Appendix 2B

Attachment 1: Adaptive Management Program Framework and Implementation

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2B-1.1 Overview

In the broadest sense, the set of decisions that collectively answer the question what is the "best" way to operate the Central Valley Project (CVP) and State Water Project (SWP) (hereafter, Projects) is a complex series of recurring decisions based on an ever-changing knowledge base and set of socio-ecological circumstances. The decisions about how best to operate the Projects have increased in complexity over time due to a growing number of constraints on the decision space (Figure 2B-1-1). The accumulation of constraints is one certainty in "wicked problems", which are problems that morph over time and change in response to intervention (Rittel and Webber 1973; Luoma et al. 2015).

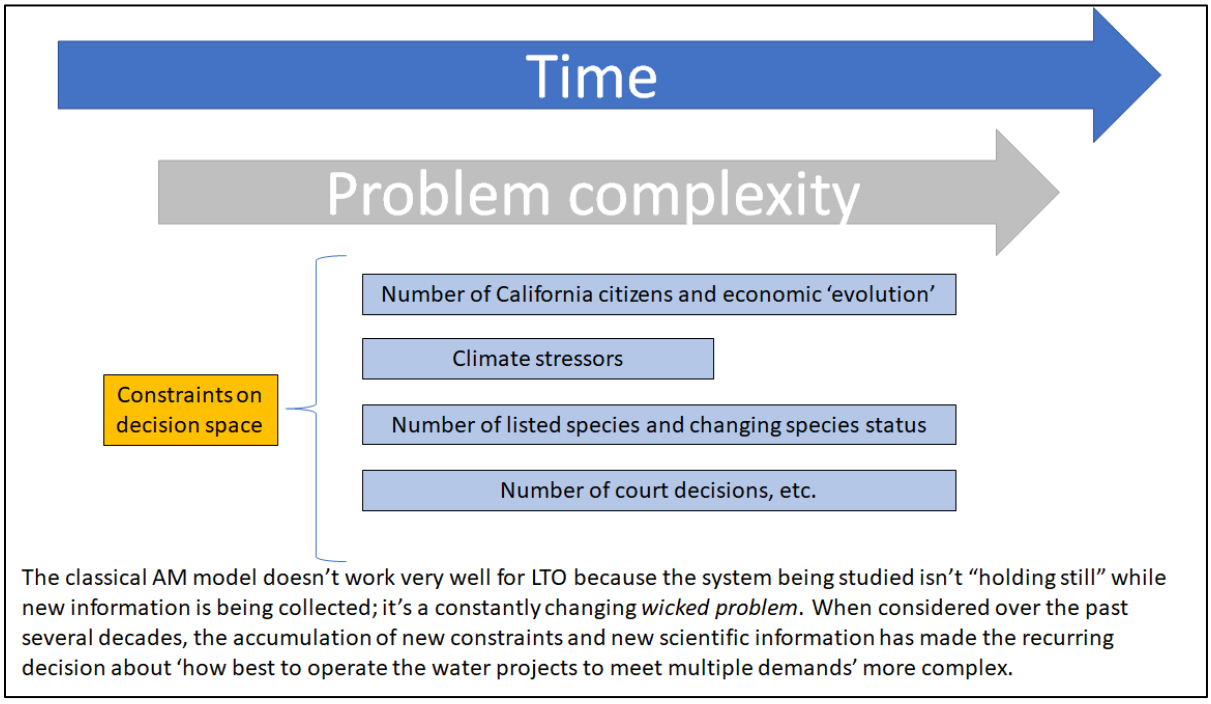

Figure 2B-1-1. Conceptual Diagram of the Increasing Complexity of Water Operations Consultations Over Time as Constraints on Decision Space Have Increased

The classical adaptive management (AM) model posed by Walters and Hilborn (1978) suggests that applying the scientific method to complex natural resource management problems is an objective way to navigate complex problems, and as such, AM has frequently been suggested as a best management practice for Project operations. However, AM as originally described does not work well in the management of systems experiencing constant change, i.e., systems that are of themselves wicked problems (DeFries and Nagendra 2017). Rather, wicked problems require a more nuanced version of AM that is better integrated in decision theory or structured decision-making (SDM; Figure 2B-1-2).

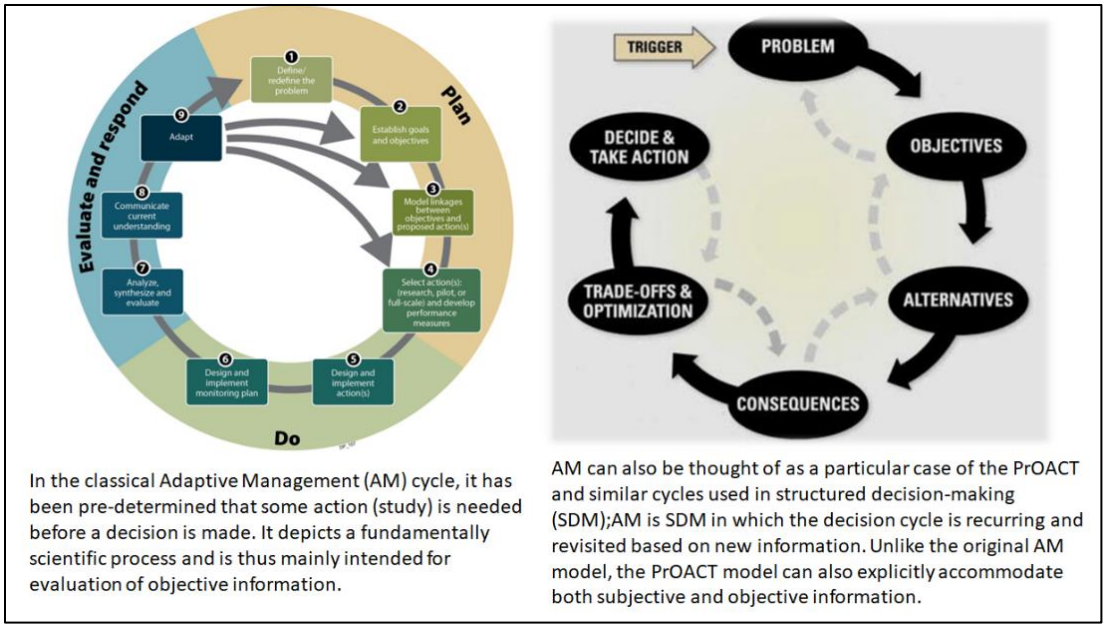

Figure 2B-1-2. Comparison of Adaptive Management as Described by Delta Science Program (2013; derived from Walters and Hilborn 1978) and the PrOACT Cycle, a Variant of the General Approach to Structured Decision-Making.

SDM is needed for wicked problems because the problems often do not remain constant long enough to robustly apply scientific methods. Further, wicked problems involve subjective values dimensions that cannot be ignored. The values can be things like different agency perspectives on the relative importance of the objectives, or socio-political constraints on decision space (Figure 2B-1-1). SDM is a set of tools that has been developed to transparently combine objective and subjective information to make the best decision that can be made with the information available at the time. The repeated use of SDM applied to a wicked problem does not stop the problem from changing over time, but it can allow necessary adaptation as the problem develops new dimensions.

Endangered species consultations on the operation of the Projects involve navigation of an evolving social-ecological system with multiple, often competing objectives. Consultations under both the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA) have been a facet of Project operations since the 1990s and are one of the drivers increasing decision complexity (Figure 2B-1-1). A conceptual model of CVP and SWP ESA/CESA consultations as a recurring decision is shown in Figure 2B-1-3. The conceptual model is superimposed on the PrOACT cycle, which is a predominant SDM framework. This does not imply that historical consultations have proceeded using decision analysis techniques, but rather to show how the process still has to move through the steps of a decision-analytic cycle. The word “cycle” describes each time a major new consultation has occurred. Several things have acted as drivers of a new consultation cycle; these are shown in yellow. In the broadest sense, the problem and the objectives do not change from cycle to cycle, but they do imply a decision involving multiple competing objectives. The Biological Assessment prepared by the U.S. Bureau of Reclamation (Reclamation) and the incidental take permit (ITP) application prepared by the California Department of Water Resources (DWR) constitute a negotiated alternative (collectively, proposed action); these documents and the resulting biological opinions issued by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (BiOps) and ITP issued by CDFW (LTO ITP) provide the analysis of the alternative; the decision is the new BiOps and LTO ITP.

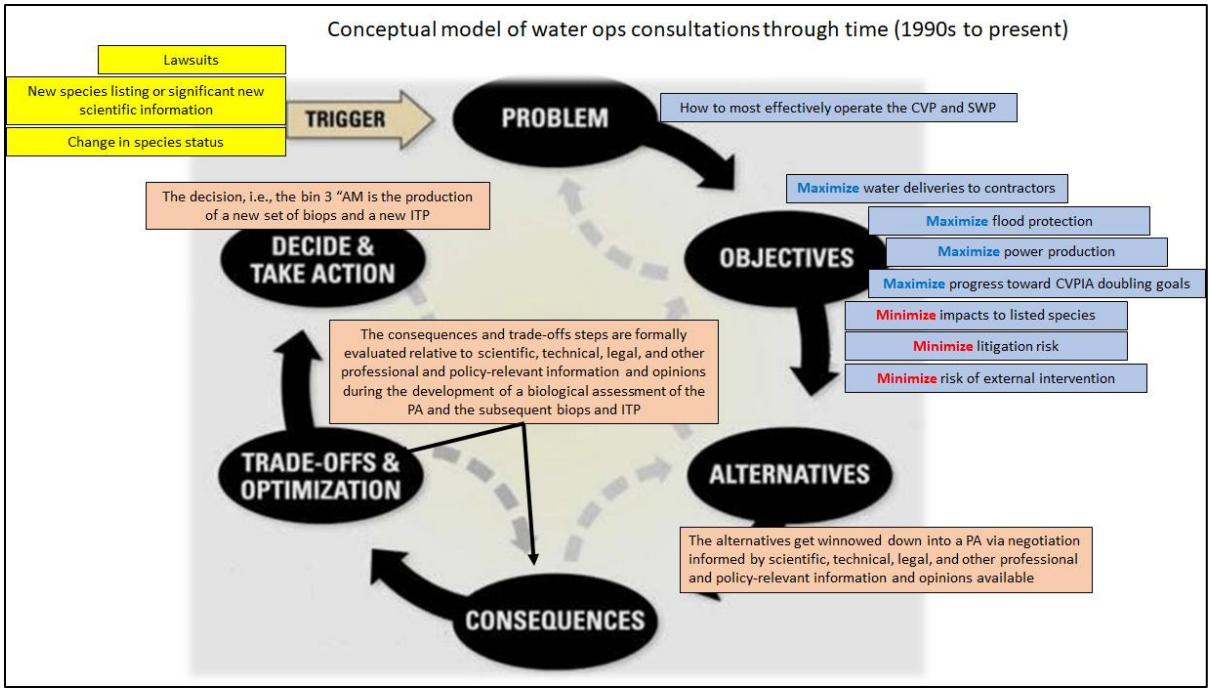

Figure 2B-1-3. Conceptual model of ESA/CESA water operations consultations as a recurring decision.

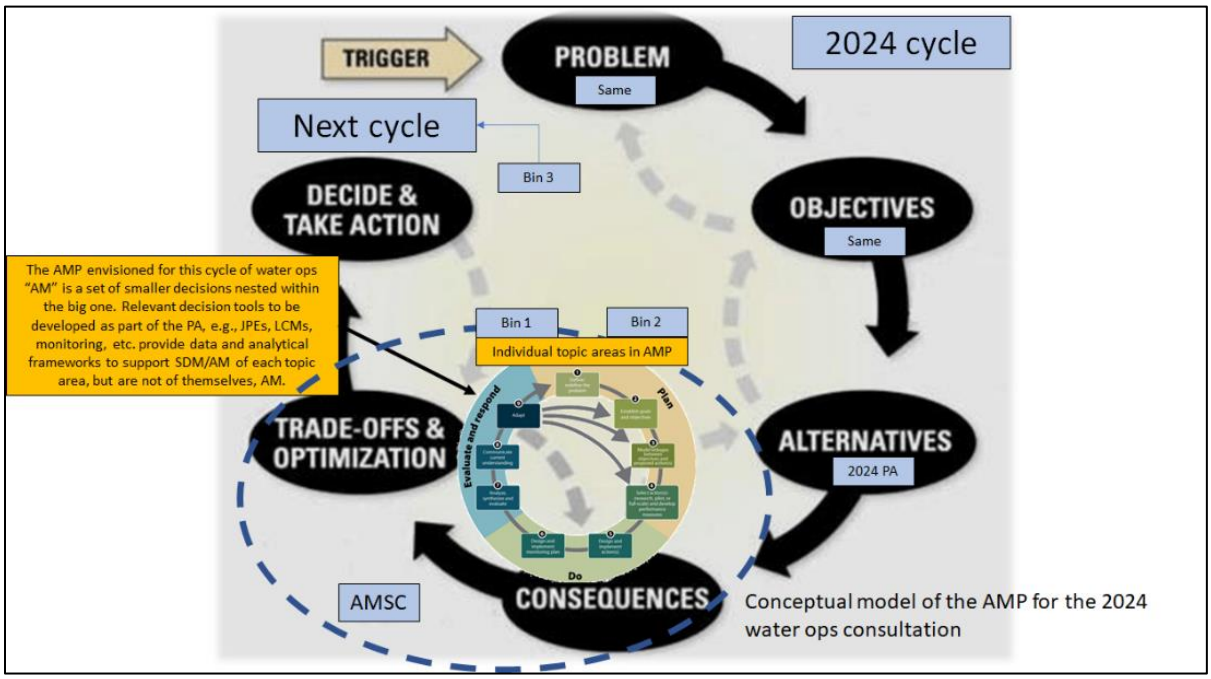

Figure 2B-1-4. Conceptual model of the Adaptive Management Program described in this attachment within the current consultation cycle. Refer to Figure 2B-1-3 for additional details.

The adaptive management framework envisioned for this cycle of water project consultations involves ongoing scientific re-evaluation of multiple topic areas that sit within the consequences and tradeoffs/optimization steps of the current Programmatic Agreement decision cycle (Figure 2B-1-4). The framework or Adaptive Management Program (Program) will be used for two major purposes. The first is to provide a potential path to modify water operations rules without a full new cycle (e.g., new full reinitiation of consultation or ITP development) if the existing and proposed studies, tools, and monitoring are developed and their use supports a change. The evaluations that could be conducted within the current cycle are called Bin 1 and Bin 2 pathways and they are differentiated depending on their timeline (see Appendix 2B, Attachment 2). Bin 1 pathways may result in modifications within three years of issuance, while Bin 2 pathways may result in modifications but are not expected in less than three years of issuance. Bin 3 pathways are longer term, and considerations are not expected to be complete within a single consultation cycle because they involve either or both long data evaluation timelines or substantial changes to authorized levels of listed species take. Topics in Bin 3 are included because they require continued data collection and analysis to inform their evaluation in the next consultation cycle.

2B-1.2 AMP Framework and Implementation

The Program will be used to evaluate and adapt the operations, actions, and related activities identified in Appendix 2B, Section 2B.3.1 and Appendix 2B, Attachment 2. This evaluation will include addressing areas of known uncertainty, improving scientific understanding by filling data gaps, and weighing whether new information should be incorporated into the relevant ESA and CESA authorizations. To do so, an Adaptive Management Steering Committee (AMSC) will oversee efforts to monitor and evaluate existing operations and related activities through existing technical teams (to the maximum extent practicable), make decisions at that level, and suggest to the Directors whether modifications or alternative actions may be warranted. The AMSC will utilize a structured decision-making process to assess the relative benefits or impacts of proposed operational changes and activities for listed species compared to what is being implemented at the time. Any proposed changes to project operations or related activities through adaptive management should provide equivalent or increased conservation benefits to the listed species.

Adaptive management typically utilizes a multi-step process. The following adaptive management framework includes elements from the Delta Plan (Delta Science Program 2013) and recommendations from the Delta Independent Science Board (2016). This framework is made up of three broad phases that are part of any scientific endeavor: (1) Plan; (2) Do; (3) Evaluate and respond. Within the phases are nine steps as represented in Figure 2B-1-2.

2B-1.2.1 Phase 1: Plan

The first phase of an adaptive management process is to plan. The suite of tools to be developed and general adaptive management topics are described in Appendix 2B, Attachment 2. As approved by the AMSC, Adaptive Management Teams (AMTs) will develop their own plan for each activity identified in Appendix 2B, Attachment 2. Annual presentations prepared by each AMT, as described in Section 2B-1.2.3.1, will include the compilation of the individual actions covered under that AMT.

The planning process begins by clearly defining the problem or question to be addressed (*Step 1*), identifying goals and objectives (*Step 2*), and identifying the model linkages between the goals, objectives, and proposed actions (*Step 3*). Models can be conceptual, statistical, physical, decision support, or simulation. The AMSC and its facilitator(s) will oversee Steps 1 and 2, then the AMTs will take a lead role in Step 3.

The proposed action, LTO ITP, and BiOps outline the problems to be addressed, the goals and objectives, and in some cases describe the conceptual linkage between the actions and the objectives. However, these steps should be formally evaluated by the AMSC and its facilitator(s) once the group is established. A list of the proposed tools to be developed as part of the AMP and the general topic areas addressed by this AMP are the subject of Appendix 2B, Attachment 2; more detail about the goals, objectives, and rationale is in the text below and in the associated effects analyses of the proposed action, BiOps, and LTO ITP.

The first part of *Step 4* in the adaptive management cycle is to decide whether a change in an existing action(s) will be recommended based on the modeling results. The proposed action, BiOps, and LTO ITP are the starting point for adaptive management actions. Future assessments may support keeping an action as is, or modifying it in some way. A key part of the Program (coordinated through the AMSC) will be the development of performance metrics (response variables for each tool, study, monitoring program, etc. associated with each adaptive management action) to guide the program (*Step 4*). Performance metrics would be measured utilizing a suite of activities including monitoring (long-term surveys; new measurements), experimental methods (e.g., fish enclosures), and modeling (e.g., 3-D modeling, life cycle modeling). Each operation and activity, and each adaptive management change must be accompanied by a set of criteria that the implementing entities can use to determine whether the action is having the anticipated effects.

2B-1.2.1.1 Structured Decision-Making

The AMSC and associated AMTs will utilize decision-analytic tools or a structured decision-making process to define relevant uncertainty, develop action alternatives, estimate consequences, and evaluate tradeoffs and preferences when making choices between alternative courses of action (e.g., *Steps 1–4* above). Structured decision-making processes can include consideration of value-based objectives and priorities as well as science-based objectives. These processes also document the basis for decisions in a transparent, organized and repeatable framework. This section provides more detailed information on examples of SDM processes currently being used by technical teams and Collaborative Science and Adaptive Management Program (CSAMP).

SDM is a collection of practices rooted in decision theory that provides a rational, organized framework for evaluating alternatives against consistent and explicit quantifiable objectives, encourages clear articulation of anticipated effects, and transparent consideration of tradeoffs and uncertainty (Figure 2B-1-5). SDM can take many forms, depending on which of the six typical steps receive greater relative emphasis. SDM can be used to help build consensus if the SDM process includes deliberation about tradeoffs and this deliberation informs the development of new alternatives that better address the range of interests represented.

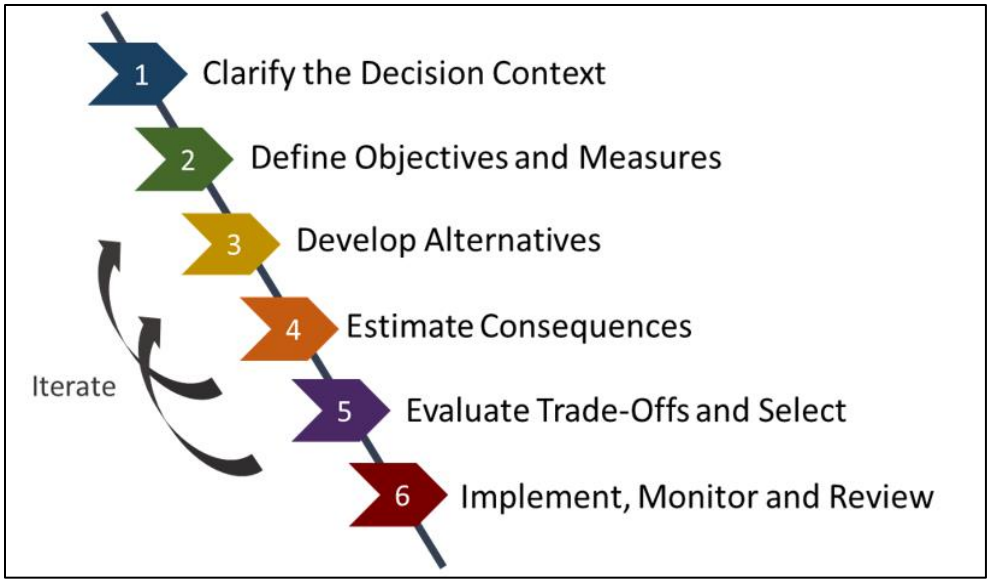

Figure 2B-1-5. Six steps of a typical SDM process (Gregory et al. 2012).

1. **Clarify the Context—**The first step is to clearly establish the planning and decision-making context through answering questions such as: What decision needs to be made and who will make it? Who else needs to be involved or consulted? What is the scope and bounds of the process and the decision (e.g., what's in and what's out)? The initial structuring step lays out a road map for both the deliberations and the analysis that will follow.
2. **Define Objectives and Measures—**Objectives define the interests and values about the decision at hand. Measures define exactly what is meant by an objective and are used to estimate and report the predicted consequences of different alternatives for making a choice.
3. **Develop Alternatives—**Alternatives are the various actions or strategies that are under consideration. This step involves iteratively developing, comparing, and refining alternatives in the search for one(s) that offers the best balance across objectives.
4. **Estimate Consequences**—Consequences of the alternatives against each objective are estimated or characterized, including identifying uncertainties. Results are typically presented in a consequence table, which is a concise summary matrix illustrating the performance of each alternative with respect to each objective, as reported by the measures.
5. **Evaluate Tradeoffs and Preferences**—Explicit choices must be made for preferred alternatives, based gains and losses for each objective. Each decision-maker is asked to make choices based on their own values and their understanding about the values of others. A variety of methods from the decision sciences are used to facilitate constructive deliberations about values and tradeoffs and to ensure that tradeoff judgments are informed, thoughtful, and transparent.
6. **Decide, Monitor, and Learn**—The focus at this stage of the process is on how to implement the decision in a way that reduces uncertainty, improves the quality of information for future decisions, and provides opportunities to revise and adapt based on what is learned. The SDM process should end with a formal transition into adaptive management and monitoring, and produce recommendations for the governance and oversight of monitoring programs, as well as triggers and mechanisms for review and amendment.

2B-1.2.1.2 Example Applications of Structured Decision-Making

SDM is being utilized by the Delta Coordination Group for the summer-fall action. During 2022, Reclamation and DWR developed an SDM approach for informing decisions regarding the Delta Smelt summer-fall habitat actions. This modeling approach utilized existing and new modeling, data, and expert opinion on the impacts of the summer-fall habitat actions to provide information on the physical and biological consequences associated with the various actions compared to a baseline of these outcomes without the summer-fall habitat actions. Through this SDM process, Reclamation and DWR also developed a multiyear monitoring and science plan that includes additional science that might be helpful to further investigate the spatial and temporal distribution of abiotic and biotic factors known to influence Delta Smelt habitat, including its food supply and access to those prey, Delta Smelt abundance, survival, and viability during the summer-fall time period.

2B-1.2.2 Phase 2: Do

The 'Do' phase of adaptive management includes two steps that occur in parallel—design and implementation of studies, monitoring, or modeling of actions as they are implemented with the explicit goal of improving the understanding of how strongly the action is affecting the vital rate or performance metric (*Step 5 and 6*).

Monitoring plans associated with each relevant operational or management action will include data management plans that describe the process for organizing and clearly documenting observations, including how data are collected; the methods, quality assurance, and calculations used; the temporal and spatial scales of the variables; and accurate site locations and characteristics. Monitoring must provide the data necessary to determine whether the performance metrics are responding to the management action(s). Monitoring plans may also include targeted research to better understand observed results and further resolve key uncertainties. Results of monitoring and research must be clearly communicated so that the information gathered, and current understanding, is broadly understood.

2B-1.2.2.1 Work Plan and Budget

AMSC Annual Work Plan and Budget

The planning and doing outlined in phases 1 and 2 will be described in an Annual Work Plan and Annual Budget prepared by the AMSC for the upcoming year. The Annual Work Plan will describe the proposed activities of the Program. This plan will include (1) monitoring and research that are part of the proposed action or are otherwise required by the SWP ITP and BiOps, (2) needed facilitation services to coordinate and support implementation of the Program, and (3) any additional monitoring and research that is planned, including any relevant monitoring and research that is part of the Interagency Ecological Program (IEP) annual work plan, as approved by the AMSC. The Annual Budget will set out projected expenditures and identify the sources of funding for those expenditures. If the Annual Work Plan describes activities that span multiple years, the budget for those activities will cover the entire period they will be implemented. The AMSC will ensure the Annual Budget accurately sets forth and makes adequate provision for the implementation of the BiOps and LTO ITP terms under which the CVP and SWP operate.

At a minimum, the Annual Work Plan and Annual Budget will contain the following information:

1. A description of the planned actions under the Program including their goals, objectives, and performance metrics.
2. A description of the planned monitoring activities and the entities that will implement those activities.
3. A description of the anticipated research to be undertaken and the entities that will conduct the studies.
4. A budget reflecting the costs of implementing the planned actions.
5. A description of the sources of funds that will be used to support the budget.

The AMSC will develop and approve the Annual Work Plan and Annual Budget with support from independent facilitators. The first Annual Work Plan and Annual Budget will be completed within the first year the AMSC begins convening, and annually thereafter. Upon approval, the Annual Work Plan will be posted on a public website.

Individual AMT Work Plans

Within 12 months of their initial meeting, each AMT will develop a work plan that describes the timeline needed to gather and/or synthesize the needed information for its purpose, all reasonable hypotheses addressed for that action, and the timeline for incorporating information into individual SDM processes. The AMSC will review the work plans for each AMT, provide direction or edits as needed, and approve the final plan when they are satisfied with it. Thereafter, each AMT will provide a presentation to the AMSC at least annually to document progress toward addressing the relevant hypotheses (see Section 2B-1.2.3.1). The work of individual AMTs and associated annual presentations can cease if a team has achieved what it was tasked to do.

2B-1.2.3 Phase 3: Evaluate and Respond

The evaluate and respond phase of adaptive management includes three key steps. Analysis, synthesis, and evaluation of the action(s) (*Step 7*) are critical for improving current understanding. Analysis and synthesis will incorporate information on how conditions have changed, expectedly and unexpectedly, as a result of the action(s). Because measurable improvement in conditions for covered species might not occur on short timescales, evaluations will also examine whether actions taken prevented deterioration of conditions that may have occurred if no actions were taken or if the action is resulting in species responses trending in the desired direction. The evaluation will examine whether performance metrics indicate that one or more of the objectives have been met as a result of the action(s). If an objective is not met, the potential reasons why it was not met will be identified. As each year's data become available, recognizing that specific actions may not be required in that particular year or sequence of years, analyses should assess whether the probability of the desired outcome has changed and, if so, how this affects decisions about the action. Within the Program it is anticipated that the AMTs will be primarily responsible for the evaluation step, while the AMSC will be primarily responsible for the response step.

Communication (*Step 8*) of current understanding gained through analysis, synthesis, and evaluation of actions and monitoring will occur through a variety of channels including: (1) regular back and forth communication between the AMSC and AMTs via the floating facilitators, and when relevant, between the AMSC and the Directors, (2) annual presentations from each AMT to the AMSC, and (3) with interested parties external to the Program by posting meeting notes on websites, giving presentations, preparing white paper reports, ensuring transparency of independent peer review materials and recommendations, and publication in peer-reviewed scientific journals.

2B-1.2.3.1 Annual Presentations by AMTs

During each implementation year, each AMT will provide at least one presentation (Annual Presentation) to the AMSC. The annual presentation will provide an overview of the AMT activities carried out during the previous implementation year.

Each AMT annual presentation will include, among other things, the following types of information:

1. An assessment of the implementation and efficacy of studies, monitoring, and modeling of actions during the prior reporting period, including new information gained.
2. Identification of tasks that have not been implemented on schedule and an explanation for the deviation from schedule. For actions that are behind schedule, a suggested schedule or process for completing them will also be included.
3. Adaptive management changes to actions resulting from the SDM process and proposed by an AMT for consideration by the AMSC, including the scientific rationale for the action.

2B-1.2.3.2 Adapt

When it is informed and equipped with new results and better understanding, the AMSC will re-examine the actions it has been evaluating (e.g., see Appendix 2B, Attachment 2). It is possible that revisions may be suggested when current information suggests doing so (*Step 9*). Possible adaptations could include anything from staying the course, to making a minor modification that can be made without formal changes to the existing LTO ITP and BiOps, to considering reinitiation or an LTO ITP amendment as mechanisms to implement a new management action or paradigm.

Decisions to adapt are anticipated to be needed at various time intervals depending on the action or environmental conditions which may delay certain actions in any particular year or series of years. Appendix 2B, Attachment 2 contains a description of the planned timeframe for each action that estimates when decisions regarding AMP actions may be ready to evaluate for potential changes. In general, one year's results, however anomalous, are seldom enough to demonstrate that an action should be subject to change as a part of the adaptive management process. Furthermore, when the analysis, synthesis, and evaluation of information learned from an action over time indicates that no benefit accrues, resources should no longer be spent on that action no matter how popular the action might be.

2B-1.3 References Cited

DeFries R., and Nagendra, H. 2017. Ecosystem management as a wicked problem. *Science* 356(6335):265–270.

Delta Independent Science Board. 2016. *Improving adaptive management in the Sacramento-San Joaquin Delta*. Sacramento, CA.

Delta Science Program. 2013. Appendix C: Adaptive management and the Delta Plan. *Delta Plan*. Sacramento, CA.

Gregory R., Failing, L., Harstone, M., Long G., McDaniels, T., and Ohlson, D. 2012. *Structured Decision Making: A practical guide to environmental management choices*. Sussex, UK.

Luoma S. N., Dahm, C. N., Healey, M., and Moore, J. N. 2015. Challenges facing the Sacramento-San Joaquin Delta: Complex, chaotic, or simply cantankerous? *San Francisco Estuary and Watershed Science* 13(3):1–25.

Rittel H. W. J., and Webber, M. M. 1973. Dilemmas in a general theory of planning. *Policy Sciences* 4:155–169.

Walters C. J., and Hilborn, R. 1978. Ecological optimization and adaptive management. *Annual Review of Ecology, Evolution, and Systematics* 9:157–188.