Water Commission's Meetings

NOTICE OF TEMPORARY PROCEDURES FOR THE

WATER COMMISSION MEETINGS

On March 17, 2020, California Governor Gavin Newsom issued Executive Order N-29-20, relating to the convening of public meetings in light of the COVID-19 pandemic. The County of Tulare hereby provides notice that it will continue to convene its regularly scheduled public meetings of the Water Commission in the BOS Conference Rooms A&B at 2800 W. Burrel Ave, Visalia, as provided in the publicly posted agenda notice, and until further notice.

Based on guidance from the California Department of Public Health and the California Governor's Office, to minimize the spread of the COVID-19 virus, members of the public are encouraged to participate in the Board meetings in the following ways:

1. REMOTE VIEWING: Listen to the live audio stream of the Water Commission meeting at

Join Zoom Meeting

https://tularecounty-ca.zoom.us/j/97308676203?pwd=bm9tZURaa09kb2FNVnFUSDJOVXlUUT09

Meeting ID: 973 0867 6203
Passcode: 599334

+1 669 900 9128 US (San Jose)

Meeting ID: 973 0867 6203

Passcode: 599334

2. PUBLIC COMMENT: If you choose not to attend the Water Commission meeting but wish to comment on a specific agenda item we have the following options available:

a. Submit written comments on an agenda item to the Clerk of the Water Commission at DEngland@ tularecounty.ca.gov for distribution to the Water Commission before the meeting. If you would like to support, oppose, or otherwise comment on a Water Commission' agenda item, please consider sending in your comment rather than attending the meeting in person. All communication, whether it is a formal letter or a one-line informal email, is read by the Water Commission. Also, if you are part of a large group that would like to comment on an agenda item, please consider commenting in writing or sending one spokesperson to speak on behalf of the group.

Written comments may also be submitted by U.S. mail, at:

Tulare County Administrative Office

c/o Clerk of the Water Commission

2800 W. Burrel Ave.

Visalia, CA 93291

b. To participate during the Water Commission meeting, please call (559) 636-5000. Each caller will, one at a time, be connected to the Board room to address the Commission in the same manner as if the caller were there in person. The caller will be requested to state his or her name and address for the record, and the caller's statements will go through the PA system in order to be heard by everyone in the room. The statements will go out on the live audio stream. The three (3) minute limit will apply to all public comments.

c. Alternatively, you may participate during the Commission meeting by submitting an email as the item is being heard. Emails should include the sender's name and address for the record. Emails should include the agenda item number and sent to the Clerk of the Water Commission at DEngland@ tularecounty.ca.gov. Every effort will be made to read your comment into the record, but some comments may not be read due to time limitations. Comments received after an agenda item will be made part of the record if received before the end of the meeting.

d. If you attend the Water Commission meeting in person, all attendees will be requested to engage in social distancing measures by maintaining a 6-foot distance from other attendees. Exposed surfaces will be sanitized prior to the meeting and attendees are encouraged to avoid contact with surfaces such as microphones and door handles. Large groups wishing to comment on a common item are encouraged to submit comments in writing or to send one spokesperson to speak on behalf of the group.

Water Commission February 8, 2021 can be viewed live through Zoom. Click here to join the Water Commission Live Stream:

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+1 669 900 9128 US (San Jose)

Meeting ID: 973 0867 6203

Passcode: 599334

TULARE COUNTY WATER COMMISSION
3:00 p.m. on Monday, May 10, 2021
BOARD OF SUPERVISORS CONFERENCE ROOM A&B
ZOOM
2800 W. BURREL AVE.
VISALIA, CALIFORNIA 93291

NOTICE TO THE PUBLIC
PUBLIC COMMENT PERIOD

At this time, members of the public may comment on any item not appearing on the agenda. Under state law, matters presented under this item cannot be discussed or acted upon by the Water Commission at this time. For items appearing on the agenda, the public is invited to make comments at the time the item comes up for the Water Commission's consideration. Any person addressing the Water Commission will be limited to a maximum of three (3) minutes so that all interested parties have an opportunity to speak. At all times, please use the microphone and state your name and address for the record.

AGENDA

1. Call to Order
2. Public Comment Period
3. Approve March 8, 2021 Minutes; April 12, 2021 Minutes (Action Item)
4. Annual Re-organization of the Water Commission (Discussion, Possible Action)
    a. Vice Chair
    b. Secretary
5. Subcommittee Appointments (Discussion, Possible Action)
6. State Water Resources Control Board Water Rights and Climate Change Report (Discussion, Possible Action)
7. Drought Response (Discussion, Possible Action)
8. Subcommittee Reports
    a. Review Legislation (Discussion, Possible Action)
9. Staff Reports (Discussion, Possible Action)
    a. Tulare-Kern DACII Program
    b. SGMA Implementation
    c. Water Commission Vacancies
    d. Form 700 and Ethics Certification
10. Commissioners' Comments
11. Future Agenda Topics
12. Next meeting – Monday, June 14, 2021
13. Adjourn

Tulare County Water Commission Contact: Denise England, staff (559) 636-5000
Tulare County Water Commission website: https://tularecounty.ca.gov/board/index.cfm/committees-commissions/water-commission

Documents related to the items on this Agenda, submitted to the Board after distribution of the Agenda packet, are available for public inspection in the Board of Supervisors Office, 2800 W. Burrel Avenue, Visalia, CA during normal business hours. Such documents are also available online, subject to staff's ability to post the documents before the meeting, at the following website: https://tularecounty.ca.gov/board/index.cfm/committees-commissions/water-commission

As a courtesy to those in attendance, please turn off or place in alert mode all cell phones and pagers.

In compliance with the Americans with Disabilities Act, if you need special assistance to participate in this meeting, please contact the Clerk of the Board's Office at (559) 636-5000

TULARE COUNTY WATER COMMISSION
3:00 p.m. on Monday, April 12, 2021
MEETING NOTES

Members Present:
Pete Vander Poel, Board Representative and Chairman
Martha Flores, TCAG Representative
Chad Wegley, District 4 Appointee*Audio Only
Steve Etchegaray, District 5 Appointee
Paul Boyer, At-Large Appointee

Members Absent:
Dennis Townsend, Board Alternate
Zack Stuller, District 1 Appointee
Eric Quinley, District 2 Appointee
Tamara Kelly, District 3 Appointee
Dominic Fino, At-Large Appointee
Mike Lane, At-Large Appointee

Staff Present:
Denise England, Tulare County Administration Office
Marit Erickson, Tulare County Counsel
Bob Irvine, TCiCT

Members of the Public Present:
Pat Pinkham Shane Smith Tricia Stever Blattler
Michael Prado

Due to technical difficulties some meeting attendees were unable to join the virtual meeting or only participate via listen-only audio

1. Call to Order
   Chairman Vander Poel called the meeting to order at 3:02 pm.

2. Public Comment Period
   Karen Johannes asked the Commission to revisit groundwater exportation.

3. Approve March 8, 2021 minutes
   Due to a lack of quorum, the minutes were tabled for the next meeting.

4. State Water Resources Control Board Water Rights and Climate Change Report
   Commissioner Lane requested this item be added to the agenda. In his absence, the Commission decided to table this item for the next meeting.

5. The American Rescue Plan Act Sewer and Water Infrastructure Opportunity
   Denise England provided an overview of the opportunity. She explained that Tulare County will receive $90 million dollars as part of the Act. A portion of that may be used for sewer and water infrastructure projects. She went on to explain the County may prioritize projects that are shovel-ready and reduce drought risk, address a long-term need, or leverage other funding sources. She asked the Commission to provide potential projects. She explained the County Administrative Officer and the Board of Supervisors would make the final determination on total dollar amount for these types of projects.

   Commissioner Boyer commented regarding NEPA and advised the county to seek clarification and possible exemption for projects. He also mentioned the Plainview Sewer project as a potential project for funding.

6. Subcommittee Reports
   a. Legislation
      Denise England indicated a Letter of Support for SB 559 (Hurtado), the Friant Kern Canal Fund, was requested by the Senator's office. She indicated she would be processing a letter for Board of Supervisors' signature.

7. Staff Reports
    a. Tulare-Kern DACII Program
    Denise England reported the Program received an extension to the grant agreement with a new term date of September 30, 2021. She reported the next PAC meeting will be Thursday, April 14th at 9:00 AM.

    b. SGMA Implementation
    There were no SGMA updates.

    c. Form 700
    Ms. England reminded the Commissioners, if not already filed, their Form 700s were due April 1, 2021.

    d. AB 1234 Ethics Training
    Ms. England reminded Commissioners to complete their AB 1234 Ethics training.

8. Commissioners Comments
    Commissioner Boyer gave farewell comments as his tenure on the Water Commission came to a close, following his retirement. He commended Tulare County and the Water Commission for the good work done on behalf of disadvantaged communities. He praised the Board of Supervisors for their balanced approach addressing water needs.

    Chairman Vander Poel thanked Commissioner Boyer for his service on the Water Commission and conveyed his appreciation for Commissioner Boyer's approach to disadvantage community water challenges.

9. Future Agenda Topics-
Groundater exportation

10. Next meeting – Monday, May 10, 2021 3:00 PM

11. Adjourn
The meeting adjourned at 3:26 pm

Documents related to the items on this Agenda, submitted to the Board after distribution of the Agenda packet, are available for public inspection in the Board of Supervisors Office, 2800 W. Burrel Avenue, Visalia, CA during normal business hours. Such documents are also available online, subject to staff's ability to post the documents before the meeting, at the following website: https://tularecounty.ca.gov/board/index.cfm/committees-commissions/water-commission

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STAFF REPORT

Recommendations for an Effective Water Rights Response to Climate Change

Identification of Data Needs and Recommendations to Incorporate Climate Change into Water Rights Permitting Policies, Procedures, and Methodologies

February 2021

Division of Water Rights
State Water Resources Control Board
California Environmental Protection Agency

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS



State of California
Gavin Newsom, *Governor*

California Environmental Protection Agency
Jared Blumenfeld, *Secretary*

State Water Resources Control Board
1001 I Street
Sacramento CA 95814
http://www.waterboards.ca.gov

E. Joaquin Esquivel, *Chair*
Dorene D'Adamo, *Vice Chair*
Tam M. Doduc, *Board Member*
Laurel Firestone, *Board Member*
Sean Maguire, *Board Member*
Eileen Sobeck, *Executive Director*

Division of Water Rights
Erik Ekdahl, *Deputy Director*

Prepared By:
Jelena Hartman, *Senior Environmental Scientist (Specialist)*
Jimmy Steele, *Water Resources Control Engineer*
Scott Frazier, *Senior Environmental Scientist*
Amanda Montgomery, *Environmental Program Manager*

Acknowledgments
Michael Anderson (California State Climatologist), Wyatt Arnold, David Arrate and Romain Maendly (Department of Water Resources), Nell Green Nylen (Center for Law, Energy & the Environment at UC Berkeley), John Callaway, Louise Conrad and Andrew Schwarz (Delta Stewardship Council) reviewed and contributed to various sections of the report.

Table of Contents

Table of Contents 2
Executive Summary 3
1 Introduction 4
2 Water Rights Overview 5
2.1 Water Rights Permitting 6
3 Permitting Water Availability Analysis 7
3.1 Supply: Unimpaired Flow 7
3.2 Demand: Senior Water Diversions 8
3.3 Demand: Instream Needs and Cumulative Impacts 9
3.4 Yield Analysis 10
4 Climate Change and California's Water 11
4.1 Temperature 12
4.2 Precipitation 13
4.3 Snowpack 13
4.4 Timing and Nature of Runoff 14
4.5 Fish and Wildlife Habitat 15
5 Select Models and Data for California 16
5.1 Resources for Groundwater Sustainability and Flood Management 16
5.2 California's Fourth Climate Change Assessment 18
5.3 Estimating Impacts on a Finer Scale 18
6 Challenges and Opportunities in Managing for the Future 19
6.1 Long-Term Shifts in Hydrologic Trends 19
6.2 Changing Runoff Patterns 21
6.3 Amplified Hydrologic Extremes 22
7 Recommendations 24
8 References 28

This report and associated resources are available on the State Water Board's webpage:
https://www.waterboards.ca.gov/waterrights/water_issues/programs/climate_change/

Executive Summary

This report identifies data needs, opportunities, and potential approaches for an effective water rights response to climate change. California's climate is changing rapidly, and historic data are no longer a reliable guide to future conditions. Regarding changes projected for California, the uncertainty lies only in the magnitude of warming, but not in whether warming will occur. Models indicate that due to warming alone, California will see less of its precipitation fall as snow, which will result in diminished mountain snow pack, less snow in lower and intermediate elevations, and less "natural water storage" in the form of snow. The wet season is projected to become wetter, and the dry season will become longer and drier.

Anyone planning to take water from a lake, river, stream, or creek for a beneficial use requires a water right of some type. California law requires that every application to appropriate surface water demonstrate a reasonable likelihood that unappropriated water is available to supply the applicant. Hence, parties interested in obtaining an appropriative water right must conduct a permitting water availability analysis as part of the permitting process. Generally, water availability for permitting is calculated by estimating the amount of unimpaired flow in a stream during the diversion season, and subtracting the demand of all senior diversions and the demand for instream needs.

Permitting water availability analyses are typically based on historical data sets. However, historical precipitation and streamflow records for the majority of the watersheds in California may not be sufficiently long to capture the full range of hydrologic variability needed to evaluate future available water supply. In addition, rising temperatures and changing precipitation patterns will affect hydrology, making future water availability increasingly difficult to reliably estimate.

Staff recommendations in this report offer a menu of options to make water rights permitting analysis more robust, and to support applicants in developing projects that will remain feasible in the future. The report concludes with a set of recommendations, which include actions to:

- Leverage existing climate change data in permitting water availability analyses
- Develop adaptive permit terms in new permits
- Implement tiered requirements for climate change analysis in permitting, with complexity based on categories such as size, location and/or project type
- Develop a fact sheet for water right applicants to incorporate climate change
- Strengthen the minimum period of record requirement for streamflow data
- Require more rigorous analytical methods to estimate supply when gage data are not available
- Expand existing network of stream and precipitation gages
- Reevaluate the existing instream flow metrics and criteria
- Revise the Fully Appropriated Stream list
- Prepare for and capitalize on capturing flood flows and storing them underground
- Plan for droughts
- Coordinate with other agencies and partners

1 Introduction

California is already experiencing the impacts of climate change, which will continue and increase over the coming decades. Current and future impacts include increasing frequency and intensity of extreme weather events, prolonged fire seasons with larger fires, increased tree mortality, heat waves, rising sea level, and storm surges. Among changes in hydrology are declining snowpack, with more precipitation falling as rain than snow, earlier snow melt, changes in the timing and volume of peak runoff, more frequent and more severe flooding, more frequent and longer droughts, and consequent impacts on water quality and water availability (Moser et al 2012, Pierce et al. 2018).

The State has taken bold action to limit the effects of climate change by enacting policies and programs to reduce emissions of greenhouse gases, both in California and in partnership with other states and countries. However, even with the most successful efforts to reduce greenhouse gas emissions, some amount of change is inevitable. Facing the threat of greater scarcity of water supplies, increased water demand, and limited water supply reliability, the State has increased focus on actions to build resilience and meet California's water needs through the 21st century.

The State Water Resources Control Board (State Water Board) has taken a variety of actions to respond to climate change. Examples include funding the expansion of recycled water to increase drought resilience, adopting regulations to increase the collection of urban storm water, and reducing flood risk and enhancing water supply. Some of the actions that increase resilience of water supply and of ecosystems, such as water conservation and efficiency, and recycled water use, also have the potential to reduce greenhouse gas emissions through replacement of existing or future water supply sources that have higher carbon footprints (Sokolow et al. 2016).

Recognizing that the implications to California's water resources due to climate change are significant, the State Water Board adopted Resolution No. 2017-0012 "Comprehensive Response to Climate Change" (State Water Board 2017b). The resolution provides direction to staff to embed climate change consideration into all programs and activities, including the need to evaluate and make recommendations on regulatory and policy changes regarding the use of models to account for projected impacts of climate change when conducting water rights water availability analyses.

The Administration's 2020 Water Resilience Portfolio outlines a vision of water management to support long-term water resilience and ecosystem health, and to build climate adaptability that works for people, the environment, and the economy. Among the suite of recommendations to strengthen regional preparedness are planning for a range of climate and growth scenarios, and incorporating climate change forecasts into permitting processes.

This report embraces and complements the vision of a resilient water system in the face of changing climate, and presents staff recommendations to make permitting water availability analysis more robust, and actions that could support an effective response to climate change within the existing water rights framework in California. The report provides an overview of California's system of water rights, and general principles of water availability analysis for

water right permitting. The report then summarizes existing information on projected climate change impacts on California's water resources, and discusses potential challenges and opportunities that climate change poses for administering the water rights system. Finally, the report identifies a range of approaches to respond, individually or in combination, to climate change, including how existing information and available data can inform water rights permitting processes, and aid applicants in selecting appropriate season, rate, and quantity of proposed diversions. The list of staff recommendations in not exhaustive, and stakeholders may propose other options not listed in this report.

2 Water Rights Overview

In California, the State Water Board administers water rights law that is intended to ensure that surface water resources are put to the fullest extent to which they are capable in the interest of the people and for public welfare, that waste and unreasonable use of the water be prevented, and that water is conserved. Within the State Water Board, the Division of Water Rights manages day-to-day matters, including permitting, development of criteria for instream flow metrics, tracking water availability in stream systems, enforcement of the water right priority system, and protection of public trust resources including fisheries and water quality standards.

A water right is legal permission to divert and use a reasonable amount of water, which must be put to a beneficial use. Anyone planning to take water from a lake, river, stream, creek, or a subterranean stream requires a water right of some type. In water rights, "beneficial use" refers to the useful purpose to which water is applied. Common beneficial uses include domestic, irrigation, power generation, municipal, and industrial uses. Groundwater recharge is not a beneficial use of water on its own, but rather is one method of storing water.

Water rights in California are based on a priority system that is used to determine who can continue taking water when there is not enough water to supply all needs. The priority status of a water right is particularly important during a drought, when some water right holders may be required to stop diverting water according to the priority of their water right. Suspension of right to withdraw water when there is not sufficient water in the system is implemented through curtailments.

The two major kinds of surface water rights in California are riparian rights, which generally come with land bordering a water source, and appropriative rights. A riparian right is usually based on ownership of land bordering a lake, river, stream, or creek, and generally has a higher priority than appropriative rights. Riparian owners may use natural flows directly for beneficial purposes on riparian land and generally report their claimed use by filing of a statement; however, riparian right holders cannot store water during a wet time for use during a drier time. In general, riparian rights are of equal priority to other riparian rights, and must share available supplies among themselves during times of water shortage.

An appropriative right allows water diversion for use on either non-riparian or riparian land, and carries a priority in relation to other appropriative rights. Appropriative rights are based on a "first in time, first in right" approach. This means the user is entitled to the full quantity of water specified under the right before junior appropriators may exercise their rights. Since 1914, the State Water Board (or its predecessor) has been the exclusive agency for establishing an appropriative water right, with priority of right based on the date an application form is filed.

2.1 Water Rights Permitting

Any person or entity that seeks to divert and beneficially use a reasonable amount of surface water may file an application to divert and use water by permit. A water right permit is an authorization to develop a water diversion and use project; it specifies the quantity, a rate of diversion, season of diversion, where, and how water will be taken and used, and other conditions such as terms to protect instream flows. While a permit authorizes a water diversion project, the right to use water is obtained through actual use within the limits described in the permit. The water right license is a vested right that confirms actual diversion and use after a permitted project was constructed, and water was beneficially used in compliance with all conditions in the permit.

Developing an application is one of the key steps for a party interested in seeking a water right, and it is critical that appropriate season, rate, and quantity of proposed diversions are requested at the time of application. Once a party has submitted a water right application, the proposed season of diversion, rate, and quantity requested may not be increased (Cal. Code Regs, tit. 23, section 699).

In deciding whether to issue permits, the State Water Board considers the features and needs of the proposed project, all existing and pending rights, and instream needs to determine whether water is available for appropriation. The State Water Board must make a finding that there is unappropriated water to supply the applicant. This finding is made by relying on the water availability analysis and other information developed during application processing. Notably, there are cases when applications are not accepted or permits are denied:

- The State Water Board will not issue a water right permit if the proposed project is not in the public interest, or if the proposed project unreasonably harms fish, wildlife, the environment, or water quality.
- The State Water Board is precluded from accepting applications for new water rights in a stream system designated as fully appropriated, unless the designation allows new applications under specified conditions. Fully appropriated stream (FAS) systems are those where there is insufficient supply for new water right applications. Streams can be fully appropriated seasonally or all year. The State Water Board has adopted a formal FAS Declaration that defines the critical reaches of each fully appropriated stream system, including the seasons in which water is unavailable for appropriation (State Water Board 1998).
- The State Water Board will not issue a permit for a water right unless there is water available for appropriation. Even if a stream is not on the Fully Appropriated Streams List, water may not be available for appropriation. California law requires that every application for a water right permit set forth sufficient information to demonstrate a reasonable likelihood that “unappropriated” (unclaimed) water is available to supply the applicant (Water Code, section 1260 (k)). The complexity of the initial showing depends on project specifics, such as project size, instream resources of the source stream, amount requested compared to estimated supply, and existing impairment in the watershed. An applicant generally conducts a more detailed permitting water availability analysis during application processing. That detailed analysis usually

considers the water needs of both instream uses, such as fisheries and recreation (Water Code, section 1243), and senior right holders.

Text Box 1: Summary of Pending Water Right Applications

According to the State Water Board's Electronic Water Rights Information Management System (eWRIMS), there are currently 349 pending applications for appropriative water rights, excluding a subset called "state filed applications".

The total combined face value of the 349 pending applications is 11.2 million acre-feet annually. While a significant amount is being requested for future appropriation, the vast majority of requested water by volume comes from just a few applications. In total, 16 percent of the pending applications account for 99.8 percent of the requested water volume. Most water right applications are for relatively small amounts of water. The distribution of pending water right applications by size is an important consideration as the State Water Board moves forward in its efforts to incorporate climate change into water rights permitting process.

Table 1. Pending Appropriative Water Right Applications (September 2020)

Application Face Value (acre-feet per year)	Number of Applications	Combined Face Value (acre-feet per year)	Percent of Total Volume Applied For (all pending applications)
< 1,000	293	27,626	0.2%
≥1,000	56	11,212,681	99.8%
Total	**349**	**11,240,306**	**100%**

3 Permitting Water Availability Analysis

Permitting water availability analyses generally are comprised of two major steps: estimating unimpaired flow, and accounting for demands for senior diverters and instream needs. The State Water Board determines the sufficiency of water availability analysis and technical approach on a project-specific basis.

While there are no statewide guidelines or established requirements for each step, the analysis must include multiple locations (i.e., points of interest) along the flow path between a proposed project and the downstream limit of the analysis (such as a bay or ocean). Complicated watersheds may require hydrologic modeling to determine whether water is available for appropriation. For example, in the Sacramento-San Joaquin River Delta (Delta) watershed, a robust hydrologic modeling tool may be necessary to estimate flows, exports, reservoir storage, deliveries, and other parameters to properly evaluate flow-availability relationships.

3.1 Supply: Unimpaired Flow

The first part of the analysis is to estimate the unimpaired flow, i.e. the amount of water that would flow down a stream if there were no diversions in the watershed. Applicants may use a number of methods to estimate the amount of unimpaired flow at proposed points of diversion, and other locations downstream. Typically, these methods rely on historical stream gage and precipitation data, which can be available on a daily, monthly, or a seasonal time step. While

permitting water availability analyses often use all years of an available record, there is no set requirement for the length of record considered sufficient for a rigorous water availability analysis. The exception is the region covered by the Policy for Maintaining Instream Flows in Northern California Coastal Streams (i.e., North Coast Instream Flows Policy), where a water availability analysis must include at least ten water years of complete record of daily streamflows (State Water Board 2014a).

The current preferred method to estimate supply uses stream gage data. Often, in a gaged stream system, the gage is not at the exact location of a proposed project. For example, a projects may be in the upper watershed, draining into a gaged location. Practitioners commonly use the adjustment of stream records method, which estimates streamflow for a site of interest by adjusting stream gage data from an alternative, typically downstream, location. The alternative site's gage data are typically adjusted to account for differences in drainage area and precipitation at the point of diversion compared to the gage location (State Water Board 2002).

However, fewer than 15 percent of the state's significant stream segments are well gaged (The Nature Conservancy 2018). When gage data are unavailable for a stream system, applicants can use modeling to estimate supply. Two commonly used methods to estimate average seasonal unimpaired flow in a stream system that is not gaged include:

- Reference stream gage with adjustment of streamflow records. This method transfers streamflow properties from a nearby reference gage to an ungaged site with similar watershed characteristics. The water right applicant must provide sufficient justification for the reference gage selection. Reference gage streamflow data are adjusted to account for differences in drainage area and precipitation at the reference site and the site of interest to generate a representative hydrograph (State Water Board 2002).
- Precipitation-based streamflow models. This approach, also known as rainfall-runoff models (Sitterson et al. 2017), uses precipitation data and watershed characteristics (relief, soil saturation, vegetal cover, and surface storage) to estimate runoff (i.e., streamflow) for a particular watershed area. This method is rarely used but may be appropriate if a paired reference stream gage cannot be identified. It could also be appropriate if the watershed has a robust methodology in place for unimpaired flow, such as estimates generated by California Department of Water Resources (2016).

3.2 Demand: Senior Water Diversions

The second part of the permitting water availability analysis is to estimate the existing water demand on an applicant's proposed water source. To determine whether the proposed diversion would impact senior diverters downstream, applicants must evaluate the cumulative demand of all senior diversions (both right holders, and pending water rights along the flow path between the proposed project and the downstream limit of the analysis) against unimpaired flow estimates.

Applicants rely on data in the Electronic Water Right Information System (eWRIMS) to assess senior water demand. The eWRIMS database compiles water rights information in California, such as face-value (the maximum amount of water authorized for diversion) and use information for permits, licenses, registrations, and other authorized diversions, and the annual

reports of actual diversion and use by all water right holders. Water demand data in eWRIMS have limitations which may affect the accuracy of the analysis. Some of the limitations involve reporting errors, data quality, and accounting for water diversions reported under multiple rights such as claimed overlapping rights (State Water Board 2015b).

Measurement and reporting regulation adopted by the State Water Board in 2016 (State Water Board 2016b) may, over time, improve some of the data issues related to actual water diversion and use by setting requirements related to monitoring frequency, accuracy of measurement devices, and annual reporting. The measurement requirements apply to all water rights that divert more than ten acre-feet of water per year, and the annual reporting requirements apply to all diversions. However, the eWRIMS data system lacks modern tools that would help prevent submission of inaccurate or poor-quality data. Substantial improvements or replacement of the system would be needed to ensure submission of accurate and high-quality data.

Text Box 2: Water Supply Report

Water right applicants within the geographic scope of the Policy for Maintaining Instream Flows in Northern California Coastal Streams must complete an analysis called a Water Supply Report (State Water Board 2014a). The Water Supply Report must include a set of flow frequency analyses, and quantify the amount of unappropriated water supply remaining instream after senior rights are accounted for to determine if sufficient amount of water is likely available to the proposed project. Daily data from a streamflow gage with at least ten years of record are required for the analysis, and the demand and season of all senior water right applicants, holders, and claimants must be accounted for. The Water Supply Report approach is not required in areas outside of the North Coast Policy area, although the methodology is typically provided as guidance for projects in other parts of California. The Water Supply Report may not be an appropriate approach in complicated watersheds where watershed specific modeling may be needed (such as the Bay Delta watershed).

3.3 Demand: Instream Needs and Cumulative Impacts

Consideration of instream needs is a critical component in the development of a permitting water availability analysis. The State Water Board is required to take into account, whenever it is in the public interest, the amount of water required for recreation and preservation of fish and wildlife resources. Even if an applicant can demonstrate that there is unappropriated water after accounting for senior diversions, that water may not be available for appropriation if the proposed diversion could impact fish and other aquatic and riparian species.

During water availability analysis, cumulative impacts are typically assessed at the project location and at various locations downstream. The results of these assessments often lead to terms and conditions in a water right permit that limit the timing, rate, and amount of diversion for the protection of the hydrograph and instream resources. For example, terms can set minimum bypass flows before water can be diverted, restrict the diversion season, and/or preserve portions of peak flows needed for channel maintenance. Water may not be available for appropriation in cases where the proposed project, in combination with senior diversions, significantly affects instream flows and/or affects aquatic and riparian species.

Only limited areas of California have a set of site-specific instream flow standards for the protection of instream beneficial uses. As a consequence, most watersheds in California have no established metrics that the cumulative impacts of diversions can be measured against. In the absence of site- or watershed-specific flow standards, parties pursuing projects may review if other permitting projects in their stream system have developed information that may be adapted to their project. Otherwise, parties need to develop site-specific information for their project. Developing site-specific criteria may involve consultation with fisheries agencies, modeling and/or field study, and results in a customized approach to criteria and testing of the criteria in an assessment of cumulative impacts.

Text Box 3: Instream Flow Standards

Water right applicants in areas covered by the Policy for Maintaining Instream Flows in Northern California Coastal Streams (North Coast Instream Flow Policy) generally complete a Cumulative Diversion Analysis as part of their application. The Cumulative Diversion Analysis evaluates the effects of a proposed project, in combination with existing diversions, on instream flows needed for protection of anadromous fish. Three criteria restrict the timing and amount of flow diverted by limiting the season of diversion, establishing minimum bypass flows, and limiting the maximum cumulative rate of diversion from a watershed. Water right applicants are able to use regional protective instream flow criteria, or may choose to develop site-specific criteria to evaluate whether a proposed project, in combination with senior diversions, adversely affects instream flows needed for the protection of fishery resources.

Regional criteria provide an avenue for quicker processing of applications, without the need to conduct costly site-specific fishery studies. The regionally protective season of diversion runs from December 15 through March 31, restricting new diversions to the period of highest winter flows when impacts of water withdrawals are minimized. Regionally protective minimum bypass criterion sets the minimum instantaneous flow rate that must be moving past the point of diversion before water may be diverted. The regionally protective maximum cumulative diversion criterion limits cumulative rate of all diversions in a watershed in order to preserve natural flow variability and effective channel maintenance flows to meet the habitat needs of anadromous salmonids. In other words, water may only be extracted once instream flows exceed the minimum bypass flow, and only up to the point when the sum of the rates of diversion for diverters within a watershed reaches the maximum cumulative diversion criterion (5 percent of the 1.5-year instantaneous peak flow).

In another example, diversions associated with cannabis cultivation operations are only permitted when sufficient instream flows are available. To evaluate if water is available, cannabis cultivators must comply with either existing instream flow requirements, or the Tessmann instream flow requirements, whichever is greater (State Water Board 2017a). In general, during the wet season, the Tessmann Method compares 40 percent of the mean monthly natural flow to 40 percent of the mean annual flow; the resulting instream flow requirement for any given month is the greater of the two.

3.4 Yield Analysis

As a final step, parties may conduct a yield analysis to project how much water will be available to supply their project, after accounting for senior diverter and instream needs at the

point of diversion and along the flow path. Year to year flow tends be highly variable on many streams due to California's Mediterranean climate, especially streams that are rain fed. For example, for a project with a small source watershed or where there is significant downstream demand, there may be enough flow to fully supply the project in a wet year, but only enough flow to provide a fraction of the anticipated demand during drier years. Typically, a project will test a range of water years, either by using all gage years available or a selection of years including dry periods to calculate project yields and the number of days available for diversion.

4 Climate Change and California's Water

California's Mediterranean climate is characterized by cool moist winters and hot dry summers. In addition to being strongly seasonal, California spans multiple climate zones, from temperate rainforests of the Pacific Northwest to arid deserts of the Southwest (Hanak et al. 2011). This geographic and climatic diversity results in regional hydrological variability throughout the state, with a stark climatic gradient from the cool coastal areas to hot inland areas, and big climatic differences between the Central Valley and the Sierra Nevada. Additionally, California has the greatest year-to-year precipitation fluctuations compared to anywhere else in the United States, with annual precipitation totals ranging from as little as 50 percent to more than 200 percent of long-term averages (Dettinger 2016).

Typically, a few strong storms (atmospheric rivers) during the winter provide 30 to 50 percent of California's annual precipitation and 40 percent of Sierra snowpack. With warmer air, and changing ocean conditions, atmospheric river episodes have the potential to increase in duration and intensity yielding increases in precipitation from the largest storms (Dettinger, 2016, Gershunov et al. 2019). There is also a growing body of evidence that persistence of anomalously high atmospheric pressure can deflect atmospheric rivers, significantly diminishing California water supplies (Swain et al. 2016). Furthermore, paleoclimatic evidence from tree rings, buried stumps, and lakebed sediment cores suggests decadal or longer-scale climate fluctuations, and reveals greater variability than captured in the instrumental record, particularly in the form of severe and prolonged droughts (California Department of Water Resources 2015a). Even changes beyond the State's borders have a strong influence of California's water supply, as Southern California receives approximately one-third of its water supplies from the Colorado River (Hanak et al. 2018).

Because California contains multiple climate zones, each region of the state is experiencing a combination of impacts from climate change unique to that area. While significant uncertainties still remain for long-term local precipitation and temperature changes, projections at the regional and statewide levels are already available, and suggest a continuing warming trend, greater precipitation volatility, earlier snowmelt, shifting of the timing and nature of runoff, increased frequency of droughts and flooding, and sea level rise affecting coastal and Delta water quality.

The California Fourth Climate Change Assessment, completed in 2018, confirmed the consensus of the climate change science community that the global climate and California's climate are changing rapidly, and that past is no longer a reliable guide to future conditions. Studies from the Fourth Climate Change Assessment additionally suggest that extreme events will occur more frequently in California due to climate change. For example, with warmer air,

and changing ocean conditions, atmospheric river events have the potential to increase in duration and intensity yielding increases in precipitation from the largest storms (Moser et al. 2012). Conversely, a number of studies suggest that California should prepare for more frequent, more severe, and longer-lasting droughts (He et al. 2018).

Text Box 4: Projecting Climate Impacts

Climate models and sets of future scenarios used to project climate are continuously being updated, as different modelling groups around the world incorporate higher spatial resolution, new physical processes and biogeochemical cycles, and employ scenarios rooted in socioeconomic trajectories (Editorial 2019). This report provides basic information on the general climate change traits relevant to administering water rights in California; readers are directed to other sources for the latest in the climate change science.

Climate models are a source of uncertainty in climate projections. Projections of future climate conditions are derived from global climate models (GCMs). Climate models use mathematical equations that are used to make weather forecasts but are run over much longer time horizons and represent physical processes in the atmosphere, oceans, land surface, and ice. And while climate models perform well in resolving climate variables as statistical weather information, they are not designed to resolve actual weather conditions. Climate models vary in spatial and temporal detail that they provide, as well as how well each is capable of simulating the natural variability that has been observed in different regions.

One of the largest uncertainties in predicting future climate is the course the society chooses in terms of energy and land use, resulting in different greenhouse gas emissions pathways. Scientists use a range of plausible future global greenhouse gas emission scenarios, land use, population growth, technology, economic activity, and other factors to model future climate. These scenarios are called Representative Concentration Pathways (RCPs). For example, RCP8.5 represents a high emissions scenario, also known as the “business as usual” scenario, whereas RCP4.5 represents a medium emissions scenario where societies attempt to reduce greenhouse gas emissions.

In general, climate models perform best for variables that are strongly dependent on temperature. For example, for California, the uncertainty lies only in the magnitude of warming, but not in whether warming will occur. While there is substantial uncertainty in the amount of precipitation change over California over the next few decades, the definitive likelihood of continued warming overcomes that precipitation uncertainty to create an unambiguous trend towards diminished snowpack and earlier snowmelt timing (Climate-Safe Infrastructure Working Group 2018).

4.1 Temperature

Statewide annual average air temperatures have generally risen since 1895, with temperatures increasing at a faster rate starting in the 1980s (Office of Environmental Health Hazard Assessment; OEHHA 2018). The four years from 2014 to 2017 were especially warm, with 2014 being the warmest on record. Furthermore, annual average temperatures in California are projected to rise significantly (5.0 to 8.5 °F by the end of the century), with extremely warm years and heat waves occurring more frequently (Moser et al. 2012). Interior regions in California are expected to experience greater warming than coastal areas (Pierce et al. 2018).

Projected temperature increases will affect California's hydrology, with further effects felt by the state's water supply, hydroelectric power supply, agriculture, recreation, and ecosystems (Cayan et al. 2006). Due to warming alone, California will see less of its precipitation fall as snow, which will result in diminished mountain snow pack, and less natural water storage in the form of snow. Warmer air temperatures will change precipitation and runoff patterns, affecting freshwater supply availability, and increase the risk of severe weather events such as heat waves and intense storms (OEHHA 2018). Warming also has important implications for aquatic ecosystems, particularly for fisheries where increased water temperature can affect survival and reproduction.

4.2 Precipitation

Records indicate that year-to-year variation in the annual precipitation in California has intensified over the past century, with more distinct dry and wet periods, although the overall annual precipitation accumulation trend shows little change. Climate change modeling suggests that California will continue to experience the seasonal pattern of dry summers and wet winters, as well as interannual and decadal variability marked by greater precipitation extremes (Moser et al 2012). However, there is no agreement among models on the projected trends in statewide annual precipitation.

Whether the statewide amount of precipitation is projected to increase or decrease largely depends on whether models place the regional analysis more in the northern or southern regime of large-scale change (Berg and Hall 2015). Most climate models project drier conditions in Southern California, with heavier and warmer winter precipitation in Northern California.

Additionally, seasonal changes are projected to become more pronounced. Recent research suggests that December through February will remain wet or become even slightly wetter, but shoulder spring and fall seasons will become drier (Pierce et al. 2018). In other words, the wet season will bring wetter conditions during a shorter period, whereas the dry season will become longer and drier (Gershunov et al. 2019). A longer dry season would heighten some important climate impacts including fire risk, water and energy demand, and ecosystem stress.

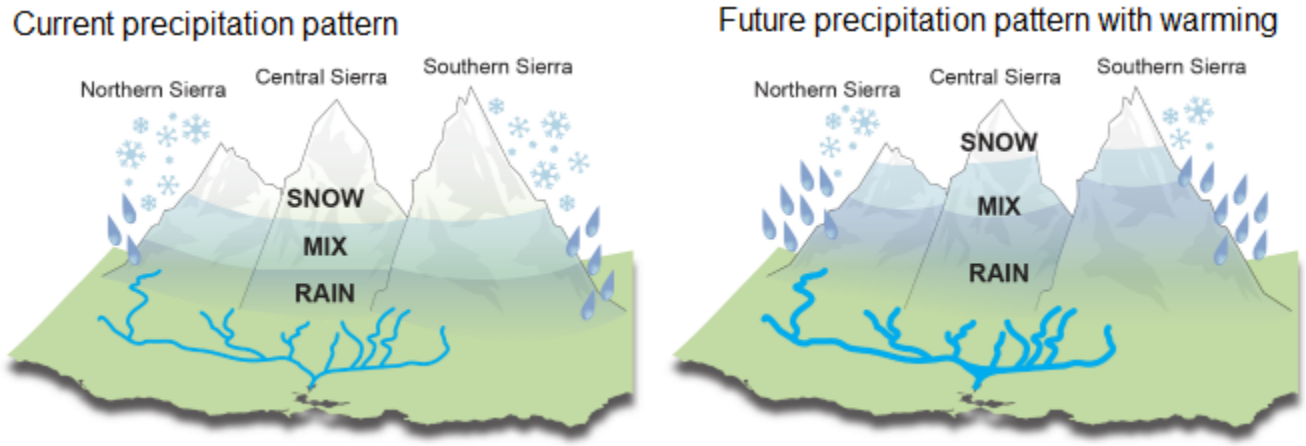
4.3 Snowpack

California's Sierra Nevada snowpack is a critical hydrologic resource, providing more than 60 percent of the water used by communities, agriculture, and industry across the state (Reich et al. 2018). Snowmelt currently supplies an annual average of 15 million acre-feet of water, which is gradually released in spring and summer (OEHHA 2018). Water stored in the snowpack also plays a vital role for the ecosystems, supplying cold water habitat for salmonids and water for forests. In recent decades, there has been a trend toward more precipitation falling as rain than snow.

By the end of the century, the Sierra snowpack may shrink to half of the historical range, resulting in reduced natural water storage (Reich et al. 2018). California's Fourth Climate Change Assessment indicates that the decline in spring snowpack will occur even if the amount of precipitation remains stable (Bedsworth et al. 2018). Warming conditions will continue the trend of less precipitation falling as snow, and snowmelt occurring earlier in the

spring (Pierce et al. 2018) with higher elevation watersheds seeing more change in precipitation patterns. For example, the San Joaquin watersheds located in higher elevations are projected to have the largest percentage increase in flood volumes because of precipitation falling more as rain instead of snow (Figure 1, California Department of Water Resources 2017). The projected decreases in snowpack will have profound effects on the availability of water for downstream storage, reservoir operations, direct diversions, flood management, and ecosystems.

Figure 1. Projected Impacts on Central Valley Precipitation Patterns (California Department of Water Resources 2017).



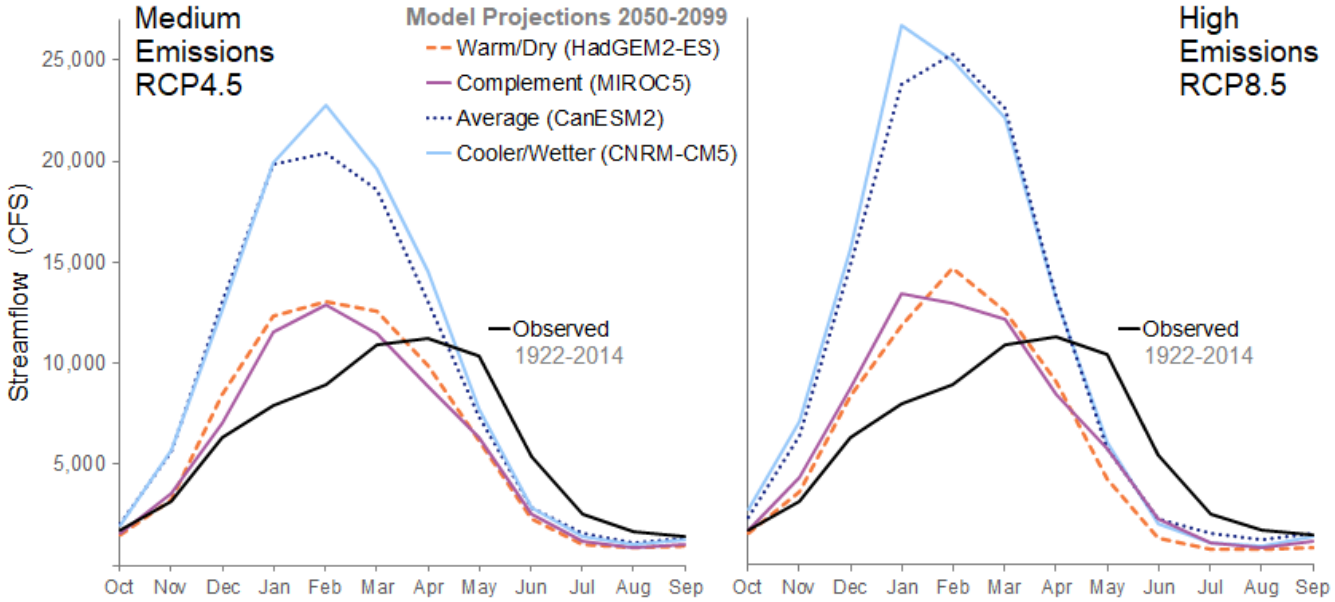
4.4 Timing and Nature of Runoff

The arrival of warmer temperatures earlier in the year causes snowmelt earlier in the year, with less spring and summer snowmelt. In addition, warming causes a greater share of precipitation to fall as rain which also affects the timing of runoff (Reich et al. 2018).

In the Sacramento River system, the peak of the average monthly runoff has shifted earlier by nearly a month between 1906-1955 and 1956-2007 (California Department of Water Resources 2015a). Additionally, the fraction of snowmelt runoff entering the Sacramento River between April and July relative to total year-round water runoff has declined over the past century (OEHHA 2018).

Watershed characteristics strongly influence the hydrological response to climate change. In higher elevation snow-fed watersheds, the timing of peak runoff is projected to move earlier in the year, with increasing flashy winter runoff while reducing spring and summer streamflow (Davenport et al. 2020). Streamflow projections for the Feather River on the Cal-Adapt streamflow tool illustrate changes to future unimpaired streamflow patterns by the end of the century (Figure 2). Climate models show peak streamflow occurring nearly two months earlier, accompanied by an increase in quantities of peak streamflow compared to the observed data.

Figure 2. Projected vs. observed monthly average unimpaired streamflow - Feather River near Oroville (adapted from Cal-Adapt streamflow tool).



4.5 Fish and Wildlife Habitat

Recent research suggests that changing climate has magnified stress on California's freshwater ecosystems. For example, past land use changes, water management, fishing, and other stressors have contributed to the loss of freshwater habitat and diversity of native species in California. Limited diversity and habitat loss left salmonids with reduced capacity to cope with increasing temperature and diminishing snowpack (Herbold et al. 2018).

Warming trends have already been documented in California's aquatic ecosystems for which long-term temperature data are available (Moyle et al. 2013). With warming temperatures, more precipitation falls as rain instead of snow, decreasing the quantity of snowmelt that supplies streams and rivers (OEHHA 2018). A decrease in the amount of snowmelt runoff affects ecosystems by reducing the amount of cold-water habitat that is available for native fish species such as salmonid fishes. Increases in water temperature and loss of cold-water flows can negatively affect migration, spawning, egg viability, and rearing conditions (OEHHA 2018).

Furthermore, changes in precipitation and runoff patterns will likely modify seasonal availability of spawning and rearing habitat for some native fish (e.g., Chinook salmon) and favor fishes that can persevere when stream flows are low and intermittent for extended periods (Moyle et al. 2013). The more the "natural" flow system in streams and rivers is modified, the less native fishes will be favored. Therefore, native fishes and native stream-dependent species will decline as stream reaches dry up or become warmer (Moyle et al. 2013).

Shorter precipitation seasons, and persistence of high temperatures longer into the fall may diminish natural flows to ecosystems, affecting water quality. Ecosystems exposed to rising sea levels, such as the Delta, are especially vulnerable to decreases in tributary flows and increasing salinity.

5 Select Models and Data for California

Thus far, California has invested in a considerable amount of research to understand how a changing climate will affect water resources, and identify ways to build resilience, adapt, and prepare for impacts of climate change.

5.1 Resources for Groundwater Sustainability and Flood Management

California Department of Water Resources (DWR) plays an important role in planning and managing much of California's water resources, systems, and infrastructure. As a result, DWR is actively involved in climate change science to analyze and assess potential impacts to California's water system, and develop adaptation responses (California Department of Water Resources 2018).

DWR developed climate change data, water operations modeling, and Delta hydrodynamic modeling for use by the Water Storage Investment Program in 2016. With additional refinements, DWR provides those climate change data, tools, and guidance material to support implementation of Sustainable Groundwater Management Act (SGMA). SGMA Climate Change Resources are in the public domain. The climatological data include historical detrended precipitation, and reference evapotranspiration along with change factors for projected climate conditions centered around 2030 and 2070. The climate projections for 2070 include three scenarios: a central tendency, and two extreme scenarios (i.e., one drier with extreme warming and one wetter with moderate warming). The hydrological data provide projected unimpaired stream inflows for major streams in the Central Valley, and streamflow change factors for areas outside of the Central Valley and smaller ungaged watersheds within the Central Valley. Applying change factors preserves historical interannual variability while the magnitude of events may be increased or decreased based on projected changes in precipitation and air temperature from global climate models.

DWR has also developed a comprehensive framework for system-wide management and flood risk reduction planning for the Sacramento and San Joaquin River Basins. The 2017 Central Valley Flood Protection Plan Update (Update) incorporated climate change into flood risk evaluations and planning. The 2022 Update will provide a wider range of potential climate change projections over a planning horizon that extends to 2072. The 2022 Update will also be supplemented by a pilot study in the Tuolumne River watershed, which will involve the development of methods and tools to support decision scaling, including climate-informed time series of simulated weather data (California Department of Water Resources 2020). Once available, these climate change resources may be used to inform other projects and planning efforts.

Text Box 5: Decision Scaling

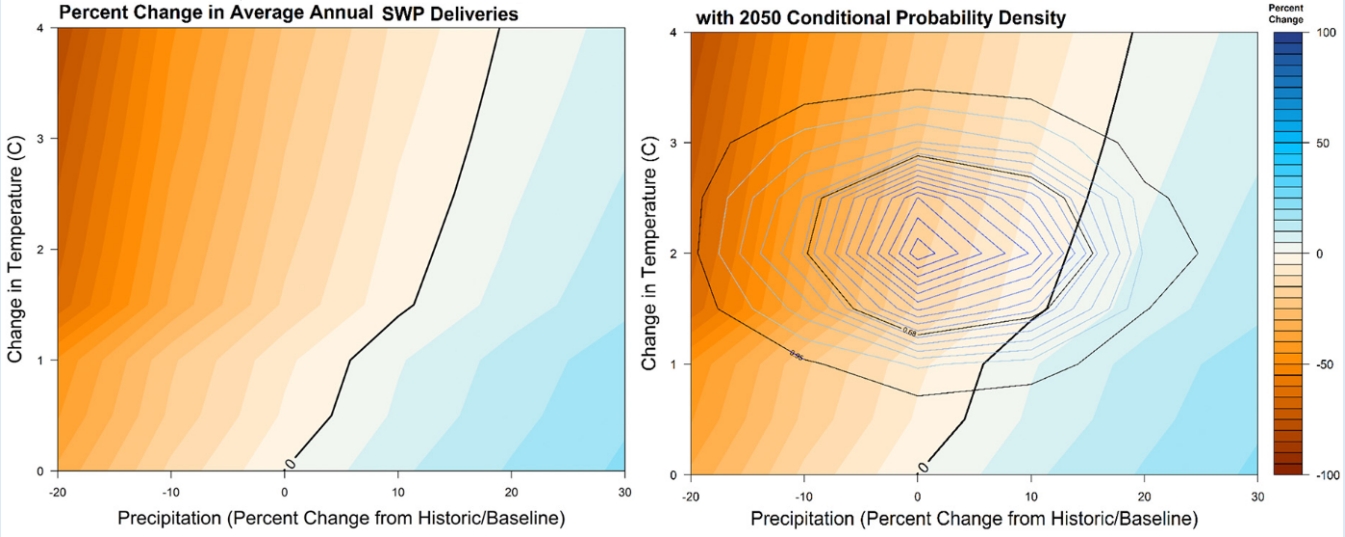
To improve planning for the uncertain effects of climate change, DWR has used "decision scaling" to systematically explore performance of the Central Valley water system over a range of temperature and precipitation changes (Schwarz et al. 2018, California Department of Water Resources 2019). The decision scaling approach allows for the assessment of sensitivity to a wide range of potential future climate conditions, the estimation of the probability of specific

outcomes, and the ability to plan for changes informed by the best available science, yet it is not reliant on a precise prediction of future values.

For example, the response surface (left panel in Figure 3) summarizes results of a two-dimensional sensitivity analysis for one of the decision-relevant metrics under a range of warming and precipitation change. The current conditions estimate for average annual State Water Project deliveries is at 0°C change in temperature, and 0 percent change in precipitation. Blue shades represent increasing average annual deliveries and orange shades represent decreasing deliveries. The black line shows that current performance level can be maintained at combinations of temperature and precipitation shifts.

A GCM-informed probability density function of climate projections for the year 2050 is superimposed on the response surface, and shows probabilistic estimates of exposure (right panel in Figure 3). The 2050 climate probability density is centered around no change in precipitation, and 2°C change in temperature, at which average annual deliveries decline by approximately 20 percent with no adaptation strategies employed.

Figure 3. Figure 3. Average Annual State Water Project Deliveries sensitivity and exposure to climate change (adapted from California Department of Water Resources 2019).



Another example of water management planning that uses the decision scaling method to incorporate climatic uncertainty is research to support use of floodwaters for managed aquifer recharge (Flood-MAR) on agricultural lands, working landscapes, and managed natural landscapes. Flood-MAR is an integrated water management strategy that can provide flood risk reduction, aquifer replenishment, drought preparedness, ecosystem enhancement, and other potential benefits. DWR is currently conducting a pilot study in the Merced River Basin that will evaluate the potential for using flood waters to recharge groundwater, and demonstrate the use of the decision scaling to explore effectiveness of different adaptation strategies (California Department of Water Resources 2020).

5.2 California's Fourth Climate Change Assessment

The State has undertaken four comprehensive climate change assessments, designed to assess the impacts and risks from climate change. Completed in 2018, California's Fourth Climate Change Assessment included several projects to improve access and presentation of climate change information (Bedsworth et al. 2018). While the general direction and trends in the projections have remained consistent with previous assessments, analysis prepared for the Fourth Assessment further refined projections for California, and provided higher spatial resolution and improved treatment of climate extremes.

Recognizing the need to use multiple global climate models while reducing the number of simulations, a subset of ten global climate models that closely simulate important aspects of California's climate were identified for use in water resources planning (California Department of Water Resources 2015b). Among the ten, the State prioritized four global climate models for the California's Fourth Climate Change Assessment (Pierce et al. 2018):

1. A warm/dry simulation (HadGEM2-ES)
2. A cooler/wetter simulation (CNRM-CM5)
3. An average simulation (CanESM2)
4. A simulation that is a complement, most unlike the first three for the best coverage of different possibilities (MIROC5)

The climate simulations developed for the California's Fourth Climate Assessment are in the public domain and available from the Cal-Adapt online portal in raster or tabular formats. The data cover 1950-2005 for the historical period, and 2006-2100 for medium and high emissions scenarios. The data include daily temperature and precipitation over California at a resolution of about 3.7 miles. Additional variables for the subset of ten models are relative humidity, wind speed, and surface solar radiation. The Variable Infiltration Capacity (VIC) land surface model was used to estimate historical and future daily hydrologically relevant variables, such as snow cover, soil moisture, runoff, water loss from plants, surface moisture and heat fluxes (Pierce et al. 2018).

5.3 Estimating Impacts on a Finer Scale

Future climate change projections are variable due to uncertainties related to greenhouse gas emissions pathways and global climate models. Hydrologic modeling informed by long-term measurement data sets can constrain the functional uncertainty of global climate model-based future hydrology projections. For example, a mechanistic, process-based hydrologic model can give a more granular representation of watershed-level water balance that can be customized to site-specific data on topography, soils, and geology.

There are several hydrologic models that can incorporate the results of downscaled global climate models to characterize the potential impacts of climate change on hydrology and water availability in a specific watershed. These hydrologic models include, but are not limited to, the Basin Characterization Model (BCM), Variable Infiltration Capacity (VIC) Model, Water Evaluation and Planning System (WEAP) Model, and the Hydrologic Modeling System (HEC-HMS).

Spatially explicit hydrologic models that quantify the water balance by comparing measured streamflow with model output can be calibrated using a historical baseline. The regional hydrological relationships between climate and landscape can then be applied to derive potentially more detailed forecasts of future climate projections at a watershed or regional-scale (Flint et al. 2013). As a result, the historical climate data in combination with future climate scenarios can provide a comprehensive dataset of regional climatic and hydrologic trends, but is also spatially detailed enough to provide fine-scale examples of local hydrological impacts of climate change on the landscape (Thorne et al. 2012).

6 Challenges and Opportunities in Managing for the Future

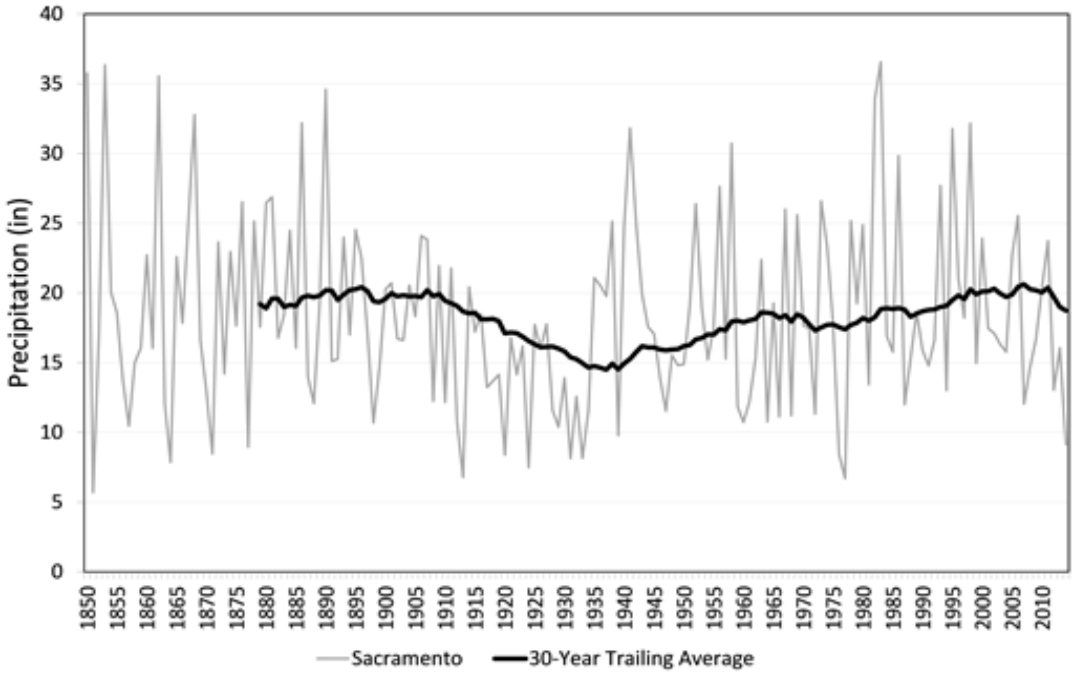
Permitting water availability analyses are generally based on historical data to estimate unimpaired flow, and to evaluate instream resource needs. As timing and amount of water flows change, historical reliability of existing water rights will change (Schwarz 2015). However, as past conditions are no longer a reliable guide to future conditions, permitting water availability analyses should incorporate climate science and projections to account for impacts of climate change. Climate change projections point to both long-term shifts in the timing and magnitude of peak streamflows, and amplified hydrologic extremes, which will make it increasingly difficult to reliably estimate availability based on the observed record. Furthermore, implementation of curtailments may become more frequent, and additional actions may be required to address impacts to water quality, and fish and wildlife. This section aims to create connections by summarizing some of the key challenges and considering opportunities to effectively respond to projected climate change when administering water rights.

6.1 Long-Term Shifts in Hydrologic Trends

Estimates of unimpaired flow typically rely on historical data. However, due to the low number of gages and relatively short period of most precipitation and gage records, particularly on the smaller stream systems, there is often not enough information to characterize multi-year or decadal hydrologic variability, which significantly limits the ability to reliably estimate water availability.

The precipitation record for Sacramento offers one example of why it is important to comprehensively characterize hydrological variability. Sacramento has one of the longest instrumental rainfall records, which extends back to the 1850s. Year-to-year variability in Sacramento rainfall is representative of California's precipitation fluctuations, and ranges from just over 5 inches to more than 35 inches per year (Figure 4). The 30-year running average (a standard reporting interval for climate averages) also exhibits variability, suggesting there are decadal-scale fluctuations in average rainfall. The 30-year running average reveals an upward trend in annual precipitation from the 1920s to 2000 (California Department of Water Resources 2015a).

Figure 4. Annual Precipitation 1850-2014 in Sacramento, California (California Department of Water Resources 2015a).



Many of California's permitted and licensed water rights reflect water availability analyses based on stream gage data from a relatively wet time period which likely does not capture drying trends or long-term drought conditions. It will be difficult for existing water right holders to divert the volume of water permitted under their water right if climate conditions swing towards drier overall trends such as those observed from 1925-1955. Such a scenario may already be occurring within the Colorado River Basin, where a 20-year drying trend has resulted in cutbacks to deliveries that were originally based upon historically higher flows (USBR).

There are several options, applied on their own or together, that would help to better characterize hydrological variability for estimating unimpaired flow in permitting water availability analysis:

- Maintain the existing stream gaging network to ensure reliable data are available for water rights administration, and support expanding the stream gaging network where possible. A robust stream gage network and more complete hydrologic data will support a more effective management of water resources.
- Strengthen analyses by expanding the minimum period of record supporting the analyses. The additional streamflow data may help to better characterize wet and dry trends, extremes, and natural hydrologic variability of the stream system.
- Update the current methodology used to adjust stream records based on alternative gage locations by increasing the number of required alternative sites with stream gage data. Updating this methodology will improve accuracy and to increase the range of historical, climatic, and hydrologic variability captured in the analysis, and could

leverage efforts to integrate various surface water and groundwater models. Another way to improve accuracy may be temporary installation of a portable stream gage(s) at requested points of diversion to pair estimated values with quantified streamflow.

- Examine reconstructed hydroclimate data to supplement gage records and get an insight into a broader range of natural hydrologic variability. Because California's instrumental hydrologic record is relatively short, other sources of information can provide critical context for understanding natural hydrologic variability (California Department of Water Resources 2015a). This may include a variety of approaches, such as examining available hydroclimate reconstructions based on tree-ring data, and pairing with local observational data to develop longer precipitation and temperature records that can be use with a hydrologic model to estimate streamflow. Hyrdoclimatic Reconstructions for Northern and Southern California River Basins are in the public domain.

6.2 Changing Runoff Patterns

The requested season, rate, and quantity of proposed diversions may not be increased once a water rights application is submitted. Shifting runoff patterns may affect water availability for many existing water rights holders. Many climate change projections for California indicate the timing of peak runoff will shift from observed historical patterns. Shifting runoff patterns (such as peaks during spring instead of summer) may eliminate or substantially limit an existing water right holder from maintaining traditional project yields. Parties facing this issue may need to seek a new water right as the season of diversion in an existing appropriative right may not be expanded. Water storage projects may need to reconfigure operations to capture peak flows when able, and to preserve carryover water to protect cold-water sensitive species needs as well as to preserve water quality in the Delta.

A common, readily available set of facts about water supply and use can make balancing competing needs less contentious and more efficient. There are multiple actions and resources that could aid incorporating climate change forecasts into permitting processes, and support effective water rights administration in the face of a changing patterns of runoff:

- The State Water Board has engaged in early efforts to incorporate climate change on specific projects by encouraging applicants to include projected climate change in their water availability analyses. Existing datasets and tools that are in the public domain can help explore how climate change will affect hydrology. Climate change resources developed by the State include projections developed for the California's Fourth Climate Change Assessment, and data and tools provided by DWR to support implementation of SGMA.

- In order to support potential water right applicants in developing projects that will remain feasible in the future, the State Water Board could develop a fact sheet to advise that parties consider how climate change could affect water availability. Consideration of several points would help applicants select appropriate season, rate, and quantity of proposed diversions, to help improve the long-term feasibility of their water right. In addition to conducting water availability analysis based on historic data, applicants should evaluate water availability under a scenario that includes projected hydrology to

assess if the project would be viable in the event of continued shifts in conditions. For instance, applicants may consider whether their application should focus on a season of diversion with a shorter precipitation period or potentially greater rate of diversion during higher peak flows. Future applicants may also need to evaluate proposed purpose of use, as warming may shift plant growing seasons earlier in the year (USDA Climate Hubs), with a possibility of exposure of buds to spring frosts earlier than the traditional frost protection season.

- In order to continue to protect and preserve fish and wildlife habitat with changing hydrology due to climate change, it may be necessary to modify existing instream flow criteria and metrics required by the North Coast Instream Flows Policy for applications and petitions on existing rights. This will likely require developing tools for identifying functional ecosystem flows and further development of scientific literature that assesses and plans for the hydrological impacts of climate change on anadromous fish species. Where regional criteria or flow objectives are not available, the State Water Board may need to consider whether existing flow conditions support aquatic beneficial uses, and how flow may change under climate change projections.
- Among opportunities to leverage ongoing efforts is the work that the Delta Stewardship Council is leading to devise approaches and conduct modeling and analyses to address the priority management questions, assess vulnerabilities, and evaluate potential adaptation options. While the work is specific to the Delta, the findings will have significant repercussions for ongoing State Water Board activity within the greater Delta watershed on instream flow requirements, habitat restoration, and triggering of basin-wide water rights conditions.
- The FAS Declaration, which identifies critical reaches of each fully appropriated stream system and times of the year when water is not available for appropriation, was last updated in 1998. With projected shift of peak runoff earlier in the year, and shorter precipitation seasons, the FAS Declaration will likely need to be updated to reflect changing runoff timing and water availability.
- The State Water Board could implement some form of decision scaling to assist in the quantitative assessment of future regional water availability. As work advances to support regional decision making with watershed-scale climate vulnerability and adaptation assessments, projecting streamflows under a range of warming and precipitation change along with relative likelihood of potential climate outcomes could support water availability analyses. Estimates of relative likelihood of potential climate outcomes could be based on either a large ensemble, or probabilities associated with a subset of global climate models recommended for California.

6.3 Amplified Hydrologic Extremes

6.3.1 Floods

Future floods are projected to be different from past floods in timing, frequency, magnitude, and form, with critical consequences for reservoir management, water storage, and water availability. However, there is also substantial opportunity in flood flows – in particular, the potential to capture flood flows for storage and subsequent use during dry periods. Managed

well, California's groundwater basins can provide a crucial buffer against drought and climate change. Future storage projects could consider underground storage, which has the potential to capture excess runoff that surface water storage cannot store due to space or flood limitations.

- Recognizing that capturing high flows is an important approach to build resilience, the State Water Board has issued guidance on water rights permitting beneficial uses associated with groundwater recharge. The State Water Board also developed temporary permit pathways, and an optional streamlined permitting process for obtaining a permanent water right for those that plan to divert high winter flows or flood flows and store that water underground. The streamlined permitting process for diverting water from high flow events to underground storage aims to support achieving groundwater sustainability, and ensure diversions are protective of native fish and wildlife. Additional benefits of groundwater sustainability projects may include preparing for changes in hydrology related to climate change, and increasing resilience of water supply.
- There is also a significant opportunity to leverage ongoing studies and programs related to climate change. For instance, DWR work to update and refine the regional flood management strategy in the Central Valley Flood Protection Plan and for implementation of Flood-MAR, can help better understand the potential frequency of high-flow events (Tuolumne River and Merced River pilot studies).

6.3.2 Drought

Drought affects the availability of water for existing water right holders. Drought also affects the management and protection of the state's ecosystems. During a drought, the State Water Board may determine there is not enough water available to serve all right holders and may curtail junior water rights, or may need to implement broad water right curtailments to preserve critical instream flow for endangered or threatened fisheries. With droughts projected to become more severe and last longer, the State Water Board may need to implement curtailments more often, for longer durations, and in an increasing number of watersheds (Schwarz 2015).

The State Water Board has already started efforts to evaluate and assess actions from the recent droughts and use the lessons learned to inform responses for future droughts. Studies of the last four major droughts distilled recommendations to improve future drought responses (Green Nylen et al. 2018), and suggested that proactive drought response planning and preparation are key components of effective climate adaptation. For example, the most recent drought of 2012-2016 required swift action to streamline the curtailment process. In the absence of established instream flows or methodologies, the State Water Board had to adopt emergency regulation establishing minimum flow requirements to protect critical flows for anadromous fish in priority watersheds during the drought (State Water Board 2014b, State Water Board 2015a). While emergency regulations are temporary, the State Water Board had to expend significant effort to make numerous determinations on an expedited basis, with a limited public process.

Among opportunities to plan and prepare for future droughts are:

- Conduct and utilize instream flow analyses to further develop instream flow recommendations for ecologically important streams to protect public trust values. Development of instream flow requirements is a key strategy needed to protect communities, fish, and wildlife in the event of droughts lasting multiple years, which is an expected outcome of climate change. Quantifying the timing, quality, and volume of flows reasonably protective of fish and wildlife beneficial uses for all California streams may reduce the need for possible future emergency regulations and other short-term efforts to establish instream flows during droughts. Developing new tools for identifying functional ecosystem flows, and establishing criteria for watersheds statewide, starting with watersheds with the greatest need, might also have an added benefit to applicants, minimizing the need to conduct site-specific studies, and providing an avenue for quicker application processing.
- Development of a rigorous curtailment methodology that can easily, quickly, and openly describe to water managers and other stakeholders the order of curtailment priorities.
- Development of either standard terms (terms that are added to all water right permits that meet certain criteria) or project-specific permit terms to address climate change considerations.

7 Recommendations for Incorporating Climate Change into Water Rights Permitting Policies, Procedures, and Methodologies

Climate change will pose increasing and new challenges to water management in California. The following list of staff recommendations offers a menu of options to make water availability analysis more robust, and actions to support an effective water rights response to climate change. Generally, there are two pathways to implement recommendations, either on a case-by-case basis, or by adopting regulation. These recommendations are preliminary and will require further exploration through stakeholder and Board engagement, possible regulatory changes, and additional staff resources to fully implement.

7-1. **Leverage Existing Climate Change Data in Permitting Water Availability Analyses:** The water availability analyses needed for permitting a new water right should account for impacts of climate change, specifically changing runoff patterns and projected changes in hydrology. The State has developed a considerable amount of data on impacts of changing climate on California's water resources. Staff's recommendation is to require applicants to use existing data, as available, to explore the potential impacts of climate change in permitting water availability analysis. The two notable sources that applicants could use are: 1) climate change data, tools, and guidance developed by the Department of Water Resources for groundwater sustainability planning, and; 2) climate simulations used in California's Fourth Climate Assessment.

Where a better watershed-specific model exists, water rights applicants may use other best available data and science to provide understanding of the projected future water availability. This approach would provide applicants with flexibility to customize their

water availability analysis and capitalize on existing studies. Some applicants are already leveraging pilot studies in their watersheds, or using data outlined above to include climate change in their water availability analyses. Early implementation for select projects would likely serve as examples for other applicants.

7-2. **Include Adaptive Permit Terms in New Permits:** Staff recommendation is to develop climate change-related terms that are triggered by the occurrence of certain hydrologic conditions as a way to make water rights responsive to future conditions. For instance, if climate change modeling informed project development, the permit could authorize adaptive changes to terms that include shifts in the rate or season of diversion. An adaptive permit term in that case would include a diversion commencement trigger that would allow a shift in diversion rate or season once projected conditions occur. Or, as another example, the State Water Board could consider permit terms triggered by a drought declaration. An adaptive permit term could restrict municipal and domestic beneficial uses to only human health and safety needs during declared drought emergencies.

7-3. **Implement Tiered Requirements for Climate Change Analysis:** The State Water Board could require a varying level of climate change analysis in new applications based on tiers as a way to reasonably balance the need for accurate water availability projections and applicant cost/workload. Most pending water right applications are from small diverters who are unlikely to have the resources or technical means to conduct advanced climate change analyses. In a tiered approach, certain project characteristics would trigger a requirement for a more rigorous analysis. For example, a more nuanced analysis required for a higher tier may entail the use of global climate models to assess the potential future impacts of climate change on the availability of water from the requested water source. A lower tier analyses could require using an extended historical time series of precipitation and streamflow data as a proxy for the potential future impacts of climate change, or use climate datasets developed by the State.

Tiers could be established based on project characteristics, such as size (a threshold based on a proposed diversion rate and/or a quantity), location (e.g., within specific or prioritized watersheds, such as the San Joaquin River, the Tulare Lake Basin, the North Coast Instream Flows Policy area, etc.), type (e.g., a specific beneficial use, for example Municipal, and other uses with hardened demand, or climate-sensitive supply or season, such as snowmelt-dominated runoff), or another metric.

7-4. **Develop Fact Sheet for Water Right Applicants to Incorporate Climate Change:** The proposed season of diversion, rate, and quantity requested cannot be increased once a new water right application is filed. In order to support potential water right applicants in developing projects that will remain feasible in the future, the State Water Board could develop a fact sheet to provide an overview of existing climate data developed for California, and to advise that parties consider how climate change could affect water availability, and evaluate proposed season, rate, and volume of diversion.

7-5. **Strengthen the Minimum Period of Record Requirement for Streamflow Data:** Because recent precipitation and streamflow data may not capture the full range of hydrologic variability, a longer streamflow record may better characterize climatic and

hydrologic variability of the stream system. The additional streamflow data may help to identify wet and dry trends, extremes, and variability to improve the accuracy of permitting water availability analysis. In the North Coast Instream Flows Policy area there is a requirement to include no less than 10 years of data when developing water availability information. Although no such requirement exists elsewhere in the state, typical water availability analysis includes the entire period of record for a gage. Additionally, the State Water Board could require longer and/or more complete hydrologic records as part of the application review process.

7-6. **Require more Rigorous Analytical Methods to Extrapolate Data to Similar Geographic Areas:** Hydrograph changes driven by climate change may exacerbate inaccuracies when estimating unimpaired streamflow in ungaged watersheds, and as a result it may be necessary to reevaluate the approach and identify alternative methodologies that increase accuracy of water availability estimates. One way to improve accuracy may be temporary installation of a portable stream gage(s) at requested points of diversion to pair estimated values based on a reference gage with measured streamflow. Another way may be using a greater number of alternative reference sites with stream gage data to increase the range of historical, climatic, and hydrologic variability captured by the analysis.

7-7. **Expand Existing Network of Stream and Precipitation Gages:** Because there is often not enough hydrologic data due to the low number of gages, maintaining existing gages and expanding the network of stream and precipitation gages is critical. Increased collection and availability of pertinent hydrologic data would support improved accuracy of future water availability analyses. Installing more gages may require increased coordination and leveraged funding with other agencies such as U.S. Geologic Survey, DWR, and California Department of Fish and Wildlife.

7-8. **Reevaluate the Existing Instream Flow Metrics and Criteria:** It may be necessary to modify existing instream criteria and metrics to better protect migration paths, spawning, and rearing for anadromous fish in a changing hydrology. Research and development of scientific literature that assesses the hydrological impacts of climate change on anadromous fish species will be needed to implement this recommendation.

7-9. **Revise the Fully Appropriated Stream (FAS) List.** State Water Board Resolution No. 98-08 (FAS Declaration) identifies critical reaches of each fully appropriated stream system and times of the year when water is not available for appropriation. With projected shift of peak runoff earlier in the year, and shorter precipitation seasons, the FAS Declaration may need to be updated. There could be potentially more FAS designations needed during the spring through fall due to changes in runoff and precipitation timing. Conversely, some fully appropriated streams may need to be reopened in order to allocate winter high-flow or flood events.

7-10. **Prepare for and Capitalize on Capturing Flood Flows and Storing them Underground:** Floods and the magnitude of the peak flows are expected to increase under many climate change projections. As a result, there may be greater opportunity to divert flood and high flows during the winter to underground storage. The State Water Board could build on DWR's efforts to update and refine hydrology projections, and

leverage data and tools supporting the Central Valley Flood Protection Plan update and implementation of Flood-MAR. These efforts may help to better understand the potential frequency of high flow events and floods as part of permitting water availability analyses, and to inform conditions for the resulting water right permits to ensure diversions are protective of native fish and wildlife.

7-11. **Plan for Droughts:** As droughts are projected to become more severe and last longer, the State Water Board may need to implement curtailments more often and in an increasing number of watersheds. The State Water Board is already evaluating and assessing what actions were successful during the most recent drought, and there are additional steps that could aid in preparing for challenges that are to be expected with future severe droughts:

- Conduct and utilize instream flow analyses to further develop instream flow recommendations for ecologically important streams to protect public trust values, which will reduce the need for possible future drought emergency regulations and other short-term instream flow efforts.
- Prioritize the development of a curtailment methodology that can easily, quickly, and openly describe to water managers and other stakeholders the order of curtailment priorities and who is affected.

7-12. **Coordinate with Other Agencies and Partners:** The State Water Board will need to coordinate and leverage efforts with other agencies and partners involved in water resource management and adaption to climate change. With a growing body of research, there is an opportunity to build upon the knowledge and gains made by State and other agencies. Potential areas of collaboration include:

- Leverage DWR Climate Change Program work to inform the implementation of SGMA, Flood-MAR, and other initiatives, coordinate efforts to improve and expand projections of hydrologic responses to climate change, and develop tools that can support water availability analysis.
- Examine opportunities for coordinating programs and jointly funding climate change science to improve water availability projections from hydrologic modeling.
- Conduct joint climate change/water availability workshops.
- Learn from successful climate change-related water availability work in other states and countries.
- Coordinate with the Delta Stewardship Council's Delta Region Climate Change Vulnerability Assessment and Adaptation Strategy, especially as related to instream flows, habitat restoration, and triggering of basin-wide water rights conditions.
- Support opportunities to meet legal standards in creative, collaborative ways, such as through voluntary solutions that enhance flows and habitat.

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