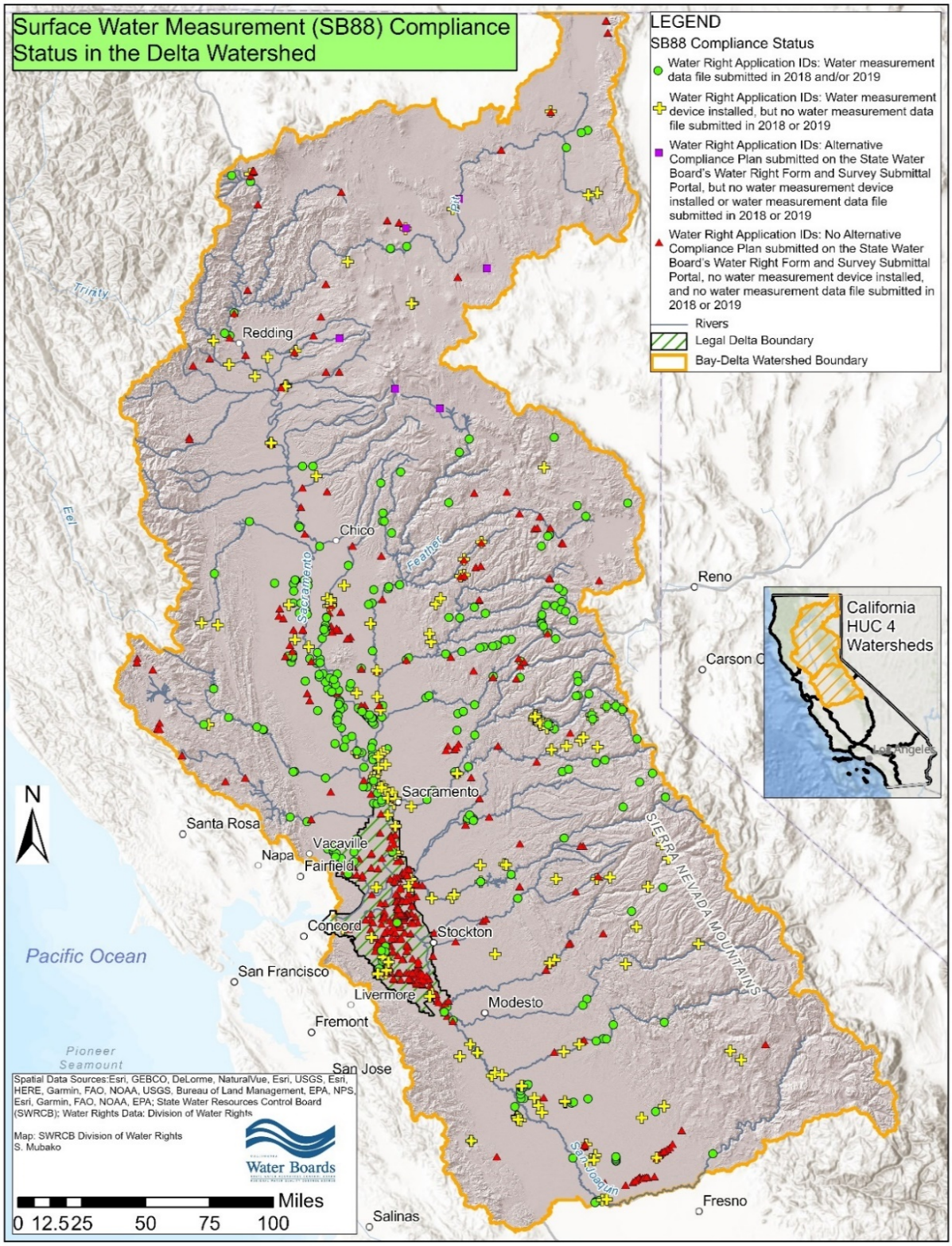
regulation includes provisions to prevent junior water right holders and claimants from diverting water that would be available under the SRSC and FRC's underlying water rights but is not being diverted in order to preserve reservoir storage for critical purposes in accordance with an operations plan developed to meet specified objectives. As a result of the approval of the emergency regulation, these demands are not reduced in the methodology.

In some cases, demand data are prorated from monthly values to shorter timesteps (assuming uniform average daily demand throughout each month) in order to better reflect the effects of precipitation and runoff events that occur on a shorter time scale in order to inform decisions to temporarily suspend curtailments. Technical Appendix A contains additional information about how water demands for various periods are estimated using monthly data.

Diversion data from 2018 is primarily used because it is the first drier year for which quality-controlled diversion data is available since updated water right measurement and reporting requirements went into effect with Senate Bill 88 (SB88). This is a reasonable source of demand data. As discussed above, other sources of demand data may also be used as appropriate. 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 the measurement device accuracy and monitoring frequency 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 rights in the Delta watershed located outside of the Legal Delta, only 57 percent (140) had installed a measurement device and submitted a measurement data file for 2018 or 2019 in accordance with SB88 as of March 2, 2021. An additional 2 percent (4) of these rights had submitted proposed Alternative Compliance Plans pursuant to SB88, and 27 percent (65) installed a measuring device but failed to submit a measurement data file for 2018 or 2019. The remaining 14 percent (35) of rights did not install a measurement device, submit a measurement data file for 2018 or 2019, or submit a proposed Alternative Compliance Plan. Compliance with the measurement requirements may be even lower for smaller diverters. Figure 7 below shows the locations of the PODs associated with the largest (those with a face value or annual reported diversion of 5,000 AF or greater) consumptive water right records in the Delta watershed and displays their SB88 compliance status as of March 2, 2021.

Figure 7. Surface Water Measurement (SB88) Compliance Status of Large Rights and Claims in the Delta Watershed[23]



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[24]
- 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 demands for minor water right types[25]
- Beneficial Uses: All beneficial uses except exclusively non-consumptive beneficial uses[26]

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 the demands for water right records with “Appropriative” and “Statement of Diversion and Use” water right types were included because minor water right types, such as

[23] Figure 7 currently shows a watershed boundary that includes Goose Lake and has not been updated to reflect current SB88 compliance. This figure will be revised in a future iteration of this report to accurately reflect the Delta watershed boundary and updated SB88 compliance.
[24] All PODs within the Delta watershed were selected except for those within the Goose Lake and Panoche Creek drainages. As described in section 2.1.3 above, these areas were excluded due to disconnection with the Delta watershed and a lack of supply data.
[25] Minor right types, such as stockponds and water right registrations, are included in the current version of the demand dataset but are assumed to constitute a negligible demand. Accordingly, all demand values for these records have been set to zero in the demand dataset.
[26] As discussed in section 2.2.4, demands for storage under non-consumptive water rights and claims have been incorporated into the demand dataset only during the wet season.

registrations and stockponds, were assumed to constitute a negligible amount of the water diversion and use within the Delta watershed.[27]

Water right records identified as non-consumptive based on their beneficial use type (e.g., hydropower generation, fish and wildlife preservation and enhancement, etc.) were also originally excluded from the analysis. 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 2.2.10 below). During the dry season, the potential impact of these non-consumptive diversions on the timing of flows is not assumed to be significant given the negligible amount of hydropower-related diversions to storage assumed to be occurring during the dry season. As discussed in section 2.2.5 below, during the wet season non-consumptive water right records that divert water to storage can make water unavailable for other users for periods of time greater than the temporal resolution of the analysis (e.g., weekly or longer). Therefore, diversions to storage under non-consumptive rights such as hydropower rights are included in the demand dataset only during the wet season to accurately reflect where these diversions make water unavailable within a month.

This initial selection of water right records resulted in a demand dataset consisting of approximately 12,000 total post-1914 appropriative water rights (excluding minor appropriative water right types) and statements of diversion and use. Of these, approximately 5,000 are post-1914 appropriative water rights and 7,000 are statements of diversion and use. The demand dataset also includes approximately 4,000 additional minor water rights, such as stockponds and registrations; the demand values for these records is assumed to be negligible and have been set to zero in the demand dataset.

As discussed in section 2.2.4 below, demands for storage under non-consumptive water rights and claims were later incorporated into the demand dataset during the wet season. After incorporating these demands, the demand dataset includes approximately 17,000 total water right records, including 6,000 appropriative water rights (excluding minor appropriative water right types), 7,000 statements of diversion and use, and 4,000 additional minor water rights (such as stockponds and registrations).

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

[27] Exclusion of the demands for these minor right types from the methodology represents a conservative assumption because it underestimates overall demand and may thus result in fewer curtailments. These diverters are still issued notices of water unavailability and curtailment orders in keeping with the principles of the water rights priority system.

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 post-1914 appropriative water rights and statements of diversion and use in 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 annual 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 approximately 580 water right records, including approximately 360 post-1914 appropriative rights and approximately 220 Statements of Diversion and Use, which could be reviewed within a limited timeframe. 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.[28] 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

[28] 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).

these rights, the reported diversion amounts within the demand dataset were updated to equal the face value of the right.

Except for the correction to reported diversions in excess of the face value of post-1914 rights, all post-1914 appropriative water rights and statements of diversion and use 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 2018 and 2019 annual reports for the largest diversions and applying corrections to rectify errors as discussed above, some diversion values remained flagged as potentially including incorrect demand information with outstanding issues that could not be resolved without further information. Examples of these 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 an error was detected but 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, claimants, 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, claimants, 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, claimants, 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, claimant, 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.

State Water Board staff also initiated an expanded quality control effort encompassing appropriative water rights with a face value (maximum diversion amount) of 1,000 AF or greater and statements of diversion and use with reported diversions of 1,000 AF or greater in either calendar year 2018 or 2019. This quality control expansion included the water rights and claims identified as non-consumptive that were previously excluded from review and added approximately 800 water right records for review. The expanded quality control effort was completed and incorporated into the methodology demand dataset on August 15, 2022.

In addition to the above, the quality-controlled 2018 and 2019 demand datasets were compared to FNF for each of these years, respectively, at the subwatershed scale (see section 2.1.3 above) and at the Sacramento and San Joaquin River watershed scales to assess the reasonableness of the demand datasets.

Further refinements to the demand dataset used in the Water Unavailability Methodology may also 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.

2.2.4 **Enhanced Reporting Forms**

Enhanced reporting information is submitted monthly by water users in accordance with the emergency regulation. Water rights and claims in the Delta watershed that have a face value or recent annual reported diversion volume of 5,000 AF or greater are required to report water diversion and use data for prior months and projected water demand data for the upcoming month. Water right holders and claimants in the Delta watershed with a face value or recent annual reported diversion volume of 1,000 AF or greater may opt to submit projected monthly demand information if the demand data need updating to accurately reflect current conditions.

Water right holders and claimants report via electronic Delta Watershed Enhanced Reporting of Actual Diversions and Projected Demand Forms (Enhanced Reporting Forms) or by coordinating with State Water Board staff to submit a spreadsheet for bulk reporting of multiple water rights and claims. The Enhanced Reporting Forms are required monthly during the effective period of the emergency regulation unless otherwise specified by the State Water Board. Separate Enhanced Reporting Forms are required for each month: Projected Demands (i.e., anticipated future diversions given existing conditions, assuming curtailments are not in place) are due in advance of a given month, and Prior Diversion reports for the same month are due after it has passed.

Projected demand data obtained through enhanced reporting is used in place of 2018 and 2019 reported diversions upon review and verification that the projected demands are plausible. Plausibility is determined via a quality control process that includes comparisons to previous diversion reports, knowledge of current conditions, and, if necessary, contacting the reporting party. Projected demand data is also used as appropriate to inform consideration of curtailment exception proposals submitted by water right holders and claimants.

Additionally, prior diversion data obtained through enhanced reporting may be used to inform future updates of the default demand dataset for more recent dry conditions. Prior diversion data may also be used to inform other refinements to the water unavailability methodology and associated evaluations.

2.2.5 **Wet Season Demand Adjustments**

Prior versions of the demand dataset were intended primarily to identify when available data indicated that natural and abandoned water supplies were unavailable for water users in the Delta watershed during the dry season. This section describes adjustments to the demand dataset for application during the wet season.

As noted in section 2.2.1, water right records identified as non-consumptive based on their beneficial use type (e.g., hydropower generation or fish and wildlife preservation and enhancement) were previously excluded from the analysis due to its prior focus on dry season operations. During the dry season these non-consumptive uses of water do not typically significantly alter the timing of flows or change the amount of water available downstream. However, during the wet season water right records with non-consumptive beneficial use types such as hydropower generation can significantly alter the timing of flows when water is diverted to storage. These diversions can make water unavailable for diversion by other users within periods of time greater than the temporal resolution of the analysis (e.g., weekly or longer). The demand dataset was adjusted to incorporate approximately 500 additional post-1914 appropriative water rights and statements of diversion and use with non-consumptive beneficial use types that were originally excluded from the demand dataset (see Technical Appendix B and the Water Unavailability Methodology Spreadsheet). For these records, the diversion values contained in the demand dataset reflect only reported diversions to storage. Non-consumptive direct diversions do not alter the timing of flows or change the amount of water available downstream and are therefore not included in the demand dataset.

A wet season adjustment quality control review effort was conducted following selection of the additional water right records with non-consumptive beneficial use types. Similar to the previous quality control review effort, the scope of the review was narrowed to produce a manageable subset of records to review within a limited timeframe. For this quality control review, post-1914 appropriative water rights and statements of diversion and use with face values or reported diversion to storage volumes of 5,000 AF or greater in either 2018 or 2019 were selected. Approximately 75 records were included

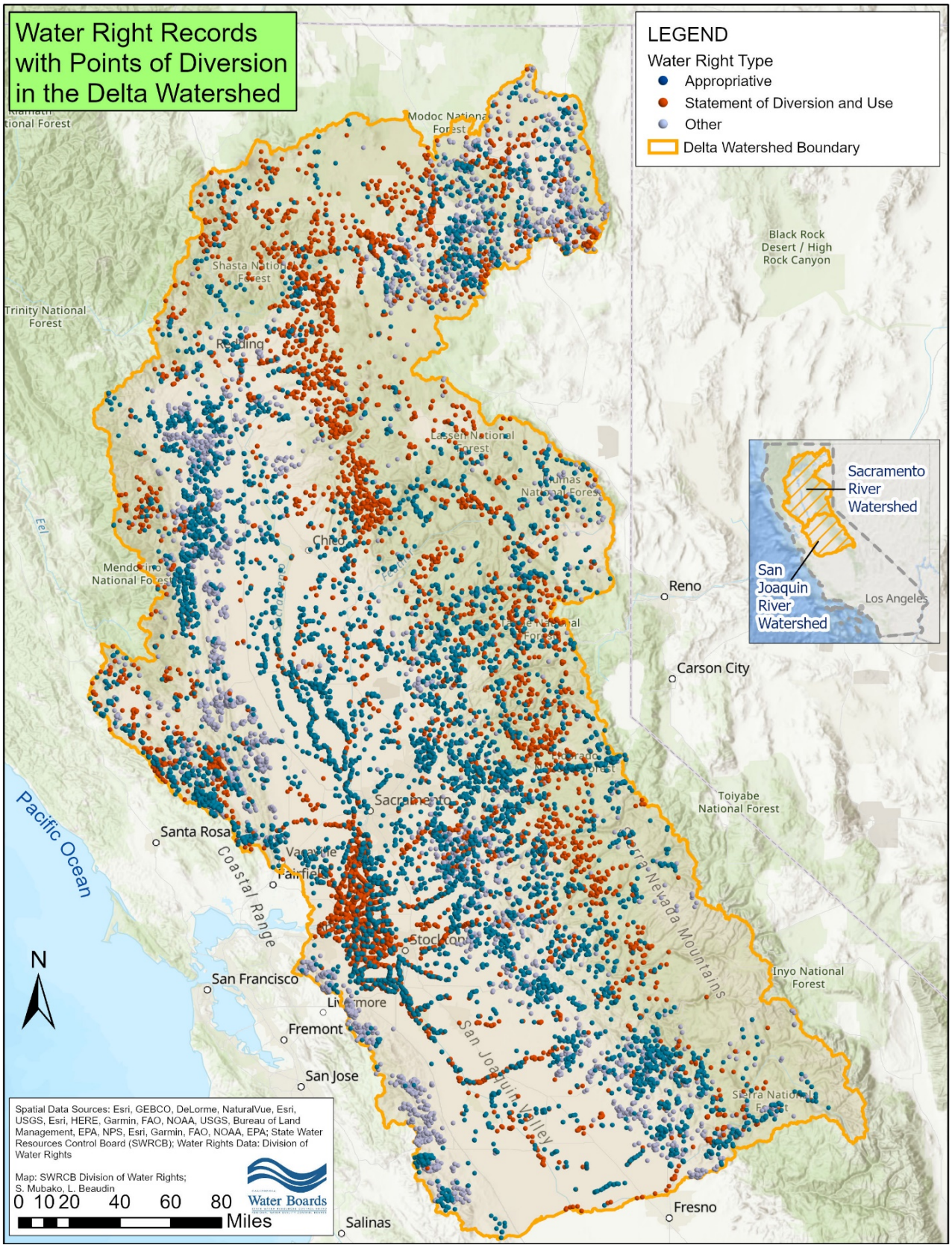
in this quality control review effort. Additional non-consumptive records were added when the quality control effort was expanded to encompass diversions of 1,000 AF or greater. The 2018 and 2019 annual reports of water diversion and use for these records were reviewed to identify and correct potential inaccuracies in the diversion to storage data using the methods described in previous sections and in Technical Appendix B.

In addition, this quality control review addressed occurrences of duplicative reporting of diversions to storage under overlapping consumptive and non-consumptive use rights. Staff compiled 2018 and 2019 reported diversion to storage volumes for all water right records, including those associated with consumptive uses, held by the same primary owners of the approximately 75 largest water right records with non-consumptive beneficial use types. When identical diversion to storage volumes were reported for consumptive and non-consumptive water right records held by the same primary owner and associated with the same diversion location, the reported diversion to storage volumes were assumed to be duplicative and the demand value for the non-consumptive water right record was changed to zero to avoid overreporting of diversion to storage volumes. Staff also reviewed information regarding overlapping reporting between consumptive and non-consumptive water right records submitted in the September 2021 Enhanced Reporting Forms, which were required pursuant to the emergency regulation, identifying additional occurrences of overlapping reporting of diversions under consumptive and non-consumptive water right records. In these cases, the demand value for the non-consumptive water right record was changed to zero.

Further refinements to the demand values for non-consumptive use rights included in the demand dataset may occur. Diverters who are aware of reporting issues, including, but not limited to overlapping reporting of diversions to storage between consumptive and non-consumptive water right records, should contact the State Water Board at Bay-Delta@waterboards.ca.gov.

Points of diversion for all water right records included in the demand dataset as of November 15, 2021, are shown in Figure 9 below. The figure was updated from the August 20, 2021 version of this report to include points of diversion for the approximately 500 non-consumptive water right records described above. Figure 9 displays points of diversion for approximately 17,000 water right records in the Delta watershed, including 6,000 Appropriative water rights, 7,000 Statements of Diversion and Use, and 4,000 additional minor rights (e.g., stockponds and registrations).

Figure 8. Water Right Records with Points of Diversion in the Delta Watershed



2.2.6 **Disaggregation of Statements of Diversion and Use**

Statements of Diversion and Use were assigned a category based on the water right claim types reported by diverters in Initial Statements of Water Diversion and Use and in 2018 and 2019 annual reports. This user-submitted information was not reviewed for accuracy as part of this analysis but represents the best information currently available. This information may be updated based on additional information, including information submitted by water right claimants through the emergency regulation process.

The following Statement of Diversion and Use categories are currently included in the demand dataset:

- Riparian
- Pre-1914
- Riparian or Pre-1914
- Reserved
- Other
- Unclassified.

The vast majority (over 95 percent) of the Statements of Diversion and Use included in the demand dataset were categorized as Riparian, Pre-1914, or "Riparian or Pre-1914." For the purposes of assigning priority within the Methodology, those water right claims categorized as "Riparian or Pre-1914" or Other were assumed to have the more senior priority of right (i.e., Riparian).[29] Technical Appendix B further describes the process used to categorize and assign priority dates to Statements of Diversion and Use.

2.2.7 **Disaggregation of Total Diversion Amounts**

Prior versions of the demand dataset included monthly and annual total diversion amounts, which combined the reported direct diversions and diversions to storage for each water right or claim. Since the April 19, 2022, version of this report, total diversion amounts have been disaggregated into discrete direct diversion and diversion to storage amounts based on information submitted in annual reports for calendar years 2018 and 2019. The disaggregation of total diversions into discrete direct diversion and diversion to storage amounts in the demand dataset informed refinements to the

[29] For the purpose of curtailment, diverters who claim both a riparian and a pre-1914 appropriative water right to serve the same place of use (or have reported diversion pursuant to a combination of such unadjudicated claims among their Initial Statement of Water Diversion and Use and their 2018 and 2019 annual reports) are treated solely as riparian claimants. Assuming, solely for curtailment determinations, that the diverter has a valid riparian right, they may continue to divert under that right, subject to its restrictions, unless and until the riparian right is curtailed. In nearly all scenarios this represents a conservative simplifying approach within the Methodology because riparian rights are assumed to be senior to all appropriative rights absent specific evidence to the contrary.

methodology, including the different spatial assignment of demand based on POD type (direct diversion or storage reservoir), the exclusion of return flows from availability to meet storage demands, and the application of return flow factors to direct diversion demand only (as described in section 2.2.11 below).

Previous quality control review efforts focused on corrections to total diversion amounts and did not apply specific corrections to the direct diversion and diversion to storage components of the total diversion. Accordingly, a supplemental quality control review effort was conducted with a focus on the water right records for which a correction to the total diversion amount was previously applied and both direct diversion and diversion to storage amounts were reported for 2018. Approximately 200 records were included in this supplemental quality control review effort. For these records, the 2018 and 2019 annual reports were reviewed and appropriate adjustments to the direct diversion and diversion to storage amounts were applied.

2.2.8 **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) of each POD. For the purpose of this analysis, demand values within the demand dataset are aggregated at the same subwatershed scale as 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 water right records in the Delta watershed have PODs that span multiple subwatersheds; of these, eleven are Project water rights, which frequently have PODs upstream at the major storage reservoirs, downstream on major tributaries, and within the Legal Delta. As described in section 2.2.9 below, the Water Unavailability Methodology treats these demands differently because of the unique circumstances of the Projects' diversions. For the rights that have PODs within multiple subwatersheds, demands for direct diversion and storage under each water right record are split among the applicable subwatersheds based on the proportion of the total active PODs diverting natural flow located within each subwatershed. No demand is split to PODs which are inactive or which are solely points of rediversion. For example, if a water right record has three associated PODs, one of which is located within the Sacramento Bend subwatershed and two are 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. These water rights are only curtailed in the

methodology if water is unavailable within all of the subwatersheds where they have demands. If all of a water right's PODs within a subwatershed are points of rediversion or inactive, these PODs are not factored into curtailment decisions (i.e., curtailment is only determined based on unavailability in subwatersheds where a water right has active demands that are met by natural flow).

For rights with PODs in multiple subwatersheds that reported both direct diversions and diversions to storage in 2018 or 2019, demands are split differently based on the nature of each POD associated with the right; direct diversion demands are only split among PODs that divert directly, while storage demands are only split among PODs which divert to storage. For example, a right associated with an upstream storage reservoir in the Upper Feather River subwatershed and a downstream point of direct diversion in the Sacramento Valley Floor subwatershed would have all of its storage demand assigned to the reservoir POD and all of its direct diversion demand assigned to the direct diversion POD in Sacramento Valley Floor. An apportionment of demand based on the actual amounts 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. However, these proration amounts may be updated based on more specific information for specific water rights as appropriate.

2.2.9 **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. Project 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.[30] 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 demands are assumed to have the lowest priority date among Delta watershed rights. In the future this assumption may be modified to only assign the portion of Project demands exported out-of-basin a lower priority date and to assign the remaining diversions for inbasin purposes the original water right priority date. However, changes to Project priority dates do not have a significant effect on the analysis given the Projects' relatively junior water right priorities.

[30] Wat. Code, §§ 11128, 11460.

Since two of three water rights associated with the New Melones Project (A014858A and A014858B) are not authorized for export out of the Delta watershed, these demands are all assumed to be met in accordance with the original priority date of the rights.

The assumed priority dates for several water rights held by Reclamation for the Friant Division of the CVP have been updated since prior versions of this report. In previous versions of the methodology, water rights A000023, A000234, A001465, and A005638 (License 1986, and Permits 11885,11886, and 11887, respectively) were all assumed to have "Project" priorities that made them the most junior rights in the watershed due to area of origin protections. The priority dates of these rights have now been changed to March 27, 1915; January 19, 1916; September 26, 1919; and July 30, 1927, respectively, to reflect the dates when the underlying applications to appropriate water were filed. This change is consistent with Reclamation's position that the Friant service area is within the watershed of origin, or an area immediately adjacent thereto which can conveniently be supplied with water therefrom, within the meaning of Water Code section 11460, and therefore Reclamation's rights associated with the Friant Division should not be considered junior to all other rights within the San Joaquin River watershed. Reclamation's position is supported by the U.S. Supreme Court's decision in *City of Fresno v. California* (1963) 372 U.S. 627.

In spring of 2022, assumed Project demands within the Legal Delta were reduced in accordance with the State Water Board's April 4, 2022 Order Approving Temporary Urgency Changes to Water Right License and Permit Terms Relating to Delta Water Quality (TUCO). Further adjustments may be made to assumed CVP and SWP demands if the Board acts to further modify Project operations in the future.

2.2.9.1 *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 water they divert originates from the Trinity River watershed. These water rights and their diversion data were removed from the demand dataset because the water associated with these diversions is imported to the Delta watershed and does not impact natural flow supplies in the watershed.

2.2.9.2 *Settlement Contractor Demands*

As discussed above, there are various water users in the Delta watershed that have settlement-type contracts with DWR and Reclamation that provide a contractual entitlement of 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 both 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 the purpose of this analysis it is assumed that most settlement contractors, with the possible 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 curtailment orders under their own water rights and would then need to rely upon contractual supplies to the extent those supplies are available.

Demands of Sacramento River Settlement Contractors and Feather River Contractors

As discussed above, as a result of very dry hydrologic conditions in 2022, DWR reduced allocations to the FRC (that have a settlement-type contract) in accordance with their respective contract deficiency provisions. This can generally be classified as a 50 percent reduction compared to full contract amounts, though diversions to riparian parcels are not subject to reduction under the contract deficiency provisions and allocations may exceed 50 percent of the full contract amount depending on the individual contractor. In addition, pursuant to Reclamation's operations plan for the CVP, deliveries to the SRSC were reduced to 18 percent of their full contractual allocation in 2022. Accordingly, before the revised regulation became effective on August 12, 2022, the demands associated with these water rights and claims were modified to reflect the reduction in contractual allocations.

Before the effective date of the revised regulation, demands associated with water rights and claims underlying FRC contracts were adjusted to reflect the monthly volumes identified in DWR's 2022 Operations Outlook, submitted as required by Condition 5 of the TUCO. April to September diversions were specified in the Operations Outlook and identified as accounting for approximately 85 percent of contract diversions under the reduction. The remaining 15 percent was apportioned to water rights underlying the FRC contracts in accordance with the allocations and irrigation seasons identified in their individual contract deficiency provisions. These volumes were apportioned to the remaining months of each contract's allowable irrigation season by month (January to March and October to December) based on 2018 monthly diversion patterns.

Prior to the effective date of the revised regulation, April through October demands associated with water rights and claims underlying the SRSC contracts were also adjusted to reflect 2022 diversion schedules accounting for the 18 percent contractual allocation when such schedules were available. In cases where a single contractor holds multiple water rights or claims, reduced contractual allocations were apportioned in order of water right priority, with demands assigned to the senior-most right or claim first. Demands for SRSCs without identified diversion schedules were reduced to 25 percent of their 2018 demands, which is equal to approximately 18 percent of their full contract amount.

Demands for water rights and claims underlying the FRC and SRSC contracts were adjusted to maintain their full amounts after the 2022 emergency regulation was approved and became effective.

Exchange Contractors

In most years, the Exchange Contractors receive replacement supplies exported from the Legal Delta in exchange for use of water from the San Joaquin River under the Exchange Contractors' underlying rights as part of settlement-type contracts related to the development of the Friant Project by Reclamation. Accordingly, all demands associated with the Exchange Contractors (represented by statements S000477, S001073, S001074, and S001098) are generally assumed to be met with previously stored CVP supplies rather than sourced from San Joaquin River water diverted under the underlying water right claims. In April through June 2022 the Exchange Contractors received a significant portion of their demand from the San Joaquin River, so assumptions regarding the location and nature of their demands were adjusted accordingly. Future adjustments to Exchange Contractor demands may be considered as operations plans for the San Joaquin River are adjusted during drought conditions.

2.2.10 Interbasin Diversions (Yuba-Bear and Drum-Spaulding)

Non-consumptive uses are generally not included in the methodology's demand dataset at this time. 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.

Following the May 12, 2021 version of this report, 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 such interbasin diversions at this time. Adjustments may be considered in the future as appropriate.

2.2.11 Accretions and Return Flow Estimates

Accretions in the valley floor during the dry season are primarily due to return flows. In recognition that only a portion of diversions are actually consumptively used due to

return flows from irrigation and, to a lesser extent, municipal uses, return flow factors were applied to diversion values within the Delta watershed demand dataset. Return flows are water that is 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. Natural depletions due to stream-groundwater interaction and demand by riparian vegetation are difficult to estimate and not accounted for in the methodology, which represents a conservative assumption that may overestimate water availability and reduce curtailments.

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 measurement gages. Rates of return flow can be estimated using models developed to simulate 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. 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. CalSim 3 return flow rates show similar trends to SacWAM results for the Sacramento 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.

Monthly return flow factors were calculated for the Sacramento and San Joaquin watersheds using model results from a CalSim 3 public release. For each watershed, the sum of return flows from all valley floor demand units (DUs) was divided by the sum of surface water diversions to all valley floor DUs to obtain a return flow factor. Demand factors, which demands are multiplied by to produce reduced demand values accounting for return flows, are simply one minus the return flow factor for the respective watershed and month. For example, if the return flow factor for a watershed in a given month is 0.2, or 20 percent, the demand factor applied in that watershed for that month would be 0.8, or 80 percent. Within CalSim 3, return flows result from all sources of water delivered to a given DU, including directly diverted surface water, previously stored surface water, and pumped groundwater. Modeled surface water deliveries are lower during drier years than in wetter years but modeled return flows remain similar due to the contribution of larger quantities of groundwater. As a result, return flow factors calculated from results for critically dry years are larger and likely overestimate the availability of water for diversion. A spreadsheet containing the calculation of return flow factors as described above is available upon request.

Prior versions of this report as applied during water year 2021 relied upon return flow factors based on CalSim 3 model results for water year 2014 due to similar hydrology and land use. As discussed above in section 2.2.9.2, land use in the Sacramento Valley is likely to be substantially reduced relative to a typical irrigation season and reuse of tailwater is likely to be maximized. In particular, rice agriculture dominates modeled return flows in the Sacramento Valley and is likely to be substantially reduced in areas drained by the Colusa Basin Drain. Consequently, return flow assumptions used in the methodology may be informed by supplementary modeling analyses incorporating the best available information regarding land use, recycling of applied water, and actual gaged return flows where available. These supplementary analyses may be conducted using CalSim 3, SacWAM, or other quantitative tools. Future curtailment status updates will specify any changes made to return flow assumptions and disclose the technical basis to water right holders and the public.

During the wet season, diversion to storage may account for a significant portion of total diversions. Because diversions to storage do not produce return flows until stored water is released and rediverted for consumptive use, demands for diversion to storage should not be scaled to account for return flows. Prior to the April 19, 2022 version of this report, the demand data had not been fully disaggregated between diversions to storage and direct diversions. The disaggregation of direct diversion and diversion to storage, described above in section 2.2.8, allows elimination of return flow factors for all diversions to storage. Since July 2022 the application of return flow factors to direct diversion demands in headwater subwatersheds is also being considered, using the same factors calculated for the respective watershed unless better data is available on return flows in individual subwatersheds. In the Legal Delta, return flows are applied based on the watershed in which a particular diversion is located (see map in Figure 4).

While return flow factors are not applied to diversions to storage, the CalSim-derived return flow data itself does incorporate return flows associated with demands met from previously stored water. It is unclear whether a more explicit incorporation of these return flows into the methodology would be appropriate given comments the Board received from Reclamation in late 2021 claiming residual control of return flows from its deliveries of stored water, and accordingly asserting that these return flows should not be incorporated into the water unavailability analysis as they are not abandoned and available for diversion by other parties. Assuming these flows contribute to return flows is a conservative assumption.

2.2.12 Exclusion of Curtailment Exceptions

Pursuant to the emergency regulation, water users can seek an exception to curtailment for several purposes. These purposes include diversions for minimum human health and safety needs, diversions for non-consumptive uses that do not decrease downstream flows in the watershed, alternative water sharing agreements that achieve the same results as curtailment, and other proposals that curtailment is inappropriate

and would not make water available to serve senior downstream water rights and claims.

Of these exceptions to curtailment, generally only those for minimum human health and safety needs represent a net consumptive use of water. Staff have analyzed the quantity of water associated with the minimum human health and safety exceptions received to date and have found that they represent a negligible quantity of water for the most part. The demand resulting from this exception is not incorporated into the demand dataset or larger methodology due to this largely negligible quantity and because its exclusion favors fewer curtailments. Demands associated with the exceptions will continue to be evaluated and substantial, significant exceptions may be incorporated into the methodology's demand dataset in the future if appropriate.

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 supply and demand on both a subwatershed level (e.g., a single tributary like the Upper Feather River) and watershed-wide level (the Sacramento and San Joaquin River watersheds). The watershed-scale analysis also includes water rights that divert from within the Legal Delta (see section 2.3.4 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 9 below is a schematic showing how this analysis is performed using the supply and demand data previously described.

As shown in Figure 9, supply and demand are first compared within headwater subwatersheds. While supplies from 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 available supply in the headwater subwatershed is considered in the watershed analysis. Headwater subwatersheds in the Sacramento River watershed include the Sacramento River and its tributaries above Bend Bridge, Stony Creek, Cache Creek, the Upper Feather River above Oroville Dam, the Yuba River, the Bear River, Putah Creek, and the Upper American River above Folsom Dam. Headwater subwatersheds in the San Joaquin River watershed are the Chowchilla River, the Upper San Joaquin River above Friant Dam, the Fresno River, the Merced River, the Tuolumne River, the Stanislaus River, the Calaveras River, the Mokelumne River, and the Cosumnes River.

Lower subwatersheds are defined as such because they contain demands that can be met by supplies from upstream tributaries (the headwater subwatersheds). The Upper

Sacramento River Valley, Sacramento River Valley Floor, and San Joaquin River Valley Floor subwatersheds, including the Legal Delta, are considered lower watersheds because demands within them may be met from multiple upstream tributaries that flow into the valley floor. 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 2.3.4 below).

Figure 9. Schematic of Supply and Demand Analysis at the Subwatershed and Watershed Levels

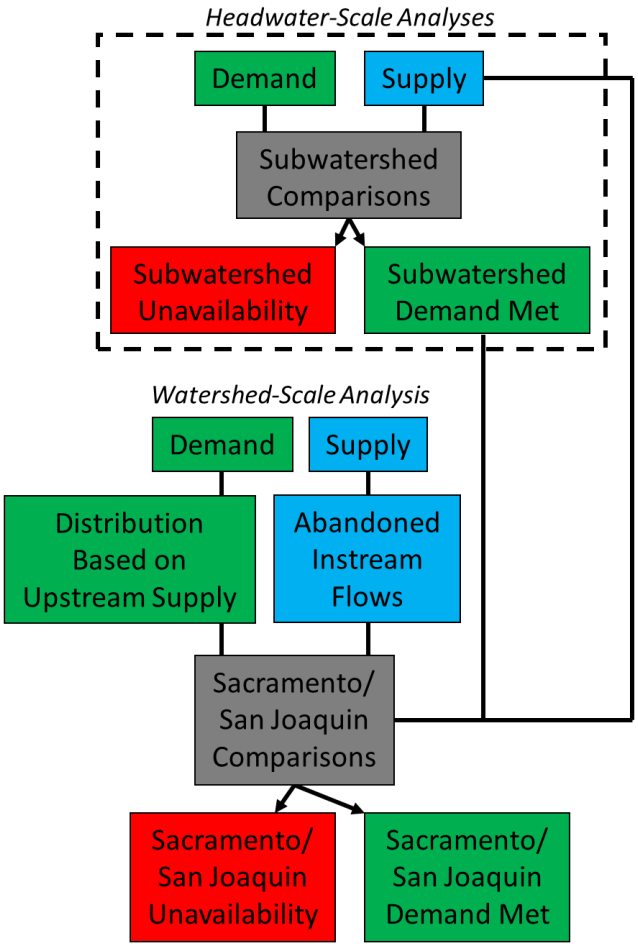
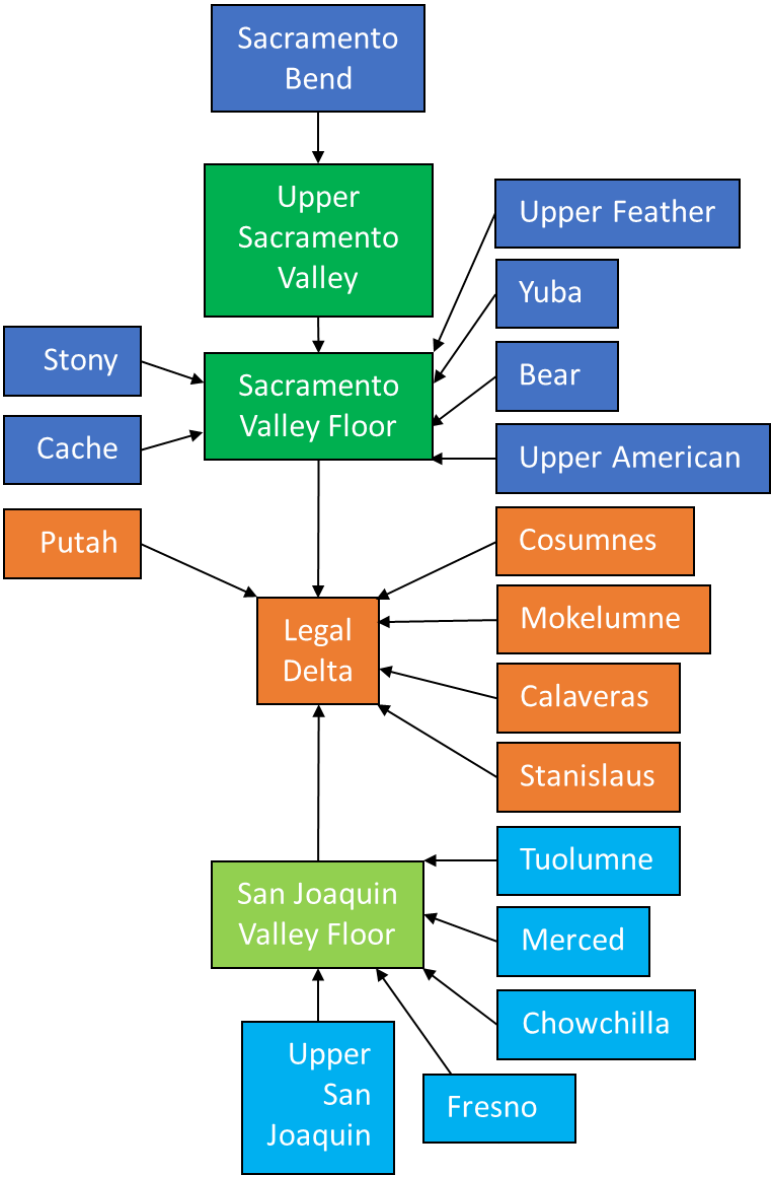


Figure 10 shows a schematic of the subwatersheds previously mapped in Figure 4. Because Putah Creek, the Stanislaus River, the Calaveras River, the Mokelumne River, and the Cosumnes River subwatersheds cross into the Legal Delta a small number of rights located in these subwatersheds and within the Legal Delta are excluded from the headwater-scale analysis and included only in the watershed-wide analyses, as they have access to water from both the Sacramento and San Joaquin Rivers (see section 2.3.4 below). As a result of refinements to the watershed-scale analysis to be implemented in conjunction with this update to the methodology report (see section 2.3.3 below), several headwater subwatersheds are assumed to provide supply only to

demands in the Legal Delta and no other demands in the valley floor outside the Legal Delta. These Legal Delta tributary subwatersheds include Putah Creek in the Sacramento River watershed and the Stanislaus, Calaveras, Mokelumne, and Cosumnes Rivers in the San Joaquin River watershed. The refined watershed analysis also assumes that the only tributary upstream of the Upper Sacramento Valley Floor subwatershed is the Sacramento River at Bend Bridge.

Figure 10. Subwatersheds Schematic



Some headwater subwatersheds in the San Joaquin River watershed were delineated based on a combination of smaller HUC10 watersheds and stream buffers because their HUC8 boundaries (see section 2.1.3 above) contain demands that are not met exclusively by supplies from within the subwatershed.

The Chowchilla River HUC8 (Middle San Joaquin-Lower Chowchilla) also includes minor east side tributaries and the mainstem of the San Joaquin River from Friant Dam to the confluence with the Merced River, so the Chowchilla River headwater subwatershed was instead defined as a combination of two HUC10s representing only the Chowchilla River drainage (Upper Chowchilla River and Lower Chowchilla River), as well as a buffer along Ash Slough below Berenda Reservoir.

The Fresno River HUC8 includes diversion points on the Eastside Bypass that are supplied by San Joaquin River flood flows, so the Fresno River headwater subwatershed was instead defined as a combination of three HUC10s (Upper Fresno River, Coarse Gold Creek, and Middle Fresno River), as well as buffers along Dry Creek below Avenue 16 ½, the mainstem of the Fresno River between Road 16 and the Eastside Bypass, and the mainstem of the Fresno River between the Road 9 diversion structure and the confluence with the San Joaquin River.

The Mokelumne River HUC8 (Upper Mokelumne) includes demands on the mainstem of the San Joaquin River within the Legal Delta, so the Mokelumne River headwater subwatershed was instead defined as a combination of five HUC10s (Upper Mokelumne River, South Fork Mokelumne River, Middle Fork Mokelumne River, Upper North Fork Mokelumne River, and Lower North Fork Mokelumne River) and a buffer along the Mokelumne River between Camanche Reservoir and the confluence with Dry Creek.

Finally, the Calaveras River HUC8 does not include demands along Mormon Slough that are supplied from the Calaveras River, so its subwatershed boundary was modified to include a buffer along Mormon Slough between the Bellota Weir and the Stockton Diverting Canal, as well as the area between the Calaveras River channel and Mormon Slough.

Previous versions of this report derived the delineation of the Mokelumne River, Chowchilla River, and Fresno River subwatersheds from the HUC8 boundaries, which resulted in their classification as lower subwatersheds. By deriving the delineations from the HUC10 boundaries as described above, these subwatersheds are able to be treated as headwater subwatersheds within the analysis; as discussed in more detail below, this enables headwater subwatershed-scale analyses to be conducted in these areas and for any unmet demand to be eliminated from the wider watershed-scale analysis (of which the lower reaches of these subwatersheds are now a part).

Diverters within headwater subwatersheds whose demand cannot be physically met by the supply available within those subwatersheds may receive notices of water unavailability or curtailment orders based on the headwater subwatershed-scale analysis. Currently, rights and claims are only curtailed if there is zero supply available to meet their demands (i.e., a right or claim is currently not curtailed even if a portion of its demand cannot be met by available supply). However, this assumption may be refined in the future. 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 unavailability at the headwater subwatershed scale is only part of the evaluation of water unavailability. 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 unavailability is evaluated in the watershed-scale analysis for the Sacramento and San Joaquin River watersheds.

2.3.2 **Treatment of Riparian Demands and Elimination of Supply and Demand in Temporarily Disconnected Headwater Subwatersheds**

The Water Unavailability Methodology does not currently specifically evaluate water unavailability for individual riparian claimants unless there is zero total supply available.[31] In times of shortage, riparian rights provide for sharing of those shortages. Given the scale and complexity of the Delta watershed, the methodology does not yet fully evaluate how that sharing should occur. However, the methodology can be used to evaluate general quantities of water that may be unavailable for riparian claimants and when riparian claimants should implement measures to address those shortages. In the future, refinements to the methodology may be made to further address water unavailability for riparian claimants.

If the headwater subwatershed analysis indicates that the total demands of riparian claimants exceed the available supply in a particular headwater subwatershed, the headwater subwatershed's supplies and demands are removed from the watershed-scale analysis for the period of analysis (e.g., 7 days or 31 days). In other words, the methodology assumes that the given stream would not have continuity with the larger Delta watershed and would be considered "temporarily disconnected" due to fulfillment of the local senior water right demands. Water rights and claims within a temporarily disconnected headwater subwatershed would not be curtailed based on the watershed-scale unavailability analysis. Abandoned instream flows from disconnected headwater subwatersheds may still be considered to contribute to watershed-scale supply (see section 2.1.6 above) unless they are assumed to be diverted by senior water right claimants within the subwatershed.

The Water Unavailability Methodology Spreadsheet, available on the State Water Board's Delta Water Unavailability Methodology webpage, contains a table in the 'Analyses' tab that summarizes which headwater subwatersheds were assumed to be disconnected from the Delta watershed during the analyzed period.

[31] Demands by Riparian-priority claims are assumed to be senior in priority to all other demands for the purposes of the methodology. As discussed above, there may be instances where a pre-1914 appropriative right is senior to a riparian. In those cases, adjustments can be made.

2.3.3 **Refined Watershed Analysis**

The update to the methodology documented by this report includes refinements to the watershed-scale analysis which improve the spatial resolution of the methodology based on the connectivity of tributary streams within the Delta watershed. Previously, the methodology analyzed water unavailability at the entire watershed scale by pooling supplies and demands for all subwatersheds within each larger watershed (the Sacramento and San Joaquin separately), including supplies from small tributaries in lower subwatersheds and demands on the valley floor. As a result of this update, each demand is now only charged against subwatersheds which are expected to contribute supply to meet this demand. Supplies from each subwatershed are tracked individually in the watershed-scale analysis, and the demand of a given water right or claim is distributed only among its subwatershed and any which flow into it ("upstream" subwatersheds, collectively) based on the magnitude of supply that is available to it from each. Figure 10 above shows the assumed connectivity of subwatersheds under this refined analysis. Water is unavailable to a given water right or claim if there is zero supply available from all upstream subwatersheds.

This refined analysis specifically addresses comments received on the methodology, namely that the watershed-scale analysis previously oversimplified where water supplies and demands are located within each watershed. By distributing demands only among supply sources located within or upstream of a given subwatershed, the refined analysis ensures that demands in one tributary subwatershed do not affect curtailments in a second tributary subwatershed if curtailments in the second subwatershed would not make water physically available in the first subwatershed. For example, curtailments in the Upper Sacramento Valley will not be made based on demands in the Upper Feather subwatershed, because the Feather River is only tributary to the Sacramento watershed in the Sacramento Valley Floor. The refined analysis will no longer result in the watershed-wide curtailment dates that are produced by the current analysis (e.g., post-1914 appropriative water rights in the San Joaquin River watershed outside of the Legal Delta with a priority date of 1919 or later being curtailed). Instead, both the subwatershed-scale analysis and the refined watershed-scale analysis will produce curtailment dates that vary based on diversion location (subwatershed and within or outside of the Legal Delta).

As mentioned above (see 2.3.1 and Figure 10), the refined watershed analysis changes the availability of supplies from several sources compared to the previous analysis. First, the majority of Sacramento watershed tributaries (Stony and Cache Creeks and the Upper Feather, Yuba, Bear, and Upper American Rivers) supply only demands on the Sacramento Valley Floor and in the Legal Delta because they flow into the mainstem of the Sacramento River below the Red Bluff Diversion Dam (the boundary between the Upper Sacramento Valley and Sacramento Floor subwatersheds). Second, supplies from Putah Creek and the Stanislaus, Mokelumne, Calaveras, and Cosumnes Rivers supply only demands in the Legal Delta because they do not supply

any demands on the Sacramento or San Joaquin valley floors outside of the Legal Delta.

The refined watershed-scale analysis does not change the headwater subwatershed analysis or other aspects of the methodology. The Water Unavailability Methodology Spreadsheet, available on the State Water Board's Delta Water Unavailability Methodology webpage, reflects the refinements discussed above.

2.3.4 **Proration of Legal Delta Demands**

Diverters with appropriative water rights with points of diversion within the Legal Delta (as defined in Water Code section 12220) may have access to water supplies entering the Legal Delta from both the Sacramento and San Joaquin River watersheds. To account for this, appropriative demands within the Legal Delta are prorated among available supply from all upstream tributaries. Whereas previous versions of the Methodology calculated their proration based on the total supply available from the Sacramento and San Joaquin watersheds, this proration is now calculated for each individual water right or claim based on the remaining water supply available from upstream subwatersheds at its priority or right (see section 2.3.2 above). This is consistent with the refined method of distributing demands between upstream subwatersheds, which is applied to rights and claims outside the Legal Delta. Compared to previous versions of the methodology, this change in Legal Delta proration calculations generally results in more water determined to be available to Legal Delta diverters, an increase in the volume of Legal Delta demand assumed to be met by available supplies, and fewer Legal Delta curtailments.

For example, if the Sacramento River watershed contributed 80 percent of the total watershed supply, the previous watershed-scale analysis would have apportioned 80 percent of each appropriative Legal Delta demand against the Sacramento River watershed's supply and 20 percent against the San Joaquin River watershed's supply. Under the refined analysis, the most senior Legal Delta right would be distributed similar to the same 80-20 split between the Sacramento and San Joaquin watersheds (comprised of a proportional spilt of each of the 20 individual subwatersheds' supplies) because nearly all supplies in the entire watershed are available at the most senior priority. The demands of a more junior water right, however, would only be charged against those tributaries which have remaining supply available at its later priority date.

Legal Delta demand prorations among upstream tributaries are calculated using the exceedance forecast selected for use in determining water unavailability for each subwatershed (see section 3.1.1 below). These supplies include abandoned instream flows in excess of FNF (see section 2.1.6 above) and do not include flows from headwater subwatersheds assumed to be disconnected from the Delta watershed (see section 2.3.2 above).

The proration of Legal Delta appropriative demands is only applicable to the assessment of water unavailability at the watershed scale and does not impact the

assessment of water unavailability at the headwater subwatershed scale. Water rights and claims with points of diversion within the Legal Delta that claim only appropriative water rights will only receive notices of water unavailability or curtailment orders if water is unavailable from all upstream subwatersheds in the watershed-scale analysis at their priority of right; the refined watershed-scale analysis does not impact this assumption. The hydrology of the Legal Delta is complex, and this proration method offers a simplified and generous assessment of water unavailability to appropriators in the Legal Delta during this critically dry period.

Consistent with the analysis contained in State Water Board Order WR 89-8, the methodology assumes that riparian claims do not have access to supply outside the watershed where they are located (i.e., a riparian claim along the San Joaquin River in the Legal Delta does not have a right to divert natural or abandoned flow of water originating from the Sacramento River). Therefore, Statements of Diversion and Use with points of diversion within the Legal Delta that claim only riparian rights are only prorated among supply from tributaries in the watershed where they are located (the Sacramento River watershed includes Putah Creek and the San Joaquin River watershed includes the Stanislaus, Calaveras, Mokelumne, and Cosumnes Rivers). Statements of Diversion and Use with points of diversion in the Legal Delta claiming both riparian rights and pre-1914 or other non-riparian categories of right were assumed for the purposes of the methodology to be riparian claims and were therefore accorded senior priority over all appropriative water rights (see section 2.2.6 above).[32]

Although the methodology has the flexibility to evaluate water unavailability over sub-monthly timesteps to consider short-term precipitation and runoff events, water unavailability analyses for the purpose of issuing curtailments in the Legal Delta are not currently performed on a timestep any shorter than 30 days (i.e., monthly). The methodology does not assume there is supply available longer than a month in the Legal Delta such that water unavailability would be affected based on the analyses discussed in Technical Appendix D. The methodology also only accounts for freshwater natural flows from the Sacramento and San Joaquin Rivers as part of available supplies and does not include any water supplies from tidal inflows to the Legal Delta. Saline water entering the Legal Delta from the San Francisco Bay via tidal action is assumed to be of insufficient quality to be usable for agricultural or municipal purposes. Technical Appendix D explains the technical analysis that supports these assumptions.

[32] This categorization of colorable riparian claims within the Legal Delta is consistent with the legal principles described in a memorandum dated December 15, 2017, regarding Issues Related to Overlap between Pre-1914 and Riparian Water Right Claims in the Legal Delta and available on the website of the Office of the Delta Watermaster (Overlap Memo).

2.4 Water Unavailability Visualizations

The Water Unavailability Methodology includes two major types of water unavailability visualizations: the headwater subwatershed visualizations (17 in total) and watershed-scale visualizations[33] (20 in total, one for each subwatershed). Samples of these graphs are provided below in Figure 11, Figure 12, and Figure 13. Demands in the visualization graphs are sorted by water right priority, with riparian demand at the bottom, followed by pre-1914 appropriative demand and post-1914 appropriative demand, which are grouped by priority decade. Project demands are stacked at the top (see section 2.2.9 above). While previous versions of the visualizations allowed for the selection of different demand datasets from 2018, 2019, or 2018 combined with enhanced reporting of projected demands, due to the complexities of the refined watershed-scale analysis (see section 2.3.3 above) the graphs now only display the single demand analysis used to make curtailment decisions on a given date.

The subwatershed visualization displays four water supply scenarios: the 10%, 50%, 90%, and 99% FNF exceedance forecasts, representing optimistic, neutral, pessimistic, and extremely pessimistic forecasts, respectively. Unless indicated otherwise, these supply forecasts are sourced from CNRFC. When conditions in the Delta watershed were extremely dry, the adjustments to the supply and demand datasets described in section 2.3 above were done using the 90% FNF exceedance forecast.[34] During the wet season when precipitation conditions were dynamically evolving, the 50% FNF exceedance forecast was used. Other scenarios, such as the 75% FNF exceedance forecast, have also been used as appropriate (see section 3.1.1 below). The watershed-wide visualizations display a single supply scenario that has been adjusted to account for disconnection at the subwatershed scale; the sample watershed-wide visualizations in the figures below display adjusted 50% exceedance forecasts.

[33] Supply and demand within the watershed-scale analyses are adjusted as described in section 2.3 above.

[34] Section 3.1.1 below describes how daily FNF may be used to determine which monthly exceedance forecast most closely represents actual conditions. From May through September 2021, the water supply forecasts used in the visualizations were the 90% exceedance forecast from DWR's May B-120. Since October 2021, CNRFC supply forecasts have generally been used due to the lack of B-120 forecasts for fall months and the need for more frequently updated forecasts.

Figure 11. Sample Headwater Subwatershed Water Unavailability Visualization (Yuba River)[35]

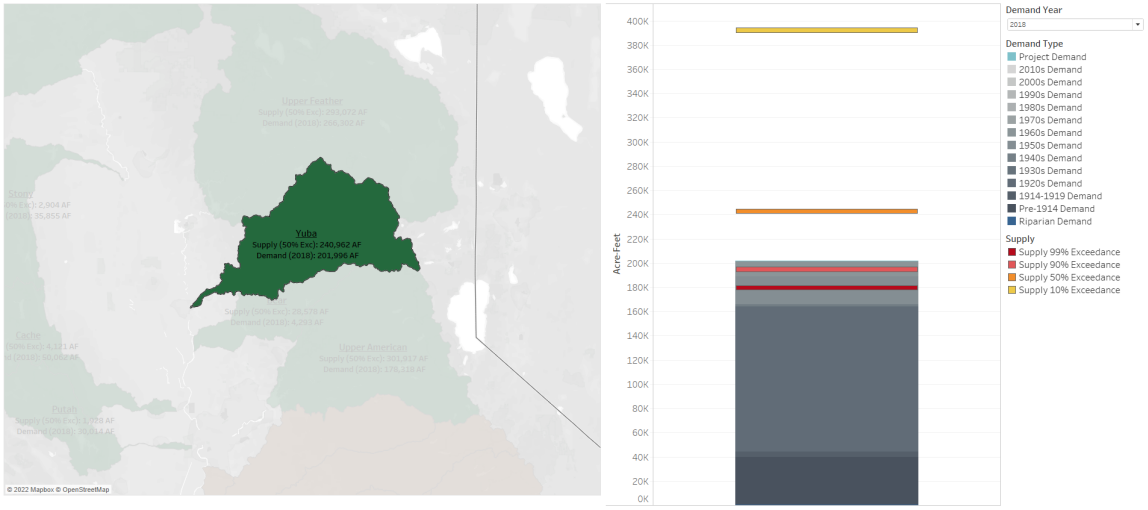
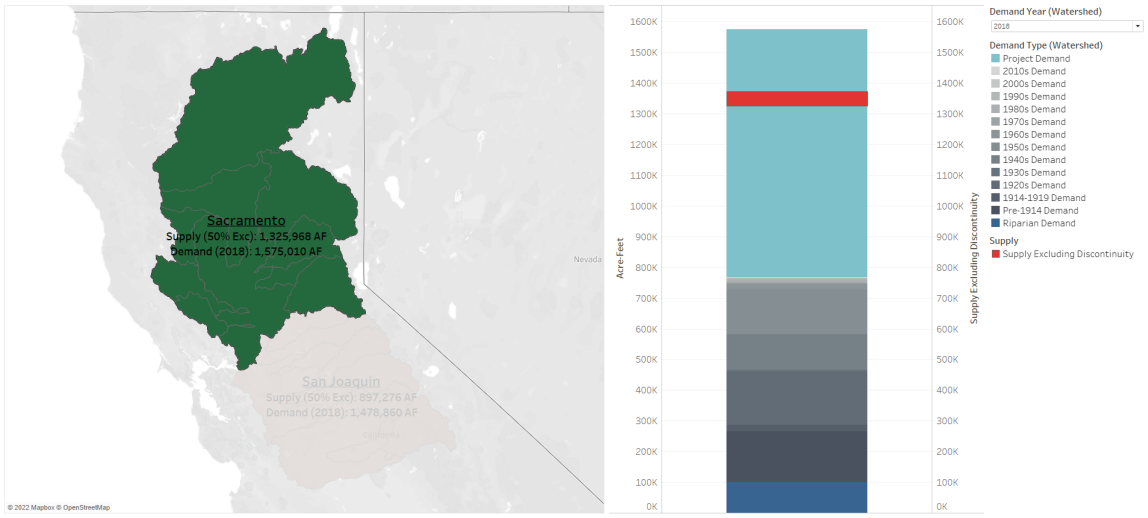
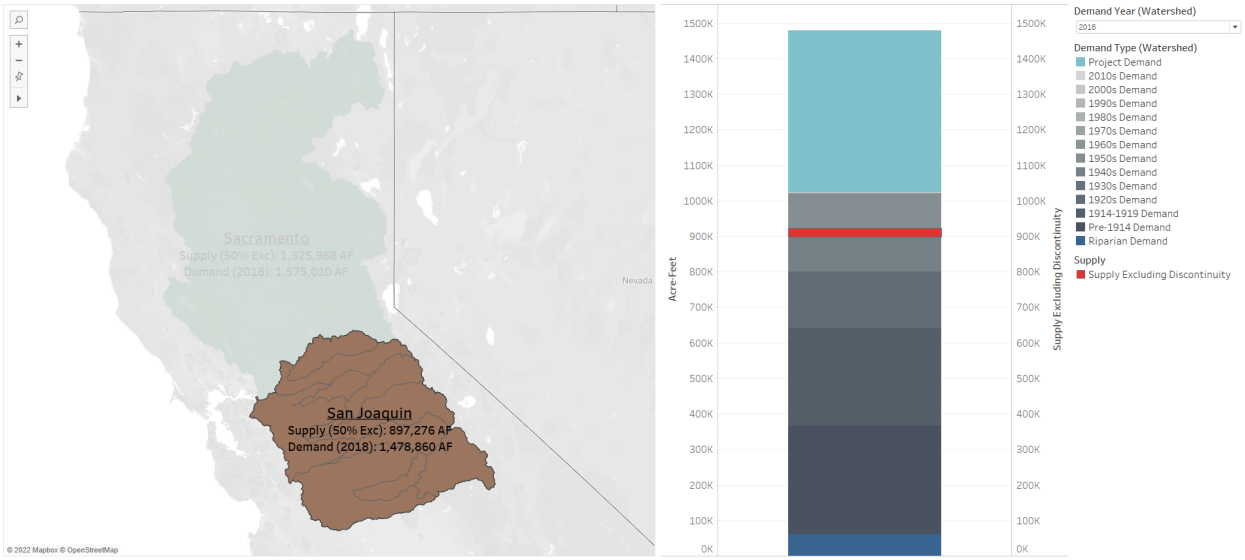


Figure 12. Sample Sacramento River Watershed Water Unavailability Visualization[35]



[35] Figure 11, Figure 12, and Figure 13 show previous versions of the visualizations that do not reflect the removal of Demand Year selection function. These figures will be revised in a future iteration of this report to accurately reflect current capabilities of the Water Unavailability Visualizations.

Figure 13. Sample San Joaquin River Watershed Water Unavailability Visualization[35]



The visualizations have been made available on the Board's Delta Water Unavailability Methodology webpage using the Tableau interactive platform and will be updated to reflect current supply conditions and forecasts. As discussed above, the 2018 demand dataset with available enhanced reporting of projected demands is generally planned to be used to assess if insufficient supply is available to meet demands (i.e., the demands positioned above the applicable supply line(s) in the visualizations). In cases where riparian demand exceeds supply (i.e., in disconnected headwater subwatersheds or for riparian demands above the applicable supply line(s) in the visualization) there may be insufficient water available to meet all riparian demands. Curtailment status updates specify which demand data are used to make curtailment decisions in order to disclose the technical basis of water demand assumptions to water right holders and the public. Section 3.1 below describes the process for issuing notices of water unavailability or curtailment orders to diverters.

3 Implementation

3.1 Issuance of Notices of Water Unavailability and Curtailment Orders

The Water Unavailability Methodology is being used to determine when there is insufficient supply to meet diverters' priorities of right within the Delta watershed based on the best available information, either at the scale of headwater subwatersheds or the broader Sacramento and San Joaquin River watersheds. Based on prior outputs of the methodology, on June 15 and July 23, 2021, the State Water Board issued notices of water unavailability (also referred to simply as "notices") to water right holders and/or

claimants in the Delta watershed indicating that water supplies are not available for their use. Notices, unlike curtailment orders, are not directives to stop diverting. 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.

Given dire water supply conditions in the Delta watershed, on August 20, 2021, based on the output of the methodology and the authority granted to the Board under the emergency regulation, the Board issued curtailment orders to all post-1914 appropriative water right holders in the Delta watershed, many pre-1914 appropriative claimants, as well as some riparian claimants. Unlike notices of water unavailability, curtailment orders are directives to stop diverting. The curtailment orders, which will continue to be updated as conditions change, require affected right holders and claimants to cease diversions when water is not available under a water right holder's or claimant's priority of right unless and until (1) they have authorization to continue diverting pursuant to one of the exceptions enumerated in the regulation or (2) they receive notice that the curtailment order has been temporarily suspended or permanently lifted. In addition, the emergency regulation authorizes the State Water Board to require enhanced reporting from some larger water users to provide additional information on past diversion and use, as well as future projected use. That information is used to inform curtailment decisions and is under evaluation for additional ways it can inform implementation of the emergency regulation in the future.

During exceptionally dry conditions in the fall of 2021, curtailments were issued when the methodology determined that any portion of a water right or claim's demand was unavailable. Due to continued needs to refill storage reservoirs and capture precipitation and snowmelt from short duration events, the methodology was modified on February 7, 2022, to only issue curtailments when zero supply is available to meet a water right or claim's demand (i.e., if any portion of a right's demand can be met by available supply, then it is not curtailed). Curtailments were issued throughout 2022 and to-date when the methodology determined that zero supply was available to meet a water right or claim's demand, particularly during dry conditions in the summer and fall months. Further adjustments may be made to this assumption to reflect limited availability, particularly for larger rights.

In recognition of the provisions of the Coordinated Operations Agreement (COA) between the SWP and CVP that identifies how to distribute available supplies and responsibilities for meeting Delta requirements, curtailments of Project rights are not being implemented when water is found to be unavailable at the watershed scale for only Project rights. Curtailments of these Project rights will be limited to periods of time when the Projects' operations have the potential to injure other water right holders and claimants. That is, at times when any non-Project water rights or claims would be

curtailed, Project rights would still be subject to curtailment. This ensures that curtailments will not interfere with the effective coordination of the Projects pursuant to the COA while also ensuring that other water right holders are not impacted.

As discussed above, appropriative diverters in the Legal Delta will only be curtailed 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. Implementation of this methodology will operate separately from issuance of curtailments pursuant to standard water right Term 91, which was reimposed in June of 2022 and lifted in December 2022.

3.1.1 **Period of Analysis and Exceedance Forecast Selection**

To evaluate water unavailability, water demands are evaluated against an appropriate supply forecast (e.g., 10%, 50%, 90%, or other exceedance forecast) for a specified period of analysis (e.g., 7 days or 31 days). The most appropriate values for these two variables, exceedance forecast and period of analysis, are selected based on the best available data.

During the initial implementation of the Water Unavailability Methodology in summer 2021, a calendar month timestep was used for the analysis due to the relatively stable hydrology at this time of year. As conditions during the fall and winter became more dynamic different analysis periods were applied that had the effect of generally reducing curtailments. This includes a shorter analysis period (7 days) used for curtailments of rights and claims outside the Legal Delta that provided for more dynamic suspension of curtailment orders if forecasted or actual precipitation events were expected to generate sufficient runoff during a particular week. A rolling 31-day future analysis period was also used, which provided for greater suspension of curtailments during the winter and spring. Because the hydrology stabilized in late spring, beginning in June 2022 the Board returned to a calendar month timestep that better reflected the shift from predominately precipitation-driven reservoir storage demands to more static direct diversion demands for agricultural purposes.

Demand values, instream flows, and gap-filling factors used in the analysis are prorated to the same analysis period as supply. Due to issues related to transit times and the duration of supply availability, the issuance of curtailments within the Legal Delta continues to be considered based on an analysis using a monthly (i.e., no shorter than 30 days) timestep. However, shorter term expected precipitation and runoff data can still be considered as appropriate in determining whether to temporarily suspend curtailments in the Legal Delta.

The selected supply data source and analysis period help to inform the selection of the most appropriate exceedance forecast for the analysis. For example, CNRFC forecasts have the highest confidence in predicting precipitation and resulting runoff within the next 7 days. Within those 7 days there is a possibility of outlying conditions (i.e., a particularly strong or weak precipitation event), but a median forecast (50%

exceedance) is expected to be the most likely predictor of supply over that period. The use of CNRFC forecasts, which are updated daily, also incorporates observed and forecasted conditions that may affect water supplies in the future. These include precipitation (or a lack thereof), snowpack levels, temperature changes that may cause snowmelt, antecedent soil moisture conditions, wind, and other factors.

Over longer periods, general climatic trends have a greater influence over the forecast. Therefore, for a longer analysis period during a critically dry year, a drier forecast such as the 75% or 90% exceedance forecast may be more appropriate. It may also be appropriate to select a higher exceedance when using a forecast that is updated less frequently or looks several months into the future, such as DWR's B-120. During the initial implementation of the Water Unavailability Methodology in summer 2021, a 90% exceedance supply forecast was used for the analysis because the most recent B-120 forecasts had been issued several months earlier in May 2021 and conditions had generally become drier since that time.

Weekly curtailment status updates from the Board have described the exceedance forecast and averaging period used in analyses informing curtailment updates. As described above, earlier updates used calendar month periods of analysis. Due to variable conditions throughout the Delta watershed, different exceedance forecasts may be used for the Sacramento River watershed, the San Joaquin River watershed, and individual subwatersheds, if appropriate.

Additional available datasets that may be used to monitor and forecast precipitation and runoff include qualitative Area Forecast or Hydrometeorological Discussions from NOAA and CNRFC, Quantitative Precipitation Forecasts (QPF) from CNRFC, Atmospheric River (AR) Activity sub-seasonal outlooks from the Center for Western Weather and Water Extremes, use of the USGS Basin Characterization Model, and other tools.

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.).[36] Currently, notices of water unavailability or curtailment orders 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.

[36] 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. 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. Since that time, modifications have been made to the methodology to support the determination of water unavailability for water right holders and claimants in the Delta watershed. These changes are described throughout this document, as well as its technical appendices.

This version of the report includes report updates in response to topics raised during the October 20, 2021 technical staff workshop, those raised in petitions for reconsideration of the August 20, 2021 curtailment and reporting orders, information and input provided during the May 12, 2022 staff workshop and corresponding written comment period ending May 19, 2022, and information and input provided during the November 9, 2022 staff workshop and corresponding written comment period ending November 16, 2022 (see section 1.6).

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 as needed to address other issues. The methodology itself may also change as appropriate to address issues that may arise. Regular updates regarding issues related to water unavailability will be provided to the public during Board meetings. Regular updates will also be provided on the Board's Delta Drought and Delta Water Unavailability Methodology webpages, including updated water unavailability visualizations.

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 the 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. As discussed above, projected demands and prior diversions submitted pursuant to the Enhanced Reporting requirements of the emergency regulation are being used in the methodology and may inform further adjustments to demand assumptions. 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 Legal Delta for lands below sea level, as described in the emergency regulation.

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 demand aggregation method (see section 2.2.8 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 is 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 diversion measurement 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 diversions and transitioning to land use-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 data of adequate quality.

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Technical Appendix A

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

Technical Appendix D

Technical Appendix D: Assessment of Water Unavailability Issues within the Legal Delta is available on the Delta Water Unavailability Methodology webpage at https://www.waterboards.ca.gov/drought/drought_tools_methods/delta_method.html