

Alignment Analysis of Climate Change Considerations Across DWR Activities

An internal assessment as part of DWR's Climate Action Plan, Phase II

Climate Change Program, California Department of Water Resources

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STATE OF CALIFORNIA
Gavin C. Newsom
Governor

THE NATURAL RESOURCES AGENCY
Wade Crowfoot
Secretary for Resources

DEPARTMENT OF WATER RESOURCES
Karla Nemeth
Director

Cindy Messer
Chief Deputy Director

Kristopher Tjernell
Deputy Director
Integrated Watershed
Management

Ted Craddock
Deputy Director
State Water Project

Gary Lippner
Deputy Director
Flood Management and Dam
Safety

Katherine Kishaba
Deputy Director
Business Operations

Steven Springhorn
Acting Deputy Director
Statewide Groundwater
Management

Eric Wulff
Acting Deputy Director
Security and Emergency
Management

Spencer Kenner
Chief Counsel
Office of Chief Counsel

Ryan Endean
Acting Deputy Director
Public Affairs Office

Kasey Schimke
Assistant Director
Legislative Affairs Office

This report was prepared under the supervision of

John Andrew.....Assistant Deputy Director

Prepared by

Wyatt Arnold.....Engineer, Water Resources, Climate Adaptation Section
Julia Ekstrom.....Senior Environmental Scientist Supervisor, Water Use Efficiency Program
Elissa Lynn.....Program Manager II, Climate Change Program
Jennifer Morales.....Senior Environmental Scientist Specialist, South Central Region Office

Acronyms Used

AF- Acre Feet
AWMP- Agricultural Water Management Plan
AWUE- Agricultural Water Use Efficiency
CAP II- Climate Action Plan Phase II
CAP III AP- Climate Action Plan Phase III, Adaptation Process
CAP III VA- Climate Action Plan Phase III, Vulnerability Assessment
CCP- Climate Change Program
CEQA- California Environmental Quality Act
CVFPP- Central Valley Flood Protection Plan
CVM- Central Valley Modeling
CVTP- Central Valley Tributaries Program
CWC- California Water Commission
CWP- California Water Plan
DCR- Delivery Capability Report
DFM- Division of Flood Management
DOP- Division of Planning
DWR- California Department of Water Resources
FAIR- Financial Assistance Internal Review
GCM- Global Climate Model
GSA- Groundwater Sustainability Agency
GSP- Groundwater Sustainability Plan
IA- Irrigated Acres
IRWM- Integrated Regional Water Management
IRWMP- Integrated Regional Water Management Plan
IWM- Integrated Water Management
MBI- Multi-benefit Initiatives
SC- Service Connections
SGM- Sustainable Groundwater Management
SGMO- Sustainable Groundwater Management Office
SGMA- Sustainable Groundwater Management Act
SWP- State Water Project
UWMP- Urban Water Management Plan
UWUE- Urban Water Use Efficiency
VIC- Variable Infiltration Capacity
WSIP- Water Storage Investment Program

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Executive Summary

This alignment analysis builds off a comprehensive examination completed by the California Department of Water Resources (DWR) to consider climate change in its planning activities titled *Climate Change Characterization and Analysis in California Water Resources Planning Studies* (Khan and Schwarz, 2010). Whereas the previously completed analysis compared how climatological and hydrologic change was considered in projects from a technical approach, this document analyses the rules and guidance that govern how climate change is considered in projects, as well as programs.

This analysis includes activities geared towards external parties, internal programs, plans and initiatives, and internal studies that are used by DWR and others. Among the plans, projects, and initiatives examined, climate change planning is considered in a variety of means: strict parameters, loose guidance, at the user's discretion, or not mentioned. In some cases, high levels of variation have led to areas of misalignment, including the level of mandate that requires the effort consider climate change, the guidance for how to incorporate climate change planning, the suggested time horizons, and the specificity of data to use.

Developing strict rules for climate change planning at the Department may not allow for the flexibility needed to manage the wide range of planning and projects DWR executes, yet it is recognized that a minimum threshold for accounting for climate change should be met and requirements should be consistent whenever possible. The goal of this alignment analysis is to examine if misalignments exist and to construct a process that ensures DWR is internally coordinated and purposeful in how it distributes its requirements or recommendations to account for climate change and how it provides guidance, data, and other resources to consider climate change.

As identified by Khan and Schwarz (2010), climate change planning alignment across DWR could be supported through the development of a standardized framework using a consistent set of approaches for implementing and guiding legislation that includes climate change planning. Subsequent development and full implementation of the [Climate Action Plan Phase II \(CAP II\)](#) is designed to address the technical misalignments across DWR. CAP II could be expanded to address externally-focused misalignments described below. As well, fuller engagement with and empowerment of the now 13-year old Climate Change Matrix Team would also facilitate alignment on climate change.

1. Introduction and Purpose

Concern and consideration of the impacts of climate change on water resource management has grown substantially over the past 30 years as impacts from greater weather extremes, reduced snowpack, higher sea-level, and changes in river flows have become evident. Models project that more precipitation will fall as rain instead of snow, exacerbating flood risks as sea-levels continue to rise, collectively creating additional challenges to the State's water supply reliability.

The State of California has established legislation and statewide policies which require consideration of climate change in planning and investments. Executive Order B-30-15 mandates State agencies to consider climate change in planning and investments, as does the subsequently enacted AB 1482 and AB 2800. Managing climate change and its impact on water supply is part of [DWR's core values](#) therefore has developed an internal [Climate Change Program](#) (CCP) as well as a [Climate Action Plan \(CAP\)](#). The CCP staffs 10 full-time employees dedicated to providing climate change projections and guidance in implementing mitigation and adaptation measures with local and regional stakeholders, within the Department, and with other State, Tribal, federal, and international entities. The CAP is a three-phased framework used by the Department to guide climate change considerations in internal decision-making.

- Phase I: Greenhouse Gas Emissions Reduction Plan (GGERP)- DWR's greenhouse gas (GHG) emissions reduction goals and strategies for both near-term and long-term planning.
- Phase II: Climate Change Analysis Guidance- A framework for consistent incorporation and alignment of analyses for climate change impacts on internal projects and program planning activities.
- Phase III: Climate Change Vulnerability Assessment and Adaptation Process (VA/AP)- The VA describes, evaluates, and quantifies the vulnerabilities of DWR's assets and business to potential climate change impacts. The AP will prioritize and address the vulnerabilities to DWR owned and operated facilities and activities throughout the state and establishes a process to guide climate change adaptation.

In addition to addressing climate change internally, DWR recommends or in some cases requires that local and regional water managers consider climate change in their planning and management. Within one region, multiple or even a single entity could be subject to several different DWR climate change planning strategies.

Inconsistencies in recommendations and requirements for considering climate change have arisen over time due either to varying mandates from State legislation, DWR's interpretation of regulatory requirements, or changes in programs or project implementation. While the goal of CAP II is to ensure consistent incorporation and alignment of analyses for climate change impacts on internal projects and program planning activities, it does not cover programs where DWR is the lead agency implementing legislation but not the project manager, such as Integrated

Regional Water Management Planning (IRWMP), Agricultural Water Management Planning (AWMP), or Urban Water Management Planning (UWMP).

Climate change planning consistency within legislation can be complicated. When legislation assigns DWR as the implementing agency, it is then charged with interpreting said legislation and developing guidance. Misalignments can form when legislative requirements call for climate change considerations and are developed or implemented without considering the requirements of related existing programs, current DWR climate change guidance, or due to the lack of applicable guidance.

Such fragmented efforts commonly occur during innovation stages for any sector of policy; consistency, while generally desirable, may not be necessary for alignment, and misalignments are not inherently malalignments. Misalignments or inconsistencies can sometimes be necessary depending on the project, stakeholders, or environmental requirements.

Another potential source of misalignment can occur when DWR is working in partnership with other entities. Efforts such as the California Water Plan, the Central Valley Flood Protection Plan, the Water Storage Investment Plan, and EcoRestore can each have multiple partners with differing goals and mandates for considering climate change. Moreover, depending upon the sources of the inconsistencies, a solution can generally be addressed through updated legislation, a coordinated agency process, or a framework for how climate change could be addressed in projects being implemented outside of DWR.

This alignment analysis inventories and examines consistency in the consideration of climate change among select DWR programs and determines if inconsistencies lead to misalignments. Findings from this assessment will inform recommendations to improve alignment among ongoing and future DWR programs in how they incorporate climate change. Within DWR, recommendations will be considered under CAP II, and through an upcoming standardized framework for implementing programs where DWR is the regulatory lead but not the project manager. Improving the alignment of water planning can also provide benefits at the local level in the development and implementation of general plans, hazard mitigation plans, and climate action plans. In summary, a consistent threshold for considering climate change in water resource planning should be met for all DWR programs and projects which should be outlined in a standardized framework.

2. Method

2.1 Process

Three steps were followed to identify alignment as shown in Figure 1. In Step 1, with the assistance of DWR managers, an inventory of programs that consider climate change impacts was taken. Step 2 involved comparing program attributes and subsequently identifying areas of inconsistencies. Step 3 was where the initial prioritization for improving alignment was developed and is addressed further in Section 6.

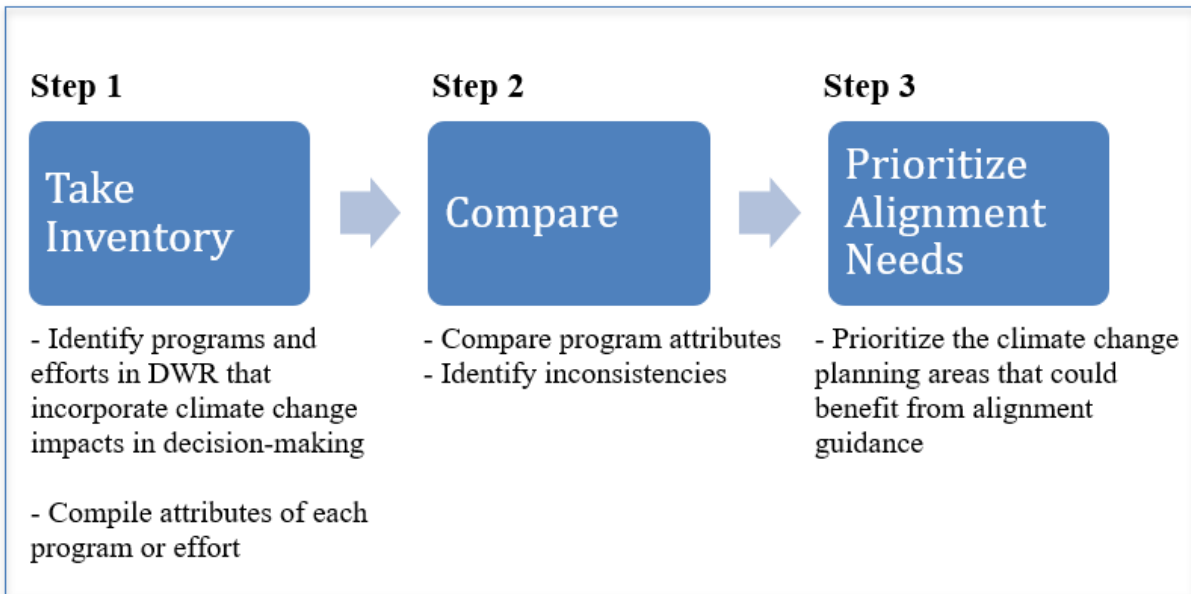


Figure 1. Process for examining alignment among DWR programs and projects.

In Step 1, thirteen programs, projects, initiatives, or plans that consider climate change impacts were chosen for this analysis based on their general representation of work at the Department, their historical or societal significance, and/or their potential to provide climate change adaptation or mitigation benefits. A set of descriptive attributes was compiled for each effort in order to provide background information and provide a comparison of how each addresses climate change:

Background Attributes

- DWR Office/Program
- Plan/project/Initiative name
- Objective
- User
- Program type
- Mandate level of plan

Climate Change Attributes

- Climate change analysis/process type
- Level of mandate for including climate change
- Year of latest climate change recommendation
- Year program was established
- Next plan update
- Geographic area covered
- Climate change impacts addressed by the effort
- Data information needs
- Climate change guidance provided
- Guidance level of detail
- Data identified in plan regulation
- Data recommendations in guidance
- Examples: specific
- Examples: related
- Legal reference (if any)

For Step 2, a selection of the above attributes was chosen for an in-depth analysis based on their ability to influence rule-making or guidance. These five attributes had the highest potential to create misalignments when inconsistent between programs. A description of these attributes can be found in the following section.

- Mandate requirement for including climate change
- Level of guidance offered
- Level of flexibility offered in rule
- Suggested time horizon
- Specificity of data to use

Step 3 is a discussion of the findings and prioritized next steps for advancing climate change alignment within DWR.

2.2 Attribute Description

Mandate requirement for including climate change

This attribute refers to the degree to which the consideration of climate change planning is required in the effort. Those required for funding or required otherwise with penalty would be considered “high,” while those programs recommending the consideration of climate change but not making it a criterion for funding would be considered “low” (or “medium,” depending on the implications of not considering climate change).

The mandate requiring the inclusion of climate change considerations in planning is generally set through legislation, sometimes with limited input from the implementing agency. The lead agency's interpretation of legislation and subsequent development of guidance, while accurate and law-abiding, could be a source of misalignment if the climate change guidance differs drastically from similar efforts within the Department.

Level of Guidance Offered

This attribute refers to the degree to which guidance for the consideration of climate change planning has been provided. Programs or projects that provide a climate change specific guidebook generally rated as "high." Those that offered limited guidance, such as a small informational paragraph within a larger guidance document, were considered "limited," and those with no climate change guidance were listed as "none."

A high level of guidance could offer stakeholders an advantage over others. However, if it comes with a requirement to follow the guidance, it may pose a challenge for those with limited internal staff capacity or technical expertise. Offering limited or no guidance can lead to confusion and an undesirably wide suite of results.

Level of Flexibility Offered in Rule

Efforts that had limited or no requirements to use specific data, tools and parameters in the consideration of climate change planning were rated as having "high" flexibility, while those with rules that stated certain datasets must be used or prescribed specific approaches under which climate change planning must be completed were rated with "low" flexibility. A rating of "medium" flexibility was given when programs offered a sufficient level of requirements to ensure consistent climate change planning among the various users but also offered a level of pliancy to accommodate for the unique characteristics and needs of individual stakeholders.

A "medium" level of flexibility seems to provide the institutional flexibility needed to adapt to climate change. Science and approaches to understand and plan for climate change impacts will continue to advance and requirements for planning for climate change impacts should allow for adopting new information and approaches. Too much flexibility can create frustrations for stakeholders and malalignments within the planning process if the requirement is interpreted differently year-to-year or one administration to another, making recent past efforts of staff and stakeholders less relevant or even obsolete.

Suggested Time Horizon

This attribute refers to the period of time identified by the effort for inclusion in the consideration of climate change. Some projects will necessitate different planning horizons. For longer-term projects, such as infrastructure planning, one might expect to see a time horizon matching the expected lifetime of the project (i.e. construction completion to re-use or salvage).

Time horizons should be clarified and justified so that they are consistent with the scope of the project.

Specificity of Data to Use

This attribute looks at whether DWR offers relevant data within guidance documents and the specificity of that guidance. Specificity of guidance in climate change planning could be as detailed as including which specific sources of data to use, what degree of warming to employ, and what level of regional resiliency to assume, contrasted with vague or no guidance provided. Overly detailed guidance requirements can be burdensome to those with limited time or internal technical expertise and/or capacity, whereas providing no guidance or limited guidance can leave planners feeling lost and lead to ineffective results.

2.3 Inventory

Thirteen DWR efforts were inventoried based on their general representation of work at the Department, their historical or societal significance, and/or their potential to provide climate change adaptation or mitigation benefits. Six of these activities are externally-focused in that they are efforts that affect local or regional water users. Four are internally-focused plans and initiatives that represent broad-scale planning efforts within the Department, and the last three are internal studies that represent information gathering and sharing both internally and externally. All climate change recommendations for these efforts have been written or updated in the last three years, and the length of existence of each program varies widely, with origin dates starting with 1986 and spanning to 2019.

The six externally-focused DWR programs target a diverse set of water user types: agricultural, urban, regional, and groundwater-reliant, as well as applicants for the Water Storage Investment Program (WSIP) and the Central Valley Tributary Program (CVTP) Round 1 and are covered in Section 3. Several of these programs require stakeholders to submit a water management plan which includes projects that will help achieve the goals of the plan. Upon Departmental approval, some programs permit the stakeholder to apply for grant funds to implement said projects. While DWR executes the requirements for the submittal of plans and ensures compliance with State mandates, it does not manage the projects. It is worth noting here that WSIP has ended and is used here only for analytical purposes:

- Agricultural Water Use Efficiency (AWUE)
- Urban Water Use Efficiency (UWUE)
- Integrated Regional Water Management (IRWM)
- Sustainable Groundwater Management (SGM)
- Water Storage Investment Program
- Central Valley Tributaries Program (Round 1)

The four internally-focused plans and initiatives represent broad-scale planning efforts within the Department and are covered in Section 4. While these documents are developed internally, many external partners contribute to their production and these plans have the potential to influence water management decisions at both regional and statewide levels. The climate change considerations made in these plans are viewed by some as reference sources for water management in California.

- California Water Plan (CWP)
- Central Valley Flood Protection Plan (CVFPP)
- DWR's Climate Action Plan Phase III: Adaptation Plan (CAP III AP)
- EcoRestore

Three DWR studies were identified as incorporating climate change and chosen for this analysis. These studies represent information gathering and sharing both internally and externally and can be found in Section 5. Climate change considerations used in these studies can influence the manner in which some of the largest water management entities conduct business. Stakeholders include urban, agricultural, municipal, and environmental entities.

- State Water Project Delivery Capability Report (DCR)
- Flood-Managed Aquifer Recharge (Flood-MAR)
- Climate Action Plan Phase III: Vulnerability Assessment (CAP III VA)

For more information about any of the efforts listed here please see Appendix A for a brief description.

Appendix B features tabulations of key attributes among recent or ongoing major DWR activities in the application of climate change analysis such as meteorological source data, downscaling procedures, ensemble versus single GCM, as well as system and hydrologic models used. A full inventory and consideration of sea level rise assumptions in DWR planning and projects will be completed as part of a future Department endeavor, such as the CAP II Working Group.

2.4 Potential Misalignments

Each of the attributes examined differed between programs, meaning no two programs or projects had the same climate change consideration requirements. In some cases, differences could have potentially negative consequences, examples of which are listed in Table 1. Ultimately, misalignments can arise if planners are being guided to assess vulnerabilities or adapt to climate change in drastically different ways. For example, tensions between two water management entities may develop when attempting to work together through a common or coordinated plan or resource if one entity (e.g., an agricultural water supplier) orients its planning, operations, and long-term investments around a set of projected futures while a

neighboring entity (e.g., an urban water utility) plans under an altogether different, less-defined construction of future climate change. A single region could be subject to, or participating in, any number of DWR efforts, each of which with differing climate change requirements or recommendations, potentially producing a variety of future outcome projections.

Table 1. Key programmatic attribute comparisons and potential consequences of inconsistency or misalignments.

<u>Attribute for comparison</u>	<u>Comparison</u>	<u>Potential consequence of inconsistency or misalignment</u>
Level of Mandate for Incorporation of Climate Change	Required versus recommended	Differing requirements for climate change planning could create a variety of futures on which stakeholders are basing their water use and management.
Level of Guidance Offered	Guidance may or may not be required by law, and the depth of guidance documents provided can vary drastically	Varying levels of guidance can result in a variety of future planning outcomes. Stakeholders with little to no guidance may have trouble identifying and incorporating existing relevant data into climate change planning. Whereas, highly detailed guidance could be burdensome, overly technical, and could quickly become outdated.
Level of Flexibility Offered in Rule	Rigidity in requirements for which climate change data to include (projections, level of temperature change, etc.) can vary	Rigidity could create a problem if not updated frequently to include the best available science, or if requirements are so inflexible as to not allow for distinct regional needs and goals.
Suggested Time Horizon	Could range from none suggested, 2050, or late century	Varying planning horizons can create abruptly different futures for the lifespan of a project or program, in addition to creating confusion and frustration among stakeholders.
Specificity of Data to Use	Could range from no identified data sources provided to very specific.	Overly detailed guidance can create a lack of flexibility and needs to be updated regularly, whereas providing little to no climate change data suggestions can leave planners at a disadvantage.

3. Findings in Externally Focused Programs and Projects

Note: As mentioned in Section 2.3 Inventory, WSIP has closed and is used here for analytical purposes only.

3.1 Level of Guidance Offered

The level of guidance offered varies from highly detailed to limited or no guidance. The IRWM, SGM and WSIP programs provide specific guidance, including datasets and time horizons. IRWM has very detailed guidance related to processes and framework for conducting vulnerability assessments and developing adaptation strategies within the [*Climate Change Handbook for Regional Water Planning*](#) (DWR 2011). WSIP and SGM intentionally utilize similar data sets and guidance for analysis, and as an ongoing program, SGM continues to improve information about extreme scenarios and updates its guidance as needed.

Similar guidance is not offered for AWUE, UWUE, or CVTP. AWUE provided a limited amount of climate change guidance in its AWMP guidebook, which is undergoing an update at this time, although the Water Code remains unchanged. UWUE guidance previously only pointed to IRWM climate change guidance documents, but the Water Code was updated in 2018 with stronger language for the requirement to include climate change considerations in urban water management. A new UWMP guidebook is pending for the 2021 planning cycle and includes further climate change guidance. CVTP provided no guidance but referenced a CCP resources document.

3.2 Level of Flexibility Offered in Rule

AWUE and UWUE provided the highest levels of flexibility, both being user-defined, but as stated above, the rule regarding the incorporation of climate change in UWUE has recently been updated and is yet to be defined. IRWM allows those developing an IRWMP to analyze climate change impacts in any manner as long as key questions related to identifying vulnerabilities and prioritizing adaptation and mitigation strategies are addressed. Applicants for IRWM Proposition 1 funds are required to answer specific questions about the inclusion of climate change, and although the methodology is not specified, project-specific metrics are, such as the contribution of the project to adapting to climate change effects on the region, changes in the amount, intensity, timing, quality and variability of runoff and recharge, effects of SLR on water supply conditions, and GHG reduction. WSIP defined specific data for applicants to use and how to use it. SGM guidance for Groundwater Sustainability Plan (GSP) development provides agencies with instructions on accounting for climate change or requires justification of using an alternative method. CVTP requires applicants to address risks from climate change but is flexible in how that is accomplished.

3.3 Suggested Time Horizon

Only two of the externally-focused programs and associated plans included specific time horizons (2030 and 2070) for consideration of projected climate change- WSIP and SGM.

3.4 Specificity of Data to Use

We found that specificity of data to use differed widely across externally-focused programs. AWUE suggests no specific datasets but instead refers to the use of “available information.” This leaves it up to the users’ discretion in determining what is “available,” which may also be influenced by what they consider salient, accessible, and trustworthy. UWUE offered no specific datasets but it is yet to be seen what the newest update will offer. IRWM also does not identify or provide specific datasets, but it does offer detailed guidance for process and methods through the *Climate Change Handbook for Regional Water Planning* (DWR, 2011) and the 2016 IRWM Guidelines require an IRWM plan to contain an evaluation of the IRWM region's vulnerabilities to climate change and potential adaptation responses based, at a minimum, on the vulnerabilities assessment in the handbook. In contrast, SGM offered, and WSIP required specific datasets of climate model-based projections. CVTP offered no datasets but referred users to a CCP resources document.

Table 2. Key attributes of the incorporation of climate change in externally focused program.

<u>Program</u>	<u>Level of Guidance</u>	<u>Level of Flexibility</u>	<u>Suggested Time Horizon</u>	<u>Specificity of Data to Use</u>
AWUE	Low	High	None	None
UWUE	Pending	Pending	Pending	Pending
SGM	High	Medium	2030, 2070 (suggested)	Highly specific and DWR offered
IRWM	High	High	None	None
WSIP	High	Low	2030, 2070 (required)	Highly specific and DWR required
CVTP	None	High	None	None

Table 3. Summary of attributes of externally focused programs and plans

<u>Program/Plan</u>	<u>DWR Office</u>	<u>Objective</u>	<u>Water User Target</u>	<u>Policy Mechanism</u>	<u>Timing</u>	<u>Mandate Level of Plan</u>
AWUE/ AWMP	IWM	To improve the efficiency of agricultural water operations and water use.	Agricultural	Plan required by law	Ongoing, next plans due 2020	Required (>25K IA)*
UWUE/ UWMP	IWM	To ensure that adequate water supplies are available to meet existing and future water needs.	Urban	Plan required by law	Ongoing, next plans due 2021	Required (>3000 SC or AF)
SGMO/ GSP	SGMO	Management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.	Basin water users	Plans required by law	GSPs are due 2020, 2022, then every 5 years, update annually	Required for medium and high priority basins
IRWM/ IRWMP	IWM	To identify and implement water management solutions on a regional scale; increase regional self-reliance, reduce conflict, and manage water to concurrently achieve social, environmental, and economic objectives.	Regional stakeholders	Grant program	Ongoing, next plans due 2021	Only required for grantmaking
WSIP	CWC	To fund public benefits associated with water storage projects funded by Proposition 1.	Project applicants and regional stakeholders	Grant program	Completed 2017	Only required for grantmaking
CVTP	DFM	Grant program to fund multi-benefit flood risk reduction projects in the Central Valley to address flood risk for urban and small communities, and/or rural areas; and enhance ecosystems by improving fish and wildlife habitat and downstream water quality.	Flood risk reduction beneficiaries and those working on supporting projects	Grant program	Round 1 Pending completion, awaiting awards in 2020	Only required for grantmaking

*Agricultural water suppliers servicing between 10,000 and 25,000 irrigated acres are only required to complete AWMPs if funding has been provided to do so.

4. Findings in Internally Focused Plans and Initiatives

4.1 Level of Mandate for Climate Change

At the time of this analysis, only one internal effort had a mandate for incorporating climate change- the CVFPP (California Water Code §9614). The CWP has included climate change projections in recent updates, however, there is no specific mandate to do so. However, Water Code 10004.6. states *(a) As part of updating The California Water Plan every five years pursuant to subdivision (b) of Section 10004, the department shall conduct a study to determine the amount of water needed to meet the state's future needs and to recommend programs, policies, and facilities to meet those needs.* While this section of the code does not explicitly mention climate change, it has been interpreted that any analysis of future supplies should include climate change considerations.

Climate change is central to developing the CAP III AP, but its creation is voluntary. DWR's CAP II, and the associated Water Resources Memorandum 75, are expected to provide more overarching requirements to plan for climate change impacts in DWR activities. The specific incorporation of climate change impact considerations in projects under the EcoRestore initiative is determined by the California Environmental Quality Act (CEQA). Climate change is noted in background documents as a reason and need for completing EcoRestore restoration targets but would be considered on a per-project basis.

4.2 Guidance Offered

In terms of guidance offered, neither the CWP or EcoRestore offered any specific climate change guidance, though they both call out the need to consider climate change. The CVFPP offers a high detail of guidance, including VIC (Variable Infiltration Capacity) simulations and hydrologic projections under climate change, including driest, median, and wettest scenarios that are under development. Of note, CWP and CVFPP alignment is the focus of a dedicated internal effort at the Department, which will be bolstered by pertinent findings from two climate change pilot studies in the Tuolumne and Merced River watersheds. The CAP III AP offers guidance through example and discussion of what climate adaptation processes involve and could be used as a framework for other projects.

4.3 Level of Flexibility

Level of Flexibility does not apply to most of the documents analyzed here in that they are not used for specific project development. However, the CVFPP and CAP III AP are both considered to have "high" flexibility.

4.4 Suggested Time Horizon

Two of the three internally-developed plans examined in this section refer to 2070 as the time horizon for considered climate change projections, whereas the CWP has a 50-year time horizon in all Updates.

4.5 Specificity of Data Used

The CVFPP has developed highly specific datasets for projected climate change. CWP’s future scenarios did look at a beyond 50-year data set and analytical approach in 2018, as opposed to the 50-year data sets used in 2013 and being planned for 2023. The upcoming CAP III AP will include technical information about any data used or discussed.

Table 4. Summary of attributes of internally focused plans and initiatives.

<u>Plan</u>	<u>Division/ Office</u>	<u>Objective</u>	<u>Mechanism</u>	<u>Timing</u>	<u>Mandate Level of Plan</u>
B160-California Water Plan Update	DOP	Presents the status and trends of California’s water-dependent natural resources; water supplies; and agricultural, urban, and environmental water demands for a range of plausible future scenarios.	Information offered by DWR	Every five years, specifically in years ending in 3 and 8	Required that DWR develop the plan
CVFPP	DMI	CA's strategic blueprint to improve flood risk management in the Central Valley: 1. Prioritize the State's investment in flood management over the next three decades 2. Promote multi-benefit projects 3. Integrate and improve ecosystem functions associated with flood risk reduction projects.	Plan required by law	Plan must be updated every five years, beginning in 2017	Required that DWR develop the Plan
Climate Action Plan Phase III AP	CCP	To develop implementable strategies to reduce the risk of climate change to DWR’s infrastructure, operations, and staff	Information offered by DWR	Updated every five years, or as needed	Offered by DWR
EcoRestore	DMI	Initiative to help coordinate and advance at least 30,000 acres of critical habitat restoration in the Delta.	Coordinating projects to consider them together	Completion goals ongoing 2020+	Required as a series of integrated projects

Table 5. Key attributes of the incorporation of climate change in internal plans and initiatives.

<u>Program</u>	<u>Mandate level for climate change</u>	<u>Level of Guidance Offered</u>	<u>Level of Flexibility</u>	<u>Suggested Time Horizon</u>	<u>Specificity of Data</u>
B160 - California Water Plan Update	None	None	N/A	50-yr planning horizon	None
CVFPP	Required (“a description of the probable impacts of projected climate change, projected land use patterns, and other challenges”; California Water Code §9614)	High	High	50-yr planning horizon from Update Plan releases (e.g. 2072)	High
Climate Action Plan Phase III AP	None	TBD	High	Mid-century (2050)	High
EcoRestore	CEQA requirements on a per-project basis	None	N/A	None	None

5. Finding in Internal Studies

5.1 Level of Mandate for Climate Change

None of the internal studies have a specific mandate to consider climate change. However, historically, the DCR has accounted for climate change at some level. The 2017 DCR did not account for climate change, with the exception of sea-level rise, but CVM has planned that all future editions will include climate change considerations.

5.2 Level of Guidance Offered

Not applicable.

5.3 Level of Flexibility

Not applicable.

5.4 Used or Suggested Time Horizon

Each uses a different time horizon. Flood-MAR generally uses 2050, the 2019 DCR will use 2035-2040, and the CAP III VA uses mid-century, up to 2070.

5.5 Specificity of Data to Use

Flood-MAR and CAP III VA are highly specific with technical details of what was developed and used for their analyses. The DCR is to be determined.

Table 6. Summary of internal studies that incorporate climate change.

<u>Plan</u>	<u>DWR Office</u>	<u>Objective</u>	<u>Mechanism</u>	<u>Timing</u>	<u>Mandate Level of Plan</u>
Flood-MAR	DOP	Explore the feasibility and effectiveness of Flood-MAR concepts, testing theories, and assessing strategies in overcoming barriers and challenges to project planning and implementation.	Pilot program with Reconnaissance Study to evaluate the feasibility of Flood-MAR and inform local entities on best management practices	Merced River Reconnaissance Study Phase 1: 2020; Phase 2: 2021	None
DCR	CVM	Provide an estimation of SWP deliveries.	Information offered by DWR for external use	Biannually	Required
CAP III VA	CCP	Develop a vulnerability assessment for facilities and activities.	Initiative of DWR’s Climate Change Program	Updated every 5 years, or as needed	None

Key attributes examined for the internally produced datasets and information differed slightly from those of the planning programs examined in the previous section. Table 7 lists key attributes of the time horizon used, the climate change projection specifications used, and the specificity of the datasets for use.

Table 7. Summarized key attributes of internal studies for the incorporation of climate change.

Program	Time Horizon Used	Projection specifications used	Specificity of Data to Use
Flood-MAR	Multiple	Using perturbed gridded temperature and precipitation (not downscaled)	Highly specific; Uses historical gridded meteorological data and paleo reconstructed annual streamflow
DCR	Twenty years in the future (“early-long term”)	Most recent approach uses ensemble-informed median	N/A
CAP III VA	Mid-century (2030 to 2070)	Decision-scaling, downscaled GCMs, and assessments for different hazards	Range of existing downscaled and DWR developed projections, including decision scaling

6. Discussion: Comparison Findings & Priority Alignment Opportunities

Among the climate change mandates and guidance examined for external programs, several areas of inconsistencies and opportunities for beneficial alignment were found. AWUE and UWUE are both well-established water use efficiency programs that have inconsistent requirements and guidance for considering climate change. UWUE has recently undergone a legislative update that includes stronger language detailing the requirement to include climate change considerations in both the assessment of projected supply sources and water demands. Per [Water Code section 10630](#), *it is the intention of the Legislature, in enacting this part, to permit levels of water management planning commensurate with the numbers of customers served and the volume of water supplied, while accounting for impacts from climate change.* Guidance on how to accomplish this new mandate will be developed in an updated UWMP guidebook in coordination with the CCP by June 2020 for implementation in the 2021 planning cycle.

Previous to this update the climate change planning requirements for UWMP, as with AWMP, were user-defined and DWR provided limited or no guidance. Within a single region, multiple stakeholders could be required to turn in both AWMPs and UWMPs and could be voluntarily turning in an IRWMP, all potentially with different climate change planning considerations. Ideally, all stakeholders would be members of their IRWM group where climate change could be considered comprehensively to create one unified climate change assessment and adaptation strategy to be used in all applications of regional planning. In addition, a discussion of how planning documents and programs relate to climate change is required in IRWM plans per local land and water planning IRWM Guideline requirements. This information could serve as a foundation of a unified assessment and strategy for the given IRWM region and in some IRWM plans this has already been done. However, as it stands, a user with a much lower or looser climate change requirement might not have an incentive for participating in a more robust planning process. Misalignments and inconsistencies in DWR's planning programs can lead to confusion and frustration among stakeholders, especially if using these plans to create larger county or city general or hazard mitigation plans.

Comparing the climate change considerations taken within internal plans and initiatives can be challenging due to the number of partners participating. CWP, CVFPP, and EcoRestore have multiple participating entities, each with a different set of climate change goals and requirements that DWR must consider. The Department realizes the importance of aligning the CWP and the CVFPP and has developed a conceptual framework for aligning future updates regarding all subjects, not just climate change. The CVTP supported flood risk reduction projects on tributaries to the Delta, including levee setbacks, levee repairs or enhancements to existing levees and other flood management infrastructure, creation or enhancement of floodplains and bypasses, groundwater recharge projects in floodplains, and land acquisition and necessary

easements for these projects; all of these activities would have been covered under the climate change requirements.

CAP II – Climate Change Analysis Guidance and forthcoming Water Resources Memorandum 75 serve as Department policy for climate change alignment across DWR projects and should be implemented across all programs. CAP II offers flexibility and defines criteria for climate change consideration based on the lifetime of the proposed project and a qualitative estimate of vulnerability to a range of climate change hazards and allows DWR programs to choose a climate change analysis approach based on needs relevant to the project. The CAP II policy is responsive to and demonstrates DWR’s compliance with AB 1482 and AB 2800. Additionally, CAP II could be expanded to incorporate guidance for externally-focused and mixed-focused projects and plans.

It must also be noted that since 2007, the Department has had a standing forum to communicate, coordinate, and align climate change information across its projects and programs—the DWR Climate Change Matrix Team. That said, Department management and staff have, at best, underutilized this team for such alignment, and, at worst, willfully ignored it.

In summary, all three categories of efforts; external, internal, and internal studies, have inconsistencies among their suggested time horizons and specificities of data to use for climate change analyses. Additionally, the external programs are misaligned with one another in terms of the level of climate change guidance offered for each effort.

To continue to improve the alignment of climate change efforts at DWR involves prioritization of where improving alignment warrants either further examination or implementing changes. The misalignments identified in this report could be informed through a comparison of climate change analyses conducted by stakeholders for AWMP, IRWMP, and UWMP to gauge how they differ and what potential areas of conflict may arise in adaptation planning, and by internally aligning CVFPP and CWP climate change technical guidance.

6.1 Next Steps

Based on this examination of efforts at DWR, one area to prioritize for alignment is within AWUE, UWUE, and IRWM. The Water Code has recently been revised for UWUE to account for consideration of climate change within the UWMPs, although guidance is under development and is yet to be seen how it will align with existing AWUE and IRWM climate change requirements and guidance. AWUE is currently undertaking an update to its guidebook, which may present an ideal and immediate opportunity for alignment. The DWR Financial Assistance Internal Review (FAIR) team has been collecting voluntary information, on behalf of the CCP, from applicants to these, and other programs, regarding their capacity to conduct climate change

planning efforts. These responses can be collected and analyzed to develop alignment guidance that better serves our stakeholders.

IRWM provides guidance through a climate change planning handbook (DWR 2011) which may benefit from an update. The handbook was developed by the CCP with partners and could be updated regardless of any particular planning period. In 2012, a study of IRWM approaches was completed through the University of Berkeley titled *Climate Change and Integrated Regional Water Management in California: A Preliminary Assessment of Regional Approaches* (Conrad, 2012) as well as *An Evaluation of Climate Change Handbook for Regional Water Planning* (Alpert, 2015) that suggested several potential DWR actions that could aid alignment, including better identifying appropriate resources for climate change planning with a focus on specific support needed for analysis of flooding and ecosystem impacts, more outreach and support to the IRMW regions, as well as a comparison of the various analytical approaches to climate change modeling to identify the best approaches for certain purposes.

SGM seemed to provide the most appropriate level of guidance and flexibility for development of GSPs and could be used as a model for other programs. Further analyzing the guidance provided under SGM and how it could be adapted to suit the needs of AWUE, UWUE and IRWM may be a starting point for this process. Alignment of these core programs could form the framework for the development of Department-wide guidance of implementing legislation which names DWR as the lead agency and requires climate change considerations.

Additional next recommended steps are that time horizons should be tailored to DWR's projects, as CAP II requires, and that data specificity in any program or plan is updated when necessary to avoid the use of outdated material. Institutionalizing these actions would help maintain continuity in cases of staff changes. Building on the existing CAP II guidance to better support climate change considerations in programs like AWMP, UWMP and IRWMP would support alignment within planning. The longer-term objective is to provide alignment of the CWP and CVFPP, employing a common vulnerability and resiliency analytical framework tied to CAP II by incorporating consistent use of the decision scaling framework, and describing vulnerabilities and resilience adaptation strategies at appropriate levels of detail. Lastly, sea level rise consideration are critical to any project or plan located in, or dependent on, the Sacramento-San Joaquin Delta and as such a full inventory of sea level rise assumptions in DWR projects and activities should be conducted as part of a future Department endeavor, such as within a CAP II Working Group.

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Appendix A

Additional information on programs, legislation, and efforts discussed

Agricultural Water Management Plans

The Water Conservation Act of 2009 (SB X7-7) requires agricultural water suppliers serving more than 25,000 irrigated acres (excluding recycled water deliveries) to adopt and submit to DWR an Agricultural Water Management Plan (AWMP). These plans must include reports on the implementation status of specific Efficient Water Management Practices (EWMPs) that were required under SB X7-7.

<https://water.ca.gov/Programs/Water-Use-And-Efficiency/Agricultural-Water-Use-Efficiency>

Urban Water Management Plans

Urban Water Management Plans (UWMPs) are prepared by urban water suppliers every five years. These plans support the suppliers' long-term resource planning to ensure that adequate water supplies are available to meet existing and future water needs.

The requirements for UWMPs are found in two sections of California Water Code, §10610-10656 and §10608. Every urban water supplier that either provides over 3,000 acre-feet of water annually or serves more than 3,000 urban connections is required to submit an UWMP.

<https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans>

Integrated Regional Water Management

Integrated Regional Water Management (IRWM) is a collaborative effort to identify and implement water management solutions on a regional scale that increase regional self-reliance, reduce conflict, and manage water to concurrently achieve social, environmental, and economic objectives. This approach delivers higher value for investments by considering all interests, providing multiple benefits, and working across jurisdictional boundaries. Examples of multiple benefits include improved water quality, better flood management, restored and enhanced ecosystems, and more reliable surface and groundwater supplies.

The IRWM story began in 2002 when the Regional Water Management Planning Act (SB 1672) was passed by the Legislature. Since then, various bond acts approved by California voters have provided over \$1.5 billion in State funding to support and advance integrated, multi-benefit

regional projects. The local match on the State resources has been impressive; often on the order of 4:1. Cities, counties, water districts, community/environmental groups, Tribes and others across the State have worked collaboratively to organize and establish 48 regional water management groups, covering over 87 percent of the State's area and 99 percent of its population.

<https://water.ca.gov/Programs/Integrated-Regional-Water-Management>

SGMA Groundwater Management

On September 16, 2014, Governor Jerry Brown signed into law a three-bill legislative package, composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA). For the first time in its history, California has a framework for sustainable groundwater management - “management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.”

SGMA requires governments and water agencies of high and medium priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge. Under SGMA, these basins should reach sustainability within 20 years of implementing their sustainability plans. For critically over-drafted basins, that will be 2040. For the remaining high and medium priority basins, 2042 is the deadline.

SGMA empowers local agencies to form Groundwater Sustainability Agencies (GSAs) to manage basins sustainably and requires those GSAs to adopt Groundwater Sustainability Plans (GSPs) for crucial groundwater basins in California.

<https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management>

Water Storage Investment Program

In November 2014, California voters approved Proposition 1, the Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Water Code, §§ 79700-79798) to provide funding to meet the three broad objectives of the California Water Action Plan:

- More reliable water supplies
- Restoration of important species and habitat
- A more resilient and sustainably managed water infrastructure

Chapter 8 of Proposition 1 appropriated \$2.7 billion to the California Water Commission to fund public benefits associated with water storage projects that improve the operation of the state water system, are cost effective, and provide a net improvement in ecosystem and water quality conditions.

<https://cwc.ca.gov/Water-Storage>

The California Water Plan

The California Water Plan, Bulletin B-160, is the State's strategic plan for sustainably managing and developing water resources for current and future generations. Required by [water code Section 10005\(a\)](#) as the status and trends of California's water-dependent natural resources; water supplies; and agricultural, urban, and environmental water demands for a range of plausible future scenarios.

The plan:

- Is updated every five years
- Provides a way for various groups to collaborate on findings and recommendations and make informed decisions regarding California's water future
 - Elected officials
 - Government agencies
 - Tribes
 - Water and resource managers
 - Businesses
 - Academia
 - Stakeholders
 - General public
- Can't mandate actions or authorize spending for specific actions
- Doesn't make project- or site-specific recommendations nor include environmental review or documentation as would be required by the California Environmental Quality Act (CEQA)
- Requires policy- and law-makers to take definitive steps to authorize the specific actions proposed in the plan and appropriate funding needed for their implementation

<https://water.ca.gov/Programs/California-Water-Plan>

Central Valley Flood Protection Plan

The Central Valley Flood Protection Plan (CVFPP) is California's strategic blueprint to improve flood risk management in the Central Valley. The first plan was adopted in 2012 and is updated every 5 years. The plan lays out strategies to:

- Prioritize the State's investment in flood management over the next 3 decades
- Promote multi-benefit projects
- Integrate and improve ecosystem functions associated with flood risk reduction projects.

Considerable progress has been made to improve flood management in the Central Valley; however, this vast region still faces significant flood risk. Approximately 1 million Californians live and work in the floodplains of the valley, which contain approximately \$80 billion worth of infrastructure, buildings, homes, and prime agricultural land. A major flood in the Central Valley could have a far greater financial impact on California and the nation than the devastation caused by Hurricane Katrina or Superstorm Sandy. Without sufficient and sustained investment in statewide flood management, the risk to life and property will increase.

<https://water.ca.gov/Programs/Flood-Management/Flood-Planning-and-Studies/Central-Valley-Flood-Protection-Plan>

DWR Climate Action Plan- Phase III

The [Phase III Climate Change Vulnerability Assessment](#) (VA) provides the first comprehensive evaluation of DWR’s vulnerabilities to expected increases in wildfire, extreme heat, and sea-level rise, as well as to changes in ecosystems and long and short-term hydrology due to climate change. The VA identifies the activities performed and specific assets owned and/or operated by DWR that have vulnerabilities related to climate change.

A supplemental report, the [Decision Scaling Evaluation of Climate Change Driven Hydrologic Risk to the State Water Project](#), documents a joint endeavor of DWR and academic partners to improve planning for the uncertain effects of climate change on the California State Water Project by integrating vulnerability-based analysis with traditional risk-based assessment methods.

The [Phase III Adaptation Plan \(AP\)](#), expected for release in 2020, will help prioritize DWR resiliency efforts such as infrastructure improvements, enhanced maintenance and operation procedures, revised health and safety procedures, and improved habitat management.

Flood-Managed Aquifer Recharge (Flood-MAR)

“Flood-MAR” is an integrated and voluntary resource management strategy that uses flood water resulting from, or in anticipation of, rainfall or snow melt for managed aquifer recharge (MAR) on agricultural lands and working landscapes, including but not limited to refuges, floodplains, and flood bypasses. Flood-MAR can be implemented at multiple scales, from individual landowners diverting flood water with existing infrastructure, to using extensive detention/recharge areas and modernizing flood management infrastructure/operations.

Flood-MAR projects can provide broad benefits for Californians and the ecosystems of the state, including:

- Water supply reliability
- Flood risk reduction
- Drought Preparedness
- Aquifer Replenishment
- Ecosystem Enhancement
- Subsidence Mitigation
- Water Quality Improvement
- Working Landscape Preservation and Stewardship
- Climate Change Adaptation
- Recreation and Aesthetics

There is strong, and growing, interest across the state in understanding the benefits, limitations, concerns, costs, and funding opportunities for Flood-MAR projects. DWR plans to work with

other state, federal, tribal, and local entities; academia; and landowners. Together, we will build on the knowledge and lessons from past and ongoing studies and programs, pursue expanded implementation of Flood-MAR, and make Flood-MAR an integral part of California's water portfolio.

<https://water.ca.gov/Programs/All-Programs/Flood-MAR>

California EcoRestore

California EcoRestore is a multi-agency initiative led by the California Natural Resources Agency. The California Department of Water Resources (DWR) is a partner on 28 of the 30 projects which seek to restore at least 30,000 acres of Sacramento-San Joaquin Delta (Delta) habitat by 2020.

EcoRestore projects are driven by world-class science and guided by adaptive management and seek to support the long-term health of the Delta and its native fish and wildlife species.

The types of habitat targeted include tidal wetlands, floodplain, upland, riparian, fish passage improvements and others.

<https://water.ca.gov/Programs/All-Programs/EcoRestore>

Delivery Capability Report 2017

This report is intended for public information about the key factors affecting the operation of the State Water Project (SWP) system in California, its long-term reliability as a source of water for beneficial use, and an estimate of its current delivery capability. Water provided by the SWP is a major component of the water supplies available to many SWP Contractors. State Water Contractors (SWC) consists of 29 legal entities that include cities, counties, urban water agencies, and agricultural irrigation districts. SWC's local/regional water users have long term contracts with DWR for all, or a portion of their water supply needs. Thus, the reliability of water from the SWP system is an important component in the water supply planning of its recipients, and ultimately affects the amount of water available for beneficial use in California.

<https://data.cnra.ca.gov/dataset/dcr2017/resource/be3e5c05-e4d2-450e-8f61-b55cc7a71301>

Appendix B

Column Attributes for Table 8 (below):

- **Type:** Whether the project supports long-term *planning*, is part of an *Environmental Impact Report or Statement (EIR/EIS)* and/or *permitting*, or mandated *reporting* to the public.
- **Hydro-Meteorological Source Data:** Temperature, precipitation and streamflow observational datasets used to construct climate conditions.
- **CMIP Archive:** The specific phase (i.e. 3 or 5) of the Coupled Model Intercomparison Project (CMIP) from which the global climate models are used.
- **Downscaling method:** The method of statistical downscaling; here, either Localized Constructed Analogs (LOCA) or Bias Corrected Spatial Disaggregation (BCSD).
- **Quantile Mapping Variables:** In the construction of period datasets, the hydro-meteorological data that are perturbed to represent the future projected climate change signal.
- **Transient or Period:** “Transient” refers to direct simulation of GCM projected temperature, precipitation, or streamflow (i.e. climate signal evolves and strengthens over time); “period” refers to statistical application of the GCM projected change signal at the future time horizon to a historic sequence (i.e. climate signal remains constant over time).
- **Planning Horizon:** The future time frame (30-year centered) chosen to represent future climate conditions.
- **GCM and RCP:** Global climate models (GCM) and representative concentration pathways (RCP) used in the analysis.
- **Hydrologic model:** The hydrologic model used to simulate energy balance and routing of runoff.
- **System model:** The water system model used to simulate reservoir operations, diversions and flows within the system of managed channels and rivers.
- **Metric(s):** The major sectors for which system performance is quantified.

Additional Table 9 column attributes (below):

- **Hydroclimate Extension Method:** Method used to extend the historical record to cover a wider estimated envelope of natural variability.
- **Perturbed Variables:** The hydro-meteorological variables systemically perturbed to represent specific types of large-scale projected changes in climate.
- **GCM Probabilities:** The archive of CMIP models and RCPs used to construct a probability density of projected future changes in the perturbed variables.

Table 8. Recent and ongoing DWR projects and activities utilizing scenario based (GCM) and downscaling methods

Project	Type	Hydro-Meteorological Source Data	CMIP Archive	Downscaling Method	Quantile Mapping Variables	Transient or Period	Planning Horizon	GCM and RCP	Hydrologic Model(s)	System Model(s)	Metric(s)
Water Storage Investment Program (WSIP)	Planning	Livneh et al. (2013)	CMIP5	LOCA	Daily: temperature/precipitation	Period	2030 & 2070 (ensemble mean) 2070 (extreme dry/hot and wet/warm)	Ensemble mean of CCTAG 10 models with 2 RCPs (4.5/8.5); Two extremes selected from CCTAG: CNRM-CM5 (RCP4.5) and HadGEM-ES (RCP 8.5)	VIC	CalSim-II DSM-II	Raw data provided for applicants to quantify various public benefits (supply / water quality / environmental / recreational etc.)
Delta Conveyance (in progress)	EIR/EIS	Livneh et al. (2013) PRISM CADWR (2014)	CMIP5	LOCA	Monthly: - Rim streamflows - Reservoir evaporation - Temperature/precipitation for Delta and groundwater model inputs	Period	TBD	TBD	VIC CalSim-Hydro Delta Channel Depletion (DCD)	CalSim-III DSM-II C2VSIM	Supply Water Quality

Project	Type	Hydro-Meteorological Source Data	CMIP Archive	Downscaling Method	Quantile Mapping Variables	Transient or Period	Planning Horizon	GCM and RCP	Hydrologic Model(s)	System Model(s)	Metric(s)
2019 Incidental Take Permit (ITP)	EIR Permitting	Livneh et al. (2013) PRISM	CMIP5	LOCA	Monthly: temperature/precipitation	Period	2035 (2020-2049)	<i>Hydrology:</i> ensemble mean of CCTAG <i>Water temp:</i> least-warming (PCMB1) and most-warming (GFDL-A2) from Brown et al. (2016)	VIC	CalSim-II DSM-II	Supply Water Quality Species
2019 Delivery Capability Report (DCR)	Reporting	Livneh et al. (2013) PRISM	CMIP5	LOCA	Monthly: temperature/precipitation	Period	2035 (2020-2049)	Ensemble mean of CCTAG (same as 2019 ITP hydrology)	VIC	CalSim-II	Supply
2018 CWP	Planning	LOCA	CMIP5	LOCA	N/A (transient)	Transient	N/A	Each individual CCTAG model and RCP (4.5/8.5)	WEAP	WEAP	Supply
2023 CWP (in progress)	Planning	LOCA	CMIP5	LOCA	N/A (transient)	Transient	2070	Each individual CCTAG model and RCP (4.5/8.5)	WEAP	WEAP	Supply Ecosystem
2017 CVFPP	Planning	Livneh et al. (2013) PRISM Observed Gages	CMIP3/ CMIP5	BCSD/LOCA	Monthly: temperature/precipitation	Period	2085	<i>1st Phase:</i> selection of model-RCPs from >100 CMIP3 models based on average annual temperature and precipitation <i>Phase B:</i> selection of 10	VIC	HEC-ResSim HEC-RAS HEC-FIA	Flood

Project	Type	Hydro-Meteorological Source Data	CMIP Archive	Downscaling Method	Quantile Mapping Variables	Transient or Period	Planning Horizon	GCM and RCP	Hydrologic Model(s)	System Model(s)	Metric(s)
2022 CVFPP <i>(in progress)</i>	Planning	Livneh et al. (2013) PRISM Observed Gages	CMIP5	LOCA	Monthly: temperature/ precipitation	Period	2072 (median) 2072 (extreme wet/hot and dry/warm)	model-RCPs from 32 CMIP5 models with 2 RCPs (4.5/8.5) based on average annual temperature and precipitation	VIC	HEC- ResSim HEC- RAS HEC-FIA	Flood
								Selection of 10 model-RCPs from 32 CMIP5 models with 2 RCPs (4.5/8.5) based on average annual temperature and precipitation			
SGMA	Planning	Livneh et al. (2013)	CMIP5	LOCA	Daily: temperature/ precipitation	Period	2030 & 2070 (ensemble mean)	Ensemble mean of CCTAG	VIC	CalSim-II	Supply
SGMA Extreme Scenarios	Planning	Livneh et al. (2013)	CMIP5	LOCA	Daily: temperature/ precipitation **Quantile <i>delta</i> mapping	Period	2070 (extreme dry/hot and wet/warm)	CNRM-CM5 (RCP4.5) and HadGEM-ES (RCP 8.5)	VIC	CalSim-II	Supply

Table 9. Recent and ongoing DWR projects and activities utilizing bottom-up (decision-scaling) methods

Project	Type	Hydro-Meteorological Source Data	Hydroclimate Extension Method(s)	Perturbed Variables	Hydrologic Model(s)	System Model(s)	GCM Probabilities	Planning Horizon	Metric(s)
SWP Vulnerability Assessment	Planning	Livneh et al. (2015)	Paleo (Meko et al. 2014)	<i>Temperature: 0-4°C</i> <i>Precipitation: -20% – +30%</i>	SAC-SMA	CalLite	40 CMIP5 models with 2 RCPs (4.5/8.5)	2050	Supply
Merced Study (in progress)	Planning	Livneh et al. (2015)	Paleo (Meko et al. 2014)	<i>Temperature: 0-4°C</i> <i>Precipitation: -20% – +30%</i>	SAC-SMA HEC-HMS	HEC-ResSim GRAT C2VSIM CalLite	40 CMIP5 models with 2 RCPs (4.5/8.5)	2040 2070 “Tipping Points”	Supply Flood Ecosystem
Tuolumne Study (in progress)	Planning	Livneh et al. (2015) Local station data	Paleo (Meko et al. 2014) Weather Generator (Steinschneider et al. 2019)	<i>Temperature: 0, +2, +3, +4°C</i> <i>Precipitation: -(+)3% per °C</i> <i>Precipitation intensity: +7% and +14% per °C</i> <i>Inter-seasonal variance of precipitation: El Nino signal amplification</i>	HEC-HMS	HEC-ResSim HEC-RAS HEC-FIA	TBD	TBD	Supply Flood Ecosystem
Subsidence Program	Planning	Livneh et al. (2015)	Paleo (Meko et al. 2014)	<i>Temperature: 0-4°C</i> <i>Precipitation: -20% – +30%</i>	SAC-SMA	CalLite	40 CMIP5 models with 2 RCPs (4.5/8.5)	Transient	Supply Drought
Delta Adapts by DSC (jointly with DWR)	Planning	Livneh et al. (2015)	Paleo (Meko et al. 2014)	<i>Temperature: 0-4°C</i> <i>Precipitation: -20% – +30%</i> <i>Interannual variance of precipitation: -50% – +50% standard deviation</i>	SAC-SMA	CalLite	32 CMIP5 models with 2 RCPs (4.5/8.5)	2050	Supply
CWP 2023 Pilot (in progress)	Planning	Livneh et al. (2015)	Paleo (Meko et al. 2014)	<i>Temperature: 0-4°C</i> <i>Precipitation: -20% – +30%</i>	WEAP	WEAP	40 CMIP5 models with 2 RCPs (4.5/8.5)	2070	Supply Ecosystem

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Appendix B References

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