LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

UPDATED STUDY REPORT

APPENDIX A

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT AND UPPER TUOLUMNE RIVER REINTRODUCTION/FISH PASSAGE ASSESSMENT FRAMEWORK

2016 ENGAGEMENT RECORD

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

TECHNICAL COMMITTEE CONFERENCE CALL

FEBRUARY 16, 2016

FINAL MEETING NOTES AND MATERIALS

La Grange Hydroelectric Project Licensing (FERC No. 14581) Fish Passage Facilities Alternatives Assessment Technical Committee Conference Call

Tuesday, February 16, 2016 11:00 am to 1:00 pm

Final Meeting Notes

	Conference Call Attendees			
No.	Name	Organization		
1	Jenna Borovansky	HDR, Inc., consultant to the Districts		
2	Steve Boyd	Turlock Irrigation District		
3	John Buckley	Central Sierra Environmental Resource Center		
4	Larry Byrd	Modesto Irrigation District		
5	Adrianne Carr	Bay Area Water Supply and Conservation Agency		
6	Jesse Deason	HDR, Inc., consultant to the Districts		
7	John Devine	HDR, Inc., consultant to the Districts		
8	Greg Dias	Modesto Irrigation District		
9	Art Godwin	Turlock Irrigation District		
10	Chuck Hanson	Hanson Environmental, consultant to the Districts		
11	Steve Holdeman	U.S. Forest Service		
12	Zach Jackson	U.S. Fish and Wildlife Service		
13	Bao Le	HDR, Inc., consultant to the Districts		
14	Ellen Levin	City and County of San Francisco (CCSF)		
15	Lonnie Moore	Citizen		
16	Gretchen Murphy	California Department of Fish and Wildlife (CDFW)		
17	Bill Paris	Modesto Irrigation District		
18	Bill Sears	City and County of San Francisco (CCSF)		
19	Chris Shutes	California Sportfishing Protecting Alliance		
20	John Wooster	National Marine Fisheries Service (NMFS)		
21	Ron Yoshiyama	City and County of San Francisco (CCSF)		

On February 16, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted a Technical Committee conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Passage/Reintroduction Assessment Framework. This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document includes the meeting agenda and read-ahead materials.

Meeting attendees introduced themselves. Mr. Le said there are two objectives for this conference call: (1) determine what studies will be completed in 2016 for the Upper Tuolumne River Fish Passage/Reintroduction Assessment Framework (Reintroduction Framework) and (2) begin discussing an approach for developing the reintroduction program goals.

Mr. Devine said one additional meeting objective is to discuss how this conference call and Workshop No. 4 (held on January 27) interface with the upcoming La Grange Project Initial Study Report (ISR) meeting (to be held on February 25) and the overall ISR process. Mr. Devine said the Districts will file a summary of the ISR meeting and then licensing participants will have an opportunity to comment on the meeting summary and request new studies and study modifications. The Districts will then have an opportunity to respond to those comments and then the Federal Energy Regulatory Commission (FERC)

will make a determination on new studies and study modifications. Mr. Devine said part of the rationale of having Workshop No. 4 and this conference call prior to the ISR meeting was to allow time to come to a decision on what studies will be completed in 2016 so that this decision can be documented in the ISR meeting notes, which FERC will review.

Mr. Wooster asked if the Districts have been in communication with FERC about the Plenary Group's (individuals participating in the Reintroduction Framework) activities, given that FERC has not been participating in the Workshops. Mr. Devine said he recently had a call with Mr. Jim Hastreiter (FERC) and briefed Mr. Hastreiter on the Plenary Group's Workshops and recent decisions. Mr. Devine said he told Mr. Hastreiter the Plenary Group is trying to come to a decision on 2016 studies and, if a decision is made, the decision will be discussed at the ISR meeting. Mr. Devine said Mr. Hastreiter had no comment.

Mr. Wooster asked if the 2016 studies to be discussed today will be implemented within the licensing process or outside the licensing process, similar to the upper Tuolumne River studies the Districts are currently conducting voluntarily. Mr. Devine said he envisioned the latter because the 2016 studies will not be held to the licensing process criteria for new studies and conducting the studies outside the licensing process allows for more freedom to collaborate amongst the Plenary Group. Mr. Wooster said he agreed, but there may come a point in the licensing process where a due date arises and the 2016 study results are not yet available. Mr. Devine said that was a good point and it will be important for the Plenary Group to keep FERC informed of its progress and schedule.

Mr. Le reviewed the table of potential studies to inform the Reintroduction Framework (Studies Table). He said the Studies Table was developed by the Districts' technical team and studies included were identified as potential studies that could support reintroduction evaluation. Mr. Le stated that not every study in the Studies Table should or would be completed. As agreed to at the January 27, 2016 Workshop, implementation of the Reintroduction Framework would be phased. Mr. Le said Phase 1 would include completing the 2016 studies and comparing the 2016 study results with the reintroduction goals (also to be developed in 2016). If the study results suggest the reintroduction goals can be met, studies in 2017 (Phase 2) may be implemented.

Mr. Wooster provided an update on the genetics study being completed by NMFS. In 2015, 17 sites were sampled in the upper Tuolumne River for resident *O. mykiss*. A total of 634 samples were collected from those 17 sites. The National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Science Center (NOAA Lab) processed the samples and is currently running the samples through algorithms. Mr. Wooster said the NOAA Lab is happy with the results so far. Mr. Wooster said the NOAA Lab will be presenting the results at a conference in June 2016, so he expected the study results will be available at that time. Mr. Wooster said the second year of sampling will take place this summer and will be informed by the first year of sampling. Samples will also be collected from the Merced River to both compare samples from the Merced River. NMFS also intends to collect samples from the lower Tuolumne River. Although NMFS received lower Tuolumne River samples from CDFW, these samples are somewhat older and NMFS is interested in collecting additional samples. The NOAA Lab will analyze the second-year samples over the winter 2016. A final report will be available by May 2017, and may be available as early as March 2017.

Mr. Wooster said NMFS has some funding for the second year of sampling, but most of the funding will be spent on the lab work, leaving little money for collecting the samples. Mr. Wooster said sample collection will rely heavily on volunteers and the National Park Service may help with sampling on the Merced River.

Mr. Devine asked what the NOAA Lab will present on at the June conference. Mr. Wooster said he did not know much about the June presentation, but he thinks the presentation will include analyses similar to analyses the NOAA Lab completed recently for the upper American River. Mr. Wooster said he did not think a final report had been released on the upper American River analyses.

Mr. Devine asked if Mr. Wooster had a sense of the scope of conclusions or recommendations that may be in the NOAA Lab's Tuolumne River genetics study report. Mr. Wooster said the study includes isolating genetic markers to determine whether there is a propensity toward anadromy and the study report will likely include this analysis. Mr. Wooster said he also expects the report will describe how the Tuolumne River samples might relate to samples from other nearby rivers and to samples from within the larger Central Valley, as well as to known hatchery strains (i.e., hatchery influence or introgression). Mr. Wooster said the report will likely not make recommendations on where to capture fish for broodstock.

Mr. Devine asked if NMFS has received the CDFW permits necessary for collecting samples on the lower Tuolumne River. Mr. Wooster said the NOAA Lab has received the necessary permits. However, due to time and funding constraints, at this time there is not an active plan to sample the lower Tuolumne River. Mr. Wooster said it would be great if individuals volunteered to help collect samples.

Mr. Wooster gave an update on an action item from Workshop No. 4, which was for NMFS to provide an abstract for the climate change study they proposed for consideration. Mr. Wooster said the study would assess the likely effects of climate change on the Tuolumne River. Mr. Wooster said he had been in communication with Ms. Andrea Ray at the NOAA Center for Dynamics in Colorado about producing an abstract for this study but so far an abstract has not been developed. Mr. Wooster said many climate change models predict changes in snow pack and water supply for the region including the Tuolumne River, and these changes would likely influence environmental conditions over the new license period. Mr. Wooster said he anticipated developing an abstract for a risk assessment approach with Ms. Ray, but that this approach would not be specific to the Tuolumne River. Instead, the abstract would describe the methodology and approach for completing a climate change study that could apply more broadly to any FERC licensing proceeding. Meeting attendees decided to table future discussions of a climate change study until an abstract is available for review.

Mr. Wooster asked if the Districts or CCSF have conducted climate change analyses and if these climate change analyses can be translated to flow or temperature impacts for use in this effort. There were no responses. Mr. Moore asked if the Districts or CCSF have ongoing studies related to the drought that could relate to climate change. Mr. Devine said a climate change study was proposed during the Don Pedro Project relicensing process, but FERC did not require the Districts to complete the study. Mr. Devine said the Districts have not completed any work during the Don Pedro Project relicensing process related to climate change.

Mr. Moore asked about the ability to model changes to the Don Pedro Project's releases and operations. Mr. Devine said the Districts produced several models (e.g., an operations model, reservoir model, lower river model, fish models) that can be used to run different outflow scenarios. The Districts provided training on how to use these models and the models are available for use by the public. Mr. Devine said he is unsure how helpful the models would be for modeling climate change impacts because the models do not include the necessary climatological inputs.

Mr. Shutes asked if CCSF has studies looking at climate change and predicting future water availability and surface runoff patterns. Ms. Levin said CCSF has done some basic sensitivity analysis of the effect of changing temperatures on inflow to the Hetch Hetchy Project Reservoir, but the analysis is dated and does not look at water supply. Ms. Levin said CCSF has a study plan that includes more downscaled work, but CCSF is unlikely to take the analysis further and the analysis will not be used to inform decision-making. Mr. Wooster asked if information on the scenarios is available. Ms. Levin said the work was not completed due to insufficient funding and CCSF will revisit the study if funding becomes available.

Mr. Shutes asked if CCSF has a temperature model for the CCSF reservoirs. Mr. Sears said CCSF has a stream temperature model of O'Shaughnessy Dam to Early Intake that was produced by Mr. Mike Deas as part of the Upper Tuolumne River Ecosystem Program (UTREP). Also as part of UTREP, McBain & Trush produced a water storage versus outflow temperature model. Mr. Sears said that is the extent of CCSF's temperature work.

Mr. Shutes asked what the NMFS habitat analysis entails. Mr. Le said the study includes collecting hyperspectral LiDAR data and some ground-truthing. Mr. Le said one of the primary reasons the Districts propose to conduct a separate habitat study is that results from the NMFS study will not be available until late summer, and when the results do become available it may be that additional habitat work including further ground-truthing is necessary. Logistically, it may be extremely challenging to complete any additional fieldwork in the fall, which would require that this study then be conducted in 2017. With regards to the overall Reintroduction Framework schedule, delaying a habitat study to 2017 is of concern to the Districts. Mr. Le said the Technical Committee has already agreed on the importance of having the habitat work completed in 2016 as part of Phase 1, therefore the Districts are interested in doing a habitat study to complement the work being completed by NMFS. Mr. Wooster agreed with Mr. Le's characterization of the NMFS study and said he expects the habitat typing data to be available in August or possibly the end of September. Mr. Devine also agreed with Mr. Le and said the habitat data is essential information. Mr. Devine said the Districts have researched the type of hyperspectral work being used in the NMFS study and reported that the experts the Districts consulted with believe the hyperspectral technique is somewhat experimental. Mr. Wooster asked what would be the scope of the Districts' habitat study since his primary concern is that this study might be duplicative as opposed to complementary to NMFS' effort. Mr. Devine said the scope is not yet determined and the Districts are open to discussing this during development of the study plan.

Mr. Le suggested that as a first step, the Districts develop a study plan for the habitat study in collaboration with the Technical Committee. Mr. Moore agreed. Mr. Wooster disagreed and said from his perspective the money would be better spent collecting data where no data is currently being collected. Mr. Wooster said the NMFS study is a 100 percent census of the study area and the data resolution is on par with data collected in the field. Mr. Devine said part of the Districts' concern with relying on the NMFS data is that a study plan or any other detailed information of NMFS's work is unavailable. Mr. Devine said the NMFS study LiDAR report had only one page about the spectral analysis and did not include anything about accuracy or penetration. Mr. Devine said the Districts are hopeful the NMFS study will produce solid information.

Mr. Wooster clarified that the NMFS study is using hyperspectral LiDAR to assess grain size for sediment out of the water. Mr. Wooster said images were taken in the field to conduct pebble counts. There has been good agreement between the hyperspectral data and the calibration data. Mr. Wooster said he does not have any other written descriptions of the hyperspectral work than what he has previously provided to the Districts.

Mr. Shutes asked for how the spawning gravel study in the Studies Table might overlap with the habitat typing work. Mr. Le said in general a spawning gravel study can be completed as part of a habitat characterization study, but given the importance of the spawning gravel study to the overall evaluation of reintroduction, the Districts decided to propose it as a separate study. Mr. Le said at Workshop No. 4, Mr. Wooster agreed with keeping the spawning gravel study separate. Mr. Wooster said the NMFS

habitat study is primarily looking at bar features at 150 cfs in the mainstem and additional work in the tributaries would be helpful.

Mr. Shutes asked which study or studies NMFS would prefer be completed instead of the Districts' habitat study. Mr. Wooster said he believes the benthic macro-invertebrate (BMI) study is a high priority study and goes hand-in-hand with the habitat typing work and the spawning gravel work. Mr. Wooster said the reservoir transit study should also be a priority and he believes the cost estimate provided by the Districts is low, based on a conversation he had with a NMFS engineer about the study. Mr. Wooster said he will get additional details about why it appears the reservoir transit study cost estimate is low and provide these details to the Technical Committee.

Mr. Le said the Districts at this time are not proposing to undertake a detailed BMI study in 2016. Mr. Le stated that from an ecological feasibility perspective, Phase 1 is designed to focus on physical habitat. If the 2016 study results suggest adequate habitat is available, limiting factor studies, such as the BMI study, could possibly be conducted in 2017 even within the current FERC schedule. Mr. Wooster believes understanding the availability of food (i.e., the BMI study) is just as important as understanding the availability of habitat and spawning gravel and thermal suitability, all of which are being studied in 2016. Mr. Shutes said he agrees the BMI study is a high priority study. Mr. Shutes said conducting the study in 2016 would provide the opportunity to conduct additional sampling in 2017, if 2016 results appear anomalous. Mr. Shutes said it would be helpful to determine upfront which riffles the BMI sampling would focus on. Mr. Shutes believes the study could be done for reasonable cost and noted that on the Feather River, they used high resolution aerial imagery to identify eight or nine riffles from which to sample BMI that effectively informed productivity. Mr. Wooster said from an economies-of-scale perspective, it may make sense to collect the BMI data at the same time as the other 2016 fieldwork. Mr. Devine said the Districts will consider today's discussion about the BMI study, explore alternatives, and will provide feedback on whether they have an interest in conducting this study in 2016.

Mr. Le summarized study decisions made thus far on the call. The Districts will develop a habitat typing study plan and discussions will continue on whether or not the Districts should conduct this study. The Technical Committee agreed the spawning gravel study should be conducted. The Districts will give further consideration to whether or not the BMI study should be completed in 2016. Mr. Le described the regulatory evaluation and socioeconomic scoping studies and asked if anyone on the phone objected to conducting these studies in 2016. There were no responses.

Mr. Devine described the hatchery practices review. Mr. Devine said there have been reports of a selfsustaining kokanee population in Don Pedro Reservoir and anecdotal evidence of self-sustaining populations of resident Chinook and rainbow trout, both of which have been stocked in the past. Mr. Devine said these populations may hamper the successful reintroduction of spring-run Chinook and/or steelhead. Ms. Murphy said a recent paper by Moyle and others mentioned the existence of juvenile Chinook in Don Pedro Reservoir. Ms. Murphy said she would send the paper to Rose Staples (HDR) for distribution to the group. Mr. Devine said the subject of hatchery practices is likely to come up in the future and that it seems advantageous to start collecting the information now. Mr. Wooster agreed that information on hatchery practices would be useful to have and, especially given the relatively low cost of completing the study, there is value in beginning the study this year. Mr. Le said he will revise the Studies Table to have a "p" for the hatchery practices review.

Mr. Shutes asked if any thought had been given to the risk of a reintroduction program introducing pathogens into the upper watershed. Mr. Shutes said it would be helpful to determine whether or not this is something to be concerned about. Mr. Le agreed and said that collecting information on disease profiles can be incorporated into the hatchery practices review. Mr. Devine also agreed.

Mr. Le asked if others have thoughts or input on 2016 studies. There were no responses.

Mr. Devine said the Districts have spoken with their technical team about whether or not it is prudent to consider fall-run Chinook in these studies. Mr. Devine said there are several reasons not to include fall-run Chinook:

- 1. Fall-run Chinook are not included in the NMFS Recovery Plan. If one of the main reasons for the reintroduction program is to advance the Recovery Plan, then the Reintroduction Framework should only consider species in the Recovery Plan (i.e., spring-run Chinook and steelhead).
- 2. There are concerns about the effects of stress from non-volitional passage on fall-run Chinook. CDFW previously expressed concern over the amount of stress placed on fall-run Chinook from passing Dennett Dam.
- 3. There may be adverse interactions between fall-run and spring-run Chinook, such as increased competition. Maintaining genetic separateness is also a concern.
- 4. The risk of predation in the lower Tuolumne River to outmigrating smolts is a significant concern.
- 5. Plenty of habitat for fall-run Chinook already exists in the lower Tuolumne River.
- 6. Passing fall-run Chinook to the upper river may create a population sink.

Mr. Wooster said the issue of whether or not to consider fall-run Chinook in the Reintroduction Framework was discussed by the fish agencies over several months. Mr. Wooster said the issues Mr. Devine raised are reasonable and Mr. Wooster does not have the answers. However, there are many unknowns with reintroducing spring-run Chinook and steelhead and we are still moving forward with those species so it does not seem unreasonable to continue to consider fall-run Chinook. Mr. Devine said the Districts would like meeting attendees to reconsider their position on including fall-run Chinook.

Mr. Le said that with regard to the objective of developing an approach for developing reintroduction program goals, the Districts propose a separate subcommittee be formed. Mr. Le said this Reintroduction Goals Subcommittee would be smaller than the Technical Committee and would develop goals independently from the information collected by 2016 study program. The Technical Committee agreed to form a Reintroduction Goals Subcommittee. Mr. Devine said all are welcome to participate and those who are interested should email Rose Staples (HDR) at <u>Rose.Staples@hdrinc.com</u>.

Mr. Le said the next steps for the Technical Committee are to develop draft study plans, with the goal of discussing these study plans on a conference call in mid-March, ahead of the next Plenary Group meeting (to be held on April 13) where approval of final study plans would be an objective. The Districts will send around a Doodle poll for the date of the next Technical Committee call. Mr. Le said the Districts will prepare notes from this meeting and send these around to the group.

ACTION ITEMS

- 1. The Districts will prepare a habitat typing study plan in collaboration with the Technical Committee.
- 2. Mr. Wooster will provide additional details about why it appears the reservoir transit study cost estimate is low.
- 3. The Districts will consider today's discussion about the BMI study and will provide feedback to the Technical Committee.
- 4. Ms. Murphy will send to Ms. Staples the paper by Moyle and others mentioning the existence of juvenile Chinook in Don Pedro Reservoir. Ms. Staples will send this paper to the Technical Committee (complete).
- 5. Mr. Le will revise the Studies Table to state the upstream hatchery practices study is a suggested study (complete).

- 6. The Districts will send around a Doodle poll for the date of the next Technical Committee call (complete; the next Technical Committee call will be on March 18 from 10:00 am to 12:00 pm Pacific).
- 7. The Districts will prepare notes from this meeting (complete).

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

TECHNICAL COMMITTEE CONFERENCE CALL

FEBRUARY 16, 2016

ATTACHMENT A

MEETING AGENDA AND READ-AHEAD MATERIALS

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La Grange Hydroelectric Project Reintroduction/Fish Passage Assessment Framework Technical Subcommittee Conference Call Tuesday, February 16, 11:00 am to 1:00 pm Conference Line: 1-866-583-7984; Passcode: 814-0607

Meeting Objectives:

- 1. Identify and decide on 2016 studies for the Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework (Reintroduction Framework).
- 2. Prepare schedule for study plan development of identified 2016 studies.
- 3. Identify and decide on a schedule for the development of reintroduction program goals.

TIME	TOPIC	
11:00 am – 11:10 am	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts)	
11:10 am – 12:20 pm	 2016 Studies to Support Reintroduction Framework (All) a. General studies list b. Discuss feedback/comments from Workshop #4 c. Updates on studies in progress d. Discuss and decide: 2016 studies Study plan development schedule for 2016 studies 	
12:20 pm – 12:50 pm	 Reintroduction Program Goals to Support Reintroduction Framework (All) a. Purpose of development of program goals (i.e., metrics for success) in the Reintroduction Framework b. Relationship to Recovery Plan c. Discuss and decide: Development schedule Participants 	
12:50 pm – 1:00 pm	Next Steps (All) a. Schedule next call and agenda topics (e.g., review 2016 draft study plans, etc.) b. Action items	

Potential Studies to Inform Reintroduction Assessment Framework For Discussion and Review
by Technical Subcommittee

Framework Category	Studies	On-going and Potential Studies for 2016 ¹	Cost Estimate	Schedule for Draft Report
Ecological	Limiting Factors Analysis and Carrying Capacity		\$340,000	December 2017
Ecological	Reservoir Transit Study		\$500,000	
Ecological	Interactions with Existing Aquatic Communities		\$250,000	
Ecological	Source Population Assessment		NMFS lead?	
Ecological	Method of Colonization		\$60,000	
Ecological	Genetics Assessment of Existing and Source Populations (NMFS has study on-going)	Х	NMFS lead	April 2017
Ecological	Climate Change Assessment (proposed by NMFS)		NMFS lead?	
Biological	Habitat Typing and Characterization ²	Р	\$240,000	Nov/Dec 2016
Biological	Upstream Migration Barriers	Х	\$220,000	Nov/Dec 2016
Biological	Instream Flow – Habitat Assessment: PHABSIM		\$300,000 ³	
Biological	Water Temperature Monitoring and Modeling	Х	\$350,000	Nov/Dec 2016
Biological	Spawning Gravel Study	Р	\$140,000	Nov/Dec 2016
Biological	Macroinvertebrate Study		\$220,000	
Biological	Swim Tunnel Study of Upper River O. mykiss		\$450,000	
Economic, Regulatory, and Other Key Considerations	Regulatory Evaluation of Reintroduction (ESA Status, BLM/USFS Management Plans, Wild and Scenic, etc)	Р	\$50,000	October 2016
Economic, Regulatory, and Other Key Considerations	Socioeconomic Scoping and Issues Identification/ Preliminary Evaluation of Impacts on Tuolumne River Uses/Users	Ρ	\$50,000	October 2016
Economic, Regulatory, and Other Key Considerations	Hatchery Practices Review, including current Don Pedro related practices.		\$50,000	

Draft Study Abstracts

Limiting Factors Analysis and Carrying Capacity

A limiting factors analysis (LFA) is a useful tool to identify and fill information gaps related to physical and biological factors controlling population dynamics of one or more target species. This type of analysis has been used extensively in California and the Pacific Northwest to identify habitat conditions, ecological interactions, and other factors that constrain salmonid population production potential. The LFA proposed herein would test hypotheses regarding potential factors that that could limit the ability of the upper Tuolumne River to support viable populations of reintroduced Chinook salmon and O. mykiss. The data analyzed and synthesized as part of a LFA can also include an analysis of carrying capacity, to determine the number of individuals of each freshwater life stage that can be supported by the available habitat. The results of a LFA provide valuable insight into possible effects of current or historical riverine habitat

¹ X = Ongoing study; P = Proposed additional 2016 study for consideration by collaborative group

² Habitat typing and characterization study proposal does not explicitly include habitat components being collected by NMFS; however, the NMFS data should be discussed in overall Assessment Framework.

³ The geographic scope and amount of available information needs to be confirmed to refine scope and cost estimate.

Potential Studies to Inform Reintroduction Assessment Framework For Discussion and Review by Technical Subcommittee

conditions on salmonid populations (or reintroduced populations), allowing managers evaluate reintroduction potential, focus future management activities, help prioritize actions, and/or refine the current understanding of limitations of the ecosystem.

Reservoir Transit Study

As detailed in FERC's study plan determination, if the fish passage facilities assessment indicate that the most feasible concept alternative for fish passage would involve either upstream or downstream passage through the project reservoirs (i.e., La Grange or Don Pedro reservoirs), a study would be required to evaluate the technical and biological feasibility of upstream (adults) or downstream (juvenile) movement of anadromous fish (as appropriate) through the project's reservoirs. Until feasible concept alternatives have been selected, the scope of this study cannot be accurately identified.

Interactions with Existing Aquatic Communities

Evaluating potential interactions with existing species in the target area is a factor that can impact reintroduction success. This constraint includes predatory and competitive interactions with other species and populations. Often times, habitat in target areas have changed from historic conditions. Consequently, aquatic communities present in target reintroduction areas may be comprised of non-native species or native invaders that have filled these available niches. Furthermore, intraspecific competition is possible if a population of the target species is already present in the target reach (i.e., *O. mykiss*). This assessment would identify the potential interactions of target reintroduction species with the existing aquatic community in the target reach and characterize the potential risks/benefits to the reintroduction program.

Source Population Assessment

Consideration of genetic and ecological characteristics of a source population is important to assessing the probability of a successful reintroduction. Ecological factors such as life history, morphological, and behavioral traits compatible with the target area will increase the probability of a successful reintroduction. Source populations that are genetically similar to the historic population may also maximize the benefits and reduce the risks of reintroduction. This assessment would identify factors that should be considered when identifying viable source populations, potential sources, associated pros and cons of each, and constraints of utilizing each source, if any.

Method of Colonization Assessment

Colonization approaches (i.e., natural, transplants, and hatchery releases) differ in the effects on the parameters that are used to assess the success or failure of a reintroduction. Method of colonization also has implications for the infrastructure and operations needed to support a reintroduction program. As such, identifying early in the process the lowest-risk strategy for colonization will be a critical component of assessing risks, constraints, and benefits of any reintroduction program.

Genetics Assessment of Existing and Source Populations

NMFS is conducting a study of the upper river *O. mykiss* fishery genetics. Request a schedule and information update for the group.

Potential Studies to Inform Reintroduction Assessment Framework For Discussion and Review by Technical Subcommittee

Climate Change Assessment

At the January 27th, 2016 Upper Tuolumne River Reintroduction Assessment Framework Workshop #4, NMFS requested that a climate change assessment be added to this potential studies list. An action item was noted at this workshop for NMFS to develop an abstract.

Habitat Typing and Characterization

Habitat mapping quantifies the type, amount, and location of river habitat types available to reintroduced anadromous salmonids of all life stages. Habitat mapping would be conducted in the field and remotely using standardized methodologies. The frequency and area of each habitat type (e.g., pool, riffle, run) would be tabulated and where potential holding pools for spring-run salmon occur, the size, depth, and vertical thermal profile of the pools will be measured to determine possible holding capacity, stratification of the pools (if any), and thermal suitability. Additional (remote) mapping tasks will include assessments of channel gradient, width, habitat areas, etc. This baseline information provides the template for many other evaluations and is critical for assessing the feasibility of reintroduction. For example, data on habitat type, area, and distribution are required to assess potential Chinook salmon and steelhead adult holding capacity, spawning habitat potential, and juvenile rearing capacity.

Upstream Migration Barriers

Little information exists to reliably assess the current quantity and quality of suitable habitat for the adult, egg, fry and juvenile life stages of anadromous salmonid species that may be considered for reintroduction in the Upper Tuolumne River watershed (i.e., above the Don Pedro Project). Prior to assessing the quality/suitability of habitat for target species, an assessment of barriers (both complete and partial) to upstream anadromous salmonid migration must first be conducted to identify the quantity of habitat that is accessible. This assessment would utilize relevant prior studies, desktop analyses, and field surveys to characterize and document the physical structure of barriers in the mainstem Tuloumne River and its tributaries upstream of the Don Pedro Project Boundary. Note that this study was requested by NMFS but per FERC's determination, was not required to be conducted by the Districts as part of the La Grange licensing process. However, to more fully support licensing participants in their development of information to supplement fish passage and reintroduction assessments, and to foster collaboration among all parties, the Districts have opted to conduct an upstream migration barriers assessment.

Instream Flow – Habitat Assessment: PHABSIM

Hydraulic models such as the Physical Habitat Simulation (PHABSIM) system are widely used and accepted tools used to produce quantitative estimates of the amount (quantity and quality) of habitat available to fish at a range of stream flows. Using measured physical channel characteristics for representative habitat types or reaches, PHABSIM modeling incorporates habitat suitability relationships for the target fish species and life stage to produce estimates of weighted usable area (WUA) in relation to stream flow. Results of PHABSIM modeling can be combined with data from habitat mapping and water temperature modeling to provide estimates of habitat availability and suitability for target species and associated life stages throughout the project area at a range of flows. Additionally, the analysis would include an evaluation of the effect of fluctuating flows on habitat value, due to the frequent peaking operations in the upper Tuolumne River. This could be evaluated by comparing habitat values on a small time-step using the high and low flows within the fluctuation range. Water temperature data would also be overlaid with the PHABSIM results to evaluate how the total amount of habitat is affected by thermal rather than physical habitat conditions.

Water Temperature Monitoring and Modeling

Potential Studies to Inform Reintroduction Assessment Framework For Discussion and Review by Technical Subcommittee

The assessment of suitable habitat quality for the adult, egg, fry and juvenile life stages of anadromous salmonid species that may be considered for reintroduction in the Upper Tuolumne River watershed (i.e., above the Don Pedro Project) is dependent upon both physical and thermal characteristics. This study would use existing and additional data to characterize the thermal regimes of the upper Tuolumne River and tributaries from the Don Pedro Project Boundary to CCSF's Early Intake to characterize locations where temperatures may be suitable for anadromous salmonid species considered for reintroduction. The study would include the development of a computer model to simulate existing thermal conditions in the study area. Note that this study was requested by NMFS but per FERC's determination, was not required to be conducted by the Districts as part of the La Grange licensing process. However, to more fully support licensing participants in their development of information to supplement fish passage and reintroduction assessments, and to foster collaboration among all parties, the Districts have opted to conduct an upstream migration barriers assessment.

Spawning Gravel Study

Spawning gravel mapping quantifies the amount, location, and suitability of gravel available for spawning by reintroduced anadromous salmonids. In a confined, high gradient river channel dominated by large substrates (boulder, cobble, bedrock) like the upper Tuolumne River, spawning gravel distribution is typically patchy and overall abundance may be low. Initial evaluation of aerial photographs and an on-river reconnaissance survey indicate this is may be the case in portions of the Tuolumne River between Wards Ferry and Early Intake. Because successful spawning and fry production are dependent on the abundance and suitability of accessible spawning gravel, spawning gravel mapping is a critical component for assessing the feasibility of reintroduction. This information is a key part of any evaluation of the factors likely to limit production and viability of an existing or reintroduced salmonid population (i.e., a limiting factors or carrying capacity analysis).

Macroinvertebrate Study

Drifting and benthic macroinvertebrates (BMI) are the primary food source for rearing salmonids in fresh water habitats. Growth of juvenile anadromous salmonids during their freshwater rearing period is critical for their survival during outmigration and ocean phases, as well as to the overall viability of the population. Studies have shown a strong relationship between the size at which juvenile salmon and steelhead migrate to the ocean and the probability that they return to fresh water to spawn. Macroinvertebrate sampling provides a measure of food availability during this important life history period. Information on macroinvertebrate prey resource availability is therefore a key component of any evaluation of the factors likely to limit production and viability of an existing or reintroduced salmonid population (i.e., a limiting factors analysis).

Swim Tunnel Study of Upper River O. mykiss

Thermal acclimation among fish species dates back to the 1940's and since 2001, thermal adaptation at the population level and among a wide variety of fish species has been convincingly supported in the peer-reviewed scientific literature. Included in this evidence base are salmon and trout species. The objective of this study would be to determine the thermal performance of the subadult *O. mykiss* population inhabiting the upper Tuolumne River to assess any local adjustments in thermal performance. The study would test the hypothesis that the *O.mykiss* population in the Upper Tuolumne River (i.e., above the Don Pedro Project Reservoir) is locally adjusted to relatively warm thermal conditions that may exist during the summer. Results of the study would be used to support habitat suitability and temperature modeling assessments.

Potential Studies to Inform Reintroduction Assessment Framework For Discussion and Review by Technical Subcommittee

Hatchery Practices Review, including current Don Pedro related practices

Assessing historic and current hatchery practices in the upper Tuolumne River will be necessary to evaluate potential risks to reintroduction. Risks include but are not limited to evolutionary (homogenization or reduced fitness), ecological (competition, predation, etc.) and disease issues. Results of the review will identify past and current hatchery practices in the reintroduction area as well as connected areas (i.e., Don Pedro Reservoir), potential risks of past/present hatchery programs to a reintroduction program, and recommendations to address identified risks.

Regulatory Evaluation of Reintroduction

The Upper Tuolumne River watershed spans several land management agencies' jurisdictions and there are management plans and regulations in place based on established resource management objectives (e.g., Wild and Scenic Management Plan, Forest Plan, BLM Management Plan). The compatibility of the potential reintroduction of *O.mykiss* and/or spring run Chinook will be evaluated relative to these current management objectives. The potential reintroduction of Endangered Species Act (ESA) listed species may overlay additional management objectives and a new regulatory framework in the upper Tuolumne River. This evaluation will include compiling and reviewing all relevant and potentially relevant existing management plans for the upper Tuolumne River and the Don Pedro Reservoir. In addition, applicable recovery plans and ESA regulations and potential population status classifications for the reintroduced species will be summarized. Responsible resource management agencies will be contacted to determine the most recent guidance documents for the study area.

Socioeconomic Scoping and Issue Identification/Preliminary Evaluation of Impacts on Tuolumne River Uses/Users

Current management of the Don Pedro Reservoir and upper Tuolumne River supports a wide range of resources, uses, and users. The upper watershed includes the Tuolumne Wild & Scenic River segment managed for several outstanding resource values and is utilized by commercial and private recreational boaters. Other uses include the City and County of San Francisco's Hetch Hetchy Project operations, private timber practices, and a recreational fishery. Don Pedro Reservoir has an active house boating and recreational fishery; county government and businesses rely upon the economic activities supported by the upper watershed. This evaluation will conduct a comprehensive survey of uses in the upper watershed and identify potential issues for consideration in the reintroduction assessment. A literature survey and review of existing information from the Don Pedro Recreation Agency, county and federal land management agencies and other sources will be conducted. Surveys and/or focus groups will be used to verify and expand upon available information on the multiple existing uses of the watershed that could be impacted by a fish reintroduction program.

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

TECHNICAL COMMITTEE CONFERENCE CALL

MARCH 18, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581) Fish Passage Facilities Alternatives Assessment Technical Committee Conference Call

Friday, March 18, 2016 10:00 am to 12:00 pm

Final Meeting Notes

	Conference Call Attendees			
No.	Name	Organization		
1	Leigh Bartoo	U.S. Fish and Wildlife Service		
2	Jenna Borovansky	HDR, consultant to the Districts		
3	Steve Boyd	Turlock Irrigation District		
4	Paul Bratovich	HDR, consultant to the Districts		
5	Adrianne Carr	Bay Area Water Supply and Conservation Agency		
6	Jesse Deason	HDR, consultant to the Districts		
7	John Devine	HDR, consultant to the Districts		
8	Art Godwin	Turlock Irrigation District		
9	Jason Guignard	FishBio, consultant to the Districts		
10	Tom Holley	National Marine Fisheries Service		
11	Zach Jackson	U.S. Fish and Wildlife Service		
12	Patrick Koepele	Tuolumne River Trust		
13	Ellen Levin	City and County of San Francisco		
14	Lonnie Moore	Citizen		
15	Marco Moreno	Latino Community Roundtable		
16	Gretchen Murphy	California Department of Fish and Wildlife		
17	Bill Paris	Modesto Irrigation District		
18	Bill Sears	City and County of San Francisco		
19	Jay Stallman	Stillwater Sciences, consultant to the Districts		
20	Cory Warnock	HDR, consultant to the Districts		
21	Scott Wilcox	Stillwater Sciences, consultant to the Districts		
22	Alison Willy	U.S. Fish and Wildlife Service		
23	John Wooster	National Marine Fisheries Service		
24	Ron Yoshiyama	City and County of San Francisco		

On March 18, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted a Technical Committee conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework). This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document includes the meeting agenda and draft study plans.

Mr. John Devine (HDR, consultant to the Districts) provided background on why the Technical Committee was formed. Mr. Devine said at Workshop No. 4 (held on January 27, 2016; meeting notes and materials are available on the La Grange Project licensing website <u>here</u>), the Plenary Group (i.e., all Framework participants) agreed to form a Technical Committee to try to come to agreement on what studies would be completed in support of implementing the Framework. On the first Technical Committee conference call (held on February 16, 2016; draft meeting notes and materials available <u>here</u>), the Technical Committee agreed to draft study plans for several studies to be conducted in 2016. The

Districts drafted five study plans and on March 16, 2016, sent these study plans to the Technical Committee for review and comment.

Mr. Devine said the objective of today's meeting is to discuss each study plan with the Technical Committee. The Districts hope that providing an overview of each study plan will help expedite the Technical Committee's study plan review. Mr. Devine said a second objective of this call is to discuss the schedule for reviewing the study plans and, if necessary, schedule another conference call prior to the study plan comment due date, to allow individuals an opportunity to ask questions or get clarification on the study plans before comments are due.

Mr. Devine reviewed the status of the action items from the February 16 Technical Committee call. All action items from that call are complete except for one; Mr. John Wooster (National Marine Fisheries Service [NMFS]) will provide additional details about why it appears the reservoir transit study cost estimate provided by the Districts appears to be low.

Mr. Jay Stallman (Stillwater Sciences, consultant to the Districts) summarized his professional background and reviewed the goals, study area, and methodology for the Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study (Spawning Gravel Study). Mr. Tom Holley (NMFS) said Chinook salmon currently exist in Don Pedro Reservoir and these fish swim upstream to spawn. Mr. Holley asked if there is existing information on where those fish spawn and said he believes snorkel studies may have been performed in the area where Chinook spawn. Mr. Devine said he has also heard that resident Chinook salmon may exist in Don Pedro Reservoir, as well as Kokannee salmon, but he is unaware of any documented observations. Mr. Holley said he believes the California Department of Fish and Wildlife (CDFW) completed snorkel surveys in the Lumsden reach and documented adult Chinook salmon during those surveys. Ms. Gretchen Murphy (CDFW) said she is unaware of snorkel surveys being done in that reach. Mr. Patrick Koepele (Tuolumne River Trust) said Mr. Steve Holdeman (U.S. Forest Service) may have information on the presence of Chinook salmon in that reach of the river. Mr. Devine said the Districts will contact Mr. Holdeman about information the U.S. Forest Service may have relevant to resident Chinook salmon or other reservoir species using the upper Tuolumne River.

Mr. Jason Guignard (FishBio, consultant to the Districts) summarized his professional background and reviewed the goals, study area, and methodology for the Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment (Habitat Mapping Study). Mr. Guignard noted that the Habitat Mapping Study Plan and Spawning Gravel Study Plan were developed in close coordination as both studies will be completed on the same rafting trips.

Mr. Lonnie Moore (citizen) asked if the Habitat Mapping Study will collect data on both drifting macroinvertebrates and benthic macroinvertebrates. Mr. Guignard confirmed the study will collect data about both types of macroinvertebrates.

Mr. Wooster said significant stage changes will likely occur during the Habitat Mapping Study fieldwork. He asked how the study will accommodate for those stage changes. Mr. Guignard said the flow schedule is not yet available for when the fieldwork will be completed. At this point, the study team is planning to complete the fieldwork at the end of the summer and/or early fall, when low flows and less flow fluctuation is anticipated. Mr. Guignard said the study team is cognizant that peaking flows may make it more difficult to collect detailed habitat mapping data.

Mr. Wooster asked if the study team will use depth sounders to collect water depth information and how the study team will account for daily flow fluctuations when water depths are measured. Mr. Guignard said depth sounders will be used. As much as possible, the study team is intending to collect data in each reach during off-peak, low flows conditions, not at on-peak flow conditions. Mr. Guignard said the study

team is still determining whether the logistics associated with this approach is realistic. Mr. Wilcox (Stillwater Sciences, consultant to the Districts) said fluctuations in flow will likely not impact depth measurements at deep pools because any fluctuations in flow will likely be a small percentage of the total pool depth. Mr. Wooster said fluctuations of two or three feet could create significant variability regarding depth measurements at shallow pools. Mr. Devine said the study team is still working out the logistics and will aim to collect data during non-peaking flows. Mr. Devine reiterated that the intent of the study is to collect data during base flow conditions. Mr. Devine said the study team will be very careful to document field and flow conditions when data is collected.

Mr. Wooster asked if the Districts can provide the model number and other specifications for the depth finders that will be used. Mr. Wooster said in his experience, the amount of fine sediment in the water seems to impact a depth finder's performance. Mr. Guignard said he does not know the model numbers or specifications offhand. Mr. Guignard said several different models will likely be used during the fieldwork. Mr. Guignard said he has experience using each model and in his previous fieldwork, each model performed well, even in the presence of fine sediment. Mr. Guignard said a stadia rod will be used to measure depths where possible and depth finders will only be used for deep pools where the stadia rod is too short. Mr. Wooster asked if a depth finder was used during the 2015 mesohabitat data collection. Mr. Wilcox said a depth finder was used for the 2015 data collection and the depth finder provided consistent measurements. Mr. Devine asked if Mr. Wooster has recommendations on what depth sounders should be used, or avoided. Mr. Wooster said he did not have specific recommendations. Mr. Wooster said depending on the hydrograph at the time of data collection, sediment from the Rim Fire may or may not create turbidity and affect the depth sounder readings, and this is something that should be considered. Mr. Devine agreed. Mr. Wilcox said turbidity was not a problem during the 2015 data collection, but that likely had to do with the dry water year. Conditions may be different for the 2016 data collection.

Mr. Wooster asked if the Districts will provide additional information on the mesohabitat mapping that was completed last summer, as part of the Upper River Barriers Study. Mr. Wilcox said the Upper River Barriers Study researchers opportunistically collected data on gravel, large woody debris, and pool depth. This data collection was unrelated to the Upper River Barriers Study and was thus not included in the Upper River Barriers Study Progress Report. Mr. Devine said the mesohabitat data is currently being summarized and will be provided to licensing participants when the summary is complete. Mr. Wooster said receiving the summary soon would be helpful for informing NMFS's comments on the study plans. Mr. Wilcox said the data can be made available, but cautioned the data may not be ready for scientific analysis. Once the data undergoes necessary internal reviews, it can be made available to the public.

Mr. Moore asked if the Habitat Mapping Study will include surveys of the riparian habitat. Mr. Wilcox said the study will only look at stream habitat. Mr. Moore said there are a number of studies recognizing the benefit of riparian habitat to salmon and steelhead and asked if a study can be done on the riparian habitat in the lower Tuolumne River and upper Tuolumne River. Mr. Devine said a riparian study of the lower Tuolumne River was completed for the Don Pedro relicensing and he will send out a link to the study report. Mr. Devine said a study of the riparian habitat in the upper river is not planned, but collecting general observations about riparian habitat could be added to one of the studies being completed. Mr. Guignard noted the Habitat Mapping Study Plan includes documenting the percent total canopy, which is the amount of riparian habitat that is shading the river. Mr. Wilcox said there is not much riparian shading in the upper river.

Ms. Borovansky (HDR) reviewed the goals, study area, and methodology for the Hatchery and Stocking Practices Review. Ms. Borovansky said the study plan includes research into the disease profiles of hatchery stocks, per discussions on the February 16 Technical Committee call.

Ms. Borovansky reviewed the goals, study area, and methodology for the Regulatory Context Study. Ms. Borovansky requested that meeting attendees submit ideas for additional plans that should be reviewed as part of this study. Mr. Bill Sears (City and County of San Francisco) requested that the Stanislaus National Forest Wild and Scenic River Plan be added to the list of plans to be reviewed. Mr. Sears said he can provide a copy of the plan if the Districts do not already have a copy.

Ms. Borovansky reviewed the goals, study area, and methodology for the Socioeconomic Scoping Study. Mr. Wooster asked if the objective of the study is to only develop a list of activities that could potentially be affected by fish passage and reintroduction, and not to assess how these activities may be affected. Ms. Borovansky confirmed Mr. Wooster is correct. Ms. Borovansky said the study is a scoping exercise to identify existing uses and activities. Once conceptual fish passage alternatives are available, the study team can begin to assess how uses and activities may be affected. Mr. Moore asked if the study team would consider expanding the study area to include the lower Tuolumne River. Mr. Devine agreed the lower river may be impacted by fish passage. He said the Hatchery and Stocking Practices Review Study Plan, Regulatory Context Study Plan, and Socioeconomic Scoping Study Plan will be reviewed, and revised if necessary, to adequately consider effects to the lower river.

Mr. Devine reviewed the schedule. The Districts are hoping to receive any comments on the study plans by March 29. The Districts will address any comments received and provide revised versions of the study plans to the Plenary Group ahead of Workshop No. 5, scheduled for April 13. Mr. Devine suggested the Technical Committee may like to have another conference call between now and March 29, perhaps on March 24, to allow individuals an opportunity to ask questions or get clarification on the study plans prior to March 29. Mr. Devine said individuals are welcome to submit questions ahead of the March 29 deadline, and study leads would do their best to quickly provide answers. All questions should be sent to Ms. Rose Staples (HDR) (rose.staples@hdrinc.com).

Mr. Wooster said given that the deadline for comments on the La Grange Initial Study Report (ISR) is April 4, it will be nearly impossible for him to provide comments on the study plans by the March 29 deadline and he likely will not have time to participate on a call on March 24. Mr. Wooster said a call the week of April 4 would work much better for his schedule. Mr. Koepele said it will be difficult for him to make the March 29 study plan comment deadline, given the April 4 deadline for ISR comments. Mr. Devine said the Districts will convene on the schedule and get back to the Technical Committee.

Mr. Wooster asked if future fish passage engineering feasibility meetings will be separate from the Plenary Group meetings. Mr. Devine said the Districts do not envision separate meetings for fish passage engineering feasibility and any technical items that arise can likely be handled by the Technical Committee or via individual communications.

Mr. Devine discussed the importance of having reintroduction program goals and how the results of the 2016 studies will be measured against those goals. Mr. Devine said the Reintroduction Goals Subcommittee (Goals Subcommittee) will take the lead on developing reintroduction program goals. Mr. Devine said eight people have volunteered to participate on the Goals Subcommittee and, based on the results of a Doodle poll, the first Goals Subcommittee call will be on Friday, April 1, from 10:00 am to 12:00 pm.

Mr. Devine said no agency personnel volunteered to participate on the Goals Subcommittee and asked what is preventing agency personnel from participating. Mr. Wooster said his schedule is already full and he does not have time to participate in another committee or on a call on April 1. Mr. Devine asked if moving the meeting until after April 4 would allow Mr. Wooster to participate. Mr. Wooster said he would likely be able to participate if the meeting is after April 4. Ms. Gretchen Murphy (CDFW) said she does not have time to participate in the Goals Subcommittee given her upcoming field season. Ms.

Alison Willy (U.S. Fish and Wildlife Service) said she is also too busy to participate. Mr. Devine said it may be that at the first Goals Subcommittee meeting on April 1, a rough schedule is developed and then the broader group is canvased to determine the date for the second meeting. Mr. Wooster said he may be able to attend the second meeting or, if he is unable to attend, he can provide his comments after the meeting.

Mr. Devine reviewed action items from today's call and said the Districts will send out meeting notes.

Meeting adjourned.

ACTION ITEMS

- 1. Incomplete action item from February 16 Technical Committee call: Mr. Wooster will provide additional details about why it appears the reservoir transit study cost estimate provided by the Districts appears to be low.
- 2. Mr. Sears will provide a copy of the Stanislaus Forest Wild and Scenic River Plan. (complete)
- 3. Mr. Devine will send to the Technical Committee the snorkel survey report provided by Mr. Holley. (complete)
- 4. The Districts will contact Mr. Steve Holdeman (U.S. Forest Service) about information the U.S. Forest Service may have relevant to resident Chinook salmon or other reservoir species using the upper Tuolumne River.
- 5. The Habitat Practices Study Plan, Regulatory Context Study Plan, and Socioeconomic Study Plan will be revised to consider effects on the lower Tuolumne River (as well as Don Pedro Reservoir and the upper Tuolumne River).
- 6. HDR will send out a link to the Lower Tuolumne River Riparian Information and Synthesis Study Report (W&AR-19). (Rose to complete on 3/22)
- 7. The Habitat Mapping Study Plan will be revised to include completing general observations of riparian habitat, in addition to the percent total canopy which is already included in the study plan.
- 8. Given scheduling constraints discussed at the meeting, the Districts will revisit the current schedule including the March 29 due date for comments on the study plans and will report back to the Technical Committee. (complete)
- 9. The Districts will provide results from the 2015 habitat data collection work. This should be completed, with QA/QC done, by mid-April.
- 10. The Districts will provide notes from today's meeting. (complete)

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

TECHNICAL COMMITTEE CONFERENCE CALL

MARCH 18, 2016

ATTACHMENT A

MEETING AGENDA AND DRAFT STUDY PLANS

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La Grange Hydroelectric Project Reintroduction Assessment Framework Technical Committee Conference Call Friday, March 18, 10:00 am to 12:00 pm Conference Line: 1-866-583-7984; Passcode: 230-0743

Meeting Objectives:

- 1. Review and discuss 2016 study plans for the Upper Tuolumne River Reintroduction Assessment Framework (Reintroduction Framework).
- 2. Identify schedule for study plan finalization in advance of April 13, 2016 Plenary Group meeting.
- 3. Discuss next steps on Reintroduction Program Goals subgroup.

TIME	TOPIC	
10:00 am – 10:15 am	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts) Review Action Items from Last Call (All)	
10:15 am – 11:30 am	 2016 Study Plans to Support Reintroduction Framework (All) a. Present and discuss study plans b. Identify schedule for study plan finalization (for presentation at April 13, 2016 Plenary Group meeting) 	
11:30 am – 11:50 am	 Reintroduction Program Goals to Support Reintroduction Framework (All) a. Purpose of developing program goals (i.e., metrics for success) in the Reintroduction Framework Assessment b. Relationship to Recovery Plan c. Update: Schedule Participants Next steps 	
11:50 am – 12:00 pm	Next Steps (All) a. Schedule next call and agenda topics b. Action items from this call	

DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT AND MODESTO IRRIGATION DISTRICT

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which is to identify and develop concept-level alternatives for upstream and downstream passage of Chinook salmon and steelhead at the La Grange and Don Pedro dams. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to characterize the distribution, quantity, and quality of suitable Chinook salmon and steelhead spawning gravel in the upper Tuolumne River.

2.0 STUDY AREA

The study area for mapping Chinook salmon and steelhead spawning gravel in the upper Tuolumne River includes the approximately 24-mile reach from the upstream limit of the Don Pedro Project (approximately RM 81) to Early Intake (approximately RM 105).

3.0 STUDY GOALS

Successful Chinook salmon and steelhead spawning and fry production are dependent on the abundance and quality of suitable spawning gravel. Information on the amount, distribution, and quality of spawning gravel are critical components in estimating habitat carrying capacity and assessing limiting factors. Limited information is available to describe the distribution, quantity, and quality of spawning gravel in the upper Tuolumne River. The goal of this study is to characterize the distribution, quantity, and quality of suitable Chinook salmon and steelhead spawning gravel in the upper Tuolumne River. The study objectives are:

- map the distribution of potentially suitable spawning gravel available for Chinook salmon and steelhead in the upper Tuolumne River;
- assess the quality of potentially suitable spawning gravel based on gravel size characteristics, sorting, angularity, embeddedness, substrate depth, and permeability measured in a representative sample of gravel patches; and
- quantify the amount of suitable spawning gravel in the reach between RM 81 and RM 105.

Study results will help inform the feasibility of introducing Chinook salmon and steelhead into the upper Tuolumne River.

4.0 STUDY METHODS

4.1 Spawning Gravel Mapping

Probable locations of gravel patches will initially be delineated in a Geographic Information System (GIS) using the best available aerial photography. This desktop mapping step will inform field staff as to the approximate distribution of gravel deposits and the most efficient logistical process for locating and mapping those deposits in the field. Field mapping criteria and protocols will be consistent with studies in the lower Tuolumne River (TID/MID 1992, 2013), and will be refined following this initial desktop analysis, as needed.

Potentially suitable spawning gravel patches will then be delineated in the field on map tiles from high resolution orthorectified aerial imagery (e.g., 8-13-2007 photography and mapbook). A laser range finder will be used to measure the approximate dimensions of each gravel patch, if necessary to support the delineation of patch areas on field tiles. Each patch will be assigned a unique ID. Field delineation of potentially suitable spawning gravel patches will be performed by a two-person crew using whitewater raft support to access the study reach. The crew will stop frequently to locate and investigate preliminary gravel polygons obtained from desktop mapping and any other deposits that appear to meet the mapping criteria. Inflatable kayaks may also be used to navigate unwadable areas requiring investigation. To the extent feasible, mapping will be performed during low or off-peak flow conditions to optimize visibility of potentially suitable spawning gravels. Supplemental access to limited portions of the study reach are available at vehicle road crossings and by foot, depending on terrain and river flow.

4.1.1 Gravel Particle Size Criteria

Species-specific spawning gravel size criteria that will be used to delineate potentially suitable spawning gravel for Chinook salmon and steelhead in the upper Tuolumne River study reach are summarized in Table 1.0. These particle size criteria, based on D_{50} reported in the literature, may be refined in coordination with the Technical Committee prior to the field effort. Chinook salmon typically spawn in substrates with a D_{50} of 11–78 mm (0.42–3.0 in) (Platts et al. 1979, as cited in Kondolf and Wolman 1993, Chambers et al. 1954, 1955, as cited in Kondolf and Wolman 1993). Steelhead typically spawn in substrates with a D_{50} of 10–46 mm (0.4–1.8 in.) (Barnhart 1991, Kondolf and Wolman 1993). Wolman (1954) pebble counts will be conducted in selected areas to calibrate visual estimates of grain size parameters using methods developed by Bunte and Abt (2001). Patches with substantially different surface particle size characteristics will be delineated separately.

4.1.2 Minimum Gravel Patch Size Criteria

Minimum patch size criteria for mapping potentially suitable spawning gravel will be determined prior to the field effort based on (1) a combination of the minimum area required for a spawning Chinook salmon or steelhead pair and (2) the scale and resolution of available imagery used as a base for field mapping tiles. The minimum spawning area generally identified for Chinook salmon is approximately 12 m² (Healy 1991, Bjorn and Reiser 1991, Ward and Kier 1999). Steelhead typically defend a redd only during the period of active spawning, and therefore the area required for a spawning steelhead pair is approximately equal to the disturbed area of the redd. The average area encompassed by a steelhead redd is $4.4-5.4 \text{ m}^2 (47-58 \text{ ft}^2)$ (Bjornn and Reiser 1991; Orcutt et al. 1968). For mapping purposes, we assume a minimum patch size of approximately 6 m² is required for a steelhead pair to build and defend a redd. The minimum mappable size of potentially suitable spawning gravel patches based on the scale and resolution of available imagery will be evaluated during the desktop gravel mapping step described above.

Table 1.0Summary of potential spawning gravel mapping criteria for Chinook salmon and
steelhead in the upper Tuolumne River.

Species	Gravel D ₅₀ mm (in.)	Minimum Patch Size Required for Spawning, m ² (ft ²)	References
Chinook salmon	10–78 (0.4–3)	12 (130)	Platts et al. 1979, Chambers et al. 1954, 1955, all as cited in Kondolf and Wolman 1993; Healy 1991, Bjorn and Reiser 1991, Ward and Kier 1999
Steelhead	10–46 (0.4–2)	6 (65)	Barnhart 1991, Kondolf and Wolman 1993, Bjornn and Reiser 1991, Orcutt et al. 1968

Note: D_{50} – diameter of particle (in millimeters) at which 50 percent of the sample is smaller (*e.g.*, median).

4.2 Spawning Gravel Quality

In addition to the particle size and patch size criteria described above, characteristics informing spawning habitat quality will be collected for each patch. These will include additional gravel particle size parameters (e.g., D_{16} , D_{84}); characterization of particle sorting, angularity, and embeddedness; and an estimate of the average substrate depth (where feasible).

4.2.1 Field Observations of Gravel Quality

Sorting describes the homogeneity of surficial particles within a patch. Spawning salmonids prefer substrates that are relatively well sorted. The degree of sorting will be visually estimated using the comparison chart in Compton (1985). Angular grains tend to pack more tightly than rounded particles and are more likely to slow intragravel flow. More loosely packed and rounded particles also increase a fish's ability to dislodge the substrate during redd construction. The degree of particle angularity within a patch will be visually estimated based on the comparison chart in Powers (1989). Substrate embeddedness describes the presence of fine sediment in the gravel interstices. Substrate embeddedness is measured by selecting a random sample of coarse surface particles within the patch and measuring the percent of the particle that is surrounded or buried by fine sediment (fines and sands <2 mm). This would be conducted concurrent with pebble count procedures. The substrate depth required for redd construction and egg deposition likely depends on the size of the spawning female and on particle size characteristics, as well as flow depth and velocity. Chinook salmon egg pocket depths range from 8 to 51 cm (3 to 20 in), with an average of 22 cm (8.5 in) (Burner 1951). Steelhead egg pocket depths range from 15 to 28 cm (6 to 11 in), with an average of 21 cm (8.4 in) (Briggs 1953).

4.2.2 Gravel Permeability

Gravel permeability will be collected to characterize incubation conditions and estimate predicted survival-to-emergence. The quality of spawning gravel will be assessed by measuring streambed permeability at select patches following the methods of Barnard and McBain (1994). Gravel inflow rate (ml/sec), which is an index of intragravel permeability (cm/hr), will be measured using a steel standpipe adapted from the Terhune Mark VI standpipe design (Terhume 1958; Barnard and McBain 1994). At select gravel patches, the standpipe will be driven into the gravel to an approximate depth of 30 cm (12 inches) using a protective end cap and sledge hammer. A battery powered peristaltic pump (e.g., IP Masterflex brand pump or equivalent) will be used to create a 2.5 cm head differential in the standpipe and the rate at which water is drawn from the pipe will be drawn through the perforations in the standpipe buried in the gravel, and a stopwatch will be used to measure the time required to collect a volume of water.

Gravel permeability can be highly variable within and between patches in a reach. Therefore, a sampling plan will be developed based on the results of the spawning gravel mapping effort. The sampling plan will outline an approach and provide field protocols for characterizing the permeability of potential spawning patches throughout the study reach. The approach will generally rely on assigning patches to a morphologic unit (e.g., pool tail) and sampling from consistently similar positions within a morphologic unit. Sampling will occur in the morphological unit(s) that are best exhibit the effects of fine sediment supply on spawning gravel quality and that have the highest potential value to spawning Chinook and steelhead. Permeability sampling results may be stratified by subreach, as appropriate. Desktop and field-based mapping of potentially suitable spawning gravel patches will inform an appropriate system for delineating morphological units, appropriate permeability sampling locations within those units, and appropriate delineation of any subreaches.

4.2.3 Gravel Quality Ranking

When a gravel patch is deemed "usable" based upon initial measurements associated with particle size criteria, a qualitative ranking of overall suitability from 1 (poor) to 10 (good) will be assigned to each patch based on an overall assessment of the following physical characteristics (substrate particle size, sorting, angularity, embeddedness, gravel depth, permeability, and patch location and size). A separate ranking will be assigned for Chinook salmon and steelhead. Although reliable rankings rely heavily on the professional judgment and personal experience of the survey participants, this ranking will allow comparison of patch quality. Rankings will be summarized as follows: 1-3= low suitability, 4-7= medium suitability, and 8-10= high suitability.

4.3 Data Processing and Analysis

Potentially suitable spawning gravel patches delineated on field tiles will be digitized using GIS, and area estimates for each patch will be calculated. The quantity and quality of potentially suitable spawning gravel patches will be summarized in tabular format.

Results to be reported include the following:

• shapefiles with polygons of potentially suitable spawning gravel patches and associated patch attributes;

- a database of attributes for each mapped gravel patch (i.e., measured and/or estimated particle size parameters, sorting, angularity, embeddedness, estimated mean depth [where feasible], associated channel morphological feature, and quality score);
- mean, minimum and maximum gravel inflow rates (ml/sec) as an index of intragravel permeability (cm/hr) for each sample site, presented by river mile location; and
- derived mean permeability (cm/hr) by river mile.

5.0 STUDY SCHEDULE

The anticipated schedule is to conduct the initial office-based analysis in May-June 2016, with subsequent field surveys in August/September 2016 for gravel mapping and gravel quality assessments. Mapping of potentially suitable spawning gravel will occur over two separate five-day field trips. Permeability sampling will occur over one three-day field trip to be conducted after the gravel mapping is completed. A draft report will be provided to the Technical Committee in November 2016 with a final report to be included in the February 2017 Updated Study Report.

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DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT AND MODESTO IRRIGATION DISTRICT

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

Socioeconomic Scoping Study

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which is to identify and develop concept-level alternatives for upstream and downstream passage of Chinook salmon and steelhead at the La Grange and Don Pedro dams. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Socioeconomic Scoping Study is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to evaluate the potential socioeconomic effects of reintroducing Chinook salmon and steelhead into the upper Tuolumne River above the Don Pedro Project.

2.0 STUDY GOALS

The goal of this study is to develop a comprehensive description of the human environment, activities, and current uses of the resources and facilities in the study area that may be impacted by constructing and/or operating fish passage facilities and the introduction of anadromous fish upstream of the Don Pedro Project.

3.0 STUDY METHODS

Socioeconomic considerations are identified as a key element in assessing whether potential reintroduction methods could be successful (Andersen et al. 2014). Current management of the Don Pedro Reservoir and upper Tuolumne River supports a wide range of resources, uses, and users. The upper watershed includes the Tuolumne Wild & Scenic River segment managed for several outstanding resource values and is utilized by commercial and private recreational boaters. Other uses of the watershed include the City and County of San Francisco's operation of the Hetch Hetchy Project, private

timber practices, and a recreational fishery. Don Pedro Reservoir provides numerous recreational activities, including house boating and a popular recreational fishery. County government and businesses benefit from the economic activities supported by the upper watershed.

As part of this study, a comprehensive survey of uses in the upper watershed will be conducted and potential issues will be identified for consideration in the reintroduction assessment. A literature survey and review of existing information from the Don Pedro Recreation Agency, county and federal land management agencies, and other sources will be conducted. Surveys and/or focus groups will be used to verify and expand upon available information related to existing uses of the watershed that could be impacted by a fish reintroduction program. The information collected in this study is designed to support and expand upon the socioeconomic considerations identified in the Framework, such as recreation impacts (e.g., river recreation, reservoir recreation, recreational fishing) and impacts on private resources (e.g., timber resources, private landowners), and will be considered in any socioeconomic evaluation done once reintroduction and fish passage options are further developed.

4.0 STUDY SCHEDULE

The anticipated schedule is the study team will gather available literature and consult licensing participants and agencies from April to July 2016. The literature review and data gathering will be completed over the summer, with a draft report issued to the Technical Committee by October 2016. The final report will be included in the February 2017 Updated Study Report.

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DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT AND MODESTO IRRIGATION DISTRICT

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

Regulatory Context for Reintroduction

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which is to identify and develop concept-level alternatives for upstream and downstream passage of Chinook salmon and steelhead at the La Grange and Don Pedro dams. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Regulatory Context for Reintroduction review is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to evaluate federal, state, and local regulatory issues that may be associated with the reintroduction of Chinook salmon and steelhead into the upper Tuolumne River above the Don Pedro Project.

2.0 STUDY AREA

The study area will encompass the upper Tuolumne River basin, including Don Pedro Reservoir and the mainstem Tuolumne River, and associated tributaries (North Fork Tuolumne River, Clavey River, Cherry Creek, etc.), and surrounding public and private land.

3.0 STUDY GOALS

This regulatory review will evaluate federal, state, and local regulatory issues associated with the potential introduction of listed and protected fish species into the Tuolumne River upstream of the Don Pedro Project. The upper Tuolumne River basin spans the jurisdictions of several federal land management agencies (United States Forest Service [USFS], Bureau of Land Management [BLM], and National Park Service [NPS]). Current activities related to fisheries management (stocking, setting of fishing areas, seasons, limits, and catch quotas) are the responsibility of the State of California. With the potential introduction of protected anadromous salmonids, regulatory requirements related to such laws as
the Endangered Species Act, Magnuson-Stevens Fishery Conservation and Management Act, Clean Water Act, National Environmental Protection Act, the Federal Land Policy and Management Act, and California Environmental Quality Act may become relevant to activities occurring in the study area. The goals of this study are to:

- identify applicable existing legal precedent, regulatory guidance and resource management plans in the study area;
- identify additional regulatory guidance and rules that may apply to or affect the reintroduction of spring-run Chinook and/or steelhead; and
- identify and define potential federal, state, and local regulatory issues associated with the potential fish passage/reintroduction program.

4.0 STUDY METHODS

The introduction of new species into the upper river may affect current uses and regulatory requirements/restrictions. A comprehensive understanding of the regulatory aspects of introducing federal- and state-listed species to the upper Tuolumne River watershed is necessary. For purposes of this evaluation, the regulatory context is defined as legal precedent, rules, regulations and guidelines in land and species management that may apply to land and species management in the study area.

State and federal resource management agencies will be contacted to confirm all relevant guidance documents and supporting materials are identified. A summary of regulations and authorities applicable and potentially applicable to activities in the watershed will be completed. This study report will include a matrix of species and land management goals, responsible authorities, and applicable laws and regulations relevant to current and future proposed activities in the watershed. An initial list of documents to be reviewed is provided below and will be expanded as necessary based on consultation with licensing participants.

- Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead (National Marine Fisheries Service 2014)
- Sierra Nevada Forest and Community Initiative (SNFCI) Action Plan (Sierra Nevada Conservancy 2014)
- The State of the Sierra Nevada's Forests (Sierra Nevada Conservancy 2014)
- Tuolumne Wild and Scenic River Comprehensive Management Plan and supporting documents (NPS 2014)
- Sierra Nevada Forest Plan and Amendments (USFS 2004, 2013)
- Stanislaus National Forest Plan Direction (USFS 2010)
- Sierra Resource Management Plan (BLM 2008)
- Steelhead Restoration and Management Plan for California (California Department of Fish and Game 1996)
- Tuolumne County General Plan (Tuolumne County 1996)
- Red Hills Management Plan (BLM 1985)

5.0 STUDY SCHEDULE

The anticipated schedule is to gather relevant plans and consult licensing participants and agencies from May through July 2016. A draft report will be provided to the Technical Committee in November 2016 with a final report included in the February 2017 Updated Study Report.

6.0 **REFERENCES**

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DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT AND MODESTO IRRIGATION DISTRICT

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

Hatchery and Stocking Practices Review

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which is to identify and develop concept-level alternatives for upstream and downstream passage of Chinook salmon and steelhead at the La Grange and Don Pedro dams. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Hatchery and Stocking Practices Review is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to inform an evaluation of the potential for hatchery stocking practices to affect Chinook salmon and steelhead that may be introduced into the upper Tuolumne River above the Don Pedro Project.

2.0 STUDY AREA

The study area for this desktop literature review will encompass the upper Tuolumne River basin, including Don Pedro Reservoir and the mainstem Tuolumne River, and associated tributaries (North Fork Tuolumne River, Clavey River, Cherry Creek, etc.), to the extent that information is available regarding historical or current hatchery and stocking practices.

3.0 STUDY GOALS

The overall goal of this study is to assess historical and current hatchery stocking practices in the upper Tuolumne River basin and identify potential interaction of stocking activities with the reintroduction of anadromous salmonids to the reach of the Tuolumne River between the upstream end of the Don Pedro Project and the City and County of San Francisco's Early Intake. Specific objectives of this study are listed below:

- identify the species, source hatcheries and their stocking practices in the area, and time periods of fish that were historically stocked in the upper Tuolumne River, tributaries to the upper Tuolumne River, and in Don Pedro Reservoir;
- identify stocking location and seasonal timing of stocking for species currently stocked (and that may be stocked in the future) in the upper Tuolumne River, tributaries to the upper Tuolumne River, and in Don Pedro Reservoir;
- identify and describe self-sustaining potamodromous populations (species of fish that migrate [upstream or downstream] exclusively in freshwater) originating from previously stocked species, their life history characteristics, and population characteristics, as available;
- identify available information on documented incidents of disease in hatchery stocks and in the upper Tuolumne River basin;
- describe life histories of stocked species, as well as their spatial and temporal migrations and distributions to identify the potential to interact with reintroduced anadromous salmonids;
- describe potential spatial and temporal overlap of stocked species and lifestages with potentiallyreintroduced species and lifestages (i.e., steelhead and spring-run Chinook salmon) in the upper Tuolumne River; and
- identify potential effects of historical and existing/future hatchery and stocking practices on efforts to reintroduce anadromous salmonids to the upper Tuolumne River.

4.0 STUDY METHODS

A desktop literature review will be conducted and is expected to include review of agency technical memoranda, fish stocking data, fish health information, journal articles, and websites to identify and describe historical, current and future fish hatchery and stocking practices in the upper Tuolumne River Basin. Agencies and organizations involved with fish hatchery and stocking activities will be contacted to gather additional information on historical and existing fish stocking activities in the study area, including the Don Pedro Recreation Agency and California Department of Fish and Wildlife.

Based on the information collected regarding historical and current/future stocking practices, existing hatchery operations, life histories of stocked fish species, and literature on interactions between stocked fish species and anadromous salmonids, potential effects of hatchery and stocking practices to an anadromous salmonid reintroduction effort will be described and evaluated. Potential risks associated with hatchery and stocking practices to an anadromous salmonid reintroduction salmonid reintroduction program will be identified and described.

5.0 STUDY SCHEDULE

The anticipated schedule is to conduct the desktop literature review and contact agency staff from May to July 2016. A draft report will be provided to the Technical Committee in November and a final report will be included in the February 2017 Updated Study Report.

6.0 **REFERENCES**

Turlock Irrigation District and Modesto Irrigation District (TID/MID). 2016. Fish Passage Facilities Alternatives Assessment Progress Report. Prepared by HDR, Inc. Appendix to La Grange Hydroelectric Project Initial Study Report. February 2016.

DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT AND MODESTO IRRIGATION DISTRICT

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which is to identify and develop concept-level alternatives for upstream and downstream passage of Chinook salmon and steelhead at the La Grange and Don Pedro dams. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to characterize habitat distribution, abundance, and quality in the upper Tuolumne River.

2.0 STUDY AREA

The study area will include the mainstem of the upper Tuolumne River from the upstream limit of the Don Pedro Project (approximately RM 81) to Early Intake (approximately RM 105).

3.0 STUDY GOALS

The primary goal of this study is to provide information on habitat distribution, abundance, and quality in the upper Tuolumne River. This information will inform evaluations in the Framework and is critical for assessing the feasibility of anadromous salmonid reintroduction, estimating potential population size and developing engineering alternatives for the upper Tuolumne River. Specific objectives include:

- document the number, size and distribution of mesohabitats available in the upper Tuolumne River;
- collect detailed data on habitat attributes in representative reaches of the upper Tuolumne River;

- documenting potential pool holding habitat for over-summering adult Chinook salmon; and
- collect drift and substrate samples of macroinvertebrates (salmonid prey organisms).

4.0 STUDY METHODS

For this assessment, habitat mapping will quantify the type, amount, and location of habitat types available to potentially reintroduced anadromous salmonids during their riverine life stages (adult holding/spawning, incubation and rearing). Habitat mapping will be conducted in the field and remotely using standardized methodologies. The frequency and area of each habitat type (e.g., pool, riffle, run) will be tabulated and where potential holding pools for adult Chinook occur, the size and depth of the pools will be measured to determine possible holding capacity. Additional mapping tasks will include assessments of channel gradient, width, habitat areas, etc.

Habitat mapping will consist of mapping all mesohabitat units between Early Intake (RM 105) and the upstream limit of the Don Pedro Project (approximately RM 81), and collecting detailed habitat data in a sub-set of the mapped mesohabitat units.

4.1 Task 1. Mesohabitat Mapping

Reconnaissance level mapping in the summer of 2015 consisted of mesohabitat classifications (Table 1.0) for portions of the reach between Lumsden (Merals Pool at RM 96) and approximately RM 81. In 2016, habitat mapping will be extended up to Early Intake (RM 105), and gaps in mapping between RM 96 and approximately RM 81 will be comprehensively assessed to obtain a more complete dataset. Habitat units will be identified visually by a boat-based survey crew and mapped on pre-existing high-resolution color aerial photographs. Boundaries of mesohabitat units will also be geo-referenced in the field with a handheld GPS unit.

Mesohabitat types	Definitions/ Criteria	
Deep Pool	>6 ft max depth	
Shallow Pool	<6 ft max depth	
Glide/ Pool tail	Typically in the downstream portion of a pool with negative bed slope where converging flow approaches the riffle crest. Wide, shallow, flat bottom with little to no surface agitation. Substrate type is typically smaller than riffle, but coarser than pool and often provides best salmonid spawning habitat.	
Run	Long, smoothly flowing reaches, flat or concave bottom, and deeper than riffles with less surface agitation. Higher velocities than pools.	
Boulder	Moderate to low gradient riffles, runs, and glides with numerous large	
Garden/Pocket Waterboulders/obstructions that create scour pockets and eddies with near zero velocity. clear thalweg present due to multiple flow paths.		
		Cascade/ Chute
and/or bedrock. Consisting of alternating small waterfalls and can have shallow pools in		
	middle and margin of channel at low flows.	
High Gradient	>4% gradient. Substrate is usually large boulder and bedrock (>24")	
Riffle	······································	
Low Gradient	<4% gradient Substrate is usually small boulder and large cobble(6-24")	
Riffle	(47) gradient. Substrate is usually small bounder and range couble(0.24)	
Side Channel	Contains < 20% of total flow. Connected at top and bottom to main channel at low flow.	
Backwater	Low to zero velocities. Only connected to main channel from one end.	

Table 1.0Mesohabitat mapping units and criteria for the mainstem Tuolumne River.

Mapped habitats will be digitized and added to the project GIS layer for mapping, as well as for quantitative and spatial analysis. Color maps will be created to depict the type and location of habitats

throughout the study area and in relation to important features such as tributaries, potential passage barriers, access points, and water temperature monitoring locations. The frequency and area of each habitat type (e.g., pool, riffle, run) will also be tabulated.

4.2 Task 2. Habitat Inventory Mapping

Additional (remote) mapping tasks will include assessments of channel gradient, width, habitat areas, etc. following the CDFW Level III habitat typing methodology (CDFG 2010). Methods will be similar to habitat typing conducted in the lower Tuolumne River (TID/MID 2013). Sampling units selected for detailed habitat measurements will encompass approximately 10 to 20 percent of the study reach, as recommended in CDFG (2010). The habitat typing field effort will consist of a team of three biologists surveying the river by raft. The study area will be divided into seven sampling reaches, based on length of river rafted daily (two reaches from Early Intake to Lumsden and five reaches from Lumsden to Wards Ferry). Within each individual sampling reach, a one mile section will be randomly selected for habitat typing. Prior to the field assessment, the team will use maps and existing aerial photographs to delineate the specific reaches to be surveyed.

A suite of measurements consistent with the Level III CDFW criteria (Table 2.0) will be made within each mesohabitat type along each of the selected one-mile reaches. Data will be recorded on standardized datasheets to ensure all data are collected in a consistent manner. A photograph of each and GPS coordinates will be recorded at the bottom of each habitat unit. Unit length and width will be measured with a laser range finder. Depths will be measured using a stadia rod or handheld depth finder. Large woody debris (LWD) count will include a count of LWD pieces with a diameter greater than one foot and a length between six and twenty feet, as well as pieces greater than twenty feet in length, within the bankfull width. Percent total canopy will be measured using a spherical densiometer at the upstream end of each habitat unit in the center of the wetted channel. The remaining habitat parameters including substrate composition, substrate embeddedness, shelter complexity, and bank composition types will be visually estimated. Within each sampling reach, stream gradient will also be measured using a clinometer over a distance of at least 20 bankfull channel widths. In addition, the size and depth of each pool will be collected throughout the study reach to help quantify the amount of potential Chinook salmon adult holding habitat.

Data	Description
Form Number	Sequential numbering
Date	Date of survey
Stream Name	As identified on USGS (U.S. Geological Survey) quadrangle
Legal	Township, Range, and Section
Surveyors	Names of surveyors
Latitude/Longitude	Degrees, Minutes, Seconds from a handheld GPS
Quadrant	7.5 USGS quadrangle where survey occurred
Reach	Reach name or river mile range
Habitat Unit Number	The habitat unit identification number
Time	Recorded for each new data sheet start time
Water Temperature	Recorded to nearest degree Celsius
Air Temperature	Recorded to nearest degree Celsius
Flow Measurement	Available from USGS monitoring stations
Mean Length	Measurement in feet of habitat unit
Mean Width	Measurement in feet of habitat unit wetted width
Mean Depth	Measurement in feet of habitat unit
Maximum Depth	Measurement in feet of habitat unit
Depth Pool Tail Crest	Maximum thalweg depth at pool tail crest in feet

Table 2.0List of data collected as part of Level III CDFW habitat mapping.

Data	Description
Pool Tail Embeddedness	Percentage in 25% interval ranges
Pool Tail Substrate	Dominant substrate: silt, sand, gravel, small cobble, large cobble, boulder, bedrock
Large Woody Debris Count	Count of LWD within wetted width and within bankfull width
Shelter Value	Assigned categorical value: 0 (none), 1 (low), 2 (medium), or 3 (high) according to complexity of the shelter.
Percent Unit Covered	Percent of the unit occupied
Substrate Composition	Composed of dominant and subdominant substrate: silt, sand, gravel, small cobble, large cobble, boulder, bedrock
Percent Exposed Substrate	Percent of substrate above water
Percent Total Canopy	Percent of canopy covering the stream
Percent Hardwood Trees	Percent of canopy composed of hardwood trees
Percent Coniferous Trees	Percent of canopy composed of coniferous trees

Results to be reported include the following:

- Ground-mapped habitat units
 - Total number of habitat units, by type
 - Total length of habitat units, by type
 - Number of habitat units (frequency)
 - Average width of habitat units, by type
 - Number and relative frequency of dominant instream cover types
 - Reach summary data (e.g., average bankfull width and depth, LWD density (within wetted and bankfull))
- Pool holding habitat
 - Total number of pools identified as potential holding habitat (and the criteria of determination)
 - Average and maximum pool depth
 - Percentage of pools with \geq 5% cover
 - Map showing the suitable holding pools in each 1-mile sampled reach of the upper Tuolumne River
- Tributary mapping data and reconnaissance level mainstem Upper Tuolumne River habitat data collected in 2015

4.3 Task 3. Macroinvertebrate Assessment

If time and logistics allow as the final field schedule is developed, a macroinvertebrate assessment will be conducted following the methods outlined below.

4.3.1 Study Goals

Drifting and benthic macroinvertebrates typically comprise the primary food source for rearing salmonids in fresh water habitats (Allan 1978, Fausch 1984, Harvey and Railsback 2014). Information on macroinvertebrate prey resource availability is a component of an evaluation of the factors affecting production and viability of an existing or introduced salmonid population. The density and taxonomic composition of drifting macroinvertebrates can provide a relative measure of food availability for driftfeeding salmonids. To provide a relative measure of food availability for salmonids within the water column, a literature search of similar streams and macroinvertebrate studies in the region (Sierra foothill region) will be conducted. Substrate sampling for benthic macroinvertebrates will provide data that can be used in a standardized bioassessment approach to evaluate the potential for physical habitat impairment. The objectives of the macroinvertebrate assessment are to:

- collect and analyze macroinvertebrate drift samples to determine whether the taxonomic composition and density of drift is consistent with other regional systems currently supporting healthy salmonid populations; and
- collect and analyze benthic macroinvertebrate samples from the substrate to develop metrics for bioassessment and comparison with similar streams and data sets.

4.3.2 Study Methods

4.3.2.1 Sampling Site Selection

The study area for macroinvertebrate sampling within the upper mainstem of the Tuolumne River is from RM 81 to Lumsden Bridge (RM 98). The location and number of sampling sites and sampling frequency will represent the seasonal variability of macroinvertebrate populations and related seasonal variability of food resources for stream-dwelling salmonids during the primary salmonid rearing and growth period (spring-fall), as well as the variability of physical habitat characteristics in each study reach.

Number of sites

Depending on opportunities encountered during stream habitat mapping, drift and benthic macroinvertebrate samples will be collected at five sites, equating to approximately one site per 3.5 river miles.

Locations

Drift sampling will occur in the vicinity of Lumsden and at four additional downstream locations corresponding to locations selected for overnight camping during each five-day (four-night) rafting trip. Drift samples will be collected in riffle or run habitats selected opportunistically in the vicinity of overnight camping locations along each study reach. At each overnight camping location, drift sampling locations will be selected based on suitable depth, velocity, substrate, and accessibility/safety considerations, with two sites per location and two replicates (net placements) per site.

Benthic macroinvertebrate sampling will occur at suitable riffles initially identified in the office using aerial photographs and verified in the field. One composite sample will be collected daily from a suitable riffle or combination of suitable fast-water habitat types during the five-day raft-based sampling.

Sample timing and frequency

Macroinvertebrate sampling will be conducted daily during the five-day raft-based sampling effort. Drift sampling in late summer (September) will characterize food resources available to rearing juvenile anadromous salmonids prior to overwintering. Spring sampling may also occur if scheduling allows in conjunction with other field efforts. In many temperate streams, aquatic macroinvertebrate diversity and abundance peak during spring and summer and are reduced in late summer and fall. Peak feeding and growth by rearing salmonids occur when prey availability and water temperatures are relatively high, maximizing net energy gain (Rundio and Lindley 2008, Stillwater Sciences 2007, Wurtsbaugh and Davis 1977). Exact sampling dates for this study may be adjusted within the general seasonal period to coincide with other sampling efforts in order to maximize efficiency and accommodate river flow levels. However, macroinvertebrate sampling should not occur during periods of very high flows or when river discharge is changing rapidly due to safety and access concerns and the potential effects of flow fluctuations on invertebrate drift (Brittain and Eikland 1988).

Drift sampling will begin each afternoon by 1700 hours and proceed until approximately 2000 hours. This sample timing is intended to collect drifting macroinvertebrates during the daily period when feeding activity is often greatest for juvenile Chinook salmon and trout (Sagar and Glova 1988, Johnson 2008) and to avoid pre-dawn and post-dusk peaks in drifting macroinvertebrates that may not be available to drift-feeding salmonids at low light levels. The timing and duration of drift sampling can be adjusted if needed to accommodate rafting safety concerns or logistical constraints. All drift sampling should occur during the peak afternoon-evening feeding period and have the same start and end time.

The timing of the benthic macroinvertebrate sampling is not seasonally dependent, but will be coincident with the drift sampling effort to maximize efficiency and reduce the amount of field sampling time required for the study. Benthic macroinvertebrate samples will be collected once per day during the raft-based sampling effort, typically during mid-day or as determined by the location of suitable sampling riffles and logistics of the habitat mapping study.

4.3.2.2 Sampling Protocols

Invertebrate drift sampling

Drift samples will be collected using stationary nets with rigid rectangular openings and tapered, nylon mesh bags with a collection jar fitted at the downstream end – similar to drift nets used by other researchers (Brittain and Eikeland 1988), including the 1987–1988 drift studies in the lower Tuolumne River (Stillwater Sciences 2010). All drift nets will be identical, with a mesh size small enough to capture small invertebrates such as immature chironomids that may be important salmonid prey, while also large enough to minimize clogging (e.g., 250–500 μ). There is no standard mesh size for drift nets, with mesh size instead chosen according to study objectives, and to represent a compromise between filtration efficiency and clogging (Svendsen et al. 2004).

At each sampling location two transects will be selected perpendicular to the river and two drift nets will be placed at each transect: one near shore and one in the thalweg or as close to the thalweg as water depth and velocity will safely allow. Each drift net will be anchored in the water column using steel (e.g., rebar stakes or fence posts) driven into the stream bed, with the bottom of the net at least 10 cm above the river bottom and the top of the net at least 4–5 cm above the water surface. This vertical net placement ensures capture of terrestrial-origin organisms originating from outside the stream (Leung et al. 2009), which may be an important diet component for anadromous salmonids (Tiffan et al. 2014, Leung et al. 2009, Rundio and Lindley 2008) while avoiding capture of organisms crawling on the substrate. Because drift composition is not uniform across the channel (Waters 1969), placement of near-shore and mid-channel drift nets allows sampling of each portion of the channel to represent potential differences in taxonomic composition, origin (aquatic vs. terrestrial), density, or other factors. During sampling, the drift nets will be attended by one or more field crew members to monitor for approaching rafts or other safety hazards. If needed, field personnel will verbally warn rafters of the potential hazard and assist rafts in avoiding the nets.

Drift nets will be deployed for three hours each day (1700–2000 hours). The width and depth of the submerged portion of each net will be measured upon installation to calculate the effective net area (i.e., the area being sampled). Water velocity will be measured at the midpoint of each net mouth immediately after net installation, at the midpoint of sampling (after 1.5 hours), and immediately before retrieving the net. The three velocity values will be used to calculate the average water velocity at the mouth of each net during sampling, and the average velocity will be multiplied by the sampled area to determine the total volume of water passing through each net during the sampling event. Because net clogging during sampling can gradually reduce the velocity of water passing through the net, an average of several water

velocities measured over the course of sampling provides a more accurate measure of volume than a single velocity measure.

After removing each drift net from the water, the contents will be carefully washed to the end of the net and into the collection bottle using river water. The bottle will then be removed and all contents will be transferred to a sample container, labeled, and preserved with 95% ethanol for later processing.

Benthic sampling

Benthic sampling will be conducted using a modified version of the targeted riffle composite (TRC) method described in the California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment Standard Operating Procedure (Ode 2007). The TRC has been widely used in California by state and federal water resource agencies, is consistent with the methods of EPA's Environmental Monitoring and Assessment Program (EMAP) (Peck et al. 2006), and has been adopted as the standard riffle protocol for bioassessment in California (Ode 2007). A similar methodology, the former California Stream Bioassessment Protocol (CSBP) and later the California Monitoring and Assessment Program in the lower Tuolumne River from 2001–2005 and from 2007–2009 (Stillwater Sciences 2010). The SWAMP TRC method was recently used to collect benthic macroinvertebrate samples in the upper Merced River as part of the Merced River Alliance Biological Monitoring and Assessment project (Stillwater Sciences 2008).

Due to site access constraints and non-wadeability in most habitat types, a modified version of the SWAMP protocol will be used to select riffles or other suitable fast-water habitat types for TRC sampling. Whereas the SWAMP protocol specifies that habitats (riffles or other fast-water habitats) for TRC sampling should be selected randomly from a pre-established reach 250 meters in length, riffles sampled for this study will instead be selected randomly from among all potentially wadeable riffles that are accessed during the habitat mapping study and were initially identified in the office by examining high-resolution color aerial photographs of the study reaches. During field sampling, the field crew will carry a set of the aerial photographs with potential sampling riffles identified, to enable identification of alternative sampling riffles if needed. Using the office-based method, a total of five riffles will be selected for sampling. Riffles selected for sampling will be spaced sufficiently to enable sampling of an average of one riffle per day during the five-day raft-based field effort.

In the field, riffles initially selected for benthic sampling will be evaluated individually as they are encountered during the rafting trip to determine whether substrate, depth, and velocity are suitable for sampling, and if they can be sampled safely. A riffle will be deemed suitable if it has enough gravel or cobble substrate to allow collection of up to eight non-overlapping benthic samples in areas that can be safely accessed on foot by a two-person field crew (i.e., depth and velocity do not prohibit safe access and sampling). If a riffle initially chosen for TRC sampling is unsuitable, the crew will proceed to the next suitable riffle. Ideally, a total of five riffles or other fast-water habitats will be sampled in the study reach using the TRC method. At each riffle selected for TRC sampling, physical habitat and water chemistry data will be collected following the SWAMP protocol for the "basic" level of effort (Ode 2007). These data include GPS coordinates and photographs of the site, water temperature, pH, dissolved oxygen, specific conductance, channel width, riparian canopy cover, bank stability, and channel gradient.

The TRC approach specifies collection of benthic samples at eight riffles within each 250 meter sampling reach (Ode 2007). However, preliminary examination of aerial photographs indicates that the riffles in the upper Tuolumne River are relatively infrequent and widely spaced, thus selection of a 250 meter sampling reach containing multiple riffles will likely be infeasible. A modified approach will therefore be used, which will entail collection of eight benthic samples per riffle. If additional suitable riffles or other

suitable fast-water habitat types (e.g., run or pool tail) are located in close proximity to a riffle that has been selected for TRC sampling and can be safely accessed on foot, the required eight samples will be collected at locations distributed randomly among the suitable habitats. Sampling locations in each riffle or combination of fast-water habitat types at each site will be selected randomly using a digital stopwatch or random number chart, as described in Ode (2007). Samples will be collected using a standard D-frame kick net with 500- μ mesh. At each sampling location, a 0.09 m² (1 ft²) area of bottom substrate will be sampled immediately upstream of the net following methods described in Ode (2007). All eight samples collected at each site (riffle or combination of fast-water habitats) will be combined into a single composite sample for the site, preserved in 95% ethanol, and labeled for laboratory processing.

4.3.2.3 Analysis and Reporting

All macroinvertebrate samples will be processed in the laboratory following standardized methods and the data will be entered into a database. Processing will enumerate and identify organisms to the taxonomic level necessary to calculate commonly reported biological metrics (numerical attributes of biotic assemblages) for each sample site from the benthic samples (i.e., TRC samples) and identify the diversity and abundance of primary salmonid prey items in the drift. Benthic macroinvertebrate metrics may include those calculated for benthic macroinvertebrate samples collected in the lower Tuolumne River from 2000–2005 and 2007–2009 (Stillwater Sciences 2010). Laboratory analysis of drift samples will also include length measurement of individual organisms, to allow calculation of biomass at a later date, if desired, to provide a relative measure of energy content and available fish food resources. Results will be included in a technical report that evaluates the adequacy of the macroinvertebrate prey resources to support healthy populations of juvenile anadromous salmonids, as indicated by comparison of the taxonomic composition and relative abundance (drift density) of the upper Tuolumne River macroinvertebrate drift samples with drift samples from other salmonid streams.

5.0 STUDY SCHEDULE

The study will be completed during the summer and fall of 2016; a detailed field schedule will be developed in conjunction with other field studies.

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LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

REINTRODUCTION GOALS SUBCOMMITTEE CONFERENCE CALL

APRIL 13, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581) Fish Passage Facilities Alternatives Assessment Reintroduction Goals Subcommittee Conference Call

Wednesday, April 13, 2016 10:00 am to 12:00 pm

Conference Call Attendees		
No.	Name	Organization
1	Leigh Bartoo	U.S. Fish and Wildlife Service
2	Steve Boyd	Turlock Irrigation District
3	Anna Brathwaite	Modesto Irrigation District
4	Paul Bratovich	HDR, consultant to the Districts
5	Jesse Deason	HDR, consultant to the Districts
6	John Devine	HDR, consultant to the Districts
7	Greg Dias	Modesto Irrigation District
8	Steve Edmondson	National Marine Fisheries Service
9	Art Godwin	Turlock Irrigation District
10	Chuck Hanson	Hanson Environmental, consultant to the Districts
11	Patrick Koepele	Tuolumne River Trust
12	Bao Le	HDR, consultant to the Districts
13	Ellen Levin	City and County of San Francisco
14	Bill Paris	Modesto Irrigation District
15	Bill Sears	City and County of San Francisco
16	Chris Shutes	California Sportfishing Protection Alliance
17	John Wooster	National Marine Fisheries Service
18	Ron Yoshiyama	City and County of San Francisco

Final Meeting Notes

On April 13, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted a Reintroduction Goals Subcommittee conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework). This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document includes the meeting agenda and meeting read ahead materials.

Mr. Bao Le (HDR, consultant to the Districts) said there are two primary components of Framework implementation: (1) collecting site-specific technical, regulatory and socioeconomic information, and (2) assessing that information in the context of the goals for reintroduction in order to evaluate reintroduction feasibility. Mr. Le reviewed the timeline for developing reintroduction goals, noting that goals are needed by the fall of 2016. Mr. Le said this meeting is intended to initiate discussions about developing goals. On today's call meeting attendees will discuss why setting goals is important, potential sources of information for developing goals, and specific examples of goals at other Central Valley reintroduction programs. Mr. Le said if there is time, attendees may begin to discuss what goals might look like for the Tuolumne River.

Mr. Steve Edmondson (National Marine Fisheries Service [NMFS]) said HDR may be able to provide examples of other reintroduction programs the company has worked on that have used a decision matrix similar to the Framework. Mr. Le said he will inquire within HDR as to whether there are examples applicable to the Tuolumne River. Mr. John Devine (HDR) said NMFS may also have worked on

projects, perhaps projects in the Pacific Northwest, which could serve as examples relevant to the effort here. Mr. Edmondson said he is not familiar with any projects that are using a decision framework, like this process. Mr. Edmondson noted there will be a workshop with fish passage experts, both from federal agencies and the private sector, to discuss designing fish passage at high head dams. Mr. Le said he encourages anyone with knowledge of projects that may be applicable to this project to provide information they think might be useful. Later in the meeting, Mr. Edmonson said he had sent an email query out to other NMFS offices about the use of a framework in other reintroduction programs, and none of the individuals who responded to his email were aware of a process similar to the Framework being used elsewhere.

Mr. Le said he thinks Anderson et al. (2014; included in Attachment A) provides a sound basis for evaluating the feasibility of a reintroduction program for the Tuolumne River. In particular, the paper describes the importance of assessing a reintroduction program's potential benefits, risks, and constraints. While the focus is often on achieving success, a reintroduction program must also manage risk associated with the effort and be cognizant of working within the program's constraints. Mr. Le encouraged meeting attendees to read the paper and provide feedback.

Mr. Le said he believes the paper is particularly relevant for the Tuolumne River because the paper approaches reintroduction planning from the perspective of recovery of salmonid species listed under the Endangered Species Act (ESA), which is also the driving motivation behind the NMFS Recovery Plan (2014; available online <u>here</u>). The NMFS Recovery Plan lists the upper Tuolumne River as a candidate reach for steelhead and spring-run Chinook. Mr. Le said the Recovery Plan seems like an obvious source of information to explore to inform the development of reintroduction goals. Mr. Le asked if meeting attendees had any thoughts about the Recovery Plan and using that document as a source of information for helping to craft reintroduction goals and objectives for the Tuolumne River. No one responded. Mr. Le requested that meeting attendees review the Recovery Plan and provide feedback on whether the Recovery Plan is relevant to developing reintroduction goals on the Tuolumne River.

Mr. Paul Bratovich (HDR) provided a summary of the reintroduction program on the Yuba River. Mr. Bratovich noted that several individuals on this call, including Mr. Steve Edmondson (NMFS), Mr. Chris Shutes (California Sportfishing Protecting Alliance), and Mr. John Wooster (NMFS) have participated in the reintroduction program for the Yuba River. Mr. Bratovich said the reintroduction initiative on the Yuba River has evolved over several years. Most recently, goals and objectives were agreed to in a concept plan, which accompanied the settlement term sheet. Mr. Bratovich said the goals and objectives of a reintroduction program are much different from fish passage facility operational performance criteria, and that the two must not be confused. Mr. Bratovich said there are a number of ways in which reintroduction goals may be structured. Mr. Bratovich said the NMFS Recovery Plan has a section about recovery goals and population goals. However, these goals are structured differently than goals being developed for the Stanislaus River. Goals for the Yuba River are structured differently than both goals in the NMFS Recovery Plan and goals for the Stanislaus River.

Mr. Bratovich said one possible route is to create numeric goals and objectives, such as the number of individuals needed for a viable population. "Viability" is defined in the NMFS Recovery Plan by numeric criteria and extinction risk, but "viability" would still need to be defined as it pertains to the potential river and project. Mr. Bratovich said a "simpler criteria" that has been identified by Lindley may also be used. These criteria have four parameters: abundance, productivity, spatial structure, and diversity.

Mr. Bratovich said one issue to consider when developing reintroduction goals is in-basin versus out-ofbasin effects. For example, a reintroduction program with a goal tied to a species population metric such as the number of returning adults will be assuming responsibility for out-of-basin and/or non-project effects, such as predation, ocean conditions, sportfishing and commercial fishing. One approach to defining goals that can remove out-of-basin and non-project effects is to define goals based on the number of individuals at various life stages that can be supported by managing suitable habitat.

Mr. Bratovich said the Yuba River concept plan reintroduction goals are based on providing suitable habitat to support a low extinction risk, as interpreted by the simpler criteria from Lindley and others. In particular, the goals specify a number of individuals in terms of habitat, and do not assume responsibility for numbers of returning adults. Mr. Bratovich noted the project is currently in settlement negotiations.

Dr. Chuck Hanson (Hanson Environmental, consultant to the Districts) gave a summary of the reintroduction program on the San Joaquin River. Dr. Hanson said talks of reintroduction on the San Joaquin River first began in 1988 when the National Resources Defense Council sued the U.S. Bureau of Reclamation (Reclamation). After many years of litigation and many environmental studies, the parties settled in 2006. The settlement agreement had several components. In particular, the settlement agreement: (1) recommended that several projects be implemented in order to successfully re-establish spring-run Chinook; (2) provided goals for re-establishing a self-sustaining naturally reproducing population of spring-run Chinook downstream of Friant Dam, and (3) formed a Technical Advisory Committee to provide advice on what needed to be done for the program to be successful.

Dr. Hanson said one of the first tasks of the new program was to compile into a single document all the existing environmental information about the reach identified for reintroduction, so that existing conditions and problem areas could be identified. With the data compilation in hand, the Technical Advisory Committee determined that reintroduction would focus on spring-run Chinook, and a secondary focus would be on fall-run Chinook.

Dr. Hanson said in October 2007, a document entitled *Recommendations on Restoring Spring-Run Chinook to the San Joaquin River* was released. The document recommended that the reintroduction strategy be compatible with existing conditions, such as the carrying capacity of the spawning gravel and existing water temperatures. The program should be responsive to natural selection processes. The "build it and they will come" approach was eliminated from consideration because it was likely there were not enough strays to make the program feasible. The program should aim to create a founding population with life history characteristics that match the anticipated environmental conditions. The founding population should also exhibit broad genetic diversity. Genetic diversity was important for fostering natural selection and thus creating a population that was genetically suited to conditions in the San Joaquin. The document also recommended the founding population be demographically diverse, with broad life history expression for juvenile rearing, with the goal that adults would return at multiple age classes, thus building resiliency.

Dr. Hanson said given there had been no Chinook present in the system for over 50 years, it was decided that the San Joaquin River reintroduction program would be best implemented through four phases: (1) Reintroduction Period; (2) Interim Period (during this period, infrastructure would be constructed and begin operating); (3) Population Growth Period (during this period, escapement and reproduction would take place); and (4) Maintenance Period (this is the long-term period of program operation). Dr. Hanson said at the beginning of the process, the number of returning adults was selected as the metric that best reflected whether the program was accomplishing its objective (i.e., to produce a self-sustaining, naturally reproducing population). The Reintroduction Period focused on achieving a five-year running average escapement of at least 2,500 fish, with a minimum escapement of 500 fish.

Dr. Hanson said the team looked at multiple life stage strategies for the founding population to mimic populations that had been established previously in northern California. The team looked into collecting eggs, fry, and juveniles from Deer Creek and Mill Creek, but there were political sensitivities to that

approach. The team, which included NMFS, USFWS, and Reclamation, among others, determined a politically feasible strategy was to build a conservation hatchery. A conservation hatchery would increase the number of juveniles available for use by the program and would be helpful in low water years. To minimize impacts to natural populations, the conservation hatchery would use surplus fish from the Feather River Hatchery.

Dr. Hanson said currently the team has permits to import eggs and fry from the Feather River. CDFW started the conservation hatchery with fall-run Chinook. Currently, CDFW is applying what has been learned from raising the fall-run Chinook and is shifting the hatchery operations to spring-run Chinook. Dr. Hanson said the program is currently introducing spring-run into the system and trapping and hauling fall-run Chinook. The program monitors reproduction, fry emergence, juvenile migration, abundance of juveniles, and survival by reach, among other metrics. The program is also currently addressing multiple problems that have arisen unexpectedly, including seepage, impacts to agricultural and other water users, levy instability, and predation issues. Due to predation, the program is not producing as many juveniles as was previously anticipated.

Dr. Hanson said the program estimated adult escapement based on an analysis of the limiting factors. The analysis provided a useful framework, but it now must be applied to site-specific factors. The team is realizing that original projections for how long it would take to implement the project were overly optimistic, in part due to interdisciplinary issues that were not anticipated. Dr. Hanson said he will send Mr. Le documents related to the reintroduction approach. Dr. Hanson said he sees many parallels between the Yuba River and Tuolumne River in terms of establishing a successful reintroduction program.

Mr. Le noted that for the programs on the Yuba River and San Joaquin River, the summaries provided by Mr. Bratovich and Dr. Hanson describe a phase of the program where the decision to reintroduce fish had already been made. However, for the Tuolumne River, NMFS has stated in a previous workshop that a decision to reintroduce fish has still not yet been made. Mr. Le asked whether in either of the processes, there was a phase of the process that focused on evaluating reintroduction feasibility toward a "go/no go" decision. Both Mr. Bratovich and Dr. Hanson noted that reintroduction programs were identified from settlement discussions and a structured evaluation framework such as that proposed for the Tuolumne River had not been implemented. Mr. Bratovich said many millions of dollars were previously spent collecting information on the Yuba River, and all that information was available to inform the reintroduction planning process. Dr. Hanson said preliminary discussions for the San Joaquin focused on what it would take to meet the requirements suggested by the limiting factor analysis. Mr. Le said it appears the process on the San Joaquin was driven by limiting factors such as thermal suitability and carrying capacity, and not independently by goals. Mr. Le noted this is different from what this group is trying to do on the Tuolumne River, which is to collect the information in parallel but independent of developing the reintroduction program goals and success criteria, and then evaluate the information and criteria hand-in-hand to evaluate whether the goals can be met (i.e., feasibility) prior to considering implementation. Mr. Le stated that careful planning and evaluation was a valuable point he took from review of the Anderson et al. (2014) since the authors had noted that in their review of the salmonid reintroduction literature, there remain large uncertainties in the success of reintroduction in establishing self-sustaining populations, particularly for programs employing active colonization strategies.

Mr. Wooster asked Dr. Hanson to highlight a few of the parallels between the situation on the San Joaquin River and the situation on the Tuolumne River. Dr. Hanson said both rivers are in the southern geographic range of the target species, and both rivers share similar hydrologic and temperature concerns. In addition, habitat features such as the availability of spawning gravel are also problematic. Dr. Hanson noted too that both rivers exhibit poor survival of juvenile outmigrants.

Mr. Yoshiyama said he believes that the genetics of spring-run and fall-run on the Feather River cannot be genetically distinguished from one another. Mr. Yoshiyama said he sees the Feather River Chinook population as a gradation of life history timings and forms, with very early migrants that would be classified as spring-run and later fish that would be classified as fall-run. Mr. Yoshiyama said that this gradation would have repercussions for the Tuolumne River. Mr. Yoshiyama asked if the group here is more interested in achieving life history diversity, as opposed to achieving a true spring-run life history. Mr. Yoshiyama said it may make it easier to achieve a spring-run life history on the Tuolumne River if genetic mixing between fall-run and spring-run is not a concern. Dr. Hanson confirmed that the Feather River spring-run do not have unique genetics. Instead, the fish are a blend. Dr. Hanson noted that on the San Joaquin River, the team had to move away from a focus on maintaining genetic diversity to a focus on life history.

Mr. Le noted that on the San Joaquin, prior to the decision to move away from fall-run, the initial program was going to use fall-run as surrogates and then move to spring-run. Mr. Le asked what consideration had been given to how to separate out the two sets of fish, given that their life histories overlap both temporally and spatially. Dr. Hanson said consideration had been given to how flows or mechanical intervention could be used to separate the two runs. Dr. Hanson said genetic testing is currently underway to better understand the issue Dr. Yoshiyama raised.

Mr. Devine asked Mr. Bratovich to describe how the Framework was developed. Mr. Bratovich said he was unaware of examples where a similar reintroduction framework had been used. However, all the components of the Framework are issues that have been addressed at other projects and/or were issues Anderson et al. (2014) recommended be addressed. Mr. Bratovich said the Framework is simply a visual representation of those components. Mr. Devine said the Framework was an attempt to systematically bring together, organize, and sequence all the biological and ecological criteria, regulatory issues, and engineering considerations. Mr. Devine said one takeaway from Anderson et al. (2014) is that failing to approach reintroduction in a systematic way often leads to problems down the road. Mr. Devine discussed the importance of having a site-specific framework that reflects the specific issues of the watershed.

Dr. Yoshiyama said one item of note in Anderson et al. (2014) is that in order to assess the success of a reintroduction program, fish generations must be monitored for several decades. Dr. Yoshiyama said this group must also consider what indicators should be monitored in order to assess whether the program is failing or has failed. Mr. Le agreed that monitoring is a key component of evaluating a program, and that he thinks it will be necessary to include an adaptive component that provides an opportunity for a programmatic course correction. Mr. Le said his takeaway from Anderson et al. (2014) is that the first step in a reintroduction program is first determining whether the program is worth doing.

Mr. Shutes said it is a good idea in the beginning to identify front-end decisions that could have dramatic consequences for the success or failure of the program. For example, if the goal is to reintroduce fall-run on the San Joaquin, and there isn't enough water to get the fall-run to move to suitable habitat, it does not necessarily mean the program is doomed to fail, only that the limiting factor must be identified.

Mr. Le summarized issues discussed by Mr. Bratovich and Dr. Hanson that may be considered while developing reintroduction goals and objectives for the Tuolumne River. Mr. Le asked if others have thoughts about what would be realistic goals for this program. There was no response. Mr. Le asked if others thought the goals should be tied to habitat availability, escapement, and/or the NMFS Recovery Plan. Mr. Le added that there did not seem like a reason to pursue reintroduction if the end goal is not to support delisting the species. Mr. Shutes said in addition to the approach of tying goals to habitat, he believes the goals should apply to a defined geographic area, so that metrics are not based on out-of-basin factors beyond the control of the program and program proponents. An example would be a goal based

on juveniles per spawner. Mr. Shutes said he recommended that each meeting attendee or entity sketch out a short high-level narrative goals proposal to be shared with the rest of the Reintroduction Goals Subcommittee. With those ideas in hand, the group can begin to consider something more quantitative. Mr. Shutes noted that objectives considered for the Yuba River may be helpful to reference and attendees might also consider how goals for the Tuolumne River might relate to the NMFS Recovery Plan criteria. Mr. Le suggested each Subcommittee member or entity send HDR a short bulleted list with thoughts on goals for a Tuolumne River reintroduction program and how success might be defined. The bulleted list could be a narrative/qualitative or quantitative. HDR will combined the lists and circulate the compilation for discussion on the next subcommittee call.

Mr. Edmondson asked if there is a reason why the group is not moving forward with the engineering feasibility portion of the study. Mr. Edmondson said he does not believe this exercise in setting goals is something that needs to happen in a step-wise manner, and he wondered how long this process will continue without moving forward with the engineering feasibility. Mr. Devine said the biological criteria must be known in order to develop reliable cost estimates and accurate facility designs that are the correct size and layout and that operate at the correct times. Mr. Devine said designing facilities without this basic information is akin to asking a builder to design a house without knowing how many people will live in it. The builder can design a house, but the design and cost estimate will be meaningless because the design was not based on solid information. Mr. Devine said it is not good practice to guess what the biological criteria are that will inform the design. Mr. Devine said the Districts asked for input on the biological criteria in Technical Memorandum No. 1, and the Districts are open to having a meeting to discuss in detail what biological criteria are needed for the design. Mr. Devine said differences in expected performance standards for the facilities, biological criteria, and percent efficiencies would result in the design of very different facilities.

Ms. Ellen Levin (City and County of San Francisco) asked how NMFS would go about building a fish passage facility without first knowing the goals of the facility. Mr. Edmondson said NMFS has contracted for fish passage engineering studies for the Merced River and the Yuba River. Mr. Edmondson said these studies use the NMFS fish passage design document, which is currently being updated, and provides the basic information on what is needed to design a facility. Mr. Edmondson said NMFS would look to expectations and performance criteria at state-of-the-art fish passage facilities to determine these factors for the Tuolumne River study. Mr. Edmondson said he believes the conceptual engineering feasibility can move forward in parallel with this effort to develop goals, and does not need to be in sequence. Mr. Edmonson said his concern is delay to the schedule, and in order to keep costs down the schedule should move forward as efficiently as possible.

Ms. Levin said she agreed this process must be done right. Ms. Levin said it is very unclear what the reintroduction goals should be and what it is that this program is trying to accomplish. Ms. Levin said without those goals, it is unknown how the design can move forward. Ms. Levin said that while a generic fish passage facility can be designed, without first knowing the goals of the facility the design could be at completely the wrong scale. Ms. Levin said if state-of-the-art is what NMFS wants, a state-of-the-art facility could be what is designed, but the end results may be incredibly expensive and completely overdesigned. Ms. Levin said the better approach would be to first determine what facilities are needed. Mr. Edmondson reiterated that he believes the conceptual engineering feasibility can move forward based on information provided in the NMFS design criteria. One can decide to build a house on a lot without first knowing what color the curtains will be. Mr. Edmondson said the NMFS design criteria provides guidance on layout sizing and performance elements. Mr. Edmondson said he is taken aback to hear that engineers who design fish passage for a living are unable to move forward with the engineering. Mr. Edmondson said he would be happy to put pen to paper and provide the biological information requested in TM No. 1.

Mr. Shutes said a middle ground between no definition and complete definition is to use ranges for these types of data. In some cases, it may be instructive to see what cost differences result when assuming a range, such as the costs to build a facility that accommodates 2,000 fish compared to facility designed to accommodate 10,000 fish. Mr. Shutes said he thinks it reasonable for meeting attendees to provide some initial thoughts and ideas. Mr. Shutes said these initial thoughts would not be commitments, but just general ideas. Mr. Shutes said perhaps the group could sit down and have a conversation about these numbers so that the engineering can move forward. Mr. Shutes said he agrees that planning for a range will provide a result with wide error bars. However, planning for a range will provide a sense of the scale of facility anticipated here. Mr. Shutes said he believes it is appropriate for the development of the goals and objectives to take place in parallel with engineering at the scale NMFS is referring to.

Mr. Devine said the Districts can move forward with the engineering using a range, but the range must be based on sound information. Mr. Devine said the Districts welcome feedback on biological criteria that is based on solid science. Mr. Edmondson asked what level of engineering will be completed for the facility designs. Mr. Devine said this is a conceptual engineering study, but the engineering must still be based in fact, otherwise the results are guaranteed to be wrong. Mr. Devine questioned why money should be spent to estimate something when the estimate is based on guesses.

Mr. Le noted there are examples of fish passage projects in the Pacific Northwest that moved forward with designing conceptual-level facilities, but in those cases there were existing runs and habitat suitability data to base the designs on. Mr. Le said similar information for the Tuolumne River does not exist. Two of the target species do not currently exist in the river. Mr. Le said the carrying capacity work NMFS is completing (available in October 2016) and work the Districts will be completing this summer will be very helpful for informing the design process. Mr. Le said he agrees with Mr. Devine and Mr. Shutes that a separate call may be needed to help move this forward. Mr. Le said the Districts will take on an action item to move this forward.

Mr. Le asked if meeting attendees are amendable to providing their initial thoughts about reintroduction goals and ideas. The ideas could be narrative/qualitative or quantitative, and need not be longer than one page. Mr. Le said the ideas would be considered as draft conceptual ideas, the purpose of which would be to stimulate conversation, and would be considered and discussed without attribution. Mr. Le said HDR will consolidate the ideas and circulate the compiled document. Mr. Le asked if two weeks is enough time to provide these initial thoughts.

Mr. Edmondson proposed that instead of meeting attendees providing their ideas, HDR create a proposal and allow meeting attendees to comment on that proposal. Mr. Devine said that is a possibility. Mr. Dias said getting feedback from meeting attendees on the proposal would be important. Mr. Le asked if Mr. Edmonson proposed this alternative because two weeks is an insufficient amount of time to draft ideas. Mr. Edmondson said he thinks it will be more efficient for HDR to draft a proposal and allow others to provide their comments. Mr. Edmondson said this approach is similar to how these documents are typically created in a FERC proceeding. In such proceedings, a contractor develops the product and stakeholders provide comments on that product. Mr. Edmondson said he thinks the one-pagers could all come out very differently, and since much of that variety won't be reflected in the final product, it would not be a good use of time. Mr. Devine said the Districts will consider Mr. Edmondson's suggestion and provide feedback. Mr. Edmondson said that would be acceptable.

Mr. Le said the Districts will send out notes from this meeting.

Meeting adjourned.

ACTION ITEMS

- 1. Mr. Le will inquire within HDR as to whether there are examples of other reintroduction programs that have used a decision matrix similar to the Framework and that are applicable to the Tuolumne River.
- Dr. Hanson will send Mr. Le documents related to the approach to reintroduction on the San Joaquin River. The Districts will provide these documents to the Reintroduction Goals Subcommittee. (complete)
- 3. Mr. Edmondson will put pen to paper and provide the biological basis the engineering needs to make progress as outlined in TM No. 1.
- 4. The Districts will facilitate a future meeting to discuss the biological criteria necessary to move forward the engineering study.
- 5. The Districts will consider and provide feedback on Mr. Edmondson's suggestion that the Districts provide a one-pager about goals, and circulate this one pager for comment, instead of individual attendees and entities providing their own one-pagers.
- 6. The Districts will send out meeting notes. (complete)

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

REINTRODUCTION GOALS SUBCOMMITTEE CONFERENCE CALL

APRIL 13, 2016

ATTACHMENT A

MEETING AGENDA AND READ-AHEAD MATERIALS

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La Grange Hydroelectric Project Reintroduction Assessment Framework Reintroduction Goals Subcommittee Conference Call Wednesday, April 13, 10:00 am to 12:00 pm Conference Line: 1-866-583-7984; Passcode: 8140607

Meeting Objectives:

- 1. Review and confirm the purpose of the Reintroduction Goals Subcommittee.
- 2. Present and discuss examples of reintroduction assessment goal(s) development.
- 3. Discuss development of reintroduction assessment goal(s) relevant to the Tuolumne River Reintroduction Assessment Framework.
- 4. Identify next steps on Reintroduction Goals Subcommittee.

TIME	TOPIC
10:00 am – 10:15 am	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts)
10:15 am – 10:45 am	 Reintroduction Assessment Framework – Development of Program Goals. Why Is It Important? What Purpose Does it Serve? (All) a. Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery, Andersen et al. b. NMFS Recovery Plan
10:45 am – 11:15 am	Development of Reintroduction Goals - Examples a. Yuba River (Paul Bratovich) b. San Joaquin River (Chuck Hanson)
11:15 am – 11:50 am	 Process for Developing Tuolumne River Reintroduction Goals (all) a. Part 1: Narrative goal(s) statement b. Par 2: Quantitative metrics
11:50 am – 12:00 pm	Next Steps (All) a. Schedule next call and agenda topics b. Action items from this call

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Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery

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ARTICLE

Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery

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Abstract

Local extirpations of Pacific salmon *Oncorhynchus* spp. and steelhead *O. mykiss*, often due to dams and other stream barriers, are common throughout the western United States. Reestablishing salmonid populations in areas they historically occupied has substantial potential to assist conservation efforts, but best practices for reintroduction are not well established. In this paper, we present a framework for planning reintroductions designed to promote the recovery of salmonids listed under the Endangered Species Act. Before implementing a plan, managers should first describe the benefits, risks, and constraints of a proposed reintroduction. We define benefits as specific biological improvements towards recovery objectives. Risks are the potential negative outcomes of reintroductions that could worsen conservation status rather than improve it. Constraints are biological factors that will determine whether the reintroduction successfully establishes a self-sustaining population. We provide guidance for selecting a recolonization strategy (natural colonization, transplanting, or hatchery releases), a source population, and a method for providing passage that will maximize the probability of conservation benefit while minimizing risks. Monitoring is necessary to determine whether the reintroduction successfully achieved the benefits and to evaluate the impacts on nontarget

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species or populations. Many of the benefits, especially diversity and the evolution of locally adapted population segments, are likely to accrue over decadal time scales. Thus, we view reintroduction as a long-term approach to enhancing viability. Finally, our review of published salmonid reintroduction case studies suggests that large uncertainties remain in the success of reintroduction in establishing self-sustaining populations, particularly for programs employing active methods.

Reintroducing species to areas from which they have been extirpated is a common and sometimes successful approach to conserving biodiversity. Indeed, reintroductions played a prominent role in some of the most spectacular success stories in conservation, including species that have recovered from the brink of extinction such as the Arabian oryx *Oryx leucoryx* (Spalton et al. 1999) and alpine ibex *Capra ibex ibex* (Stüwe and Nievergelt 1991). However, despite considerable cost and effort, reintroduction efforts often fail to establish self-sustaining populations (Wolf et al. 1996; Fischer and Lindenmayer 2000). A recent proliferation of reintroduction literature suggests that scientifically based management principles can improve the efficacy of these efforts (Seddon et al. 2007; Armstrong and Seddon 2008).

Conceptually, reintroductions offer an enormous potential to benefit the conservation of Pacific salmon Oncorhynchus spp. and steelhead O. mykiss (anadromous Rainbow Trout). For many anadromous salmonid populations, the primary cause of local extirpation is easily identified: obstructed access to suitable spawning and rearing habitats due to dams or other stream blockages. Large barriers are responsible for extirpation from nearly 45% of the habitat historically occupied by Pacific salmon and steelhead in the western contiguous United States (McClure et al. 2008a). Numerous smaller structures, such as irrigation diversion dams and culverts, also limit access to anadromous salmonid habitat (Gibson et al. 2005). Impassable dams are only one cause of declining salmonid populations and local extirpations (NRC 1996), but they are widespread. The removal or circumvention of dams and other barriers, therefore, provides many opportunities for the reestablishment of natural populations of Pacific salmon.

Despite the potential benefits of reintroduction, regional recovery planners must grapple with a variety of challenges in selecting and implementing such projects. Which populations should be prioritized for reintroduction? What methods should be used to reintroduce anadromous salmonids? How should managers evaluate whether efforts have been successful? Although previous authors have provided general guidelines for fish reintroductions (Williams et al. 1988; Minckley 1995; George et al. 2009; Dunham et al. 2011), the unique biology and management of Pacific salmon and steelhead merit special consideration.

In this paper, we provide recommendations for planning reintroductions of anadromous salmonids, focusing primarily on Pacific salmon and steelhead. Our guidelines are intended to help resource managers design reintroduction programs that contribute to the recovery of Pacific salmon and steelhead listed under the U.S. Endangered Species Act (ESA) by establishing or expanding self-sustaining natural populations. Thus, we present recommendations couched in the terminology, scientific concepts, and broad conservation objectives guiding ongoing salmonid recovery efforts under the ESA (McElhany et al. 2000). The International Union for the Conservation of Nature (IUCN 1998) defined reintroduction as "an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated." Using this broad definition, we consider a suite of management approaches to reintroduction, including passive strategies, such as barrier removal followed by natural colonization, and active strategies, such as transplanting or hatchery releases.

Reintroductions alter patterns of connectivity among populations. We therefore first develop a metapopulation framework to describe the ecological processes governing population connectivity and their evolutionary consequences. We then broadly overview a set of planning concepts (benefits, risks, and constraints) to help guide scoping efforts and determine if a proposed reintroduction has conservation merit. Next, we describe methods of executing reintroductions that increase the likelihood of achieving benefits while overcoming constraints and reducing risks, including a review of examples in which these methods have been employed. Finally, monitoring is essential to assess whether the effort was successful and, if not, how the program should be modified. Throughout, we focus on biological issues, acknowledging that a socioeconomic cost-benefit analysis will be crucial for policy decisions regarding large-scale restoration projects.

A METAPOPULATION PERSPECTIVE

A regional, landscape perspective is important for effective salmonid recovery (ISAB 2011). We therefore present our recommendations within a metapopulation conceptual framework. A metapopulation is a collection of spatially structured populations inhabiting discrete habitat patches, with dispersal between patches providing some level of connectivity between populations (Hanski and Gilpin 1997). Reintroductions intentionally alter connectivity among populations, so it is important to consider the consequences of such actions on the demography, ecology, and evolution of the metapopulation at large. The metapopulation concept is readily applied to anadromous salmonids (Schtickzelle and Quinn 2007) and especially the case of population colonization. Pacific salmon have a strong tendency to return to their natal stream but also "stray" and breed in nonnatal streams (Hendry et al. 2004), providing the interpopulation dispersal characteristic of metapopulations. Dispersal, combined with variation in population growth rate, can lead to source–sink dynamics whereby populations with net demographic deficits (i.e., "sinks") are supported by immigration from populations with net demographic excesses (i.e., "sources") (Pulliam 1988). For colonizing Pacific salmon, source population dynamics will, in large part, determine the rate of numerical and spatial expansion (Pess et al. 2012).

Salmonid metapopulations might adopt a variety of different structural configurations depending on the spatial arrangement of habitat, heterogeneity in habitat quality among patches, and connectivity between populations (Schtickzelle and Quinn 2007; Fullerton et al. 2011). Metapopulation structure is useful to conceptualize the potential outcomes of reintroductions (Figure 1). Furthermore, an assessment of metapopulation structure might inform reintroduction methods. For example, a reintroduction that expands an existing population (Figure 1A) or establishes a new well-connected population (Figure 1B) might achieve success through passive natural colonization, whereas active methods might be required for more isolated reintroduction sites (Figure 1C).

Metapopulation structure, and the degree of connectivity among populations, also affects the evolution of locally adapted traits. Spatially structured populations experiencing different selection regimes within a heterogeneous landscape will tend to evolve traits advantageous in each environment, a process that is counterbalanced by connectivity between populations, which tends to homogenize gene pools (Barton and Whitlock 1997). Local adaptation is a fundamental aspect of salmonid population structure (Taylor 1991; Fraser et al. 2011). Furthermore, life history diversity exhibited by locally adapted populations buffers salmonid species against environmental variation, increasing stability and resilience (Greene et al. 2010; Schindler et al. 2010) while reducing extinction risk (Moore et al. 2010).

Increasing population connectivity, an implicit goal of all reintroduction programs, can have both positive and negative consequences on species viability. Some level of connectivity is beneficial because it can lead to the colonization of new habitat (Pess et al. 2012), demographically rescue extant populations experiencing periods of low productivity or abundance (Pulliam 1988), and provide new genetic material essential for fitness in populations suffering from fragmentation (Tallmon et al. 2004). However, excessive connectivity can have negative consequences such as genetic homogenization (Williamson and May 2005) and demographic synchrony (Liebhold et al. 2004), both of which would tend to reduce resilience.

For administering listing and recovery of Pacific salmon under the ESA, the National Marine Fisheries Service (NMFS) uses an explicitly defined population structure. For vertebrates,

FIGURE 1. Possible effects of reintroduction on metapopulation structure are as follows: (A) increase the abundance of the existing population, (B) establish a new, independent population well connected to the metapopulation, (C) establish a new, independent population isolated from the other populations, (D) establish a new, independent mainland population in a historic mainland–island metapopulation, and (E) establish a new, independent sink population in a historic mainland–island metapopulation. In these diagrams, the size of the circle represents habitat capacity, the shade represents population density (darker shades are more dense), the thickness of the arrows represents the magnitude of connectivity, and the dashed lines indicate intermittent connectivity. These scenarios are not intended to represent all possible outcomes.

the ESA allows listing of Distinct Population Segments (DPSs), subspecies, or entire species. For Pacific salmon, the NMFS has defined a DPS to be an Evolutionary Significant Unit (ESU), which is a population or group of populations that is both substantially reproductively isolated from other populations and represents an important component of the evolutionary legacy of the species (Waples 1991). For steelhead, the NMFS uses the joint NMFS–U.S. Fish and Wildlife Service DPS definition



Before reintroduction After reintroduction

(NMFS 2006). We refer to both Pacific salmon ESUs and steelhead DPSs as ESUs in this paper for consistency and brevity. Similar to metapopulations, most Pacific salmon ESUs contain multiple independent populations that interact through dispersal (e.g., Myers et al. 2006; Ruckelshaus et al. 2006). Furthermore, metapopulation concepts are explicitly considered in the criteria used to evaluate the viability of Pacific salmon and steelhead ESUs and the populations within them (McElhany et al. 2000).

PLANNING CONCEPTS: BENEFITS, RISKS, AND CONSTRAINTS

Before implementing a reintroduction, it is essential to comprehensively consider the potential outcomes. Poorly planned reintroduction efforts might waste resources that would be better invested in other conservation approaches or, worse, impair the viability of an extant population. In evaluating a potential reintroduction, there are three primary concepts to consider: the benefits if the reintroduction is successful, the risks of causing biological harm to extant populations, and the constraints that might prevent population establishment. Weighing the potential benefits against the risks and constraints will help determine whether or not to implement a proposed reintroduction (Figure 2).

Benefits

Due to our focus on ESA-listed salmonids, we assess benefits with the same criteria used to evaluate recovery under the ESA. The biological viability of salmonid ESUs and the populations within them is dependent upon four characteristics: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). We use these same attributes for evaluating the potential benefits of a reintroduction that successfully establishes a selfsustaining population (Table 1). Abundance, productivity, and spatial structure (i.e., connectivity) are variables in metapoulation models useful for guiding salmonid management (Cooper

TABLE 1. Potential benefits of a successful reintroduction.



Constraints and biological risks

FIGURE 2. Framework for gauging the net benefit of reintroduction options, with darker colors representing a higher likelihood of contributing to conservation and recovery goals. In each case, the benefits are weighed against the constraints and risks of the project. In quadrant 1 (Q1), the benefits are high and the overall constraints and risks are low, providing the best opportunity for reintroduction to effectively contribute to the recovery objectives. Quadrant 2 (Q2) also has a high potential benefit, but either the difficulty in implementation or the risk of a negative outcome makes projects in this region less attractive. Both quadrants 3 (Q3) and 4 (Q4) have relatively low benefits; some in quadrant 3 may be selected owing to the low risk and ease of execution, whereas those in quadrant 4 will generally be avoided.

and Mangel 1999; Fullerton et al. 2011; Pess et al. 2012), and diversity promotes resilience at a broad, regional (hence metapopulation) scale (Moore et al. 2010; Schindler et al. 2010).

Numerical increases in abundance and productivity are perhaps the most obvious benefits afforded by reintroductions.

Туре	Definition	Potential benefit afforded by reintroduction
Abundance	Total number of naturally spawned fish in a population or ESU	Increase the carrying capacity of an existing population or establish a new, discrete, demographically independent population
Productivity	Numerical ratio of recruits in generation t to the spawners that produced them in generation $t - 1$	Increase average vital rates (e.g., reproductive success, survival) of an extant population or ESU by reestablishing occupancy of high quality habitat
Spatial structure	Geographic arrangement of fish across the landscape and connectivity of populations linked by dispersal	Reduce isolation of extant populations, thereby restoring natural patterns of dispersal and connectivity within the metapopulation
Diversity	Variation in morphological, behavioral, and genetic traits within a population or ESU	Reestablish occupancy of habitats that are rare or underrepresented within the extant distribution, thereby promoting ecological and evolutionary processes responsible for local adaptation and diverse life histories

Increased abundance has several beneficial consequences, including shielding a population from extinction due to stochastic variability (Lande 1993), minimizing genetic processes that can reduce fitness in small populations (Allendorf and Luikart 2007), exceeding thresholds for depensatory density-dependent processes (Liermann and Hilborn 2001), and providing marinederived nutrient subsidies to aquatic and riparian ecosystems (Gende et al. 2002). Status evaluations of ESA-listed Pacific salmon and steelhead populations focus on numerical productivity (Ford 2011), or population growth rate as it is known in the ecological literature, so recruits per spawner is also an important variable to consider. Reintroductions can have either positive or negative impacts on the productivity of a given population or ESU, depending on the quality of the new habitat and survival through migration and ocean rearing. In general, a reintroduction resulting in a "sink" has far less value for long-term viability than a reintroduction yielding a self-sustaining population. Indeed, reintroduction to a sink would result in a net loss if the animals would have been more productive in their natal habitat. However, in highly connected metapopulations, sinks may increase the stability of the entire system by promoting higher abundance in source populations (Foppen et al. 2000).

Reintroductions that reduce the isolation of formerly connected extant populations will benefit spatial structure (Figure 1). In practice, this can be estimated as the extent to which a newly established population would reduce gaps between spawning areas or populations that were not historically separated. Given the spatial arrangement, models of dispersal, and estimates of habitat capacity, reintroduction could target areas that might have a significant role in metapopulation connectivity and serve as sources supporting less productive populations (Figure 1D; Fullerton et al. 2011; Pess et al. 2012). In addition, at the ESU scale, dispersion of populations across the landscape helps reduce vulnerability to catastrophic events (Good et al. 2008), so increasing spatial complexity via successful reintroduction will reduce ESU extinction risk.

Reintroductions can enhance salmonid diversity through a variety of mechanisms. Dams often selectively block access to certain habitat types, particularly snowmelt-dominated headwater streams (Beechie et al. 2006; McClure et al. 2008a). Therefore, reintroductions into habitats that are rare or underrepresented within the extant species distribution may promote unique local adaptations and life history traits. Barrier removal may provide seaward access for populations of facultatively migratory species (e.g., O. mykiss) that historically had anadromous components (Brenkman et al. 2008b). Reintroductions to large watersheds with multiple tributaries and subbasins also offer opportunities to enhance diversity through the evolution of population substructure and local adaptation to distinct spawning areas. In general, a reintroduction that establishes a new locally adapted population will provide a greater benefit to diversity than one that expands an existing population (Figure 1A, 1B).

Outlining the time frame required to achieve reintroduction benefits will help set expectations and establish benchmarks for monitoring. Some reintroductions may provide immediate benefits within a generation or two, but those requiring adaptation to new habitat will likely take decades. If an implemented project suffers initial setbacks and lacks a scientifically based timeline of expectations, it might be unnecessarily abandoned or altered before it has a chance to succeed. In general, reintroduction can provide benefits to viability characteristics that change on ecological time scales (abundance, productivity, and spatial structure) faster than benefits to diversity, which will accumulate over generations as a reintroduced population becomes demographically independent and evolves in response to local selective pressures. Salmonids have developed population structure within 20 years of introduction to new environments (Ayllon et al. 2006); evidence that such divergence is adaptive has been found after 50-100 years (Hendry et al. 2000; Quinn et al. 2001; Koskinen et al. 2002).

Moreover, in some cases adaptive evolution might be necessary to observe significant increases in abundance. Indeed, there is often a time lag from the initial introduction of an invading species to population growth that might be explained by evolutionary processes required to increase population fitness (Sakai et al. 2001). Dams have altered the evolution of traits such as adult spawn timing, embryonic development rate, and juvenile migration strategies (Angilletta et al. 2008; Williams et al. 2008), so some level of adaptive evolution may be necessary to overcome this "Darwinian debt" if reintroduction includes restoration of the natural flow regime (Waples et al. 2007b).

Risks

We define risks as unintended or undesirable negative consequences for nontarget species or nontarget populations of the reintroduced species (Table 2). Minimizing those risks is important if a reintroduction is to have a positive overall conservation effect (George et al. 2009). Here we outline the concepts underlying four categories of risk: evolutionary, demographic, ecological, and disease. More details on minimizing them are provided below in the Executing a Reintroduction section.

In terms of evolutionary risks, reintroduction could result in genetic homogenization, reduced fitness, or both. Transfers of fish between basins and large-scale hatchery releases, historically common practice throughout the Pacific Northwest, have eroded population structure that is essential for the local adaptation and hence fitness of salmonid populations (Williamson and May 2005; Eldridge and Naish 2007; McClure et al. 2008b). Hatchery fish often have lower fitness than wild fish when both groups breed sympatrically (Araki et al. 2008). Thus, although hatchery releases may provide short-term demographic benefits, they may compromise fitness in the long term, thereby limiting the probability of recovery (Bowlby and Gibson 2011). In many cases, populations or spawning areas near the reintroduction site are of conservation concern. Fish

Туре	Description	Methods of minimizing risk
Evolutionary	Homogenized population structure and reduced fitness within reintroduction site and adjacent areas	Avoid geographically and genetically distant source populations; opt for natural colonization rather than hatchery releases or transplanting; design passage facilities to minimize straying to adjacent areas
Demographic	Depletion of source population via removal of adults or gametes for reintroduction	Ensure that source population can sustain removal for multiple successive years or opt for natural colonization rather than hatchery releases or transplanting
Ecological	Invasion by nonnative species and suppression of preexisting native species within reintroduction site	Design passage facilities with selective access; avoid hatcher releases that alter density-dependent ecological interaction
Disease	Spread of pathogens	Establish baseline disease levels prior to reintroduction; screen individuals for pathogens prior to release

TABLE 2. Summary of the major reintroduction risks, defined as unintended or undesirable negative consequences for nontarget species, nontarget populations, spawning areas, or life history types of the reintroduced species.

released into the reintroduction site, and their offspring, may not return there as adults, so fitness reductions and the erosion of population structure of the wild populations in adjacent spawning areas are potential consequences of excessive straying.

Reintroductions also pose demographic risks because the removal of individuals from the source population may harm its viability. If reintroduced fish experience poor reproductive success, the new habitat may become a sink that depletes an extant population but fails to provide the benefit of a newly established self-sustaining population. Transplanting or collecting broodstock from wild populations will exacerbate this risk, but it applies in concept to natural colonization as well. Ensuring that the population donaiting colonists has a net demographic excess (i.e., it is a true "source" in metapopulation source–sink dynamics) will help reduce demographic risks.

Nonnative fishes present a serious conservation threat to salmonids in the Pacific Northwest (Sanderson et al. 2009) and may invade the reintroduction site following barrier removal (Fausch et al. 2009). Invasion might not only reduce the likelihood of reintroduction success but also threaten preexisting native species. A careful examination of the likelihood of nonnative dispersal into the new habitat entails identifying any proximate populations of nonnative fishes and evaluating habitat suitability above the barrier. It is also important to consider whether reintroduction might suppress preexisting native species (which might be threatened or endangered themselves) through competition or predation. The few empirical assessments of reintroduction impacts have found little effect on preexisting native species (Pearsons and Temple 2007; Buehrens 2011).

Finally, reintroductions have potential to spread disease (Viggers et al. 1993). Colonists may serve as vectors of disease spread within the species they are intended to benefit, thereby hindering conservation efforts (Walker et al. 2008), or transmit pathogens to other species or resident life history types currently occupying the target site. Hatchery fish in particular, due to the crowded conditions in which they are typically reared, may act as vectors of disease transfer to wild populations (reviewed in Naish et al. 2008). Reintroduced animals might also be vulnerable to endemic pathogen strains within new habitat, and this could decrease the likelihood of successful population establishment if the effect is severe. Establishing a baseline of pathogen densities within the area prior to reintroduction will permit monitoring of disease during reintroduction (Brenkman et al. 2008a), and screening captively reared or transplanted animals prior to release will minimize the risk of spreading disease. Both are important components of reintroduction.

Constraints

We define a constraint as a factor limiting the ability of colonists to establish a self-sustaining population (Table 3). In some cases, an extirpated area may have a high potential to benefit long-term recovery, but current conditions do not support a reintroduction. Evaluating whether the original causes of the extirpation have been adequately ameliorated is an important step in determining whether a site is "reintroduction ready" (IUCN 1998). Importantly, more than one factor may have led to the original extirpation, and in many cases determining a logical sequence of restoring functioning conditions will be an important component of the reintroduction effort. Here, we describe the primary constraints affecting the ability of colonists to reach the reintroduction site, their reproductive success, and the survival of their offspring.

In many cases, migration barriers are the most obvious constraint to the reestablishment of a natural population. Evaluating the best methods for providing passage at barriers is heavily dependent on engineering and social considerations such as the geological setting, human benefits derived from the barrier, and expense. Furthermore, many river systems with reintroduction opportunities have more than one blockage to anadromous

Туре	Description	Required action
Barriers	Engineering issues; prioritization among multiple blockages in a watershed or region	Removal or circumvention
Habitat quality	Poor habitat quality will limit reproductive success of colonists and survival of their offspring	Restoration prior to reintroduction
Migratory and ocean survival	Poor survival along migration corridor and during ocean residence	Improve survival through downstream dams; estuary restoration; wait for favorable ocean conditions or scale expectations to match poor ocean conditions
Harvest	Reduces number of potential colonists and survival of their offspring	Reduce fishing pressure on potential source population(s) during colonization
Interactions with other species and populations	Competition and predation from native and nonnative species	Suppress predator population or transport fish during migration to avoid predators
Changing conditions	Climate and land-use change will alter geographic patterns of habitat suitability	Prioritize reintroductions that enhance diversity, are likely to serve as refuges in a warming climate, or are located in river networks whose high connectivity will allow species distributions to shift in response to climate change

TABLE 3. Summary of constraints to reintroductions, defined as factors that might limit the ability of colonists to establish a self-sustaining population.

passage, requiring prioritization among multiple removal or circumvention options.

The quality of habitat in the reintroduction site will have a large effect on colonist productivity. In gauging habitat quality within an area targeted for reintroduction, planners should consider the requirements of all life phases. Spatially explicit models incorporating known fish-habitat relationships (e.g., Scheuerell et al. 2006; Burnett et al. 2007; Pess et al. 2008) can help identify potentially productive streams; determining the anthropogenic degradation of habitats can draw on the many efforts (largely expert opinion) to identify degraded habitat (e.g., subbasin or recovery plans). Where habitat quality is low due to anthropogenic disturbance, habitat restoration may be necessary for successful reintroduction and premature efforts to put fish into degraded habitat may simply be a waste of resources. For example, liming of rivers affected by acidification (Hesthagen and Larsen 2003) and reducing pollution (Perrier et al. 2010; Kesler et al. 2011) were necessary components of reestablishing Atlantic Salmon Salmo salar runs in Europe. When restoration is necessary, process-based restoration will maximize the long-term sustainability of habitat improvements (Beechie et al. 2010).

Interactions with existing species in the target area could influence the likelihood of a successful reintroduction. Dams that block salmonid habitat often create the warm, lentic reservoirs preferred by nonnative fishes (e.g., Channel Catfish *Ictalurus punctatus*, Smallmouth Bass *Micropterus dolomieu*, Yellow Perch *Perca flavescens*, and Walleye *Sander vitreus*) and "native invaders" (e.g., Northern Pikeminnow *Ptychocheilus oregonensis*), species that consume a considerable quantity of salmonids (Sanderson et al. 2009; Carey et al. 2012). Competition and predation from preexisting species might not be confined to reservoirs or degraded habitats. Nonnative Brook Trout *Salvelinus fontinalis*, for example, have invaded relatively pristine, free-flowing streams throughout the Pacific Northwest (Sanderson et al. 2009) and may have suppressed populations of ESA-listed Chinook Salmon *O. tshawytscha* (Levin et al. 2002). Slimy Sculpin *Cottus cognatus*, a native generalist predator, reduced the recruitment success of reintroduced Atlantic Salmon (Ward et al. 2008).

Due to climate forcing (Mantua et al. 2010) and alterations in land use (Bilby and Mollot 2008), salmonid habitat quality is likely to change over the time required for a reintroduction to result in a self-sustaining population. Thus, the likely future condition of the reintroduction site is an important consideration in reintroduction planning efforts. Climate and land-use models can inform restoration opportunities (Battin et al. 2007; Lohse et al. 2008) but have been applied to relatively few watersheds. In the absence of large-scale predictive models, two qualitative guidelines for reintroductions warrant consideration. First, dams selectively block access to certain habitat types (Beechie et al. 2006; McClure et al. 2008b), suggesting that reintroduction to mountain headwater reaches with higher elevations and cooler temperatures may provide refuges in a warming climate. Second, maintaining a diversity of habitat types will buffer against uncertainty in the response of salmonid populations to climate change (Schindler et al. 2008), suggesting that reintroduction should target habitats that are unique, rare, or underrepresented in the current species distribution.

High mortality during migration and ocean rearing due to impaired migratory corridor, poor ocean conditions, or harvest pressure may limit reintroduction success. Passage through



FIGURE 3. Minimizing biological risks in reintroduction planning. Biological risks are unintended negative consequences that may harm nontarget species, other populations, spawning areas, or life history types of the reintroduced species.

downstream dams, for example, may reduce the migratory survival of juveniles, either directly or through delayed effects that manifest in subsequent life stages (Budy et al. 2002; Schaller and Petrosky 2007). Dams may also cause the delay and eventual failure of upstream-migrating adults (Caudill et al. 2007). It is possible to improve survival through dams, even large ones (Ferguson et al. 2007), and this may be an essential action prior to reintroduction. Marine survival patterns are also a major determinant of salmonid population productivity. Ocean survival responds to long-term climatic processes such as the Pacific Decadal Oscillation (Mantua et al. 1997), as well as short-term processes such as interannual variation in sea surface temperature, marine upwelling, and river conditions experienced during migration (Mueter et al. 2005; Scheuerell and Williams 2005; Scheuerell et al. 2009; Petrosky and Schaller 2010). As our ability to identify favorable ocean and river conditions improves (e.g., Burke et al. 2013), there may be opportunities to time reintroduction efforts to favorable conditions. Harvest rates vary among ESUs and in some cases may limit recolonization potential. Fishing quotas set on aggregate stocks may constrain the ability to selectively reduce harvest rates on individual colonizing populations and their sources.

EXECUTING A REINTRODUCTION: COLONIZATION, SOURCE POPULATION, AND PASSAGE

In this section, we discuss the strategies for recolonization, the choice of a source population, and, in the case of reintroductions involving barriers, the techniques used to provide passage. Decisions related to these three execution elements will largely determine reintroduction risks (Figure 3). We define the colonization strategy as the mechanism of fish movement into the reintroduction site; it can be either passive (natural colonization) or active (transplanting or hatchery releases). We suggest that it is important to consider the colonization strategy and source population as two separate planning decisions. For example, even in cases where a hatchery stock is the source, it may be possible to reduce evolutionary risks by allowing hatchery adults to colonize naturally rather than planting hatchery-produced juveniles.

Colonization Strategy

The three basic types of colonization strategies are natural, transplant, and hatchery release. Importantly, these approaches differ in the effects on the viability parameters that will ultimately be used to judge the success or failure of a reintroduction. In general, natural colonization is the lowest-risk approach because it minimizes the interruption of natural biological processes. Transplanting and hatchery releases can immediately place fish in the reintroduction site, but tend to increase the risks associated with reintroduction relative to natural colonization. Fortunately, active reintroduction strategies will be most necessary for isolated reintroduction sites (e.g., Figure 1C), the very situations where evolutionary risks of straying to neighboring extant populations are the lowest. In general, a precautionary
Is there a reasonable likelihood of natural colonization from a nearby spawning area or population?



FIGURE 4. Decision framework for selecting a low-risk colonization strategy and source population. This diagram does not encompass every possibility but is intended to highlight the key decisions affecting reintroduction risks. Boxes indicate decision endpoints.

approach, outlined in Figure 4, adopts the lowest risk colonization strategy that has a reasonable chance of promoting long-term improvement in population and ESU viability.

What is the minimum number of fish necessary to establish a self-sustaining population? This is a crucial question applicable to all three colonization strategies whenever the goal is to establish a new population (e.g., Figures 1B–1E). On one hand, depensatory processes (Allee effects) may depress productivity at low densities through a variety of mechanisms (Courchamp et al. 1999; Liermann and Hilborn 2001) and, if the effect is severe, prevent population establishment following reintroduction (Deredec and Courchamp 2007). On the other hand, reintroduced species, particularly those with an extensive stream-rearing juvenile phase, may be released from density-dependent processes during colonization and enjoy high survival due to the lack of competition (Pess et al. 2011). Although the ultimate result will depend heavily on the constraints (Table 3), the choice of colonization strategy will have a strong influence on the number of fish that reach the reintroduction site. Here, we outline the benefits and risks of each colonization strategy, providing empirical examples if they are available.

Natural colonization.—Pacific salmon can rapidly exploit newly accessible habitat through natural colonization, which we define as volitional dispersal into a reintroduction site without human-assisted transport. Following construction of a fishway circumventing an anthropogenic blockage, Pink Salmon O. gorbuscha naturally dispersed upstream and established selfsustaining populations in multiple subbasins of the Fraser River, British Columbia, within a decade (Pess et al. 2012). Chinook Salmon and Coho Salmon O. kisutch immediately colonized habitat made accessible by modification of a dam on the Cedar River, Washington (Kiffney et al. 2009; Burton et al. 2013), and both species produced a significant number of returning adult offspring that bypassed the dam in the next generation (Anderson et al. 2010; Anderson et al. 2013a). In this system, extensive dispersal by juvenile Coho Salmon, including immigration into a tributary where survival was relatively high, contributed to colonization success (Pess et al. 2011; Anderson et al. 2013b). Steelhead and fluvial Rainbow Trout accessed Beaver Creek, Washington, in the very first season after barrier removal (Weigel et al. 2013). Atlantic Salmon naturally colonized rivers in Estonia, Norway, England, and France following improvements in water quality (Hesthagen and Larsen 2003; Perrier et al. 2010; Griffiths et al. 2011; Kesler et al. 2011), and some of these examples resulted from long-distance dispersal. Dam removal promoted natural colonization of the Upper Salmon River, New Brunswick, by Atlantic Salmon, though this population later crashed to near zero abundance for unknown reasons (Fraser et al. 2007).

In some cases, increasing water releases from dams has promoted natural colonization. In the Bridge River, British Columbia, Coho Salmon, Chinook Salmon, and steelhead were observed immediately following restoration of flow to a 4km reach that had been dewatered for decades (Decker et al. 2008). Experimental water releases from dams on the Alouette and Coquitlam rivers, British Columbia, led to the reappearance of Sockeye Salmon *O. nerka* after 90 years of extirpation, and genetic and otolith analysis confirmed that the anadromous adults were the offspring of resident kokanee (lacustrine Sockeye Salmon) (Godbout et al. 2011).

Natural disturbances and circumvention of natural barriers provide additional examples of natural colonization. Steelhead recolonized the Toutle River, Washington, to relatively high densities 7 years after a catastrophic destruction following the eruption of Mount Saint Helens (Bisson et al. 2005). Natural colonization tends to proceed more slowly (e.g., decades) in initially barren glacial emergent streams, as evidenced by rates of Coho Salmon and Pink Salmon colonization in Glacier Bay, Alaska (Milner and Bailey 1989; Milner et al. 2008). Several salmonid species rapidly colonized Margaret Creek, Alaska, following construction of a fish ladder at a falls, although the Coho Salmon and Sockeye Salmon populations were supplemented by hatchery releases (Bryant et al. 1999).

Establishing a self-sustaining population via natural colonization is contingent on a reasonable likelihood of natural dispersal into the new habitat. The probability of colonization, in turn, is determined by metapopulation attributes such as the location of the potential source population, abundance of the source population, and stray rate (i.e., connectivity) as a function of distance (Pess et al. 2012). Despite these observations, it is difficult to predict precise colonization rates following barrier removal. Most examples of natural colonization by Pacific salmon in Table 4 had nearby, relatively robust source populations, but colonization rates of isolated reintroduction sites are likely to be much lower. Furthermore, one might predict colonization rate to vary by species, but there are few multispecies comparisons to guide expectations (Table 4). In this situation, habitat preferences and life history patterns offer a means to make species-specific predictions (Pess et al. 2008).

Natural colonization minimizes anthropogenic disturbance to biological processes during population establishment and expansion. Natural colonization provides the greatest opportunity for the evolution of locally adapted traits through natural selection on individuals that disperse into the new habitat, sexual selection during reproduction of the initial colonists, and natural selection on their offspring. In many cases, evolution resulting from the novel selection pressures during colonization may increase population fitness and the likelihood of establishment (Kinnison and Hairston 2007). In the Cedar River, Washington, strong selection on the breeding date and body size of Chinook Salmon and Coho Salmon colonists emphasized the importance of natural and sexual selection in promoting local adaptation during reintroduction (Anderson et al. 2010, 2013a).

Transplanting adults.—In areas that are isolated or distant from extant populations, long-distance dispersal from extant populations may be unlikely. In these cases, transplanting can ensure that an adequate number of adult fish reach the reintroduction site. Under this strategy, adult fish are trapped at one location then transported to the reintroduction site, where they are released to breed naturally. Here, we describe the process and consequences of transplanting from both hatchery and wild sources.

Although stock transfers have been common for Pacific salmon, there are relatively few examples in which only adults were released (Withler 1982). In programs that combined transplanted adults with hatchery releases (e.g., Burger et al. 2000; Spies et al. 2007), it is difficult to isolate the effects of each strategy. In a reintroduction or supplementation context, transplants often involve surplus hatchery adults. For example, hatcheryorigin spring Chinook Salmon were transplanted to Shitike Creek, Oregon because the habitat was considered underseeded 15 years after dam removal and produced a significant fraction of the juveniles captured the following spring (Baumsteiger et al. 2008). Atlantic Salmon that had spent their entire lives in captivity successfully spawned following release into Wilmot Creek, Ontario (Scott et al. 2005b). Transplanting adults is frequently used to circumvent large dams and reservoirs in a "trap and haul" strategy (Table 5), and we discuss this approach further in the Providing Passage section below.

TABLE 4. Examples of anadromous salmonid reintroductions from the published literature.

Location	Date initiated	Species	Colonization strategy	Passage provision	References
Fraser River, British Columbia	1947	Pink Salmon	Natural colonization	Fishway	Pess et al. 2012
Clearwater River, Idaho	1960	Chinook Salmon	Hatchery juveniles	Dam removal	Narum et al. 2007
Upper Salmon River, New Brunswick	Mid-1960s	Atlantic Salmon	Natural recolonization	Dam removal	Fraser et al. 2007
Connecticut River, Connecticut, Massachusetts, Vermont, and New Hampshire	1967	Atlantic Salmon	Hatchery juveniles	Fishways	Gephard and McMenemy 2004; Ward et al. 2008
River Thames, England	1975	Atlantic Salmon	Natural colonization and hatchery juveniles	None	Griffiths et al. 2011
Rivers Rhine, Ems, Weser, and Elbe, Germany	1978	Atlantic Salmon	Hatchery juveniles	Primarily fishways	Monnerjahn 2011; Schneider 2011
Point Wolfe River, New Brunswick	1982	Atlantic Salmon	Hatchery juveniles	Dam removal	Fraser et al. 2007
Sawtooth Valley lakes, Idaho	1993	Sockeye Salmon	Hatchery juveniles	None	Griswold et al. 2011; Kalinowski et al. 2012
Middle Fork Willamette River, Oregon	1993	Chinook Salmon	Transplanted adults	Trap and haul	Keefer et al. 2010, 2011
Various Norwegian rivers	Mid-1990s	Atlantic Salmon	Natural colonization and hatchery juveniles ^a	None	Hesthagen and Larsen 2003
Seine River, France	Mid-1990s	Atlantic Salmon	Natural colonization	None	Perrier et al. 2010
River Selja, Estonia	Mid-1990s	Atlantic Salmon	Natural colonization and hatchery juveniles ^b	None	Väsemagi et al. 2001
Bridge River, British Columbia	2000	Chinook Salmon, Coho Salmon, steelhead	Natural colonization	Increased water releases from dam	Decker et al. 2008
Wilmot Creek, Ontario	2000	Atlantic Salmon	Transplanted adults	None	Scott et al. 2005a, 2005b
Salmon River, New York	2000	Atlantic Salmon	Hatchery juveniles	None	Coghlan and Ringer 2004
Shitike Creek, Oregon	2002	Chinook Salmon	Transplanted adults	Dam removal	Baumsteiger et al. 2008
Cedar River, Washington	2003	Chinook Salmon, Coho Salmon	Natural colonization	Fishway	Kiffney et al. 2009; Anderson et al. 2010, 2013a, 2013b; Pess et al. 2011; Burton et al. 2013
Various Lake Ontario	2003	Atlantic Salmon	Hatchery juveniles	None	Coghlan et al. 2007

tributaries, New York

Location	Date initiated	Species	Colonization strategy	Passage provision	References
Alouette and Coquitlam rivers, British Columbia	2005	Sockeye Salmon	Natural colonization	Increased water releases from dams	Godbout et al. 2011
River Purtse, Estonia	2005	Atlantic Salmon	Natural colonization and hatchery juveniles ^c	None	Kesler et al. 2011
Beaver Creek, Washington	2005	Steelhead	Natural colonization	Fishways	Weigel et al. 2013

^aColonization strategy varied by river.

^bGenetic analysis indicates that natural dispersal, not hatchery releases, were primarily responsible for colonization.

^cHatchery releases commenced after natural colonization was observed.

Conceptually, transplanting allows for natural patterns of natural and sexual selection within the new habitat and thus has many of the benefits of natural colonization. The offspring of any adults that successfully spawn will spend the entire freshwater phase, from embryonic incubation to the smolt migration, within the reintroduction site. Compared with hatchery releases, this will increase their exposure to natal odors and local geomorphic, hydrologic, and biotic conditions, all of which are likely to promote local adaptation. However, transplanting introduces artificial selection of the individuals that reach the reintroduction site. In some cases, natural selection during migration could be important for the evolution of traits (i.e., body morphology or energy reserves) that are advantageous for a particular migration route (i.e., long or steep) (Quinn et al. 2001). Thus, considering the run timing, size, and other phenotypic traits of individuals selected for transplantation is an important component of minimizing the negative, unintended consequences of transplanting.

The number and frequency of transplants is an important consideration. Reintroductions with many individuals are more likely to be successful (Wolf et al. 1996; Fischer and Lindenmayer 2000), but with few salmonid examples, it is difficult to provide precise guidance on the number to transplant. Metapopulation structure might provide guidance, as reintroduction sites isolated from the regional metapopulation are unlikely to receive large numbers of natural colonists and, therefore, will require a greater number of transplanted fish than those connected to potential source populations. Williams et al. (1988) observed that 50 individuals (25 males and 25 females, annually) is the absolute minimum for establishing a hatchery population in a controlled setting, so transplanting to a dynamic river environment will certainly require a greater number of fish. Some fraction of transplanted adults may die prior to spawning (Keefer et al. 2010) or depart the release site because they fail to detect natal odors (Blair and Quinn 1991). Continuing transplants for a full generation and into a second generation provides additional reproductive potential and new genetic material that may reduce the impact of a genetic bottleneck (e.g., Hedrick and Fredrickson 2010). In addition, selecting the highest quality habitat within the reintroduction site for the release site may increase the reproductive success of the colonists.

We suggest that reintroduction should maximize the total number of fish transplanted while minimizing the risks (Table 2), which are likely to increase as the number of fish transplanted increases. Given the same total number of transplanted fish, risks might be reduced by releasing a small number of fish each year for many years rather than many fish for a short period. The release strategy will affect density-dependent processes, which in turn will affect both the performance of the reintroduced species and the ecological risks of reintroduction. For example, it may be possible to reduce density-dependent processes by dispersing colonists among several release sites (Einum et al. 2008). With few empirical examples, the outcomes of these risks are difficult to precisely predict a priori, highlighting the importance of a well-designed monitoring program.

Hatchery releases.-The third colonization strategy is a hatchery reintroduction that stocks artificially propagated juvenile fish or eggs within the reintroduction site. There are a number of examples of reintroductions releasing hatchery-produced juveniles (Table 4). In the Clearwater River, Idaho, out-of-basin stocks were used to reintroduce ocean- and stream-type Chinook Salmon; these hatchery populations are now sustained by returns to the Clearwater River, and the naturally produced juveniles of the two run types are genetically distinct (Narum et al. 2007). Hatchery releases of Atlantic Salmon reintroduced to the Connecticut River (flowing through Connecticut, Massachusetts, Vermont, and New Hampshire) are also sustained by local returns (Gephard and McMenemy 2004). However, abundances in the Connecticut River and in other reintroduced New England populations have continued to decline despite heavy stocking, and there is very little natural spawning because most returning adults are bred in captivity (Wagner and Sweka 2011). A captive broodstock hatchery program has played an essential role in the persistence of Snake River Sockeye Salmon, which reached critically low abundances in the mid-1990s (Griswold

TABLE 5.	Examples of proposed, of	ongoing, or relatively	recent reintroduction pr	rograms for Pacific salmon,	steelhead, and Bull Tro	ut Salvelinus confluentus.
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River basin	Species	Comments on execution
Elwha River, Washington	Chinook Salmon, steelhead, Coho Salmon, Pink Salmon, Chum Salmon <i>O. keta</i> , Sockeye Salmon, Bull Trout	Removal of Elwha and Glines Canyon dams; for some species, adults trapped within lower Elwha River relocated above former dam site
Umbrella Creek and Big River, Ozette Lake, Washington	Sockeye Salmon	Hatchery releases for both locations; some natural colonization of Big River prior to hatchery releases
Cowlitz River, Washington	Chinook Salmon, Coho Salmon, steelhead	Hatchery releases, trap and haul above Mayfield, Mossyrock, and Cowlitz Falls dams
Clackamas River, Oregon North Santiam River, Oregon South Santiam River, Oregon	Bull Trout Chinook Salmon, steelhead Chinook Salmon, steelhead	Transplanted juvenile and adult fish from Metolius River Trap and haul adults above Big Cliff and Detroit dams Trap and haul adults above Foster and Green Peter dams
Calapooia River, Oregon McKenzie River, Oregon White Salmon River, Washington	Chinook Salmon, steelhead Chinook Salmon Chinook Salmon	Removal of Brownsville, Sodom, and Shearer dams Trap and haul adults above Cougar and Trail Bridge dams Removal of Condit Dam
Hood River, Oregon	steelhead, Coho Salmon Chinook Salmon	Removal of Powerdale Dam; hatchery releases derived from
Deschutes River, Oregon	Chinook Salmon, steelhead, Sockeye Salmon	neighboring Deschutes River Hatchery releases for Chinook Salmon and steelhead; passage for adults and juveniles around Reregulation, Pelton, and Round Butte dams
Umatilla River, Oregon	Chinook Salmon, Coho Salmon	Hatchery releases
Yakima River, Washington	Sockeye Salmon, Coho Salmon	Sockeye Salmon: adults captured at Priest Rapids Dam transplanted above Cle Elum Dam; Coho Salmon: hatchery releases
Wenatchee River, Washington	Coho Salmon	Hatchery releases
Methow River, Washington	Coho Salmon	Hatchery releases
Okanogan River, Washington	Chinook Salmon, Sockeye Salmon	Hatchery releases for both species; passage above McIntyre Dam for Sockeye Salmon
Walla Walla River, Washington	Chinook Salmon	Hatchery releases
Lookingglass Creek, Oregon	Chinook Salmon	Hatchery releases derived from nearby Catherine Creek
Big Sheep Creek, Oregon	Chinook Salmon	Transplant surplus hatchery adults captured in adjacent Imnaha River
Pine Creek, Oregon	Chinook Salmon, steelhead	Transplant surplus hatchery adults captured at Hells Canyon Dam
Klamath River, California and Oregon	Chinook Salmon, Coho Salmon, steelhead	Proposed removal of Iron Gate, Copco 1, Copco 2, and J.C. Boyle dams
San Joaquin River, California	Chinook Salmon	Proposed under San Joaquin River Restoration Settlement Act

et al. 2011). Although this population is demographically dependent on the hatchery, abundance has grown substantially in recent years and progress has been made towards the reestablishment of natural reproduction. The hatchery has retained approximately 95% of the genetic diversity present in the founders of the captive broodstock program (Kalinowski et al. 2012).

There are also examples of hatchery reintroductions, mainly of Atlantic Salmon, that have failed, or that have had insufficient time, to generate persistent returns of hatchery fish. Despite decades of stocking nonlocal Atlantic Salmon on the Thames River, most adult Atlantic Salmon observed recently have dispersed naturally from nearby river systems (Griffiths et al. 2011). Although some Atlantic Salmon returned to Point Wolfe Creek, New Brunswick, following 4 years of hatchery releases, the population subsequently crashed, similar to neighboring populations in the inner Bay of Fundy (Fraser et al. 2007). Atlantic Salmon have been reintroduced to several rivers in Germany, but these populations are still demographically reliant on importing nonlocal eggs and fry despite some observations of natural spawning (Monnerjahn 2011). Finally, the initial phase of Atlantic Salmon reintroduction to tributaries of Lake Ontario in New York State has focused on experimental testing of various release strategies and sites in an effort to maximize survival (Coghlan and Ringler 2004; Coghlan et al. 2007).

Overall, despite initial successes in establishing hatchery populations in some systems, we found no clear-cut examples in which a reintroduction employing hatchery releases yielded a self-sustaining naturalized population. Importantly, even the most successful programs to date continue to release hatchery fish, so it is largely uncertain whether any natural spawning would persist without supplementation. It is worth noting, however, that hatchery releases have been used to introduce self-sustaining salmonid populations to new locations not previously inhabited by the species in question. Out-of-basin hatchery releases established multiple self-sustaining populations of Sockeye Salmon in Lake Washington, Washington, but it is uncertain whether these areas historically supported anadromous fish (Gustafson et al. 1997; Spies et al. 2007). Other examples include Sockeye Salmon in Frazer Lake, Alaska (Burger et al. 2000), Pink Salmon in the Great Lakes (Kwain 1987), and Chinook Salmon in New Zealand (Quinn et al. 2001). Collectively, these results suggest that it is possible to establish runs of anadromous fish through hatchery releases, and perhaps failed reintroduction efforts did not adequately solve the problems that caused extirpation in the first place (i.e., constraints).

Employed in a conservation setting, hatcheries generally aim to reduce the early life mortality that occurs in the egg incubation and juvenile-rearing phase relative to that of natural spawning (Waples et al. 2007a). Thus hatchery releases have the potential to approach juvenile-rearing carrying capacities faster than the other two approaches, and this may ultimately lead to a greater number of adults returning to the reintroduction site within a generation or two of reintroduction. In addition, hatchery releases may provide opportunities to test the effectiveness of new passage facilities without risking wild fish from a lowabundance source population.

However, even if managed properly, hatchery releases pose significant evolutionary and ecological risks. Domestication selection, or adaptation to a captive-breeding environment, can reduce the fitness of animals released into the wild (Frankham 2008) as well as the fitness of the wild component of a supplemented population (Ford 2002). Indeed, hatchery fish often have lower reproductive success than naturally spawned fish when both groups breed sympatrically in the wild (Araki et al. 2008), and domestication selection, which can occur in a single generation, seems a likely mechanism (Christie et al. 2012; Ford et al. 2012). Large-scale hatchery programs tend to erode population structure more than small ones (Eldridge and Naish 2007), so the risk of genetic homogenization is likely to be proportional to the number of fish released. In terms of ecological risks, hatchery releases could induce density-dependent processes that would limit the growth, survival, and other vital rates of naturally produced fish (Buhle et al. 2009; Kostow 2009).

These risks apply not only to the incipient population within the reintroduction site but also to any nearby extant populations. Hatchery reintroduction programs should therefore aim to minimize straying to proximate extant populations. Acclimating juvenile hatchery fish in the target area prior to release may improve the precision of homing (Dittman et al. 2010). Hatchery fish released into a reintroduction site may also interact ecologically with juvenile wild fish originating from proximate spawning areas in downstream rearing habitats, potentially competing for limited resources. The specific breeding protocols and rearing practices will influence the severity of these ecological and evolutionary effects, but some level of risk is unavoidable.

An important consideration for hatchery reintroductions is the length of time over which supplementation is planned. Evolutionary and ecological risks will tend to increase with the duration and magnitude of hatchery releases. A precautionary model would aim for a brief release of one to two generations, followed by cessation for at least a similar time frame, accompanied by a monitoring program to track performance. Such a pulsed release would provide the initial demographic boost to establish a population in an area unlikely to be colonized naturally and subsequently permit natural and sexual selection to shape local adaptation and the expression of natural diversity patterns. In the event that more than a generation or two of supplementation is needed to rebuild the run, specifying a timeline for phasing out releases in a detailed plan prior to reintroduction will help prevent hatchery efforts from becoming institutionalized. Abundance targets for naturally spawned fish would indicate when the incipient population has sufficient reproductive potential without supplementation. Contingencies for short-term environmental trends would permit flexibility in the timeline should poor migratory or ocean survival delay population establishment.

Choice of Source Population

Source populations with life history, morphological, and behavioral traits compatible with the target area will increase the probability of successful reintroduction. Anadromous salmonids are frequently adapted to local environmental conditions (Taylor 1991; Fraser et al. 2011), and so some source populations may be more successful than others during colonization. For example, following circumvention of a natural barrier, multiple populations of Sockeye Salmon were introduced to Fraser Lake, Alaska, and each preferentially colonized the habitats most similar to the source (Burger et al. 2000). Reintroductions employing transplants or hatchery releases must explicitly choose a source population; evaluating potential sources of natural colonization will help predict patterns of population expansion (Pess et al. 2008) and interpret reintroduction results (Burton et al. 2013). We suggest that reintroduction planners consider the genetic and ecological characteristics of potential source populations.

In general, selecting a source genetically similar to the historic population that inhabited the reintroduction site would maximize the benefits and reduce the risks of a reintroduction. Matching the genetic lineage of the extirpated population or spawning area as closely as possible helps ensure that following a successful reintroduction, regional population structure would accurately represent natural patterns of evolutionary diversity and thus contribute to long-term ESU viability. The evolutionary risks of straying to adjacent populations during reintroduction will be reduced if the source is genetically similar to these populations. In practice, genetic analysis may not be possible, so one might assume an isolation-by-distance model (e.g., Matala et al. 2011) and use the distance along the river corridor between the reintroduction site and source as a coarse guide for comparing options. Regardless of the specific criteria, ESUs were designated to comprise lineages with a distinct evolutionary legacy (Waples 1991), so reintroductions using sources with out-of-ESU ancestry would rarely, if ever, be expected to provide clear conservation benefits to an ESU.

Ecological considerations should focus on the morphological and behavioral traits of the source population and whether they are well suited for the reintroduction site. One approach is to assume that similar habitats promote the evolution of similar traits and evaluate metrics such as elevation, precipitation, and hydrologic patterns or composite indices such as the U.S. Environmental Protection Agency's ecoregions. However, sometimes genetic and ecological patterns will be in conflict. Some coastal rivers, for example, contain both fall- and spring-run Chinook Salmon populations, which are more genetically similar to each other than to other populations of the same run type in different major rivers (Waples et al. 2004). In these cases, selecting a source population will involve some degree of compromise.

Potential source populations affected by hatchery production require special consideration. Three main factors will determine the ecological and genetic suitability of a hatchery stock. The first is its origin. Stocks that were founded with individuals collected near the reintroduction site, preferably within the same basin, present less evolutionary risk than more distantly related stocks. Many of the most widespread hatchery stocks are mixed-lineage, composite-origin stocks with significant contributions from several populations, sometimes from separate ESUs (Busby et al. 1996; Myers et al. 1998). Although these stocks are probably the most available, and hence logistically practicable for reintroductions, they also pose much greater evolutionary risks than locally derived stocks. A second consideration is the current breeding protocol. Programs that operate under an integrated model by consistently incorporating wild or naturally spawned broodstock (without posing demographic risks to that population) will reduce (but not eliminate) domestication selection compared with segregated programs (Mobrand et al. 2005). A final consideration is the number of generations that the stock has been artificially propagated. Domestication selection accumulates over time, making populations that have been artificially propagated for many generations less similar to their wild counterparts than stocks that have been in captivity for few generations (Araki et al. 2008; Frankham 2008). In

some cases, a hatchery stock directly derived from native fish that inhabited the reintroduction site may retain the only genetic legacy of the extirpated population and may be desirable for that reason.

What are the options if there is an unacceptable demographic risk of depleting the most attractive source population? In some cases, managers must either wait for the most appropriate stock to recover to levels that could sustain removal or select a less desirable stock that can immediately provide sufficient donors. This is a difficult trade-off, especially if recovery of depleted potential source populations is uncertain or is expected to take several generations even under optimistic scenarios. When removal does occur, monitoring should track the source population abundance during reintroduction to ensure that it remains healthy. If a single population cannot sustain removal for reintroduction, it may be possible to combine individuals from several sources. From a genetic perspective, this could have either positive or negative consequences. On one hand, mixing sources could benefit the genetic diversity of the colonist group, but on the other, it could lower fitness via outbreeding depression (Huff et al. 2010).

Finally, for facultatively migratory species, the presence of resident conspecifics may provide additional reproductive potential and serve as a source population. For example, resident Rainbow Trout frequently spawn with anadromous steelhead (McMillan et al. 2007; Pearsons et al. 2007). In fact, O. mykiss often exhibit partial anadromy in which a single, panmictic, interbreeding population contains both resident and migratory individuals (McPhee et al. 2007; Heath et al. 2008). Resident populations isolated by dams may retain significant anadromous ancestry and the physiological traits of smoltification (Clemento et al. 2009; Godbout et al. 2011; Holecek et al. 2012). However, if selection against anadromy has occurred in the resident population, it is also possible that secondary contact with reintroduced anadromous fish might decrease the rate of anadromy in the combined population. Life history models (Satterthwaite et al. 2009, 2010) offer one method of predicting the complicated interactions between resident fish and reintroduced anadromous populations. Regardless, we suggest that promoting the persistence and reproductive contribution of resident fish directly descended from formerly anadromous populations inhabiting the reintroduction site will ultimately contribute to local adaptation, diversity, and long-term viability.

Providing Passage

Providing passage is relevant to all reintroductions involving barriers regardless of the colonization strategy or the choice of source population. This must include passage for adults migrating upstream to spawning grounds as well as juveniles migrating downstream towards the ocean. Plans for passage can be categorized as either volitional or active transport (i.e., trap and haul).

Under volitional passage, a barrier is modified or removed such that fish arrive at the site under their own power, swimming through or around and eventually past the former blockage. Primary examples include culvert replacements, dam removals, engineered step-pools, fish ladders, increased releases from upstream dams, and screened bypass facilities for juveniles. Volitional fish passage facilities have advantages over more managed methods because they operate constantly, require little if any handling, are less stressful to the fish, are mechanically less likely to break, and are less costly to maintain and operate. A primary biological consideration is the degree to which passage structures reduce juvenile and adult migrant survival relative to a free-flowing river. Unnaturally high mortality imposed by passage at barriers will have to be compensated for elsewhere in the lifecycle to maintain a self-sustaining population. Furthermore, depending on the design, water velocity and gradient may restrict passage to certain species or size-classes, reducing the diversity of the incipient population. If poorly designed, passage facilities could increase the risk of straying into nontarget populations or spawning areas.

Barrier or dam removal is a special case of volitional passage that will provide substantial ecological benefits beyond salmonid recovery. Dam removal can repair riverine ecosystem processes, such as natural flow regime, sediment and wood transport, and nutrient cycling, that create and maintain habitat for many plants and animals (Poff and Hart 2002; Roni et al. 2008). The rehabilitation of these processes, especially where they have been substantially altered, will certainly provide long-term benefits for the Pacific salmon and steelhead populations targeted for reintroduction. However, in the short term, dam removal is a disturbance that may increase turbidity and deposit fine sediment downstream or mobilize toxic-laden materials (Stanley and Doyle 2003). Therefore, it is an approach most appropriate for enhancing long-term viability rather than rapid increases in abundance, and these "side effects" are important considerations for the planning process. Several recent dam removals (Table 5) provide important opportunities to study the salmonid response to dam removal.

In some cases, it may be possible to incorporate selective access into a volitional passage strategy. This would involve a weir, gate, or trap such that fish are handled prior to upstream passage. Such structures increase operation and maintenance costs and may adversely affect adults due to increased handling. However, they also allow managers to exclude fish that could undermine reintroduction objectives. For example, excluding the homogenizing influence of hatchery colonists may benefit diversity and excluding nonnative fish would reduce the ecological risks of reintroduction. Such structures would also assist research and monitoring because they would permit precise counts and measurements of fish.

Active transport, sometimes called trap and haul, is most appropriate for situations in which volitional passage is not logistically, technically, or biologically possible. Large dams, especially several occurring in sequence, are more likely to require trap and haul than small structures due to engineering and socioeconomic constraints. Particularly for juveniles, impoundments may present challenges that cannot be overcome with volitional passage, such as low water velocity that disrupts fish migration, predators that reduce survival below acceptable levels, or downstream passage routes that cannot be engineered to be safe and effective. Selection or exclusion of particular groups of fish will be fundamentally simple. Passage via trap and haul is similar in concept to a transplanting colonization strategy and thus has many of the same benefits, risks, and consequences.

Trap and haul, often combined with hatchery releases, is employed in several ongoing large-scale reintroduction efforts (Table 5). These examples will provide crucial case studies to evaluate the success and refine the methods of reintroducing Pacific salmon and steelhead above large, high-head dams. Research on the Middle Fork Willamette River, Oregon, has found significant prespawn mortality related to poor condition of spring Chinook Salmon adults prior to release and warm temperatures encountered in the migration corridor (Keefer et al. 2010). In addition, juvenile mortality at dams was high and deep-water passage routes severely restricted passage in the spring, when Chinook Salmon would ordinarily migrate downstream but reservoirs were filling rapidly (Keefer et al. 2011).

Despite few published examples, we suspect that at highhead dams, transporting adults upstream is much easier (and less expensive) than providing safe, efficient downstream passage for their offspring. Juvenile fish will be vulnerable to sizeselective predation in reservoirs (Poe et al. 1991; Fritts and Pearsons 2006) and dam passage mortality unless they are collected and routed around these hazards. Survival rates will vary by species, life stage, and timing of migration but are likely to depend on the efficiency of juvenile collection methods and the design of engineered bypasses at dams. In some cases, successful reintroduction will require a mechanistic understanding of dam passage mortality, but this is difficult to predict generally and varies substantially by dam. For example, some studies have found greater mortality in small fish (Ferguson et al. 2007) while others found greater mortality in large fish (Keefer et al. 2011). Consequently, detailed studies of route-specific juvenile mortality rates are likely to be an essential component of reintroductions involving active transport (Keefer et al. 2011).

Execution Overview

One thing is clear—each case will be unique, and reintroduction planners will face trade-offs between the benefits and risks in selecting a colonization strategy, choosing a source population, and providing passage. These options need not be mutually exclusive, as a carefully planned reintroduction program may decide to use multiple colonization strategies. A precautionary model would initially adopt a low-risk approach and monitor its success, thereby permitting a scientific evaluation of whether higher-risk strategies are necessary. For active reintroduction strategies, planners could view an initially small release as a pilot study to assess reintroduction benefits and risks prior to full implementation. Our review of the salmonid reintroduction literature (e.g., Table 4) suggests that there are large uncertainties in the success of reintroduction in establishing self-sustaining populations, particularly for programs employing active colonization strategies. Despite the increased risks of methods such as transplanting adults and hatchery releases, we found no direct evidence that these approaches have established a demographically independent, self-sustaining natural population. It is possible that situations in which active methods have been employed are inherently more difficult, but a lack of rigorous scientific evaluation precludes us from describing the benefits, risks, and constraints more explicitly or quantitatively. We strongly encourage managers of reintroduction efforts to disseminate results so that we may build on lessons learned in planning future programs.

MONITORING

Monitoring is an essential component of any reintroduction program (Williams et al. 1988; IUCN 1998; George et al. 2009), permitting an assessment of whether or not the reintroduction was successful. Monitoring before, during, and after the reintroduction provides information on both the target and neighboring populations that is needed to evaluate modifications to the program execution in an adaptive management feedback loop. In addition, monitoring provides the data that is essential for the effective planning of future programs.

We suggest that the monitoring program focus on the benefits, risks, and constraints likely to have a large impact on the success of the project. First, in order to quantify the benefits and determine if the goals have been achieved, unambiguously stating project objectives at the outset will help identify specific monitoring metrics (Tear et al. 2005). Second, for reintroductions in which the initial planning efforts identified some risks (Table 2), there must be monitoring in order to determine whether the benefits outweighed the risks. Third, monitoring constraints will promote a mechanistic understanding of why a reintroduction succeeded or failed. Even where barriers block migration, other factors may have contributed to extirpation. Consequently, although some biological constraints (Table 3) may have been addressed prior to reintroduction, others may persist that will limit project success. Identifying factors that limit survival and reproductive success will provide insight towards alternative reintroduction strategies that might lessen a negative impact. The specific monitoring methods will vary depending on the benefits, risks, and constraints of the reintroduction effort; Roni (2005), Johnson et al. (2007), and Schwartz (2007) provide guidance on establishing a robust monitoring program.

It is difficult to provide general criteria on whether a reintroduction effort has succeeded or failed because every situation is likely to be different. However, writing a detailed reintroduction plan, including specific viability targets or benchmarks, is a crucial component of project implementation. This will simplify interpretation of monitoring data, clarify any need for adaptive management during the program, and prevent the institutionalization of actions (e.g., hatchery releases) that impose risk to nontarget populations or spawning areas. In deriving targets and benchmarks, the reintroduction plan should explicitly consider patterns in annual abundance, productivity, and survival of comparable populations. We strongly urge all entities conducting or planning reintroductions to write a publicly available implementation plan that includes robust monitoring because it is essential to a scientifically rigorous reintroduction effort and will improve our ability to effectively conserve species in the future.

CONCLUSIONS

We have based our approach to planning, executing, and monitoring reintroductions upon the broad conservation goals and scientific principles guiding the recovery of ESA-listed Pacific salmon and steelhead populations. We acknowledge that there are other possible goals for reintroductions, including providing harvest opportunities, which might lead to different approaches than those described here. Although our recommendations are specifically designed for ESA recovery, more generally they are intended to promote the natural demographic, ecological, and evolutionary processes essential to the conservation benefit of all reintroductions, regardless of formal listing status. Even in cases where ESA recovery is not the primary goal, the concepts discussed here will help evaluate the overall conservation value of a reintroduction (Figure 5).

Legend Weak conservation value Strong conservation value 1. Evolutionary lineage of source population Genetically distant Locally derived 2. Current genetic relationship between source and reintroduced population Similar Divergent 3. Demographic reliance on hatchery releases or transplanting Ongoing, highly reliant Self-sustaining 4. Degree of local adaptation Not adapted Locally adapted 5. Demographic connectivity to other populations in the ESU Isolated Functioning in local metapopulation 6. Generations that reintroduced population has been self-sustaining None Many FIGURE 5. Factors to consider in evaluating the conservation value of rein-

FIGURE 5. Factors to consider in evaluating the conservation value of reintroductions. Each bar is intended to represent a gradient of outcomes in between the extremes described at either end. The extent to which natural demographic, ecological, and evolutionary processes operate uninterrupted will strongly influence the overall conservation value of a reintroduction. Despite the number of salmonid reintroductions (e.g., Tables 4 and 5), the science of reestablishing previously extirpated salmonid populations is still in its infancy. We found few direct assessments of reintroduction benefits, risks, and constraints, forcing us to provide general, qualitative rather than specific, quantitative recommendations. If reintroduction is to become a successful recovery tool, it is essential that monitoring and dissemination of results become standard practice in nearly every program. Rigorous scientific evaluation is particularly important for projects at large dams or those using active colonization strategies because they face the highest constraints and greatest risks.

The number and scale of Pacific salmon and steelhead extirpations suggest that reintroduction offers great potential to advance salmon recovery. However, complicated trade-offs, challenging obstacles, and uncertainty over the ultimate result confront reintroduction planners. Combined with the multiple generations probably required to achieve potential benefits, this suggests that reintroduction will rarely be a quick fix for improving the status of an ESU or population at immediate risk of extinction. It is also important to remember that reintroduction is only one management option. In some cases, reintroduction may be essential for the conservation of a particular life history type or evolutionary lineage. In other cases, management strategies designed to improve the reproductive success, survival, and productivity of extant populations might offer a better return on the investment dollar than reintroduction. We suggest that evaluating the potential benefits, risks, and constraints is necessary to weigh reintroduction against other management options and ensure that reintroductions contribute to long-term population and ESU viability.

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LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

TECHNICAL COMMITTEE CONFERENCE CALL

APRIL 18, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581) Fish Passage Facilities Alternatives Assessment Technical Committee Conference Call

Monday, April 18, 2016 11:00 am to 12:00 pm

Final Meeting Notes

	Conference Call Attendees					
No.	Name	Organization				
1	Alison Boucher	Tuolumne River Conservancy				
2	Steve Boyd	Turlock Irrigation District				
3	Anna Brathwaite	Modesto Irrigation District				
4	Larry Byrd	Modesto Irrigation District				
5	Jarvis Caldwell	HDR, consultant to the Districts				
6	Jesse Deason	HDR, consultant to the Districts				
7	John Devine	HDR, consultant to the Districts				
8	Greg Dias	Modesto Irrigation District				
9	Jason Guignard	FISHBIO, consultant to the Districts				
10	Chuck Hanson	Hanson Environmental, consultant to the Districts				
11	Bao Le	HDR, consultant to the Districts				
12	Lonnie Moore	Citizen				
13	Gretchen Murphy	California Department of Fish and Wildlife				
14	Bill Sears	City and County of San Francisco				
15	Chris Shutes	California Sportfishing Protection Alliance				
16	Niccola Ulibarri	Stanford University				
17	Scott Wilcox	Stillwater Sciences, consultant to the Districts				
18	John Wooster	National Marine Fisheries Service				
19	Ron Yoshiyama	City and County of San Francisco				

On April 18, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted a Technical Committee conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework). This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting.

Mr. Bao Le (HDR, consultant to the Districts) noted the deadline for Technical Committee comments on the study plans has been extended from April 22 to April 29. The Districts will revise the study plans based on comments received and will provide revised study plans to the Technical Committee for final comments. Mr. Le said the Districts plan to send final study plans to the Plenary Group ahead of Workshop No. 5, which is scheduled for May 19.

Mr. Le provided an overview of the draft study plans discussed on the March 18 Technical Committee call. Mr. Le noted that last week, the Districts sent the draft Upper Tuolumne River Instream Flow Study Plan to the Technical Committee for review and comment. Mr. Le said the lead for this study, Mr. Jarvis Caldwell (HDR), will be providing a summary of this study plan on today's call. In addition, the study leads for the other draft study plans are also on this call and available to answer any questions attendees may have on those studies.

Mr. Caldwell reviewed the goals, study area, and methodology for the Upper Tuolumne River Instream Flow Study (Instream Flow Study). Mr. John Wooster (National Marine Fisheries Service) asked if the fieldwork for this study will be completed in tandem with the fieldwork for the Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment (Habitat Mapping Study), or if the Habitat Mapping Study will be completed first. Mr. Caldwell said the Districts plan to complete the Habitat Mapping Study first and use information collected from that study to inform study site selection for the Instream Flow Study.

Mr. Wooster asked if the Instream Flow Study will be completed in 2016. Mr. Caldwell said the study will be completed in the fall of 2016. Mr. Wooster asked if, given that schedule, the necessary flows will be available. Mr. Wooster noted that higher flows associated with rafting are generally unavailable after Labor Day. Mr. Caldwell said based on the hydrology he has reviewed, standard operations upstream of the study reach provide a range of flows on a daily basis. Mr. Caldwell said that during the five or seven days at an Instream Flow Study site, he expects the study team will be able to capture a range of flows. Mr. Caldwell noted the study team is still working out the fieldwork logistics.

Mr. Wooster said the Instream Flow Study Plan states there will be two or three study sites, but it is unclear whether that means two or three sites per river reach or two or three sites for the entire study. Mr. Caldwell said there will be two or three sites identified between Lumsden Falls and the upstream end of the Don Pedro Project.

Mr. Larry Byrd (Modesto Irrigation District) asked if there is particular reason why the study cannot be completed before Labor Day, when higher flows are available. Mr. Caldwell said it is important that the Habitat Mapping Study first be completed, as information from that study is required to help select study sites for the Instream Flow Study. Mr. Caldwell said a range of flows at each site is necessary to calibrate the model. Mr. Caldwell reiterated that the study team is still working on the schedule logistics. Mr. Byrd asked when the study site locations will be determined. Mr. Le responded that the study team had been waiting for the summer flow schedule to be released in order to finalize the summer fieldwork schedule. Mr. Le said the study team anticipates fieldwork for the Habitat Mapping Study and the Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study (Spawning Gravel Study) will be completed in late June or early July, in time to compile the results for consideration in the Instream Flow Study.

Mr. Chris Shutes (California Sportfishing Protection Alliance) said the Middle Fork American River Project relicensing instream flow model provided output in a series of tables that depicted how habitat changed from one flow to another. Mr. Shutes asked if the Districts' two dimensional (2D) model (i.e., River 2D) will be able to capture changes in habitat during flow fluctuations. Mr. Caldwell said he is familiar with the analysis Mr. Shutes is referring to, and in that project, model output was depicted using effective habitat tables, which are also known as wedge tables. Mr. Caldwell said at the site level, these tables provide some indication of how total habitat suitability (i.e., WUA) for a specific life stage changes from one flow to another, which may be important for understanding how general habitat changes with flow. Mr. Caldwell said such tables, however, do not help explain or show where the habitat goes in the river with changes in flow. This may be more important for non-mobile life stages (e.g., spawning/incubation) than for mobile life stages (e.g., fry and juvenile). Mr. Caldwell said for this study, time series analysis will be completed that will use GIS to show habitat over a range of flows. This analysis is more spatial and visual than what is provided by wedge tables.

Mr. Shutes asked for an explanation why holding habitat will not be modeled. Mr. Caldwell confirmed the study plan states holding habitat will not be modeled. Mr. Caldwell said one reason holding habitat will not be modeled is that habitat suitability criteria for holding habitat are not available. Another reason is that the Habitat Mapping Study will already be evaluating pools from the perspective of habitat

holding. Mr. Caldwell said habitat generated by River 2D may be used to look at variables such as depth and velocity, but habitat suitability criteria will not be used. Mr. Caldwell noted that the ongoing Upper Tuolumne River Basin Temperature Monitoring and Modeling Study is analyzing temperature, which is a driving variable in habitat suitability. Mr. Scott Wilcox (Stillwater Sciences, consultant to the Districts) said regarding spring-run Chinook holding habitat, that particular habitat is not well-suited for modeling because the habitat is specific pools, which are better characterized by taking depth and temperature measurements at those specific locations.

Mr. Shutes requested that the Districts send out the habitat suitability criteria used for spring-run Chinook on the McCloud. Mr. Wilcox said he will send out that information.

Mr. Wooster said the study plan states that habitat suitability criteria for spring-run Chinook on the McCloud were developed for the reintroduction program. Mr. Wooster said that is not quite accurate. The study was implemented as part of the relicensing proceeding at the request of the State Water Resources Control Board (SWRCB), and not at the request of the Interagency Fish Passage Steering Committee, which was the entity working on the reintroduction program. Mr. Wooster said the study plan states the Interagency Fish Passage Steering Committee stemmed from the NMFS Recovery Plan, and this is also inaccurate. Mr. Caldwell said he will revise the study plan to clarify this. Mr. Wilcox said the SWRCB requested the study on behalf of the SWRCB as well as other agencies, including NMFS, because NMFS had stated reintroduction on the McCloud was imminent. Mr. Wilcox said regardless of how the study came about, the criteria developed by the study are relevant to this effort for the Tuolumne River. Mr. Wooster agreed the study is relevant, and he only sought to clarify how the study came about.

Mr. Wooster said that if specific flow releases are arranged as part of this study, it would be helpful for NMFS to be kept informed as those flows may have implications for NMFS fieldwork. Mr. Devine said the Districts will not be arranging specific flow releases for the Instream Flow Study and that planning for field work will be under conditions dictated by CCSF's flow schedule at the time of study implementation. However, Mr. Devine stated in order to ensure the field program for the study occurs under appropriate flow conditions, the Districts would remain in close coordination with CCSF to better understand what the likely flow schedule will be in the late summer and fall and will keep licensing participants informed of what they find out.

Mr. Le reviewed the schedule for finalizing the study plans. Mr. Le said Technical Committee comments on the study plans are due by April 29. The study leads will revise the study plans based on comments received and the Districts will provide revised drafts to the Technical Committee on May 3. Final Technical Committee comments on the study plans will be due on May 6. The Districts anticipate sending final study plans to the Plenary Group on May 10. At Workshop No. 5, which will take place on May 19, an objective will be to get approval from the Plenary Group on the study plans in time to begin implementing the studies this summer.

Mr. Le said the Districts will provide notes from this meeting.

Meeting adjourned.

ACTION ITEMS

1. The Districts will send out the habitat suitability criteria used for spring-run Chinook on the McCloud River. (complete)

2. Mr. Caldwell will revise the Instream Flow Study Plan to clarify how the McCloud River habitat suitability study came about and that the Interagency Fish Passage Steering Committee was not a result of the NMFS Recovery Plan. (complete)

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT WATER TEMPERATURE SUBCOMMITTEE CONFERENCE CALL

SEPTEMBER 15, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581) Fish Passage Facilities Alternatives Assessment Water Temperature Criteria Subcommittee Conference Call

Thursday, September 15, 2016 1:00 pm to 3:00 pm

Final Meeting Notes

	Meeting Attendees						
No.	Name	Organization					
1	Allison Boucher	Tuolumne River Conservancy					
2	Steve Boyd	Turlock Irrigation District					
3	Paul Bratovich	HDR, consultant to the Districts					
4	Jean Castillo	National Marine Fisheries Service					
5	Greg Dias	Modesto Irrigation District					
6	Jesse Deason	HDR, consultant to the Districts					
7	John Devine	HDR, consultant to the Districts					
8	Art Godwin	Turlock Irrigation District					
9	Andy Gordus	California Department of Fish and Wildlife, Fresno					
10	Chuck Hanson	Hanson Environmental, consultant to the Districts					
11	Jonathan Knapp	City and County of San Francisco					
12	Patrick Koepele	Tuolumne River Trust					
13	Bao Le	HDR, consultant to the Districts					
14	Ellen Levin	City and County of San Francisco					
15	Lonnie Moore	Private citizen					
16	Gretchen Murphey	California Department of Fish and Wildlife					
17	Bill Paris	Modesto Irrigation District					
18	Bill Sears	City and County of San Francisco					
19	Chris Shutes	California Sportfishing Protection Alliance					
20	Ron Yoshiyama	City and County of San Francisco					

On September 15, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted the first Water Temperature Criteria Subcommittee (Temperature Subcommittee) conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework. This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document provides meeting materials.

Mr. Bao Le (HDR, consultant to the Districts) welcomed meeting attendees. Mr. Le said meeting materials for this call are available on the La Grange Project licensing website. There are three documents: (1) meeting agenda, (2) Temperature Subcommittee draft process and schedule, and (3) water temperature criteria matrix. Mr. Le said the process and schedule document is meant to provide a draft description of the purpose of the Temperature Subcommittee and what the Temperature Subcommittee will accomplish. Mr. Le said the water temperature criteria matrix is the result of an action item the Districts had from Workshop No. 5, held on May 19, 2016, to develop a document summarizing what water temperature criteria were developed for the Yuba River, as well as what criteria were developed for other potentially relevant programs in the Central Valley.

Mr. Le reviewed the meeting agenda and the meeting objectives. Mr. Le asked if there are any questions. There were none.

Mr. Paul Bratovich (HDR) reviewed the draft process and schedule document. Mr. Bratovich said evaluating thermal habitat suitability is a fundamental component in determining the feasibility of a reintroduction program, especially for anadromous salmonids. Mr. Bratovich added that evaluating water thermal habitat suitability could be considered as an appropriate initial step in evaluating physical habitat suitability or availability because if habitat is not thermally suitable then it will not be suitable from other habitat perspectives. Mr. Bratovich said the process and schedule document briefly discusses why the Temperature Subcommittee was formed and the purpose of the group. The document also describes what work the Temperature Subcommittee will accomplish and provides an implementation schedule. By December 2016, the goal is to have a technical document that evaluates thermal habitat suitability for reintroduction purposes. Mr. Bratovich noted there is a lot to accomplish in a relatively short amount of time.

Mr. Bratovich said the Temperature Subcommittee needs to establish the purpose of the proposed activities. The purpose could be as simple as establishing the technical basis for evaluating temperature regimes in different reaches of the Tuolumne River. Mr. Bratovich said drilling down to specific objectives will help frame exactly what the Temperature Subcommittee will do and how it will be done. To evaluate thermal habitat suitability, the Temperature Subcommittee must first confirm target species being considered for reintroduction, life stage periodicities, what river reaches should be considered, and at what times temperature criteria are applicable.

Mr. Le said some work has already been done to establish an area of consideration and target species and life stage periodicities. Fieldwork for the Upper Tuolumne River Basin Fish Migration Barriers Study is nearing completion and total barriers have been identified in some of the tributaries and could be used to help identify evaluation reaches. Mr. Le said relevant information on proposed species and some life stage periodicity information is also available in the Fish Passage Facilities Assessment Technical Memorandum (TM) No. 1 (available here on the La Grange Project licensing website). Mr. Le noted that although this document was provided to licensing participants for review in fall 2015 and identified additional relevant information needs, the Districts have not received any feedback on TM No. 1.

Mr. Bratovich said he has been involved in several processes similar to this one, and in these other processes it had been very helpful at the beginning of the process to produce a glossary of terms. Mr. Bratovich said terms related to thermal habitat suitability, such as "optimal", are often interpreted to mean different things by different individuals. A glossary of terms helps ensure all members of the team are speaking the same language. Mr. Le said the Districts will develop a glossary of terms.

Mr. Bratovich said that after the purpose of the Temperature Subcommittee is established, the next step is to undertake a comprehensive literature review. Mr. Bratovich said some comprehensive reviews of information in the Central Valley have already been completed. There is a lot of information available in the Central Valley as well as in the rest of California and the Pacific Northwest. Mr. Bratovich said a literature review completed by the Yuba Salmon Forum (YSF) contains over 100 references and this literature review would be a good basis to start this effort. This group will also want to include site-specific data, if available, for the Tuolumne River as well.

Mr. Bratovich said once the literature review is completed, the next step is to turn the information collected into a suite of water temperature index values that indicate suitability for reintroduction purposes by such variables as species, run, and life stage. Once water temperature index values are created, the Temperature Subcommittee will need to determine what metrics will be used. There are many different types of metrics, such as maximum weekly average temperature (MWAT) and seven day average daily maximum (7DADM). The literature review will produce a number of different options to support further discussion. Once the Temperature Subcommittee decides on a metric, thermal habitat

suitability will be evaluated using data produced by the Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study.

Mr. Le asked if anyone would like to share additional thoughts regarding the purpose of the Temperature Subcommittee or the overview document. Mr. Chris Shutes (California Sportfishing Protection Alliance) said a lot of the activities proposed for the Temperature Subcommittee were addressed previously in the YSF process. Mr. Shutes said many individuals on this conference call participated in that process. Mr. Shutes noted that the YSF had a lot of stakeholder buy-in. Mr. Bratovich agreed with this point. Mr. Shutes suggested that the document prepared for the YSF entitled *Water Temperature Considerations for Yuba River Basin Anadromous Salmonid Reintroduction Evaluations* be distributed to the Temperature Subcommittee for review. The Temperature Subcommittee can determine how much can be adapted for this process. We can also walk through how YSF decisions were made and why, and this may help the process for the Tuolumne River move along quicker and be more cost-effective. Mr. Le said that is a good point and part of the rationale for including Mr. Bratovich in this process was his YSF experience. Mr. Le said the Districts see the YSF serving as a foundation for the work to be done here and using the available information from that process seems prudent as a means to avoid "reinventing the wheel".

Mr. Le asked if there are any questions about the overall process or the suite of objectives. There were none.

Mr. Le said the implementation schedule laid out in the overview document is fairly aggressive. The goal is to complete all objectives by the end of 2016. The end product will be a technical document summarizing the findings.

Mr. Le said the Districts had an action item from Workshop No. 5 to summarize water temperature criteria from other processes in the Central Valley. This information is summarized in the water temperature criteria matrix. Mr. Le noted that based on the four or five processes summarized in the matrix, there is quite a bit of variation among watersheds regarding criteria, metrics, and compliance. Mr. Le added that the matrix is not intended to be an endorsement by the Districts of any one process in particular. Dr. Chuck Hanson (Hanson Environmental, consultant to the Districts) added that the purpose of the matrix is to facilitate discussion and provide a central source of information. The matrix summarizes information available in technical reports and various other sources related to water temperature criteria on the American River, Feather River, San Joaquin River, Shasta River, and Yuba River developed for FERC processes, State Board processes, and other processes. The document also summarizes EPA (2003) criteria to provide context for federal river-specific criteria. Dr. Hanson said the matrix is a living document that can serve as a cornerstone to help define temperature criteria from a suitability perspective as well as a sub-optimal perspective.

Mr. Le asked if there are any comments about the matrix and if individuals know of additional rivers or reaches to add to matrix. He also asked if individuals think the matrix is informative. Ms. Jean Castillo (National Marine Fisheries Service [NMFS]) said she thinks the matrix is very informative, especially since she is new to the area. Ms. Castillo said she thinks a glossary of terms is a great idea. She added that a list of acronyms would also be helpful. Mr. Le said the Districts will prepare an acronym list in addition to a glossary of terms.

Mr. Le asked the individuals on the call to review the matrix. He said the Districts welcome any comments, thoughts, or additions to the document. Mr. Le reiterated that the matrix is a living document.

Regarding the literature review, Mr. Le said information collected by previous review efforts will serve as a valuable starting place. It is now time to get feedback on what management agency literature and

documents must still be reviewed. Mr. Bratovich added that basin-specific information must also be reviewed.

Mr. Le said the objective of the next Temperature Subcommittee call will be to present and discuss the results from the literature review. Prior to the next call, Mr. Le asked that members of the Temperature Subcommittee provide any information they think is relevant to the literature review, whether or not it may have already been reviewed as part of the YSF literature review. Mr. Le said any information should be sent to Ms. Rose Staples (HDR) at rose.staples@hdrinc.com.

Mr. Le said there is also a need to establish the species of interest. At this time, fall-run Chinook, springrun Chinook, and steelhead are being considered the target species of interest. However, Mr. Le noted that the Districts are skeptical about whether fall-run Chinook should still be considered a species of interest. At this time, the Districts will keep fall-run Chinook as part of the evaluation but wanted to make this point about their concerns. The Districts welcome feedback on this topic. Ms. Castillo said she will check back with her NMFS colleagues about this. Ms. Gretchen Murphey (California Department of Fish and Wildlife [CDFW]) asked what species are being considered by the Reintroduction Goals Subcommittee. Mr. Le said until further feedback is received, the Reintroduction Goals Subcommittee is considering all three as species of interest. Mr. Lonnie Moore (private citizen) said he recently filed a paper on the FERC docket related to this topic. The paper summarizes historical information and previous studies about the historical presence of fall-run Chinook, spring-run Chinook, and steelhead in the Tuolumne River.

Mr. Le asked if there are any comments or questions about the literature review. There were none.

Ms. Murphey asked if an updated Don Pedro Project Swim Tunnel Study Report has been released. Mr. John Devine (HDR) said an updated study report was recently filed with FERC and should be appearing in the FERC docket soon. He said he would be happy to send a link to Ms. Murphey if she is unable to find it. [On September 20, 2016, Mr. Devine emailed Ms. Murphey to explain he had been mistaken and an updated Swim Tunnel Study Report had not been filed with FERC. Mr. Devine said on September 6, 2016, the Districts received comments on the January 2015 draft Swim Tunnel Study Report from CDFW. The Districts will file the final report once the Districts respond to and address CDFW's comments.]

Mr. Le said the Districts would like to have the next Temperature Subcommittee call in mid-October. Between now and the next call, Temperature Subcommittee members will plan to provide information to add to the literature review and the Districts will develop an acronym list and glossary of terms in addition to updating the body of literature relevant to temperature suitability criteria. Mr. Le requested that feedback on the literature review be provided to Ms. Staples by Friday, September 23.

Meeting attendees discussed dates for the next Temperature Subcommittee call. Mr. Le said the Districts will send out a Doodle poll for October 11, 12, 14, 17 and 18. The Districts will also send out notes from today's call.

Ms. Castillo requested that Mr. Le send her a copy of TM. No.1. Mr. Le said he will send this.

Dr. Ron Yoshiyama (City and County of San Francisco) requested that the year be added to future meeting agendas and meeting notes. Mr. Le said the year will be added to future meeting documents.

ACTION ITEMS

- 1. The Districts will distribute *Water Temperature Considerations for Yuba River Basin Anadromous Salmonid Reintroduction Evaluations* to the Temperature Subcommittee for review.
- 2. The Districts will prepare a glossary of terms.
- 3. The Districts will prepare an acronym list.
- 4. Ms. Castillo said she will check back with her NMFS colleagues about species for consideration.
- 5. Temperature Subcommittee members will provide feedback on information that should be considered as part of updating the existing YSF literature review by Friday, September 23.
- 6. The Districts will send out a Doodle poll for the next Temperature Subcommittee call. (complete)
- 7. The Districts will send out meeting notes. (complete)
- 8. Mr. Le will send Ms. Castillo a copy of TM No. 1. (complete)
- 9. The Districts will add the year to future meeting documents.

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

WATER TEMPERATURE SUBCOMMITTEE CONFERENCE CALL

SEPTEMBER 15, 2016

ATTACHMENT A

MEETING AGENDA AND MATERIALS

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La Grange Hydroelectric Project Reintroduction Assessment Framework Water Temperature Criteria Subcommittee Conference Call Thursday, September 15, 1:00 pm to 3:00 pm Conference Line: 1-866-583-7984; Passcode: 814-0607

Meeting Objectives:

- 1. Review and discuss Water Temperature Criteria Subcommittee Overview.
- 2. Develop subcommittee "purpose" statement, specific objectives and confirm subcommittee schedule.
- 3. Review and discuss Water Temperature Criteria Matrix for select Central Valley reintroduction/fish passage programs (Districts' action item).
- 4. Discuss available existing information and identify scope for additional water temperature literature review.

TIME	TOPIC
10:00 am – 10:15 am	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts)
10:15 am – 10:45 am	 Water Temperature Criteria Subcommittee (All) a. Why is it important? (Districts) b. Discuss Subcommittee Overview Document (Bao Le/Paul Bratovich)
10:45 am – 11:15 am	 Water Temperature Criteria Subcommittee (All) a. Develop Purpose Statement and Objectives (Paul Bratovich) b. Confirm Schedule (Bao Le)
11:15 am – 11:50 am	 Temperature Criteria Matrix and Literature Review Discussion (All) a. Temperature Criteria Matrix (Chuck Hanson) b. Existing Information and Additional Need for a Literature Review (Paul Bratovich)
11:50 am – 12:00 pm	Next Steps (All) a. Schedule next call and agenda topics b. Action items from this call

La Grange Hydroelectric Project Licensing (FERC No. 14581) Upper Tuolumne River Reintroduction Assessment Framework Water Temperature Subcommittee – Draft Process and Schedule

Overview and Subcommittee Purpose

Water temperature considerations are a primary component of assessing any potential anadromous salmonid reintroduction effort. As such, the Upper Tuolumne River Reintroduction Assessment Framework Plenary Group has established a water temperature subcommittee to begin investigating water temperature considerations pertinent to anadromous salmonid reintroduction opportunities in the accessible reaches of the Tuolumne River upstream of Don Pedro Reservoir (Upper Tuolumne River).

The subcommittee, working in collaboration, is anticipated to address a suite of specific tasks related to the investigation of water temperature considerations, including the following:

- Establish the purpose ("charter") for the water temperature subcommittee.
- Evaluate the need for and if appropriate, conduct a comprehensive literature review of lifestagespecific water temperature relationships for target species of interest (TBD by the subcommittee).
- Identify a suite of water temperature index (WTI) values representing summarization of the literature review.
- Select water temperature criteria for each species-specific lifestage for reintroduction evaluation in the Upper Tuolumne River.
- Identify the water temperature evaluation methodological approach including metrics and application to monitoring and/or modeling data.
- Conduct species and lifestage-specific water temperature evaluations.
- Prepare a technical document reporting the results for all of the above objectives.

Subcommittee Purpose

An initial step in the process will be to establish the purpose for the subcommittee. Once a purpose has been established, detailed subcommittee objectives will also be identified

Comprehensive Literature Review and Water Temperature Index Values

For each species under consideration, an evaluation will be conducted to determine whether a comprehensive review of available literature to identify lifestage-specific water temperature index values is appropriate. For species requiring a literature review, this information may be used in the evaluation of thermally suitable habitat for reintroduction of anadromous salmonids in the Upper Tuolumne River. The thermal requirements of anadromous salmonids, in particular Chinook salmon and steelhead, have been extensively studied in California and elsewhere. The literature review will draw upon regional research, and if available, site specific information to inform the selection of WTI values to be used in the subcommittee's evaluation of the water temperature-related reintroduction potential in the reaches of the Upper Tuolumne River. Other considerations regarding thermal suitability may also be considered such as local adaptation, genetics, and information on potential source populations of target species.

Criteria Selection

In order to support a subsequent evaluation of thermally suitable habitat for selected target species in the Upper Tuolumne River, the subcommittee will collaboratively need to identify, define, and select appropriate water temperature criteria (e.g., WTIs, metric(s), lifestages, temporal distributions, etc.) based upon the available information resulting from the literature review and relevant site-specific information from Tuolumne River studies, if available.

Selecting and Implementing an Evaluation Approach

For the evaluation of thermally suitable habitat for potential reintroduction of anadromous salmonids into the upper Tuolumne River Basin, it is anticipated that water temperature modeling and/or monitoring will be applied for a comparison among selected rivers and reaches in the Basin. Concurrent with subcommittee activities, the Upper Tuolumne River Temperature Monitoring and Modeling Study is being implemented in support of the La Grange Hydroelectric Project licensing. Because this study has been approved by licensing participants, including those participating on the subcommittee, it is proposed that the model being developed as part of this study be used to support the thermally suitable habitat evaluation.

Reporting

As noted above, results of subcommittee activities will be summarized in a technical document. The technical document will undergo subcommittee review and be provided to the Upper Tuolumne River Reintroduction Assessment Framework Plenary Group when complete.

Implementation Schedule

It is envisioned that the aforementioned water temperature considerations will be addressed by the subcommittee through a series of subcommittee meetings corresponding to a schedule for the completion of key steps. At each step of the way (i.e., each meeting) the objective is to obtain agreement/acceptance of the topic addressed. A schedule is as follows:

- September 15, 2016
 - Convene subcommittee and develop "purpose" statement and objectives.
 - Review available, existing information and identify scope for additional literature review of lifestage-specific water temperature relationships.
 - Confirm subcommittee schedule.
- Early October 2016
 - Present/discuss results of literature review.
 - Identify a suite of WTI values representing a summarization of the literature review.
- Mid- to late October 2016
 - Select water temperature criteria for each species-specific lifestage for reintroduction evaluation.
 - Existing water temperature guidelines/standards.
 - Site-specific WTIs.
- November 2016

- Identify the water temperature evaluation methodological approach.
 - Water temperature metrics.
 - Metrics application to water temperature model and/or monitoring data.
- Conduct species and lifestage-specific evaluations.
- Prepare draft technical document reporting the results for all of the above objectives.
- December 2016
 - Prepare a final technical document.

Project	Species	Life Stage	Water Temperature	Timeframe	Location	Metric	Source(s)	Notes
Lower American River	Steelhead	Juvenile (rearing)	65°F or less (at the Watt Avenue Bridge)	May 15 – October 31	Watt Avenue Bridge	Daily average temperature (DAT)	Water Forum 2006 Water Forum 2007 NMFS 2009, as amended 2011, Biological Opinion	
			If analysis during the formulation of the					
			Temperature Plan indicates					
			temperature target will					
			prematurely exhaust the					
			available cold water in Folsom Reservoir, the					
			target water temperature in					
			the summer may be					
			increased by 1°F increments					
	Fall-run Chinook	Fall-run Chinook Adult (spawning)	60°F or less	As early in October as	Hazel Avenue			
	Tun Tun Chintook	Egg (incubation)	00 1 01 1055	possible	Thizer Avenue			
			56°F or less	As early in November as possible	Hazel Avenue			
Lower Feather	Spring-run Chinook and	run Chinook and Not identified steelhead	56°F	January - April	Robinson Riffle	Daily mean	SWRCB 2010	
	steelhead		56-63°F ¹	May 1-15				
			63°F	May 16 - August				
			63-58°F ²	September 1-8				
			58°F	September 9-30				
			56°F	October - December				
San Joaquin	Fall-run Chinook and	Adult	64°F	September	Above Merced	7-day average of the daily	CALFED 2009	Per modeling report
	steennead	Egg (incubation)	55°F	October - December	Above Merced	temperature (7DADM)		(CALFED 2009): "It should be emphasized that the stakeholders agreed that the Panel criteria should only
		Juvenile (rear	Juvenile (rearing)	61°F	January – April 15	Above Tuolumne Above Stanislaus (first two weeks of April)		
		Smolt	57°F	April 16 - May	Above Stanislaus			comparing simulated
		Juvenile (rearing)	61°F	June - August	Above Stanislaus (first week of June) Mossdale (2 nd week of June – third week of July) Vernalis (forth week of July – August)			alternatives and should not be construed as an agreed upon criteria in establishing temperature policy in the basin. "

Water Temperature Criteria for Select California Central Valley River Systems

¹ Indicates a period of transition from the first temperature to the second temperature. ² Indicates a period of transition from the first temperature to the second temperature.

Project	Species	Life Stage	Water Temperature	Timeframe	Location	Metric	Source(s)	Notes
Shasta	Winter-run Chinook	Egg/Alvin	56°F or less	May 15 – September 30	Between Balls Ferry and Bend Bridge	Daily average temperature (DAT)	BOR 2016 NMFS 2016	Scenarios identified to manage water to 55°F or less (7DADM) through the winter run spawning area.
	Spring-run Chinook	Egg/Alvin	56°F or less	October				
Yuba	Steelhead	Adult (migration)	$64^{\circ}F^{3} / 68^{\circ}F^{4}$	August – March	Smartsville, Daguerre Point Dam, Marysville	t Maximum weekly average temperature (MWAT) Average daily water temperature (ADT) and monthly exceedance distributions	River Management Team (RMT) 2013	
		Adult (holding)	61°F / 65°F	August – March	Smartsville, Daguerre Point Dam, Marysville		Average daily water	
		Adult (spawning)	54°F / 57°F	January – April	Smartsville and Daguerre Point Dam			
		Egg (incubation)	54°F / 57°F	January – May	Smartsville and Daguerre Point Dam			
		Juvenile (rearing and downstream movement)	65°F / 68°F	Year-round	Daguerre Point Dam and Marysville			
		Smolt (emigration)	52°F / 55°F	October – April 15	Daguerre Point Dam and Marysville			
	Spring-run Chinook	Adult (immigration)	64°F / 68°F	April – September	Smartsville, Daguerre Point Dam, Marysville			
		Adult (holding)	61°F / 65°F	April – September	Smartsville, Daguerre Point Dam, Marysville			
		Adult (spawning)	56°F / 58°F	September – October 15	Smartsville			
		Egg (incubation)	56°F / 58°F	September – December	Smartsville			
		Juvenile (rearing and downstream movement)	61°F / 65°F	Year-round	Daguerre Point Dam, Marysville			
		Smolt (emigration)	63°F / 68°F	October – May 15	Daguerre Point Dam, Marysville	, nd rre rre		
	Fall-run Chinook	Adult (immigration and staging)	64°F / 68°F	July – December	Daguerre Point Dam and Marysville			
		Adult (spawning)	56°F / 58°F	October – December	Smartsville and Daguerre Point Dam			
		Egg (incubation)	56°F / 58°F	October – March	Smartsville and Daguerre Point Dam			
		Juvenile (rearing and downstream movement)	61°F / 65°F	December 15 – June	Daguerre Point Dam and Marysville			

 ³ Upper optimum water temperature index (WTI).
 ⁴ Upper tolerance WTI.

Project	Species	Life Stage	Water Temperature	Timeframe	Location	Metric	Source(s)	Notes	
EPA	Salmon and trout	Adult (migration)	<64°F <68°F generally in lower part of river basins that likely reach temp naturally, if there are cold-water refugia	Unspecified (species specific)	NA	7DADM EPA 2003	7DADM	EPA 2003	Note: source is EPA Region 10 Guidance for Pacific Northwest state and Tribal Temperature Water Quality Standards.
	Salmon and trout	Adult (spawning) Egg (incubation) Fry (emergence)	<55°F	Unspecified (species specific)	NA				
	Salmon	Juvenile (rearing)	<61°F	"Early year"	Mid- to upper river basin			"Core" juvenile rearing	
	Salmon	Smolt	<59°F	Unspecified (species specific)	NA				
	Steelhead	Smolt	<57°F	Unspecified (species specific)	NA				
	Salmon and steelhead	Juvenile (rearing)	<64°F	"Late year"	Lower river basin			"Non-Core" juvenile rearing	

Sources:

CALFED. 2009. San Joaquin River Basin, Water Temperature Modeling and Analysis. October 2009.

EPA (U.S. Environmental Protection Agency). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B-03-002. April. NMFS (National Marine Fisheries Service). 2016. Sacramento River Temperature Management Plan concurrence letter. June 28, 2016.

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LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT WATER TEMPERATURE SUBCOMMITTEE CONFERENCE CALL

OCTOBER 14, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581) Fish Passage Facilities Alternatives Assessment Water Temperature Criteria Subcommittee Conference Call

Friday, October 14, 2016 1:00 pm to 3:00 pm

Final Meeting Notes

Meeting Attendees			
No.	Name	Organization	
1	Steve Boyd	Turlock Irrigation District	
2	Paul Bratovich	HDR Inc., consultant to the Districts	
3	Jean Castillo	National Marine Fisheries Service	
4	Jesse Deason	HDR Inc., consultant to the Districts	
5	John Devine	HDR Inc., consultant to the Districts	
6	Greg Dias	Modesto Irrigation District	
7	Tim Heyne	California Department of Fish and Wildlife	
8	Bao Le	HDR Inc., consultant to the Districts	
9	Ellen Levin	City and County of San Francisco	
10	Lonnie Moore*	Private citizen	
11	Gretchen Murphey	California Department of Fish and Wildlife	
12	Bill Paris	Modesto Irrigation District	
13	Bill Sears	City and County of San Francisco	
14	Chris Shutes	California Sportfishing Protection Alliance	
15	John Wooster	National Marine Fisheries Service	
16	Ron Yoshiyama	City and County of San Francisco	

* Joined call about 15 minutes late.

On October 14, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted the second Water Temperature Criteria Subcommittee (Temperature Subcommittee) conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework). This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document provides meeting materials.

Mr. Bao Le (HDR, consultant to the Districts) welcomed meeting attendees. Mr. Le said the purpose of the Temperature Subcommittee is to establish a technical basis for evaluating thermal suitability for the purposes of the Framework. As background, Mr. Le said the Upper Tuolumne River Basin Fish Migration Barriers Study Progress Report included several statements about thermal suitability in the upper Tuolumne River. In the agency's comments on the report, the National Marine Fisheries Service (NMFS) stated that such statements were premature. Given that no thermal suitability criteria had yet been decided on by licensing participants, the Districts agreed with NMFS's comments that statements about thermal suitability were premature. Subsequently, the topic of thermal suitability criteria was discussed by the Plenary Group. As part of implementing the Framework, the Plenary Group decided to create the Temperature Subcommittee.

Mr. Le summarized discussions at the September 15 Temperature Subcommittee call. Mr. Le said on the call, licensing participants discussed the temperature criteria matrix prepared by the Districts. Mr. Le said the water temperature criteria matrix was the result of an action item the Districts had from Workshop No. 5 to develop a document summarizing what water temperature values were developed for the Yuba River,

as well as what information were developed for other potentially relevant programs in the Central Valley. Mr. Le said at the September 15 conference call, licensing participants decided the best path forward was to first update the literature review completed by the Yuba Salmon Forum (YSF). The literature review would be updated to include results from recent studies as well as site-specific information about the Tuolumne River. Mr. Le said on the first Temperature Subcommittee call, the Districts requested that any feedback on what information or data should be added to update the YSF literature review be provided by September 23. Mr. Le said no feedback was received.

Mr. Bratovich (HDR) said the YSF completed a comprehensive literature review of Central Valley temperature experiments and field observations. Mr. Bratovich said the literature review contains over 100 references and that many of the individuals on this call participated in the YSF. Mr. Bratovich noted that where data needed to be augmented, the review extended to information collected in the Pacific Northwest. Based on the information collected, the YSF developed water temperature index values for each life stage of spring-run Chinook and steelhead. Ultimately, the YSF identified upper optimal and upper tolerable index values for each life stage. Maximum weekly average temperature (MWAT) was used as the metric.

Mr. Le said the Districts have updated the YSF literature review, and this draft was provided to licensing participants yesterday. The foundation of the document is Appendix A of "Water Temperature Considerations for Yuba River Basin Anadromous Salmonid Reintroduction Evaluations" (Bratovich et al. 2012). Additional information has been added, including site-specific information about the Tuolumne River collected as part of the Don Pedro Project relicensing proceeding and data collected for the temperature criteria matrix (provided to Temperature Subcommittee members prior to the September 15 call).

Mr. Bill Sears (City and County of San Francisco) asked what is the difference between "water temperature criteria" and "index values". Mr. Bratovich said there is a lot of phraseology that can influence how data may be interpreted or understood. Some literature references water temperature "guidelines". EPA (2003) refers to both "criteria" and "guidelines". Mr. Bratovich said "index values" is a term used to reference specific water temperature values that are indicative of a specific physiological response. Mr. Bratovich said some of the references collected in the YSF literature review use Celsius while others use Fahrenheit. Some references provided values to a tenth of a degree while others used whole integers. Mr. Bratovich said YSF chose whole-integer "values of consideration" for evaluating thermal suitability.

Ms. Gretchen Murphey (California Department of Fish and Wildlife) requested that the Literature Review Summary provide values in Celsius as well as Fahrenheit. Mr. Le said future iterations of the document will provide values in both Celsius and Fahrenheit.

Mr. Le said the YSF literature review identified life stage specific temperature information by species (i.e., steelhead and Chinook) although fall-run and spring-run Chinook values were grouped together. Mr. Bratovich noted that separate holding values for spring-run Chinook were also established.

Mr. Le asked if anyone on the call has looked at the updated literature review. Ms. Murphey said she reviewed part of the document. Mr. Chris Shutes (California Sportfishing Protection Alliance) said he also reviewed part of the document.

Mr. Shutes noted that the the Swim Tunnel Study Report is included in the updated literature review. Mr. Shutes said he is trying to understand how that study is relevant to thinking about reintroduction. Mr. Shutes asked how the Districts see the study as being relevant for the purposes of evaluating reintroduction in the upper Tuolumne River. Mr. Le said the Don Pedro Project relicensing studies included several studies that seemed natural to include in the updated literature review, including the Swim Tunnel Study and the two fish model studies, W&AR-06 and W&AR-10. Mr. Le said in general, studies were added to the

literature review if they provided site-specific data. Once the literature review is complete, the next step would be to discuss what implications these studies may have for reintroduction. Mr. John Devine (HDR) added that site-specific data on the thermal tolerance of juvenile *O. mykiss* seemed appropriate regarding possible relevance to temperature benchmarks on the Tuolumne River.

Mr. Shutes asked if the Districts would like comments on what still should be added to the literature review or comments on the relevance and usefulness of the studies included in the literature review for evaluating reintroduction. Mr. Le stated that although comments were due on September 23 and none were received, comments are still welcome. Mr. Le said at a minimum, individuals should provide any key studies or data or other relevant information that may be missing from the literature review. Comments on how specific studies included in the literature review may or may not be relevant to considering reintroduction would also be valuable.

Meeting attendees discussed when comments on the updated literature review should be provided. Comments are due to Ms. Rose Staples (HDR) at <u>rose.staples@hdrinc.com</u> by November 1, 2016.

Mr. Shutes said the Literature Review Summary is currently in the form of a narrative, with the temperature values sprinkled throughout. In the YSF Planning Document, the numbers were displayed in tables. It may be useful to display the numbers in both a narrative form and in tables. Ms. Jean Castillo (National Marine Fisheries Service [NMFS]) agreed that a table would be helpful. Mr. John Wooster (NMFS) asked what would be the difference between the table prepared for the first Temperature Subcommittee call and this new table. Mr. Le replied that the matrix discussed on the first call summarized temperature values identified in several Central Valley reintroduction or salmon management programs. This new table would display numbers pulled from the literature review, which would also include the numbers from the matrix.

Mr. Le said the narrative provides a lot of helpful background on the nature and context of the studies. However, a table summarizing relevant numbers could be added to the narrative section of each life stage. Meeting attendees agreed with this approach.

Mr. Wooster asked if there is a central location where the references are stored. Mr. Le and Mr. Bratovich confirmed copies of all the references are available. Mr. Wooster asked if copies of all the references, or select references, can be shared with the group. Mr. Le said he can provide any references that may be of interest, if folks first send him a list of the references they would like to review. Mr. Wooster said he would provide a list of the references he would like.

Mr. Le said the next Temperature Subcommittee call will be in early- or mid-November to discuss what water temperature index values should be used and to start establishing a technical basis for evaluating thermal suitability. Meeting attendees discussed the date for the next Temperature Subcommittee call. Mr. Le said he will send out a Doodle poll with possible meeting dates. Mr. Le said prior to the next call, the Districts will provide an updated literature review and responses to any comments received on the updated literature review.

Mr. Le asked if there were any comments on the glossary of terms. Ms. Castillo said the glossary was helpful. Mr. Le asked meeting attendees to review the glossary of terms and provide comments on what additional terms should be added by November 1, 2016.

ACTION ITEMS

- 1. Future iterations of the literature review summary will provide values in both Celsius and Fahrenheit.
- 2. Licensing participants will provide comments on the updated literature review and glossary of terms to Ms. Rose Staples at <u>rose.staples@hdrinc.com</u> by November 1, 2016.
- 3. The Districts will update the literature review narrative to include tables at the end of each life stage section that summarize the relevant temperature values identified in the associated subsection.
- 4. Mr. Wooster will send Ms. Rose Staples a list of references that he would like to review and Ms. Rose Staples will send him those references.
- 5. Mr. Le will send out a Doodle poll with possible meeting dates. (complete)
- 6. Prior to the next Temperature Subcommittee call, the Districts will send out an updated literature review and responses to any comments received on the updated literature review.
- 7. The Districts will send out meeting notes from this call. (complete)

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

WATER TEMPERATURE SUBCOMMITTEE CONFERENCE CALL

OCTOBER 14, 2016

ATTACHMENT A

MEETING AGENDA AND MATERIALS

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La Grange Hydroelectric Project Reintroduction Assessment Framework Water Temperature Criteria Subcommittee Conference Call Friday, October 14, 2016, 1:00 pm to 3:00 pm Conference Line: 1-866-583-7984; Passcode: 8140607

Meeting Objectives:

- 1. Review and discuss water temperature literature review summary, glossary of terms/acronym list (Districts' action item).
- 2. Discuss potential water temperature index (WTI) values that may be relevant to the Upper Tuolumne River Reintroduction Assessment Framework.
- 3. Discuss next steps and schedule for WTI selection.

TIME	TOPIC
1:00 pm – 1:15 pm	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts)
1:15 pm – 2:45 pm	 Water Temperature Literature Review Summary, Glossary of Terms/Acronym List (All) a. Summary of documents (Districts) b. Subcommittee discussion and relevance to selection of WTI values (All)
2:45 pm – 3:00 pm	Next Steps (All) a. Schedule next call and agenda topics b. Action items from this call

UPPER TUOLUMNE RIVER REINTRODUCTION ASSESSMENT FRAMEWORK WATER TEMPERATURE CRITERIA SUBCOMMITTEE

LIFESTAGE-SPECIFIC WATER TEMPERATURE BIOLOGICAL EFFECTS AND INDEX TEMPERATURE VALUES

Literature Review Summary

INTRODUCTION

The La Grange Hydroelectric Project (La Grange Project), owned and operated by the Turlock Irrigation District and Modesto Irrigation District (TID/MID), is currently undergoing the Federal Energy Regulatory Commission (FERC) Integrated Licensing Process. As part of this process, the Districts are implementing a FERC-approved Fish Passage Facilities Alternatives Assessment which consists of developing general design criteria and design considerations applicable to upstream and downstream fish passage facilities at the La Grange Project. Design criteria and considerations include such items as site-specific physical and operational parameters; applicable regulatory requirements; National Marine Fisheries Service (NMFS),U.S. Fish and Wildlife Service (USFWS), and California Department of Fish and Wildlife (CDFW) biological and engineering design criteria; site-specific biological/habitat information relevant to the sizing and configuration of facilities; and any other information gaps that may affect siting, sizing, general design parameters, capital cost, and operating requirements of potential fish passage facilities.

To make certain that detailed, site-specific information is available to support and adequately inform decisions regarding fish reintroduction and fish passage, TID, MID, and licensing participants came to a consensus on the need for and utility of an Upper Tuolumne River Reintroduction Assessment Framework (Framework). The Framework is intended to provide a comprehensive, collaborative, and transparent approach for evaluating the full range of potential issues associated with the future reintroduction of anadromous fish to the upper Tuolumne River. In addition to considering aspects of the technical feasibility of building and operating fish passage facilities, the Framework considers the interrelated issues of ecological feasibility, biological constraints, economics, regulatory implications, and other considerations of reintroduction. Elements of the Framework are interconnected, with fish passage construction and operational requirements needing to properly reflect biological constraints, ecological constraints, ecolog

Water temperature considerations are a primary component of assessing any potential anadromous salmonid reintroduction effort. In support of the Framework, the Districts and licensing participants established a Water Temperature Criteria Subcommittee to begin investigating water temperature considerations pertinent to anadromous salmonid reintroduction opportunities in the accessible reaches of the Tuolumne River upstream of Don Pedro Reservoir (upper Tuolumne River). On September 15, 2016, the Districts hosted the first conference call for the Water Temperature Criteria Subcommittee (draft meeting notes from this call were distributed on October 3 for a 30-day comment period). On the conference call, attendees discussed the need for a comprehensive literature review of regional and site-specific information to inform the selection of water temperature index values to be used in an evaluation of the water temperature-related reintroduction potential in the reaches of the upper Tuolumne River. Meeting attendees agreed that the literature review performed for the Yuba Salmon Forum (Appendix A; Bratovich et al. 2012) to support the anadromous salmonid reintroduction assessment in this watershed coupled with site-specific temperature studies or data for the Tuolumne River, if available, would be a good basis for this effort. The following represents and updated literature review summary and is provided to the Water Temperature Criteria Subcommittee to support selection of water temperature index values for the Framework.

STEELHEAD LIFESTAGE-SPECIFIC WATER TEMPERATURE INDEX VALUES

Adult Immigration and Holding

Water temperatures can control the timing of adult spawning migrations and can affect the viability of eggs in holding females. Yuba County Water Agency (YCWA) *et al.* (2007) suggests that few studies have been published examining the effects of water temperature on either steelhead immigration or steelhead holding, and none of the available studies were recent (Bruin and Waldsdorf 1975; McCullough *et al.* 2001). The available studies suggest that a dverse effects occur to immigrating and holding steelhead at water temperatures exceeding the mid 50°F range, and that immigration will be delayed if water temperatures approach approximately 70°F. Water temperature index values of 52°F, 56°F, 61°F, 65°F and 70°F were chosen because they provide a gradation of potential water temperature effects, and the available literature provided the strongest support for these values.

Because of the paucity of literature pertaining to steelhead adult immigration and holding, an evenly spaced range of water temperature index values could not be achieved. We also used some pertinent information related to other salmonids (e.g., Chinook salmon). 52°F was selected as a water temperature index value because it has been referred to as a "recommended" (Reclamation 2003), "preferred" (McEwan and Jackson 1996; NMFS 2000; NMFS 2002), and "optimum" (Reclamation 1997a) water temperature for steelhead adult immigration. Increasing levels of thermal stress to this life stage may reportedly occur above the 52°F water temperature index value. 56°F was selected as a water temperature index value because 56°F represents a water temperature above which adverse effects to migratory and holding steelhead begin to arise (Bruin and Waldsdorf 1975; Leitritz and Lewis 1980; McCullough et al. 2001; Smith et al. 1983). 50-59°F is referred to as the "preferred" range of water temperatures for California summer steelhead holding (Moyle et al. 1995). Whereas, water temperatures greater than 61°F may result in "chronic high stress" of holding Central Valley winter- run steelhead (USFWS 1995a). 65°F was selected as a water temperature index value because steelhead (and fall-run Chinook salmon) encounter potentially stressful temperatures between 64.4-73.4°F (Richter and Kolmes 2005). Additionally, over 93% of steelhead detections occurred in the 65.3-71.6°F range, although this may be above the temperature for optimal immigration (Salinger and Anderson 2006) and/or may modify migration timing due to holding in coldwater refugia (High et al. 2006). 70°F was selected as the highest water temperature index value because the literature suggests that water temperatures near and above 70.0°F may result in a thermal barrier to adult steelhead migrating upstream (McCullough et al. 2001) and are water temperatures referred to as "stressful" to upstream migrating steelhead in the Columbia River (Lantz 1971 as cited in Beschta et al 1987). Further, Coutant (1972) found that the upper incipient lethal temperature (UILT) for adult steelhead was 69.8°F and temperatures between 73-75°F are described as "lethal" to holding adult steelhead in Moyle (2002).

As part of the Framework, TID and MID, in collaboration with stakeholders developed a table of established water temperature criteria from select salmon and steelhead programs in the Central Valley (Temperature Criteria Matrix; presented at the September 15, 2016 Water Temperature

Subcommittee conference call). The table was developed to support the Framework's Water Temperature Criteria Subcommittee whose purpose is to establish a technical basis to evaluate water temperature regimes for target anadromous salmonid reintroduction into the Tuolumne River upstream of Don Pedro Reservoir. For steelhead adult immigration, the Temperature Criteria Matrix identified 64°F in for the San Joaquin (CALFED 2009) and 64°F (Upper Optimum Value) and 68°F (Upper Tolerable Value) for the Yuba Reintroduction Assessment (Bratovich *et al.* 2012). For steelhead adult holding, the Temperature Criteria Matrix identified 61°F (Upper Optimum Value) and 65°F (Upper Tolerable Value) for the Yuba Reintroduction Assessment (Bratovich *et al.* 2012).

EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (EPA 2003b) identifies 64°F (7DADM) for "salmon and trout" migration.

Spawning and Embryo Incubation

Relatively few studies have been published directly addressing the effects of water temperature on steelhead spawning and embryo incubation (Redding and Schreck 1979; Rombough 1988). Because anadromous steelhead and non-anadromous rainbow trout are genetically and physiologically similar, studies on non-anadromous rainbow trout also were considered in the development of water temperature index values for steelhead spawning and embryo incubation (Moyle 2002; McEwan 2001). From the available literature, water temperatures in the low 50°F range appear to support high embryo survival, with substantial mortality to steelhead eggs reportedly occurring at water temperatures in the high 50°F range and above. Water temperatures in the 45-50°F range have been referred to as the "optimum" for spawning steelhead (FERC 1993).

Water temperature index values of 46°F, 52°F, 54°F, 57°F, and 60°F were selected for two reasons. First, the available literature provided the strongest support for water temperature index values at or near 46°F, 52°F, 54°F, 57°F, and 60°F. Second, the index values reflect a gradation of potential water temperature effects ranging between optimal to lethal conditions for steelhead spawning and embryo incubation. Some literature suggests water temperatures \leq 50°F are when steelhead spawn (Orcutt et al. 1968) and/or are optimal for steelhead spawning and embryo survival (FERC 1993; Myrick and Cech 2001; Timoshina 1972) and temperatures between 39-52°F are "preferred" by spawning steelhead (IEP Steelhead Project Work Team (no date); McEwan and Jackson 1996), a larger body of literature suggests optimal conditions occur at water temperatures $\leq 52^{\circ}$ F (Humpesch 1985; NMFS 2000; NMFS 2001a; NMFS 2002; Reclamation 1997b; SWRCB 2003; USFWS 1995b). Further, water temperatures between 48-52°F were referred to as "optimal" (FERC 1993; McEwan and Jackson 1996; NMFS 2000) and "preferred" (Bell 1986) for steelhead embryo incubation. Therefore, 52°F was selected as the lowest water temperature index value. Increasing levels of thermal stress to the steelhead spawning and embryo incubation life stage may reportedly occur above the 52°F water temperature index value.

54°F was selected as the next index value, because although most of the studies conducted at or near 54.0°F report high survival and normal development (Kamler and Kato 1983; Redding and Schreck 1979; Rombough 1988), some evidence suggests that symptoms of thermal stress

arise at or near 54.0°F (Humpesch 1985; Timoshina 1972). Thus, water temperatures near 54°F may represent an inflection point between properly functioning water temperature conditions, and conditions that cause negative effects to steelhead spawning and embryo incubation. Further, water temperatures greater than 55°F were referred to as "stressful" for incubating steelhead embryos (FERC 1993). 57°F was selected as an index value because embryonic mortality increases sharply and development becomes retarded at incubation temperatures greater than or equal to 57.0°F. Velsen (1987) provided a compilation of data on rainbow trout and steelhead embryo mortality to 50% hatch under incubation temperatures ranging from 33.8°F to 60.8°F that demonstrated a two-fold increase in mortality for embryos incubated at 57.2°F, compared to embryos incubated at 53.6°F. In a laboratory study using gametes from Big Qualicum River, Vancouver Island, steelhead mortality increased to 15% at a constant temperature of 59.0°F, compared to less than 4% mortality at constant temperatures of 42.8°F, 48.2°F, and 53.6°F (Rombough 1988). Also, alevins hatching at 59.0°F were considerably smaller and appeared less well developed than those incubated at the lower temperature treatments. From fertilization to 50% hatch, Big Qualicum River steelhead had 93% mortality at 60.8°F, 7.7% mortality at 57.2°F, and 1% mortality at 47.3°F and 39.2°F (Velsen 1987). Myrick and Cech (2001) similarly described water temperatures >59°F as "lethal" to incubating steelhead embryos, although FERC (1993) suggested that water temperatures exceeding 68°F were "stressful" to spawning steelhead and "lethal" when greater than 72°F.

As part of the Don Pedro Hydroelectric Project FERC relicensing process, the TID and MID conducted an *O. mykiss* Population Study (TID/MID 2014) for the Lower Tuolumne River below La Grange Diversion Dam. The goal of the study is to provide a quantitative population model to investigate the relative influences of various factors on the lifestage specific production of *O. mykiss in* the Tuolumne River including water temperature effects on population response for specific in-river lifestages. The study noted that although no literature information could be identified regarding upper temperature limits for spawning initiation, maximum temperature limits for spawning are assumed to be on the order of 15° C (59° F) inferred from egg mortality thresholds for resident *O. mykiss* (Velsen 1987) as well as steelhead (Rombough 1988). Similarly, for egg incubation, the model allowed for a broad range of flow and water temperature conditions using the completed model, an initial acute mortality threshold of 15° C (59° F) was included based upon a literature review by Myrick and Cech (2001).

For steelhead spawning and embryo incubation in the Yuba River, the Framework Temperature Criteria Matrix identified 54°F and 57°F for Upper Optimum and Upper Tolerable values, respectively (Bratovich *et al.* 2012).

EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (EPA 2003b) identifies 55°F (7DADM) for "salmon and trout" spawning and egg incubation.

Juvenile Rearing & Downstream Movement

Water temperature index values were developed to evaluate the combined steelhead rearing (fry and juvenile) and juvenile downstream movement lifestages. Some steelhead may rear in

freshwater for up to three years before emigrating as yearling+ smolts, whereas other individuals move downstream shortly after emergence as post-emergent fry, or rear in the river for several months and move downstream as juveniles without exhibiting the ontogenetic characteristics of smolts . Presumably, these individuals continue to rear and grow in downstream areas (e.g., lower Feather River, Sacramento River, and Upper Delta) and undergo the smoltification process prior to entry into saline environments. Thus, fry and juvenile rearing occur concurrently with post-emergent fry and juvenile downstream movement and are assessed in this Technical Memorandum using the fry and juvenile rearing water temperature index values.

The growth, survival, and successful smoltification of juvenile steelhead are controlled largely by water temperature. The duration of freshwater residence for juvenile steelhead is long relative to that of Chinook salmon, making the juvenile life stage of steelhead more susceptible to the influences of water temperature, particularly during the over-summer rearing period. Central Valley juvenile steelhead have high growth rates at water temperatures in the mid 60°F range, but reportedly require lower water temperatures to successfully undergo the transformation to the smolt stage.

Water temperature index values of 63°F, 65°F, 68°F, 72°F, and 75°F were selected to represent a gradation of potential water temperature effects ranging between optimal to lethal conditions for steelhead juvenile rearing. The lowest water temperature index value of 63°F was established because Myrick and Cech (2001) describe 63°F as the "preferred" water temperature for wild juvenile steelhead, whereas "preferred" water temperatures for juvenile hatchery steelhead reportedly range between 64-66°F. 65°F was also identified as a water temperature index value because NMFS (2000; 2002a) reported 65°F as the upper limit preferred for growth and development of Sacramento and American River juvenile steelhead. Also, 65°F was found to be within the optimum water temperature range for juvenile growth (i.e., 59-66°F) (Myrick and Cech 2001), and supported high growth of Nimbus strain juvenile steelhead (Cech and Myrick 1999).

Increasing levels of thermal stress to this life stage may reportedly occur above the 65°F water temperature index value. For example, Kaya et al. (1977) reported that the upper avoidance water temperature for juvenile rainbow trout was measured at 68°F to 71.6°F. Cherry et al. (1977) observed an upper preference water temperature near 68.0°F for juvenile rainbow trout, duplicating the upper preferred limit for juvenile steelhead observed in Cech and Myrick (1999) and FERC (1993). Empirical adult O. mvkiss population data from the North Yuba, Middle Yuba, South Yuba, Middle Fork American, and Rubicon rivers were collected in 2007-2009 were plotted against temperature (Figure 4 of Bratovich et al. 2012). The temperature used was the 8th largest average daily temperature during the summer (i.e., up to seven days had higher daily average temperatures). The data show a population density break at about 68.0°F. Although smaller population densities occurred at higher temperatures, the largest population densities occurred at temperatures near 68.0°F or less. In addition growth for a 200 mm juvenile *O. mykiss* versus temperature for three food levels (percent of maximum consumption = 30%, 50%, and 70%) was evaluated. The average empirically derived percent of maximum consumption in an adjacent watershed (Middle Fork American Fork River) was 50% (Hanson et al. 1997). Positive growth only occurs up to approximately 68°F. Because of the literature

describing 68.0°F as both an upper preferred and an avoidance limit for juvenile *O. mykiss*, and because of the empirical fish population data and bioenergetics growth data, 68°F was established as a upper tolerable water temperature index value.

A water temperature index value of 72°F was established because symptoms of thermal stress in juvenile steelhead have been reported to arise at water temperatures approaching 72°F. For example, physiological stress to juvenile steelhead in Northern California streams was demonstrated by increased gill flare rates, decreased foraging activity, and increased agonistic activity as stream temperatures rose above 71.6°F (Nielsen *et al.* 1994). Also, 72°F was selected as a water temperature index value because 71.6°F has been reported as an upper avoidance water temperature (Kaya *et al.* 1977) and an upper thermal tolerance water temperature index value of 75°F was established because NMFS and EPA report that direct mortality to rearing juvenile steelhead results when stream temperatures reach 75.0°F (EPA 2002; NMFS 2001b). Water temperatures >77°F have been referred to as "lethal" to juvenile steelhead (FERC 1993; Myrick and Cech 2001). The UILT for juvenile rainbow trout, based on numerous studies, is between 75-79°F (Sullivan *et al.* 2000; McCullough 2001).

A swim tunnel study conducted on the Lower Tuolumne River (TID/MID 2016) generated high quality field data on the physiological performance of Tuolumne River *O. mykiss* acutely exposed to a temperature range of 13 to 25°C. The data indicated that wild juvenile *O. mykiss* represents an exception to the expected based on the 7DADM criterion for juvenile rearing set out by EPA (2003b) for Pacific Northwest *O. mykiss*. The study recommended that a conservative upper aerobic performance limit of 71.6°F, instead of 64.4°F (EPA), be considered in re-determining a 7DADM for this population.

The Lower Tuolumne River *O. mykiss* Population Study (TID/MID 2014) identified the upper incipient lethal temperature (UILT) for *O. mykiss* juveniles has been estimated at 22.8–25.9°C (73–79°F) (Threader and Houston 1983). In the model, an initial mortality threshold of 25°C (77°F) daily average temperature was selected for *O. mykiss* juveniles. Note also that both fry rearing and resident adult rearing lifestages of *O. mykiss* also had UILT values of 77°F to support the model.

For steelhead juvenile rearing, the Temperature Criteria Matrix identified 65°F for the Lower American River (Water Forum 2007); 61°F for the San Joaquin (CALFED 2009); and 65°F (Upper Optimum Value) and 68°F (Upper Tolerable Value) for the Yuba (Bratovich *et al.* 2012).

EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (EPA 2003b) identifies 64°F (7DADM) for "salmon and steelhead" juvenile rearing.

Yearling + Smolt Emigration

Laboratory data suggest that smoltification, and therefore successful emigration of steelhead smolts, is directly controlled by water temperature (Adams *et al.* 1975). Water temperature index values of 52°F and 55°F were selected to evaluate the steelhead smolt emigration life stage, because most literature on water temperature effects on steelhead smolting suggest

that water temperatures less than 52°F (Adams *et al.*1975; Myrick and Cech 2001; Rich 1987a) or less than 55°F (EPA 2003a; McCullough et al. 2001; Wedemeyer et al. 1980; Zaugg and Wagner 1973) are required for successful smoltification to occur. (Adams et al. 1973) tested the effect of water temperature (43.7°F, 50.0°F, 59.0°F or 68.0°F) on the increase of gill microsomal Na⁺-, K⁺-stimulated ATPase activity associated with parr-smolt transformation in steelhead and found a two-fold increase in Na^+ -. K^+ -ATPase at 43.7 and 50.0°C, but no increase at 59.0°F or 68.0°F. In a subsequent study, the highest water temperature where a parr-smolt transformation occurred was at 52.3°F (Adams et al. 1975). The results of Adams et al. (1975) were reviewed in Myrick and Cech (2001) and Rich (1987b), which both recommended that water temperatures below 52.3°F are required to successfully complete the parr-smolt transformation. Further, Myrick and Cech (2001) suggest that water temperatures between 43-50°F are the "physiologically optimal" temperatures required during the parr-smolt transformation and necessary to maximize saltwater survival. The 52°F water temperature index value established for the steelhead smolt emigration life stage is the index value generally reported in the literature as the upper limit of the water temperature range that provides successful smolt transformation thermal conditions. Increasing levels of thermal stress to this life stage may reportedly occur above the 52°F water temperature index value.

Zaugg and Wagner (1973) examined the influence of water temperature on gill ATPase activity related to parr-smolt transformation and migration in steelhead. They found ATPase activity was decreased and migration reduced when juveniles were exposed to water temperatures of 55.4° F or greater. In a technical document prepared by the EPA to provide temperature water quality standards for the protection of Northwest native salmon and trout, water temperatures less than or equal to 54.5° F were recommended for emigrating juvenile steelhead (EPA 2003b). Water temperatures are considered "unsuitable" for steelhead smolts at >59°F (Myrick and Cech 2001) and "lethal" at 77°F (FERC 1993).

The Lower Tuolumne River *O. mykiss* Population Study (TID/MID 2014) identified an initial UILT mortality threshold of 77°F daily average temperature for *O. mykiss* smolts on the basis of literature reviews by Myrick and Cech (2001).

For steelhead smolt emigration, the Temperature Criteria Matrix identified 57°F for the San Joaquin (CALFED 2009) and 52°F (Upper Optimum Value) and 55°F (Upper Tolerable Value) for the Yuba (Bratovich *et al.* 2012).

EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (EPA 2003b) identifies 57°F (7DADM) for steelhead smolt.

CHINOOK SALMON LIFESTAGE-SPECIFIC WATER TEMPERATURE INDEX VALUES

It has been suggested that separate water temperatures standards should be developed for each run-type of Chinook salmon. For example, McCullough (1999) states that spring-run Chinook salmon immigrate in spring and spawn in 3rd to 5th order streams and, therefore, face different migration and adult holding temperature regimes than do summer- or fall-run Chinook salmon,

which spawn in streams of 5th order or greater . However, to meet the objectives of the current literature review, run-types are not separated because: (1) there is a paucity of literature specific to each life stage of each run-type; (2) there is an insufficient amount of data available in the literature suggesting that Chinook salmon run-types respond to water temperatures differently; (3) the water temperature index (WTI) values derived from all the literature pertaining to Chinook salmon for a particular life stage will be sufficiently protective of that life stage for each run-type; and (4) all run- types overlap in timing of adult immigration and holding and in some cases are not easily distinguished (Healey 1991).

Adult Immigration and Holding

The adult immigration and adult holding life stages are evaluated together, because it is difficult to determine the thermal regime that Chinook salmon have been exposed to in the river prior to spawning and in order to be sufficiently protective of pre-spawning fish, water temperatures that provide high adult survival and high egg viability must be available throughout the entire pre-spawning freshwater period. Although studies examining the effects of thermal stress on immigrating Chinook salmon are generally lacking, it has been demonstrated that thermal stress during the upstream spawning migration of sockeye salmon negatively affected the secretion of hormones controlling sexual maturation causing numerous reproductive impairment problems (McCullough *et al.* 2001).

The water temperature index values reflect a gradation of potential water temperature effects that range between those reported as "optimal" to those reported as "lethal" for adult Chinook salmon during upstream spawning migrations and holding. The water temperature index values established for the Chinook salmon adult immigration and holding lifestage are 61°F, 65°F, and 68°F. Although 56°F is referenced in the literature frequently as the upper "optimal" water temperature limit for upstream migrations. For example, Boles *et al.* (1988), Marine (1992), and NMFS (1997b) all cite Hinze (1959) in support of recommendations for a water temperature of 56°F for adult Chinook salmon immigration. However, Hinze (1959) is a study examining the effects of water temperature on incubating Chinook salmon eggs in the American River Basin. Further, water temperatures between 38-56°F are considered to represent the "observed range" for upstream migrating spring-run Chinook salmon (Bell 1986).

The lowest water temperature index value established was $61^{\circ}F$, because in the NMFS biological opinion for the proposed operation of the Central Valley Project (CVP) and State Water Project (SWP), $59^{\circ}F$ to $60^{\circ}F$ is reported as..."*The upper limit of the optimal temperature range for adults holding while eggs are maturing*" (NMFS 2000). Also, NMFS (1997b) states..."*Generally, the maximum temperature of adults holding, while eggs are maturing, is about* $59^{\circ}F$ *to* $60^{\circ}F$ " ...and... "Acceptable range for adults migrating upstream range from $57^{\circ}F$ *to* $67^{\circ}F$." Oregon Department of Environmental Quality (ODEQ; 1995) reports that "...many of the diseases that commonly affect Chinook become highly infectious and virulent above $60^{\circ}F$." Study summaries in EPA (2003a) indicate disease risk is high at $62.6^{\circ}F$. Additionally, Ward and Kier (1999) designated temperatures <60.8°F as an "optimum" water temperature threshold for holding Battle Creek spring-run Chinook salmon. EPA (2003a) chose

a holding value of 61°F (7DADM) based on laboratory data various assumptions regarding diel temperature fluctuations. 61°F is also a holding temperature index value for steelhead (see above). The 61°F water temperature index value established for the Chinook salmon adult immigration and holding life stage is the index value generally reported in the literature as the upper limit of the optimal range, and is within the reported acceptable range. Increasing levels of thermal stress to this life stage may reportedly occur above the 61°F water temperature index value.

An index value of 65°F was established because Berman (1990) suggests effects of thermal stress to pre-spawning adults are evident at water temperatures near 65°F. Berman (1990) conducted a laboratory study to determine if pre-spawning water temperatures experienced by adult Chinook salmon influenced reproductive success, and found evidence suggesting latent embryonic abnormalities associated with water temperature exposure to pre-spawning adults that ranged from 63.5°F to 66.2°F. Ward et al. (2003; 2004) identified an extended period of average daily temperatures above 67°F during July as measured at the Quartz Bowl that preceded the onset of significant pre-spawn mortalities. During 2002, temperatures exceeded 67°F a total of 16 days with a maximum of 20.8°C on July 12. During 2003, temperatures exceed 67°F a total of 11 days with a maximum of 20.9°C on July 23. However during other years when there were minimal pre-spawn mortalities, maximum daily average water temperature at Quartz Bowl never exceeded 67°F more than an few days (Ward et al. 2004; Ward et al. 2006; McReynolds et al. 2007; McReynolds and Garman 2008). During each of the years when Chinook salmon temperature mortality was not observed at Butte Creek (2001, 2004-2007), on average, daily temperature did not exceed 65.8°F for more than 7 days (Figure 6 of Bratovich et al. 2012). Tracy McReynolds (Pers. Comm. October 2011) indicated that an upper tolerable holding temperature of 65°F was reasonable based on her experience.

An index value of 68°F was established because the Butte Creek data and the literature suggests that thermal stress at water temperatures greater than 68°F is pronounced, and severe adverse effects to immigrating and holding pre-spawning adults, including mortality, can be expected (Berman 1990; Marine 1997; NMFS 1997b; Ward *et al.* 2004).

Water temperatures between 70-77°F are reported as the range of maximum temperatures for holding pool conditions used by spring-run Chinook salmon in the Sacramento-San Joaquin system (Moyle *et al.* 1995). Migration blockage occurs for Chinook salmon at temperatures from 70-71+°F (McCollough 1999; McCullough *et al.* 2001; EPA 2003b). Strange (2010) found that the mean average body temperature during the first week of Chinook salmon migration on the Klamath River was 71.4°F. The UILT for Chinook salmon jacks is 69.8-71.6°F (McCullough 1999). The upper limit for spring-run Chinook salmon holding in Deer Creek is reportedly 80.6°F, at which point temperatures exceeding this value become "lethal" (Cramer and Hammack 1952, as cited in Moyle *et al.* 1995). As a result of the potential effects to immigrating and holding adult Chinook salmon that reportedly occur at water temperatures greater than or equal to 68°F, index values higher than 68°F were not established.

For Chinook adult immigration, the Framework Temperature Criteria Matrix identified 64°F (Upper Optimum Value) and 68°F (Upper Tolerable Value) for the Yuba River (Bratovich et al. 2012). For Chinook adult holding, the Framework Temperature Criteria Matrix identified 61°F

(Upper Optimum Value) and 65°F (Upper Tolerable Value) for the Yuba River (Bratovich *et al.* 2012).

EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (EPA 2003b) identifies 64°F (7DADM) for "salmon and trout" adult migration.

Spawning and Embryo Incubation

The adult spawning and embryo (i.e., eggs and alevins) incubation life stage includes redd construction, egg deposition, and embryo incubation. Potential effects to the adult spawning and embryo incubation life stages are evaluated together using one set of water temperature index values because it is difficult to separate the effects of water temperature between lifestages that are closely linked temporally, especially considering that studies describing how water temperature affects embryonic survival and development have included a pre-spawning or spawning adult component in the reporting of water temperature experiments conducted on fertilized eggs (Marine 1992; McCullough 1999; Seymour 1956).

The water temperature index values selected for the Chinook salmon spawning and embryo incubation life stages are 56°F, 58°F, 60°F, and 62°F. Anomalously, FERC (1993) refers to 50°F as the "optimum" water temperature for spawning and incubating Chinook salmon. Additionally, for the adult spawning lifestage, FERC (1993) reports "stressful" and "lethal" water temperatures occurring at $>60^{\circ}$ F and $>70^{\circ}$ F, respectively, whereas for incubating Chinook salmon embryos, water temperatures are considered to be "stressful" at <56°F or "lethal" at $>60^{\circ}$ F. Much literature suggests that water temperatures must be less than or equal to 56°F for maximum survival of Chinook salmon embryos (i.e., eggs and alevins) during spawning and incubation. NMFS (1993b) reported that optimum water temperatures for egg development are between 43°F and 56°F. Similarly, Myrick and Cech (2001) reported the highest egg survival rates occur between water temperatures of 39-54°F. Reclamation (unpublished work) reports that water temperatures less than 56°F results in a natural rate of mortality for fertilized Chinook salmon eggs. Bell (1986) recommends water temperatures ranging between 42-57°F for spawning Chinook salmon, and water temperatures between 41-58°F for incubating embryos. USFWS (1995a) reported a water temperature range of 41.0°F to 56.0°F for maximum survival of eggs and yolk-sac larvae in the Central Valley of California. The preferred water temperature range for Chinook salmon egg incubation in the Sacramento River was suggested as 42.0°F to 56.0°F (NMFS 1997a). Alevin mortality is reportedly significantly higher when Chinook salmon embryos are incubated at water temperatures above 56°F (USFWS 1999). NMFS (2002a) reported 56.0°F as the upper limit of suitable water temperatures for spring-run Chinook salmon spawning in the Sacramento River. The 56°F water temperature index value established for the Chinook salmon spawning and embryo incubation life stage is the index value generally reported in the literature as the upper limit of the optimal range for egg development and the upper limit of the range reported to provide maximum survival of eggs and yolk-sac larvae in the Central Valley of California. Increasing levels of thermal stress to this life stage may reportedly occur above the 56°F water temperature index value.

High survival of Chinook salmon embryos also has been suggested to occur at incubation temperatures at or near 58.0°F. For example, (Reclamation Unpublished Work) reported that

the natural rate of mortality for alevins occurs at 58°F or less. Combs (1957) concluded constant incubation temperatures between 42.5°F and 57.5°F resulted in normal development of Chinook salmon eggs, and NMFS (2002a) suggests 53.0°F to 58.0°F is the preferred water temperature range for Chinook salmon eggs and fry. Johnson (1953) found consistently higher Chinook salmon egg losses resulted at water temperatures above 60.0°F than at lower temperatures. In order to protect late incubating Chinook salmon embryos and newly emerged fry NMFS (1993a) has determined a water temperature criterion of less than or equal to 60.0°F be maintained in the Sacramento River from Keswick Dam to Bend Bridge from October 1 to Seymour (1956) provides evidence that 100% mortality occurs to late October 31. incubating Chinook salmon embryos when held at a constant water temperature greater than or equal to 60.0°F. For Chinook salmon eggs incubated at constant temperatures, mortality increases rapidly at temperatures greater than about 59-60°F (see data plots in Myrick and Cech 2001). Olsen and Foster (1957), however, found high survival of Chinook salmon eggs and fry (89.6%) when incubation temperatures started at 60.9°F and declined naturally for the Columbia River (about 7°F/month). Geist et al. (2006) found high (93.8%) Chinook salmon incubation survival through emergence for naturally declining temperatures (0.36°F/day) starting as high as 61.7°F; however, a significant reduction in survival occurred above this temperature.

The literature largely agrees that 100% mortality will result to Chinook salmon embryos incubated at water temperatures greater than or equal to 62.0° F (Hinze 1959; Myrick and Cech 2003; Seymour 1956; USFWS 1999). Approximately 80% or greater mortality of eggs incubated at constant temperatures of 63° F or greater (see data plots in Myrick and Cech 2001). Olsen and Foster (1957) found high mortality of Chinook salmon eggs and fry (79%) when incubation temperatures started at 65.2° F and declined naturally for the Columbia River (about 7° F / month). Geist *et al.* (2006) found low Chinook salmon incubation survival (1.7%) for naturally declining temperatures (0.36° F/day) when temperatures started at 62.6° F

As part of the Don Pedro Hydroelectric Project FERC relicensing process, the TID and MID developed a Chinook Salmon Population Model Study (TID/MID 2013) for the Lower Tuolumne River below La Grange Diversion Dam. The goal of the study is to provide a quantitative population model to investigate the relative influences of various factors on the lifestage specific production of Chinook salmon in the Tuolumne River including water temperature effects on population response for specific in-river lifestages. The Chinook Salmon Population Model (TID/MID 2013) established an initial estimate of 60.4°F as the upper limit for initiation of spawning (Groves and Chandler 1999); also interpreted as the temperature at which spawning habitat will be considered usable by spawners. To address the egg and alevin lifestages, the model established an initial acute egg/alevin mortality threshold of 58°F (TID/MID 2013).

For Chinook spawning and incubation, the Framework Temperature Criteria Matrix identified 60°F or less (as early in October as possible) and 56°F or less (as early in November as possible) for Lower American River fall-run Chinook (Water Forum 2007); 64°F (spawning) and 55°F (incubation) for San Joaquin fall-run Chinook (CALFED 2009); 56°F for Shasta River winter and spring-run Chinook (SWRCB 2016); and 54°F (Upper Optimum Value) and 57°F (Upper Tolerable Value) in the Yuba (Bratovich et al. 2012).

EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality

Standards (EPA 2003b) identifies 55°F (7DADM) for "salmon and trout" spawning, egg incubation, and fry emergence.

Juvenile Rearing and Downstream Movement

Water temperature index values were identified for the combined spring-run Chinook salmon rearing (fry and juvenile) and juvenile downstream movement lifestages, for the reasons previously described regarding steelhead. Fry and juvenile rearing occur concurrently with post-emergent fry and juvenile downstream movement, and are assessed in this Technical Memorandum using the fry and juvenile rearing water temperature index values.

The water temperature index values of 60°F, 65°F, 68°F, 70°F and 75°F were identified for the spring-run Chinook salmon juvenile rearing and downstream movement lifestage . The lowest index value of 60°F was chosen because regulatory documents as well as several source studies, including ones recently conducted on Central Valley Chinook salmon fry and juveniles report 60°F as an optimal water temperature for growth (Banks *et al.* 1971; Brett *et al.* 1982; Marine 1997; NMFS 1997b; NMFS 2000; NMFS 2001a; NMFS 2002; Rich 1987b). Water temperatures below 60°F also have been reported as providing conditions optimal for fry and fingerling growth, but were not selected as index values, because the studies were conducted on fish from outside of the Central Valley (Brett 1952; Seymour 1956). Studies conducted using local fish may be particularly important because *Oncorhynchus* species show considerable variation in morphology, behavior, and physiology along latitudinal gradients (Myrick 1998; Taylor 1990b; Taylor 1990a). More specifically, it has been suggested th at salmonid populations in the Central Valley prefer higher water temperatures than those from more northern latitudes (Myrick and Cech 2000).

The 60°F water temperature index value established for the Chinook salmon juvenile rearing and downstream movement life stage is the index value generally reported in the literature as the upper limit of the optimal range for fry and juvenile growth and the upper limit of the preferred range for growth and development of spring-run Chinook salmon fry and fingerlings. FERC (1993) referred to 58°F as an "optimum" water temperature for juvenile Chinook salmon in the American River. NMFS (2002a) identified 60°F as the "preferred" water temperature for juvenile spring-run Chinook salmon in the Central Valley. Increasing levels of thermal stress to this life stage may reportedly occur above the 60°F water temperature index value.

The index value of 65°F was selected because it represents an intermediate value between 64.0°F and 66.2°F, at which both adverse and beneficial effects to juvenile salmonids have been reported to occur. For example, at temperatures approaching and beyond 65°F, sub-lethal effects associated with increased incidence of disease reportedly become severe for juvenile Chinook salmon (EPA 2003a; Johnson and Brice 1953; Ordal and Pacha 1963; Rich 1987a). Conversely, numerous studies report that temperatures between 64.0°F and 66.2°F provide conditions ranging from suitable to optimal for juvenile Chinook salmon growth (Brett *et al.* 1982; Cech and Myrick 1999; Clarke and Shelbourn 1985; EPA 2003a; Myrick and Cech 2001; NMFS 2002; USFWS 1995b). Maximum growth of juvenile fall-run Chinook salmon has been reported to occur in the American River at water temperatures between 56-59°F (Rich 1987b) and in Nimbus Hatchery spring-run Chinook salmon at 66°F (Cech and Myrick 1999).

Growth for a 100 mm juvenile Chinook salmon versus temperature for three food levels (percent of maximum consumption = 30%, 50%, and 70%) was evaluated. The average percent of maximum consumption in an adjacent watershed (Middle Fork American Fork River) for O. mykiss was 50% (Hanson et al. 1997). Positive growth only occurs up to approximately $64^{\circ}F$ for food levels expected in the wild (e.g., 50% maximum consumption).

A water temperature index value of 68°F was selected because, at water temperatures above 68°F, sub-lethal effects become severe such as reductions in appetite and growth of juveniles (Marine 1997; Rich 1987a; Zedonis and Newcomb 1997). Chronic stress associated with water temperature can be expected when conditions reach the index value of 70°F. For example, growth becomes drastically reduced at temperatures close to 70.0°F and has been reported to be completely prohibited at 70.5°F (Brett et al. 1982; Marine 1997). 75°F was chosen as the highest water temperature index value because high levels of direct mortality to juvenile Chinook salmon reportedly result at this water temperature (Cech and Myrick 1999; Hanson 1991; Myrick and Cech 2001; Rich 1987b). Other studies have suggested higher upper lethal water temperature levels (Brett 1952; Orsi 1971), but 75°F was chosen because it was derived from experiments using Central Valley Chinook salmon and it is a more rigorous index value representing a more protective upper lethal water temperature level. Furthermore, the lethal level determined in Rich (1987b) was derived using slow rates of water temperature change and, thus, is ecologically relevant. The juvenile Chinook Salmon UILT based on numerous studies is 75-77°F (Sullivan et al. 2000; McCullough et al. 2001; Myrick and Cech 2001).

Based upon information reviewed for Chinook salmon juvenile mortality (Brett 1952; Orsi 1971), the Chinook Salmon Population Model (TID/MID 2013) established an initial UILT mortality threshold of 77°F for Chinook salmon juveniles as a daily average water temperature. Note that the model also selected this same value for fry mortality.

For Chinook juvenile rearing, the Framework Temperature Criteria Matrix identified 61°F for the San Joaquin (CALFED 2009) and 61°F (Upper Optimum Value) and 65°F (Upper Tolerable Value) for both fall and spring-run Chinook in the Yuba River (Bratovich *et al.* 2012).

EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (EPA 2003b) identifies 61°F (early year) and 64°F (late year) for salmon juvenile rearing based upon a 7DADM.

Yearling + Smolt Emigration

Juvenile Chinook salmon that exhibit extended rearing in the lower Yuba River are assumed to undergo the smoltification process and volitionally emigrate from the river as yearling+ individuals. Water temperature index values of 63°F, 68°F and 72°F were selected for the spring-run Chinook yearling+ emigration lifestage.

A water temperature index value of 63°F was selected because water temperatures at or below this value allow for successful transformation to the smolt stage, and water temperatures above this value may result in impaired smoltification indices, inhibition of smolt development, and decreased survival and successful smoltification of juvenile spring-run Chinook salmon . Laboratory experiments suggest that water temperatures at or below 62.6°F provide conditions that allow for successful transformation to the smolt stage (Clarke and Shelbourn 1985; Marine 1997; Zedonis and Newcomb 1997). 62.6°F was rounded and used to support an index value of 63°F. Indirect evidence from tagging studies suggests that the survival of fall-run Chinook salmon smolts decreases with increasing water temperatures between 59°F and 75°F in the Sacramento-San Joaquin Delta (Kjelson and Brandes 1989). A water temperature index value of 68°F was selected because water temperatures above 68°F prohibit successful smoltification (Marine 1997; Rich 1987a; Zedonis and Newcomb 1997). Support for an index value of 72°F is provided from a study conducted by (Baker *et al.* 1995) in which a statistical model is presented that treats survival of Chinook salmon smolts fitted with coded wire tags in the Sacramento River as a logistic function of water temperature. Using data obtained from mark-recapture surveys, the statistical model suggests a 95% confidence interval for the upper incipient lethal water temperature for Chinook salmon smolts as 71.5°F to 75.4°F.

Based upon information reviewed for Chinook salmon juvenile mortality (Brett 1952), the Chinook Salmon Population Model (TID/MID 2013) established an initial mortality threshold of 77°F for Chinook salmon smolts as a daily average water temperature.

For Chinook smolt migration, the Framework Temperature Criteria Matrix identified 57°F for the San Joaquin (CALFED 2009) and 63°F (Upper Optimum Value) and 68°F (Upper Tolerable Value) for both fall and spring-run Chinook in the Yuba River (Bratovich et al. 2012).

EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (EPA 2003b) identifies 59°F (7DADM) for salmon smolt.

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Upper Tuolumne River Reintroduction Assessment Framework Water Temperature Criteria Subcommittee Water Temperature Evaluation <u>Glossary of Terms</u>

- Acute temperature criteria water temperature identified as being in the **acute temperature zone** for a particular species/lifestage.
- Acute temperature exposure water temperature exposure that is less than 7 days and results in 50% mortality.
- Acute temperature zone zone where acute water temperature exposure occurs with potential for rapid mortality; **zone of resistance**.
- Average daily temperature (ADT) average of temperatures in a 24-hour period.
- Chronic temperature criteria water temperature identified as being in the **chronic temperature zone** for a particular species/lifestage.
- Chronic temperature exposure water temperature exposure that is long-term or \geq 7 days and results in 50% mortality.
- Chronic temperature zone zone where chronic water temperature exposure occurs with no or reduced growth and reproduction and increased mortality; **zone of tolerance**.
- Critical thermal maximum very short duration (minutes) mortality after acute temperature exposure.
- Diel temperature temperature over 24-hour period.
- Diurnal temperature temperature fluctuations between high and low or day and night of the same day.
- Lifestage periodicity season/dates corresponding to a specific lifestage (e.g. spring-run Chinook salmon spawning); identified through study of a particular watershed.
- Maximum weekly average temperature (MWAT) the highest value calculated for all possible 7-day periods over a given time period (e.g. season or lifestage) and generally used to summarize instream water temperature variation occurring on daily or seasonal basis for evaluation of chronic water temperature impacts; found by calculating mathematical mean of multiple, equally spaced, daily water temperatures over a 7-day consecutive period.
- Optimum temperature range zone of temperatures where fish growth, reproduction, and behavior is not appreciably affected by temperature.
- Seven (7)-day moving average temperature (7DMA) "smoothed" average of temperatures over a period of time using moving seven day subsets.

1

- Seven(7)-day moving average daily maximum temperature (7DMADM) "smoothed" water temperature metric describing the maximum 7-day average of the daily maxima; calculated by adding the daily maximum temperatures recorded at a site on seven consecutive days and dividing by seven, uses moving seven day subsets.
- Seven (7)-day average daily maximum temperature (7DADM) water temperature metric describing the maximum 7-day average of the daily maxima; calculated by adding the daily maximum temperatures recorded at a site on seven consecutive days and dividing by seven.
- Upper incipient lethal temperature (UILT) boundary between lower end of **acute temperature exposure** range and upper end of **chronic temperature exposure** range; where 50% mortality occurs after 7 days (If a shorter duration is used, temperatures will be correspondingly higher).
- Upper optimal WTI (UOWTI) temperatures where physiological processes (growth, disease resistance, normal development of embryos) are not stressed by temperature; **optimal temperature range** identified for specific lifestage.
- Upper tolerance WTI (UTWTI) temperature identified as the boundary between sustained (chronic) tolerance and no tolerance; boundary between **zone of tolerance** and **zone of resistance** identified for a specific lifestage.
- Use designation category applied to a waterbody that determines which water quality standards (WQS) will be enforced.
- Volitional migration upstream or downstream migration occurring when anadromous fish are physiologically ready.
- Water quality standards (WQS) specified concentrations/values of various water quality parameters not to be exceeded as established by the U.S. Environmental Protection Agency (EPA) and/or state for beneficial uses such as aquatic life and drinking water.
- Water temperature index (WTI) description of water temperatures that are optimal and/or tolerated by an aquatic species; developed empirically through laboratory and field studies.
- Water temperature exceedance curves used to identify probabilities/duration of time that lifestage-specific **WTI** values would be exceeded over a given time.
- Water temperature metrics provide index of temperature over a period of time (e.g. MWAT, 7DADM).
- Water year type describes amount of precipitation received during water year (e.g. critically dry to wet).

2

Zone of resistance – water temperature zone between the **UILT** (7 days) and **critical thermal maximum**.

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

REINTRODUCTION GOALS SUBCOMMITTEE CONFERENCE CALL

OCTOBER 20, 2016

MEETING AGENDA AND MATERIALS
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La Grange Hydroelectric Project Licensing (FERC No. 14581) Fish Passage Facilities Alternatives Assessment Reintroduction Goals Subcommittee Conference Call

Thursday, October 20, 2016 1:00 pm to 3:00 pm

Final Meeting Notes

Meeting Attendees		
No.	Name	Organization
1	Allison Boucher	Friends of the Tuolumne
2	Steve Boyd	Turlock Irrigation District
3	Jean Castillo	National Marine Fisheries Service
4	Jesse Deason	HDR, consultant to the Districts
5	John Devine	HDR, consultant to the Districts
6	Chuck Hanson	Hanson Environmental, consultant to the Districts
7	Patrick Koepele	Tuolumne River Trust
8	Bao Le	HDR, consultant to the Districts
9	Lonnie Moore	Private citizen
10	Gretchen Murphey	California Department of Fish and Wildlife
11	Bill Paris	Modesto Irrigation District
12	John Wooster	National Marine Fisheries Service
13	Ron Yoshiyama	City and County of San Francisco

On October 20, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted the second Reintroduction Goals Subcommittee (Goals Subcommittee) conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework). This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document provides meeting materials.

Mr. Bao Le (HDR, consultant to the Districts) welcomed meeting attendees. Mr. Le said the purpose of the Goals Subcommittee is to establish the overall purpose of the reintroduction program. Mr. Le summarized discussions at the first Goals Subcommittee call, held on April 13, 2016, noting that the call included a lot of discussion about developing a narrative goals statement. After the call, HDR staff, with some reluctance, took an action item to develop an initial draft statement that would serve as a starting point for collaboratively identifying the goal of the reintroduction program or how program success would be defined. Mr. Le said having a defined goal is an important part of the Framework. Currently, the National Marine Fisheries Service (NMFS) and the Districts are collecting information on the upper Tuolumne River to help understand such factors as habitat availability, thermal suitability, and migration barriers. Mr. Le said in order to evaluate the feasibility of a reintroduction action, these data must be evaluated against a defined reintroduction goal(s).

Mr. Le reviewed the meeting agenda and asked if there are any questions about the agenda or the purpose of the meeting. Mr. Wooster noted that Mr. Le said the purpose of the Goals Subcommittee is to develop a statement for the reintroduction "program". Mr. Wooster said he considers a reintroduction "program" to be something that is currently being implemented, whereas this group is evaluating the potential for reintroduction and various other issues that spun out of the FERC-approved Fish Passage Facilities Alternatives Assessment. Mr. Wooster said he believes using the word "program" is little confusing and seems premature. Mr. Le said use of the word "program" is not meant to imply anything specific. Mr. Le said NMFS likely has ideas on what they think success would look like regarding reintroducing fish into the upper Tuolumne River. Mr. Le said he thinks the question is basic; if there is a potential action to put fish into the upper Tuolumne River that are not there currently, what is the objective of this action and how will we know if it is successful? Mr. Le said using the word "program" is not meant to imply there is currently a program in place or that it is known exactly what such a program might entail. Mr. Wooster said he agreed with Mr. Le's description, but he thinks we should look for a different term to use that suggests that we are currently at the evaluation stage. Dr. Ron Yoshiyama (City and County of San Francisco) suggested using the term "reintroduction concept goals". Mr. Le noted that the word "program" is only used in the agenda, and it is not used in the draft goals statement. Mr. Wooster said he is in favor of the phrase "reintroduction goals". Mr. Le said the term "reintroduction goals" will be used going forward.

Mr. Le said part of today's meeting will be spent discussing why having a goal is important. Mr. Le said on the first Goals Subcommittee call, the Districts introduced literature from state and federal agencies in the Pacific Northwest about the need for sound planning related to reintroduction. Anderson et al. (2014) focused on ESA-listed salmonids and is particularly pertinent to our discussions here. A key message from Anderson et al. (2014) is that best practices for reintroduction are not well established. Given the significance of an action like introducing a species, whether the species is new to the reach or one that was previously extirpated, a significant amount of planning is necessary and should include consideration of the benefits, risks, and constraints of the action. Mr. Le said Anderson et al. (2014) supports having the types of discussions this group is having, and knowing in advance the biological goals of the program.

Mr. Le said in addition to Anderson et al. (2014), another important document to consider is the Framework prepared by Mr. Paul Bratovich (HDR). The Framework considers such important components as the goals and objectives of the reintroduction, ecological considerations, biological constraints, regulatory and socioeconomic considerations, and engineering constraints.

Mr. Le said the NMFS Recovery Plan is another important guiding document to help develop and inform a reintroduction goal. Mr. Le said it would be helpful to hear from Mr. Wooster (NMFS) and Ms. Castillo (NMFS) on what NMFS would consider the goal to be. Mr. Le said the goal could be quantitative or qualitative.

Mr. Le asked if individuals on the call knew of other relevant documents to consider. Mr. Le asked if there were any comments or questions. There were none.

Mr. Wooster said regarding the Temperature Subcommittee, he was unable to locate the final version of Bratovich et al. (2012), and requested that Mr. Le send him a copy. Mr. Le said he will do that.

Mr. Le said Ms. Rose Staples (HDR) previously emailed out to this group a draft goals statement. HDR developed this statement in response to an action item from the first Goals Subcommittee call. Mr. Le apologized for the delay in sending out the draft goals statement. He noted that developing the statement was much harder than had been anticipated, given that there are many different and complex issues at play and a diverse group of interests. Mr. Le said the statement is not meant to be attributable to any stakeholder and was intended to serve as a starting point for collaborative discussions to further development of a statement.

Mr. Le reviewed the statement and noted that the statement intended to represent the diversity of potential interests that had been discussed previously. For example, the "identify and evaluate" language in the statement is meant to indicate that may be several reintroduction options to choose from and that currently we are in the early stages of planning which requires that all options be evaluated. Mr. Le said though we

may not all agree on the results of the evaluation, it is important that the evaluation is based on solid information that everyone agrees to. The language "reasonable efforts which may enhance and assist" is meant to acknowledge that for any approach, cost and cost/benefit is an important consideration. Mr. Le said it is well known that a reintroduction program can be very expensive, and Anderson et al. (2014) identified cost, and more specifically socioeconomics, as a component to consider. Mr. Le said the final part of the statement, "in the recovery of ESA listed salmonids in the Central Valley", relates to the NMFS Recovery Plan for listed species, and tying the goal to recovery and establishing a distinct population. Mr. Le asked for thoughts or comments on the draft goals statement.

Mr. Wooster said the phrase "in the Central Valley" is potentially too broad for what this group is trying to accomplish. Mr. Wooster said the NMFS Recovery Plan breaks up the Central Valley into sub-regions, each of which has separate recovery goals. Mr. Wooster said an example is the South Central Valley region (which includes the Tuolumne River). The NMFS Recovery Plan states the goal for this region is two populations each of steelhead and spring-run Chinook salmon. This goal is at odds with what we would try for on the Tuolumne River, which would be one population of steelhead and one population of springrun Chinook (i.e., you could not attain more than one population for each listed species). Mr. Wooster said he did not understand why the statement does not focus on the Tuolumne River, since that is what this group is focusing on. Mr. Le said Mr. Wooster brought up a good point about how the NMFS Recovery Plan contains different goals by sub-region. Mr. Le said the rationale behind "in the Central Valley" was to provide geographic relevance. Mr. John Devine (HDR) said that when the statement was being discussed internally, it seemed important to tie the statement more broadly back to the recovery of ESA listed species for the Central Valley. Mr. Le noted that establishing a population of a listed species on the Tuolumne River would not automatically mean meeting the recovery objectives; therefore, it seemed best to frame the statement in the context of the Central Valley, which seemed to be the appropriate geographic scope as it related to ESA recovery. Mr. Wooster said based on this discussion, he better understands the rationale behind using Central Valley in the statement. Mr. Wooster said the actions may be specific to the Tuolumne River, but the goals statement speaks to how the results would apply to the greater region as it relates to recovery. Mr. Le said he agrees with Mr. Wooster's characterization and that the statement is meant to capture the geographic scope of recovery.

Mr. Wooster said the larger group has been discussing actions to benefit fall-run Chinook, which are not ESA listed. Mr. Wooster asked how consideration of fall-run Chinook fits into this goals statement. Mr. Le said that is a good point, and the statement would need to be modified to included fall-run Chinook, given that fall-run Chinook is not ESA listed. Mr. Wooster said he does not have a suggestion of how to modify the statement, but he agrees it should be modified to include fall-run Chinook. Mr. Patrick Koepele suggested naming the three species under consideration directly in the goals statement. For example, "assist in the recovery of Central Valley steelhead, Central Valley spring-run Chinooks salmon, and fall-run Chinook salmon in the southern Central Valley". Mr. Le said the word "recovery" is used specifically in the context of ESA, so it should not be applied to fall-run Chinook. To include fall-run Chinook, we may need to add an additional sentence to the goals statement. Mr. Le said regarding Mr. Wooster's earlier point about the goals in the Recovery Plan, given that fall-run Chinook are not included in the Recovery Plan, it may make sense to have an independent discussion of how to define goals for fall-run Chinook. To determine goals for fall-run Chinook, we may need to look beyond the Recovery Plan. Dr. Yoshiyama suggested revising the statement to use the phrase "at-risk salmonids". This language would work for all three species given that fall-run Chinook is a candidate species. Dr. Yoshiyama said corollary statements could be added that are specific to each species. Mr. Le said it would be helpful to get additional feedback on the statement and Dr. Yoshiyama's suggestion of corollary statements is an option worth considering. Mr. Le stated corollary statements could be quantitative or narrative. Mr. Le also asked the group whether additional information or literature may be helpful to developing these statements.

Mr. Devine said regarding the internal discussions that took place to draft the goals statement, some individuals thought numeric measurements should be part of the goal. However, HDR couldn't decide what those numbers should be. That is the genesis behind the "identify and evaluate" language in the statement. The reasoning behind that language was the term "evaluate" implies a quantitative goal or metric, without having to pinpoint a specific quantitative goal. Mr. Devine noted that identifying quantitative goals seems important.

Dr. Yoshiyama agreed that there needs to be a quantitative component in this discussion. Dr. Yoshiyama said he thinks there is a difference between a quantitative goal and a quantitative metric or benchmark. One does not necessarily need a quantitative goal to have a quantitative metric. We can proceed without a quantitative goal, and just do as much as we can to foster steelhead or spring-run Chinook, and then use a quantitative metric or benchmark to assess our progress. That way, we can avoid painting ourselves into a corner where the goal may be unattainable. Mr. Devine said the Districts believe it would be inappropriate to invest a considerable amount of money into a reintroduction program without knowing how success is defined and when it can be achieved. Mr. Devine said the Districts believe the only way to move forward without a defined goal is to do so by starting small and building incrementally based on certain benchmarks. Dr. Yoshiyama said he agreed with Mr. Devine and it is important to ask that if the goal was a certain number of fish, what would it take to achieve that target. Dr. Yoshiyama said that wouldn't necessarily mean setting a goal, but instead setting a target or strawman, and then determining what it would take to establish that return such as what ocean survival would be needed and how many smolts and spawners would be needed. With this approach, we can figure out what the costs would be, and this would be an extremely important part of that, but without having a final goal set in stone.

Mr. Devine said he thinks that the target does eventually need to tie back to recovery, especially when talking about listed species. Regarding the southern Central Valley targets, Mr. Devine asked what would be a sufficient number of fish to achieve recovery.

Mr. Le said that HDR prepared the draft statement, but the HDR staff are not experts in the NMFS Recovery Plan or the overall management of salmonids of the Central Valley. Mr. Le said it is important that individuals like Mr. Wooster, Ms. Castillo, and Ms. Murphey, as well as other agency staff with jurisdiction, provide guidance and leadership as this group revises and adds to the goals statement. If we decide the goals will be tied to recovery, we might look to the Recovery Plan or other documents to tease out numbers related to viability or distinct populations.

Mr. Wooster said establishing quantitative goals for steelhead is a much different exercise than establishing quantitative goal for spring-run Chinook. Regarding spring-run Chinook, Lindley (2007) is a good place to start to determine what constitutes a viable population. Mr. Wooster said from there, he would turn to additional staff at NMFS for guidance, specifically Mr. Brian Ellrott, who is the NMFS Recovery Coordinator, and Mr. John Ambrose, who is the NMFS Reintroduction Coordinator. Mr. Wooster said there may be some value to having them participate in a call, or the next call, with this group. Mr. Devine said that would be very helpful.

Mr. Devine said Mr. Wooster had mentioned earlier about the Recovery Plan having goals to establish an "independent and viable" population, and Mr. Devine said that perhaps the goals could tie in to what is meant by "independent and viable". Mr. Wooster said Lindley (2007) is often what NMFS uses to quantify what would be an independent and viable population. Mr. Wooster said Lindley (2007) is a starting point. Mr. Wooster said looking at the Tuolumne River scale, there are two questions to consider: (1) what kind of independent population can be made on the Tuolumne River and (2) how would that independent population relate to the distinct population segment (DPS) or evolutionarily significant unit (ESU). Mr. Wooster said when NMFS is completing a jeopardy analysis, the agency looks at what is happening on the

river and how that relates to the ESU. Mr. Le asked Mr. Wooster to send him Lindley (2007), and Mr. Wooster said he would do that.

Mr. Le asked Mr. Wooster to elaborate on the differences between defining quantitative objectives for spring-run Chinook and defining quantitative objectives for steelhead. Mr. Wooster said regarding quantitative metrics, one can plan on regular intervals of Chinook. Returns of Chinook may be traced back to a single cohort, and the population trends are on three-year averages. With steelhead, there is no guarantee of when or if an individual will smolt, which makes the species more difficult to measure than Chinook. Mr. Wooster said we may be able to look to the Pacific Northwest for examples of how to quantify goals for steelhead. Or, we may need to instead consider habitat metrics, such as how much suitable habitat exists, perhaps by life stage. Mr. Wooster said Dr. Yoshiyama made some good points about estimating outmigrant survival based on different scenarios.

Regarding how steelhead life history is considered in the NMFS Recovery Plan, Mr. Le asked if NMFS considers numbers of resident fish. Mr. Wooster said resident population numbers are not considered from a recovery standpoint, but they are something that NMFS is aware of. Mr. Wooster said a large increase in the resident population would not trigger any changes to the listing for steelhead. Mr. Le said this appears to be similar to how bull trout are treated in the Pacific Northwest, as the bull trout ESA listing seeks to protect the migratory form of the species and does not consider resident bull trout in listing status. Mr. Wooster said he is not very familiar with bull trout, but it sounds like a similar situation. Mr. Wooster said Mr. Ellrott would be a good person to ask about the finer details of how steelhead life history is considered in the NMFS Recovery Plan, given that he was the primary author.

Mr. Le asked if there are any other initial thoughts or input on the draft statement. Mr. Le said participation by Mr. Ellrott and/or Mr. Ambrose may be helpful, and asked that Mr. Wooster reach out to these two individuals to determine their interest and availability in participating. Mr. Wooster said Mr. Ellrott would be good to include now, but Mr. Ambrose usually gets involved in these types of processes once they are further developed.

Mr. Le asked if there are any other initial thoughts on the statement. There were none.

Mr. Le said it is important that the goals statement be developed in a collaborative way, and that individuals take some time to review the statement and provide feedback. Mr. Le asked that individuals provide modifications or additions to the statement, corollary statements, quantitative goals, and/or potential sources of information that might help in developing the statement further. Feedback might also be a completely new statement, or input that the statement is headed in the wrong direction. Mr. Le asked that feedback be provided by Thursday, November 3. Mr. Le said all feedback received will be compiled, along with the feedback received today. We will discuss all the feedback on the next call.

Meeting attendees discussed dates for the new Goals Subcommittee call. Mr. Le said he will send out a Doodle poll.

Meeting adjourned.

ACTION ITEMS

- 1. Going forward, the phrase "reintroduction goals" will be used instead of "program goals".
- 2. Mr. Le will send Mr. Wooster a copy of Bratovich et al. (2012). (complete)
- 3. Mr. Wooster will send Mr. Le a copy of Lindley (2007). (complete)
- 4. Mr. Wooster will contact Mr. Ellrott and Mr. Ambrose about participating on the Goals Subcommittee.
- 5. Meeting attendees will provide feedback on the goals statement, as well as additional documents that may be helpful for drafting the goals statement, by Thursday, November 3, 2016 to Ms. Rose Staples at <u>rose.staples@hdrinc.com</u>.
- 6. HDR will compile and organize feedback received on the goals statement.
- 7. Mr. Le will send out a Doodle poll.

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

REINTRODUCTION GOALS SUBCOMMITTEE CONFERENCE CALL

OCTOBER 20, 2016

ATTACHMENT A

MEETING AGENDA AND MATERIALS

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La Grange Hydroelectric Project Reintroduction Assessment Framework Reintroduction Goals Subcommittee Conference Call Thursday, October 20, 2016, 1:00 pm to 3:00 pm Conference Line: 1-866-583-7984; Passcode: 814-0607

Meeting Objectives:

- 1. Review and confirm the purpose of the Reintroduction Goals Subcommittee.
- 2. Review and discuss preliminary draft reintroduction goals statement.
- 3. Identify next steps on Reintroduction Goals Subcommittee.

TIME	TOPIC
1:00 pm – 1:15 pm	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts)
1:15 pm – 1:45 pm	 Reintroduction Assessment Framework – Development of Program Goals. Why Is It Important? What Purpose Does it Serve? Potential sources to further inform goal development (All) a. Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery, Andersen et al. b. NMFS Recovery Plan c. Others?
1:45 pm – 2:45 pm	 Tuolumne River Reintroduction Goals – preliminary draft narrative statement (All) – <i>"Identify and evaluate, in collaboration with stakeholders, reasonable efforts which may enhance and assist in the recovery of ESA listed salmonids in the Central Valley."</i> a. Brief background on draft narrative statement b. Discuss feedback/refinement from subcommittee members c. Need for quantitative metrics?
2:45 pm – 3:00 pm	Next Steps toward (All) a. Schedule next call and agenda topics Action items from this call

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

REINTRODUCTION ASSESSMENT FRAMEWORK

WATER TEMPERATURE/REINTRODUCTION GOALS SUBCOMMITTEE IN-PERSON MEETING

DECEMBER 1, 2016

FINAL MEETING NOTES AND MATERIALS WILL BE AVAILABLE ON THE LA GRANGE PUBLIC WEBSITE AT <u>WWW.LAGRANGE-</u> <u>LICENSING.COM</u> AFTER FEBRUARY 15, 2017