GRANT APPLICATION FORM
CALIFORNIA STREAM FLOW ENHANCEMENT PROGRAM

***NOTE: EVERY QUESTION MUST BE ANSWERED IN ORDER FOR THE APPLICATION TO BE CONSIDERED**

APPLICANT INFORMATION

Applicant Name (Organization): The Metropolitan Water District of Southern California
Address: 700 North Alameda Street, Los Angeles California 90012

Project Manager Name: Alison Collins
Telephone: 916-650-2628
Email: acollins@mwdh2o.com

Authorized Signatory Representing Applicant Organization:
Name: Jeffrey Kightlinger
Title: General Manager

Federal Tax ID#: 956002071

Organization Type:

☒ Public Agency - The Metropolitan Water District of Southern California is a public agency, a copy of the company's urban water management plan is available upon request.
☐ Nonprofit Organization
If qualified under Section 501(c)(3) provide 501(c)(3) nonprofit organization number: _____
☐ Public Utility*
☐ Mutual Water Company*
☐ Federally Recognized Indian Tribe
☐ State Indian Tribe listed on the Native American Heritage Commission's California Tribal Consultation List

*Public Utilities and Mutual Water Companies must describe a clear and definite public purpose and benefit to the customers of the water system

LANDOWNER(s) INFORMATION

Landowner Name: Not applicable; infrastructure for the life cycle monitoring station will be on the mainstem of the San Joaquin River downstream of the last major tributary (Stanislaus River), however the exact project location will be determined by the technical team (see section *Approach and Feasibility* for more details on the role of the technical team).

Private ☐ State ☐ Federal ☐ Local ☐ Tribal ☐Other ☒ Not Applicable

Contact Name: Not applicable
Telephone: Not applicable Email: Not applicable

Signatory Representing Landowner: Not applicable
Name: Not applicable Title: Not applicable

PROJECT INFORMATION

Project Name: Designing a San Joaquin Basin Steelhead Monitoring Program to Inform Enhanced Stream Flow Decisions

Funding Amount Requested From WCB (round to the nearest $1000): $780,000

Total Project Cost (round to the nearest $1000): $1,222,000

Month and Year WCB Funding Needed: (If proposal is funded, grants are likely to be fully executed in June 2017) June 2017

Proposed Start Date: 6/1/2017
Estimated Completion (Funds must be expended by April 30, 2021): 4/30/2021

Elected Representatives for Project
State Senate District(s): www.senate.ca.gov

District number	Name
18; additional districts: 19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40	Bob Hertzberg

Assembly District(s): www.assembly.ca.gov

District number	Name
37; additional districts: 38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59, 60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,	Das Williams

Project Type

☒ Planning, Scientific Studies, Monitoring, and Assessment
☐ Implementation

☐ Acquisition

Project Eligibility and Summary

Projects must measurably enhance stream flows at a time and location necessary to provide fisheries or ecosystem/habitat benefits or improvements that enhance existing flow conditions and are greater than required applicable environmental mitigation measures or compliance obligations.

Provide a brief (2 paragraph or less), clear description of the project and an explanation of how the project will meet the requirements of eligible project type(s).

The goal of enhanced stream flow is to benefit fish and wildlife and contribute to the recovery of special status, threatened, endangered or at risk species. The California Central Valley steelhead (*Oncorhynchus mykiss*) Distinct Population Segment (DPS) was listed as federally threatened in 1998 (63 FR 13347) and reaffirmed in 2006 (71 FR 834). One of the greatest challenges in managing for resilient steelhead populations is adequate data to inform the population status and trends, especially in the San Joaquin Basin (Johnson and Lindley 2016). Without significant improvements to existing monitoring programs for steelhead in the Southern Sierra Diversity Group (SSDG) the extent to which actions related to instream flow enhancement, habitat restoration, and/or water export restrictions function to improve SSDG steelhead will remain difficult to quantify. When species become rare, estimation of their abundance and temporal distribution can be difficult with traditional monitoring techniques. Yet, these are the data necessary to determine if stream flow enhancement actions are contributing to recovery. This can be even more difficult with species, such as Central Valley steelhead, that express multiple life histories and complete their lifecycle over a wide geographic area. The goal of this project is to deliver a steelhead life-cycle monitoring station infrastructure and a structured decision making (SDM) framework for assessing alternative enhanced stream flow actions that contribute to the recovery of threatened steelhead populations in the San Joaquin Basin. To accomplish this, a scientific technical team of San Joaquin Basin stakeholders will 1) design and deploy infrastructure to support a functioning life-cycle monitoring station for quantifying and evaluating alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions; and 2) develop a SDM framework that facilitates adaptive management of stream flow enhancement actions that contribute to recovery of San Joaquin Basin steelhead populations. This multi-stakeholder group will be comprised of technical staff from state (California Department of Fish and Wildlife, Department of Water Resources) and federal agencies (National Marine Fisheries Service, US Fish and Wildlife Service, US Bureau of Reclamation), water districts (Metropolitan Water District of Southern California, East Bay Municipal Utility District), and non-governmental organizations (Trout Unlimited).

An adaptive management facilitator will lead the technical team in setting management objectives, identifying concerns, and collaborating in a design charrette to plan the infrastructure of the life-cycle monitoring station. The life-cycle monitoring station will be deployed in the field over four different sampling seasons and will be tested and refined to ensure that the data generated is sufficient to meet the objectives set by the technical team. At the end of each sampling season the technical team will review what objectives were met, what were not, and what lessons can be applied to the upcoming sampling season. The life-cycle monitoring station will produce data that compliments existing monitoring and recovery efforts, including the Scientific Evaluation Process (SEP), and the Science Integration Team (SIT) which need San Joaquin steelhead data to monitor biological goals of the State Water Board's San Joaquin River flow objectives and to develop life-cycle models for prioritizing Central Valley Improvement Act (CVPIA 1992) restoration actions, respectively. In addition, this proposal, in collaboration with CDFW, will be vital in jump-starting a robust life-cycle monitoring station in the San Joaquin Basin that will complement CDFWs efforts to develop a system-wide Central Valley Steelhead Monitoring Program (Fortier et al. 2014). The Central Valley Steelhead Monitoring Program outlines a framework for system-wide steelhead monitoring with efforts to date focused on adult monitoring in the Sacramento River and its tributaries. While there are long-term objectives of expanding the monitoring program into the San Joaquin Basin, no explicit timeline for improving monitoring in the San Joaquin Basin has been identified. The project proposed here will provide the framework to evaluate the efficacy of monitoring steelhead populations in the San Joaquin Basin in accordance with the protocol outlined in the Department's Comprehensive Steelhead Monitoring Plan (Fortier et al. 2014). The product of this effort will ultimately contribute to the information needed to enhance stream flows to protect and restore functional ecological flows for the benefit of steelhead.

Mitigation Project

Mitigation cannot be funded under this program. Is any portion of the project a required mitigation or to be used for mitigation under CEQA, NEPA, CESA, ESA, CWA, Porter-Cologne, other pertinent laws and regulations, or a permit issued by any local, State, or federal agency?

☐ Yes ☒ No

If yes, provide explanation.

Coordination with the California Conservation Corps (CCC) and Certified Local Corps:

All applicants are required to consult with the CCC. Has consultation occurred?

☒ Yes ☐ No

If yes, submit consultation form. If the Corps will be used, they must be included in the Budget. Consultation form and instructions can be found here: http://www.ccc.ca.gov/work/programs/prop1/Pages/default.aspx

CHECKLIST

NOTE: The following information must be attached to the application.

☒ Project location map and photos showing project area

☐ Detailed project drawing for implementation projects (a sketch showing relevant features of the proposed restoration project, include engineering design drawings, if available)

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and a detailed project drawing is not required at this time.

☒ Budget using supplied Budget Template. **Please Note**: There are three separate Excel sheets, please complete all three.
- ☒ Budget
- ☒ Cost Share
- ☒ Project Summary

☐ Land Tenure/Site Control/ Landowner Access agreements or templates for projects with on-the-ground work

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and a land tenure/site control/landowner access agreements are not required at this time.

☐ For projects that alter the amount or timing of water instream(s) include Water Rights Permits or Other Documentation

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and water rights permits are not required at this time.

☐ For Implementation Proposals, include both a Long-Term (20+ years) Maintenance / Management Plan and a Monitoring / Reporting Plan

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and a long-term maintenance/management plan and monitoring/reporting plan are not required at this time.

☒ California Conservation Corps and Certified Community Conservation Corps Consultation Review Document
http://www.ccc.ca.gov/work/programs/prop1/Pages/default.aspx

PROJECT DETAILS

PROJECT LOCATION

Clearly delineate project location and boundaries:

Project location: Nearest City: Manteca County(ies): San Joaquin

Street: Airport Way Cross streets: Division Road

APN's: Durham Ferry State Recreation Area

In what sub-basin or watershed is the stream(s) located?

San Joaquin River

What is the name of the stream(s) this project will directly enhance?

San Joaquin River, Stanislaus River, Merced River, Tuolomne River

To what stream is the project stream a tributary to?

The San Joaquin River is a tributary to the Sacramento / San Joaquin River delta.

Answer the following using Global Positioning System (GPS) coordinates (in Decimal Degrees, e.g. 38.5729, -121.4984).

***Note**: Latitude/Longitude can be determined using Google Earth, http://itouchmap.com/latlong.html, and other on-line resources*

37.688945°, -121.275659°

PRIMARY REACH (the section of the stream that will directly reflect the project's benefits):

Everything upstream

Total River Miles (approximate length of reach): 300

Upper End River Mile GPS Coordinates

Latitude (e.g. 38.572906): 37.697090° Longitude: (e.g. -121.498440): -120.420227°

Lower End River Mile GPS Coordinates

Latitude: 37.688945° Longitude: -121.275659°

SECONDARY REACH (if applicable)

Not Applicable

Total River Miles (approximate length of reach): Not Applicable

Upper End River Mile GPS Coordinates

Latitude: Not Applicable Longitude: Not Applicable

Lower End River Mile GPS Coordinates

Not Applicable

Latitude: Not Applicable Longitude: Not Applicable

[Provide additional reaches benefiting from project as necessary]

POINT(S) OF DIVERSION (identify points of diversion located within project area that may be affected by the project)

Not Applicable

Latitude (e.g. 38.572906): Not Applicable

Longitude: (e.g. -121.498440): Not Applicable

Add points as necessary

Latitude: Not Applicable Longitude: Not Applicable

APPLICABILITY TO SOLICITATION PRIORITIES

1. Stream flow enhancement is defined as "A change in the amount, timing and/or quality of the water flowing down a stream, or a portion of a stream, to benefit fish and wildlife." How will the proposed project enhance stream flows? Clearly illustrate the current condition of the stream, identify the problem(s) and what is required to solve the identified problem(s).

The San Joaquin River was once one of two great sources of freshwater to the Sacramento/San Joaquin Delta. In recent years, a combination of increasing agricultural/urban demands and drought conditions have caused portions of the San Joaquin River to run dry, jeopardizing the survival of native anadromous fishes like Southern Sierra Diversity Group (SSDG) steelhead. A life-cycle monitoring station will address three major information gaps that can inform management of steelhead in the San Joaquin Basin. First, the life-cycle monitoring station will allow mangers to estimate the relative abundance of adult steelhead returning to the San Joaquin Basin. Second, the life-cycle monitoring station will quantify the number of juvenile steelhead

from a cohort that migrate downstream. Together with an adult abundance estimate, juvenile abundance allow estimation of the number of migrating juveniles that are produced per spawning steelhead (recruits per spawner), a common metric for assessing the productivity status and trends of a salmonid population. Finally, the life-cycle monitoring station can be used to assess how stream flow and other environmental conditions influence migration timing, abundance, and productivity of SSDG steelhead.

The information generated from this life-cycle monitoring station can be used to implement targeted management actions that will promote steelhead recovery. For example, it is not possible to evaluate whether actions regulating stream inflow-to-export ratios in the 2009 Biological Opinion are providing the intended protections to threatened steelhead migrating from the San Joaquin River into the Delta. In order for stream flow enhancement, defined as "a change in the amount, timing, and/or quality of the water flowing down a stream, or a portion of a stream to benefit fish and wildlife" to be effective, the period of enhanced stream flow must overlap with the occurrence of target species in space and time. Thus, the life-cycle monitoring station can identify conditions when export reductions will benefit steelhead. Life-cycle monitoring data can also inform an incidental take limit for the State Water Project (SWP) and Central Valley Project (CVP) fish facilities that varies as a function of steelhead population size rather. Currently the take limit is a fixed number and it is not known whether steelhead salvaged at the SWP and CVP represent 2, 5, 10, or even 50% of the steelhead in the basin.

In addition to Delta protective measures, this study will allow managers to assess how adult migration and juvenile emigration varies with San Joaquin River Basin flows. As previously mentioned, one of the advantages of using the life-cycle monitoring station is that it allows for enumeration of steelhead over long periods of time. Teasing out when peak migrations occur could be critical for identifying potential upstream stream flow measures.

The California Water Action Plan

The objectives of the California Water Action Plan 2016 Update (Brown Administration 2016, updated in 2016 in response to a drought crisis) include steps to restore fish populations that are now listed as endangered or threatened in order to meet goals to "restore important species and habitat". Below we describe how our proposed project is consistent with the ten actions in that plan:

1. **Make conservation a way of life**

Understanding the magnitude and timing of flow enhancement that steelhead need to carry out their life cycle makes water conservation an integral part of this project. Current inflow-export ratios in the Delta are protectively broad because few data exist to identify when steelhead move through the Delta and how much flow they require. A steelhead life-cycle monitoring station integrated with the structured decision making framework can be used to assess alternative enhanced stream flow actions that maximize the benefits to threatened San Joaquin Basin steelhead in the most water efficient manner. For example, data from the life-cycle monitoring station will provide fine scale temporal estimates of when juvenile steelhead arrive in the Delta,

allowing managers to precisely apply export regulations to the period when steelhead are at risk of entrainment, potentially resulting in an equally protective, but narrower window for export regulations. More precise application of export regulations improves water supply reliability while conserving enough cold, clean water at the right times of year necessary to ensure species abundance and health and ecological function.

2. **Increase regional self-reliance and integrated water management across all levels of government**

Integrated water management balances the objectives of improving public safety, fostering environmental stewardship, and supporting economic stability. Balancing these objectives at the local level can save energy by reducing water imports from other areas. Our project will provide managers with better understanding of how much water steelhead need and when they need it, allowing them to meet commitments of environmental stewardship while balancing water needs of local communities. This can be viewed as a multi-benefit project because restoring environmental conditions to support sustainable fish populations also improves environmental conditions for a self-reliant local community.

3. **Achieve the co-equal goals for the Delta**

The Delta Stewardship Council was created to achieve co-equal goals by attaining a more reliable water supply and protecting and restoring the Delta ecosystem by working with the Delta Science Program, the Interagency Ecological Program and others to implement the Delta Science Plan to support Delta science, with a primary focus on supporting adaptive management actions to recover listed species. This project will evaluate the effectiveness of California's stream flow enhancement program on steelhead recovery in the San Joaquin Basin, the second largest river basin in the Central Valley. Presently, critical information is lacking on the current state and recovery needs of anadromous salmonids, particularly steelhead, throughout the Central Valley. The goal of the proposed project is to recover listed steelhead in the San Joaquin Basin by collecting baseline information on abundance and migration timing. We will deliver a steelhead life-cycle monitoring station infrastructure and a structured decision making framework for assessing alternative enhanced stream flow actions to identify the timing, magnitude, and duration of enhanced flows that optimize recovery potential of San Joaquin Basin steelhead and water supply reliability.

4. **Protect and restore important ecosystems**

Within the last 150 years, over 80 percent of the Central Valley's historic floodplain, riparian and seasonal wetlands have been lost. This loss has contributed to the decline of salmon and steelhead, fragmented and restricted habitat, and impacted water supply and water quality. Steelhead and salmon are key indicators of the health of natural water flows because their life cycles' connect all aspects of the ecosystem, from the headwaters of tributaries used for spawning, rivers for migration, estuaries for rearing, and the ocean for maturation. Therefore, restoring aquatic ecosystems for salmonids benefits many other species and communities. Through this action, the Department of Fish and Wildlife (CDFW) and the Department of Water Resources (DWR) will lead the state's effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River to restore a self-sustaining salmon fishery

while avoiding adverse water supply impacts. However, without knowledge of existing status and abundance of steelhead and salmon in the San Joaquin, it is impossible to set restoration goals and measure progress towards achieving them. Broad efforts to restore the ecosystems steelhead rely on include eliminating barriers to fish migration, restoring forest health in watersheds, restoring degraded stream and meadow systems, and protecting and expanding strategically important lands by reducing pollution and runoff. Measuring success of these restoration efforts requires identifying objectives of the management action and measuring response metrics. This project will deliver a steelhead life-cycle monitoring station infrastructure and structured decision making framework for assessing alternative stream flow enhancement actions as well as actions related to habitat restoration, and/or water export restrictions. Status and trends of steelhead and salmon populations are good metrics for restoration success because they connect all aspects of aquatic ecosystems. The proposed project to implement a monitoring station in the lower San Joaquin River will also assist with Chinook salmon recovery efforts because every migrating salmonid passing the station will be identified and enumerated.

5. **Manage and prepare for dry periods**

Water shortages caused by droughts will become more frequent with climate change. As climate change proceeds it will become more difficult to attain the coequal goals of reliable water supply and a healthy Delta ecosystem. Therefore, it is imperative to make California's water system more resilient. It is during critical drought conditions that adaptive management can have the greatest benefits for fisheries, water quality, and water supply needs. We will convene a scientific technical team of San Joaquin Basin stakeholders to a develop life-cycle monitoring infrastructure integrated with a structured decision model (SDM) framework that maximize the benefits to threatened San Joaquin Basin steelhead in the most water efficient manner. Structured decision making requires 1) identifying explicit objectives, 2) multiple management alternative actions, and 3) models (conceptual or statistical) capable of predicting the effect of management actions (Conroy & Peterson, 2013). With buy-in from resource management, recommendations produced from this team based on trends in data collected from a collaboratively designed project will inform fish (CDFW, NOAA, USFWS) and water resource management agencies (DWR, USBR, SWRCB) who are charged with making decisions that enhance stream flow. One of the ways in which stream flow could be enhanced for steelhead during droughts is to streamline water transfers in such a way that transfers occur when steelhead need flows for migration or need flows to keep redds cool, based on abundance and timing data collected at the monitoring station.

6. **Expand water storage capacity and improve groundwater management**

Climate change will bring drought conditions more frequently and is already reducing our largest natural storage system, the Sierra snowpack. More precipitation is falling as rain rather than snow, which means snows melt earlier and more rapidly. All of this highlights the importance of managing surface and groundwater storage into the future. Recharging groundwater storage takes pressure off of increasing demands on reservoir storage thereby creating greater flexibility to manage flows to restore anadromous fish populations. As California's population continues to

grow, increasing reliance on reservoir storage is inevitable, and releases from those reservoirs will have to be managed in a way that supports anadromous salmonids downstream of dams. In such highly managed systems, life-cycle monitoring station(s) like the one proposed here are essential for identifying the hydrograph conditions that support salmonid populations.

7. **Provide safe water for all communities**

Access to safe, clean, and affordable water is a basic human right. Efficiencies that can be gained by consolidating drinking water and groundwater quality programs into a single agency charged with restoring and protecting water quality will have multi-benefits that include public health and environmental stewardship. In the same way, funding that is dedicated to improving sanitary wastewater infrastructure for disadvantaged communities and improving access to clean drinking water will end up improving water quality in local watersheds that support anadromous salmonids. In addition to monitoring the status of these systems to prevent or mitigate anticipated shortfalls during drought, our proposed steelhead life-cycle monitoring station can use fish condition indices to serve as an independent indicator of the health of the watershed. Signs of disease and poor conditioned fish may provide an early warning indication of problems in water infrastructure for the state to manage proactively.

8. **Increase flood protection**

Climate change is projected to magnify the intensity and frequency of catastrophic flooding events. When flooding occurs, public safety and health is endangered and pollution from runoff can endanger fish populations. One of the ways that the state has committed to reducing such risks is by investing in levee improvements. State funding that prioritizes improvements to Delta levees can benefit fish habitat by building setback levees behind existing levees and encouraging vegetation to grow as a buffer to the new levee system. Multiple benefits are achieved when natural habitat takes the place of rip-rap and provides fish migrating through or rearing in the Delta with food and cover. As previously mentioned, healthy, sustainable steelhead populations signal a healthy, resilient water system because their life cycle connects headwaters to the ocean.

9. **Increase operational and regulatory efficiency**

Increasing operational and regulatory efficiency through better technology and improved procedures can result in improved coordination and more accurate data for decision making. In particular, this project will help to improve state and federal interagency coordination and water contractor coordination on real-time forecasting and management associated with meeting water quality control objectives to optimize project operations and avoid fishery impacts. We will achieve this by providing more precise data on the arrival timing and abundance of steelhead as they enter the region of the Delta impacted by water project operations. Steelhead comprise 0.2% of all fish caught in the Mossdale trawl, the only monitoring program in place to signal arrival of San Joaquin Basin steelhead into the Delta. However, the 10-15 minute trawls operated during the day are not well suited for sampling steelhead because salmonids are well known to migrate at night. A passive sampling design, such as a resistance board weir we are initially proposing for the technical team to evaluate, allows for continuous monitoring of steelhead returning and

outmigrating from the San Joaquin Basin. In terms of operational efficiency, a structure such as this will provide managers with more accurate data on abundance and migration timing so that export regulations can be tuned to have maximal benefit for fish and provide greater efficiency for exports.

10. Identify sustainable and integrated financing opportunities

Part of identifying sustainable and integrated financing opportunities involves eliminating barriers to funding multi-benefit projects. The state's strategy to identify all potential funding sources for water-related projects will ultimately result in a stronger funding base for ecosystem restoration and increase the demand for the long term life-cycle monitoring stations necessary to evaluate system dynamics and improve future decision-making. The steelhead life-cycle monitoring station infrastructure proposed here fits well within CDFWs efforts to develop a Central Valley Steelhead Monitoring Program (Fortier et al. 2014). At the conclusion of the proposed project, a life-cycle monitoring station will be ready for long-term implementation by CDFW or another appropriate resource agency. Thus, WCB funding, along with cost-share contributions from Metropolitan Water District, will cover 36% of the design and implementation costs for a monitoring program the State has identified as necessary, but do not currently have a timeline for implementation. Further, securing funding for long-term monitoring will be made easier with the establishment of a multi-stakeholder designed life-cycle monitoring station.

CONSISTENCY WITH AND IMPLEMENTATION OF STATE AND OTHER PLANS

2. Describe how the project advances, is consistent with, or in conflict with any applicable local, regional, or statewide plans, such as the California Water Action Plan, the WCB Strategic Plan, the State Wildlife Action Plan, Recovery Plans, general plans, county plans, specific area plans, regional conservation plans, climate action plans, watershed management plans, etc. Identify the pertinent plan(s) and the date adopted by the applicable local/regional entity.

As requested in the proposal solicitation Table 6 Technical Review Evaluation Criteria and Scoring Standards the extent to which the project promotes, implements, and advances the California Water Action Plan is included in the above section APPLICABILITY TO SOLICITATION PRIORITIES.

WILDLIFE CONSERVATION BOARD STRATEGIC PLAN (FY 2014-2019)

Monitoring and Adaptive Management

WCB recognizes that monitoring and adaptive management are essential to ensure that California's investments produce a conservation benefit. Monitoring is also important for describing success and sharing lessons learned. WCB is committed to advance monitoring and adaptive management of the projects it funds. This project explicitly proposes to deliver steelhead life-cycle monitoring station infrastructure and a structured decision making framework for assessing alternative enhanced stream flow actions that contribute to the recovery

of threatened steelhead populations in the San Joaquin Basin. The life-cycle monitoring station will also be able to able to assess effects of upstream restoration in the second largest river basin in the Central Valley. Importantly, a life-cycle monitoring station will establish baseline data and facilitate adaptive management of stream flow enhancement actions that contribute to recovery of San Joaquin Basin steelhead populations. The following description identifies how this project addresses applicable *strategic directions* identified in the WCB Strategic Plan (CWCB 2014).

Goal A. Environmental Protection and Conservation

1. **Fund projects and landscapes that provide resilience for native wildlife and plant species in the face of climate change.**

It is impossible to evaluate effects of climate change or the effectiveness of projects that facilitate migration of species and provide habitat connectivity between habitat areas without a robust monitoring program. We propose to complement the steelhead monitoring program that CDFW is implementing in the Sacramento River by establishing a steelhead life-cycle monitoring station in the San Joaquin River (Eilers et al. 2010). By doing so, it will be possible to establish baseline data on abundance and migration timing and begin building a time series to evaluate effects of climate change and success of restoration efforts and climate benefits of projects in both of the primary river basins of the Central Valley.

2. **Fund projects and landscape areas that conserve, protect, or enhance water resources for fish and wildlife.**

Precipitation in San Joaquin River tributaries in the southern Central Valley is relatively low in comparison to precipitation in the northern part of California, and agricultural demands have caused the San Joaquin River to run dry in times of drought. Such conditions jeopardize the persistence of anadromous salmonids and native fish assemblages in the southern Sierra Nevada, which is why it should be a high priority conservation area for the WCB to target. Efforts are already underway to reintroduce spring-run Chinook salmon into the San Joaquin River (NMFS 2013), but to date, little is known about the condition and recovery needs of steelhead in the Southern Sierra Diversity Group (Williams et al., 2016). By funding this project, the WCB would be investing in data collection efforts that would inform future restoration and stream flow enhancements for recovery of *O. mykiss*.

3. **Fund projects that support the implementation of Natural Community Conservation Plans, Habitat Conservation Plans and recovery of listed species.**

By funding this project, the WCB would be investing in data collection efforts that support Natural Community Conservation Plans and Habitat Conservation Plans. The proposed project will be the first robust life-cycle monitoring station in the mainstem of the San Joaquin River specifically focused on monitoring steelhead and informing actions to support their recovery in the San Joaquin watershed. The location of the life-cycle monitoring station will be positioned in the lower reach of the San Joaquin River ensuring that fish captured there are anadromous and providing an opportunity to assess the effectiveness of habitat improvements occurring upstream in any of the San Joaquin's tributaries because both juvenile and adult life history stages of steelhead will be monitored.

4. **Invest in priority conservation projects recommended under CDFW's land acquisition evaluation process or within other conservation plans supported by CDFW.**

In October, 2010, CDFW produced a Central Valley Steelhead Monitoring Plan (Eilers et al. 2010) which is discussed in further detail in its own section below. It is highlighted here because CDFW prioritized identifying the spatial distribution of steelhead throughout the Central Valley in order to assess their current range and observe changes in their range before any recommendations for land acquisitions to support steelhead recovery can be made. CDFW chose to begin implementing steelhead monitoring in the Sacramento River rather than the San Joaquin because it supported more robust steelhead populations. We are proposing to catalyze the implementation of a steelhead life-cycle monitoring station in the San Joaquin because its populations are so vulnerable, especially during periods of prolonged drought.

5. **Improve transparency and efficiency of WCB and CDFW project evaluation and recommendations to approve or deny applications.**

Because the proposed project is a life-cycle monitoring station, steelhead abundance and migration data generated from this project will assist WCB and CDFW in using a science-based decision making process to evaluate the effectiveness of stream flow enhancement programs or restoration projects that occur within the San Joaquin watershed. Decisions that are based on quantitative data tend to be objective and provide greater transparency.

Goal B. Environmental Restoration and Enhancement

1. **Invest in projects and landscape areas that help provide resilience in the face of climate change, enhance water resources for fish and wildlife and enhance habitats on working lands.**

WCB's goal to target projects that enhance habitat that support migration of species is particularly important for anadromous salmonids. The population response to riparian corridor and anadromous salmonid habitats can be evaluated using the steelhead life-cycle monitoring station infrastructure we are proposing. Impacts of climate change can also be assessed with time-series of abundance and migration timing data, both of which are currently lacking in the San Joaquin Basin. The life-cycle monitoring station that we develop in the mainstem San Joaquin River will collect long-term information on steelhead abundance, migration timing, and conditions of migration, enabling assessment of whether restoration efforts upstream increase steelhead population abundance and decrease extinction probability.

2. **Expand project monitoring and evaluation of restoration activities to assess long-term project success, moving beyond compliance monitoring.**

This project will help WCB monitor the effectiveness of restoration projects designed to recover depleted steelhead in the San Joaquin Basin. The life-cycle monitoring station will provide monitoring data. Integrating the monitoring station design with a SDM framework developed by the multi-stakeholder technical team will facilitate adaptive management of restoration activities, including stream flow enhancement, that contribute to recovery of San Joaquin Basin steelhead populations. Monitoring is a requirement of adaptive management necessary for evaluating

system dynamics and improving future decision-making Semi-permeable resistance board weirs are widely used to monitor salmonids primarily because their passive design is efficient for monitoring fish passage at all times of day. Results such as change in abundance or migration patterns will assist the WCB with measuring the impact of its restoration action investments in the San Joaquin watershed and inform decisions-making for future restoration activities.

3. **Provide opportunities for greater public involvement in restoration projects.**

This project will involve the participation of local California Conservation Corps in checking and maintaining fish traps at the life-cycle monitoring station. In addition to the public availability of videos of adult steelhead passage, local participation will contribute to WCB's goal to foster an ethic of environmental stewardship among local communities.

DEPARTMENT OF FISH AND WILDLIFE CENTRAL VALLEY STEELHEAD MONITORING PLAN (2010)

One of the primary actions of CDFW Central Valley Steelhead Monitoring Plan (Eilers et al., 2010) is to monitor the status and abundance of steelhead in select rivers in the following Diversity Groups:

- Northwestern California
- Basalt and Porous Lava
- Northern Sierra
- Southern Sierra

The proposed project will help CDFW by establishing a life-cycle monitoring station for steelhead in the Southern Sierra Diversity Group (SSDG) where none currently exists. Part of this effort will include the contribution of data to a centralized database run by CDFW and participation in a coordinated system of annual reports. Region 4 biologists recommend monitoring in all the major tributaries of the San Joaquin, including the mainstem, but recognize that monitoring steelhead population in this area are especially challenging due to a scarcity of fish. As mentioned elsewhere, by setting the proposed location for our project in the lower San Joaquin River, we will ensure that fish monitored passing the station are steelhead and not resident rainbow trout. Identifying anadromous fish is a problem for monitoring programs in the tributaries where resident fish are present.

CDFW Fisheries Branch leadership have expressed a desire for long term life-cycle monitoring stations to be implemented in several rivers in the Central Valley. Present monitoring programs lack sufficient data to provide reliable data. The proposed project will focus on bringing together biologists from Region 4 and the Fisheries Branch with other technical experts to design a life-cycle monitoring station in the San Joaquin River that will provide data needed to assess steelhead viability and identify the management actions required to recover steelhead in the SSDG.

The proposed project follows the recommendations in the monitoring plan that feasibility of semi-permanent monitoring structures be evaluated prior to implementation. The multi-

stakeholder technical team will ensure a feasible life-cycle monitoring station by identifying at the outset the objectives (e.g. juvenile steelhead enumeration) and concerns (e.g. impacts on non-target species) that must be considered in monitoring station design. During this period implementation of the life-cycle monitoring station will be dynamic, with ongoing evaluation and refinement to maximize data quality and minimize identified concerns.

DIVERSITY AND SIGNIFICANCE OF BENEFITS

3. Considering anadromous fish; or special status, threatened, endangered or at risk species, what limiting factor(s) will be addressed by this project?
    a. Will these limiting factor(s) be eliminated or reduced?

Our project's overall objective is to provide data that will inform flow management for sensitive and ESA listed fishes both in the San Joaquin River tributaries and in the Delta. A primary outcome will be information on the magnitude and timing of instream flows that correlate with juvenile steelhead arriving in the Delta and adult steelhead returning to the San Joaquin Basin. The CCV-Steelhead distinct population segment (DPS) is at a high risk of extinction and the Southern Sierra Diversity Group (SSDG) of Central Valley steelhead (San Joaquin River and tributaries) is considered an especially imperiled population segment and (NMFS 2009, Williams et al. 2016). In Central Valley regulated rivers, understanding how water project operations promote, maintain, or suppress the expression and survival of the anadromous life-history form of *O.mykiss* is one of the greatest challenges in managing for resilient steelhead populations (Williams et al. 2016). In the 2016 viability assessment for Pacific steelhead, Williams et al. (2016) noted that, "In the San Joaquin River tributaries specifically, there is great uncertainty in the extent to which the production of anadromous juveniles from tributaries is low and/or whether mortality of juvenile steelhead is so high during outmigration so as to preclude higher numbers of returning adult steelhead." The lack of information on steelhead abundance and factors influencing steelhead migration and mortality is a limiting factor in managing steelhead populations. The development of life-cycle monitoring station infrastructure through this project will generate data necessary to inform protective management actions to support San Joaquin Basin steelhead. This life-cycle monitoring station will be able to count the number of juvenile steelhead leaving the San Joaquin Basin, determine the timing and conditions under which steelhead migrate into the Delta, collect information on the condition of fish during outmigration. Collection of tissues from juvenile and adult steelhead collected for genetic parentage-based analysis may, for the first time, allow an estimate of San Joaquin-origin steelhead smolts entrained into the South Delta water export facilities. Genetic samples can potentially provide insight into the interrelationship between the anadromous steelhead and resident rainbow trout populations in the San Joaquin Basin. The information collected from the sampling program will help to alleviate the factor currently limiting management of resilient steelhead populations, which is insufficient data to evaluate the status and trends of steelhead in the San Joaquin Basin, including the role of environmental conditions, including water project operations, on the expression of the anadromous steelhead life history (Williams et al. 2016). A weir based life-cycle monitoring station will generate the best available science to inform decisions regarding

water resources and has proven successful in other systems; some of the best steelhead population-level data is from the operation of the weir on Battle Creek (Williams et al. 2016). In addition, the data collected on steelhead abundance and timing and conditions of migration will help inform the timing and location of when enhanced stream flows are needed to provide fisheries and ecosystem benefits

b. What future work will need to occur to eliminate the limiting factor(s) in this reach?
    i. Are there plans for future improvement within the project area?
    ii. Is there funding lined up for future efforts?

This project will develop, pilot, and refine infrastructure that will support a functioning life-cycle monitoring station that can be implemented on a long-term basis to generate much needed information on steelhead. Data from a life-cycle monitoring station can be used to evaluate how sensitive and ESA-listed fishes in the San Joaquin River tributaries and Delta respond to natural and enhanced stream flow conditions. This proposal falls under the planning/scientific study project category and funding is not arranged for future implementation efforts. However, we believe resource agencies and stakeholders are more likely to secure long-term funding for a life-cycle monitoring station if it is already designed and implemented with the multi-stakeholder approach we are proposing.

If funded we will deliver a steelhead life-cycle monitoring station infrastructure and a structured decision making framework for assessing alternative enhanced stream flow actions that contribute to the recovery of threatened steelhead populations in the San Joaquin Basin. Long-term operation of the life-cycle monitoring station would qualify for the implementation category funding under the WCB Proposition 1. In addition, given the technical team is comprised of stakeholders from various non-profits, resource and water agencies, it will be well suited to secure long-term funding sources through a group collaboration or by applying to other grants such as CVPIA.

4. Will this project provide additional ecosystem benefits beyond stream flow enhancement? If so, describe what other ecological problems, beyond streamflow, will the project address.

Our project will provide multi-faceted benefits to flow management. The value of enhanced stream flows to the San Joaquin Basin and Delta ecosystems is debated because there is great uncertainty in the outcome. The State Water Resources Control Board (SWRCB) has an ongoing effort to re-evaluate and possibly change minimum flow standards for San Joaquin Basin tributaries (http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/). San Joaquin River flows are also extremely consequential for Delta flow management and water project operations. Biological Opinions (NMFS 2009, USFWS 2008) regulate South Delta exports as a function of total inflow from the San Joaquin Basin by the Old and Middle River

(OMR) net flow standard. Thus, data from a life-cycle monitoring station can inform: 1) whether San Joaquin Basin flows should be protected from diversion in the Biological Opinions, thereby reducing stress or improving habitat for threatened and endangered species; and 2) more efficient use or reuse of San Joaquin Basin waters. In addition to OMR regulations, the National Marine Fisheries Service's 2009 Biological Opinion limits the ratio of water that can be exported from the pumped facilities relative to the amount of San Joaquin River inflow into the Delta (I:E ratio). As with OMR flow standards, our proposed project will yield information we expect will be very important to either maintaining existing standards, or suggesting ways that standards could be modified to provide improved habitat conditions, reduced stress, and increased efficiency in the conveyance and diversion of waters. Tools and information that can identify the timing, durations, magnitude and environmental conditions for river flow augmentation for mutual benefit of fisheries and water supply reliability are urgently needed to cope with climate change and potentially more frequent drought conditions. Our proposed project provides critical information to the decision-making processes that will seek to minimize the impacts of increasing drought frequency.

In addition, our project will yield information about other important fish species and life stages, including the following:

- San Joaquin River restoration project. The proposed life-cycle monitoring station will be operated at a time when adult and juvenile spring-run Chinook salmon will be migrating through the San Joaquin River mainstem. The data collected on spring-run abundance and timing will help inform the restoration program if their stream flow strategy is supporting a self-sustaining population of spring run.
- Chinook salmon fry. Flow management in the San Joaquin Basin since the 1990s has focused on Chinook salmon smolts emigrating in April-June. However, recent otolith microchemistry studies indicate juveniles outmigrate over a broader range of dates, including fry emigrants (January-March) that can contribute substantially to adult returns (Sturrock et al. 2015). Juvenile outmigration tends to occur on high flow events, suggesting flow management can increase the diversity in outmigration timing, thereby increasing population resilience through the "portfolio effect" (Carlson and Sattherwaite 2011). Though San Joaquin Basin Chinook salmon fry are assumed to reach the Delta in winter and early spring, no data is currently available on flow conditions necessary to support production of this life history type. Our project will provide an estimate of San Joaquin Basin Chinook salmon fry reaching the Delta and allow associations with flow to be evaluated.
- Adult white and green sturgeon. Sturgeon have recently been confirmed to occur in the San Joaquin Basin (https://www.fws.gov/sfbaydelta/documents/study_cites_sturgeon_spawning_in_the_san_joaquin_river_usfws_news_release.pdf), but no information is available on their numbers or correspondence between flow events and passage. Our project will provide data how many, when and under what flow conditions adult sturgeon enter the San Joaquin Basin.

5. Are the ecological benefits anticipated from the completed project part of or tied to other habitat protection or improvement efforts in the watershed?

☒ Yes ☐ No

a. If so, briefly list and describe the projects recently implemented, underway, or planned that will help to achieve the habitat goals associated with enhancing instream flows. Please describe the relationship between this proposal and the habitat restoration activities addressing other limiting factors.

Numerous habitat restoration and habitat enhancements are underway (or planned) in the San Joaquin River which will benefit from the proposed work. The USFWS Anadromous Fish Restoration Project (https://www.fws.gov/lodi/anadromous_fish_restoration/afrp_index.htm) and the San Joaquin River Restoration Program (http://www.restoresjr.net) provide numerous specific examples. We expect this project will yield information and an SDM framework to facilitate the adaptive management of stream flow enhancement actions that contribute to recovery of San Joaquin Basin steelhead populations and make other anadromous fish restoration efforts in the San Joaquin Basin more effective and successful.

b. If the proposal is similar to or related to other past or current projects in the region, what shortcomings of these projects will this proposal address?

Currently, there are a few monitoring efforts occurring in the San Joaquin Basin but they are typically not operated to capture the full life history of steelhead and do not employ gear that is efficient for measuring steelhead abundance. Screw traps are deployed in tributaries to the San Joaquin River primarily to estimate the abundance and timing of juvenile fall run Chinook salmon. Although these traps capture *O. mykiss* fry (and occasionally parr), large populations of resident rainbow trout occur in these tributaries and observations of fry and parr cannot be used to assess behavior or demographics of the anadromous life history type (i.e. steelhead). Additionally, these trapping programs were designed principally to sample juvenile Chinook so they are not operational during the entire steelhead migration window and are easily avoided by large (1+ years) migratory steelhead juveniles that are able to swim around the traps. Thus, data from these traps cannot be reliably used to predict how flow enhancements upstream will affect expression and abundance of steelhead smolts, or their arrival time to the Delta. A trawl is operated in the San Joaquin River near Mossdale which is far enough downstream that individuals captured are likely to be migrating toward the ocean. However, this trawl rarely captures steelhead, with only 139 individuals (0.2% of total catch) sampled between 1994 and 2011. The reason for this may be related to the rarity of steelhead smolts, but this is difficult to conclude because the trawl operates during daylight hours, whereas anadromous salmonids primarily migrate at night. Additionally, the duration of each tow is short (10-30 minutes) relative to the large volume of water in the channel. Thus, the trawl is poorly configured for capturing a relatively rare species that primarily moves through the sampling area when it is not operating.

The proposed location of this life cycle monitoring station is particularly important (Figure 3). The proposed life cycle monitoring station would be deployed farther downstream than any of the life cycle monitoring stations currently in use in the Central Valley and would be the first of its kind designed to sample both adult and juvenile steelhead. By situating the life-cycle monitoring station in the mainstem fish produced in all upstream tributaries can be sampled Distinguishing resident from anadromous life history forms is important and a lack of over-summer habitat for rainbow trout in this region of the San Joaquin River means there is a high probability that juveniles captured at this location are migratory steelhead smolts. There are a variety of options that can be employed for passage through a weir-based life-cycle monitoring station. Fish may be allowed to pass unimpeded, with their presence recorded on different types of video equipment, or they may be trapped to permit selective passage and facilitate collection of tissue and record other relevant biological information. These methods are well known and have been used successfully with other populations of anadromous salmonids (Zimmerman and Zabkar 2007). We also propose to use hatchery-origin smolts to conduct efficiency trials and use the resulting data to estimate abundance of natural-origin fish arriving to the Delta.

The monitoring we are proposing in the mainstem San Joaquin River builds upon existing programs by improving the accuracy and precision of estimates of timing of steelhead arrival timing in the Delta and overall abundance estimates for the San Joaquin River Basin. There is great potential that once this life cycle monitoring station is established in the mainstem, and some of the sampling efforts in the tributaries to the San Joaquin are improved to more efficiently sample steelhead, data generated from them can be used in conjunction to evaluate different stream flow actions and gain insight into what actions promote anadromy. We can also generate estimates for migration timing between when steelhead are observed in the tributaries compared to when steelhead enter the delta using techniques such as mark-recapture programs that tag steelhead in the tributaries and recapture them in the mainstem.

6. Describe the benefits of meeting project objectives (including enhanced knowledge).
    a. How will ecological benefits of the project be realized?

Convening a technical team to develop the objectives, pilot, test and refine the life cycle monitoring station will ensure that by the end of Year 3 we will have a functioning monitoring station that can be implemented for evaluating stream flow conditions and steelhead responses to flow enhancement efforts and generate data to inform water resources management decisions. This tool will enhance our knowledge of steelhead and identify the timing, durations, magnitude and environmental conditions for river flow augmentation for mutual benefit of fisheries and water supply reliability. The development of a structured decision making framework integrated with a life cycle monitoring station will facilitate evaluation and monitoring of alternative stream flow enhancement actions. This will result in stream flow enhancement actions that are targeted at the right time of year to promote steelhead survival and ensure that water project operations are protective of steelhead.

b. Quantify to the best of your ability the ecological benefits anticipated from successful completion of this project.

- Steelhead: Development of a functioning life cycle monitoring station that can be used to evaluate enhanced stream flow actions will help identify the timing, duration, and magnitude of enhanced stream flow actions that will allow for the full suite of ecological benefits, described above, to be realized.
- Spring-run Chinook salmon: The proposed life cycle monitoring station will be operated at a time when adult and juvenile spring-run Chinook salmon will be migrating through the San Joaquin River mainstem and the data collected on spring run abundance and timing will help inform the restoration program if stream flow strategies support a self-sustaining population of spring-run. Our project will provide an estimate of San Joaquin Basin Chinook salmon fry reaching the Delta and allow associations with flow to be quantified.
- Sturgeon: A life-cycle monitoring station can provide data on how many adult white and green sturgeon are entering and exiting the San Joaquin River, the timing of these migrations, and what flow conditions adult sturgeon use to enter the San Joaquin Basin.

How will the benefits of the project be maintained for 20+ years?

This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and long-term funding for a 20 year project does not apply to this proposal. However, the proposed project will develop, pilot, and refine infrastructure that will support a functioning life cycle monitoring station for steelhead as prerequisite actions for implementation of a long-term life-cycle monitoring station. Once established, the life-cycle monitoring station would be well-suited for a future WCB Proposition 1 solicitation under the implementation project category. We will also actively seek other opportunities for grant funding (e.g. CDFW Proposition 1 solicitations, CVPIA charters). Further, technical team of stakeholders from various non-governmental organizations, resource and water agencies will begin to looking long-term funding sources through group collaborations or applying to other grants solicitations.

DURABILITY OF INVESTMENT

7. What is the durability/permanency of the stream flow enhancement? What are the provisions to maintain the enhancement and for what period of time?

This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category. The project deliverables and most valuable products will be infrastructure that will support a function life cycle station that can be used to quantify and evaluate alternative stream flow enhancement actions and a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations. The life cycle monitoring station will generate information needed to fill knowledge gaps and the SDM

framework produced can be used by water and natural resource policy and management agencies to asses and evaluate the success of different stream flow enhancement actions that contribute to steelhead recovery that can be used in perpetuity. Success of this project is ensured by the technical team of stakeholders, led by an adaptive management facilitator. Including all stakeholders in this process will ensure success in the development and completion of the project's deliverables because the resource agencies who make natural resource policy and management decisions (e.g. NOAA, CDFW, USFWS, USBR, DWR, MWD, etc) will be involved in the entire design, implementation, and development of both the life cycle monitoring station and structured decision support model; this process ensures that these deliverables are vetted by all stakeholders which will result in the development of products these agencies can use to influence and manage stream flow enhancement efforts.

Another step to ensure the durability/permanency of the deliverables will be a final report that will include a synthesis of all findings and provide conclusions about the infrastructure for the life cycle monitoring station and how this tool should be used for evaluating stream flow enhancement actions, recommendations for resource management on experiments or studies that use the life cycle monitoring station to evaluate alternative enhanced stream flow actions and current management practices, as well as future stream flow enhancement actions that could be developed and quantified/evaluated using the SDM framework and monitoring system we have delivered. In addition, all of the information included in the report will be drafted into manuscript in a format suitable for publication in a scientific peer-reviewed journal in which participants of the technical team will be contributing authors. Publishing this information will bring credibility and attention to the development of this monitoring infrastructure which will assist in the effective dissemination of information and deliverables generated from the project.

8. How will the completed project deliver sustainable outcomes into the future? Describe the long-term management that will assure the entire project's sustainability beyond the term of the grant agreement?

The project will deliver a sustainable, long-term SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and the infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions. While this proposal falls under the Planning and Scientific Studies project category, the information generated from the SDM framework and life cycle monitoring station will provide data needed to adaptively manage stream flow enhancement actions to benefit steelhead. These data will contribute to recovery of San Joaquin Basin steelhead populations and can be used to inform near and long-term management actions that extend beyond the term of the grant agreement. The project will develop, pilot, and refine infrastructure that will support a function life cycle monitoring station which can be used to evlauate alternative stream flow enhancement actions. The project will develop these deliverables to qualify for future implementation funding through this grant process.The project

deliverables will be sustainable for future use because the technical team will include resource agencies who make natural resource policy and management decisions (e.g. NOAA, CDFW, USFWS, BOR, DWR, MWD, etc) from the ground up. Thus, all deliverables will be supported and vetted through this stakeholder team, resulting in self-directed products these agencies can use to influence and manage stream flow enhancement efforts. In addition, the infrastructure that will support a functioning life cycle monitoring station for steelhead will generate data to inform stream flow enhancement efforts and will be designed to collect necessary data to inform additional management actions (e.g. NMFS requires information on steelhead abundance to inform their status, viability, and recovery efforts; AFRP requires information on steelhead life history to better plan restoration actions, etc). The life cycle monitoring station will generate information needed to fill knowledge gaps and the adaptively manage stream flow enhancement actions to benefit steelhead that can be used in perpetuity by natural resource policy and management agencies influencing stream flow enhancement efforts.

All data produced by this project will deliver sustainable outcomes into the future by being made publically available to Bay Delta Live, an open data platform that is accessible to the public. See section Task 1 Program Management *and Administration* – The lead PIs (see section PROJECT TEAM QUALIFICATIONS) will be Alison Collins (MWD), Jason Hassrick (ICF International) and Steve Zeug (Cramer Fish Sciences). Alison Collins will oversee contract execution of the study. Together, all three PIs will manage execution of the study, data management and ensure that the project is carried out on budget and on time.

Task 2 Assemble technical team to develop study design and protocol – Beginning in 2017, the PIs will form and solicit technical input from a team of state, federal and private scientists and other technical experts on the development of a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations. Led by an adaptive management facilitator in developing structured decision models, the technical team will meet for a two to three day workshop as soon as funding is awarded to develop the SDM framework and infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions before any equipment is deployed in the field.

Task 3 Pre-season meeting – (All) Throughout the course of the project the technical team will engage in the annual technical team cycle outlined in Figure 4 and described in the section Technical team process under the section SCIENTIFIC MERIT – SCIENTIFIC BASIS. The purpose of pre-season meetings is to incorporate objectives and concerns identified into each iteration of the sampling season. Jason Hassrick and Steve Zeug will work with CDFW, USFWS and NMFS to amend existing take permits as needed and ensure compliance with CEQA for streambed alteration.

Task 4 Draft protocols for field crew and sampling, life cycle monitoring station installation, testing, and removal – (Cramer/ICF) Protocols for monitoring infrastructure installment and

removal, data collection, and monitoring efficiency studies (e.g. mark-recapture) must be updated prior to each sampling season based on any modifications decided upon by the technical team in pre-season meetings.

Task 5 Document objectives and concerns – (All) Objectives and concerns identified by the technical team in the beginning of each monitoring cycle will be formalized in a pre-season report developed by Cramer and ICF that will be used in designing a monitoring program plan in Task 6. Meetings will be held at the beginning, middle and end of each season to evaluate results and make adjustments to SDM framework as needed.

Task 6 Meeting on monitoring plan – (All) The technical team will engage in a design charrette where the actual infrastructure and design of the monitoring system will be developed. The adaptive management facilitator will ensure that the infrastructure and design of the life cycle monitoring station will meet the means objectives and minimizes concerns that technical team identified in the previous steps (Figure 4).

Task 7 Draft annual monitoring plan – (Cramer/ICF) The infrastructure and design of the life cycle monitoring station will be formalized in a monitoring program plan outlined in during the design charrette process for the monitoring program plan.

Task 8 Implement a steelhead monitoring program – (Cramer/ICF/CCC) This task represents the data collection phase of the monitoring program that will occur between November and June when adult steelhead are migrating upstream to spawn and juvenile steelhead are migrating downstream to the ocean. December 2017 is the targeted initial date for field deployment; however, actual deployment date will be dependent on securing all necessary permits. The infrastructure for the life cycle monitoring station will follow the design agreed upon by the technical team. The station will be constructed and deconstructed over a two-to-three day period with a crew of 12-15 CCC staff at the beginning and end of each field season. During sampling season the station will be checked daily in coordination with one local California Conservation Corps staff. Depending on permit logistics and infrastructure design the life cycle monitoring station will be deployed and operational for the following sampling seasons: Dec 2017-June 2018, Nov 2018-June 2019, Nov 2019-June 2020, Nov 2020-Jan 2021. We recognize that no sampling gear is perfectly efficient; weirs can be overtopped in high flows, rotary screw traps are more easily avoided by large fish, and beach seines and trawls do not sample continuously. To estimate the efficiency of our juvenile sampling design we will perform efficiency tests in the second and third year of the project. The detection efficiency of the sampling design will be estimated using mark-recapture methods whereby a known number of marked smolts are released upstream and later recaptured at the sampling station. Estimating detection efficiency is necessary to convert the total number of smolts observed at the monitoring station in to an estimate of total smolt abundance.

Task 9 Data management and analysis – (Cramer/ICF) All Data collected during this project will be QA/QC'd by Cramer and ICF staff. Data will be entered into a Microsoft ACCESS relational database maintained by Cramer Fish Sciences using data templates in the California Environmental Data Exchange Network (CEDEN). Taxonomic data will also be directly served to Bay Delta Live (www.baydeltalive.com), through a Shiny application linked to the statistical program R (R Core Team 2012), and on the Central Valley steelhead monitoring database hosted by CDFW. For more details on data management see section DATA MANAGEMENT AND ACCESS.

Task 10 Iterative management meetings with technical team – (All) This is anticipated to be a conference call among technical team members to discuss mid-season results and obtain feedback on the life cycle monitoring station. Disseminating within season results to the technical team will provide the opportunity to trouble shoot the monitoring system or make a tweak to improve the monitoring system to generate data to meet the means objectives.

Task 11 Objectives met / not met, lessons learned to be applied in next cycle – (Cramer/ICF) An "End of Cycle" report developed by the adaptive management facilitator with assistance from Cramer and ICF will be delivered outlining what objectives were met, what were not, and what lessons can be applied to the upcoming cycle. This is an opportunity to reflect if the data generated by the infrastructure and monitoring system are sufficient to quantify the means objectives for a SDM framework that will meet the ultimate objective of enhanced stream flow to benefit steelhead and contribute to the recovery of steelhead populations. This report will document progress and results from the life cycle monitoring station for each annual cycle

Task 12 End-of-project meetings – (All) Four technical team meetings will be held in the final year of the project to develop the final report and manuscript that will include a discussion of findings, conclusions, recommendations for follow-up, ongoing, or future activities. For more details on what this report and draft manuscript will entail please see section Technical team process.

Task 13 Final report – (Cramer/ICF) This will serve as a living document of a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations and how to use the developed infrastructure that will support a functioning life cycle monitoring station to quantify and evaluate alternative stream flow enhancement actions. The framework documented in this plan will be a key deliverable for resource agencies to use in guiding evaluation of the effectiveness and success of alternative stream flow enhancement actions on twenty-year planning horizons.

DATA MANAGEMENT AND ACCESS for more information on how project generated information will be handled, stored, and shared for long-term management that will assure the entire project's sustainability beyond the term of the grant agreement.

CLIMATE CHANGE CONSIDERATIONS

9. Describe the extent to which climate change considerations are adequately taken into account in the proposed project, including how future climate conditions might affect the project's long term benefits. Using the latest regional scenarios, predictions and trends, describe how the project objectives may be vulnerable to impacts (fire, drought, species and habitat loss, etc.) from climate change. What design, siting, or other measures are you incorporating into the project to reduce these vulnerabilities?

Climate change is projected to erode California's spring snowpack, which has been the source of 70% of the state's water storage, compared with long-term average storage capacity of major reservoirs. Last year was the smallest snowpack on record, worse than 90% below average, caused by record warm winter temperatures. Within 50 years, snowpack as marginal as last year could occur more than once every decade (Dettinger and Anderson 2015). Lack of spring snowpack makes it difficult to replenish reservoirs, some of which are the primary controls on Delta inflows. In addition to reduced inflow, peak stream flow timing changes are projected to shift in response to earlier spring snowmelt under 21st century warming trends (Stewart et al. 2004). Salmonid life histories are highly dependent on local environmental conditions, which are tightly linked to climate. Evolutionary responses in peak migration and spawning dates, egg and juvenile growth and development rates, thermal tolerance, and disease resistance are all factors that are hypothesized to have complex interactions and Climate change will affect these factors through earlier and reduced Delta inflow (Crozier et al. 2008). For example, optimal temperature ranges within a fish's aerobic scope are narrower because of the additional energetic cost of migration, and any additional stressors due to climate change, such as hypoxia or increased disease prevalence, can render migration impossible (**Error! Reference source not found.**). As anadromous repeat spawners, steelhead are more exposed to changes in migratory conditions than other salmonids because they return to the ocean as kelts. Little is known about their ocean life stage, other than that they tend to be highly surface oriented, with strong preferences for narrow sea surface temperature conditions that may determine the extent of marine migration (Hayes et al. In Press). Rising sea surface temperatures will increase stratification of the upper ocean, and associated changes in wind patterns will potentially change the timing and availability of upwelling of nutrient-rich bottom water (Di Lorenzo 2015). Anadromous salmonids have evolved life history strategies that allow them to maximize growth by taking advantage of the relatively high production of the marine environment. However, reduced primary production from changes in upwelling dynamics and increasing ocean acidification, with associated changes in phytoplankton community composition, are likely to result in less productive and more variable marine food availability. Coupled with loss of spawning habitat resulting from reduced Delta inflow, steelhead are confronted with a daunting future in which mitigating the detrimental effects of climate change will require careful monitoring and management of enhanced stream flow in Delta tributaries.

The proposed infrastructure is designed to accommodate changing hydrologic conditions. A resistance board design is attached to the substrate and the panels that make up the weir are positively buoyant. This makes the structure resilient to high flows which will readily flow over the weir when stage height exceeds design specifications. As flood water recedes, the weir resumes operation. This makes the sampling design robust to flashy conditions expected from more precipitation falling as rain within the watershed under climate change. Without robust monitoring data, it will be impossible to assess under what conditions San Joaquin steelhead migrate, how climate change is altering migration patterns, and what changes to project operations are needed to combat climate change impacts. With the infrastructure that will support a function life cycle monitoring station we can examine which environmental factors trigger migration, and with this knowledge, recommend management flow enhancement strategies (e.g. water releases or export restrictions) that can mitigate for future climate change conditions, such as decreased magnitude and timing of spring flows. This is why establishing and implementing a steelhead life cycle monitoring station infrastructure and a structured decision making framework for assessing alternative enhanced stream flow actions that contribute to the recovery of threatened steelhead populations in the San Joaquin Basin should be a high priority for efforts to enhance stream flow in the south Delta.

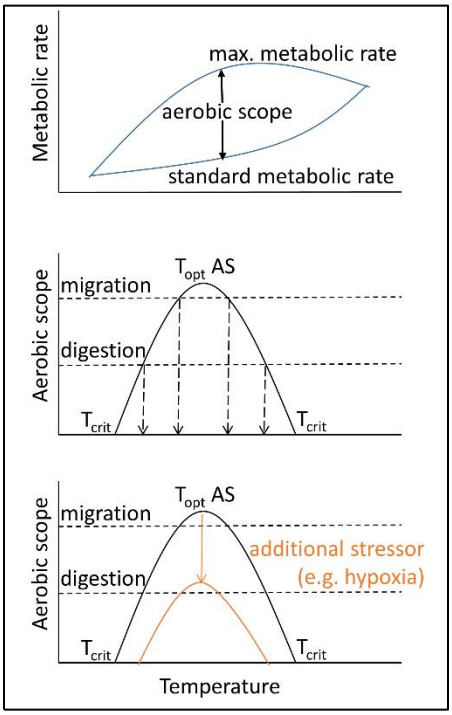

Figure 1. (Top) Changes in maximum and standard metabolic rate with temperature. (Middle) Aerobic scope (AS) with optimal temperature (Topt) and critical temperatures (Tcrit) where aerobic scope goes to zero. Some activities, such as migration, require more energy than other activities, such as digestion, and thus require a narrower temperature range. (Bottom) A decrease in aerobic scope due to an environmental stressor can render migration impossible. *Adapted from Whitney et al. (2016).*

10. Will the project reduce effects of climate change? Please describe.

While the infrastructure and life cycle monitoring station will not be able to reduce the effects of climate change with a good monitoring program we will be unable to assess the impacts of climate change (e.g. how climate change is altering migration patterns) or make recommendations on what project operations are needed to combat climate change impacts. The data generated from this project will be used to recommend management flow enhancement strategies that can mitigate for future climate change conditions, such as decreased magnitude and timing of spring flows.

APPROACH/FEASIBILITY

11. Has the applicant completed the environmental documents (including CEQA, which is required prior to WCB approval of funding for implementation) and obtained the necessary State, federal and local permits for the projects? If not, give the current status and expected completion date(s).

- If the proposed project qualifies for a CEQA exemption(s), please specify which exemption and why it qualifies. If the project does not qualify for a CEQA exemption, specify who is the "lead agency" under CEQA, the status of preparing the environmental review document, and your views as to which type of document would be required for the project. Provide the State Clearinghouse Number if available. For more information on CEQA, visit: https://www.califaep.org/ceqa/ceqa-flowchart.

Feasibility of this kind of project depends on the capabilities of the participants of the technical team, the organization of the team, availability of equipment, and the necessary state and federal permits to do the work. Our research team are experts in their respective fields and are intimately familiar with the Central Valley's rivers and delta and with the agency personnel who work in the system. Moreover, we have the knowledge and resources to carry out the work proposed in this project.

One of the biggest hurdles in conducting a field study in the Delta is the ability to obtain permits for sampling waters where ESA/CESA listed species occur. The first six months to a year of the proposed project involves the formation and collaboration of a technical team, including state and federal representatives, to develop a research and life cycle monitoring station that satisfies CEQA requirements prior to installation. Representatives from CDFW, NOAA, EBMUD and TU have provided letters of support indicating their willingness to be involved in the technical team with a goal to establish a well-designed steelhead research and life-cycle monitoring station in the San Joaquin Basin. In addition, representatives from USFWS, DWR, and BOR have indicated their willingness to participate and be part of the technical team. Previous weir based life-cycle monitoring station projects performed by one of the sub-contractors (Cramer Fish Sciences) did not require a CEQA permit. However, once the monitoring plan objectives have

been set and the design is developed by the technical team we will apply for CEQA, if necessary. In addition, CDFW streambed alteration permits and additional State, federal, and local permits for the project will be obtained. Our team already has many of the State, federal and local requisite collection permits to perform the work of this project. Lenny Grimaldo, Brad Cavallo and Steve Zeug have State CDFW Scientific Collector Permits. Lenny Grimaldo also possess a federal ESA Section 10-a Recovery Permits for incidental take of delta smelt (USFWS TE-36109B-0), steelhead and winter-run Chinook salmon (NMFS 19400), and a CDFW 2081 MOU Permit for longfin smelt. All permits are valid through 2018. If this project is funded by WCB amendments will be made to all permits to include take of steelhead.

Previous experience suggests that this team can accomplish the proposed work (See biographical summaries under the section PROJECT TEAM QUALIFICATIONS). In addition, most of the members of this team have worked in the Delta in various capacities on substantial research projects related to salmonids. A research project of this scale requires close collaboration and frequent communication with the scientific community to ensure that impacts to target and non-target species are limited by coordinated sampling efforts. The team has an excellent track record of working with Delta agencies (CDFW, CDWR, USFWS, USBR, MWD, SFCWA, SWRCB, IEP, and the DSP) to ensure project success.

Finally, we do not anticipate natural, financial, or operational limitations will prevent us from conducting our work. There is a potential that steelhead will be rare and in low abundance as a result of a prolonged drought; however, 2016 was a moderate water year, suggesting that fish should have good returns by 2018.

12. What would happen to the project if no funds were available from the WCB? What project opportunities or benefits could be lost if the project is not implemented in the near future? Explain:
    - If WCB awards only partial funding, are other funding sources available?
    - We coordinate with other funders. Have you applied to other funding entities, Prop 1 or other, for all or part of this project? Identify these entity(ies).

If no funds were available from the WCB a life cycle monitoring station for steelhead would not be established in the San Joaquin River, there would be no monitoring program to generate data and no program to generate the best available science on the timing of steelhead delta entry, stream flow patterns, hydrologic conditions, and environmental variables correlated with juvenile migration and Delta entry, no estimates of juvenile and adult abundance, and no determination of the percentage of San Joaquin Basin juveniles salvaged at the South Delta export facilities. Management actions involving water project operations will continue to be uninformed because data are lacking on steelhead abundance and timing of delta entry during periods of migration. In addition there will be no life cycle monitoring station in place to assess the benefits of enhanced

flow actions for steelhead. As part of the ground work for this application we've spent a lot of time reaching out to other non-profits, resource agencies, and water agencies to promote this project and secure participation of these organizations and individuals on the technical team which will develop, pilot, and refine a steelhead life cycle monitoring station to asses stream flow enhancement actions and generate information needed to manage resilient steelhead populations. Despite funding not yet having been secured, we have still managed to garner support for the proposed multi-stakeholder approach to design a life-cycle monitoring station. Included in this support are commitments (including in-kind services) from resource agencies, water users, and non-government organization biologists to participate in the technical team. If WCB does not fund this project it will be a missed opportunity to achieve a rare collaborative solution to the widely recognized need for improved steelhead monitoring data in the San Joaquin Basin.

If the WCB only awarded partial funding there are no other funding sources immediately available to fund the proposal. There is potential to apply to future CDFW Proposition 1 solicitations and CVPIA charters, however given the short timeline of the WCB Prop 1 (projects must be completed by 30 April 2021) these other funding sources would not be available until part way through the project and funding is not guaranteed.

At this point in time we have not applied to other funding entities.

13. Is (are) the landowner(s) willing to allow the construction of the project and agreeable to the proposed maintenance plan for the project on a long-term basis (typically, 20 years or more)? See Solicitation Section 3.7

    - If access or long-term maintenance is required from a party other than the perspective grantee, provide a draft landowner access agreement.

Not applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and thus long-term implementation agreements have been explored but not agreed upon, therefore the landowners have not been approached about their willingness to allow the construction of the project and the proposed maintenance plan for the project on a long-term basis (typically, 20 years or more).

14. Willing Seller: Projects that involve acquisition of water, water rights and/or property must involve a willing seller. If your project includes acquisition, please describe the status and expected conclusion of landowner negotiations.

Not applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and thus is not an acquisition project and does not have a willing seller.

SCIENTIFIC MERIT – SCIENTIFIC BASIS

15. Describe the scientific basis of the proposed project illustrating how the best available science will be utilized and how, if relevant, the project will address key scientific uncertainties and fill information gaps. How will the data collected be managed and made publicly available?

PURPOSE AND BACKGROUND

The purpose of this project is to generate the best available science needed to enhance stream flows for ESA-listed San Joaquin Basin steelhead populations by developing 1) a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations and 2) infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions.

Designing stream flow strategies that benefit Endangered Species Act-listed Central Valley steelhead (*Oncorhynchus mykiss*) is especially challenging because *O. mykiss* express both anadromous ('steelhead') and resident ('rainbow trout') life histories. Steelhead populations in the San Joaquin Basin (the Southern Sierra Diversity Group; SSDG) are recognized as particularly imperiled; however, recovery actions are limited by a poor understanding of the distribution of, and gene flow between, steelhead and rainbow trout (Lindley et al. 2007).

The lack of a robust monitoring program in the San Joaquin River is currently limiting informed stream flow enhancement actions for steelhead. Data generated from the life cycle monitoring station proposed here will reduce uncertainty about the status of steelhead and facilitate the evaluation and prioritization of current and future enhanced flow actions intended to increase survivorship of steelhead through the San Joaquin River and Delta. Enhanced stream flow can be achieved through a combination of water releases from reservoirs in the San Joaquin Basin and export restrictions from CVP/SWP. This life cycle monitoring station will be a valuable tool for assessing effects of these different stream flow enhancement actions on steelhead and provide SDM framework for evaluating alternative stream flow enhancement actions.

In the National Marine Fisheries Service's 2009 Biological Opinion on the long-term operation of the SWP and CVP, two actions regulating flow were specified as reasonable and prudent alternatives (RPAs) to protect San Joaquin River-origin steelhead smolts as they migrate through the Delta on their way to the Pacific Ocean (NMFS 2009). The first action limits the ratio of water that can be pumped from the facilities relative to the amount of discharge into the Delta from the San Joaquin River (I:E ratio, Action IV.2.1 in place April to May). The second action limits net flows toward the facilities in the Old and Middle River corridor (controlled primarily through exports, Action IV.2.3 in place January to March). Both of these actions are intended to reduce entrainment of salmonids and steelhead into the facilities and enhance San Joaquin River stream flow to provide conditions favorable for successful migration. The actions are in effect from January to May when SSDG steelhead are thought to be most abundant in the Delta. Data

to inform these actions is limited because sufficient monitoring is not being implemented. Here, we propose an effort where an adaptive management facilitator will guide a scientific technical team of stakeholders (see Community Support and Collaboration) in the development of a SDM framework to adaptively manage stream flow enhancement actions to benefit steelhead and infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions..

Integration with current monitoring efforts

Enhancing stream flows for a species requires knowledge of the structure and performance of the population of interest. First and foremost, the abundance and timing of SSDG steelhead arrival in the Delta is a crucial piece of information needed to guide when stream flow enhancement or reduced water exports measures should be implemented (timing and duration). Given the variability in both California's hydrological cycle and steelhead life history, it is unlikely that fixed calendar year actions (i.e., April and May reductions) are providing maximum intended benefits to SJR steelhead. Second, without population estimates, it is impossible to ascertain if the number of steelhead salvaged at the SWP and CVP represents a significant portion or small fraction of the emigrating population. A system-wide monitoring program that can robustly measure emigrating and migrating steelhead is critically needed to understand such population dynamics.

Currently, there are a few monitoring efforts occurring for steelhead in the San Joaquin Basin but they are typically not operated to capture the full life history of steelhead and do not employ gear that is efficient for measuring steelhead abundance. Screw traps are deployed in tributaries to the San Joaquin Basin primarily to estimate the abundance and timing of juvenile fall run Chinook salmon. Although these traps capture *O. mykiss* fry (and occasionally parr), large populations of resident rainbow trout occur in these tributaries and observations of fry and parr cannot be used to assess behavior or demographics of the anadromous life history type (i.e. steelhead). Additionally, these trapping programs were designed principally to sample juvenile Chinook salmon so they are not operational during the entire steelhead migration window and likely avoided by large (1+ years) migratory steelhead juveniles that are able to swim around the traps. Thus, data from these traps cannot be reliably used to predict how flow enhancements upstream will affect expression and abundance of steelhead smolts, or their arrival time to the Delta. A trawl is operated in the San Joaquin River near Mossdale which is far enough downstream that individuals captured are likely to be migrating toward the ocean. However, this trawl rarely captures steelhead, with only 139 individuals (0.2% of total catch) sampled between 1994 and 2011. The reason for this may be related to the rarity of steelhead smolts, but this is difficult to conclude because the trawl operates during daylight hours, whereas anadromous salmonids primarily migrate at night (McDonald 1960, Blake and Horn 2006, Chapman et al. 2013). Additionally, the duration of each tow is short (10-30 minutes) relative to the large volume of water in the channel. Thus, the trawl is poorly configured for capturing a relatively rare species that likely moves through the sampling area when it is not operating.

Given the issues with current monitoring programs identified above, a new effort would need to 1) sample during the period when steelhead are migrating, 2) have a high enough capture efficiency to sample a relatively rare species, and 3) not allow large juveniles to easily avoid the trap.

APPROACH AND FEASIBILITY

Technical team process

The ultimate objective of enhanced stream flow is to benefit steelhead and contribute to the recovery of steelhead populations. The technical team will set mean management objectives to reach this ultimate goal (e.g. capacity to learn, reducing cost, reduce impact to stakeholder). The technical team will also determine the infrastructure that should be used to develop a monitoring system that will be able to evaluate the means objectives identified by the technical team (e.g. where and how to implement a sampling program to meet means objectives). The technical team will include members with expertise in fisheries biology, hydrology, geomorphology and compliance and will be modeled after the Science Integration Team (SIT). SIT is a technical team that is led by an adaptive management facilitator and is tasked with quantifying research priorities for the Central Valley Improvement Act Anadromous Fish Restoration Program's goals to double anadromous fish populations. Many of the members on the SIT will also be represented on our proposed technical team. The monitoring data generated from this project will support monitoring data that the SIT will need to inform its steelhead decision support model The technical team will be led by an independent facilitator experienced in developing structured decision making frameworks for adaptive management. The role of this independent facilitator is to 1) ensure that all technical team members are able to contribute to the means objectives identified, 2) to summarize technical team member discussions, 3) to facilitate discussion, 4) to ensure that decisions are agreed upon by all individuals in the technical team and 5) progress is made to develop a SDM framework.

Figure 4 outlines the steps which the technical team will go through to develop a SDM framework for adaptively managing stream flow to benefit steelhead populations; items in dashed boxes are the foci of technical team meetings and the solid boxes are deliverables. We will walk through each of the boxes shown in Figure 4.

Objectives Identified

At the beginning of the project the technical team of state, federal, water districts, academics, and non-governmental organizations will participate in a two to three day workshop to divide the ultimate objective of enhanced stream flow to benefit steelhead and contribute to the recovery of steelhead populations into means objective, which is an objective that will help meet our ultimate objective (Conroy and Peterson 2013). Examples of means objectives identified in Kirsch et al. 2016 (in review) for the management and monitoring of adult spring-run Chinook Salmon (Oncorhynchus tshawytscha) returning to the San Joaquin River Restoration Programs (SJRRP)

Restoration Area that could apply here include maximize learning, maximize feasibility, and minimize financial cost.

Concerns Identified

The technical team will identify any concerns that they have with the SDM framework to enhanced stream flow to benefit steelhead and contribute to the recovery of steelhead populations. Examples of concerns may include reducing the cost of the life cycle monitoring station or minimizing impacts of the life cycle monitoring station has to non-target species. It is likely that many of the concerns identified will turn into means objectives that will be listed in the previous 'Objectives Identified' step.

Beginning of Cycle Report (annual deliverable)
This report will include a summary of what means objectives and concerns were identified in the previous steps ('Objectives Identified' and 'Concerns Identified') by the technical team for the SDM framework to enhance stream flow to benefit steelhead.

Design Charrette for Monitoring Plan

The technical team will engage in a design charrette where the actual infrastructure and design of the monitoring system will be developed. The adaptive management facilitator will ensure that the infrastructure and design of the life cycle monitoring station will meet the means objectives and minimizes concerns that the technical team identified in the previous steps. For example, if the mean objective is to maximize learning then the infrastructure and design of the life cycle monitoring station may include infrastructure that facilitates the trapping of fish for sampling (e.g. identified to species, counted, measured, and tissue samples collected for genetic analysis). However, if the mean objective is to minimize impacts to non-target species then the infrastructure of the life cycle monitoring station may not capture fish but instead use cameras to passively count fish as they migrate pass the monitoring station.

As a starting point for discussion, we propose that the technical team consider an angled permeable resistance board weir, capable of sampling adults at the most upstream end and juveniles at the most downstream end. Ideally this life cycle monitoring station would be deployed in November and removed in June to cover the entire period of adult immigration and juvenile emigration. We suggest that the technical team consider that the location of this station be in the mainstem of the San Joaquin River below the confluence of the Stanislaus River but upstream of the limit of tidal influence (Figure 3). The proposed location of the life cycle monitoring station is particularly important. Deploying infrastructure for a monitoring system in this section of river would be farther downstream than any of the current monitoring programs in the San Joaquin Basin. The mainstem location means that fish produced in any tributary would pass this monitoring system. Distinguishing resident from anadromous life history forms is important and a lack of over-summer habitat for rainbow trout in this region of the San Joaquin

River means there is a high probability that juveniles passing this location are exhibiting the anadromous life history form.

We are asking the technical team to start with the evaluation of a weir based life cycle monitoring station to determine if the sampling system could generate data that will meet the means objectives identified because weirs enable many different infrastructure configurations that range from passive to active sampling of fish passing the monitoring station. There are a variety of options that can be employed for passage through a weir. Fish may be allowed to pass unimpeded, with their presence recorded on different types of video equipment, or they may be trapped to permit selective passage and facilitate collection of tissue and record other relevant biological information. These methods are well known and have been used successfully with other populations of anadromous salmonids (Zimmerman and Zabkar 2007).

Background on weir operation

Weirs are a common fish capturing and guidance device that have been used in a wide range of river systems to guide, collect and observe migratory species (Zimmerman and Zabkar 2007). This technology is already deployed in other Central Valley rivers to segregate different races of Chinook salmon and enumerate the numbers of salmon passing into spawning reaches (Anderson et al. 2015). Additionally, similar devices have been used to sample migrating juvenile salmonids of a similar size as steelhead (Furey et al. 2016).

A resistance board weir is a temporary structure composed of positively buoyant panels attached to the substrate that spans the entire width of the channel (Figure 2). This structure guides all fish to a single point of passage in the structure. At this point of passage, fish may be guided to a constriction where they are photographed as they pass upstream, or they may be captured in a live trap that provides an opportunity for tagging and/or collecting tissue samples prior to passing fish. A similar trap can be employed for emigrating smolts on the upstream side of the weir that would provide an opportunity for enumeration, tagging and tissue sampling. A resistance board design can adjust to varying water levels (within a range) because the buoyant panels move up and down as flow fluctuates providing resilience to high or unexpected flow changes. The flow rate the weir can tolerate is a function of depth and velocities, which is site dependent; we suspect the weir could be designed to function at flows up to 3,000cfs. A weir can passively sample over a 24 hour period to encompass the diel periods when steelhead are likely to be migrating and because it can span the entire channel, there will be a large increase in efficiency relative to a trawl.

Having described the benefits of a weir design above, we recognize that a critical part of the collaborative, technical process for developing a long term, robust steelhead monitoring program will involve considering potential tradeoffs of such a life cycle monitoring station on the mainstem San Joaquin River. For example, the location of the weir in the San Joaquin River has potential to affect non-target migratory species (e.g. fall- and spring-run Chinook salmon and

white sturgeon). Another potential concern for locating the life cycle monitoring station in the mainstem could be high turbidity that decreases efficiency of the optical cameras to count fish. The technical team will determine if this type of life cycle monitoring station will be able to meet the means objectives identified by the group. If a weir is unable to meet the mean objectives for the SMD framework the technical team will explore other life cycle model stations that could be deployed.

Monitoring Program Plan (deliverable)

The infrastructure and design of the life cycle monitoring station will be formalized in a monitoring program plan outlined in the previous step 'Design Charrette for Monitoring Plan'.

Data Collection and In season Results Dissemination

The life cycle monitoring station that is designed will be built and deployed in the field for sampling. These periods of deployment will ensure that the infrastructure that make up the monitoring system functions and generates data that will meet the means objectives identified by the technical team. Disseminating within season results to the technical team will provide the opportunity to trouble shoot the monitoring station making adjustment to improve the monitoring station to generate data that will meet the means objectives identified in the SDM framework. We will also conduct efficiency trials with juvenile fish to enable estimates of steelhead abundance outmigrating to the Delta.

End of Cycle Report: What objectives were/not met, lessons to be applied in the upcoming cycle (deliverable)

An "End of Cycle" report will be delivered outlining what objectives were met, what were not, and what lessons can be applied to the upcoming cycle. This is an opportunity to reflect if the data generated by the infrastructure and monitoring system are sufficient to quantify the means objectives for a SDM framework that will meet the ultimate objective of enhanced stream flow to benefit steelhead and contribute to the recovery of steelhead populations.

Once the annual cycle is complete it will begin again for the next season of the project. The technical team will review the means objectives set the previous year and decide if these objectives are sufficient to meet the ultimate objective of enhanced stream flow to benefit steelhead and contribute to the recovery of steelhead populations. If not the technical team can add or subtract means objectives or concerns that were laid out the previous year and thus engage in the cycle laid out in Figure 4 and described above.

The final deliverables will be:

1) A SDM framework that facilitates adaptive management of stream flow enhancement actions that contribute to recovery of San Joaquin Basin steelhead populations

2) Infrastructure to support a functioning life cycle monitoring station for quantifying and evaluating alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions

A final report will include, among other things, a discussion of findings, conclusions, recommendations for follow-up, ongoing, or future activities. This report will include 1) a synthesis of all findings and provide conclusions about the infrastructure for the life cycle monitoring station and how this tool should be used for evaluating stream flow enhancement actions, 2) recommendations for resource management on experiments or studies that use the life cycle monitoring station to evaluate alternative enhanced stream flow actions and current management practices, and 3) future stream flow enhancement actions that could be developed and quantified/evaluated using the SDM framework and monitoring station we have delivered. In addition, all of the information included in the report will be drafted into manuscript in a format suitable for publication in a scientific peer-reviewed journal in which participants of the technical team will all be contributing authors.

Figure 2. Photograph of a resistance board weir in the Stanislaus River. The adult passage is in the foreground and boat passage can be seen in the background. The positively buoyant panels can adjust as flows increase or decrease throughout the sampling season.

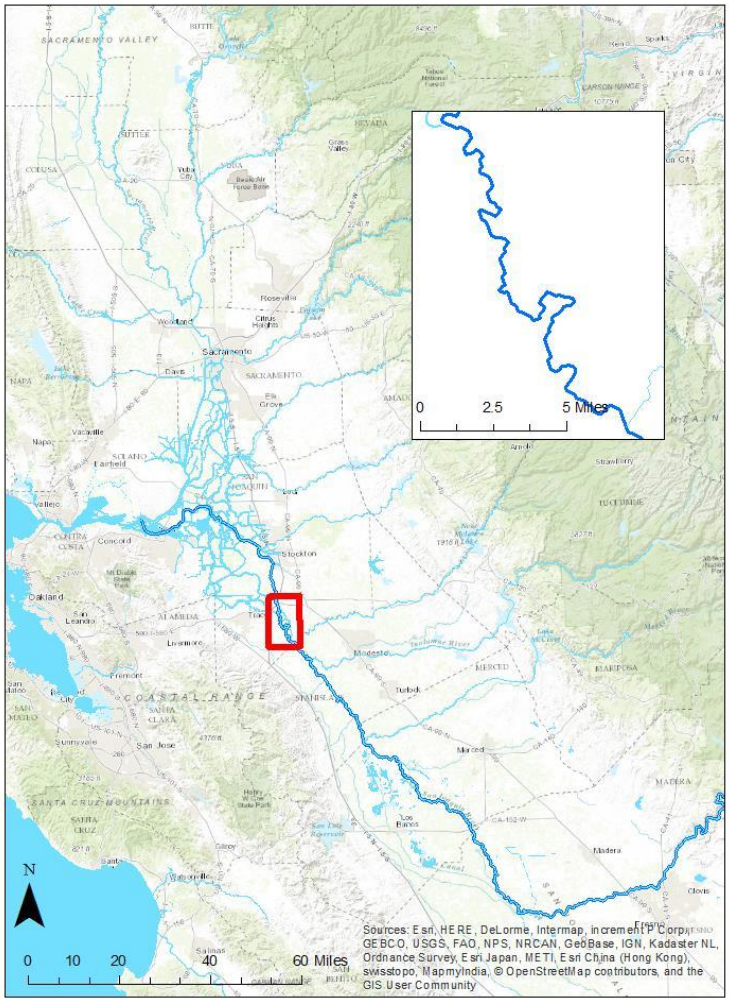

Figure 3. Proposed steelhead life cycle monitoring station on the lower San Joaquin River (red box) between the confluence with the Stanislaus River and the Head of Old River (upstream extent of tidal influence).

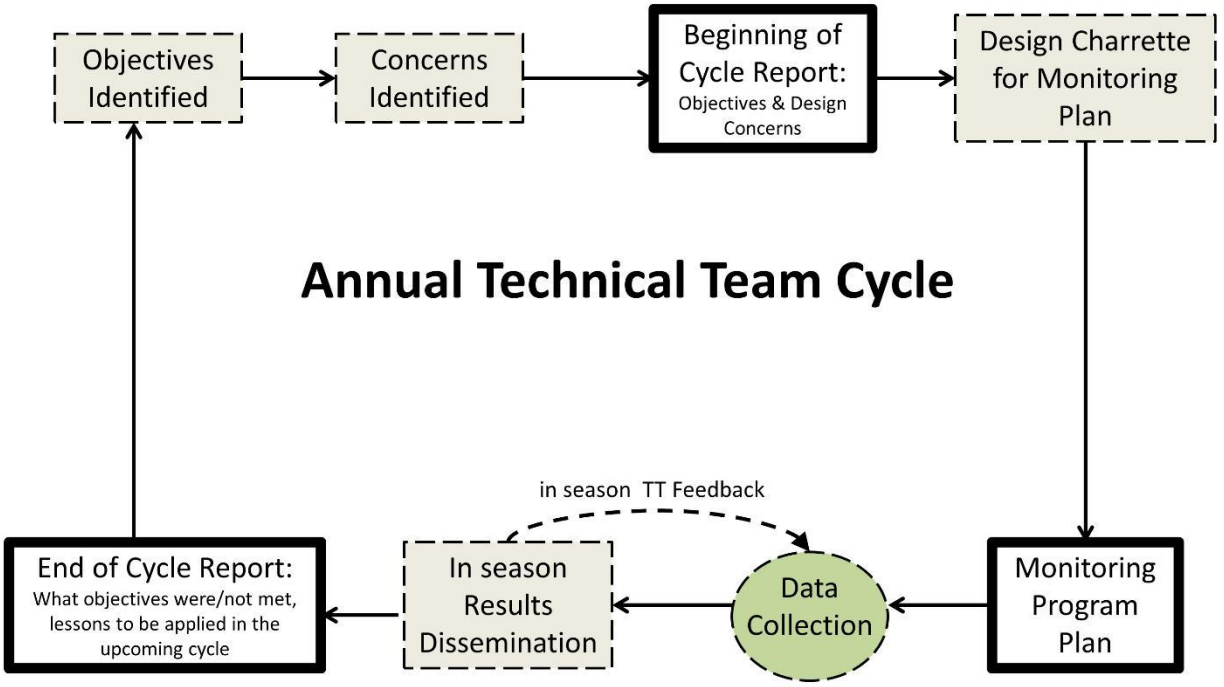

Figure 4. A conceptual model for an Annual Technical Team Cycle. Items in solid boxes are deliverables. Dashed boxes are the foci of TT meetings as it goes through the cycle.

SCIENTIFIC MERIT – SCIENTIFIC BASIS

Lotic fish have evolved a variety of behaviors to take advantage of local stream flow characteristics for reproduction, migration and access to habitats needed to complete their life cycle (Poff et al. 1997, Bunn and Arthington 2002). Declines in lotic fish populations are often attributed to alteration of the natural stream flow regime that interrupts, inhibits or prevents essential ecological processes for these fish (Thorp et al. 2006, Poff and Zimmerman 2010). A major challenge to designing stream flow enhancement strategies that benefit and protect lotic fish species is acquiring knowledge of how different life stages respond to flow variation and the temporal distribution of each life stage in the affected area (Richter et al. 1997, Olden et al. 2006).

Understanding the performance of a population requires reliable indicators of its characteristics. There are several common metrics that are used to characterize the health and dynamics of populations. One of the most common is abundance, how many individuals are in the population? This may be measured at a single life stage or multiple life stages. The ability to use these data requires that abundance is estimated with a level of precision that allows the detection of trends (increasing or decreasing) among years and modeling them as a function of variables that can be controlled by management actions, such as flow. With estimates of the abundance of multiple life stages, it becomes possible to estimate metrics related to population productivity, such as the number of juveniles produced per spawner.

Studies in the Central Valley and elsewhere indicate that the two life-history types of steelhead (anadromous and resident) frequently interbreed and resident fish can produce anadromous offspring and vice versa (Donohoe et al. 2008; Zimmerman et al. 2009; Courter et al. 2013, Kendall et al. 2014) Indeed, expression of the two forms has been shown to be both heritable and environmentally influenced (Thrower et al. 2004, Sloat et al. 2014, Phillis et al. 2016). Studies also indicate that frequency, timing, and the size at which steelhead migration occurs varies tremendously with stream flow mediated growth conditions (Merz 2002, Satterthwaite et al. 2010). Thus, stream flow enhancement strategies can potentially benefit steelhead populations by promoting the conditions that favor expression of anadromy and associated life-history variation (Zimmerman et al 2009, Couter et al. 2013, Kendall et al. 2014).

The life cycle monitoring station we are proposing in the mainstem San Joaquin River builds upon existing programs by reducing uncertainty in timing estimates of steelhead arrival to the Delta and overall abundance estimates for the San Joaquin Basin. If a life cycle monitoring station can be established in the mainstem San Joaquin River there is great potential to couple this with sampling efforts in the tributaries. Leveraging existing monitoring infrastructure in the tributaries would allow for tributary-specific estimates of populations characteristics, including travel time to the Delta, relative smolt production, and stream flow enhancement actions that promote the anadromous life history of steelhead.

Currently, the best source of information on juvenile steelhead in the Delta comes from the South Delta salvage facilities. Data from the State and Federal salvage facilities suggests natural-origin steelhead are most abundant in the months of February and March (**Error! Reference source not found.**), suggesting the RPA action implemented in April and May do not fully match the temporal distribution of steelhead in the Delta. Further, the salvage facilities collect both Sacramento River-origin and San Joaquin River-origin fish; however, there is currently no way to visually determine steelhead basin of origin. Therefore, the ability to assess the benefits of flow management actions for steelhead is significantly inhibited by an inability to monitor the abundance and timing of smolts produced by SSDG steelhead populations.

Knowledge of adult life stages is also currently insufficient to understand steelhead population dynamics. Weirs are operated on San Joaquin River tributaries but are not operated in a way that is useful to answer questions about how enhancing stream flows can benefit resident rainbow trout versus anadromous steelhead and the data are not readily available. Existing weirs in San Joaquin tributaries are principally operated to enumerate fall-run Chinook salmon, but only collect visual (video/infrared) data.

Answers to the following questions are needed to evaluate current stream flow management for steelhead in the Delta and design enhanced stream flows to support recovery of this species.

1) How many San Joaquin River-origin steelhead arrive in the Delta?

2) When do San Joaquin River-origin smolts arrive in the Delta?

3) How do stream flow patterns and other environmental variables correlate with Delta entry of juvenile steelhead?

4) How many (and when) are steelhead adults are entering the San Joaquin Basin?

5) What percentage of juveniles salvaged at South Delta export facilities are estimated to originate from the San Joaquin Basin?

In summary, development of Infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions is a valuable and necessary tool to quantify the success of stream flow enhancement efforts. Data generated from the life cycle monitoring station can be used to assess current management practices and influence future natural resources and efforts to enhance stream flow to benefit and support steelhead. The SDM framework we develop will help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations and guide natural resource managers on how to use the life cycle monitoring station to assess stream flow enhancement actions. Our final report will also provide descriptions of experiments or studies that use the life cycle monitoring station to test effectiveness of enhanced stream flow actions.

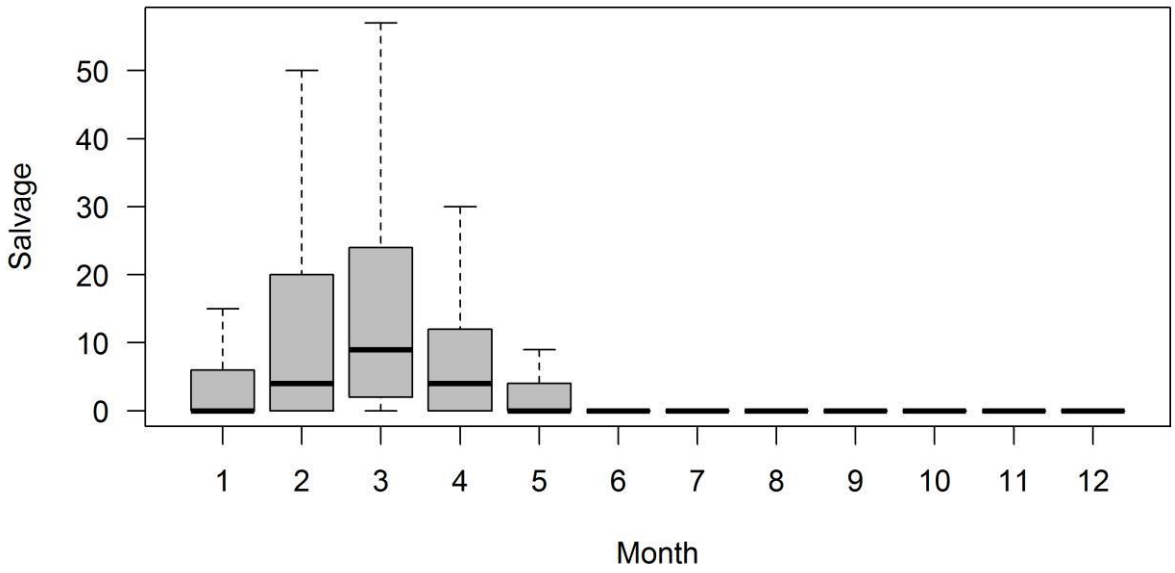

Figure 5. Salvage of wild steelhead at the State and Federal facilities in the South Delta between 1998 and 2014.

MONITORING, ASSESSMENT, AND REPORTING

See section MONITORING, ASSESSMENT AND REPORTING for details how the project will be monitored and assessed to determine project success and reporting deliverables.

DATA MANAGEMENT AND ACCESS

See section Task 1 Program Management *and Administration* – The lead PIs (see section PROJECT TEAM QUALIFICATIONS) will be Alison Collins (MWD), Jason Hassrick (ICF International) and Steve Zeug (Cramer Fish Sciences). Alison Collins will oversee contract execution of the study. Together, all three PIs will manage execution of the study, data management and ensure that the project is carried out on budget and on time.

Task 2 Assemble technical team to develop study design and protocol – Beginning in 2017, the PIs will form and solicit technical input from a team of state, federal and private scientists and other technical experts on the development of a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations. Led by an adaptive management facilitator in developing structured decision models, the technical team will meet for a two to three day workshop as soon as funding is awarded to develop the SDM framework and infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions before any equipment is deployed in the field.

Task 3 Pre-season meeting – (All) Throughout the course of the project the technical team will engage in the annual technical team cycle outlined in Figure 4 and described in the section Technical team process under the section SCIENTIFIC MERIT – SCIENTIFIC BASIS. The purpose of pre-season meetings is to incorporate objectives and concerns identified into each iteration of the sampling season. Jason Hassrick and Steve Zeug will work with CDFW, USFWS and NMFS to amend existing take permits as needed and ensure compliance with CEQA for streambed alteration.

Task 4 Draft protocols for field crew and sampling, life cycle monitoring station installation, testing, and removal – (Cramer/ICF) Protocols for monitoring infrastructure installment and removal, data collection, and monitoring efficiency studies (e.g. mark-recapture) must be updated prior to each sampling season based on any modifications decided upon by the technical team in pre-season meetings.

Task 5 Document objectives and concerns – (All) Objectives and concerns identified by the technical team in the beginning of each monitoring cycle will be formalized in a pre-season report developed by Cramer and ICF that will be used in designing a monitoring program plan in Task 6. Meetings will be held at the beginning, middle and end of each season to evaluate results and make adjustments to SDM framework as needed.

Task 6 Meeting on monitoring plan – (All) The technical team will engage in a design charrette where the actual infrastructure and design of the monitoring system will be developed. The adaptive management facilitator will ensure that the infrastructure and design of the life cycle monitoring station will meet the means objectives and minimizes concerns that technical team identified in the previous steps (Figure 4).

Task 7 Draft annual monitoring plan – (Cramer/ICF) The infrastructure and design of the life cycle monitoring station will be formalized in a monitoring program plan outlined in during the design charrette process for the monitoring program plan.

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2018, Nov 2018-June 2019, Nov 2019-June 2020, Nov 2020-Jan 2021. We recognize that no sampling gear is perfectly efficient; weirs can be overtopped in high flows, rotary screw traps are more easily avoided by large fish, and beach seines and trawls do not sample continuously. To estimate the efficiency of our juvenile sampling design we will perform efficiency tests in the second and third year of the project. The detection efficiency of the sampling design will be estimated using mark-recapture methods whereby a known number of marked smolts are released upstream and later recaptured at the sampling station. Estimating detection efficiency is necessary to convert the total number of smolts observed at the monitoring station in to an estimate of total smolt abundance.

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Task 12 End-of-project meetings – (All) Four technical team meetings will be held in the final year of the project to develop the final report and manuscript that will include a discussion of findings, conclusions, recommendations for follow-up, ongoing, or future activities. For more details on what this report and draft manuscript will entail please see section Technical team process.

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and contribute to recovery of San Joaquin Basin steelhead populations and how to use the developed infrastructure that will support a functioning life cycle monitoring station to quantify and evaluate alternative stream flow enhancement actions. The framework documented in this plan will be a key deliverable for resource agencies to use in guiding evaluation of the effectiveness and success of alternative stream flow enhancement actions on twenty-year planning horizons.

DATA MANAGEMENT AND ACCESS for details on how project information and data will be handled, stored, and made publicly available.

16. Identify any new or innovative technology or practices that will be used, and explain rationales for their use.

Several innovative technologies will be used during this project. A resistance board weir has not been deployed as far downstream as we are proposing for sampling anadromous fishes in the San Joaquin River. Although this type of weir is not new, it will be deployed to sample both adult and juvenile steelhead simultaneously (Figure 5). In collaboration with CDFW the life cycle monitoring station can provide sampling opportunities related to their current steelhead life cycle monitoring station in the Sacramento Basin by providing opportunities to detect fish that were previously implanted with PIT tags. Fish that CDFW tags in the Sacramento River or its tributaries can then be detected if they stray into the San Joaquin Basin when returning to spawn. Additionally, opportunities to collect fish in the mainstem San Joaquin River can be combined with upstream monitoring efforts in the tributaries to gain a more complete picture of steelhead ecology. Opportunities will also be available to obtain data on Chinook salmon and white sturgeon that will pass the life cycle monitoring station during their respective migrations.

Although the technical team will make final decisions on methodology, it is likely that optical video will be used at some point during weir deployment. Video images can be further processed using imaging software to identify individual fish when they are recaptured at other locations and may assist in estimation of population metrics. For example, fish can be “captured” with an image at the proposed monitoring station and then “recaptured” with an image at one of the upstream weirs in the San Joaquin River tributaries. This would provide information on the distribution of individuals among tributaries and pre-spawning survival of retuning adults. In addition, genetic techniques can be used to answer questions about steelhead that would be difficult to answer with traditional fisheries techniques.

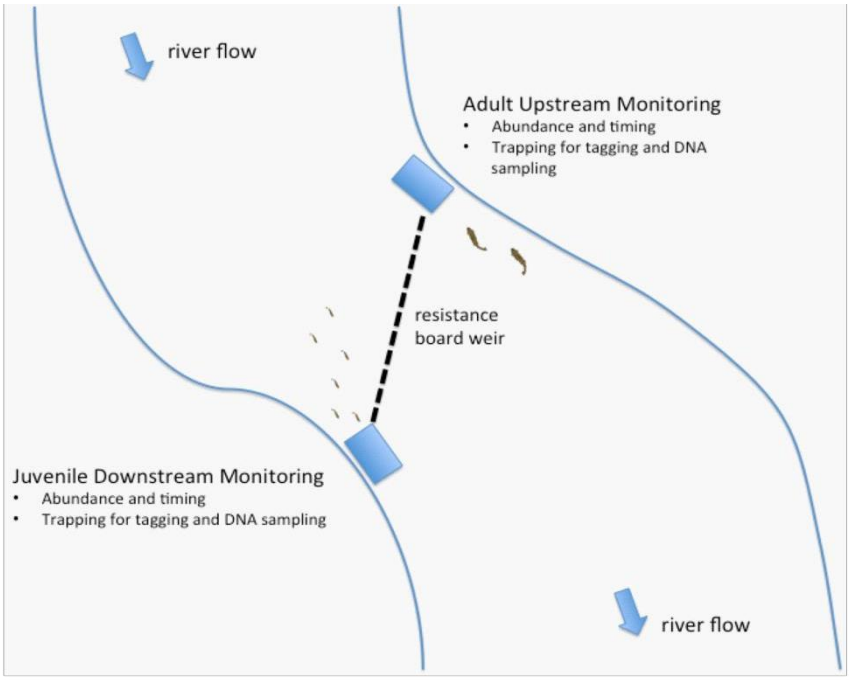

Figure 6. General representation of weir design with passage for both juveniles and adults.

MONITORING, ASSESSMENT AND REPORTING

17. For projects involving restoration, construction or land acquisition, describe your 20-year management and monitoring plans. As appropriate for meeting project and program objectives, WCB advocates including the costs for gauging or metering equipment necessary to capture flow results.

    - Who will be responsible for implementing ongoing management and monitoring?
    - Beyond the proposed estimated completion date, who will be responsible or what options will the applicant pursue for funding the projects long-term monitoring and management?

Not applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and thus a 20-year management and monitoring plan is not applicable at this time. Alison Collins (MWD) will be responsible for implementing ongoing management and monitoring of the project during the duration of the four year grant agreement. Beyond the proposed estimated completion date of the project (April 2021) we will pursue funding for the implementation of the projects long-term monitoring and management. We will re-apply to this WCB application under the implementation category to help jump-start the long-term implementation of this project. We will also actively seek other opportunities for grant funding (e.g. CDFW Proposition 1 solicitations, CVPIA charters, etc). However, if the proposal is funded this year we will have a technical team of stakeholders from various non-profits, resource and water agencies, and the

technical team can begin to look for long-term funding sources from group collaboration or applying to other grants solicitations.

18. Describe in detail how the proposed project will be monitored and assessed to determine project success.
    a. Describe your plans for compiling baseline data. (For acquisition projects please review Solicitation Section 2.2)
    b. Describe your plans for implementing adaptive management strategies, if necessary.
    c. How will enhancements to flow be monitored and reported?
    d. How will benefits to fish and/or wildlife be documented and monitored?
    e. How will improvements to water quality be documented and monitored?
    f. How often will reports be issued giving an analysis of the data?
    g. Who is responsible for analyzing the data and issuing reports?
    h. Provide key contact information if another agency, program, or individual will be collecting, storing, and evaluating the flow, biological and water quality data.

Few baseline data exist for steelhead in the San Joaquin Basin, and a fundamental goal of the proposed project is to develop infrastructure to support a life cycle monitoring station that will generate baseline data on steelhead abundance, conditions and timing of migration for the juvenile and adult life stages and can be used to evaluate enhanced stream flow actions. The technical team will develop a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations. The technical team will engage in an iterative design and discussion process that will set mean management objectives to reach this ultimate goal of enhancing stream flow to benefit steelhead and contribute to the recovery of steelhead populations (refer to details of the technical team process in the section Purpose and Background
The purpose of this project is to generate the best available science needed to enhance stream flows for ESA-listed San Joaquin Basin steelhead populations by developing 1) a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations and 2) infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions.

Designing stream flow strategies that benefit Endangered Species Act-listed Central Valley steelhead (*Oncorhynchus mykiss*) is especially challenging because *O. mykiss* express both anadromous ('steelhead') and resident ('rainbow trout') life histories. Steelhead populations in the San Joaquin Basin (the Southern Sierra Diversity Group; SSDG) are recognized as particularly imperiled; however, recovery actions are limited by a poor understanding of the distribution of, and gene flow between, steelhead and rainbow trout (Lindley et al. 2007).

The lack of a robust monitoring program in the San Joaquin River is currently limiting informed stream flow enhancement actions for steelhead. Data generated from the life cycle monitoring station proposed here will reduce uncertainty about the status of steelhead and facilitate the evaluation and prioritization of current and future enhanced flow actions intended to increase survivorship of steelhead through the San Joaquin River and Delta. Enhanced stream flow can be achieved through a combination of water releases from reservoirs in the San Joaquin Basin and export restrictions from CVP/SWP. This life cycle monitoring station will be a valuable tool for assessing effects of these different stream flow enhancement actions on steelhead and provide SDM framework for evaluating alternative stream flow enhancement actions.

In the National Marine Fisheries Service's 2009 Biological Opinion on the long-term operation of the SWP and CVP, two actions regulating flow were specified as reasonable and prudent alternatives (RPAs) to protect San Joaquin River-origin steelhead smolts as they migrate through the Delta on their way to the Pacific Ocean (NMFS 2009). The first action limits the ratio of water that can be pumped from the facilities relative to the amount of discharge into the Delta from the San Joaquin River (I:E ratio, Action IV.2.1 in place April to May). The second action limits net flows toward the facilities in the Old and Middle River corridor (controlled primarily through exports, Action IV.2.3 in place January to March). Both of these actions are intended to reduce entrainment of salmonids and steelhead into the facilities and enhance San Joaquin River stream flow to provide conditions favorable for successful migration. The actions are in effect from January to May when SSDG steelhead are thought to be most abundant in the Delta. Data to inform these actions is limited because sufficient monitoring is not being implemented. Here, we propose an effort where an adaptive management facilitator will guide a scientific technical team of stakeholders (see Community Support and Collaboration) in the development of a SDM framework to adaptively manage stream flow enhancement actions to benefit steelhead and infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions..

Integration with current monitoring efforts

Enhancing stream flows for a species requires knowledge of the structure and performance of the population of interest. First and foremost, the abundance and timing of SSDG steelhead arrival in the Delta is a crucial piece of information needed to guide when stream flow enhancement or reduced water exports measures should be implemented (timing and duration). Given the variability in both California's hydrological cycle and steelhead life history, it is unlikely that fixed calendar year actions (i.e., April and May reductions) are providing maximum intended benefits to SJR steelhead. Second, without population estimates, it is impossible to ascertain if the number of steelhead salvaged at the SWP and CVP represents a significant portion or small fraction of the emigrating population. A system-wide monitoring program that can robustly measure emigrating and migrating steelhead is critically needed to understand such population dynamics.

Currently, there are a few monitoring efforts occurring for steelhead in the San Joaquin Basin but they are typically not operated to capture the full life history of steelhead and do not employ gear that is efficient for measuring steelhead abundance. Screw traps are deployed in tributaries to the San Joaquin Basin primarily to estimate the abundance and timing of juvenile fall run Chinook salmon. Although these traps capture *O. mykiss* fry (and occasionally parr), large populations of resident rainbow trout occur in these tributaries and observations of fry and parr cannot be used to assess behavior or demographics of the anadromous life history type (i.e. steelhead). Additionally, these trapping programs were designed principally to sample juvenile Chinook salmon so they are not operational during the entire steelhead migration window and likely avoided by large (1+ years) migratory steelhead juveniles that are able to swim around the traps. Thus, data from these traps cannot be reliably used to predict how flow enhancements upstream will affect expression and abundance of steelhead smolts, or their arrival time to the Delta. A trawl is operated in the San Joaquin River near Mossdale which is far enough downstream that individuals captured are likely to be migrating toward the ocean. However, this trawl rarely captures steelhead, with only 139 individuals (0.2% of total catch) sampled between 1994 and 2011. The reason for this may be related to the rarity of steelhead smolts, but this is difficult to conclude because the trawl operates during daylight hours, whereas anadromous salmonids primarily migrate at night (McDonald 1960, Blake and Horn 2006, Chapman et al. 2013). Additionally, the duration of each tow is short (10-30 minutes) relative to the large volume of water in the channel. Thus, the trawl is poorly configured for capturing a relatively rare species that likely moves through the sampling area when it is not operating.

Given the issues with current monitoring programs identified above, a new effort would need to 1) sample during the period when steelhead are migrating, 2) have a high enough capture efficiency to sample a relatively rare species, and 3) not allow large juveniles to easily avoid the trap.

Approach and Feasibility of the Scientific Merit section). The SDM framework to adaptively mange stream flow will be developed and adopted by participating state, federal, water districts, water user consultants, and non-governmental for long-term monitoring and management beyond the estimated completion date of the project (April 2021). The infrastructure that will support a functioning life cycle monitoring station will be developed in accordance with the protocol outline in the Department's Comprehensive Steelhead Monitoring Plan (Eilers et al. 2010, Fortier et al. 2014) and in conjunction with the monitoring efforts currently underway in Sacramento Basin can be used by resource agencies to get Central Valley wide estimates of steelhead. For details on the development of the SDM framework to adaptively manage stream flow and the infrastructure that will support a functioning life cycle refer to details in section

Purpose and Background

The purpose of this project is to generate the best available science needed to enhance stream flows for ESA-listed San Joaquin Basin steelhead populations by developing 1) a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations and 2) infrastructure that will support a functioning life cycle monitoring station that can be used to

quantify and evaluate alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions.

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Given the issues with current monitoring programs identified above, a new effort would need to 1) sample during the period when steelhead are migrating, 2) have a high enough capture efficiency to sample a relatively rare species, and 3) not allow large juveniles to easily avoid the trap.

Approach and Feasibility of the Scientific Merit section. As described in the WCB solicitation the performance of Planning Projects and Scientific Studies will be evaluated based on completion of project deliverables per the grant agreement, however the tasks for completing these phases of the project are described in Table 1.

Table 1. Summary of Performance Measures for developing a structured decision model framework for enhancing stream flow for steelhead recovery in the San Joaquin Basin.

Objective	Description	Outcome
Task 1	Program management and administration	Ensure objectives are met within budget
Task 2	Assemble technical team to develop study design and protocol	Hold an initial workshop with facilitator
Task 3	Pre-season meeting	Identify objectives and concerns (annual)
Task 4	Draft protocols for field crew and sampling, life cycle monitoring station installation, testing, and removal	Protocols updated with each beginning cycle annual report
Task 5	Document objectives and concerns	Beginning annual cycle report
Task 6	Meeting on monitoring plan	Design Charrette
Task 7	Draft annual monitoring plan	Annual monitoring plan
Task 8	Implement a steelhead life cycle monitoring station	Data collection
Task 9	Data management and analysis	Annually archived and distributed to CV steelhead program (CDFW) and hosted on Bay-Delta Live
Task 10	Iterative adaptive management meetings with technical team	Mid-season calls and in-season dissemination of results
Task 11	Objectives met / not met, lessons learned to be applied in next cycle	End of cycle annual report
Task 12	End-of-project meetings	Finalize SDM framework and infrastructure design
Task 13	Final report	Synthesis of findings, conclusions about life cycle monitoring station, recommendations on enhanced stream flow actions that can be evaluated using the SDM framework.

Task 1 Program Management and Administration – The lead PIs (see section PROJECT TEAM QUALIFICATIONS) will be Alison Collins (MWD), Jason Hassrick (ICF International) and Steve Zeug (Cramer Fish Sciences). Alison Collins will oversee contract execution of the study. Together, all three PIs will manage execution of the study, data management and ensure that the project is carried out on budget and on time.

Task 2 Assemble technical team to develop study design and protocol – Beginning in 2017, the PIs will form and solicit technical input from a team of state, federal and private scientists and other technical experts on the development of a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations. Led by an adaptive management facilitator in developing structured decision models, the technical team will meet for a two to three day workshop as soon as funding is awarded to develop the SDM framework and infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions before any equipment is deployed in the field.

Task 3 Pre-season meeting – (All) Throughout the course of the project the technical team will engage in the annual technical team cycle outlined in Figure 4 and described in the section

Technical team process under the section SCIENTIFIC MERIT – SCIENTIFIC BASIS. The purpose of pre-season meetings is to incorporate objectives and concerns identified into each iteration of the sampling season. Jason Hassrick and Steve Zeug will work with CDFW, USFWS and NMFS to amend existing take permits as needed and ensure compliance with CEQA for streambed alteration.

Task 4 Draft protocols for field crew and sampling, life cycle monitoring station installation, testing, and removal – (Cramer/ICF) Protocols for monitoring infrastructure installment and removal, data collection, and monitoring efficiency studies (e.g. mark-recapture) must be updated prior to each sampling season based on any modifications decided upon by the technical team in pre-season meetings.

Task 5 Document objectives and concerns – (All) Objectives and concerns identified by the technical team in the beginning of each monitoring cycle will be formalized in a pre-season report developed by Cramer and ICF that will be used in designing a monitoring program plan in Task 6. Meetings will be held at the beginning, middle and end of each season to evaluate results and make adjustments to SDM framework as needed.

Task 6 Meeting on monitoring plan – (All) The technical team will engage in a design charrette where the actual infrastructure and design of the monitoring system will be developed. The adaptive management facilitator will ensure that the infrastructure and design of the life cycle monitoring station will meet the means objectives and minimizes concerns that technical team identified in the previous steps (Figure 4).

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Task 12 End-of-project meetings – (All) Four technical team meetings will be held in the final year of the project to develop the final report and manuscript that will include a discussion of findings, conclusions, recommendations for follow-up, ongoing, or future activities. For more details on what this report and draft manuscript will entail please see section Technical team process.

Task 13 Final report – (Cramer/ICF) This will serve as a living document of a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations and how to use the developed infrastructure that will support a functioning life cycle monitoring station to quantify and evaluate alternative stream flow enhancement actions. The framework documented in this

plan will be a key deliverable for resource agencies to use in guiding evaluation of the effectiveness and success of alternative stream flow enhancement actions on twenty-year planning horizons.

DATA MANAGEMENT AND ACCESS

19. Refer to Section 3.5, Data Management, of the Solicitation for specific requirements related to data management activities (e.g., geospatial data, water quality data, wetland and riparian *restoration data).*

    Describe how data and other information generated by the project will be handled, stored, and shared (i.e., disseminated to the public, participants, stakeholders, and the State), taking into account the specific requirements stipulated in Section 3.5, Data Management, of the Solicitation. Environmental data collected under these grant programs must be made visible, accessible, and independently understandable to general users in a timely manner, except where limited by law, regulation, policy or security requirements. Unless otherwise stipulated, all data collected and created through WCB-funded grant projects are a required deliverable and will become the property of WCB.
    For Acquisition and Implementation projects, the data management activities described in this section shall cover the monitoring activities described in the Monitoring and Reporting Plan (Solicitation Section 3.4).

We are committed to conducting collaborative science for the Delta community. This project will generate, qa/qc and archive time series data into a Microsoft ACCESS relational database maintained by Cramer Fish Sciences using field data types and business rules that will be compatible with the *Taxonomy* and *Tissue* data templates in the California Environmental Data Exchange Network (CEDEN). Taxonomic data will also be directly served to Bay Delta Live (www.baydeltalive.com), which is an online open data platform of information, accessible by the public, generated to understand the dynamic ecosystem of the Sacramento/San Joaquin Delta, and we will serve it to the Central Valley steelhead monitoring database hosted by CDFW. Housed at NOAA's Southwest Fisheries Science Center, tissue data will be stored in a genetic database to be used for parentage-based analysis of juveniles captured at state and federal fish salvage facilities to determine what proportion of San Joaquin steelhead are salvaged in the south Delta export facilities. We are also committed to making data publically available through an open source Shiny application linked to the R environment (R Development Core Team 2012).

PROJECT TEAM QUALIFICATIONS

20. Describe your organization's qualifications, experience, and capacity to perform the proposed tasks to complete this project as proposed. Provide specific examples of similar projects completed to date.

The Metropolitan Water District of Southern California (Metropolitan) is a regional wholesaler that delivers water to 26 member public agencies, which provides an average of 1.7 billion

gallons of treated and untreated water per day to more than 19 million people in Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura Counties. As a stakeholder in the State Water Project (SWP) and the Sacramento-San Joaquin Delta (Delta), Metropolitan has invested and will continue to invest significantly in the SWP, efforts to restore sensitive fish populations in the Delta watershed, and scientific research into Delta fishes.

Alison Collins, Metropolitan Water District of Southern California

Education: M.Sc. (honors) in Fisheries Ecology from University of British Columbia, B.S. in Marine Biology from University of California at Santa Cruz.

Professional appointments:

2015 – Present: Senior Resource Specialist, Metropolitan Water District, Sacramento, CA

2014 – 2015: Fishery Biologist, NOAA Northwest Fisheries Science Center, Seattle, WA

2012 – 2014: Fisheries Biologist, Ecofish Research, Ltd., Vancouver, Canada

2006 – 2009: Technician, NOAA Southwest Fisheries Science Center, Santa Cruz, CA

Key Products:

1. **Collins, A.L.,** Hinch, S.G., Welch, D.W., Cooke, S.J. and Clark, T.D., 2013. "Intracoelomic acoustic tagging of juvenile sockeye salmon: swimming performance, survival, and postsurgical wound healing in freshwater and during a transition to seawater." *Transactions of the American Fisheries Society*, *142*(2), 515-523.
2. **Collins, A.L.,** Smyth, E., Buchanan, S. and Hatfield, T. 2013. "Tamihi Creek Run-of River Hydroelectric Project – Aquatic Baseline. Report 3: Fish Community Assessment 2012." Consultant's report prepared for KMC Energy Corp. by Ecofish Research Ltd.
3. Healey, K., Sparling, M., **Collins, A.L.,** and Hatfield, T. 2013. "Tamihi Creek Run-of-River Ramping and Connectivity Technical Report." Consultant's report prepared for KMC Energy Corp. by Ecofish Research Ltd.
4. Frechette, D., **Collins, A.L.,** Harvey, J.T., Hayes, S.A., Huff, D.D., Jones, A.W., Retford, N.A., Langford, A.E., Moore, J.W., Osterback, A.M.K. and Satterthwaite, W.H., 2013. "A Bioenergetics Approach to Assessing Potential Impacts of Avian Predation on Juvenile Steelhead during Freshwater Rearing." *North American Journal of Fisheries Management*, *33*(5), 1024-1038.
5. Hayes, S.A., Bond, M.H., Hanson, C.V., Jones, A.W., Ammann, A.J., Harding, J.A., **Collins, A.L.**, Perez, J. and MacFarlane, R.B., 2011. "Down, up, down and "smolting" twice? seasonal movement patterns by juvenile steelhead (Oncorhynchus mykiss) in a coastal watershed with a bar closing estuary." *Canadian Journal of Fisheries and Aquatic Sciences*, *68*(8), 1341-1350.

Bio: Alison Collins is a Senior Resource Specialist with the Metropolitan Water District of Southern California working with the Bay Delta Initiatives team in Sacramento. For the past 10 years, she has worked in academia, as a private consultant, and with the federal National Marine Fisheries Service focusing her research on salmon, steelhead, and trout ecology along the west coast. Alison received her B.S. in Marine Biology from U.C. Santa Cruz and her M.S. from the University of British Columbia. Her research covers a range of topics, including isotope analysis

to determine the contribution of marine subsidies to steelhead diet, acoustic tagging of salmonids to track migration, distribution, and mortality, population assessments of native fishes and aquatic communities to evaluate potential impacts of hydropower facilities on freshwater ecosystems, and the synthesis and evaluation of long term time-series status and trends of fish habitat across the California Current Ecosystem. Her current work at Metropolitan is focused on developing a research program to understand environmental covariates and stressors that influence salmonid, steelhead, and sturgeon abundance, distribution, migration, and mortality and merging these research efforts to better manage water project operations.

Corey Phillis, Metropolitan Water District of Southern California

Education: Ph.D. in Biological Sciences from Simon Fraser University, B.S. in Marine Biology from University of California at Santa Cruz.
Professional appointments:
2015 – Present: Resource Specialist, Metropolitan Water District, Sacramento, CA
2014 – 2015: Fishery Biologist, NOAA Northwest Fisheries Science Center, Seattle, WA
2003 – 2010: Research Associate, University of California at Berkeley, CA

Key Products:

1. Johnson R.C., J.C. Garza, R.B. MacFarlane, C.B. Grimes, **C.C. Phillis**, P.L. Koch, P.K. Weber, M.H. Carr. 2016. "Isotopes and genes reveal freshwater origins and composition of salmon aggregations in the coastal ocean." *Marine Ecology Progress Series*. 548:181-196. http://dx.doi.org/10.3354/meps11623
2. **Phillis C.C.**, J.W. Moore, M. Buoro, S.A. Hayes, J.C. Garza, D.E. Pearse. 2016. "Shifting thresholds: rapid evolution of migratory life histories in steelhead/rainbow trout, *Oncorhynchus mykiss*." *Journal of Heredity* 107(1) 51:60. http://dx.doi.org/10.1093/jhered/esv085.
3. Moore J.W., M.P. Beakes, H.K. Nesbitt, J.D. Yeakel, D.A. Patterson, L.A. Thompson, **C.C. Phillis**, D.C. Braun, C. Favaro, D. Scott, C. Carr-Harris, W. Atlas. 2015. "Emergent stability in a large free-flowing watershed." *Ecology* 96:340–347. http://dx.doi.org/10.1890/14-0326.1.
4. **Phillis, C.C.**, S.M. O'Regan, S.J. Green, J.E.B. Bruce, S.C. Anderson, J.N. Linton, Earth2Ocean Research Derby, B. Favaro. "Multiple pathways to conservation success." *Conservation Letters* 6(2): 98-106. http://doi.org/10.1111/j.1755-263X.2012.00294.x.
5. **Phillis, C.C.**, D.J. Ostrach, B.L. Ingram, P.K. Weber. 2011. "Evaluating otolith Sr/Ca as a tool for reconstructing estuarine habitat use." *Canadian Journal of Fisheries and Aquatic Sciences* 68 (2): 360–73. http://doi.org/10.1139/F10-152.

Bio: Corey joined Metropolitan as a fish biologist in November 2015 with 15 years of experience working with salmon and steelhead in California, Oregon, Washington, and British Columbia. He has a B.S. in Marine Biology from U.C. Santa Cruz and Ph.D. in Biological Sciences from Simon Fraser University. For Metropolitan, Corey uses fish and environmental monitoring data to evaluate and build statistical models that better inform management decisions. Corey has

authored several scientific articles on a range of topics, including how genetics influence a steelhead's decision to migrate to sea, what the chemistry of fish earbones can tell us about the migratory behavior of striped bass in the San Francisco Estuary, and how the interests of scientists, the public, and policy makers shape successful outcomes in conservation science.

Shawn Acuña, Metropolitan Water District of Southern California

Education: Ph.D. in Ecology from University of California at Davis, M.S. in Animal Biology from University of California at Davis, B.S. in Aquatic Biology from University of California at Santa Barbara.

Professional appointments:

2013 – Present: Senior Resource Specialist, Metropolitan Water District, Sacramento, CA
2011 – 2013: Postdoctoral Researcher, University of California at Davis, CA
2004 – 2011: Research Assistant, University of California at Davis, CA
2003 – 2004: Larval Systems Manager, Scientific Hatcheries, Inc., Huntington Beach, CA

Key Products:

1. Hammock, B., Hobbs, J., Slater, S., **Acuña, S.C.,** Teh, S. 2015. "Contaminant and food limitations stress in an endangered estuarine fish." *Science of the Total Environment*. 532: 316-326.
2. Feyrer, F., Hobbs, J., **Acuña, S.C.**, Mahardja, B., Grimaldo, L., Baerwald, M., Johnson, R., Teh, S. 2015. "Metapopulation structure of a semi-anadromous fish in a dynamic environment." *Canadian Journal of Fisheries and Aquatic Sciences*. 72: 709-721.
3. Lehman, P.W., Marr, K., Boyer, G., **Acuña, S.C.**, Teh, S. 2013. "Long-term trends and causal factors associated with *Microcystis* abundance and toxicity in San Francisco Estuary and implications for climate change impacts." *Hydrobologia.* 718: 141-158.
4. **Acuña, S.C.,** Baxa, D., Teh, S.J. 2012. "Sublethal dietary effects of *Microcystis* from the San Francisco Estuary on threadfin shad, *Dorosoma petenense*." *Toxicon*. 60:1191-1202.
5. **Acuña, S.C.,** Deng, D.F., Lehman, P., Teh, S.J. 2012. "Sublethal dietary effects of *Microcystis* on Sacramento splittail, *Pogonichthys macrolepidotus*." *Aquatic Toxicology*. 110:1-8.

Bio: Shawn Acuña is a Senior Resource Specialist for the Bay Delta Initiatives group in Metropolitan Water District of Southern California. He has over 15 years of experience in the field of fish biology and environmental science. He received his B.S. in Aquatic Biology at the University of California, Santa Barbara. After years of working in the field of environmental science and aquaculture he returned to continuing education and received his M.S. in Animal Biology and Ph. D in Ecology with the University of California, Davis. His research spans a wide field of laboratory and field studies from impacts from toxins such as environmental pollutants to toxin producing cyanobacteria blooms, impacts from physical stressors (salinity and temperature), and effects of nutritional stress. He has experience with gross pathology, histopathology, and nutrition and health biomarkers. His current work with Metropolitan has been on assessing responses of listed fish species in the California Delta to environmental

stressors in order to inform better water project management and promote sustainable management of listed fish species.

Lenny Grimaldo, ICF International

Education: PhD in Ecology from the University of California at Davis (UCD), M.S. in Marine Biology from San Francisco State University Romberg Tiburon Center for Environmental Studies. B.S. in Fisheries and Wildlife Biology from UCD.
Professional appointments:
2013 to present-Senior Fisheries Scientist, ICF International, San Francisco, CA.
2008-2013-Senior Fisheries Scientist, United States Bureau of Reclamation, Sacramento, CA.
1997-2008-Fisheries Biologist, California Department of Water Resources, Sacramento, CA.

Key Products:

1. **Grimaldo, L.F.**, F.Feyrer, J.Burns, and D.Maniscalco. Sampling Uncharted Waters Distribution and Rearing Habitat of Larval Longfin Smelt (*Spirinchus thaleichthys*) in the Upper San Francisco Estuary. In review Estuaries and Coasts
2. Feyrer, F.V., J. Hobbs, S.Acuna, B.Marhadja, **L.Grimaldo**, M.Baerwald, R.C. Johnson, S.Teh. 2015. Metapopulation structure of a semi-anadromous migratory fish (Sacramento splittail *Pogonichthys macrolepidotus*) shaped by climate-induced dynamic habitat fragmentation. Canadian Journal of Fish and Aquatic Sciences. 10.1139/cjfas-2014-0433
3. **Grimaldo, L.F.**, R.E. Miller, C.D. Peregrin, and Z. Hymason. 2012. Fish Assemblages in Reference and Restored Tidal Freshwater Marshes of the San Francisco Estuary. San Francisco Estuary and Watershed Science 10: 1-21.
4. **Grimaldo, L.F.**, A.R. Stewart, and W. Kimmerer. 2009. Dietary segregation of pelagic and littoral fish assemblages in a highly modified tidal freshwater estuary. Marine and Coastal Fisheries 1:200–217.
5. **Grimaldo, L.F.**, T.Sommer, N.Van Ark, E.Holland, G.Jones, B.Herbold, P.Smith, and P. Moyle. 2009. Factors affecting fish entrainment into massive water diversions in a freshwater tidal estuary: Can fish losses be managed?" North American Journal of Fisheries Management 29:1253–1270.

Bio: Lenny is a senior fisheries scientist with over 20 years of experience conducting research studies in the San Francisco Estuary. Throughout his career, Lenny has worked on several high profile studies aimed at determining factors that influence restoration success in the estuary. His research has been used to guide restoration targets and actions in the estuary. He also has been pivotal in shaping the research landscape for water diversion studies on delta smelt, one of the most highly endangered fishes in western United States. While at Reclamation, Lenny served as an expert witness on delta smelt on behalf of the United States Fish and Wildlife Service in federal court over litigation of their 2008 Biological Opinion on water operations in the Delta. Currently, Lenny is serving as the lead independent scientist for delta smelt entrainment studies conducted under the Collaborative Adaptive Management Team (CAMT) program for the San Francisco Estuary. In this role, Lenny assembled a team of university researchers, consultants,

and agency biologists to develop information and models that will help water operation management in California's fragile Bay-Delta ecosystem.

Awards: Distinguished Alumni Award from SFSU Romberg Tiburon Center (2013), USBR Star Award or outstanding performance on delta smelt biological opinion litigation (2011), California Department of Water Resources Outstanding Superior Accomplishment Directors Award (2008).

Bradley Cavallo, Cramer Fish Sciences

Education: B.S. Wildlife and Fisheries Biology, University of California Davis. M.S. Aquatic Ecology, University of Montana Missoula.

Professional Appointments
2006-present- Principal Scientist and President, Cramer Fish Sciences, Auburn, CA
1999-2006 Senior Environmental Scientist, California Department of Water Resources, Sacramento, CA
1997-1999- Biologist, California Department of Fish and Game

Key Products

1. **Cavallo, B**., Gaskill, P., Melgo, J., Zeug, S.C**.** 2015. Predicting juvenile Chinook Salmon routing in riverine and tidal channels of a freshwater estuary. Environmental Biology of Fishes DOI 10.1007/s10641-015-0383-7
2. **Cavallo, B.**, P. Gaskill, J. Melgo. 2012. Investigating the influence of tides, inflows, and exports on sub-daily flow in the Sacramento-San Joaquin Delta. Available at: http://www.fishsciences.net/reports/2013/Cavallo_et_al_Delta_Flow_Report.pdf.
3. **Cavallo, B.**, J. Merz, J. Setka. 2012. Effects of predator and flow manipulation on Chinook salmon (*Oncorhynchus tshawytscha*) survival in an imperiled estuary. Environmental Biology of Fish, published online April 2012. DOI 10.1007/s10641-012-9993-5
4. **Cavallo, B.**, R. Brown and D. Lee. 2010. Hatchery and Genetics Management Plan for Feather River Hatchery Spring-run Chinook Program.
5. **Cavallo, B.**, et al., 2004. Steelhead (*Oncorhynchus mykiss*) in a large, regulated tributary of the Sacramento River. Available at: http://www.water.ca.gov/orovillerelicensing/docs/. wg_study_reports_and_docs/EWG/04-28-04_att_10_f10_3A_steelhead_hab_use.pdf.

Bio: Mr. Cavallo is an experienced project and team leader, an effective communicator, and a resourceful problem-solver with more than 15 years of experience working on anadromous and estuarine fishery issues in California. Brad is currently President of Cramer Fish Sciences; previously he served as an environmental scientist with the California Department of Water Resources (DWR) and was the lead scientist for hydropower re-licensing at DWR. In the course of his professional career and education, Brad has attained expert knowledge of regulated rivers and estuaries, particularly related to the ecology of Chinook salmon and other anadromous fishes. He excels in high-level data analysis, including life-cycle modeling and simulation modeling of management impacts, and the development, application, and evaluation of

quantitative models for assessing aquatic habitats and fish population dynamics. Brad has worked on numerous fisheries projects, and possesses expert skill in all sampling methodologies for fishes, water quality, invertebrates, and the evaluation of habitat availability and quality among aquatic vertebrates, including development and application of techniques for assessing aquatic habitats and fish population dynamics.

Jason Hassrick, ICF International

Education: B.A. in Environmental Studies from the University of California, Santa Cruz, M.S. in Biology from Sonoma State University, and Ph.D. in Ecology and Evolutionary Biology from the University of California, Santa Cruz.

Professional Appointments:
10/2015-present-Water Resource Manager / Fisheries Biologist, ICF International, San Rafael, CA.
6/2014-10/2015-Fish Biologist, United States Bureau of Reclamation, Bay-Delta Office, Sacramento, CA.
1/2012-6/2014-Postdoctoral Researcher, NOAA Southwest Fisheries Science Center, Santa Cruz, CA.
1/2011-6/2014-Research Scientist, Farallon Institute, Petaluma, CA.

Key Products:

1. Hayes, S.A., Ammann, A., Harding, J.A., **Hassrick, J.L.**, deWitt, L., and Morgan, C. (In Press). A marine-based hypothesis for the steelhead 'half-pounder' life history, with climate change implications for anadromy in the California Current. North Pacific Anadromous Fish Commission.
2. Wilder R.M., J.L. **Hassrick, L.F.**, Grimaldo, M.F.D. Greenwood, S. Acuña, J.M. Burns, D.M. Maniscalco, P.K. Crain, T-C. Hung. In press. Feasibility of PIT and acoustic tagging for endangered adult Delta Smelt. North American Journal of Fisheries Management.
3. **Hassrick, J.L.**, M.J., Henderson, D.D., Huff, W.J., Sydeman, M.C., Sabal, J.A., Harding, A.J., Ammann, E.D., Crandall, E.P., Bjorkstedt, J.C. Garza, and S.A., Hayes. 2016. Early ocean distribution of juvenile Chinook salmon in an upwelling ecosystem. Fisheries Oceanography, 25(2), pp.133-146.
4. **Hassrick, J.L.**, Crocker, D.E. and Costa, D.P., 2013. Effects of maternal age and mass on foraging behaviour and foraging success in the northern elephant seal. Functional ecology, 27(4), pp.1055-1063.
5. **Hassrick, J.L.**, D.E. Crocker, N.M. Teutschel, B.I. McDonald, P.W. Robinson, S.E. Simmons, and D.P. Costa. 2010. Condition and mass impact oxygen stores and dive duration in adult female northern elephant seals. Journal of Experimental Biology, 213(4), pp.585-592.

Bio: Jason has over 17 years of experience in animal movement behavior and ecological research relating to aquatic science and water resource management in the Central Valley's rivers and in the San Francisco Estuary. He provides leadership in ecological research related to Endangered Species Act (ESA) species life histories by investigating how animals interact with their habitat using various forms of animal telemetry. Jason has worked as a federal agency scientist and for

non-profit and university research groups on biotelemetry research internationally, from Africa and South America to the United States. His postdoctoral research focused on using acoustic telemetry to study winter-run Chinook salmon outmigration movement patterns in the Sacramento River.

Awards: National Science Foundation pre-doctoral fellowship (2004 – 2007). Delta Science Program postdoctoral fellowship (2012-2014), USBR Star award for outstanding performance on fisheries management in relation to drought actions.

Steven Zeug, Cramer Fish Sciences

Education: B.S. in Fisheries Biology, Humboldt State University, Arcata, CA. Ph.D. in Wildlife and Fisheries Sciences, Texas A&M University, College Station, Texas.

Professional Appointments

12/2010-present- Senior Scientist, Cramer Fish Sciences, Auburn, CA.

10/2007-5/2009- Post-doctoral researcher, University of California Santa Barbara, Santa Barbara, CA.

01/2003-06/2007- Research Assistant, Texas A&M University, College Station, TX.

05/2001-07/2002- Scientific Aide, California Department of Water Resources, Sacramento, CA.

Key Products:

1. **Zeug, S.C.,** A. Brodsky, N. Kogut, A.R. Stewart and J.E. Merz. 2014. Ancient fish and recent invaders: white sturgeon (*Acipenser transmontanus*) diet response to invasive species-mediated changes in a benthic prey assemblage. Marine Ecology Progress Series 514:163-174.
2. **Zeug, S.C.** & B.J. Cavallo. 2014. Controls on the entrainment of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) into large water diversions and estimates of population-level loss. PLoS One 9(7): e101479. Doi:10.1371/journal.pone.0101479.
3. **Zeug, S.C.**, K. Sellheim. C. Watry, B. Rook, J. Hannon, J. Zimmerman, D. Cox and J. Merz. 2014. Gravel augmentation increases spawning utilization by anadromous salmonids: a case study from California, USA. River Research and Applications 30:707-718.
4. **Zeug, S.C.,** K. Sellheim. C. Watry, J.D. Wikert and J. Merz. 2014. Response of juvenile Chinook salmon to managed flow: lessons learned from a population at the southern extent of their range in North America. Fisheries Management and Ecology 21:155-168.
5. **Zeug, S.C.**, P.S. Bergman, B.J. Cavallo and K.S. Jones. 2012. Application of a life cycle simulation model to evaluate impacts of water management and conservation actions on an endangered population of Chinook salmon. *Environmental Modeling and Assessment* 17:455-467.

Bio: Dr. Zeug has a wide range of experience, having conducted fisheries investigations in a diversity of aquatic systems from headwater streams in Costa Rica to large floodplain rivers and estuaries in Texas and California. Steve's interests in fisheries biology include: river restoration, population dynamics, community interactions, and food webs. He has extensive experience with the techniques used in the measurement of aquatic communities and has conducted research on a wide range of species from gar and large river minnows to anadromous salmonids and sturgeon. Steve has authored over 20 peer-reviewed papers, multiple technical reports, and many scientific presentations related to ecology and resource management. He has a talent for quantitative analysis and guiding projects from experimental deign to communication with stakeholders and the scientific community. Steve actively leads a team of biologists in numerous projects at CFS ranging from field investigations and monitoring efforts to interdisciplinary modeling of complex adaptive management programs.

SCHEDULE AND DELIVERABLES

21. Describe in detail how the project will be carried out (i.e. provide a work plan). Illustrate the schedule demonstrating the sequence and timing of project tasks, milestones, and deliverables. Provide sufficient detail to illustrate that the project is technically feasible and provide sufficient detail illustrating how each element of the project will be implemented (e.g. methods/ techniques used, material and equipment necessary to complete each element of the project).

January 2017 – June 2017

The technical team will begin with a two or three day work shop in January 2017 following the receipt of funding. The technical team will be facilitated by someone with experience working with these types of groups and will help ensure the best product is put forward. In-kind contributions of staff time will be provided by the Metropolitan Water District (MWD), U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, National Marine Fisheries Service, United States Bureau of Reclamation, and East Bay Municipal Utility District, and Trout Unlimited. Staff from Cramer Fish Sciences (CFS) and ICF international (ICFI) will also participate in the technical team. This technical team will develop a strategy for deploying and operating a life cycle monitoring station with the goal of collecting reliable data on SSDG Steelhead while minimizing impacts on the target species and other species of special concern that may encounter the infrastructure of the life cycle monitoring station. This will include alternative approaches if the most protective techniques do not produced desirable function and efficiency. The deliverable will be a Monitoring Program Plan.

June 2017-November 2017

During this period, all relevant permits will be applied for and the life cycle monitoring station and traps will be constructed. Cramer Fish Sciences will build the life cycle monitoring station and traps and ICFI will apply for all relevant permits. The deliverable will be all project permits (or their applications based on regulatory agency timing) and a functioning life cycle monitoring station.

December 2017- June 2018

The life cycle monitoring station will first be deployed in December 2017 pending the issuance of all relevant permits. This will cover the majority of the juvenile outmigration period but will likely miss some adults migrating in November. However, this can be a time of testing initial life cycle monitoring station function, determining sampling efficiency and proving valuable data on juvenile abundance and migration timing. The technical team will be consulted on any issues with the life cycle monitoring station and updated on the implementation of alternative trapping techniques. The life cycle monitoring station will be deployed, operated and removed by CFS, ICFI, and CCC with in-kind contributions of staff from the MWD. The deliverable will be a technical report on life cycle monitoring station operation and data collection.

November 2018 –June 2019

This period will be the first complete season deployment of the life cycle monitoring station to collect adult and juvenile steelhead. The installation, operation and breakdown of the life cycle monitoring station will be performed by CFS,ICFI and CCC with in-kind staff contributions from MWD. Efficiency trials will be performed by CFS when juvenile Steelhead are available from the Mokelumne River hatchery. The technical team will be kept informed of any issues that occur during in season trapping operations. The deliverable will be a technical report on life cycle monitoring station operation and data collecting during the sample period.

November 2019-June 2020

This period is the second full season of life cycle monitoring station operation for collection of adult and juvenile steelhead. The installation, operation and breakdown of the life cycle monitoring station will be performed by CFS,ICFI, and CCC with in-kind staff contributions from MWD. Efficiency trials will be performed by CFS when fish are available from the Mokelumne River hatchery. The technical team will be kept informed of any issues that occur during in season trapping operations. The deliverable will be a technical report on life cycle monitoring station operation and data collecting during the sample period.

November 2020 − Jan 2021

During this period, the life cycle monitoring station will be installed operated and broken down by CFS, ICF, and CCC with in-kind staff from MWD. However, the limited period will likely miss a portion of adult and juvenile migrants. The limited period is required to ensure that the final project report and other tasks are completed prior to the end of the project.

Jan 2021-April 2021

Data analysis from all periods of life cycle monitoring station operations will occur during this period. The effort will be a joint effort between CFS and ICF with in-kind contributions from MWD. Analyses will include evaluation of different trapping techniques, life cycle monitoring station efficiency, estimates of abundance and the temporal distribution of juveniles and adults arriving at the life cycle monitoring station. These data will be detailed in a final project report

compiled by CFS and ICF with in-kind staff contributions from MWD. The deliverable will be a final project report.

A second technical team will be assembled composed of biologists and managers from regulatory agencies. There is expected to be high overlap with the initial technical team. The purpose of this team is to review the final project report and determine how this tool can be used to test current stream flow strategies for SSDG Steelhead and to design enhanced stream flows to increase the probability of recovery. In-kind services will be provided by multiple agencies that will provide staff for the team. Additionally, CFS and ICF staff will participate on the team. The deliverable will be a final report and draft manuscript on the SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations and how to use the developed infrastructure that will support a functioning life cycle monitoring station to quantify and evaluate alternative stream flow enhancement actions.

BUDGET - APPLICANT MUST USE BUDGET TEMPLATE (DOWNLOAD AT HTTPS://WCB.CA.GOV/). SAMPLE PROVIDED AS APPENDIX B.

22. Provide a complete line item budget for the proposed project. Provide a complete list of all partners contributing toward the project and include: 1) all sources of cash; 2) landowner's contribution; and 3) in-kind services. If in-kind services are to be used as part of the matching requirement, please explain the type of service that will be provided, the number of hours the service will be provided, and the hourly rate associated with the service. Also, be sure to identify any funding that is available for long-term operation and maintenance costs. Submit budget electronically using the attached budget templates.

Please see Appendix B.1 for budget details, Appendix B.2 for subconsultant ICF International, and Appendix B.3 for subconsultant Cramer Fish Sciences.

LEVERAGES OTHER STATE FUNDS

23. Are other STATE funds being leveraged? Describe below and use budget template to illustrate (Provide evidence of match via letters of commitment, contact name and phone number, etc.)

Jonathan Nelson, California Department of Fish and Wildlife, Senior Supervisor Environmental Scientist at the Steelhead Research and Management Program in the Fisheries Branch (916) 445-4506, has provided a letter of commitment to participate in the technical team.

Steve Tsao, California Department of Fish and Wildlife, Environmental Scientist at Region 4 (209) 853-2533 x 6#, has provided a letter of commitment to participate in the technical team.

Kevin Reece, Senior Environmental Scientist-Specialist, , California Department of Water Resources, (916) 376-9709, we have discussed this proposal with USBOR and they are supportive of the proposal and project and have offered to participate on the technical team.

Both Jonathan Nelson and Steve Tsao are unable to offer cost-share contribution to support the project because their program funding source prevents them from being cost share to other projects. However, they have indicated that they both support this proposal (see attached letters of support) and will participate on the technical team.

NON-STATE COST-SHARE FUNDS

24. Does this proposal provide non state (i.e. federal, local, private cost share (either In-kind or cash)? Use budget template available on https://wcb.ca.gov/ to illustrate (provide evidence of match via letters of commitment, contact name and phone number, etc).

Non-state cost-share funds are being offered from several sources, see Table 2 below Appendix B.1 Budget, worksheet 'Cost Share'.

IN-KIND SERVICES

In-kind services or contributions include volunteer time and materials, bargain sales, and land donations. Please describe and estimate value of current and future in-kind contributions.

In-kind services are being offered from several sources, see Table 2 below and Appendix B.1 Budget, worksheet 'Cost Share'

Jose Setka, Manager Fisheries and Wildlife at East Bay Municipal Utility District (EBMUD) has provided a support letter for the project and specified that Michelle Workman, (209)-365-1467, or one of her staff will participate on the technical team.

Rachel C. Johnson, Ph.D., Research Fish Ecologist, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA NMFS), (831) 239-8782, has provided a support letter for the project and has offered a letter of commitment to participate on the technical team.

Steve Lindley, Ph.D., Director, Fisheries Ecology Division, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA NMFS), (831) 420-3921 has provided a support letter for the project and has offered a letter of commitment for his staff to participate on the technical team.

Kim Webb, Project Leader, U.S. Fish and Wildlife Service, (209)-334-2968 x 311, has provided a support letter for the project and has offered a letter of commitment for one of her staff to participate on the technical team.

Donald Portz, U.S. Bureau of Reclamation (USBOR), (916) 978-5461, we have discussed this proposal with USBOR and they are supportive of the proposal and project and have offered to participate on the technical team

Rene Henery, California Science Director at Trout Unlimited (TU), (415) 640-0927, has provided a support letter for the project.

Table 2. Cost share commitments.

Entity Name (Name of Grant Program if applicable)	Cash [1]	Anticipated award date	In-kind [1]	Date Cash Expires	Status S, U (secured, unsecured)	Total
WCB Prop 1 (See Project Budget)	$ 779,855	N/A	N/A	N/A	N/A	$ 779,855
Applicant (MWD)	$ 392,609	N/A	$ 30,000	N/A		$ 422,609
Other State Agency(ies)						
Federal Agency(ies)						
U.S. Fish and Wildlife Service, Donald Ratcliff (209) 334-2968			$ 5,040			$ 5,040
National Oceanic and Atmospheric Administration National marine Fisheries Service, Rachel C. Johnson (831) 239-8782			$ 6,500			$ 6,500
Other sources including Project Partners						
Trout Unlimited, Rene Henery (415) 640-0927			$ 3,500			$ 3,500
East Bay Municipal Utility District, Michelle Workman (209)-365-1467			$ 4,000			$ 4,000
Total Project Cost	**$ 1,172,464**	**N/A**	**$ 49,040**	**N/A**		$1,221,504

COMMUNITY SUPPORT AND COLLABORATION

25. Does the project demonstrate broad-based public and institutional support, at the local, regional, or larger scale? Describe efforts to include stakeholders in project planning, design, outreach/education, implementation, monitoring, maintenance, etc.

A key goal for this project is to collaborate with stakeholders to ensure the best available science from all sources is incorporated into the SDM framework to facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations. Because the ultimate product from this project is to produce a life cycle monitoring station that will be adopted in the long run by California's Department of Fish and Wildlife, it requires support at both regional and local scales to be successful. The first phase of the project is the formation of a technical team of local, state and federal stakeholders to develop a life cycle monitoring station with broad institutional buy-in. This technical team will be modeled after the Science Integration Team (SIT) that is tasked with quantifying research priorities for the Central Valley Improvement Act and the Anadromous Fish Restoration Program to achieve their goals to double salmonid populations in the Central Valley. Many of the members on the SIT will also be represented on the Technical Team because the monitoring data generated from this project will support monitoring data the SIT will need to inform its steelhead decision support model. For more details on how the technical team will complete annual cycle to establish the monitoring program's objectives, concerns and engage in a design charrette" where the actual design of the life cycle monitoring station is fleshed out and agreed upon see Purpose and Background

The purpose of this project is to generate the best available science needed to enhance stream flows for ESA-listed San Joaquin Basin steelhead populations by developing 1) a SDM framework to help facilitate the adaptive management of stream flow enhancement actions to benefit steelhead and contribute to recovery of San Joaquin Basin steelhead populations and 2) infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions as well actions related to habitat restoration, and/or water export restrictions.

Designing stream flow strategies that benefit Endangered Species Act-listed Central Valley steelhead (*Oncorhynchus mykiss*) is especially challenging because *O. mykiss* express both anadromous ('steelhead') and resident ('rainbow trout') life histories. Steelhead populations in the San Joaquin Basin (the Southern Sierra Diversity Group; SSDG) are recognized as particularly imperiled; however, recovery actions are limited by a poor understanding of the distribution of, and gene flow between, steelhead and rainbow trout (Lindley et al. 2007).

The lack of a robust monitoring program in the San Joaquin River is currently limiting informed stream flow enhancement actions for steelhead. Data generated from the life cycle monitoring station proposed here will reduce uncertainty about the status of steelhead and facilitate the evaluation and prioritization of current and future enhanced flow actions intended to increase survivorship of steelhead through the San Joaquin River and Delta. Enhanced stream flow can be achieved through a combination of water releases from reservoirs in the San Joaquin Basin and export restrictions from CVP/SWP. This life cycle monitoring station will be a valuable tool for assessing effects of these different stream flow enhancement actions on steelhead and provide SDM framework for evaluating alternative stream flow enhancement actions.

In the National Marine Fisheries Service's 2009 Biological Opinion on the long-term operation of the SWP and CVP, two actions regulating flow were specified as reasonable and prudent alternatives (RPAs) to protect San Joaquin River-origin steelhead smolts as they migrate through the Delta on their way to the Pacific Ocean (NMFS 2009). The first action limits the ratio of water that can be pumped from the facilities relative to the amount of discharge into the Delta from the San Joaquin River (I:E ratio, Action IV.2.1 in place April to May). The second action limits net flows toward the facilities in the Old and Middle River corridor (controlled primarily through exports, Action IV.2.3 in place January to March). Both of these actions are intended to reduce entrainment of salmonids and steelhead into the facilities and enhance San Joaquin River stream flow to provide conditions favorable for successful migration. The actions are in effect from January to May when SSDG steelhead are thought to be most abundant in the Delta. Data to inform these actions is limited because sufficient monitoring is not being implemented. Here, we propose an effort where an adaptive management facilitator will guide a scientific technical team of stakeholders (see Community Support and Collaboration) in the development of a SDM framework to adaptively manage stream flow enhancement actions to benefit steelhead and infrastructure that will support a functioning life cycle monitoring station that can be used to quantify and evaluate alternative stream flow enhancement actions..

Integration with current monitoring efforts

Enhancing stream flows for a species requires knowledge of the structure and performance of the population of interest. First and foremost, the abundance and timing of SSDG steelhead arrival in the Delta is a crucial piece of information needed to guide when stream flow enhancement or reduced water exports measures should be implemented (timing and duration). Given the variability in both California's hydrological cycle and steelhead life history, it is unlikely that fixed calendar year actions (i.e., April and May reductions) are providing maximum intended benefits to SJR steelhead. Second, without population estimates, it is impossible to ascertain if the number of steelhead salvaged at the SWP and CVP represents a significant portion or small fraction of the emigrating population. A system-wide monitoring program that can robustly measure emigrating and migrating steelhead is critically needed to understand such population dynamics.

Currently, there are a few monitoring efforts occurring for steelhead in the San Joaquin Basin but they are typically not operated to capture the full life history of steelhead and do not employ gear that is efficient for measuring steelhead abundance. Screw traps are deployed in tributaries to the San Joaquin Basin primarily to estimate the abundance and timing of juvenile fall run Chinook salmon. Although these traps capture *O. mykiss* fry (and occasionally parr), large populations of resident rainbow trout occur in these tributaries and observations of fry and parr cannot be used to assess behavior or demographics of the anadromous life history type (i.e. steelhead). Additionally, these trapping programs were designed principally to sample juvenile Chinook salmon so they are not operational during the entire steelhead migration window and likely avoided by large (1+ years) migratory steelhead juveniles that are able to swim around the traps. Thus, data from these traps cannot be reliably used to predict how flow enhancements upstream will affect expression and abundance of steelhead smolts, or their arrival time to the Delta. A trawl is operated in the San Joaquin River near Mossdale which is far enough downstream that individuals captured are likely to be migrating toward the ocean. However, this trawl rarely captures steelhead, with only 139 individuals (0.2% of total catch) sampled between 1994 and 2011. The reason for this may be related to the rarity of steelhead smolts, but this is difficult to conclude because the trawl operates during daylight hours, whereas anadromous salmonids primarily migrate at night (McDonald 1960, Blake and Horn 2006, Chapman et al. 2013). Additionally, the duration of each tow is short (10-30 minutes) relative to the large volume of water in the channel. Thus, the trawl is poorly configured for capturing a relatively rare species that likely moves through the sampling area when it is not operating.

Given the issues with current monitoring programs identified above, a new effort would need to 1) sample during the period when steelhead are migrating, 2) have a high enough capture efficiency to sample a relatively rare species, and 3) not allow large juveniles to easily avoid the trap.
Approach and Feasibility in the section SCIENTIFIC MERIT – SCIENTIFIC BASIS.

We have discussed the project with the California Department of Fish and Wildlife Region 4 and Fisheries Branch, NOAA Fisheries Central Valley Region and the Southwest Fisheries Science Center, United States Bureau of Reclamation's San Joaquin River Restoration Program, California Department of Water Resources Temporary Barriers Program, East Bay Municipal Utility District, United States Fish and Wildlife's Anadromous Fish Restoration Program, State and Federal Contractors Water Agency, San Joaquin Tributaries Authority, State Water Resources Control Board, State Water Contractors, San Luis and Delta-Mendota Water Authority, Westlands Water District, The Nature Conservancy, and Trout Unlimited. Many of these agencies have provided letters of support for the proposal and/or letters of support to participate on the technical team.

26. Which public agencies, non-profit organizations, elected officials, and other entities and individuals support the project and why (attach support letters to application)?

Kevin Reece, Senior Environmental Scientist-Specialist, , California Department of Water Resources, (916) 376-9709, we have discussed this proposal with USBOR and they are supportive of the proposal and project and have offered to participate on the technical team
Jose Setka, Manager Fisheries and Wildlife at East Bay Municipal Utility District (EBMUD) has provided a support letter for the project and specified that Michelle Workman, (209)-365-1467, or one of her staff will participate on the technical team.

Rachel C. Johnson, Ph.D., Research Fish Ecologist, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA NMFS), (831) 239-8782, has provided a support letter for the project and has offered a letter of commitment to participate on the technical team.

Steve Lindley, Ph.D., Director, Fisheries Ecology Division, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA NMFS), (831) 420-3921 has provided a support letter for the project and has offered a letter of commitment for his staff to participate on the technical team.

Kim Webb, Project Leader, U.S. Fish and Wildlife Service, (209)-334-2968 x 311, has provided a support letter for the project and has offered a letter of commitment for one of her staff to participate on the technical team.

Donald Portz, U.S. Bureau of Reclamation (USBOR), (916) 978-5461, we have discussed this proposal with USBOR and they are supportive of the proposal and project and have offered to participate on the technical team

Rene Henery, California Science Director at Trout Unlimited (TU), (415) 640-0927, has provided a support letter for the project.

Stephanie Fong, Acting Science Program Manager at State & Federal Contractors Water Agency (SFCWA), (916) 400-4840, has provided a support letter for the project.

Terry L. Erlewine, General Manager, State Water Contractors, (916) 447-7357, has provided a support letter for the project.

Brittany Kammerer, Brittany.Kammerer@Waterboards.ca.go, State Water Resource Control Board (SWRCB), we have consulted SWRCB about this proposal and they support improving monitoring efforts for steelhead in the San Joaquin River.

Jeanette Howard, Associate Director of Science, Water Program at The Nature Conservancy (TNC), (916) 449-2850, has provided a support letter for the project.

Rene Henery, California Science Director at Trout Unlimited (TU), (415) 640-0927, has provided a support letter for the project.

DISADVANTAGED COMMUNITIES

27. Will the project provide benefits to one or more disadvantaged communities, as described in CWC section 79505.5? Please refer to Section 3.10 of the Solicitation for guidance on how to determine if the project is located within and/or will benefit a Disadvantaged Community.

Using the Department of Water Resources online mapping tool: http://www.water.ca.gov/irwm/grants/resources_dac.cfm, Tract ID Number 06077005501 is closest to the proposed project location, with a population of 4,776 and 658 households, with a median household income of $42,031. In addition to the local community, there are several disadvantaged communities, tracts and places within the service area of the Central Valley Project and the State Water Project, particularly in the Central Valley and greater Los Angeles that will be affected by stream flow recommendations generated by a steelhead life cycle monitoring station. These disadvantaged communities would benefit from the proposed project because a better understanding of steelhead migration timing and enhanced flow requirements allow for more targeted resource management actions. For example, more accurate data may reveal that a 2:1 Delta inflow to export ratio is just as protective for migrating steelhead as the 4:1 ratio that is currently being enforced. Monitoring that reveals which restoration and flow enhancement efforts are most effective and sustainable for steelhead recovery will also result in improved management of water supplies for public health and safety. Furthermore, if monitoring leads to better management of actions that enhance stream flow for fish, resulting efficiencies will also carry benefits for disadvantaged communities that rely on water for agricultural employment and food production.

WATER RIGHTS AND HYDROGEOMORPHIC FACTORS (ANSWER ALL QUESTIONS, EVEN IF THE QUESTION DOES NOT APPLY. N/A WILL BE ACCEPTED IF APPROPRIATE).

28. EXISTING WATER RIGHTS ASSOCIATED WITH THE PROPOSED PROJECT. Please fill out the following table for all of the water rights associated with your project (attach additional sheets if necessary). This information can be found using the State Water Resources Control Board's (State Water Board) Electronic Water Rights Information Management System (eWRIMS): https://ciwqs.waterboards.ca.gov/ciwqs/ewrims/EWPublicTerms.jsp

    If you have difficulty locating your water rights information using eWRIMS, consider calling the State Water Board's Division of Water Rights general helpline for assistance: (916) 341-5300.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and is not an

implementation or acquisition project and there are no existing water rights associated with the proposed project at this time.

APPLICATION OR STATEMENT NO.†	WATER RIGHT TYPE	PRIMARY OWNER	DIVERSION SEASON	DIVERSION AMOUNT*	DIVERSION RATE*
----------Example ----------					
A036958	Appropriative	Joe C. Public	12/15 – 03/31	14 acre-feet	1.0 cfs
Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

† Application numbers are for post-1914 appropriative water rights and start with the letter "A"; statement numbers are for other types of water rights, such as riparian and pre-1914 appropriative rights, and start with the letter "S".
*Include unit of measure

PROPOSED CHANGES TO EXISTING WATER RIGHTS. WOULD IMPLEMENTATION OF YOUR PROJECT REQUIRE CHANGES TO ANY OF THE WATER RIGHTS LISTED ABOVE? IF YES, PLEASE DESCRIBE THE CHANGES, SPECIFY THE PARTIES AND WATER RIGHT(S) INVOLVED (APPLICATION AND/OR STATEMENT NUMBERS), AND ANSWER THE QUESTIONS BELOW.

a) Have you or do you plan to file a petition with the State Water Board seeking approval for the changes described above?

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and a petition with the State Water Board seeking approval for the changes described above is not required at this time.

b) Does your project involve an instream flow dedication? If yes, please explain the anticipated purpose, amount, timing, duration, and geographic scope of the dedication.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and an instream flow dedication is not required at this time. However, once this infrastructure for a mainstem life cycle monitoring station is developed it can be used as a tool to evaluate stream flow conditions and steelhead responses to stream flow enhancement efforts.

c) Petitions for changes to existing water rights for the purposes of preserving or enhancing wetland habitat, fish and wildlife resources, or recreation in or on the water are processed under Water Code section 1707. Do you plan to file a petition pursuant to Water Code section 1707?

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and changes to existing water rights is not required at this time.

d) Have you consulted with the State Water Board or any other local, state, or federal agencies regarding the proposed changes and/or petitions described above? If yes, please describe the scope and outcome of the consultations.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and consultation with the State Water Board or any other local, state, or federal agencies is not required at this time. However, we have consulted with Brittany Kammerer about this proposal to develop infrastructure for a steelhead life cycle monitoring station on the mainstem of the San Joaquin River.

29. INITIATION OF NEW WATER RIGHTS. Would implementation of your project involve the initiation of new water right(s)? If yes, please describe the type of water right(s) involved, the source of water to be diverted, the method of diversion (direct diversion or diversion to storage), diversion amount, diversion rate, diversion season, and purpose(s) of use.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and initiation of new water rights is not required at this time.

30. WATER LEASES. Would implementation of your project involve a water lease? If yes, please specify the water rights(s) involved, describe the scope of the lease(s), and answer the question below.

- Have you consulted with the State Water Board or any other local, state, or federal agencies regarding the proposed the water lease(s) described above? If yes, please describe the scope and outcome of the consultations.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and a water lease is not required at this time.

31. FOREBEARANCE AGREEMENTS. A forbearance agreement is a formal arrangement between an individual or organization and a water right holder that specifies how a water diversion will be managed for instream use. These agreements do not change the terms of the water right, but specify conditions under which a water right holder will forgo diversion to allow water to be left instream. Will implementation of your project involve a forbearance agreement? If yes, please describe the anticipated scope of the agreement, the water rights that would be involved (Application and/or Statement numbers), and the parties that would be signatory to the agreement. Please provide a draft agreement, if available.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and a forbearance agreement is not required at this time.

32. OTHER VOLUNTARY AGREEMENTS. Would implementation of your project involve other formal, voluntary agreements with outside parties or organizations with regard to the operation of existing or pending water rights? If yes, please describe the anticipated scope of the agreement, the water rights that would be involved (Application and/or Statement numbers), and the parties that would be signatory to the agreement.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and voluntary agreements with outside parties or organizations with regard to the operation of existing or pending water rights is not required at this time.

33. TRANSFER OF WATER RIGHT. Would implementation of your project involve a transfer of water or water rights? If yes, please explain the anticipated purpose, amount, timing, and duration of the transfer.

- Petitions for long-term transfers of water or rights involving a point of diversion, place of use, or purpose of use are processed under Water Code section 1735, 1736, and 1737. Do you plan to file a petition pursuant to Water Code section 1735?

- Have you consulted with the State Water Board or any other local, state, or federal agency regarding the proposed changes and/or petitions described above? If yes, please describe the scope and outcome of the consultations.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and transfer of water or water rights is not required at this time.

34. WATER RIGHT COMPLIANCE ISSUES AND ENFORCEMENT PROCEEDINGS. Are there any pending water right compliance issues or enforcement proceedings associated with any of the water rights listed above? If yes, please describe the water rights involved (Application and/or Statement numbers) and the nature of the compliance issues and/or enforcement proceedings.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and water right compliance issues or enforcement proceedings is not required at this time.

35. STREAMFLOW EFFECTS. Quantitatively and qualitatively explain how the water rights changes described above will measurably enhance streamflow, and explain the significance of these effects. Please make sure your answer speaks to the geographic scope, timing, duration, and quantity of the enhancement.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and water rights changes is not required at this time. However, stream flow is a valuable resource and actions to set enhanced stream flows are expensive, therefore it is necessary that infrastructure is developed to monitoring how fishes respond to enhancement actions. Our project will provide valuable information uniquely important and influential to deliberations to identify the timing, durations, magnitude and environmental conditions for stream flow enhancement for mutual benefit of fisheries and water supply reliability that are urgently needed to cope with climate change and potentially more frequent drought conditions.

36. EFFECTS ON OTHER WATER RIGHTS. Please describe how your project will affect water availability for water rights located upstream and downstream of your project.

Not Applicable. This proposal falls under the WCB 2016 Proposition 1 California Stream Flow Enhancement Program Planning and Scientific Studies project category and an evaluation of the effects on other water rights is not required at this time.

HYDROGEOMORPHIC FACTORS

37. EFFECTS OF PROJECT ON STREAM HYDROGRAPH. Will the hydrograph of any stream be altered as a result of the proposed project? If yes, please clearly describe how the hydrograph will be altered.

The proposed project will have no effect on the San Joaquin River hydrograph. Water can pass completely through the weir with only minor changes to water surface elevation and velocity. Weirs have been used in many different stream and river systems and have a small ecological footprint relative to the amount of data generated. Our proposed weir would span all (100-150 meters) of or part of San Joaquin River and would be approximately 10-15m in width (final size will be determined by the technical team) and allow for the flow through of water and the passage of boats (see Figure 1 in "Scientific Merit"). The weir will only be in place during the period of sampling and thus will be constructed and removed on a yearly basis.

38. EFFECTS OF PROJECT ON GEOMORPHOLOGY. Is the anticipated stream flow enhancement significant enough to alter the geomorphology of affected stream channels and floodplains? If yes, please describe how these alterations would affect fish and wildlife.

The proposed project will have no detectable effect on the geomorphology of the San Joaquin River or floodplains. The weir will be placed in a region with very fine sediment and there is the potential for minor accumulation and scour. This is expected to be minimal and have undetectable effects on fish and wildlife. The infrastructure for the weir sits in the water and thus will not alter the river's geomorphology. In addition, the infrastructure for the life cycle monitoring station is only in place during the period of sampling and thus will be constructed and removed on a yearly basis.

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END OF APPLICATION