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State Water Resources Control Board

February 21, 2024

Diane Riddle
Assistant Deputy Director
Division of Water Rights
State Water Resources Control Board

SUBJECT: FINAL RESPONSE TO REQUEST FOR REVIEW OF THE FINAL DRAFT SCIENTIFIC BASIS REPORT SUPPLEMENT IN SUPPORT OF PROPOSED VOLUNTARY AGREEMENTS FOR THE SACRAMENTO RIVER, DELTA, AND TRIBUTARIES UPDATE TO THE SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA WATER QUALITY CONTROL PLAN

Dear Diane Riddle,

In October 2023, the CalEPA External Scientific Peer Review Program received your request for external scientific peer review for the subject proposal. The review was conducted by seven independent, neutral, and objective scientific experts as described in a draft response letter from the Program dated 06 February 2024. That letter included reviewers' names, affiliations, curriculum vitae, initiating letters, and draft review reports.

Staff from the Division of Water Rights determined that the review reports independently and collectively addressed all assumptions, conclusions, and findings under review. The review reports have been brought into compliance with web accessibility standards. This letter forwards those reports and concludes this peer review request.

If you have any questions, please contact me directly.

Sincerely,

Dorena Goding

Dorena Goding
CalEPA External Scientific Peer Review Program
Office of Research, Planning, and Performance
State Water Resources Control Board
Dorena.Goding@waterboards.ca.gov

Approved reviewers:

1. Joseph Domagalski, Ph.D.
   Program Chief, Biogeochemistry and Contaminants, California Water Science Center
   United States Geological Survey
   6000 J Street, Placer Hall
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2. Stephen Katz, Ph.D.
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3. Margaret Palmer, Ph.D.
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   University of Maryland
   4112A Plant Sciences Building, 4291 Fieldhouse Drive
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4. N. LeRoy Poff, Ph.D.
   Professor of Biology, Department of Biology
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5. John Sabo, Ph.D.
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   Professor, Department of River-Coastal Science and Engineering
   Tulane University
   627 Lindy Boggs Center
   New Orleans, LA 70118

6. Mario Barletta, Ph.D.
   Professor, Laboratory of Ecology and Management of Coastal and Estuarine Ecosystems (LEGECE)
   Oceanography Department
   Federal University of Pernambuco
   Av. Arquitetura, s/n?, Cidade Universit?ria, 50740-550, Pernambuco, Brazil

7. Daren M. Carlisle, Ph.D.
   Manager, Ecological Flows Program
   United States Geological Survey Kansas Water Science Center
   1217 Biltmore Drive, Lawrence, KS 66049

Attachments:

(1) 25 October 2023 Request by Diane Riddle for Scientific Peer Review

(2) Web Accessible Reviews
   i. Joseph Domagalski, Ph.D.
   ii. Stephen Katz, Ph.D.
   iii. Margaret Palmer, Ph.D.
   iv. N. LeRoy Poff, Ph.D.
   v. John Sabo, Ph.D.
   vi. Mario Barletta, Ph.D.
   vii. Daren M. Carlisle, Ph.D.

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TO: Dorena Goding
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Office of Research, Planning, and Performance
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FROM: Diane Riddle, *Diane Riddle*
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DATE: 10/25/2023

SUBJECT: Request for External Scientific Peer Review of the Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary

Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan

Title of Proposal for Review

This request is regarding Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan

OUR INTENDED ADOPTION DATE OF THE PROPOSED RULE IS as early as late 2024.

State Water Resources Control Board staff requests that you initiate the process to identify external scientific peer reviewers for *Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan (September 2023)*, per the requirements of California Health and Safety Code section 57004.

Purpose of Review

The State Water Resources Control Board (State Water Board) is currently in the process of updating and implementing the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). In 2022, the State Water Board received a Memorandum of Understanding signed by state and federal agencies and water users proposing Voluntary Agreements (VAs) for updating and implementing the Bay-Delta Plan. The State Water Board is in the process of evaluating and considering the VAs. This *Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan* (hereafter referred to as the ***Draft Supplement Report***; State Water Board et al. 2023a) is part of that process and has been prepared to document the science supporting the proposed provisions included in the VAs.

The updates to the Bay-Delta Plan are focused on the reasonable protection of native fish and wildlife beneficial uses of water. The VAs propose to update the plan by adding a new narrative ecosystem protection objective and proposed flow and non-flow habitat commitments. Specifically, the VAs propose: 1) a new Narrative Viability Objective to achieve the viability of native fish populations; and 2) to provide the participating parties' share, during implementation of the VAs, to contribute to achieving the existing Narrative Salmon Protection Objective, and propose doing so by 2050. The flow and non-flow habitat restoration assets are intended to improve spawning and rearing capacity for salmonids and other native fish species. The VA proposal includes provisions for adaptive management of the VA assets, supported by a governance structure and monitoring, reporting, and evaluation of the effectiveness of VA measures for achieving the two narrative objectives (September 2023 Draft VA Proposal [California Natural Resources Agency et al. 2023]).

When All Supporting Documents and References will be Available at the FTP Site

October 25, 2023

Requested Review Period

The State Water Board requests that scientific peer review be accomplished within 45 days.

Necessary Areas of Expertise for Reviewers

We request one reviewer with technical expertise in environmental flows, and three to four reviewers with expertise in aquatic ecology, including salmonid ecology, riverine restoration ecology and habitat modeling, estuarine fish ecology, and wetland restoration ecology and habitat modeling. We anticipate that some reviewers may have overlapping areas of expertise, for example, the same reviewer may have expertise in salmonid ecology and riverine restoration ecology and habitat modeling, which is why we are requesting a range of three to four reviewers with expertise in aquatic ecology. Below we detail which assumptions, findings, and conclusions found in Attachment 2 should be reviewed according to the reviewer's area of expertise.

<u>Environmental Flows</u>
We request at least one reviewer with expertise in environmental flows to evaluate the report's assumptions, findings, and conclusions about how aquatic ecosystem stressors, including stressors resulting from water management infrastructure and altered flow regimes, have contributed to declines of native fish species (Conclusion 1 of Attachment 2) and about how the quantity and timing of VA flow assets could provide benefits to native species by mitigating aquatic ecosystem stressors and increasing species abundances to contribute to achieving the Narrative Salmon Protection Objective and the Narrative Viability Objective (Conclusions 2-4 of Attachment 2).

<u>Salmonid Ecology</u>
We request at least one reviewer with expertise in salmonid ecology to evaluate the assumptions, findings, and conclusions of how aquatic ecosystem stressors have contributed to declines of salmon populations (see Conclusion 1 of Attachment 2), and how the combination of VA flow and non-flow habitat restoration assets can contribute to achieving the Narrative Salmon Protection Objective by providing additional instream flow, increasing the area of suitable spawning and rearing habitat, and mitigating other

aquatic ecosystem stressors (Conclusions 2 and 3 of Attachment 2). Reviewer(s) should also have the expertise to evaluate the methods and assumptions of the quantitative and qualitative analyses of VA benefits for contributing to achieving the Narrative Salmon Protection Objective (See Habitat modeling, and Qualitative evaluations of benefits under Conclusion 5 of Attachment 2).

Estuarine Fish Ecology

We request at least one reviewer with expertise in estuarine fish ecology to evaluate the assumptions, findings, and conclusions of how aquatic ecosystem stressors have contributed to declines of native fish species in the Bay-Delta (see Conclusion 1 of Attachment 2). Reviewer(s) should also evaluate the report's conclusions regarding how the combination of VA flow and non-flow habitat restoration assets can contribute to achieving the Narrative Salmon Protection Objective and the Narrative Viability Objective by providing additional flow, increasing suitable Delta and estuarine habitat, and mitigating other aquatic ecosystem stressors (Conclusions 2 and 4 of Attachment 2). Lastly, reviewer(s) should evaluate the methods and assumptions of the quantitative and qualitative analyses of VA benefits for contributing to achieving the Narrative Salmon Protection Objective and the Narrative Viability Objective (See Habitat modeling, Flow-abundance relationships, Flow threshold analysis, and Qualitative evaluations of benefits under Conclusion 6 of Attachment 2).

Riverine Restoration Ecology and Habitat Modeling

We request at least one reviewer with expertise in riverine restoration ecology and habitat modeling to review the report's conclusions about how the combination of VA flow and non-flow habitat restoration assets can increase the availability of suitable spawning and rearing habitat in the Bay-Delta and its tributaries to contribute to achieving the Narrative Salmon Protection Objective and the Narrative Viability Objective (Conclusions 2 and 3 of Attachment 2). Reviewer(s) should also evaluate the methods and assumptions of the quantitative and qualitative analyses of VA assets for contributing to achieving the Narrative Salmon Protection Objective and the Narrative Viability Objective (See Habitat modeling, and Qualitative evaluations under Conclusion 5 of Attachment 2).

Wetland Restoration Ecology and Habitat Modeling

We request that at least one reviewer with expertise in wetland restoration ecology and habitat modeling review the report's conclusions regarding how the combination of VA flow and non-flow habitat restoration assets can contribute to achieving the Narrative Salmon Protection Objective and the Narrative Viability Objective by providing additional flow, increasing suitable Delta and estuarine habitat, and mitigating other aquatic ecosystem stressors (Conclusions 2 and 4 of Attachment 2). These reviewer(s) should also have the expertise to evaluate the methods and assumptions of the quantitative and qualitative analyses of VA habitat restoration benefits for contributing to achieving the Narrative Salmon Protection Objective and the Narrative Viability Objective (See Habitat modeling, and Qualitative evaluations of benefits under Conclusion 6 of Attachment 2).

Refer to Attachment 2 for more details.

Contact Information

Laura Twardochleb is the project manager: laura.twardochleb@waterboards.ca.gov

Attachments

Attached please find:

1. Attachment 1: Plain English Summary.
2. Attachment 2: Scientific Assumptions, Findings, and Conclusions to Review.
3. Attachment 3: Individuals who Participated in the Development of the Proposal.
4. Attachment 4: References Cited.

Attachment 1: Plain English Summary

Background

The State Water Resources Control Board (State Water Board or Board) is considering amendments to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan) that is developed and adopted pursuant to the provisions of the Porter-Cologne Water Quality Control Act (Porter-Cologne) and the federal Clean Water Act.

A water quality control plan consists of three parts (Wat.Code, § 13050(j)):

1) beneficial uses of water to be protected by the plan;
2) water quality objectives to protect those uses; and
3) a program of implementation needed for achieving the water quality objectives.

Water quality objectives are the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses (Wat. Code, § 13050(h)). Components of the Bay-Delta Plan when implemented also: 1) carry out provisions of the reasonable use doctrine (Cal. Const. Art. X, § 2; Wat. Code, §§ 100, 275, and 1050); 2) protect public trust resources (see National Audubon Society v. Superior Court (1983) 33 Cal.3d 419,189 Cal. Rptr. 346); and 3) carry out statutory principles pertaining to water rights (Wat. Code, §§ 183, 1243, 1243.5, 1251, 1253, and 1256-1258). As such, the Bay-Delta Plan addresses overlapping water quality and water supply issues and plans for their coordination.

The Bay-Delta Plan currently includes various water quality, flow, and water project operational objectives to protect beneficial uses in the Bay-Delta, including municipal and industrial, agricultural, and fish and wildlife uses. Objectives for the protection of fish and wildlife are included in Table 3 on pages 14 to 17 of the 2018 Bay-Delta Plan (2018 Water Quality Control Plan (ca.gov)) and its associated footnotes, figures, and tables. Among other requirements, Table 3 includes objectives for Delta outflows throughout the year; minimal mainstem Sacramento River inflows from September to December; and water project operational constraints in the interior Delta including year-round export limitations based on total Delta inflows, export limitations based on San Joaquin River inflows that apply from April 15 to May 15, and Delta Cross Channel gate closure requirements that apply from November through June. Currently, the Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Reclamation) have primary responsibility for implementing the Bay-Delta Plan objectives as required by the Board's revised Water Right Decision 1641 (D-1641). In D-1641, the State Water Board accepted various agreements between DWR and Reclamation and other water users to assume responsibility for meeting specified Bay-Delta Plan objectives. As a result, the Board conditioned DWR's water right permits for the State Water Project and Reclamation's water right license and permits for the Central Valley Project to require water releases and water management actions to meet the flow and water quality objectives. The State Water Board determined in 2009 that the Bay-Delta Plan's flow and water quality objectives were not providing reasonable protection of fish and wildlife beneficial uses and needed to be updated.

The State Water Board began a process to update the Lower San Joaquin River flow and southern Delta salinity components of the Bay-Delta Plan in 2009 and completed that process in 2018 with the adoption of the 2018 Bay-Delta Plan. That update did not update the Sacramento River and other Delta components of the Bay-Delta Plan that are associated with this peer review. The State Water Board initiated the process to update the Sacramento River and Delta components of the Bay-Delta Plan in 2012. In 2016, the State Water Board released a draft *Scientific Basis Report in Support of New and Modified Requirements for Inflows from the Sacramento River and its Tributaries and Eastside Tributaries to the Delta, Delta Outflows, Cold Water Habitat, and Interior Delta Flows* documenting the science supporting possible Sacramento River and tributary inflow and cold-water habitat, Delta outflow, and interior Delta flow updates to the Bay-Delta Plan (referred to as the Sacramento/Delta Update to the Bay-Delta Plan). Based on public comments, that report was updated, and the updated version was submitted for independent scientific peer review. The report was further updated based on the peer review and a final version of the report was released in 2017 (2017 Scientific Basis Report; State Water Board 2017). In 2018, the State Water Board released a Framework for the Sacramento/Delta Update to the Bay-Delta Plan that described staff proposed Sacramento/Delta Inflow, Cold Water Habitat, Inflow-Based Delta Outflow, and Interior Delta Outflow objectives and a general description of proposed changes to the program of implementation for those objectives (Framework (ca.gov)). The Framework identified a proposed regulatory approach and identified the possibility for voluntary approaches to either voluntarily implement the objectives identified in the Framework or propose alternate voluntary measures to provide for the reasonable protection of fish and wildlife that differ from the flow and other measures evaluated in the 2017 Scientific Basis Report (State Water Board 2017).

Proposed Voluntary Agreements (VAs)

In 2022, the State Water Board received a Memorandum of Understanding, hereafter referred to as the VA Term Sheet, signed by state and federal agencies and water users proposing voluntary agreements (VAs) for updating and implementing the Bay-Delta Plan (California Natural Resources Agency et al. 2023). Specifically, the VAs propose the following: 1) a new narrative objective to achieve the viability of native fish populations; and 2) a commitment to provide the participating parties' share, during implementation of the VAs, to contribute to achieving the existing Narrative Salmon Protection Objective by 2050. The new Narrative Viability Objective is to "maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations". The Narrative Salmon Protection Objective (also referred to as the salmon doubling goal or the Narrative Salmon Objective in the VA Term Sheet) is an existing narrative objective in the Bay-Delta Plan to double salmon populations relative to the reference population of 1967-1991. The VAs propose to achieve these objectives through implementation of flow and non-flow habitat restoration on participating tributaries (VA tributaries) to improve spawning and rearing capacity for salmonids and other native fishes.

Following submittal of the VA Term Sheet, the VA parties developed additional components of the VA proposal that are being provided to the peer reviewers, including a Draft Strategic Plan, a Draft Governance Program, and a Draft Science Plan. Together with the VA Term Sheet, this package is referred to as the September 2023 Draft VA proposal (California Natural Resources Agency et al. 2023). The VA Term Sheet states of the Draft Strategic Plan, "The VA Parties will propose an initial Strategic Plan for approval in the update to the Bay-Delta Plan, along with other elements of the VAs. The plan will provide multi-year guidance for the implementation of flow and other measures, set priorities to guide the Science Program, and establish reporting procedures related to implementation and effects." Also as described in the VA Term Sheet, the Draft Governance Program is intended to "direct flows and habitat restoration, conduct assessments, develop strategic plans and annual reports, implement a science program, and hire staff and contractors". This Governance Program would include a Systemwide Governance Committee to oversee overall coordination of the VA Program, and Tributary/Delta Governance Entities that would oversee implementing the agreements for which that entity is responsible. The VA Science Program is proposed to "(A) inform decision-making by the Systemwide Governance Committee, Tributary/Delta Governance Entities, and VA Parties; (B) track and report progress relative to the metrics and outcomes stated in Appendix 4; (C) reduce management-relevant uncertainty; and (D) provide recommendations on adjusting management actions to the Systemwide Governance Committee, Tributary/Delta Governance Entities and VA Parties" (California Natural Resources Agency et al. 2023). The framework for the VA Science Program is proposed to be collaboratively developed by the VA Parties in coordination with the State Water Board.

On the eighth year of the VAs, the State Water Board would consider the reports, analyses, information, and data from the VA Science Program, as well as recommendations from the VA Governance Committee and the Delta Independent Science Board to decide the future of the VA program. If the VAs are substantially achieving the stated objectives, the VA Parties would continue implementation of the VAs without any substantial modification in terms. If the VAs are expected to achieve the stated objectives with some modifications, the VA Parties would continue implementation with substantive modifications in terms. However, if the VAs are not expected to achieve the stated objectives, then either 1) new agreements may be negotiated or 2) the State Water Board would impose regulations to implement the Bay-Delta Plan.

Draft Supplement Report

The ***Draft Supplement Report*** (State Water Board et al. 2023a) serves as an addendum to the 2017 Scientific Basis Report (State Water Board 2017) by documenting the science supporting the anticipated benefits of the proposed VAs in support of their consideration as part of the Sacramento/Delta Update to the Bay-Delta Plan. This report builds on the 2017 Scientific Basis Report with scientific information supporting specific flow and non-flow habitat restoration actions in the tributaries, flood bypasses, and Delta outlined in the VAs. It does not duplicate information in the 2017

Scientific Basis Report, so both documents are needed for the full scientific analysis of the proposed alternatives for updating the Sacramento/Delta components of the Bay-Delta Plan. The 2017 Scientific Basis Report is referenced throughout both the ***Draft Supplement Report*** and Attachment 2 below to provide necessary background. However, the assumptions, findings, and conclusions that reviewers are asked to evaluate in Attachment 2 pertain only to the ***Draft Supplement Report***, as the 2017 Scientific Basis Report has already undergone external scientific peer review. The ***Draft Supplement Report*** is not intended to support possible updates to the portions of the Bay-Delta Plan covering the lower San Joaquin River, which could incorporate lower San Joaquin River VAs, including the Tuolumne River VA proposal, and would be subject to a separate process and subsequent analysis.

The ***Draft Supplement Report*** (State Water Board et al. 2023a) compares VA assets to the same reference condition as the 2017 Scientific Basis Report (State Water Board 2017). The VA assets as modeled in the ***Draft Supplement Report*** do not fully match the volumes (volumes can be higher or lower) identified in the VA Term Sheet in part because the theoretical accounting base ("2019 BiOps condition") upon which the VA flows are added is different than the reference condition. As explained in the ***Draft Supplement Report***, the VA flows are intended to be added to the Delta outflows required by State Water Board Decision 1641 (D-1641) and resulting from the 2019 federal Biological Opinions (collectively "2019 BiOps condition"). The 2019 BiOps condition assumes less stringent federal Endangered Species Act Biological Opinion requirements and omits state Endangered Species Act requirements as compared to the reference condition. This results in different (generally less) flows added than identified in the VA Term Sheet.

In addition, two VA scenarios were included in the ***Draft Supplement Report*** (State Water Board et al. 2023a) and compared to the reference condition. Because the Friant Water Authority's VA proposal was uncertain during development of the report and the Tuolumne River VA proposal is being evaluated through a separate process, the VA assets are evaluated through a "VA scenario" including the Tuolumne and Friant VA contributions and a "VA w/o San Joaquin contributions" scenario that does not include the Tuolumne and Friant flow contributions.

The ***Draft Supplement Report*** (State Water Board et al. 2023a) compares the VA flow assets to the reference condition using results from hydrology and operations modeling that was conducted using the Sacramento Water Allocation Model (SacWAM).[1] SacWAM is a hydrologic and system operations model developed on the Water Evaluation and Planning system platform for planning studies in the Sacramento/Delta

[1] The SacWAM model was subject to a prior peer review and the model is not requested to be reviewed.

watershed.

This ***Draft Supplement Report*** (State Water Board et al. 2023a) was developed by State Water Board staff in collaboration with staff from the California Department of Fish and Wildlife (CDFW) (lead for aquatic ecosystem stressors analysis and description of VA assets on the Sacramento River and tributaries) and DWR (lead for aquatic ecosystem stressors in the Bay-Delta Estuary, hydrology and modeling support, analytical approach, and anticipated VA outcomes). Data used in analyses and modeling in support of the conclusions in the ***Draft Supplement Report*** have been provided as a publicly accessible data package on the Environmental Data Initiative website and can be accessed with the following website link: https://doi.org/10.6073/pasta/84da1b1691b2d2f0f4b61019af1467eb (State Water Board et al. 2023b).

The ***Draft Supplement Report*** was made available for public comment on January 2023. Following receipt of public comments, the draft was revised as appropriate and this final ***Draft Supplement Report*** (State Water Board et al. 2023a) is being submitted for peer review pursuant to the requirements of California Public Health and Safety Code, section 57004, which requires that the scientific basis of any statewide plan, basin plan, plan amendment, guideline, policy, or regulation undergo external scientific peer review before adoption.

Attachment 2: Scientific Assumptions, Findings, and Conclusions to Review

1. Native aquatic species have been declining in tributaries, off-stream habitats, and the Bay-Delta due to aquatic ecosystem stressors.

The 2017 Scientific Basis Report (State Water Board 2017) describes a variety of aquatic ecosystem stressors that are negatively impacting native fish species in the Sacramento-San Joaquin Delta ("Delta" hereafter) and its tributaries. The Sacramento/Delta Update to the Bay-Delta Plan is primarily focused on providing reasonable protection for native fish and other aquatic species rearing or residing in or migrating through the Delta. The life-histories and other information regarding the relevant species are described in Chapter 3 of the 2017 Scientific Basis Report. The 2017 Scientific Basis Report reviews aquatic ecosystem stressors affecting the viability of these species, including alterations to the natural flow regime by water project operations and infrastructure (Chapter 2 of the 2017 Scientific Basis Report), physical habitat loss and alteration, degraded water quality, non-native species, fishery management related impacts, and climate change (Chapter 4 of 2017 Scientific Basis Report).

Chapter 2 of the ***Draft Supplement Report*** (State Water Board et al. 2023a) reviews the updated science since the 2017 Scientific Basis Report (State Water Board 2017) was finalized regarding aquatic ecosystem stressors in the Delta and its tributaries that are impacting native fish species. Water operations and water management structures such as dams, levees, and channelization have altered natural flow regimes and resulted in physical habitat loss, reduced habitat connectivity, and reduced ecosystem productivity and food supply. Physical habitat loss or alteration in the Delta and its tributaries has reduced the quantity and quality of spawning and rearing habitat for Chinook salmon and native estuarine species. Dams on many of the tributaries have prevented salmon from accessing their natal spawning grounds. Flow alterations have caused redd dewatering, increased temperatures, and decreased dissolved oxygen in tributaries during spawning and rearing seasons and have affected habitat connectivity during salmon outmigration. Section 2.1 reviews aquatic ecosystem stressors in the Bay-Delta Tributaries.

Section 2.2 reviews the effects of aquatic ecosystem stressors in off-channel habitats, including floodplain habitats. Altered flow regimes have resulted in loss of floodplain rearing habitat, which has reduced food supplies from these productive environments to salmon and native estuarine species. Moreover, the Delta has lost 98% of its historical acreage of tidal wetlands, representing a significant loss of spawning and rearing habitat for native estuarine fish species. Emerging threats such as harmful algal blooms, climate change, and invasive species are impacting the suitability of the remaining Bay-Delta estuary habitat. Aquatic ecosystem stressors in the Bay-Delta are reviewed in section 2.3, while other system-wide stressors are reviewed in section 2.4. In addition, section 2.5 documents the impacts of aquatic ecosystem stressors on tribal uses of water in the Bay-Delta.

2. The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.

Chapter 3 of the 2017 Scientific Basis Report (State Water Board 2017) establishes the importance of environmental flows for maintaining the viability of native aquatic species and describes the relationship between tributary inflows, interior Delta flows, and Delta outflow and species abundance indices. The 2017 report in Section 4.2 also discusses the importance of physical habitat combined with a more natural flow regime for recovery and maintenance of native fish species. The ***Draft Supplement Report*** (State Water Board et al. 2023a) elaborates on the importance of providing physical habitat restoration and increased flows in Sections 6.1.4 and 6.2.4. The dynamic components of habitat such as turbidity and salinity are influenced heavily by freshwater flow. If restoration projects increase the amount of stationary physical habitat but flow conditions do not provide optimal dynamic habitat, the expected benefits of habitat restoration will not be realized. Similarly, if high flows provide optimal water quality in areas with unsuitable physical habitat, then the expected benefits of flow will not be realized. Increased flows combined with physical habitat restoration would together be more effective at improving environmental conditions for native aquatic species in the Bay-Delta than either flow or physical habitat restoration alone. The VA proposal (California Natural Resources Agency et al. 2023) includes a set of flow and non-flow habitat restoration actions, or assets, in selected tributaries, flood bypasses, and the Delta that provide the majority of the flow to the Sacramento/Delta watershed.

The VA flow and non-flow assets are described in detail in Chapter 3 of the ***Draft Supplement Report*** (State Water Board et al. 2023a) and a summary of assets is provided in Table ES-1. Flow assets are expected to be concentrated in January through June, with some flexibility outside of this period, with more limited flow assets also planned for fall months. Priority months include April through May, and priority water year types include Dry, Below Normal, and Above Normal water years. Flows during these time periods and water year types are intended to increase the quality and area of spawning and rearing habitats for salmonids in the tributaries and off-channel habitats and provide benefits for estuarine species such as longfin smelt. Proposed restoration actions target spawning and rearing capacity for juvenile salmonids, as well as other native fishes. Tributary restoration actions are intended to restore spawning and rearing habitat area sufficient to support approximately 25% of the offspring of the salmon doubling goal population for each VA tributary. Specific narrative objectives for protection of native species are described in Box ES-1 and Section 1.4 of the ***Draft Supplement Report*** (State Water Board et al. 2023a).

Restoration actions are also intended to improve regional aquatic food supply and improve connectivity between the in-channel and the new and existing floodplains. Where appropriate, restoration actions are intended to be integrated with and complementary to VA flow assets. While the VAs, in part, intend to avoid temperature impacts, the VAs do not include an explicit commitment to cold water temperature benefits. Table 2-1 of the ***Draft Supplement Report*** (State Water Board et al. 2023a) summarizes hypotheses for how VA assets may improve environmental conditions for native species by addressing aquatic ecosystem stressors.

The ***Draft Supplement Report*** (State Water Board et al. 2023a) quantitatively models and qualitatively reviews the benefits of flow and non-flow habitat restoration assets for native species, with methods described in Chapters 4 and 5. An overview of the benefits of VA assets is provided in the Executive Summary, and Chapter 6 provides a detailed description of the qualitative and quantitative benefits of the VA assets for increasing spawning and rearing habitat and species abundance indices. The VAs are expected to increase spawning and rearing habitat acreage as shown in Figures ES-1 and 2 and Tables ES-2 and 3 in the Executive Summary. As shown in Tables ES-4 and 5 and Figure ES-3, the VAs are also expected to increase estuarine fish habitat area and abundance indices, as well as the frequency of exceeding ecological flow thresholds.

3. The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving the narrative objective to double salmon populations relative to the reference population of 1967-1991, by 2050 (Narrative Salmon Protection Objective or salmon doubling goal).

Chapter 6 of the ***Draft Supplement Report*** (State Water Board et al. 2023a) details the expected benefits of VA assets toward providing the participating parties' share, during implementation of the VAs, to contribute to achieving the Narrative Salmon Protection Objective by 2050. The specific salmon habitat objective for the initial 8-year term of the VAs is to create enough additional suitable spawning and rearing habitat necessary to support 25% of the offspring of the doubling goal populations on participating VA tributaries. The VA non-flow habitat benefits are evaluated against this objective in the ***Draft Supplement Report***. The results of the habitat analysis in Chapter 6 indicate that VA non-flow assets are expected to produce more suitable habitat for fall-run Chinook salmon during spawning and rearing as compared to the reference condition. For spawning habitat, both existing and VA habitat in all VA tributaries except the American River would exceed the habitat necessary to support 25% of the offspring of the doubling goal populations. ***Draft Supplement Report*** Section 6.1.1 presents the expected increases in salmonid spawning habitat. Improvements to the quantity of in-channel and floodplain rearing habitat varies by tributary. The rearing habitat needed to support 25 percent of the doubling goal population is projected to be met in the Mokelumne, Sacramento (for spring-run Chinook salmon), and Yuba Rivers in both the reference condition and VA scenarios, and in the Feather River in the VA scenario, but not in any scenario in the American and Sacramento Rivers (for fall-run Chinook salmon). Increases in floodplain inundation frequency and duration resulting from the VA flow and non-flow measures are also expected to increase food production for salmon. ***Draft Supplement Report*** Section 6.1.2 provides the expected increases in salmonid rearing habitat.

VA flow assets could improve habitat conditions for salmonids in the VA tributaries by providing improved habitat connectivity to side-channels and floodplains, as well as higher dissolved oxygen levels and possible temperature benefits. Increased flow may also benefit salmonids in the Delta by increasing habitat connectivity and food production, and decreasing the time salmon spend migrating through the Delta where they are subject to elevated predation levels. Overall, the VA flow and non-flow assets could reduce aquatic ecosystem stressors on salmonids during rearing and outmigration. ***Draft Supplement Report*** (State Water Board et al. 2023a) Sections 6.1.3 and 6.1.4 review the expected benefits of increased flow for salmonids and the synergy between flow and non-flow habitat.

4. The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving a new Narrative Viability Objective to "maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations".

The expected benefits of flow and non-flow habitat restoration assets for native species are presented in Chapter 6 of the ***Draft Supplement Report*** (State Water Board et al. 2023a). These assets are evaluated for their ability to contribute toward achieving the new Narrative Viability Objective through potential increases in species abundance and availability of suitable habitat in the Delta and estuary, and potential improvements to food availability and water quality (see ***Draft Supplement Report*** Section 6.2 for an overview of the evaluation approaches).

Increased flow is expected to increase the abundance indices of longfin smelt, starry flounder, Sacramento splittail, and California bay shrimp during most water year types, with the greatest increases expected during Dry years (See Figure 6-12). The largest benefits of VA flow assets are expected for longfin smelt, with a potential 16% increase in their abundance index over reference condition during Dry years. Increased flow is also expected to increase the frequency of achieving ecological flow thresholds associated with benefits to species or with important X2[2] thresholds, although in some

[2] X2 is the location in the Bay-Delta where the tidally averaged bottom salinity is 2 parts per thousand. It is expressed as the distance in kilometers from the Golden Gate Bridge and used as a proxy for the location of the dynamic low salinity habitat.

cases there are slight decreases. Some of the greatest benefits (3–6 percentage point increases) of the VAs are expected for winter-run Chinook Salmon outmigration, bay shrimp, starry flounder, and Chipps Island X2. These increases in flow could benefit native species and increase their abundances by increasing food availability in high quality habitats, by improving water quality, and by reducing the prevalence of invasive species. Section 6.2.1 of the ***Draft Supplement Report*** (State Water Board et al. 2023a) documents the expected benefits of VA flow assets for native fish populations.

Expected changes in Delta and estuary habitat resulting from VA flows and non-flow habitat restoration are provided in the ***Draft Supplement Report*** (State Water Board et al. 2023a) Section 6.2.2. Changes in habitat acreage are shown for Delta smelt, longfin smelt, and salmonids during different water year types (See Figure 6-13). Overall, the habitat restoration measures are expected to change the area of suitable Delta and estuarine habitat by between -3,204 acres and 7,917 acres, with results differing by water year type and species. The greatest increase of 19% habitat area over reference condition is expected for Delta smelt juveniles during Below Normal years, and the greatest decrease of 11% habitat area is expected for Delta smelt larvae during Wet years. In addition to providing more area of suitable habitat depending on species and water year type, the VA habitat restoration assets could benefit native fish populations by improving water quality, habitat connectivity, and food supply through increased productivity and export of food resources throughout the Bay-Delta estuary (See Table 6-6). Section 6.2.3 evaluates benefits of habitat restoration for maintaining viable native fish populations.

5. The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.

The ***Draft Supplement Report*** (State Water Board et al. 2023a) utilizes a combination of different quantitative approaches to assess expected changes in flow and salmonid spawning and rearing habitat availability resulting from VA flow and non-flow habitat restoration assets. Qualitative analyses are used to evaluate how changes in flow and habitat availability could provide benefits to salmonids to contribute toward achieving the Narrative Salmon Protection Objective.

Habitat modeling

Section 5.1 details the modeling methods and assumptions used to quantify the effects of the VA flow and non-flow assets on the availability of salmonid spawning and rearing habitat in the Bay-Delta tributaries and off-channel habitats. Key assumptions of those analyses relate to the calculation of habitat area needed to support 25% of the doubling goal offspring (see Table 5-1) and the estimation of existing suitable habitat area and quantification of VA restored suitable habitat (see Tables 5-5, 5-6, and 5-7 for data sources). Spawning, instream rearing, and floodplain habitat modeling, describing the quantity of VA habitat as a function of flow, relies on flow-habitat relationships provided by VA tributary parties and output from hydrology and operations modeling. The habitat modeling also uses depth, velocity, and cover criteria and applies a temperature threshold to quantify suitable habitat (see Sections 5.1.3.2, 5.1.3.3, and 5.1.3.4 and Table 5-4).

The ***Draft Supplement Report*** (State Water Board et al. 2023a) also uses the Meaningful Floodplain Event (MFE) approach to evaluate the increase in meaningful floodplain inundation events resulting from VA flow and non-flow measures (see Section 5.1.3.4). The MFE method was designed conservatively and likely underestimated the amount of floodplain habitat that would be available, assuming the restored habitat is accessible and suitable. An additional assumption of the floodplain evaluation is that flood bypasses with limited access to fish will be made more accessible in the future by infrastructure projects not explicitly identified in the VA proposal (California Natural Resources Agency et al. 2023) or analyzed in the ***Draft Supplement Report*** (see Section 5.1.3.4).

Although only flow and velocity were used to produce the flow-suitable area relationships of VA non-flow habitat assets, other factors such as cover are also important. The ***Draft Supplement Report*** (State Water Board et al. 2023a) assumes that all quantified habitat area will be suitable to fish and thus that completed restoration projects will fulfill all necessary suitability criteria in Table 5-4, including cover criteria. Because suitability criteria have yet to be finalized by the VA Parties for the VA non-flow habitat assets, the assumptions about habitat suitability in the ***Draft Supplement Report*** may not align with the final accounting procedure the VA Parties will use to ensure the proposed habitat restoration projects conform to suitable habitat. Furthermore, the draft accounting methods do not fully align with the assumptions in the ***Draft Supplement Report***, since there is flexibility in those accounting methods that was not possible to model (see Section 5.1.3.2 of the ***Draft Supplement Report*** for an overview of the non-flow habitat accounting methods and how they differ from the assumptions in the analyses). Thus, the amount of suitable habitat produced by the VAs may differ from the values presented in the ***Draft Supplement Report***. When the VA accounting procedures are finalized, they will provide additional certainty in how the assets would be provided and thus in the benefits these assets would be expected to provide.

Qualitative evaluations of benefits

The ***Draft Supplement Report*** (State Water Board et al. 2023a) qualitatively evaluates the benefits of VA flow and non-flow habitat assets for salmonids in Sections 6.1.3 and 6.1.4. Limited information is available to quantify the benefits of non-flow habitat restoration for improving the viability of salmon populations. Therefore, the report presents a literature review of observed benefits of habitat restoration in the Bay-Delta and its tributaries and other similar ecosystems to evaluate the effects of the proposed VA habitat restoration for contributing to achieving the Narrative Salmon Protection Objective. In addition to quantifying how increased flow enhances the quantity of suitable habitat for salmonids, the VA flow assets are expected to provide other benefits that are difficult to quantify. Therefore, the ***Draft Supplement Report*** also relies on literature review to evaluate how the VA flow measures may provide other improvements in environmental conditions for the benefit of salmonids, such as increased food availability, and decreased travel time through the Delta during the outmigration period.

6. The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.

Several quantitative approaches are used in the ***Draft Supplement Report*** (State Water Board et al. 2023a) to model expected changes in flow, estuarine habitat availability, and species abundance indices resulting from VA flow and non-flow habitat restoration assets. Qualitative analyses are also used to evaluate how changes in flow and habitat availability could provide benefits to native Delta and estuarine species to contribute to the Narrative Viability Objective. Similar to the methods used to evaluate whether the proposed VAs could contribute toward achieving the Narrative Salmon Protection Objective, the analyses used to evaluate benefits for native estuarine species included a number of assumptions described at a high level in chapter 7 of the ***Draft Supplement Report***.

Habitat modeling

Section 5.3 of the ***Draft Supplement Report*** (State Water Board et al. 2023a) provides the details of modeling steps taken to analyze the effects of the VA assets on the availability of suitable habitat in the Bay-Delta. Delta flow and salinity were simulated using inputs from hydrology and operations modeling. The flow and salinity outputs from these simulations were then overlayed on bathymetric grids representing the expected geometry of the Bay-Delta when VA habitat restoration is included. Layers of observed temperature and turbidity data were also included as thresholds for suitable water quality (see Section 5.3.5.3). Finally, because the initial simulations of Bay-Delta habitat were based on outdated hydrology and operations modeling and it was infeasible to reproduce these simulations, the final predicted area of suitable habitat relied on regression relationships to predict habitat area using Delta outflow and export data from updated hydrology and operations modeling (see Section 5.3.6).

Flow-abundance relationships

The ***Draft Supplement Report*** (State Water Board et al. 2023a) presents similar flow-abundance analyses as the 2017 Scientific Basis Report (State Water Board 2017), which analyzed relationships between native species abundance indices and Delta outflow. The mechanisms behind the flow-abundance relationships vary by species and are not fully understood, but the abundances of several native species residing in, rearing in, or migrating through the Bay-Delta estuary show persistent positive relationships with the volume of Delta outflow during the winter and spring (2017 Scientific Basis Report Sections 3.2.2, 3.5.4, 3.7.4, 3.9.4, and 3.10.4). Using these flow-abundance relationships from the 2017 Scientific Basis Report (2017 Scientific Basis Report Section 5.3.3), the ***Draft Supplement Report*** presents expected changes in abundance indices of longfin smelt, starry flounder, Sacramento splittail, and California Bay shrimp based on modeled changes in Delta outflow resulting from the VA assets (***Draft Supplement Report*** Section 6.2.1). Consistent with the approach taken in the 2017 Scientific Basis Report, these results are meant to give a general sense of the relative benefit each species may realize for a given flow scenario or asset, and they should not be interpreted as a prediction of future population abundances. ***Draft Supplement Report*** Section 5.2 details the methods used to model flow-abundance relationships.

Flow threshold analysis

The ***Draft Supplement Report*** (State Water Board et al. 2023a) presents similar flow threshold analyses as the 2017 Scientific Basis Report (State Water Board 2017), which analyzed the frequency of achieving ecologically relevant flow thresholds. Flow thresholds were chosen in the 2017 Scientific Basis Report to represent the flows at which specific benefits are achieved, generally to support the needs of specific species, but some thresholds were chosen to correspond to the locations of dynamic low-salinity habitat (as defined by X2, the location where the tidally averaged bottom salinity is 2 parts per thousand) known to be beneficial for native species. The definition of each flow threshold and the methods to evaluate them are provided in Section 5.4 of the ***Draft Supplement Report***, but additional information and the rationale for each threshold can be found in Chapters 3 and 5 of the 2017 Scientific Basis Report. The ***Draft Supplement Report*** presents expected frequencies of achieving each flow threshold based on modeled flows resulting from the reference condition and VA scenarios (***Draft Supplement Report*** Section 6.2.1).

Qualitative evaluations of benefits

The ***Draft Supplement Report*** (State Water Board et al. 2023a) qualitatively evaluates the benefits of VA flow and non-flow habitat assets for native Delta and estuarine species in Sections 6.2.1, 6.2.3, and 6.2.4. Limited information is available to quantify the benefits of non-flow habitat restoration for improving the viability of native fish populations. Therefore, the ***Draft Supplement Report*** presents a literature review of observed benefits of habitat restoration in the Bay-Delta and other similar ecosystems to evaluate the effects of the proposed VA habitat restoration to contribute toward achieving the Narrative Viability Objective. These qualitative analyses include literature review to evaluate how the VA flow and non-flow measures may provide other improvements in environmental conditions for the benefit of native fish species, such as increased food availability, improved habitat connectivity, and water quality.

Attachment 3: Individuals who have Participated in the Development of the Proposal

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Charles Young
Brian Joyce
Jack Sieber
Pat Crain
Bill Mitchell

FlowWest
Mark Tompkins
Ashley Vizek

RMA
Stacie Grinbergs

Attachment 4: References Cited

Key References Identified in Attachment 2

State Water Resources Control Board (State Water Board), California Department of Water Resources, and California Department of Fish and Wildlife. 2023a. *Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan.* September 28, 2023. Sacramento, CA.

State Water Resources Control Board (State Water Board). 2017. *Scientific Basis Report in Support of New and Modified Requirements for Inflows from the Sacramento River and its Tributaries and Eastside Tributaries to the Delta, Delta Outflows, Cold Water Habitat, and Interior Delta Flows*. State Water Resources Control Board, CEPA Sacramento, CA.

California Natural Resources Agency, California Environmental Protection Agency, California Department of Water Resources, California Department of Fish and Wildlife, United States Bureau of Reclamation, Contra Costa Water District, East Bay Municipal Utility District, Friant Water Authority, Garden Highway Mutual Water Company, Glenn-Colusa Irrigation District, Kern County Water Agency, Metropolitan Water District of Southern California, Modesto Irrigation District, Regional Water Authority, River Garden Farms, San Francisco Public Utilities Commission, San Luis and Delta-Mendota Water Authority, Solano County Water Agency, State Water Contractors, Sutter Mutual Water Company, Tehama-Colusa Canal Authority, Turlock Irrigation District, Western Canal Water District, Westlands Water District, Yuba Water Agency. 2023. *September 2023 Draft Voluntary Agreement Proposal: Draft Strategic Plan for the Proposed Agreements to Support Healthy Rivers and Landscapes.*

State Water Resources Control Board (State Water Board), California Department of Water Resources, California Department of Fish and Wildlife. 2023b. Data used in the Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan. Environmental Data Initiative. DOI: https://doi.org/10.6073/pasta/84da1b1691b2d2f0f4b61019af1467eb

Reviewer: Joseph Domagalski, United States Geological Survey, January 22, 2024

Review of Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan

Based on my expertise and experience, I am reviewing the findings, conclusions, and assumptions 1,2, and 4. Comments for those three are given below:

1.) Native aquatic species have been declining in tributaries, off stream habitats, and the Bay-Delta due to aquatic ecosystem stressors.

The document provides very good evidence and explanation of aquatic species decline from stressors including food supply and ecosystem productivity, physical habitat loss/alteration, and movement and connectivity. I agree that the flow alterations proposed are likely to have benefit to offset declines as a result of the above stressors.

I found the document to be lacking in the water quality discussion. The reader was directed to a 2017 document on water quality. Although the 2017 document addressed water quality concerns adequately for that time period, new challenges since 2017, are not addressed in the Water Quality discussion. There are new studies that have come out since 2017 on various contaminants including pesticides and mercury, and emerging contaminants that should be considered. In addition, one of the largest changes in water quality, happening how, and how it might affect food supply, the upgrade to the Sacramento Regional Sanitation District, which will affect the Nitrogen budget to the Delta is not addressed. It is unclear how changes in flow will affect primary productivity (food sources) going forward. The document also only briefly mentioned *Microcystis* and *Aphanizomenon* species. The recent *Heterosigma* bloom which actually fish death was not mentioned. It is still very unclear how changes in flow or habitat will affect harmful algal blooms and needs further consideration.

2.) The combination of non-flow habitat restoration and flows proposed as part of the Vas are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.

I found the discussion on flow alterations to be generally adequate, but it was unclear from reading the document what types of restoration projects (non-flow) are being proposed. Flow alterations providing more wetland habitat is very likely to improve food production in the Delta. Likewise, the discussion on habitat connectivity, where practical, should improve conditions. There was discussion in the various sections on physical habitat for tributaries to the Delta such as dam barriers that are unlikely to be addressed at any time soon because of the expense. At the very least, it would have been helpful to see any possible prioritization of these difficult issues to improve habitat connectivity.

The flood plain discussion was generally well written, and improvements discussed there will likely provide benefits to native species.

3.) The proposed combination of flow and non-flow habitat restoration assets provided by the Vas are expected to improve conditions for native species to contribute to achieving a new Narrative Viability Objective to "maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the production of viable native fish populations."

Although the draft report does not provide any guarantees of success, and there are some deficiencies, such as noted above for all water quality considerations, the framework is considered a very good starting point. An adequate monitoring program will be necessary, as indicated in the Conclusions section, along with associated adaptive management would be likely to lead to the Viability Objective for water quality conditions.

In summary, the overall report is very well presented, and it was helpful to read in Chapter 1 what previous reviewers commented on and how the present draft built on those comments.

Review of: Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan (State Water Board et al. 2023a) (aka *Final Draft* below)

Conducted by Stephen L. Katz PhD, Adjoint Associate Professor, the School of the Environment, Washington State University.

Based on my expertise and experience, I am reviewing the findings, assumptions, or conclusions I agreed I could review with confidence:

> **Conclusion #1**: Native aquatic species have been declining in tributaries, offstream habitats, and the Bay-Delta due to aquatic ecosystem stressors.
>
> **Conclusion #2**: The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.
>
> **Conclusion #3**: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving the narrative objective to double salmon populations relative to the reference population of 1967-1991, by 2050 (Narrative Salmon Protection Objective or salmon doubling goal).
>
> **Conclusion #5**: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.
>
> **Conclusion #6**: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.

General Comments

Positive Features:

River networks are complex systems, and so assembling a comprehensive and defensible habitat and target species response plan is a particularly challenging enterprise. The authors have done a great job in assembling a lot of complex information in a well-organized and reasoned plan.

It is particularly encouraging to see a relatively broad ecosystem-based approach to the VA assessment. This manifests in a large investment in the Final Draft to nutrient supply, primary production and forage production for the target species. It is also present in the discussion of invasives, climate change, disease and nutrition (e.g. TDC) interacting with habitat to affect the anticipated outcomes. There are additional issues that do not appear in the Final Draft that I will remark on below, but even in its current state, there is a commitment to ecosystem-based approach that is commendable.

A particularly positive feature of the VA's, present as a statement in the VA Terms Sheet (although not in this Final Draft), is the idea of an adaptive management scheme to scientifically evaluate effectiveness, that includes a "safe to fail" experimental approach. It has been a long concern of mine that we don't learn, and therefore derive value from failures – of which there are many. This has been a strong disincentive to maintain effectiveness monitoring programs across the salmon recovery domain, and a major impediment to successful habitat restoration programs.

Below, I criticize various aspects of this Final Draft. Those critiques on first read may appear to be dismissive of this effort. That is not correct. Preparing these plans is very difficult work and this document demonstrates a lot of effort and a high professional standard on the part of the authors and contributors. And even with the critiques I make below, I am still optimistic that if the VA's are implemented as described, there will likely be observable environmental improvements that result.

Features of Concern:

I will mention a number of specific technical items that are of concern below, but there are some overarching issues with the approaches or tools used to arrive at the conclusions listed above. These overarching issues however, exist within a context. In this case, the nature of administrative rule making or implementing regulatory agreements demands approaches and tools that are accessible to a more diverse audience than strictly academic scientists. So, for example, models such as PhabSIM may have severe limitations that cause academics to reject their use (and on which I will comment below), but their accessibility, relatively easy interpretability and ease of use may outweigh their problems in this context. Indeed, in those places where the approach in the Final Draft is not the most contemporary or most defensible, using the identified approach does not mean that the conclusion is wrong or unsupported. Rather, it means that problems or limitations in some of the underlying assumptions reduces our confidence in the conclusions ultimately being satisfied. Deciding if these approaches are, or are not satisfactory is an administrative decision (how much confidence in a forecast does one need to make a decision?), not a scientific one. As such, remarks I make below should not be seen as somehow condemnations of the choices or methods used by the authors, but rather as reasons I am less confident in some of these conclusions than others. As a consequence, I express my concerns in terms of my confidence in these conclusions, rather than saying they are, or are not correct.

In section 1.3.1.13 there is an explanation for not relying on a life cycle modelling approach. The argument for not moving to a life cycle model amounts to 1) wanting to remain consistent with a previous method, 2) a life cycle model for this system was not at hand and 3) the available inputs were not compatible with available life cycle models. The first reason is somewhat compelling; I appreciate the desire to keep consistent methods to make comparability easier. However, that argument only works up to the point where a better tool is accessible and it is too costly to the credibility of the enterprise to maintain one's grip on an obsolete or inadequate tool. Validation and calibration are paths to maintaining comparability in this case. The latter two arguments are not compelling. Life cycle models do not have to be complex or inflexible with respect to what data inputs they rely on (e.g. Scheuerell et al., 2021; DiFillippo et al., 2021). They can be quite complex, and many are, but they really only require that you evaluate survivorship in all parts of the life cycle – and that can be as simple as the data allow. For anadromous fish in particular, where the sources of mortality/stressors are so discretized between spawning, rearing, ocean run and adult returns, this is particularly important. To support confidence in any of the fish-related Conclusions, some measure of relative impact of the VA's versus any other survival challenge is necessary. How does the reader know if increasing flood plain habitat for rearing is going to be sufficient for your objectives if the reader doesn't know how important that source of mortality is versus some other stressor later in the life of the fish? You rely on an estimate of egg-to-fry survival in section 5.1.2 of the Final Draft, I don't see a reason not to find estimates of other survivals and apply them. Not taking this approach is a significant challenge to the confidence the reader can put into the conclusions. I point out several specific cases below that could have benefited from this approach.

Comments regarding the Conclusions:

Conclusion #1: Native aquatic species have been declining in tributaries, offstream habitats, and the Bay-Delta due to aquatic ecosystem stressors.

Viewed narrowly, confidence in this conclusion is high and the basis for that confidence is presented in the Scientific Basis Report (State Water Board, 2017), the 2009, 2014 & 2019 Biological Opinions on the Central Valley projects (NMFS 2009, 2014, 2019), as well as other studies cited in the Final Draft. As it is worded, this conclusion is well supported with findings based on monitoring and relatively few assumptions.

That being said however, if Conclusion #1 was worded to indicate that native aquatic species were declining solely due to ecosystem stressors that occur within the tributaries, offstream habitats and Bay-Delta – it would not be well supported. As pointed out in a number of the cited literature, a significant amount of salmon mortality occurs in the oceanic, out-of-basin portion of the life history. As a specific example cited in the Final Draft, there is strong evidence that poor survival of Sacramento River Fall Chinook that occurred in 2004 and 2005 brood years was due in large part to anomalous ocean conditions, with in-basin habitat stressors being contributory but not exclusively to blame for the declines (Lindley et al., 2009).

I bring this up in part because the wording of Conclusion #1 is unambiguous and declarative, as if to say "this is THE problem". So, it could easily be interpreted as exclusive of other stressors, which would be misleading.

More importantly, and as a general comment on the Final Draft, there is little to no acknowledgement of the role of variable ocean conditions on salmon survival, or how that might impact recovery within the Central Valley. This is a significant omission. This is the sort of issue one could address with a life-cycle model approach (e.g. Chasco et al., 2021), rather than solely a habitat capacity approach. The ocean portion of the life cycle is mentioned obliquely in a couple of places in the context of Thiamine deficiency possibilities (e.g. page 2-29 et seq.) and the uncertainties surrounding climate change (e.g. page 2-30), but nowhere are the out of basin stressors addressed – even to address the question "are the proposed actions in the fresh water portion of the life cycle big enough to overcome population level stressors that occur outside the fresh water portion of the life cycle?", and none of the proposed VA's actions address the oceanic portion of the life cycle. This is significant, as failure to be explicit about the relative role of oceanic stressors lowers one's confidence that the proposed VA's will achieve their objectives (Conclusions 3 & 5). Are the parties prepared to spend the $2.5 Billion (identified in the VA Terms Sheet) on the freshwater actions, be successful in recovering the hydraulic environment of the tributaries and delta, but get no credit for recovering the depressed fish stocks because the ocean was always the bigger problem? To be clear, I am not saying the ocean definitely is the bigger problem, but there are some who would, and the conclusions would be better supported if there was a consideration of the relative impacts of tribs vs. delta vs. ocean.

Conclusion #2: The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.

As a general statement, this conclusion is reasonably well supported, but dependent on two significant conditionals. In particular, Table 2-1 does a good job of organizing the mechanistic hypothesis being applied to each anticipated response to increased flow and habitat amenity improvement. The mechanistic hypotheses amount to saying that if we improve the habitat, it will benefit the fish and wildlife that depend on the habitat capacity and quality for key life stage survival. In each case the stated hypothesis is at least rational, and in most cases not controversial.

The conclusion as stated is narrow however. Management actions may have <u>some</u> benefit, but fail to reach critical benchmarks or functional thresholds. Indeed, the habitat may respond to the action as anticipated, but the fish may not respond at all, or may not respond sufficiently to be detected with monitoring data. Conclusions 3, 5 & 6 have specific thresholds, so I will address that uncertainty below; here I will comment on the narrow conclusion.

Confidence in this conclusion is affected by at least two conditionals. The first is that streamflow improvement actions have a significant and limiting size effect. The second is that increasing habitat capacity does not directly affect fish productivity and abundance.

Size effect: Regardless of the management approach to increase stream flows, there is a size effect where changes in stream flow are either undetectable or ambiguous up to some critical size of management action. Surface storage in reservoirs to augment later-in-time stream flows has been shown to be specifically determined by the size of the reservoir, expressed as Impounded Runoff Index (IRI), or the ratio of the reservoir capacity to mean annual flow (Batalla et al. 2004). Dams with large IRI are more effective at altering flow, dams with low IRI are less effective to ineffective in altering downstream flow (Kondolf and Batalla 2005). Water market approaches, as described in the VA's, are very popular (e.g. Crammond 1996; Ise and Sunding 1998; Landry 1998; Grafton et al. 2010; Jones and Colby 2012), but the empirical evidence on their effectiveness is very rare, and ambiguous as to performance (where effectiveness is based on flow measurements rather than agreements entered into). The Walker Basin program may be the rare case of successfully increasing environmental flows. In 2011 and 2012, instream monitoring showed an increase in stream flow attributable to water rights acquisitions of 0.09 and 0.81 cubic metre per second, an augmentation on top of a base flow of 1 and 10 cubic meter per second, or an 8-9% increase (Elmore et al. 2016). Other large water markets, such as the Murray-Darling plan in Australia (Williams and Grafton 2019; Grafton and Williams 2020), the Whychus Creek plan in Oregon (Aylward and O'Connor 2017) and the Columbia Basin Water Transaction Program (Katz and Luff, 2020) provide little to none or equivocal empirical evidence of improvements of instream flow. Much of this lack of support can be traced to lack of enforcement of the water trade agreements, but there is also a size effect; single larger allocations have proven to be more effective than numerous smaller allocations (Null et al. 2017). (A clear size effect is also seen in other flow augmentation restoration types, such as logging & intentional burnings (e.g. Stednick, 1996; Jung et al. 2009; Kinoshita and Hogue 2015), but they are not represented in the VA's as far as I can tell).

In chapter 4 of the Final Draft, the amounts of flow augmentation above Reference Condition are listed in tables 4-2, 4-3, 4-5, 4-7, 4-9 & 4-11. The allocations attributable to the VA's average out to between 1.24% (Yuba River) to 5.5% (Feather River) over baseline (setting aside the negative allocation in the Putah River, which is two orders of magnitude smaller than the Sacramento in base flow). The allocations are presented in terms of volume (TAF), but the base flows are in terms of flux (cfs - which is the unit likely to be measured to validate these allocations), which makes a direct comparison difficult and dependent on the schedule of flow modifications (see below). Referring to the limited scheduling information in sections 4.3-4.9 of the Final Draft, it looks like the changes in flux are expected to be similar – i.e. 1%-3% (Walker Basin augmentation was 8-9% - 2-3 times as large). Those are small changes relative to the precision of most monitoring programs of which I am aware. Are these large enough to be measured with whatever monitoring program is put in place?

Section 8.4 of the VA Terms Sheet says:

> 8.4 In coordination with the State Water Board and other Parties, the Department of Water Resources, and the U.S. Bureau of Reclamation will develop accounting procedures to assure that flows and habitat restoration provided under the VAs are additional contributions as stated in Section 4. These procedures will be incorporated into the Implementation Agreements, as appropriate, and will be subject to approval by the State Water Board.

But there are no specifics with respect to how the monitoring will be performed to do that accounting. Obviously, the details are "To Be Determined", but having to evaluate the Final Draft without them limits one's confidence. Details about the precision of the accounting mechanisms would increase confidence in Conclusion #2.

Overarching Habitat Capacity Assumptions: It is also important to remember that the fish are wild, rather than domestic. The relevance of that here is that human activity can reduce the numbers of fish deterministically (i.e. we can certainly kill fish via harvest, habitat loss, etc.), but cannot force the production of new wild fish as we would with domestic animals. The foundational assumption of a restoration-based recovery plan is that by reducing the contribution to mortality from specific sources, such as lost or degraded habitat quality, we will see a consequent increase in the number of wild fish. This may not be unreasonable in specific cases (e.g. Roni 2019; Roni et al., 2010; Liermann et al., 2017), but the mechanisms are passive (i.e. we can't force fish to mate with each other and do so more frequently), and even if we change the habitat as anticipated, we may not see more fish. For example, if current abundances of fish are below the current carrying capacity of the habitat, then increasing habitat capacity further via restoration is unlikely to increase population size. An ecological illustration is the middle fork of the Salmon River; the Frank Church River of No Return wilderness has near-pristine habitat quality and so putting restoration there should not improve things for fish. However, Chinook salmon in that area are below carrying capacity and listed as endangered under the ESA.

Confidence in Conclusion #2 would be increased if there was an explicit assessment of how close to the current carrying capacity the current fish populations are. Confidence in Conclusion #2 would also be increased if a discussion of the size effect and overarching habitat capacity issues were more explicitly addressed in Chapter 7 of the Final Draft (Conclusions and Uncertainties).

In re choice of units TAF vs. CFS: TAF is a unit that makes more sense in an administrative agreement. It addresses the relevant question: “how much water are we buying to improve environmental flows?” CFS on the other hand is a measurable outcome from the management action and it is what people are likely to measure in any monitoring program. I appreciate that the authors may not know at this time what the augmentation schedules are, and indeed the information provided indicates different schedules in different water years, but right now its problematic to be working in both units at different places in the Final Draft.

In addition to an overarching habitat capacity assumption, there are also issues with specific methods deployed in habitat capacity assessments. I will remark on those in response to Conclusion #5 below.

Conclusion #3: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving the narrative objective to double salmon populations relative to the reference population of 1967-1991, by 2050 (Narrative Salmon Protection Objective or salmon doubling goal).

Confidence in Conclusion #3 is low. There are technical issues with the assumptions and methods used to forecast population changes, but I will address those below. My confidence in this conclusion is low principally because of what it asks of the fish populations in terms of response.

As of this writing, it is January of 2024. If the VA’s are implemented quickly, we might expect the plan to be implemented in 2025. The narrative objective is forecasting a doubling of the population 2050, or 25 years later. So, a doubling of population in 25 years.

We can express population growth in terms of the marginal population growth rate, λ (lambda). Lambda is the ratio of population size next year to the population size this year and is expressed as:

$$\lambda = \frac{N_{t+1}}{N_t}$$

Lambdas greater than 1.0 indicates a growing population, less than 1.0 a shrinking population. The results of each year can be substituted into the equation recursively to estimate population sizes into the future for any number of years for a given value of lambda. Conversely, for a given difference in population size over a given number of years, we can estimate what the necessary lambda would need to be to achieve that population growth. A doubling of population in 25 years can be estimated as:

$$\lambda_{necessary} = e^{\left(\frac{\ln\left(\frac{2N_t}{N_t}\right)}{25\ years}\right)} = 1.03$$

To double the population size in 25 years, we would need a lambda of 1.03. If implementation is delayed, the required marginal population growth rate would be even larger. In this context, 1.03 is not impossible to observe, but it is a relatively big number for the marginal population growth rate. McClure et al. (2003) reported estimated lambdas for 165 salmon stocks in 12 ESU's in the Columbia River Basin. The stocks approximate the tributaries in the California Central Valley, and an ESU approximates a couple to a dozen stocks in aggregate. In the Columbia River study, only 35 out of 165 stocks (~21%) had a lambda that equaled or exceeded 1.03, and none of the ESU's had a lambda that large. The estimates were made assuming no influence of hatchery fish on native fish estimates, if hatchery fish are spawning in the wild (a likely condition) the estimates would be lower and the number of populations that would meet or exceed 1.03 would be fewer (McClure et al., 2003). The Columbia River is a salmon recovery domain that has sustained over decades intensive habitat restoration programs to increase population growth rates (Katz et al., 2007; Barnas et al., 2015), so the investments have been made to improve lambdas there. Stocks are smaller than ESU's, and a given year-to-year fluctuation can strongly affect the estimate of lambda, where larger units are averaging the variance in the estimates of each stock and have lower variances. Regardless, lambdas of 1.03 or larger are not impossible, but they are the exceptions rather than the rule. It is least rare enough to lower one's confidence that the water management/recovery plan will sustain rates that high over 25 years. Regardless, the confidence that the VA's will support such an average population growth rate for the next 25 years is low, not because of deficiencies in the VA's, but rather because of what it asks from the fish populations.

At the same time, it is worth pointing out that of all the populations with a lambda equal or greater than 1.03, none of them had a lower 95% confidence interval on the estimate that was greater than 1.0 (McClure et al., 2003). Therefore, in the face of the high variability seen in population-scale abundance estimates, none of the estimates were statistically different than 1.0. That means one could do the proposed VA's, have a positive environmental response, have marginal growth rates necessary to reach the doubling objective, and still not be able to demonstrate it. Confidence in Conclusion #3 would be marginally increased if there was a more detailed description of the monitoring program that the VA's parties are going to use to demonstrate fish population responses (conditional on the necessary marginal population growth rates being sustained).

Conclusion #5: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.

Assessing confidence in this conclusion is difficult and to some extent context-dependent. Overall however, habitat capacity models (e.g. PHABSIM) are problematic due to their assumption that increasing capacity will produce more fish (Overarching Habitat Capacity Assumptions in reference to Conclusion #2 above). More specifically however, each of the modelling approaches have their own problems, some of which are detailed below. In sum, these models are not generally satisfying in terms of their assumptions and scientific validity, especially with respect to specific forecasts of fish response, and they have been harshly critiqued in the academic literature (e.g. Railsback, 2016; reviewed in Nestler et al., 2019). I would assess confidence in this Conclusion as low from a scientific perspective.

That having been said, these models are tractable to execute and they provide digestible answers to management-relevant questions like "How many fish will I get for my restoration dollar?" Furthermore, in many limited situations, improving habitat quantity and quality has resulted in a desired direction of population response, and so in broad terms the results agree with modelled forecasts (e.g. Beecher et al., 2010). As a result of their ease of use, digestibility of their results, and a broad track record of use, they have become very popular at the science/management/policy interface (e.g. Railsback, 2016; Reiser and Hilgert, 2018). And that utility does have high value.

So, what are the specific problems with this approach? The analysis described in Chapter 5 to estimate the amount of quality habitat for fish relies on a habitat capacity model, such as PHABSIM (Physical HABitat SIMulation, section 5.1.3). Other models exist, such as River2D (Katopodis 2003), and MesoHABSIM (Parasiewicz 2001; Parasiewicz and Walker 2007). PHABSIM is part of a family of approaches called the Instream Flow Incremental Methodology (IFIM; Bovee et al. 1998). IFIM is a broad conceptual toolbox that considers a variety of aspects of stream ecology.

PHABSIM consists of starting with hydraulic model outputs which are linked with habitat suitability criteria (HSC) to map habitat quality for specified life-stages of target species at different discharges. The hydraulic modelling development in the Final Draft does look well supported and validated (e.g. appendix B Tables). Once one has this hydraulic framework, the amounts of habitat weighted by habitat quality (as indicated by HSC's) can be integrated across a stream reach at discharges of interest to produce a metric called weighted usable area (WUA). This is accomplished by applying HSCs for each species life-stage of interest to each location within a specific stream network across a range of discharges. This applied weighting is then summed for each discharge and species life-stage to generate a WUA value (e.g., for juvenile Chinook salmon at 250 cfs). The output allows comparison of the relative habitat value of different discharges for a particular species and life-stage.

Experience with PHABSIM has revealed a number of constraints and problems with its use. The weightings applied to the area of habitat rely on a representative stream reach (or a critical reach if one is identified) for assessment of impacts of hydrologic changes to fish. Where multiple reaches are expected to be affected by flow augmentation, it may be necessary to model multiple reaches. In either case, there is a critical need to validate that each representative reach where the fish/habitat relationships are developed (often a small area) is truly representative of the locations where the WUA estimates are going to be made (often a larger area). Validation of the HSC's and WUA can be accomplished with field measurements at one or more known discharges, which presents multiple challenges. One challenge is in order for fish-habitat capacity models to be applied across a stream network, the underlying relationship between observed fish preference must reflect a global, or population-wide preference rather than fish making the best of what habitat variability is available. Where this assumption has been tested, it is not supported (e.g. McMillan et al. 2013). Another problem is that performing the necessary research to validate the HSC's over the whole domain of interest is complex, demanding and often expensive, and consequently rarely done. It has been typical to substitute expert opinion or some other narrative knowledge to set the HSC's. Wrapping that expert opinion in a complicated, technologically intensive model can make things look more scientific, but it doesn't fundamentally change the fact that the outcome is an opinion, not a scientific finding derived from research. This sort of opinion ends up lying somewhere between a hypothesis, if the forecasts are tested, or a guess, if they are not (Lancaster & Downes, 2010). Indeed, uncertainty over HSCs has received considerable criticism. Critiques have also challenged if the variables used to construct HSCs are the variables most relevant in the case of changes in stream discharge (e.g. Gaillard et al., 2010; Railsback 2016).

These approaches have also been critiqued for inappropriate treatment of scale. The flow models that are combined with habitat data to evaluate capacity are often developed over different and potentially incompatible scales (Wu and Li 2006). In addition, since one is accumulating habitat units to estimate WUA, the WUA metric may apply over many habitat units, that could each vary greatly, and have different consequences for different species or life stage.

In the Final Draft, the HSC are presented as aggregated data for the whole tributary (e.g. Fig. 5-2 & 5-3 and associated text). The original data is sourced as Gill & Thompkins (n.d.), which is a series of web pages maintained by the Central Valley Project Improvement Act (https://cvpia-osc.github.io/DSMhabitat/index.html). There the data are sourced to a spreadsheet of data provided by a contact at California Dept. of Fish and Wildlife. The source file is a spreadsheet that shows summary tables of WUA estimates for each tributary. The description of how the data was collected in terms of where and when in a manner that would allow one to evaluate how representative of the entire stream network the specific HSC estimates were (i.e. answering the critiques above) is not provided. The Final Draft would benefit from making this sourcing more explicit.

It does appear that the source data are derived from actual observations such as snorkel surveys and are not just expert opinion. Those counts are typically arduous to acquire, and it does suggest these analyses were conducted in a relatively professional manner compared to many other examples I am aware of.

For these reasons it is difficult to characterize the quantitative and qualitative analyses as using appropriate assumptions and being scientifically valid in a scientific research context. However, in other contexts, the reliance on these models, the degree of aggregation, and the role of opinion and judgement in the model products they produce, may be more acceptable. Thus, my confidence in Conclusion #5 is low, but I do understand why people use them.

This is another case where a life cycle-type model approach would do better service to this question. Life cycle models don't have to be complex, and some are quite resilient to data poor situations (Scheuerell et al., 2021), but they would at least allow for more transparent testing of the assumptions relied upon here.

The Final Draft would also benefit from including some of these uncertainties in this approach in Chapter 7 Conclusions and Uncertainties. Item 9 on the list of uncertainties doesn't really capture the nature of this issue.

Conclusion #6: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.

Conclusion #6 is difficult if not impossible to evaluate because viability is not defined in the Final Draft, or in the supporting documentation.

The Narrative Viability Objectives are defined in Box ES-1 in the Executive Summary, and they are repeated in several places including other documents.

> "The proposed new Narrative Viability Objective states:
>
> > Maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations. Conditions and measures that reasonably contribute toward maintaining viable native fish populations include, but may not be limited to, (1) flows that support native fish species, including the relative magnitude, duration, timing, temperature, and spatial extent of flows, and (2) conditions within water bodies that enhance spawning, rearing, growth, and migration in order to contribute to improved viability. Indicators of viability include population abundance, spatial extent, distribution, structure, genetic and life history diversity, and productivity. Flows provided to meet this objective shall be managed in a manner to avoid causing significant adverse impacts to fish and wildlife beneficial uses at other times of the year."

This language says the population viability is an objective. That is great, but it does not define what constitutes "viability" in this context.

It is apparent that this language and the idea of viability is drawn from earlier documents (State Water Control Board, 2017 & 2023). However, those documents also do not define viability. They use essentially the same language.

Viability in salmon recovery is consistent with the common understanding of the word viability. It connotes some level of persistence or sustainability over time, and it at implies some level of resilience in the face of stressors or challenges.

In the context of species management and recovery however, it can mean different, specific things. It usually connotes some form of sustainability, but it may or may not be synonymous with

- Self-sustaining with or without human intervention?
- Self-sustaining with or without hatchery supplementation?
- 100-year extinction risk below 50%? 25%? 1%?
- etc...

Viability is an expression of how the population is expected to do into the future, which is unknown of course. So, viability is expressed as a risk assessment in the face of possibly multiple stochastic stressors. It needs a level of expectation and, since nothing lasts forever, a planning time horizon. McElhaney et al. (2000) define population viability as:

> "We define a viable salmonid population as an independent population of any Pacific salmonid (genus Oncorhynchus) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100- year time frame."

Because we don't know the future, one typically performs a Population Viability Analysis (PVA). One version of a PVA develops an estimate of survival over time for the species of interest using time series of abundance of adults, and hopefully additional life stages. This model is then used to project into the future many possible population abundance trajectories with stochastic variation in the survivorships (mimicking the possible response to stressors). In the process, one can build a distribution of abundances at some benchmark time in the future, say 100 years. The proportion of trajectories that have crossed zero within that 100-year window (i.e. gone extinct) is the extinction probability. In different situations, “negligible” might be 1% chance, 5% chance, 0.01% chance, based on the risk tolerance of the responsible parties.

Developing Viability criteria can be challenging for several reasons and the approach has been applied in some situations that have been criticized. For those cases where a quantitative PVA is challenging, McElhaney et al. (2000) provide some Viability Guidelines to provide a set of should do’s that are more operational in a management context. They include:

1. ESUs (= Demographic unit desired to be viable) should contain multiple populations.
2. Some populations in an ESU should be geographically widespread.
3. Some populations should be geographically close to each other.
4. Populations should not all share common catastrophic risks.
5. Populations that display diverse life-histories and phenotypes should be maintained.
6. Some populations should exceed VSP guidelines.
7. Evaluations of ESU status should take into account uncertainty about ESU-level processes.

All of these details in what viability means impose obligations on policies, regulations, and agreements (and their supporting budgets) that are used to address something like the Narrative Viability Objective. Therefore, defining what viability means is critically important.

Neither the Final Draft, nor the supporting documents, contain a PVA, or text that is functionally similar to the Viability Guidelines, or any statement on what this program considers “negligible risk”, or over what time horizon viability is desired to be maintained. There is no explicit statement regarding if viability can rely on continuing human intervention (e.g. hatcheries – although the focus on native fish in the Conclusion I am not reviewing suggests hatchery and wild fish are treated differently).

This is an important omission. Without some specificity regarding what “viability” means for the Voluntary Agreements, one cannot honestly evaluate if the quantitative and qualitative analyses used appropriate assumptions to get there. It’s not clear how the Final Draft is anticipating the improved assets will help meet the objective if the objective is not defined. That being the case, the appropriateness and validity of that analysis is kind of moot.

On this basis, my confidence is Conclusion #6 is low. The Final Draft would benefit from some detail regarding the meaning of viability and/or some statements regarding how actions taken will affect viability. For example, in section 3.1 it says:

> “The habitat restoration measures described below would be additive to physical conditions and regulatory requirements existing as of December 2018, … Implementation of such measures by Parties … would be considered as contributing toward implementation of the Narrative Salmon Protection Objective (referred to as the Narrative Salmon Objective in the VA Term Sheet) and Narrative Viability Objective. The habitat restoration described below represents the habitat restoration commitments from Appendix 2 of the VA Term Sheet.”

Fair enough, but how? Which restoration actions affect risk and how? In the absence of that connection, is viability just a property that is along for the ride while we increase abundance?

In addition, extinction risk is never zero. Therefore, Chapter 7 (Conclusions and Uncertainties) would benefit from some discussion of extinction risk. The plan could go into place and more or less work, but there is a non-zero probability that the population will still crash and possibly go extinct anyway. That risk should be acknowledged.

Other Concerns

Page 2-5: Beavers are discussed as a bad thing in that beaver dams may be passage barriers. This is not always the case, and adding beaver dams is one of the few habitat restoration techniques that can successfully reduce storm flow magnitude (Nyssen et al., 2011), augment instream flows (Gurnell, 1998; Pollack et al., 2014), help reconnect stream flow and groundwater (Pollack et al., 2014) and are relatively inexpensive. Beavers are not always a bad thing.

Groundwater is almost completely missing as a player in this story. There are numerous mentions of groundwater in Table A1-1 in the context of management actions that include ground water pumping. However, there is no explicit discussion of groundwater in either the impacts of, or constraints imposed on the VA's, or the ecological role of groundwater for the fish. Groundwater and hyporheic flows are critically important to habitat quality for a variety of salmon species, but especially Chinook spawners (e.g. Geist et al., 2002; Malcolm et al., 2004; Hanrahan, 2008), and may ultimately limit your ability to increase spawning habitat. This is a significant omission in the Final Draft.

Page 6-1, 6-25, 6-26 and elsewhere: In discussing the increased access to wetlands for rearing and out-migrating fish, there is a consistent message that more primary production is a desirable thing. It is suggested that more primary production leads to more zooplankton forage for young fish, which leads to faster fish growth rates and better survival for smolts. In relatively oligotrophic systems, such as high headwater streams, this model is likely true. Indeed, it is the basis for nutrient addition restoration projects (e.g. Sanderson et al., 2009). But lower in river systems, particularly where agricultural runoff has pushed the system toward relative eutrophy, more nutrients doesn't necessarily make for healthier fish (Vitusek et al., 1997; Compton et al., 2006). The Final Draft would benefit by placing the anticipated new habitat into a relative context based on water quality with respect to nutrient loads.

References

Aylward, B., and R. O'Connor. 2017. Whychus Flow Restoration: An Environmental Water Transactions Case Study. Portland: AMP Insights. Available online at: http://www. ampinsights. com/s/Whychus. pdf.

Barnas, K. A., S. L. Katz, D. E. Hamm, M. C. Diaz, and C. E. Jordan. 2015. Is habitat restoration targeting relevant ecological needs for endangered species? Using Pacific salmon as a case study. Ecosphere 6: 1–42.

Batalla, R. J., C. M. Gomez, and G. M. Kondolf. 2004. River impoundment and changes in flow regime, Ebro River basin, northeastern Spain. Journal of Hydrology 290: 117–136.

Beecher, H. A., B. A. Caldwell, S. B. DeMond, D. Seiler, and S. N. Boessow. 2010. An empirical assessment of PHABSIM using long-term monitoring of coho salmon smolt production in Bingham Creek, Washington. North American Journal of Fisheries Management 30: 1529–1543.

Bovee, K. D., B. L. Lamb, J. M. Bartholow, C. B. Stalnaker, and J. Taylor. 1998. Stream habitat analysis using the instream flow incremental methodology. Geological Survey Reston, VA Biological Resources Div.

Chasco, B., Burke, B., Crozier, L. and Zabel, R., 2021. Differential impacts of freshwater and marine covariates on wild and hatchery Chinook salmon marine survival. PloS one, 16(2), p.e0246659.

Compton, J.E., Andersen, C.P., Phillips, D.L., Brooks, J.R., Johnson, M.G., Church, M.R., Hogsett, W.E., Cairns, M.A., Rygiewicz, P.T., McComb, B.C. and Shaff, C.D., 2006. Ecological and water quality consequences of nutrient addition for salmon restoration in the Pacific Northwest. Frontiers in Ecology and the Environment, 4(1), pp.18-26.

Crammond, J. D. 1996. Leasing water rights for instream flow uses: A survey of water transfer policy, practices, and problems in the Pacific Northwest. Envtl. L. 26: 225.

DeFilippo, L.B., Buehrens, T.W., Scheuerell, M., Kendall, N.W. and Schindler, D.E., 2021. Improving short-term recruitment forecasts for coho salmon using a spatiotemporal integrated population model. Fisheries Research, 242, p.106014.

Elmore, L. R., S. E. Null, and N. R. Mouzon. 2016. Effects of environmental water transfers on stream temperatures. River Research and Applications 32: 1415–1427.

Gaillard, J.-M., Hebblewhite, M., Loison, A., Fuller, M., Powell, R., Basille,M., & Van Moorter, B. 2010. Habitat–performance relationships: find-ing the right metric at a given spatial scale.Philosophical Transactions ofthe Royal Society B: Biological Sciences,365, 2255–2265. https://doi.org/10.1098/rstb.2010.0085

Geist, D.R., Hanrahan, T.P., Arntzen, E.V., McMichael, G.A., Murray, C.J. and Chien, Y.J., 2002. Physicochemical characteristics of the hyporheic zone affect redd site selection by chum salmon and fall Chinook salmon in the Columbia River. North American Journal of Fisheries Management, 22(4), pp.1077-1085.

Grafton, R. Q., C. Landry, G. D. Libecap, S. McGlennon, and R. O’Brien. 2010. An integrated assessment of water markets: Australia, Chile, China, South Africa and the USA. National Bureau of Economic Research.

Grafton, R. Q., and J. Williams. 2020. Rent-seeking behaviour and regulatory capture in the Murray-Darling Basin, Australia. International Journal of Water Resources Development 36: 484–504.

Gurnell, A. M. 1998. The hydrogeomorphological effects of beaver dam-building activity. Progress in Physical Geography 22: 167–189.

Hanrahan, T.P., 2008. Effects of river discharge on hyporheic exchange flows in salmon spawning areas of a large gravel-bed river. Hydrological Processes: An International Journal, 22(1), pp.127-141.

Ise, S., and D. L. Sunding. 1998. Reallocating water from agriculture to the environment under a voluntary purchase program. Review of Agricultural economics 20: 214–226.

Jones, L., and B. G. Colby. 2012. Measuring, monitoring, and enforcing temporary water transfers: Considerations, case examples, innovations and costs. Innovative Water Transfer Tools for Regional Adaptation to Climate Change.

Jung, H. Y., T. S. Hogue, L. K. Rademacher, and T. Meixner. 2009. Impact of wildfire on source water contributions in Devil Creek, CA: Evidence from end-member mixing analysis. Hydrological Processes: An International Journal 23: 183–200.

Katopodis, C. 2003. Case studies of instream flow modelling for fish habitat in Canadian Prairie rivers. Canadian Water Resources Journal 28: 199–216.

Katz, Stephen L., Katie Barnas, Ryan Hicks, Jeff Cowen, and Robin Jenkinson. 2007. “Freshwater Habitat Restoration Actions in the Pacific Northwest: A Decade’s Investment in Habitat Improvement.” Restoration Ecology 15 (3): 494–505.

Katz, S.L. and B.T. Luff, 2020. Review of Evidence for Management Action Effectiveness of Streamflow Restoration. Prepared for the Washington Department of Fish and Wildlife. pp:101 [Technical Report available at: https://www.coastsalmonpartnership.org/document_library/review-of-evidence-for-management-action-effectiveness-of-streamflow-restoration/]

Kinoshita, A. M., and T. S. Hogue. 2015. Increased dry season water yield in burned watersheds in Southern California. Environmental Research Letters 10: 014003.

Kondolf, G. M., and R. J. Batalla. 2005. Hydrological effects of dams and water diversions on rivers of Mediterranean-climate regions: examples from California, p. 197–211. In Developments in Earth surface processes. Elsevier.

Lancaster, J., & Downes, B. J. 2010. Linking the hydraulic world of individual organisms to ecological processes: Putting ecology into ecohydraulics. River Research and Applications,26, 385–403. https://doi.org/10.1002/rra.1274

Landry, C. 1998. Market transfers of water for environmental protection in the western United States. Water Policy 1: 457–469.

Liermann, Martin, George Pess, Mike McHenry, John McMillan, Mel Elofson, Todd Bennett, and Raymond Moses. "Relocation and recolonization of coho salmon in two tributaries to the Elwha River: Implications for management and monitoring." Transactions of the American Fisheries Society 146, no. 5 (2017): 955-966.

Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L. W. Botsford, D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, and T. H. Williams.

2009. What caused the Sacramento River fall Chinook stock collapse? NOAA Technical Memorandum NMFS-SWFSC-447, 125 pp.

Malcolm, I.A., Soulsby, C., Youngson, A.F., Hannah, D.M., McLaren, I.S. and Thorne, A., 2004. Hydrological influences on hyporheic water quality: implications for salmon egg survival. Hydrological Processes, 18(9), pp.1543-1560.

McClure, Michelle M., Elizabeth E. Holmes, Beth L. Sanderson, and Chris E. Jordan. 2003. "A Large-Scale, Multispecies Status Assessment: Anadromous Salmonids in the Columbia River Basin." Ecological Applications 13 (4): 964–89.

McElhany, P., Rucklelshaus, M.H., Ford, M.J., Wainwright, T.C. and Bjorkstedt, E.P., 2000. Viable salmonid populations and the recovery of evolutionarily significant units. Available at: https://repository.library.noaa.gov/view/noaa/3139/noaa_3139_DS1.pdf

McMillan, J. R., M. C. Liermann, J. Starr, G. R. Pess, and X. Augerot. 2013. Using a stream network census of fish and habitat to assess models of juvenile salmonid distribution. Transactions of the American Fisheries Society 142: 942–956.

National Marine Fisheries Service (NMFS). 2009. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and the State Water Project. National Marine Fisheries Service, Long Beach, CA. Available: https://media.fisheries.noaa.gov/2022-02/nmfs-biological-conference-opinion-long-term-operations-cvp-swp.pdf.

National Marine Fisheries Service (NMFS). 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. National Marine Fisheries Service, California Central Valley Area Office, Sacramento, CA. Available: https://media.fisheries.noaa.gov/dam-migration/central_valley_salmonids_recovery_plan-accessible.pdf

National Marine Fisheries Service (NMFS). 2016. Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Coordination Act Recommendations for Relicensing the Oroville Facilities Hydroelectric Project, Butte County California (FERC Project No. 2100-134). Available: https://repository.library.noaa.gov/view/noaa/27563

National Marine Fisheries Service (NMFS). 2019. Biological Opinion on the Long-Term Operation of the Central Valley Project and the State Water Project. West Coast Region. Available: https://repository.library.noaa.gov/view/noaa/22046.

Nestler, John M., Robert T. Milhous, Thomas R. Payne, and David L. Smith. 2019. History and review of the habitat suitability criteria curve in applied aquatic ecology. River Research and Applications 35, no. 8: 1155-1180.

Null, S. E., N. R. Mouzon, and L. R. Elmore. 2017. Dissolved oxygen, stream temperature, and fish habitat response to environmental water purchases. Journal of environmental management 197: 559–570.

Nyssen, J., J. Pontzeele, and P. Billi. 2011. Effect of beaver dams on the hydrology of small mountain streams: example from the Chevral in the Ourthe Orientale basin, Ardennes, Belgium. Journal of hydrology 402: 92–102.

Parasiewicz, P. 2001. MesoHABSIM: A concept for application of instream flow models in river restoration planning. Fisheries 26: 6–13.

Parasiewicz, P., and J. D. Walker. 2007. Comparison of MesoHABSIM with two microhabitat models (PHABSIM and HARPHA). River Research and Applications 23: 904–923.

Pollock, M. M., T. J. Beechie, J. M. Wheaton, C. E. Jordan, N. Bouwes, N. Weber, and C. Volk. 2014. Using beaver dams to restore incised stream ecosystems. Bioscience 64: 279–290.

Railsback, S. F. 2016. Why it is time to put PHABSIM out to pasture. Fisheries 41: 720–725.

Reiser, D. W., and P. J. Hilgert. 2018. A Practitioner's Perspective on the Continuing Technical Merits of PHABSIM. Fisheries 43: 278–283.

Roni, P., G. Pess, T. Beechie, and S. Morley. 2010. Estimating Changes in Coho Salmon and Steelhead Abundance from Watershed Restoration: How Much Restoration is Needed to Measurably Increase Smolt Production? North American Journal of Fisheries Management 30(6):1469–1484. https://doi.org/10.1577/M09-162.1.

Roni, Philip. 2019. Does river restoration increase fish abundance and survival or concentrate fish? The effects of project scale, location, and fish life history. Fisheries 44, no. 1: 7-19.

Sanderson, B.L., Coe, H.J., Tran, C.D., Macneale, K.H., Harstad, D.L. and Goodwin, A.B., 2009. Nutrient limitation of periphyton in Idaho streams: results from nutrient diffusing substrate experiments. Journal of the North American Benthological Society, 28(4), pp.832-845.

Scheuerell, Mark D., Casey P. Ruff, Joseph H. Anderson, and Eric M. Beamer. 2021. An integrated population model for estimating the relative effects of natural and anthropogenic factors on a threatened population of steelhead trout. Journal of Applied Ecology 58, no. 1:114-124.

State Water Resources Control Board (State Water Board). 2017. Scientific Basis Report in Support of New and Modified Requirements for Inflows from the Sacramento River and its Tributaries and Eastside Tributaries to the Delta, Delta Outflows, Cold Water Habitat, and Interior Delta Flows. (PCFFA-168) State Water Resources Control Board, CEPA Sacramento, CA.

State Water Resources Control Board, California Department of Water Resources, and California Department of Fish and Wildlife. 2023. Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan. September. (ICF 103625.0.002.01.004.01.) Sacramento, CA.

Stednick, J. D. 1996. Monitoring the effects of timber harvest on annual water yield. Journal of hydrology 176: 79–95.

Vitousek, P.M., Aber, J.D., Howarth, R.W., Likens, G.E., Matson, P.A., Schindler, D.W., Schlesinger, W.H. and Tilman, D.G., 1997. Human alteration of the global nitrogen cycle: sources and consequences. Ecological applications, 7(3), pp.737-750.

Williams, J., and R. Q. Grafton. 2019. Missing in action: Possible effects of water recovery on stream and river flows in the Murray–Darling Basin, Australia. Australasian Journal of Water Resources 23: 78–87.

Wu, J., and H. Li. 2006. Concepts of scale and scaling, p. 3–15. In Scaling and uncertainty analysis in ecology. Springer.

Margaret Palmer, Professor, University of Maryland

Jan 14, 2024

Signed:

Item Reviewed: Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan

Based on my expertise and experience, I am reviewing the findings, assumptions, or conclusions I agreed I could review with confidence:

- Conclusion #1: Native aquatic species have been declining in tributaries, off-stream habitats, and the Bay-Delta due to aquatic ecosystem stressors.
- Conclusion #2: The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.
- Conclusion #3: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving the narrative objective to double salmon populations relative to the reference population of 1967-1991, by 2050 (Narrative Salmon Protection Objective or salmon doubling goal).
- Conclusion #4: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving a new Narrative Viability Objective to “maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations.
- Conclusion #5: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.
- Conclusion #6: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.

Review

In general, the VA Plans Report is thorough. There is uncertainty in much of what is planned and some of this is well acknowledged but some of it is not. Much of what is written is based on hypotheses because parts are based on untested assumptions and qualitative analyses. This is out of necessity of course -- largely due to the many factors that interact in complex ways to influence fish populations. Below, I provide general comments relevant to the conclusions I agreed to review; specific suggestions are provided in the numbered items that follow. I want to stress that these are only meant to be suggestions to improve the report. It is a dense document and without committing much to memory from earlier reports such as the 2017 Scientific Report, some of the suggestions stem from how difficult it is for the reader to find the evidence associated with each statement in the VA plan report. I leave it to the authors and oversight Program to make the final determination of which suggestions they deem useful.

Conclusion #1: Native aquatic species have been declining in tributaries, off-stream habitats, and the Bay-Delta due to aquatic ecosystem stressors

General Comments:

There is abundant evidence that fish metrics indicate major declines of relevant species. This evidence is described with supporting research citations in the supplement and the evidence was easy to find in the 2017 Scientific Report. Further, current flows in the Sacramento River and its Tributaries (referred to as "the system" hereafter in this review) are benefitting nonnative fish and nonnative species are dominating regions in the watershed where there is the greatest flow alteration. The decline in natives is greatly affected by problems with spawning and so the VA plan addresses well. The importance of flow regime for such native species is supported by extensive research in many riverine systems -- namely, flow regimes (magnitude, timing of peaks and lows, etc.) are well known to be critical to the life cycles of man fish. Additionally, there is extensive literature showing that altered flows and temperatures (which are typically related in regulated rivers) benefit nonnative fish and other nonnative taxa. Dams are clearly barriers for migration and spawning as is habitat loss. In sum, there is clear evidence from studies of this system and from extensive studies in other systems that the stressors described in Sections 2.1 are associated with declines in native species. Scholars assume that loss of habitat (especially for spawning and rearing) is a major factor leading to fish declines in rivers such as the ones under study here, although separating this effect from the effects of other stressors is difficult. The same thing can be said about the relative effect of direct take of fish and the effects of disease; the report acknowledges these uncertainties.

1. It is clear from the data that while climate has been changing in the broad region, the results are not outside the range of conditions for which native species are adapted (Ingram and Malamud-Roam 2023), so to argue that climate change is a stressor needed more support early on in the VA plan report.

2. The potential that reduced food is a stressor and likely influencing the decline of the fish population is not well supported – if it is, it is hard to separate out its effects from other stressors. The plan should cite the evidence *in this section* and acknowledge the high level of uncertainty. I note there are citations elsewhere that are relevant but see comments later in my review.

Conclusion #2: The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.

Conclusion #3: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving the narrative objective to double salmon populations relative to the reference population of 1967-1991, by 2050 (Narrative Salmon Protection Objective or salmon doubling goal

General Comments:
My general comments refer to both conclusions including: "expectations" that the proposed actions will "provide benefits" and "improve conditions for native species to contribute to achieving the objective of doubling salmon populations relative to the reference…" The words I have underlined to emphasize that these are only expectations (not guarantees) and that benefits and conditions are highly relative terms.

The additive assets of the outflows are proposed for the correct time of the year (January – June) given the life histories of the species (when they migrate, spawn, etc.) and importantly the VA plan includes flexibility. Given that water years can be quite different depending on weather conditions this flexibility is important and thus should ensure benefits to the fish and other native species. The habitat additions will increase potential spawning and rearing habitat and given the levee setbacks, breaches, and side-channel improvements planned, it is reasonable to conclude this could benefit the species however this assumes species use the habitat (see specific comment 1 below).

The report nicely provides evidence that flow is statistically important for outmigration success of salmonids on the Sacramento (section 6.1.3, page 6-17) and provides a 2017 published study showing that the duration "of floodplain flooding in the Yolo Bypass positively affected total growth in coded wire tagged hatchery-origin fall-run Chinook salmon in the bypass" (section 6.1.3, top of page 6-18). Given that the flow releases planned will increase flow releases I agree this should increase growth of fall-run Chinook (if spawning is successful).

Specific Comments:

1. Research has shown that just creating habitat does not guarantee use and more importantly benefits that lead to increased production system wide – if water quality remains poor (e.g., temperature, turbidity, etc.), it does not matter how much habitat is available. The VA plan cites Roni et al. (2008) as evidence to support that statement and Roni et al. does provide general support but it also states that evidence is limiting and may only lead to increases in local abundance i.e., not production. I suggest the authors carefully read Taylor et al. (2019, *Environ Evid (2019) 8:19.* https://doi.org/10.1186/s13750-019-0162-6) and better acknowledge uncertainty around a link between habitat availability and increased fish production system wide.

2. Cooper-Hertel (2022, https://www.researchgate.net/publication/363541666) note that habitat capacity sufficient to support juvenile Chinook is higher in more complex habitats in terms of morphological-topographic complexity. While the VA plan notes multiple times that current conditions in many rivers resulted in limited habitat complexity, the only place I found in which the report refers to correcting this problem with the proposed actions is in section 3.14:

> *"Non-flow assets for the Feather River include restoration of 5.25 acres of instream habitat, 15 acres of spawning habitat, and 1,655 acres of floodplain habitat. This consists of added instream habitat complexity and side-channel improvements."*

It would be helpful for the plan to address expected changes in complexity more thoroughly, including how it is defined and assessed, as well as addressing this for all of the relevant rivers.

3**.** There is relatively high uncertainty that increased habitat such as that proposed in the VA plan will benefit food resources – it depends on many factors and presence of habitat that is inundated does not guarantee this. It would be good to have some uncertainty estimation and in addition evidence that food is limiting to the fish. Section 6.1.4 (third para) does provide references indicating abundant food resources are "high-value" in the off-stream habitats of the Sacramento but is there system-specific evidence that food increases with created or flow restored (inundation) habitats? If the Sturrock et al. (2022) study provides that evidence, please cite it here.

3. The below text on page 6.1 of the Final VA Supplemental Report (starting with the second sentence) should have a citation. Similar numerically specific statements are made in multiple places in Chapter 6 and while such statements are likely supported in the modeling studies section, having specific references in chapter 6 would be especially useful. It should be easy for the reader to find the evidence for these specific numerical findings in this or other reports.

> *For spawning habitat in all watersheds except the American River, both existing and VA habitat exceed the habitat necessary to support approximately 25 percent of the offspring of the doubling goal populations (the target of the 8-year term of the VAs) and the VA habitat exceeds 50 percent of the required habitat. Rearing habitat improvements varied by tributary, with the 25-percent target being met in the Mokelumne, Sacramento (spring run), and Yuba Rivers for both the reference condition and VA, and in the Feather River in the VA scenario.*

There was convincing evidence provided (page 7-17, section 6.1.3, second sentence) with regards to the probable benefits of increased of out-migration:

> *Studies using acoustic tagged salmonids on the Sacramento River show that flow was the most important covariate in predicting outmigration success (Michel et al. 2015; Notch et al. 2020). Flow-survival thresholds have recently*

been developed using spring and summer season salmonid releases in the Sacramento River, based on river stage at Wilkins Slough (Michel et al. 2021).

To my understanding, such evidence was not provided using studies specific to this system with regards to floodplain habitat. As indicated in the report, it "may" benefit the species. If I missed it somewhere in the report, it would be good to have uncertainty noted here or refer the reader to estimates of those somewhere on the report.

Conclusion #4: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving a new Narrative Viability Objective to "maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations."

The Va plan evaluation of the ability of the assets to improve water quality, flow, habitat, and "other watershed" conditions is covered mostly in Chapter 6 of the plan. In general, the plans are strong and there seems to be good evidence that flow is the most important factor in out-migration success of salmon for the Sacramento River (section 6.1.3 page 6-17).

1. As indicated earlier, potential habitat area will be increased but there is no guarantee it will be used sufficiently to ensure it will "support and maintain fish populations." It would be good to cite the uncertainty specifically for habitat use. I was pleased to see the bootstrapping described in section 5.2, but it seemed like this only applied to outflow. The reference to Roni et al. (2008) in section 6.1.2.1 page 6-6 refers to the response to in-stream structure not just habitat area. Perhaps the below (section 6.2.2.2 page 6-9) is the correct reference? It would be good to clarify.

"Fish yields have also been found to increase with water surface area in floodplains (Bayley 1991 as cited in Jeffres et al. 2008; USFWS 2014)."

2. What exactly are the additional modifications, changes, and enhancements referred to in the below text (section 6.1.2.2 page 6-12) and how likely are these to happen?

"*This will need to be accompanied by additional topographic modifications, land management changes, and habitat enhancements in these flood basins to generate the full 20,000 acres of floodplain habitat identified in the VA*s"

3. There could be stronger acknowledgement that improvements to water quality will likely be limited and for which of the following – temperature, water quality, turbidity. I would like at least a qualitative estimate of how likely these are to be improved (section 6.2.1 page 6-23).

Conclusion #5: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving

the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.

Conclusion #6: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid

In general, the quantitative analyses seem quite good when they refer to specific assets. The qualitative analyses are mostly the best that can be done given the limited specific data available for some of the aspects associated with improvements of fish populations. So many factors influence them and many of them interact that it is impossible to have highly quantitative analyses for everything. I do, however, think there are places where more acknowledgement of uncertainty (low, medium, or high at least) should be included – I have indicated these in the above numbered comments. Mostly they refer to habitat use. I think in general the assumptions underlying the analyses are valid except as noted below.

1. As alluded to multiple times in my review, the assumptions underlying the habitat benefits – especially to actually increase populations rather than local abundances -- are not particularly strong. I think this may need more justification/support. i.e., see assumption 3 in Summary Chapter 7 page 7-2

> *“Analysis of habitat restoration benefits is based on the assumption that restored sites will replicate natural ecosystem functions and that restoration sites will be maintained over time such that species benefits do not diminish over time.“*

To: State Water Resources Control Board of California via CalEPA Peer Review Program

From: N. LeRoy Poff, Ph.D., Professor of Biology, Colorado State University, Fort Collins, CO 80523

Subject: Scientific review and comments on Conclusions 1,2, 3, 4, 5, and 6 of document: *Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan (September 2023)*

Submitted: January 22, 2024

Based on my expertise and experience, I am reviewing the findings, assumptions, or conclusions I agreed I could review with confidence. My aim is to comment on whether "the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices." I was a peer reviewer on the 2017 Scientific Basis Report and will not repeat here my extensive comments on flow-abundance relationships from that previous review.

CONCLUSION 1: Native aquatic species have been declining in tributaries, off-stream habitats, and the Bay-Delta due to aquatic ecosystem stressors.

Many stressors across the inland tributaries and the Delta are qualitatively listed in **Table 2-1** of the report, including basal food production, physical habitat loss, water quality components, and habitat connectivity. These stressors impair species performance independently of flow alteration, but they are often exacerbated when interacting with flow impairment. There is ample evidence from the broader biological and ecological literature that these stressors often cause impairment of biological vital functions, such as growth, survival and population production, and thus it is a reasonable presumption that much of the reduction of native species in recent decades is driven by these multiple stressors. In sum Conclusion 1 is well supported by empirical evidence and literature review.

CONCLUSION 2: The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.

The report correctly acknowledges, based on extensive scientific understanding, that high quality non-flow habitat (both static and dynamic**, Figure 2-1**) is needed to sustain fish populations. Given the degraded nature of much non-flow habitat, physical restoration combined with adequate flows can create "functional" habitat, which is justifiably expected to increase salmonid production by some amount. Fish require habitat of different types (spawning, rearing, feeding, refuges from extremes) at different life stages to complete their life cycle and reproduce. These habitat types vary seasonally and across different tributary systems and spatially within the Bay-Delta. Scientific evidence and understanding accumulated over recent decades support that, in flow-impaired systems, environmental flows can enhance fish populations; however, flow restoration alone is not sufficient. Other factors may be co-limiting fish population recovery, including habitat impairment. The VA flows and habitat provisions are intended to enhance habitat conditions in several tributaries (**Chapter 3**) of the Bay-Delta System to support the 25% doubling goal for native fish abundance. Implementation of the VAs is expected to enhance native fish production and thus "provide benefits" to native fish populations. This is a reasonable expectation based on experience and ample research publications reported in the scientific literature. Conclusion 2 is well supported by best available scientific understanding.

<u>CONCLUSION 3</u>: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving the narrative objective to double salmon populations relative to the reference population of 1967-1991, by 2050 (Narrative Salmon Protection Objective or salmon doubling goal).

As described in **Box ES-1** (p. ES-4) the Narrative Salmon Protection Objective aims to achieve a "doubling of natural production of chinook salmon from the average production of 1967-1991" by maintaining water quality and generally favorable watershed conditions.

The "doubling goal" objective is applied independently to each river/tributary and to the Delta (**Chapter 5**). A pre-existing working paper and USFWS document (referenced on p. 5-4) provide the data source for "reference" escapement estimates per tributary, and those numbers are simply doubled to set the target. Tributary-scale capacity to achieve the doubling goal is modeled with parameters of spawner sex ratio, available redd spawning area, available juvenile rearing area, and egg-to-fry survival ratio (p. 5-4), and the identification of how much suitable restoration habitat is available per tributary (**Tables 5-5, 5-6, 5-7**). These parameter estimates carry unspecified uncertainty in the model outputs; however, this seems a reasonable approach for a high-level evaluation of the potential for enhancing salmonid populations through the tributary-scale VA habitat restoration process.

Model outputs show changes in VA habitat restoration (median across-year value for each tributary and across water year types) with attainment of the 25% of doubling goal relative to reference condition for salmonid spawning habitat (**Section 6.1.1**), for salmonid in-channel rearing habitat (**Section 6.1.2.1**) and for floodplain and fish food production (**Section 6.1.2.2**). Generally, these proposed VA habitat restoration projects indicate an expected improvement for native fishes, although there is variation in magnitude of improvement among tributaries and among water year types. I consider Conclusion 3 to be well supported scientifically. (However, I note I did not see any analysis as to whether these projects would be expected to deliver the projected enhance salmon population by the specified date of 2050.)

<u>CONCLUSION 4</u>: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving a new Narrative Viability Objective to "maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations".

The Narrative Viability Objective aims to "maintain the natural production of viable native fish populations" (**Box ES-1**). It specifies the need to "enhance spawning, rearing, growth and migration in order to contribute to improved viability."

Given that the proposed combination of flow and non-flow habitat restoration assets supports contributes to the Narrative Salmon Protection Objective (Conclusion 3), I infer that such combination should "support and maintain the natural production of viable fish populations." Thus, I find Conclusion 4 is supported (but see more detail on this issue under my comments on Conclusion 6).

<u>CONCLUSION 5</u>: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.

In determining the VAs contribution to "habitat", two approaches were taken, one for salmonids in tributaries and the other for native fishes in Delta estuaries.

For salmonids, "habitat" was categorized as: (a) "spawning habitat" which comprises physical locations having a combination of depth and velocity conditions (and suitable thermal regime and sheltering cover) that fall within empirically established features suitable for salmonid spawning, including the timing of the habitat availability relative to the fish life cycle and reproductive timing; (b) in channel "rearing habitat," defined as defined by suitable flow-depth-duration features; (c) "floodplain rearing habitat" which comprises out-of-channel habitat available when the rivers overflows their banks. Such habitat must be "accessible" or hydrologically connected to the river (e.g., not isolated from the river by levees, etc.) Such floodplain rearing habitat is primarily available on regulated or artificial water bodies (e.g., diversion canals).

Modeling of salmonid spawning and in-channel rearing habitat was done with PHABSIM, a 2-d hydraulic model widely used in water resources and fisheries management. PHABSIM has been criticized for its simplifications, but it is generally accepted as an appropriate modeling tool for cold-water salmonid habitat, which can be relatively well described in simple terms of water depth and velocity. More spawning and rearing habitat logically leads to the qualitative expectation that salmonid populations will benefit proportionally, assuming no other limiting environmental factors (e.g., too warm temperatures, adequate cover) or biological factors (e.g., predation mortality).

The Report makes clear that floodplain rearing habitat is qualitatively important for salmonid juveniles, but such habitat must be accessible via hydrologic connectivity, and this would be a VA goal. Improving such connectivity along modified waterways should enhance juvenile salmonid growth and potential population numbers.

For estuarine species, modeled improvement of native species was based on flow-abundance relationships (from the 2017 Scientific Basis Report) and 2-d hydrodynamic modeling of suitable habitat availability in the Delta given modeled outflows associated with VA projects. These results (**Figure 6-12**) indicate mostly positive enhancements of expected native species abundances under the increased flows from the VAs.

In sum, I find Conclusion 5 to use appropriate assumptions and to be scientifically valid.

CONCLUSION 6: **The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.**

The challenge of "maintaining the natural production of viable fish populations" is not a trivial one, especially for a spatially and temporally complex Bay-Delta system that has been extensively altered by human activities over the last many decades. The system is currently characterized by impaired hydrologic regimes, habitat loss and degradation, and a lack of natural connectivity between habitats. Absent intentional efforts to restore habitat and flows and their connectivity, we should expect continued decline in fish abundances at both local and system-wide scales. In principle, attaining any increase in fish populations, even the relatively small ones expected based on this Report, should contribute to enhancing population viability. Given global warming and associated increasing probability of population and habitat "bottlenecks (due to more frequent lower flows, altered timing of flows and warmer water temperatures), even incremental improvements in habitat as projected to occur under implementation of the VAs, become potentially crucial for enhancing overall system resilience. The quantitative and qualitative analyses underlying the findings of this Report are rigorous and scientifically valid in the face of deep uncertainties about the future, and they represent a rigorous basis from which to conduct the implementation of the VAs in an adaptive framework that may provide a foundation for continuing watershed restoration in the future.

Reviewer: Dr. John Sabo,
Affiliation: ByWater Institute, Tulane University
Review Date: 01/22/2024

Scientific review and comments on Conclusions 1,2, 3, 4, 5, and 6 of document: Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan (September 2023)

Dear Review Committee:

Based on my expertise and experience, I am reviewing the findings, assumptions, or conclusions I agreed I could review with confidence:

Conclusion #1: Native aquatic species have been declining in tributaries, offstream habitats, and the Bay-Delta due to aquatic ecosystem stressors.

Conclusion #2: The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.

Conclusion #3: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving the narrative objective to double salmon populations relative to the reference population of 1967-1991, by 2050 (Narrative Salmon Protection Objective or salmon doubling goal).

Conclusion #4: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving a new Narrative Viability Objective to "maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations."

Conclusion #5: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.

Conclusion #6: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.

I address each of these conclusions one by one below,

Sincerely,

John Sabo

Conclusion #1: Native aquatic species have been declining in tributaries, offstream habitats, and the Bay-Delta due to aquatic ecosystem stressors.

This conclusion is well supported by both the scientific literature, the 2017 Scientific Basis Report and the Draft Supplement Report ("the DSR"). Components of Chapter 2 of the Draft Supplement Report that are relevant to my assessment:

1) Food supply/ ecosystem productivity
   Managed systems like the Sacramento-San Joaquin River typically have very modest or minimal connectivity between channel and off channel habitats. Similarly, delta ecosystems that are as heavily managed as the SF Bay Delta have low to negligible natural wetland and marsh habitat. Floodplain connectivity and natural marsh ecosystem habitat in deltas are essential for providing conditions for levels of primary and secondary productivity and protection for juvenile fish to deliver food resources to them. Most of this knowledge comes from tropical basins like the Mekong and Amazon rivers. However there is ample knowledge for these critical habitat connections in American (non-tropical) rivers like the Colorado and the Sacramento. These connections are incredibly difficult and expensive (and idiosyncratic) to measure. They are nonetheless paramount.

2) Physical habitat loss/alteration
   The Sacramento-SJ river system has suffered incredible habitat loss as a result of channelization and segregation of floodplains and river by levees. This reduction in lateral habitat which is essential for rearing of juveniles is one of the most important interventions that the VA can make—building back these connections is paramount for meeting the Narrative Viability Objective (NVO) and Narrative Salmon Production Objective (NSPO or "doubling goal"). One challenge addressed by the Draft Supplement Report analysis is the distinction between flow and non-flow habitat and their interaction and this is perhaps the most key piece of this analysis.

3) Water quality
   The main concerns here are temperature and salinity. Temperature is a key consideration of flow-related habitat in the mainstem and tributaries as operations and their timing can affect temperature. The DSR does an adequate (not exceptional) job at reviewing and addressing potential temperature related issues with riverine juvenile salmonids and an exceptional job with salinity and its effects on delta-based estuarine species.

4) Movement/migration/ passage/connectivity

   The ability of adult salmonids to pass through large dams is arguably the most important stressor on the system and salmonid viability, as it prevents access to the majority of upstream spawning habitat. This stressor is not addressed by the VA assets and is difficult to imagine remediating.

5) Invasive species
Invasive species, especially freshwater piscivores, are a key stressor on successful outmigration of juvenile salmonids. This is NOT addressed by the VA assets.

6) Direct take
Having worked in Washington and seen the fisheries in Alaska for Chinook Salmon, I am always amazed that any take is allowed in California given the stressors mentioned above. Having said this, there is potential for incredible recruitment in California and hence the desire to harvest. The VA assets do not address direct take but it is a key stressor.

7) Disease
Compared to direct take, my personal professional opinion is that this stressor is minimal—except when it emanates from hatcheries. The VA assets do not address disease in any meaningful way.

8) Climate change
The DSR does a poor job of addressing climate change in my opinion. Likely climate transformations include, longer and deeper drought and more intense flooding with increasing water storage in atmospheric rivers and ENSO. These conditions will present enormous challenges for operators of federal and state reservoirs to just protect people much less deliver the VA Assets. Yes eight years is "near-term" climate change. But we will see changes in this coming decade and preparing to adapt to these changes is a challenge worth embedding into the VA Assets.

Conclusion #2: The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.

This conclusion is supported by the quantitative and qualitative analysis in the DSR; in some places, support is not exceptional. Flows and off-channel habitat are good for fish, this is well supported by literature dating back to the 1990s and more recent studies on design flows. On a scale of 1 to 10 (10 good, 1 poor) I think the proposed VAs are likely (8 out of 10) to provide benefits for native species in tributaries and moderately likely (5 out of 10) to provide benefits for native species in the Bay-Delta ecosystem.

The DSR addresses the intersection between flow and non-flow habitat assets—you need both and you need both to coincide such that the habitat created has water when fish need it. This is paramount to the success of the VA assets. They need to be coordinated and the coordination of flows (in time) with non-flow habitat (in space) needs to be monitored and evaluated carefully.

The timing of flows is obviously important. The "Where, When and How they are connected to offchannel locations" is much more important than How Much. The VA Assets make great commitments in terms of how much—consistent with the intent of the original CVPIA (of 500 TAF and thousands of acres of floodplain). The DSR also does a reasonable job at justifying the connection between these commitments and the salmon doubling goal by using literature resources (quantitative) and expert opinion (qualitative) and other qualitative analyses. The more difficult thing is to deliver flows and habitat where they matter—to solve the space-time coincidence of flow and non-flow assets. A sophisticated management and evaluation (M&E) program will be required to measure the impacts of both habitat assets on fish viability. This is a holy grail in fish ecology that has yet to be delivered by science.

Conclusion #3: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving the narrative objective to double salmon populations relative to the reference population of 1967-1991, by 2050 (Narrative Salmon Protection Objective or salmon doubling goal).

Flows and lateral habitat are good for salmon restoration. On a scale of 1 to 10 (10 good, 1 poor) I think the proposed VAs are likely (8 out of 10) to contribute to doubling salmon populations relative to the reference population of 1967-1991 but only moderately likely (5 out of 10) to increase them by more than 25% relative to the reference population.

The calculations for area of habitat needed for rearing and spawning are based on very old studies in very different systems. The rearing studies—the best available that I know of—are from SE Canada on Brook Trout and from the 1990's. Similarly the spawning studies—possibly the most detailed available—are from sockeye salmon in British Columbia or Alaska. Why the state of California does not have equally comprehensive and detailed measurements of juvenile home range and adult nest sizes for Chinook Salmon (both runs) and steelhead in the Sac-San Joaquin system baffles me. If they do, the analysis in the DSR is outdated and needs revision. I am assuming old information from completely different species is the status quo and that the DSR is as a result, sound because it is based on best available not best possible science.

Having said this, the calculations and estimates of habitat requirements for rearing and spawning **are sound** (based on different species and systems) and the logic model for doubling makes sense, ***and assuming*** *that the relationships between habitat availability and spawning success (larval escapement from redd) and escapement of juveniles to the Bay Delta are both* ***linear to an upper threshold ("hockey stick")***.

Two conclusions about non-flow habitat assets made by the DSR that are relevant and important, especially in the context of accounting and management & evaluation of the implementation of the VA assets:

- Non-flow habitat is *not* habitat without flow. New lateral habitats restored for rearing of juvenile fish, must be connected to the mainstem and maintain adequate connection (Meaningful Floodplain Events, MFEs) such that fish can enter, feed for adequate time and leave without becoming stranded in relict oxbows. This will take on the ground measurement and is hard to model, hence my distinction between scores of 8 (qualitatively benefits salmon) and 5 (adds more than 25% of the habitat necessary for doubling).

- Non-flow habitat as measured by depth and velocity is a good proxy, but vegetative cover may be equally or more important in terms of providing protection from piscivore and avian predation. This needs more attention and science in forthcoming M&E.

Conclusion #4: The proposed combination of flow and non-flow habitat restoration assets provided by the VAs are expected to improve conditions for native species to contribute to achieving a new Narrative Viability Objective to "maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations."

On a scale of 1 to 10 (10 good, 1 poor), I think the VA's have a good chance (7 out of 10) of creating conditions sufficient to support and maintain the natural production of viable native fish populations in the Delta, if the timing of flow habitat assets allows for fish to move into restored non-flow habitat assets in the western Bay Delta. This chance is lower (4 out of 10) if there is not coordination between flow and non-flow habitat assets in space and time.

Conclusion #5: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.

The use of SacWAM (based on WEAP) is clever and industry (not gold) standard across the global Integrated Water Resources Management (IWRM) field. WEAP does not offer the same sophistication in terms of optimization that is offered in the CalSim package. If the VA partners want to understand how best to deliver the VA Assets and connect this to the Salmon Doubling Goal and Viability in the delta, they will need to revert to CalSim 2 or 3. Nevertheless, it is a robust model for understanding tradeoffs and improvements made by the VA assets in terms of flow related habitat.

Per my comments above, sub-monthly analysis may be necessary to understand potential booms or busts in the interaction between flow and non-flow habitat. Monthly WEAP is not enough to get the timing right. I know there are tradeoffs between computation time (decision-readiness) of the simultations and realism. But high temps for 2 days could be bad for a redd, and an acute flood could fush juveniles into and off channel habitat and strand them there making the non-flow habitat a sink rather than a source.

The use of expert opinion to understand spatial variability (across the watershed) in the relationship between flow and habitat quality was clever. I don't doubt that each of the experts interviewed are the most reputable and reliable witnesses of biology in the system. Still, I don't think expert witness testimony is enough to know if the VA assets will produce the results (25% of the doubling goal) that the VA partners want to achieve. Expert opinion is laudable. We need to work harder to quantify the relationships between flow and non-flow assets and viability with standard, data-driven models and collect the data necessary to manage salmon and other fish populations with science.

In my opinion, the flow-fish viability modeling that underpins the DSR as well as the 2017 Draft Basis Report (DBR) is weak. This is not a weakness of the proposed VAs but rather of the scientific process that the state takes on in this realm in general. The process that the DSR takes is based on industry standard methods underpinning the DBR and I think the DSR has done a reasonable job at combining quantitative and qualitative methods to qualify the potential impact of VA assets on fish given the lack of spatially explicit data and modeling relationships between either type of asset and fish survival and outmigration.

The State agencies should consider updating flow-fish modeling for the state, especially for salmon in freshwater ecosystems. There are ample data and a plethora of new time series methods—MARSS and choice modeling (logistic regression)—that could be used to understand space-time connections between flows, flow timing and fish survival or (less preferred) fitness (i.e., size, and its correlation with outmigration survival).

Conclusion #6: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.

The methods used to assess VA flow and non-flow habitat assets in delivering viability of native fishes in the Bay Delta are less of a departure from the Draft Basis Report (2017). Hence I have very little to comment on. One key finding that I think warrants much more quantitative analysis is the space-time coincidence of flow with non-flow habitat (restored wetlands). Restored wetlands in the Bay Delta are useless without flow that brings fish to them and the proper salinity to make those habitats proper nursery habitats.

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SUBJECT: REVIEW AD HOC REVIEW OF FINAL DRAFT SCIENTIFIC REPORT OF PROPOSED VOLUNTARY AGREEMENTS FOR SACRAMENTO RIVER, DELTA, AND TRIBUTARIES UPDATE TO SAN FRANCISCO BAY WATER QUALITY CONTROL PLAN

Referee Report

General comments

First, I would like to congratulate the State Water Resources Control Board, the California Department of Water Resources, Fish and Wildlife, and the University of Berkley for how you are leading this process of restoring an aquatic *ecosystem. This topic is actual and undoubtedly has scientific merit. The* methodology developed in this study to restore an aquatic ecosystem could be replicated in other parts of the world. However, regardless of that, during the review process, some comments, criticisms, and suggestions were addressed in this referee report's specific comments section (below).

Specific Comments.

Conclusion #1: ***Native aquatic species have been declining in Sacramento River basin and Estuary – Delta due to aquatic ecosystem stressors.***

In chapter 1 of the final report, the authors reach this conclusion based on the articles on this subject. It is very informative. Most of the information that supports this conclusion was from "State Water Board, 2017". The authors described the stressors and their consequences principally related to the juveniles' lateral movements (Dam stressor).

Based on this information, I would suggest continuing to study all habitats that this Salmon and other native species need to complete their life cycle in this basin. This study must consider the variables season and the aquatic habitats in different portions of the river and adjacent coastal areas. With the data obtained, if used in this sample design, it will be possible to understand what is happening in this Aquatic Ecosystem. It could be used as a model to replicate in different parts of the world. Figures ES-1 and two show that the American River (spawning and rearing habitats) and Sacramento River (rearing habitats) are under 25% of DG Ac. The table ES-2 o model suggests the area in Acres of the spawning habitats which each river would have to support 25 percent of the doubling Goal. These models take into consideration all years together. It would be nice if each year were analyzed independently. However, they must be analyzed for the season (*e.g*. fall run; spring run), as shown in Table ES-2 for Sacramento River.

*Conclusion #2****. The combination of non-flow habitat restoration and flows proposed as part of Vas are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.***

The rivers which belong to the Bay-Delta ecosystem have habitat connectivity restrictions. Connectivity between the rivers and the flood bypass is limited by dam operations, levees, and flood control weirs that all control lateral habitats' inundation (frequency and duration). All these variables could inhibit fish passage into and out of the bypasses if not well managed. For that reason, the monitoring of these variables is essential. However, these lateral habitats should be monitored to evaluate if they are being limited in area due to the increase in juveniles' densities.

Table 3-1 (Chapter 3) represents the contribution of habitat restoration. Among the efforts include activities to increase spawning habitat, instream rearing habitat, and flood plain habitats, which should improve the rearing and spawning capacity of the native fish species.

All studied rivers have flow and non-flow assets, except the Friant System. Currently, many projects in each river to restore habitats are intended to begin implementation in 2024. Whereas it is possible, I would like to follow this implementation closely. If it works, it would be nice if this method could be replicated in other river basins around the world.

Conclusion #4. ***The proposed combination of flow and non-flow habitat restoration assets provides by Vas are expected to improve conditions for native species to contribute to achieving a new Narrative Viability Objective to "maintain water quality conditions, including flow conditions in and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations."***

Chapter 4 of the final report describes the changes in hydrology and system operations that could occur because of the proposed VAs. Analyzing Figure 4-1, the modelled Sacramento River and "reference" (do not specify) inflow. I have some questions about this figure: What do vertical bars mean? From where were the monthly flow of the Sacramento River and the reference condition taken? I will extend my doubts to the other rivers that were modelled. In addition, the river flow would increase in the Sacramento River between December and April, during the Winter. Yuba, American rivers, and Delta have the same monthly flow tendencies.

The Delta outflow effects of water purchases were assumed to be provided, as shown in Table 4-1 by Sacramento. It is described in the same way as the other rivers. This report suggests that VA flow actions are intended to be concentrated during April and May, which are generally for most Sacramento River tributaries that showed an increase in river runoff. Theoretically, it makes sense to concentrate on this activity during this time of the year. However, analysing Figure 4-1, I suggest the months of February and March to do so. Principally, for scenarios below normal (BN), above normal (AN) and Wet (W) (Table 4-2). With the studies realized in this region, I would suggest that increasing the river flow this month will be helpful for each ontogenetic phase of these native species. The species' needs to complete their life cycle were considered when these months were suggested.

The tributary habitat analysis calculates the habitat need in area (Acres) to support doubling goal population in the rearing and spawning area for each tributary (Table 5-1). It is an interesting, predictable model's inference. However, it is necessary to evaluate if the model describes the reality. Based on this information, I recommend testing an additional hypothesis to evaluate if the models' predictions reflect what is happening in this aquatic environment.

Conclusion #5: ***The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non -flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.***

The overall approach for the quantitative and qualitative analysis of tributary non-flow assets is well explained in Chapter 5. Tributary non-flow assets include constructed spawning, instream rearing, and flood plain rearing habitat for fall-run Chinook salmon and spring run in Sacramento River (Table 3-1) and were evaluated under different scenarios. The analysis considers comparisons of the VA flow and non-flow assets to the reference condition.

According to this report, the fall-run rearing period is defined as February through June, representing the period that could benefit rearing juveniles' salmonids by increasing rearing habitat. On the other hand, the fall-run spawning period is defined as October through December. It is taking this information into account when the models' scenarios. The scenarios were evaluated to provide measurable, biologically significant benefits and additional suitable spawning, instream rearing, and floodplain rearing habitat to fall-run Chinook salmon and spring run in the Sacramento River. The analysis was primarily focused on habitat for fall-run Chinook salmon, and it was expected that the habitat created for fall run would provide benefits to other runs and other native fish species. For that reason, the quality of the water must be monitored also. This subject is not taken into consideration in these models' predictions.

*Conclusion #6****. The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.***

This study developed mainly qualitative models considering the studies carried out on population dynamics, biology and ecology of native species that occur in this aquatic ecosystem, in historical data on the flow of rivers in this ecosystem. Considering the most critical results produced by this study, with the increase in river flow, there will be an increase in the habitat area that juvenile Chinook salmon need to complete their life cycle. In addition, it is concluded that the probability of an increase in this species' ontogenetic density would increase. This information was highlighted in this report. Now, it is necessary to test these models' predictions. The next phase of this project needs to develop a sample design, which should be conducted for all these aquatic ecosystem rivers, habitats, and seasons to evaluate if all these models' predictions precisely describe this aquatic ecosystem. Based on the information listed above, I recommend that the next phase of this project be the study of ***"Seasonal Fluctuation of Density and Biomass of the Native Species in this Aquatic Ecosystem***". An integrated sample design must be conducted, considering the different habitats, seasons, rivers, Delta, and bays.

***Ad hoc* Referee's Suggestions.**

All analyses conducted in this study provide estimates of expected population changes for native species as an indicator of environmental health. They also provide a qualitative description of population benefits and ecosystem improvements that are expected to habitat restoration and additional flows contributing to higher springtime flows. However, quantitative data models still need to be conducted. For that reason, the next phase of this project must be to conduct a study about the seasonal fluctuation of density and biomass for juveniles, sub-adults, and adults (ontogenetic phase) of these native species in this Aquatic Ecosystem. The sample design that this study must follow must be idealized for this specific aquatic ecosystem (Sacramento River, Tributaries, Delta, and San Francisco Bay), taking as covariates Area (rivers, Delta, Bay), habitats (the most critical habitats that each ontogenetic phase of these native species need to complete their life cycle), and season (rainy and dry season). With these data, it will be possible to evaluate if the models' predictions reflect the natural ecological function of these nursery habitats. With the information obtained in this next project phase, if carried out as suggested above, it will be possible to "calibrate" the models proposed in this report.

The quantitative Biological, Ecological and Environmental outcomes are missing in this report. In general, the model estimates, statistical analysis for hypothesis tests, and the analysis of the residuals still need to be included. Therefore, it is difficult to evaluate if these predictable conclusions based on these models will describe the natural scenarios proposed, for example, if the river flow increases.

Independent of that, this is an excellent tool to start to plan an aquatic ecosystem restoration. Based on these critics, I would suggest that the main topic for the next phase of this project would be ***"Seasonal fluctuation of density and biomass of the native species in the function of river runoff, habitat and river."*** An integrated sample design must be conducted, considering the different habitats, seasons, rivers, Delta, and bays. With the data which will be generated in this new phase of this project, it will be possible to test all hypotheses proposed in this report (Table 2-1) and if the models are precise in describing the relation between river flow and species density, and biomass with flood habitats increment. Therefore, this suggested study should consider studying the physicochemical variables, nitrates, phosphorus, POPs, trace metals, and microplastics.

Recife, February 5th, 2024

Prof. Dr. Mário Barletta

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Date: 5 February, 2024
From: Daren M. Carlisle, PhD. U.S. Geological Survey

To Whom it May Concern:

Based on my expertise and experience, I am reviewing the findings, assumptions, and conclusions I agreed I could review with confidence, including: Conclusion #1, Conclusion #2, Conclusion #5, Conclusion #6.

Before addressing each conclusion, I offer a few general thoughts.

First, an editorial comment. I found it impossible to conduct this review without consulting both the Supplemental and 2017 Reports. I was initially overwhelmed by the roughly 800 pages of material, but the organization of both reports was clear and made searching for information relatively easy. My biggest frustration was with acronyms embedded in the many data graphs that were so crucial to understand. Frankly, the graphs were not produced to stand alone and therefore required searching through paragraphs and the acronym glossary for explanations. This was the most frustrating aspect of my review.

Second, the Bay ecosystem is obviously complex and not fully understood. Nevertheless, the Supplemental Report and its 2017 companion describe a monumental effort to search the literature, gather relevant data, integrate models, interpret results, and synthesize information—all in an effort to anticipate whether an obviously subtle management action (the VA) would have positive effects on key species of concern. In my opinion, the Supplemental Report authors were wise to attack this problem on two fronts: qualitative predictions based on relevant literature, and quantitative modeling.

Last, previous reviewers of the Supplemental Report expressed concern about insufficient quantification of uncertainty in the analyses. This is also my primary concern. The issue is especially critical because the models are largely sequential. That is, the output of one model becomes input into a subsequent model. Consequently, it is critical to know how uncertainty propagates through the modeling system and how sensitive the final predictions are to alternative assumptions earlier in the process. In my opinion, the Supplemental Report does not go far enough to address this issue. I offer specific examples and suggestions below. In contrast, the qualitative predictions based on literature reviews appear to be rigorous and a significant early step in an adaptive management cycle.

Conclusion #1: Native aquatic species have been declining in tributaries, offstream habitats, and the Bay-Delta due to aquatic ecosystem stressors.

For this conclusion, I examined—for each species of concern— the Supplemental Report and the 2017 Report for two key pieces of evidence. First, I evaluated whether data from established and documented monitoring program(s) had revealed—with known uncertainty—that populations of key species have declined over some fixed time interval. Second, I evaluated whether monitoring and research demonstrate the causal factors for observed (if any) population declines in the Bay and its tributaries.

In general, I believe the evidence is strong that populations of *most* key aquatic species have declined. For most species, the 2017 report provides strong evidence based on standardized monitoring data over several decades that can be readily discerned. Granted, the rates and magnitudes of decline vary highly among species, and the uncertainty associated with those declines is rarely reported. Nevertheless, it is possible to qualitatively conclude that most populations have declined over the last 30-40 years.

The conclusion that population declines are "due to aquatic ecosystem stressors" is more nuanced. If we assume that "stressors" implies *anthropogenic* physical, chemical, or biological (e.g., non-native species) factors in general, then the conclusion is almost certainly true given the massive, documented changes to environmental conditions in the Bay and its tributaries over the last several decades. However, definitively attributing these declines to specific stressors is likely impossible for most species, but there is a preponderance of evidence that flow and habitat are among the most influential factors.

Species-specific comments and summaries are provided below.

Chinook Salmon

The population declines for Chinook Salmon shown in Table 3.4-3 are dramatic and appear to come from a reliable monitoring approach. Additional evidence for specific sub-populations of chinook is provided in Section 3.4 from monitoring data dating back nearly 50 years (e.g., Figures 3.4.3, 3.4.5, etc). Although no uncertainty (e.g. confidence intervals) estimates are provided in these tables and figures, reductions in salmon populations from other sources of information and for other west-coast stocks are obvious.

Both reports rightfully acknowledge that many potentially interacting stressors contribute to salmon population declines in the Bay and its tributaries. Loss of access to spawning areas caused by dams is a self-evident cause of population decline. The many, largely anecdotal observations in the Supplemental Report also suggest that other physical barriers and reduced habitat conditions (e.g., water temperature) contribute to salmon mortality. Stronger evidence was provided in the 2017 report, Section 3.4.5.1, where data show that a combination of flow restoration and physical barrier manipulation (e.g., DCC gate closure) was associated with higher salmon populations in the Mokelumne River. Granted, there are potentially other factors at play and uncertainty estimates are not provided, but the Mokelumne results over several years of interventions (pulse flow and DCC gate closure) could be a microcosm for the results of adaptive flow and habitat management in other tributaries, and provide evidence that loss of flow regime components contributes to the decline in salmon populations. Reported correlations in the 2017 report between hydrology and salmon populations (e.g., Figures 3.4-12 - 14) are not very convincing alone given the imbalanced observations (i.e., few at high flows) and likely large range in the prediction interval of fitted regression models. Nevertheless, they do contribute to the multiple lines of evidence that are presented in both reports, and suggest that higher flows than currently exist would be generally beneficial to salmon.

Longfin Smelt

The 2017 report provides strong evidence for the conclusion that the longfin smelt population is in decline (Figure 3.5-1). Similarly, the presented evidence is strong that suggests additional outflows from the delta are likely to be a positive influence on the longfin smelt population.

Green & White Sturgeon

Population trend estimates for white sturgeon are highly uncertain and appear to be based solely on indirect evidence from molecular data. Population trends for white sturgeon are also highly uncertain, although recent quantitative estimates of population abundance are below recovery goals. Trends in recruitment of white sturgeon (Figure 3.6-1) appear to be highly variable through time—although uncertainty is not reported. Several studies are summarized, most of which found higher recruitment in wet years relative to dry years. However, the 2017 report acknowledges that further studies are needed to determine the causal factors contributing to declines in sturgeon populations (Page 3-64). Despite this acknowledged uncertainty, the report argues (Table 3.6-1) for the existence of a threshold. Unfortunately, this value is apparently arrived at via visual inspection of the data and lacks quantitative rigor.

Sacramento Splittail

Evidence is strong that the population decline of Sacramento splittail is significant (Figure 3.7-1). This conclusion is based on data from a regular monitoring program over several decades. In addition, these same monitoring data also strongly suggest (Figure 3.7-2) that the population is positively influenced by Feb-May flow magnitude. Curiously, the 2017 report (Page 3-70) recommends a flow rate of 30-47 thousand cfs to support this species, yet the confidence interval from Figure 3.7-1 would argue for a 20-50 thousand cfs range, and a prediction interval computed on the same regression fit would likely yield an even larger range. As a consequence, the target flows recommended in Table 3.7-1 should probably include a wider range.

Delta Smelt

Evidence for delta smelt population decline is overwhelming because it is based on standardized, long-term monitoring data. The 2017 report presents several correlations (Figs. 3.8-2 & 3.8-3) between smelt population indices and various flow metrics, suggesting that higher flows in certain seasons would benefit the population.

Starry Flounder

The starry flounder population appears to have declined from 1980-2015 (Fig. 3.9-1), but large outliers and annual fluctuation add uncertainty to this conclusion. The presented evidence (Fig. 3.9-2) also suggests there is a slight positive effect of flow on the population.

California Bay Shrimp

Despite being commercially harvested for over a century, and despite the fact that the shrimp population is related to flow (Fig. 3.10-2), the population shows no declining trend since 1980. Curiously, the recommended flow of 21,000 cfs does not consider uncertainty about the flow-population relationship. Given that the interest is whether a given flow predicts a given population level, it seems that prediction intervals (rather than confidence intervals) should be employed here, and that the recommended flow criterion should reflect the range of prediction uncertainty. Despite this criticism, I applaud the use of multiple analytical approaches followed to determine an optimal flow for the shrimp population!

Conclusion #2: The combination of non-flow habitat restoration and flows proposed as part of the VAs are expected to provide benefits for native species in tributaries and the Bay-Delta ecosystem.

The conclusion that habitat and flow restoration will benefit native species rests on the hypothesis that habitat and flow are limiting factors for native species populations—i.e., are the primary causes of population decline. The 2017 and Supplemental reports provide reviews and new analyses as evidence for the causative influence of flow on the populations of key species. However, the evidence is weak that any particular ecosystem stressor(s) are the cause of population declines. Indeed, identification of the particular stressors responsible for population declines would require intensive monitoring and research likely far beyond all available resources. For some species, a great deal of research into the causes of population decline has been done, and these are highlighted in the reports. But for most species, the relative importance of flow modification, habitat degradation, invasive species, pesticides, excess nutrients, etc. etc. cannot be quantified, nor is it likely to *ever* be quantified. Both reports acknowledge this limitation.

Given the difficulty with identifying specific causes of population declines, is it reasonable to assume that flow is of primary importance? For several reasons, I believe this is a reasonable assumption. First, there is broad scientific consensus that flow influences water temperature, water quality, and many other key physical and chemical aspects of habitat suitability, and specific literature reviews for key and other Bay species are in agreement. Second, the populations of most species considered in the 2017 Report were quantitatively associated with the magnitude and timing of flows into and through the Bay. Finally, the many anecdotal observations recorded in the Supplemental and 2017 reports collectively point to the absence of flow and associated habitat loss as likely causal factors. Collectively, these various lines of evidence are substantial.

In summary, the hypothesis that flow and habitat restoration will provide benefits to native species is reasonable in my opinion. But it would be more transparent if this "conclusion" was characterized as a hypothesis with substantial support, that nevertheless requires testing in concert with monitoring and evaluation. Finally, both reports reiterate—rightly so— that flow restoration alone will not improve salmon populations unless habitat improvements and reductions in other stressors also occur.

Conclusion #5: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets for contributing toward achieving the Narrative Salmon Protection Objective use appropriate assumptions and are scientifically valid.

A critical aspect of Conclusion #5 is the hydrologic modeling. I don't have the expertise to comment on the finer points of SacWAM and other hydrologic models, but they have apparently been used for decision making in recent years and therefore presumably been appropriately reviewed. Further, the Supplemental Report (Section 4.1) clearly acknowledges that the hydrologic changes expected from the VAs "are relatively small compared with the volume of water in the system…" and that due to unknowns such as timing of reservoir operations, project execution, and weather (e.g., dry vs. wet years), there is much uncertainty in the predicted hydrologic effects of the proposed VAs. Indeed, this uncertainty is clearly illustrated in Figures 4-1, 4-2, etc. In my opinion, the hydrologic predictions component is transparent and adequately caveated—again assuming SacWAM and the other hydrologic models have received appropriate peer review.

Given the hydrologic predictions, there are several subsequent linkages necessary to predict outcomes for the Salmon Protection Objective. First, there is the computation of required areal extent of habitat needed to support the objective. Table 5-2 presents the parameters used to make this calculation. The Supplemental Report acknowledges there are assumptions and uncertainties in this calculation, but curiously does not actually incorporate the uncertainty into model estimates. Without question, each parameter value presented in Table 5-2 is ONE possible realization from a distribution of possible values. The Supplementary Report acknowledges this for just one parameter—the egg-to-fry survival parameter—and addresses the issue with the claim that the parameter value used in the computations represents the “upper bound” of possible values and therefore produces a “conservative” estimate. How is it known to be an upper bound? Is it based on an actual physiological limitation? And what of the other parameters?

There is no question that generating predictions of habitat area requires assumptions and are highly uncertain. But the Supplementary Report falls short of actually quantifying this uncertainty and propagating it through the sequence of modeling steps. One relatively simple improvement would be to use the literature to generate a reasonable distribution of values for each parameter in Table 5-2. Then, repeat Equations 3-5 a thousand times (say), each time randomly drawing a value from the aforementioned distributions of each parameter. Predictions are then presented as a distribution with known uncertainty rather than a single value as presented in Table 5-1. A similar procedure was used for generating predictions from the flow-abundance relationships in the Bay (5.2), so why not here?

The next major component in addressing this objective is to quantify the relationship between discharge (water level) and habitat for both existing and future conditions. There is of course a long history of scientific achievement in this realm summarized and promulgated via the Instream Flow Council, among others. The underlying methods such as the PHABSIM have also been soundly criticized in recent decades. Despite this criticism, the approach described in the Supplementary Report for existing conditions appears to be rigorous—combining both literature and data compilation with local expert judgment. There will of course always be sources of uncertainty in PHABSIM models, such as changes to channel morphology, but I believe the Supplementary Report describes the most rigorous approach feasible at the current time.

A different Method was used to quantify habitat under the VA scenario, wherein local information and data were used to develop predictions relative to the fixed set of suitability criteria presented in Table 5-4. I read this section several times but the methodological details remain unclear. Nevertheless, the Supplementary Report provides clear and frequent declarations of the assumptions underpinning the estimates of habitat improvements under VA. Table 5-4 presents a range of values for some components, but a single value for others (e.g., temperature). Because these criteria are so important in defining the the success of the VA relative to salmon habitat, I believe the table should be improved to provide a range of conditions for all components and, ideally, a distribution of values that could then be an input source for subsequent modeling.

The Supplementary report Chapter 6 presents “anticipated biological…outcomes” of the VA. These estimates are, essentially, the outcome of all preceding model estimations—with the output of one model becoming the input of a subsequent model. Given the lack of quantification of uncertainty in most of the preceding model steps and consequently the absence of propagating that uncertainty from one model to the next, estimates of salmon habitat improvements (e.g., Figure 6.1) must be viewed with skepticism. Indeed, the figure captions clearly report that the confidence intervals shown do not actually characterize the uncertainty of the estimates. Yet despite the unknown uncertainty, the report makes several striking conclusions based on these estimates, such as the statement that "…the VAs offer 49 to 122 percent more spawning habitat in the American River…"(Page 6-4). I simply cannot see how such quantitative declarations are supported by model results given the unknown uncertainty.

In summary, I believe the Supplementary Report makes an admirable attempt to quantify the ecological benefits of the VA for salmon, but falls short at rigorously accounting for uncertainty. Adding to this issue is the fact that the Report makes strong, quantitative inferences and comparisons despite this lack of uncertainty. Indeed, some inferences are made that appear to take modeled quantities at their face value—which I believe to be unjustified. In contrast to the quantitative analyses, I believe the Report presents solid qualitative evidence from the literature that proposed management actions (VA) will likely increase abundance of at least some salmon populations.

Conclusion #6: The quantitative and qualitative analyses used to evaluate the benefits of VA flow and non-flow habitat assets to contribute toward achieving the Narrative Viability Objective use appropriate assumptions and are scientifically valid.

Like the conclusions for the salmon objective, predicted benefits of the VA to other native fishes are highly uncertain at this time. Many of my criticisms of the salmonid predictions also apply to other fish species, but it was refreshing to see some attempt to estimate uncertainty as described in section 5.1–although it is unclear how samples of parameter estimates from a regression model were obtained without bootstrapping the observations as well (needs more explanation). Like the salmonid objective, there is a series of hydrological and bathymetric modeling that I can only presume has been peer reviewed and accepted as the best available for the purposes presented in the report.

Identification of thresholds has been a topic of debate in the ecological literature and is especially problematic in section 5.3.5.3 of the Supplemental Report. For example, the temperature criteria for delta smelt are presented in table 5-10 and the literature sources for those values are given in the next paragraph. Examination of these sources revealed that the "thresholds" are based on an acute (short term) experimental exposure in a laboratory, where the biological outcome of the experiment was an indicator of physiological stress. There is value in these types of experiments, but the limitations are important to recognize, foremost of which is that physiological stress does not equate to population decline. Rather, it is an indication that some individuals within the population would be physiologically stressed (not necessarily die) if exposed to those temperatures for a short period of time. Notwithstanding this limitation, the Supplemental Report applies these acute thresholds to a large, spatially heterogenous area where water temperature predictions are limited to monthly averages. The Supplemental Report needs to more clearly identify these limitations and justify the inherent assumptions in this approach.

Similar limitations exist for setting thresholds for other key Bay species, but it must be emphasized that there is no straightforward solution. There are few, if any, experimentally derived thresholds that can be unambiguously applied to populations in natural systems. At best, the literature must be thoroughly searched for estimates of chronic (long-term) temperature thresholds, then applied in a way that explicitly quantifies and propagates uncertainty through the various connected physical, chemical, and biological models. Although I do not doubt the literature was thoroughly searched and summarized in the Supplemental Report, I am less confident that the uncertainty was appropriately considered in the model procedures.

Population estimates for Bay species were made using regression equations that predict population indices given outflow magnitudes. These equations were presented in the 2017 report and referenced again in the Supplemental Report. In presenting predictions from these models (Section 6.2.1), the Supplemental Report for the first time makes a striking declaration (Page 6-20): That the

> "…*results are meant to give a general sense of the relative benefit each species may realize for a given flow scenario and they should not be interpreted as predictions of future population abundances*."

I searched in vain for these phrases earlier in the Supplemental Report. It is striking that this important caveat is buried in a paragraph more than 100 pages into the document, along with the implication that it only applies to the population model estimates for the Bay species. Why make this declaration now? Given the assumptions and uncertainty in all the previous quantitative analyses, surely this caveat applies to the entire Supplemental Report and should have been made clear in the Introductory material. Yet, the subsequent paragraphs (Page 6-20) contain conclusions that seem to interpret results and make comparisons in violation of the caveat just mentioned. In essence, the interpretive limits of model results are unclear to me and appear to also be unclear to the report authors.

The model results displayed in Figure 6-12 suggest that the VA effects on key species populations may be very subtle and therefore difficult to detect. Indeed, population estimates from monitoring data likely have higher uncertainty than the few percentage-point changes depicted in Figure 6-12. Again, this may be an over-interpretation on my part, but it illustrates the fundamental challenge of detecting subtle effects in a noisy and unpredictable system.

In summary, I again find that anticipated biological outcomes generated from qualitative analysis of the literature appear to be sound and justified. In contrast, the quantitative methods, while appropriate and laudable, require more justification for some assumptions and, most importantly, a more rigorous accounting of model uncertainty.

Given the nature of the system being modeled, uneven quantitative data, and high uncertainty, I would recommend modeling approaches such as Bayesian Networks, for example (Zeigler, M.P., Rogers, K.B., Roberts, J.J., Todd, A.S. and Fausch, K.D. (2019), Predicting Persistence of Rio Grande Cutthroat Trout Populations in an Uncertain Future. North Am J Fish Manage, 39: 819-848. https://doi.org/10.1002/nafm.10320)