TUOLUMNE RIVER FISHERIES STUDY PLAN
DON PEDRO HYDROELECTRIC PROJECT (FERC NO. 2299)

Prepared By

Tim Ford, Aquatic Biologist, Turlock and Modesto Irrigation Districts
Noah Hume, Consulting Aquatic Ecologist, Stillwater Sciences
Scott Wilcox, Consulting Fishery Biologist, Stillwater Sciences
Ronald Yoshiyama, Consulting Fishery Biologist, University of California

For

Turlock Irrigation District
and
Modesto Irrigation District

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TUOLUMNE RIVER FISHERIES STUDY PLAN

This Tuolumne River Fisheries Study Plan (Study Plan) has been prepared in response to the letter of December 20, 2006 from George H. Taylor of the Federal Energy Regulatory Commission (FERC) to the Turlock Irrigation District (TID) and the Modesto Irrigation District (MID) (FERC Letter). The plan is intended to address information needs under Article 58 of the Project license that were identified during the review of the 2005 Ten Year Summary Report (TID/MID 2005a) and in subsequent discussions.

The primary goals of the Study Plan are the continuation of long-term trend monitoring and undertake studies that clarify the major factors that currently affect and potentially limit the Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead-rainbow trout (*O. mykiss*) populations in the Tuolumne River and will include attempting to determine the composition of the *O. mykiss* population. The Study Plan also is intended to be congruent with current management actions that have been implemented to protect the salmon population as well as to inform the development of future management actions.

The tasks outlined in the plan, associated methods, and implementation schedules are described in the order of the issues identified in the FERC Letter. The primary changes included in the current Study Plan from the draft of February 2, 2007 are as follows:

1. Addition of a riverwide acoustic tracking of smolt outmigrants under Instream Flows
2. Inclusion of length/wt in RST data collection efforts for juvenile health under Instream Flows and Fry Survival.
3. Expansion of egg survival studies to two years under Habitat Restoration
4. Addition of Chinook salmon otolith studies under Fry Survival
5. Addition of a two-year adult telemetry study under Steelhead Presence/Protection
6. Inclusion of higher flow range and expanded monitoring for spatial segregation study under Predator Control.
7. Inclusion of wintertime sampling in direct predator sampling study under Predator Control

I. INSTREAM FLOW

Identified FERC Issue:
The FERC Letter states that there is a lack of evidence that either smolt survival or spawner escapement has increased in response to the increased flows under the 1996 FERC order. The FERC Letter requests: 1) additional smolt survival study data to better define the smolt survival relationship, in particular for flows above 4,000 cfs, 2) Coded-Wire Tag (CWT) studies and improvements in screw trap methodology to more accurately estimate smolt survival and production, and 3) testing of alternative spring pulse flow schedules based on water year type.

Districts' Issue Assessment:
On July 31, 1996, FERC issued an order amending the Districts' FERC license for the New Don Pedro Project, requiring increases in instream flow. In addition to providing increased summer flows for resident life stages of Tuolumne River salmonids, the amended flow schedule required dedicated volumes of water for use in managed spring and fall pulse flows for the purposes of promoting juvenile salmon out-migration and adult salmon up-migration, respectively. As presented in Figure 3.5.2.5-4 of the 2005 Ten Year Summary Report and Figure 4 of the more

recent Report 2005-6 (TID/MID 2005b), CWT smolt survival studies have provided only a broad estimate of a flow-survival relationship for the lower Tuolumne River. Associating escapement with particular flows is difficult due to the many within-basin and out-of-basin factors (i.e., Delta export pumping, year-to-year variations in predator abundance, ocean conditions and harvest, etc.) exerting influence on salmon survival as measured by escapement. Higher smolt survival in the Tuolumne River was associated with the four tests already done with flood flows of 4,000 cfs and greater, lower survival was associated with tests done at low flows near 600 cfs, and more variable results were obtained at intermediate flows. However, based upon cooperative analysis of the Mossdale recovery data by the TRTAC participants, other factors associated with the high variability of the existing data indicate low likelihood of reaching more precise resolution regarding survival vs. flow in the managed flow range of about 1,000-3,000 cfs. The Districts have no confidence that additional CWT smolt survival studies will provide meaningful management conclusions regarding particular flow thresholds associated with subsequent spawner returns.

Instream Flow Hypotheses:
From a biological standpoint, the most plausible mechanistic connection between flow and survival is that higher flows are associated with either reduced predator densities/predator effectiveness in particular habitats or reduced exposure time for juvenile and smolt outmigrants. Predator habitat has been created by pre-project in-channel mining in the river. Following are study hypotheses and methods to better assess the design of the pulse flow allocation of the existing FERC Flow Schedule.

> Hypothesis 1: Chinook salmon smolt outmigrant survival increases non-linearly with flow due to reduced predator habitat suitability at higher flows, with decreasing benefits to increased survival above an unidentified flow threshold.
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> Hypothesis 2: High winter flows cause movement of rearing Chinook salmon fry out of the gravel-bedded reaches of the Tuolumne River and through areas of higher predator density at times when predator efficiency is lower due to low temperatures and reduced visibility for predators due to turbidity, thereby increasing river-wide fry and smolt production and subsequent escapement.

Between 1986 and 2005, 13 paired release CWT smolt survival studies were conducted in the Tuolumne River using hatchery-reared Chinook salmon from the Merced River hatchery. To examine Hypothesis No. 1, there have already been four river-wide smolt survival estimates at flows of 4,000 cfs or more.

Several multiple mark-recapture (MMR) smolt survival studies of sub-reaches within the Tuolumne River in conjunction with multiple screw trap locations have also been carried out (TID/MID 2005a). Rotary Screw Trap (RST) monitoring near the river mouth has been conducted during the spring outmigration period from 1995 to the present (TID/MID 2005a, 2006). To examine Hypothesis No. 2 above, greater than 70% of the outmigration period has been sampled in 6 of 12 years of RST operation.

Recommended Approach and Methods:
Based upon the above, the Districts question the benefit of further CWT studies in regard to both the monetary costs and risks of continued use of large numbers of non-Tuolumne-origin hatchery fish. Section 8 of the FSA specifies strategies to increase naturally occurring (non-hatchery) salmon and to protect any remaining genetic distinction of Tuolumne salmon stock. In addition,

availability of CWT study fish depends on the run size in the Merced River and egg take at the Merced Hatchery - both are presently low. For example, the California Department of Fish and Game (CDFG) has already stated they will not provide any CWT study fish for Vernalis Adaptive Management Plan (VAMP) smolt survival evaluations in 2007. CDFG, a signatory to the VAMP, also did not provide the allocated study design number of smolts for the VAMP studies in 2006. Periodic increases in the Tuolumne River Chinook population appear to be associated with very high flood flows from the entire four-river San Joaquin basin during wetter water years. As a means of documenting river-wide production under varying water year types as well as testing the effectiveness of alternative flow allocation, the proposed study plan element will be as follows:

1) Expanded Analysis of Existing CWT Data at Other Recovery Locations. Hypothesis No. 1 will be examined by utilizing the independent estimates of smolt survival from the following recovery locations: the Mossdale trawl, the Central Valley Project (CVP) and the State Water Project (SWP) salvage facilities, the Antioch and Chipps Island trawls, ocean harvest, and returning escapement. In addition to calculating year-by-year survival estimates, compiled CWT recovery data will be analyzed and fitted to an appropriate statistical model that makes direct use of total numbers of CWTs released and recovered.

2) Experimental Winter Pulse Flow Schedule. As a means of addressing Hypothesis No. 2 above, the Districts, in coordination with the TRTAC, during wetter water years and without an increase in the required FERC flow schedule volumes, will make pre-flood control releases as available by determination of the Districts during the period of late January through March. Such pre-flood control releases will be for approximately 3 to 5 days in duration and at approximately 500 cfs, 1,000 cfs, and 1,500 cfs peak flow for study purposes. The goal will be to conduct two pulse flow events at each of the three flow levels by March 2011. The study period may be extended through March 2016 if water for the study releases is not available through March 2011.

3) Paired Rotary Screw Trap (RST) Monitoring. In addition to the 2006 paired RST data that have been collected, continue paired RST monitoring from 2007–2011 at upstream (e.g. River Mile (RM) 30 near Waterford) and downstream (RM 5 near Grayson) locations. Monitoring will be conducted between January and the end of the primary smolt outmigration season (typically late May or early June). In order to examine Hypothesis No. 1, RST recovery data will be analyzed in regard to year-to-year variations in fry and smolt movement and timing in response to managed winter pulses and natural variations in river flow, and b) additional analyses will compare relative production of fry and smolt life stages to subsequent cohort production under various water year types and parent stock size. The costs for operation of the lower RST for three years will be funded under the current TRTAC monitoring program (CDFG Grant No. ERP-04-S04).

4) Reach and River-wide Acoustic Tracking. Hypothesis No. 1 will be further examined by the use of acoustic tags in smolts as an extension of similar studies to be performed in conjunction with the VAMP acoustic tagging study. The specific study design will be integrated as appropriate with the VAMP study design. Generally, (1) acoustic tags would be surgically implanted in smolts (hatchery or natural, depending on availability or other criteria), (2) groups of about 20-50 smolts would be released at about 3 sites in the Tuolumne River, and (3) about 3 stationary receivers and 1 mobile receiver would used to record smolt movement and determine predation losses. The study would be conducted during the primary smolt outmigration period at three different flows. One study would be conducted at flows of less than 1,000 cfs, the second at a flow between 1,000 to 4,000

cfs, and the third at a flow greater than 4,000 cfs. The study flow would be provided for up to ten consecutive calendars days in conjunction with VAMP study flows and/or flood management flows, as available through spring 2011. The study period may be extended through spring 2016 if one or both higher flow levels are not available through spring 2011. Survival data will be analyzed consistent with VAMP assessments to validate existing survival vs. flow relationships and in coordination with the related study under Issue V – Predator Control.

Table 1 Summary of methods, metrics, and schedule to examine Instream Flow issue

Approach	Methods	Metrics	Schedule	Report Progress/Product
1. Expanded CWT Analysis	Analysis of validated CWT recovery data from all recovery locations.	1. Goodness of fit of proposed models. 2. Survival prediction interval for particular pulse flow levels (e.g., 1,000 cfs, 2,000 cfs, etc.)	Initial analysis in 2008	Complete analysis by 7/1/2011 (allows for decoding and return of majority of ocean and adult spawners of 2005 release)
2. Experimental Winter Pulse Flows	Up to six winter pulse flows (500 cfs, 1000 cfs, 1,500 cfs) of variable timing and duration.	Pulse flow magnitude, frequency and duration (USGS Gages at La Grange and Modesto).	Late January to March for the period 2008–2011. but may be extended through March 2016 if water not available	Annual FERC reports detailing flow operations. Complete analysis by 7/1/2012 unless study period extended.
3. Paired Rotary Screw Trap Monitoring	Deploy and monitor RSTs at RM 29 and RM 5 between January and early June (2007–2011).	a) Daily fry counts in response to flow levels and flow change, b) Annual fry and smolt production. c) Ratio of fry to smolt production as related to subsequent escapement.	January to May/June for the period 2007–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
4. Reach and Riverwide Acoustic Tracking	Deploy three fixed and one mobile hydrophone in the river. Conduct releases of 30–50 smolts with tags at each location for 3 test flows: < 1,000 cfs; 1,000-4,000 cfs; and > 4,000 cfs. Monitor smolt passage and habitat use.	Reach and riverwide survival at three flows.	April/May for the period 2008–2011, but may be extended through spring 2016 if water not available for higher flows	Data reports and preliminary analysis with annual FERC reports. Complete analysis by 7/1/2012 unless study period extended.

II. HABITAT RESTORATION

Identified FERC Issue:
The FERC Letter states the remaining habitat restoration projects should be completed and effectiveness of all projects should be assessed. Identified needs were efforts that aim to increase spawning habitat utilization and reduce redd superimposition by flow management, gravel restoration, and gravel augmentation in upstream spawning areas. Identified monitoring studies related to habitat utilization include: 1) a study to evaluate gravel quality using egg survival to emergence, gravel size and type, sedimentation, and flow penetration of spawning beds, and 2) an assessment of spawning utilization at restored spawning areas.

Districts' Issue Assessment:
Unrelated to and predating the New Don Pedro Project, gold and gravel mining and related activities within and adjacent to the Tuolumne River have created many of the habitat problems that adversely impact salmonid production. For example, predator isolation projects aim to restore mined-out areas to more natural riverine habitat conditions, thereby reducing or isolating predator fish or their impacts. The pre-project status of the mined-out areas was recognized in Section 12g of the 1995 FERC Settlement Agreement (FSA)(TID/MID 1996) by establishing a maximum funding ceiling of $1 million that the Districts and CCSF were required to contribute and by encouraging all FSA parties to seek and cooperate in obtaining outside funding.

To provide a firm scientific foundation upon which to proceed in accordance with Section 12, Non-flow Options, of the FSA, the Tuolumne River Habitat Restoration Plan (McBain & Trush 2000) was developed for the TRTAC. Recognizing the difficulties in accurately assessing population responses to restoration activities, the Restoration Plan was based upon a physical process-based approach that links physical inputs (e.g., stream flow, sediment), physical processes (e.g., sediment transport, bank erosion, fine sediment deposition), habitat structure (e.g., shallow-gradient riffles, well-sorted and clean spawning gravels) and subsequent biological responses of the in-river life stages (e.g., spawning use, increased incubation success, lower density-dependent mortality, etc.). Based upon the findings of the Restoration Plan, and following the 1997 flood, ten restoration projects were identified by the TRTAC (TID/MID 2005a) which far exceeded the $1 million required to be provided by the Districts and CCSF under FSA Section 12g. Completing those projects was always contingent upon obtaining major outside funding and the ability to proceed through implementation. Nearly $30 million was subsequently secured, subject to various timelines and contingencies.

The Districts remain committed to the goal of completing the currently funded restoration projects and will endeavor to obtain additional outside funding to complete other TRTAC restoration projects. At this time, three of the ten identified projects have been completed [Gravel Mining Reach (GMR)-I, RM 43, and SRP 9]. Due to a variety of issues outlined in the 2005 Ten Year Summary Report, implementing further projects has been highly problematic and several (GMR-IV, SRP 10, and gravel cleaning) have no current plan to proceed. The Districts are presently working with the CDFG to determine if funding formerly designated for GMR-III can be applied to both GMR-II (which had lost its primary funding) and GMR-III. The Coarse Sediment augmentation project (actually gravel augmentation at multiple sites) and the Gasburg Creek sedimentation project are presently planned to begin construction in summer 2007. The Coarse Sediment project will address spawning gravel habitat utilization by coarse sediment addition within the spawning reach.

Habitat Restoration Hypotheses:
In addition to geomorphic process-based hypotheses regarding the effects of habitat restoration actions, the following hypotheses apply to biological responses by Tuolumne River salmonids to habitat restoration actions.

> Hypothesis 1: Gravel augmentation will increase the extent and spawning utilization by Chinook salmon and *Oncorhynchus mykiss* relative to control sites within the spawning reaches of the Tuolumne River.
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> Hypothesis 2: Gravel augmentation will improve spawning gravel quality and salmonid egg incubation conditions (permeability, dissolved oxygen, and intragravel temperature) at augmentation sites, which will in turn improve survival during incubation and emergence success of salmonid eggs deposited by spawning adults.
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> Hypothesis 3: Elimination of in-channel mining pits results in reduction of predator abundance/effect at these sites and an increase in Chinook salmon outmigrant survival.

Fall-run Chinook spawning surveys have been conducted in the Tuolumne River in each year by CDFG under Project study plans since 1971, with redd and carcass recovery locations/reaches being reported consistently since 1981 (TID/MID 2005a). In order to evaluate Hypothesis No. 1, the Districts conducted habitat suitability mapping throughout the spawning reach in 1988 (App 6 in TID/MID 1992), followed by an additional gravel quality assessment by the TRTAC in 1999-2001 that followed the 1997 flood scour event (Report 2004-12 in TID/MID 2004). Experience on the Tuolumne River shows that the combination of the decline in spawning habitat, due to the 1997 flood, and the accompanying increase in spawner preference for upstream riffles relative to downstream areas, suggests hypotheses No.1 is well supported and that the planned gravel augmentation projects should provide immediate benefits in the redistribution of suitable spawning areas, depending on run size.

Beginning in 1988, the Districts conducted several studies to assess Hypothesis No. 2 by examining the effects of fine sediment on survival-to-emergence of fall Chinook salmon (App 8 in TID/MID 1992). In addition, riffle and reach-wide permeability monitoring conducted by the TRTAC in 1998 and 1999 (Report 2000-7 in TID/MID 2000), redd superimposition and emergence trapping studies conducted in 1988 (App 8 in TID/MID 1992) and more recent survival-to-emergence studies conducted in 2001 (Stillwater Sciences *in prep*) suggest the habitat benefits of gravel augmentation projects improve gravel quality and egg survival-to-emergence.

Recommended Approach and Methods:
A number of restoration actions are ongoing in the Tuolumne River with associated monitoring programs that are specifically designed to assess the monitoring hypotheses above. The proposed monitoring will analyze the effectiveness of completed restoration projects, so that a better judgment and more recognition can be made regarding the potential of any future restoration projects. The following are additional analyses and monitoring activities to address the identified hypotheses:

1) Implement Coarse Sediment Augmentation. As described in the 2005 Ten Year Summary Report (TID/MID 2005a), gravel augmentation under CDFG Grant No. ERP-02-P29 is currently scheduled for implementation within the spawning reach. Approximately 100,000 cubic yards of coarse sediment will be augmented to the river at 5–6 locations in the reach between La Grange Dam (RM 52.0) and Riffle 12 (RM 45.5). The highest

priority is given to the 3.5 mile reach between Riffle A3/4 (RM 52.0) and Basso Bridge (RM 47.5). Priority sites include: Riffle A3/4 (RM 52.0), Riffle A5/6 (RM 51.2), Riffle 1A2 (RM 50.6), Riffle 3A (RM 49.6), Basso Pool (RM 47.5). The number of sites to be implemented will be dictated by the cost of coarse sediment, the volume of coarse sediment needed for each site, and the available funds. Implementation will occur in 2007 and 2008 contingent upon final contract authorization by CDFG, river flow, and permitting approvals.

2) Spawning Habitat Utilization. To examine Hypothesis No. 1, on-the-ground spawning habitat mapping will be conducted in conjunction with detailed redd mapping in each of 3 years of the current TRTAC monitoring program (CDFG Grant No. ERP-04-S04). A combination of float and ground surveys will be conducted. Redd locations and habitat characteristics including water depth, velocity, and particle size will be recorded for each redd. Fine scale habitat suitability and redd mapping will be conducted adjacent at gravel augmentation sites under a pending amendment of the Coarse Sediment Transfusion Project (CDFG Grant No. ERP-02-P29). As these projects are implemented, Hypothesis No. 1 will also be examined in the context of rates of redd superimposition at augmentation sites relative to reference riffles in one year of the current TRTAC monitoring program (CDFG Grant No. ERP-04-S04).

3) Egg Survival Studies. Hypothesis No. 2 will be examined under a pending amendment of the Coarse Sediment Transfusion Project (CDFG Grant No. ERP-02-P29). Recognizing the results of previous survival-to-emergence studies on the Tuolumne River and other rivers have been variable and subject to logistical constraints, the planned study will utilize egg chambers and instrumentation (e.g., permeability, intra-gravel flow and DO, Temperature., etc.) in artificial redds at augmentation and reference sites. Egg incubation studies are budgeted for two years, 2007 and 2008. If Chinook eggs are not available in 2007 for this task to be implemented, then only one year of incubation studies will be conducted.

4) Redd Monitoring and Emergence Trapping. To improve upon the linkages between gravel quality and spawning incubation success within existing spawning riffles and those with gravel augmentation, a one year redd monitoring and emergence trapping study will be conducted between 2008–2010 depending on augmentation project status and river flows. The study will build upon planned redd monitoring studies discussed above and will use emergence traps (App 8 in TID/MID 1992) placed over natural redds at treatment and control sites followed by daily fry counts to relate them to the size and fecundity of the spawning female. Post-emergence permeability and bulk sampling at control riffles and at gravel augmentation sites will be used to quantitatively assess gravel quality in comparison to the adjacent riffle as well as quantitative assessments of any potential fry entombment.

5) Assessment of the 1995 FSA Section 12 Program. The Districts with cooperation with the TRTAC shall complete in 2011 an assessment of the effectiveness of all projects sponsored or implemented by the TRTAC and other gravel addition projects and of the feasibility of constructing alternative projects. The assessment will include results of spawning habitat and redd mapping efforts, redd superimposition studies, gravel quality assessment, and survival-to-emergence studies on both a river-wide basis and as they relate to the effectiveness of gravel augmentation projects implemented between 2001 and 2009. Increased extent of spawning habitat utilization and reach-wide distribution of

spawning locations will be compared to pre-project assessments and previous studies to address Hypothesis No. 1. Similarly, the results of planned gravel quality assessments and survival-to-emergence studies will be used to compare spawning and egg incubation success at both a project site and reach level (Hypothesis No. 2).

Table 2 Summary of methods, metrics, and schedule to examine Habitat Restoration issue

Approach	Methods	Metrics	Schedule	Report Progress/Product
1. Coarse Sediment Augmentation	Direct augmentation of coarse sediment having suitable spawning size characteristics at 5–6 sites	Comparison of actual distribution of spawning sites with River2D modeling results.	Conducted over two years 2007–2008	Report in annual FERC report when project completed
2. Spawning habitat utilization	1) Delineation of suitable spawning gravel between RM 51–38 based on depth velocity and particle size criteria. 2) detailed redd measurements	Comparison of redd densities at reference and reconstructed riffle sites, relative to spawning habitat availability and river mile location.	1) Spawning use mapping in each January between 2008–2010. 2) Detailed redd measurements and superimposition study in one year between 2008–2010.	Project monitoring reports submitted to CDFG under ERP-02-P29 will be included in annual FERC reports. Complete report by 7/1/2011.
3. Egg survival studies	Egg chamber experiments combined with gravel quality and in-situ conditions (velocity, temp, DO).	Egg survival of treatment and control redds in response to gravel quality indices and permeability.	Studies in each of two years (fall 2007 and 2008), depending upon availability of eggs	Project monitoring reports submitted to CDFG under ERP-02-P29 will be included in annual FERC reports. Complete report by 7/1/2011.
4. Redd monitoring and emergence trapping	Emergence traps placed over natural redds at treatment and control sites. Permeability and bulk sampling at control riffles and at gravel augmentation sites to assess gravel quality	Daily fry counts, timing and production of treatment and control redds. Estimates of egg survival response to gravel quality indices and permeability.	Once during 2008-2010 depending on augmentation project status and river flows	Data reports and preliminary analysis in annual FERC reports, with final report by 7/1/2011.
5..Assessment of the 1995 FSA Section 12 Program	Evaluate current restoration projects including: predator isolation, channel reconstruction and gravel augmentation projects.	Compare to project specific geomorphic and biological response metrics	2007–2011	Complete analysis by 7/1/2011.

III. FRY SURVIVAL

Identified FERC Issue:
The FERC Letter requests a statistically valid estimate of fry production per female spawner and of fry distribution, including site-specific fry emergence, fry distribution over time, and fry transport relative to flow.

Districts' Issue Assessment:
Fry Production/Female spawner indices in the 2005 Ten Year Summary Report using average and peak fry density from seining to female spawners indicate little relationship between flow and fry production. It is expected that both absolute fry production and the ratio of fry production to female spawners will continue to be highly variable from year-to-year.

Fry Survival Hypotheses:
Prior seine and RST monitoring suggests flood years with large and early-season fry dispersal are associated with higher subsequent production. Peak fry captures in RSTs and downstream fry movements, observed in seining surveys, typically occurred in the January to early March timeframe and were generally associated with high flows or abrupt flow increases. The following hypotheses are designed to examine the effectiveness of managed winter pulse flows to better simulate these naturally occurring events in maintaining and enhancing fry production and subsequent escapement.

> Hypothesis 1: Early migrating fry contribute substantially to subsequent escapement
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> Hypothesis 2: High winter flows cause movement of rearing fry out of the gravel-bedded reaches of the Tuolumne River and through areas of higher predator density at times when predator efficiency is lower due to low temperatures and increased turbidity (reduced visibility for predators), thereby increasing river-wide fry and smolt production and subsequent escapement.

The Districts have conducted annual seine surveys throughout the Tuolumne River since 1986, with consistent data collection methods and sample sites since 1996 (TID/MID 2005a). Annual seine reports contain bi-weekly and seasonal estimates of salmon density by location, river section, and on a river-wide basis as well as indices of fry density to female salmon. Bi-weekly estimates of fry density at the seining sites have been compared to the annual hydrographs to examine Hypotheses No. 1 and No. 2 in conjunction with annual spawner estimates provided by CDFG.

RST monitoring has been conducted during the spring outmigration period from 1995 to the present (TID/MID 2005a, 2006), with early season monitoring during the fry emigration period conducted in 1999–2002 and in 2006. These data have been used to examine the fry emigration timing hypotheses above in comparison to the annual hydrographs. Due to limitations in the length of the survey seasons and the lack of availability of fry size information, river-wide fry production estimates are limited to the years 1999 and 2000 (TID/MID 2006), and 2006.

River-wide RST monitoring at a lower river site is funded for CDFG implementation over a three year period under the current 3-year river-wide monitoring program developed by the TRTAC (CDFG Grant No. ERP-04-S04). Daily trap recoveries may be used in expansions to develop river-wide fry and smolt production estimates.

Recommended Approach and Methods:
RST monitoring, seine surveys, and spawning surveys will provide additional data to construct statistical estimates of fry production per female spawner. The Districts will conduct the following monitoring study elements to address the identified issues and hypotheses above.

1) Paired Rotary Screw Trap Monitoring. As described under Instream Flow, five additional years (2007–2011) of paired RST monitoring will be conducted at upstream (e.g. RM 29 near Waterford) and downstream (RM 5 near Grayson) locations, between January and the end of the primary smolt out-migration season in early June. Hypothesis No. 1 will be examined by comparing fry production at the downstream trap and subsequent escapement under managed flows and flood control releases, primarily during late January through March. Hypothesis No. 2 will be examined by comparisons of emigration timing, daily trap captures and annual production with flow in the Tuolumne River.

2) River-wide Seining Surveys. Hypothesis No. 2 will be examined by use of seining data to provide detailed information on fry movement in response to river flow. In addition, seining data will be used in conjunction with RST data to provide longer-term estimates of inter-annual variability in relative density and length estimates as well as providing detailed information on fry movement in response to river flow, historical seining sites [R1A, R5A, R23C, R57, R74, Legion, Venn, Shiloh Rd., Laird Park (San Joaquin River) and Garner Cove (San Joaquin River)] will continue to be sampled as in past years.

3) Micro-Chemical Analysis of Otoliths Collected from Annual Escapement Surveys. In order to further examine Hypothesis No.1, otoliths samples will be collected from carcass recoveries during the 2007 and 2008 spawning seasons. In 2009, analysis of otolith microchemistry and microstructure will be made using Sr:Ca ratios within growth rings to indicate lengths of residency within freshwater, estuarine, and marine waters (Zimmermann 2005). Depending upon the condition of otoliths collected in 1987 and 1988 by consultants for the Districts and otoliths collected by CDFG in other years, sub-samples of otoliths from adults reared under several water year types will be examined to determined whether fry contribution to adult varies with spring outflow volume.

4) Synthesis of Ongoing and Planned Studies with RST Data. The redd monitoring and emergence study that is to be conducted under Habitat Restoration to address habitat restoration hypotheses will be used in conjunction with planned surveys of spawning habitat, redd mapping, the redd superimposition study, and the existing redd superimposition model (Report 1996-6 in TID/MID 1997) to provide estimates of fry production for particular escapement levels. These estimates will be compared with the results of RST monitoring data described above to strengthen the linkages between escapement levels, spawning gravel conditions, fry and smolt production.

Table 3 Summary of methods, metrics, and schedule to examine Fry Survival issue

Approach	Methods	Metrics	Schedule	Report Progress/Product
1. Paired Rotary Screw Trap Monitoring	Deploy and monitor RSTs near Waterford (RM 5) and near Grayson (RM 29) between January and early June.	a) Daily fry counts in response to flow levels and flow change, b) Annual fry and smolt production. c) Ratio of fry to smolt production as related to subsequent escapement.	January to May/June for the period 2007–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
2. River-wide Seining Surveys	Bi-weekly seine surveys in the Tuolumne River (R1A, R5A, R23C, R57, R74, Legion, Venn, Shiloh Rd.) and San Joaquin River (Laird Park and Gardner Cove)	Relative density and fork length by location. Estimates of fry movement rate in response to river flow.	January to May/June for the period 2007–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
3. Micro-chemical Analysis of Otoliths Collected from Annual Escapement Surveys.	Sr:Ca ratios in otoliths growth rings of adult Chinook carcass recoveries from several water year types.	Duration of juvenile residency in fresh water.	Otolith collection in 2007 and 2008. Analysis in 2009	Data reports and preliminary analysis with annual FERC reports (2009–2010). Complete analysis by 7/1/2012.
4. Synthesis Of Ongoing and Planned Studies with RST Data	Estimate fry production for particular escapement levels. Compare redd monitoring, fry emergence, and superimposition with results from RST monitoring.	Relationships of escapement to fry production, fry survival, gravel quantity, gravel quality, and redd superimposition.	2007–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.

IV. STEELHEAD PRESENCE/PROTECTION

Identified FERC Issue:
The FERC Letter requests that the size and habitat needs of the *O. mykiss* population in the Tuolumne River be determined. FERC also requests monitoring to document the absence or presence of anadromous *O. mykiss* (steelhead) of the population. FERC requests additional study elements to determine the flow and habitat needs of steelhead if they are present in the Tuolumne River population. Studies should include comparisons to steelhead data from nearby rivers.

Districts' Issue Assessment:
The Districts consider questions regarding habitat needs of anadromous *O. mykiss* to be the same as habitat needs of resident *O. mykiss*. Although agency monitoring (McEwan 2001) has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers to the north of the Tuolumne, studies of otoliths from both live *O. mykiss* captures and carcasses recovered by CDFG to date have not indicated that the Tuolumne River has a self-sustaining steelhead population (TID/MID 2005a). In addition, Mokelumne and Calaveras river steelhead are dominated by hatchery-origin non-native Central Valley steelhead stock.

Neither the Districts nor their consultants have been able to obtain the necessary regulatory authorization under Section 10 of the Endangered Species Act (ESA) to perform steelhead tracking studies or to determine habitat preferences. Also, no permits have been made available for sacrificial sampling of *O. mykiss* to determine anadromy by micro-chemical analysis of otoliths. Therefore, without explicit Fish Agency support for these sampling programs it may not be possible to address the steelhead issue requested in the FERC letter utilizing currently available methods of study mandated to protect the anadromous form of *O. mykiss* under the ESA. .

In accordance with the 1995 FSA, TID has proceeded with development of an irrigation only diversion at RM 26 and the Turlock Area Drinking Water Project (now called Turlock Regional Surface Water Supply Project). Assuming that a mutually agreeable multi-party funding arrangement can be achieved for the capital and annual operation and maintenance costs of the fish-only portion of the supplemental irrigation water project, then diversions for supplemental irrigation water at RM 26 could possibly begin by June 1, 2009. Commercial operation of the Regional Project is estimated to begin in 2011.It is anticipated that diversions for the Regional Project could initially add up to 50 cfs of additional flow during the summer of all water year types, with a maximum capacity of near 100 cfs depending on project demands and available multi-party funding for supplemental irrigation water diversions.

Hypotheses:
Whether or not a self-sustaining steelhead population is present in the lower Tuolumne River and because any anadromous and resident *O. mykiss* in upstream areas have the same habitat requirements as Chinook Salmon, the Districts believe the identified issue is best addressed by documenting the relative abundance and the habitat requirements of *O. mykiss* present in the Tuolumne River in order to test the following hypotheses:

> Hypothesis 1: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.

Hypothesis 2: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.

Hypothesis 3: A self-sustaining population of anadromous *O. mykiss* (steelhead) is present on the Tuolumne River.

The Districts have long documented the presence of *O. mykiss* in the Tuolumne River (TID/MID 2005a). As noted in the 2005 Ten Year Summary Report, FERC began informal consultation with NOAA Fisheries and the Districts in 2003 regarding steelhead issues. That consultation was followed by several information requests and submittals by the Districts. Hypotheses No. 1 is partially addressed with past summertime snorkel observations that show *O. mykiss* distribution and habitat use has extended downstream by several miles in response to the increased flows under the flow schedules in the 1996 FERC Order (TID/MID 2005a).

As described under Habitat Restoration, a number of ongoing monitoring activities are underway to assess Hypotheses No. 1 and No. 2 above. The Coarse Sediment Management Plan (Report 2004-12, TID/MID 2004) included conceptual designs with appropriate gravel sizes and habitat features intended to provide favorable spawning and feeding stations for *O. mykiss*. These habitat design recommendations have also been included in the recently completed Bobcat Flat/RM 43 restoration projects as well as coarse sediment augmentation projects planned for implementation in 2007–2008.

Building upon pre-project and post-project monitoring of suitable in-channel rearing habitat at the SRP-9 and GMR-I restoration project sites (McBain & Trush and Stillwater Sciences 2006), the hypotheses above will be examined by comparisons of observed life stages of *O. mykiss* at constructed and planned gravel augmentation sites relative to reference riffles in each of three years of the current TRTAC monitoring program (CDFG Grant No. ERP-04-S04). Surveys will be conducted using electrofishing, snorkel, and seining methods as allowed by the fish agencies. Lastly, further fine scale habitat suitability mapping will be conducted adjacent to gravel augmentation sites under a pending amendment of the Coarse Sediment Transfusion Project (CDFG Grant No. ERP-02-P29).

Recommended Approach and Methods:
As described above, there are several ongoing monitoring programs related to post-project monitoring of completed and planned restoration projects. Each program has its own set of inter-related hypotheses and performance metrics that range from geomorphic and fluvial processes, to the fishery resource objectives discussed in the FERC public meeting on July 25, 2006; and on to broader issues of riparian and ecosystem functioning and NEPA/CEQA compliance. At this time, the Districts believe that the projects that have been initiated to date will address the monitoring issues above. Below the Districts describe analyses and additional monitoring activities to address the identified hypotheses:

1) Summer Population Estimate. The proposed surveys make use of a two-phase sampling approach using bounded count population estimates (Hankin and Mohr 2001) from snorkel and electrofishing surveys of representative habitat types within areas where *O. mykiss* have been frequently observed during the summer in the lower Tuolumne River (approximately RM 52-40). In the first phase, 24 sampling units will be selected to span the major habitat types (i.e., riffles, runs, pools) represented in the river. These sites will be surveyed using standard snorkel survey techniques (Edmundson et al. 1968, Hankin and Reeves 1988, McCain 1992, Dolloff et al. 1996) and calibrated to electrofishing

techniques described by Reynolds (1996) and Beechie et. al (2005). Where possible, block nets will be used to prevent migration in and out of the sample site and will facilitate an accurate assessment of the sample population. In the second phase, four sites of each habitat type will be randomly selected for an additional three survey passes using a combination of snorkel and electrofishing surveys. Limited backpack electrofishing outside of spawning and rearing areas for Chinook salmon is currently permitted under the CDFG 4d permit program, with a Section 10 permit pending with NMFS. Sample methods may be modified depending upon permitting restrictions. In all, this represents 60 dive passes to be conducted by 2–4 divers over 3–4 days. Analysis methods will generally follow the estimators described in Hankin and Mohr (2001) with population estimates on a habitat unit, length and areal basis from the existing Tuolumne River GIS. The surveys will be conducted during summers 2007 through 2011.

2) Sampling of *O. mykiss* for Anadromy. As a means of testing Hypothesis No. 3, the Districts will seek permits for scientific collection of *O. mykiss* samples for a period of four years (2008–2011). Contingent upon permitting support from NMFS and CDFG, the Districts will collect otoliths from up to 10 percent of all juvenile *O. mykiss* captured during river-wide seining, RST monitoring, and electrofishing for subsequent otolith analysis using micro-chemical testing of Sr:Ca ratio within growth rings (Zimmermann 2005). Adult *O. mykiss* will be captured during spring in two surveys using hook and line sampling. Otoliths will be collected from a subset of adult *O. mykiss*. Analysis of otoliths from adults will be used to determine the proportions of resident and anadromous *O. mykiss*. Analysis of otoliths from adults will be used to indicate the proportion of resident and anadromous *O. mykiss*. Analysis of juvenile otoliths will be used to determine maternal anadromy and steelhead spawning within the Tuolumne River.

3) Adult *O. mykiss* Tracking Study. Contingent with permitting approval, habitat use and needs of adult *O. mykiss* will be assessed in a 2-year acoustic tracking study performed in conjunction with other tracking studies under Instream Flows and Predator Control. Adult fish will be captured by angling and acoustic tags surgically implanted, followed by both passive (using fixed hydrophones) and active monitoring (using mobile hydrophones). As a means of addressing future habitat restoration projects, Hypothesis No. 2 will be examined by determining habitat associations and potential spawning locations of *O. mykiss* within the river. The tracking study will be performed from approximately January 1 through March 31 of each study year.

4) Synthesize Results of Past and Ongoing Studies by 2012. Using all of the past and ongoing monitoring studies described above, the Districts will synthesize the results of ongoing studies and the above new surveys and studies to compare *O. mykiss* abundance and distribution at habitat restoration sites implemented between 2001 and 2009. Increased downstream extent of rearing habitat will be compared to pre- and post-project assessments at gravel augmentation sites (CDFG Grant No. ERP-02-P29) and previous surveys to address the hypotheses above. To the extent feasible, pertinent steelhead data from nearby rivers will be used as a means of informing the development of potential restoration and management actions in the future.

Table 4 Summary of methods, metrics, and schedule to examine Steelhead Presence/Protection issue

Approach	Methods	Metrics	Schedule	Report Progress/Product
1. Summer Population Estimate	Two-phase snorkel surveys calibrated by electrofishing.	Population abundance by habitat unit type	June and July 2007-2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
2. Sampling of *O. mykiss* for Anadromy	Collect otoliths from juvenile and adult *O. mykiss.*	Micro-chemical testing of Sr:Ca ratio within otolith growth rings	2008–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
3. Adult *O. mykiss* Tracking Study	Acoustic tagging of adult *O. mykiss* during winter. Monitor riverwide movement and habitat use in conjunction with other acoustic tracking studies under Instream Flows and Predator Control.	Movement patterns and habitat associations	January though March 2008–2009	Data reports and preliminary analysis with annual FERC reports (2009–2010). Complete analysis by 7/1/2012.
4. Synthesize Results of Past and Ongoing Studies by 2012	Compare *O. mykiss* abundance and distribution at habitat restoration sites implemented between 2001 and 2009. Assess downstream extent of rearing habitat and compare to pre- and post project studies.	Change in distribution and abundance of O. mykiss	2007–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.

V. PREDATOR CONTROL

Identified FERC Issue:
The FERC letter requests the identification and implementation of measures to reduce predation on salmon smolts by other species and monitoring to determine the effectiveness of the control measures.

Districts' Issue Assessment:
Non-native bass have a significant and substantial presence within the lower Tuolumne River because of the extensive abandoned in-channel mining pits within the river, which were created, and never mitigated, by the mining industry prior to the construction of the New Don Pedro Project. Predation by non-native bass has long been considered by parties to the FSA and others to be a primary factor limiting survival of juvenile Chinook salmon in the lower Tuolumne River (CDFG 1987; TID/MID 1992, Appendix 22). Two of the ten priority habitat restoration projects identified under Section 12 of the 1995 FSA were pond isolation projects for the purposes of separation of predator habitat from habitat used by rearing and outmigrating salmonids.

The results of previous predation studies, restoration project monitoring, habitat suitability modeling for predators and juvenile salmon, and the recommendations of the Tuolumne River Adaptive Management Forum (AMF) (USFWS and CALFED 2001) support the need for coordinated, site-specific and river-wide predator monitoring to provide guidance and generate testable hypotheses for predator management and restoration measures. Identification and implementation of effective measures to reduce predation will require a program of Hypothesis-driven studies and monitoring to analyze predator response to a range of river flow, turbidity, and temperature conditions. The following general approaches to reduce predation have been identified:

Channel Restoration
The SRP 9 and 10 projects were selected by the TRTAC as two predator isolation projects of the ten identified priority projects under Section 12 of the 1995 FSA. The projects function to reduce the availability of low velocity habitat preferred by bass, habitat restoration can be an effective but expensive means of reducing predation. Each SRP has the potential to reduce Chinook salmon survival because the unnaturally wide channel and deep-water conditions offer more favorable habitats to non-native largemouth and smallmouth bass, the primary predators of juvenile Chinook salmon in the lower Tuolumne River. In addition to reducing predator habitat and predator opportunity time, restoration of the SRPs also restores a natural channel and floodplain morphology scaled to the present and future flow regime, facilitates sediment transport and routing, increases riparian vegetation, and restores Chinook salmon rearing habitat in these degraded areas.

Predator Removal
As discussed in the Ten Year Summary Report, the Districts support evaluation of direct removal of bass as a strategy for reducing predator abundance and thereby reducing predation losses. Monitoring of largemouth and smallmouth bass abundance at the SRP 9 and 10 and control sites in 1998, 1999, and 2003 documented a pattern of population depletion following the 1997 flood and subsequent recovery during recent low water years (Reports 99-10 and 99-11 TID/MID 2000; McBain & Trush and Stillwater Sciences 2006). Implementation of bass removal methods on a regular basis would potentially result in recruitment class failure, causing longer-term depression of bass population levels.

Spatial Separation of Predator Fish from Juvenile Salmonids
As discussed in the 2005 Ten Year Summary Report, water velocity and temperature have a strong influence on the behavior and habitat use of non-native predator species such as largemouth bass and smallmouth bass. During high flows (e.g., spring pulse flows), outmigrating salmon smolts generally use more central portions of the channel, while bass likely seek lower velocities and warmer water near channel margins. Habitat suitability modeling conducted at SRP 9 for pre- and post-project conditions using the River 2D model (Steffler and Blackburn 2002) indicates that the project increases habitat segregation between bass and outmigrating Chinook salmon and may provide a "safe-velocity corridor" for outmigrant salmon during relatively low flow conditions. Because high flows may help to spatially separate predators and salmon smolts, exposure of juvenile salmon to predation is thereby reduced. Modeling predicts that, due to distinct differences in habitat usability between bass and salmon, this effect will occur at predictable flow thresholds in specific habitat types (e.g., riffles and unrestored SRPs). Developing a better understanding of predator response to spring flow pulses may contribute to the timing and the design of pulse flows that are more effective in reducing predation.

Temporal Separation of Predator Fish from Juvenile Salmonids
As discussed above under Instream Flows, periodic increases in Chinook salmon escapement in the Tuolumne River appear to be associated with high season-wide flows across the San Joaquin basin during wetter water years. On a river-wide scale, the primary mechanistic connection between flow and salmon survival is that higher flows are associated with either reduced predator densities in particular habitats or reduced exposure time for juvenile and smolt outmigrants. High early season (i.e., winter) flows may effectively "flush" rearing salmon fry from the primary upstream spawning and rearing reaches into downstream reaches and out into the San Joaquin River and Delta. The low water temperatures and high turbidity levels that can occur during these high winter flows may further act to reduce predation pressure in downstream reaches. This means of temporal separation of predators and prey could be experimentally implemented by releasing winter pulse flows to promote early salmon outmigration, with the added benefit of reducing predator efficiency during the pulses.

Turbidity Enhancement
As discussed in the 2005 Ten Year Summary Report, the Districts support the development of methods of increasing turbidity during winter and spring periods as a way of providing cover and movement stimuli for fry and juvenile salmon. Turbidity reduces the predation efficiency of visual predators (e.g., bass) and thus provides a form of cover for juvenile salmon migrating in the river (TID/MID 1992, Appendix 23). At turbidity levels that commonly occur in the lower Tuolumne River, predation efficiency of largemouth bass was reduced by 95% (Ligon et al., in press). Possible measures for increasing turbidity could include gravel cleaning or gravel addition in areas with no spawning redds as well as fine sediment removal operations from upstream pool habitats. As discussed below, managed winter pulse flows described under Instream Flows are a means of taking advantage of natural sources of turbidity by stimulating the movement of fish downstream of the Dry Creek confluence at Modesto.

Hypotheses:
Given the large cost of implementation of additional predator isolation projects, the Districts have developed several hypotheses to demonstrate the effectiveness of predator isolation projects and have identified additional measures to reduce predation on the Tuolumne River.

Hypothesis 1: Restoration of in-channel mining pits preferred by predatory bass reduces predation by decreasing the amount of time salmon are exposed to bass (i.e., predator opportunity time) and spatially separating predators from smolts.

Hypothesis 2: Increased turbidity during fry and smolt emigration reduces predation rates.

Hypothesis 3: Reducing the predator population in the river will result in reduced predation rates.

Hypothesis 4: Managed pulse flows during smolt emigration can reduce predation rates by spatially separating predators from smolts.

Hypothesis 5: High winter flows increase river-wide salmon survival and subsequent escapement by moving rearing Chinook salmon fry out of the gravel-bedded reaches of the Tuolumne River and through areas of higher predator density at times when predator efficiency is lower due to low temperatures and increased turbidity.

In partial support of Hypothesis No. 1 above, the largest escapement in the past 10 years occurred 3-years following the 1997 flood event. Although this is consistent with Hypothesis No.1, the extraordinarily high flows in January 1997 may have disrupted bass reproduction and reduced predator populations in the subsequent 1–2 years.

As stated above, predator abundance at the SRP 9/10 project and control sites has been monitored extensively between 1998 and the present. The single year of post-project predator population monitoring data (2003) indicate that the SRP 9 restoration project was not successful in reducing largemouth bass linear density during the low flow years that have occurred since project construction (McBain & Trush and Stillwater Sciences 2006). However, the project appears to have increased smallmouth bass abundance at the site relative to pre-project conditions and other SRP sites. Despite the continued high abundance of smallmouth and largemouth bass at SRP 9, habitat suitability modeling conducted at SRP 9 for pre- and post-project conditions using the River 2D model (Steffler and Blackburn 2002) indicates that the project increases habitat segregation between bass and outmigrating Chinook salmon and may provide a "safe-velocity corridor" for outmigrant salmon during relatively low flow conditions. In support of Hypotheses 2 and 3, this safe velocity corridor is expected to occur at flows of 300 cfs for the restored channel compared with 2,000 cfs and higher for deeper habitats corresponding to pre-project conditions at SRP 9 and other SRPs.

Additional post-project monitoring during higher flow years has been limited to a pilot-level assessment of predation rate and predator habitat use, conducted in spring 2006 (Stillwater Sciences and McBain & Trush 2006). Although no river-wide or population-level predator monitoring occurred in the recent high flow years 2005–2006, results of the spring 2006 predation assessment, which directly assessed predation rate by individual predators, suggest low predation rates at high flows. Due in large part to the high flows and low water temperatures during the study, only four predators (one smallmouth bass and three largemouth bass) were captured. Although radio tracking of these predators indicated preferential use of floodplain and backwater habitats with lower velocities, the surveys did not conclusively document salmon habitat use in mid-channel areas due to low smolt captures and permitting restrictions on electrofishing.

Recommended Approach and Methods:
Following is a description of additional monitoring and analyses to address the identified hypotheses regarding Predator Control in the lower Tuolumne River:

1) Predator and Smolt Tracking Studies within Restored and Unrestored Mining Pits. To test Hypotheses 1 and 4 above and the benefits of predator isolation projects, additional predator monitoring will be conducted at the SRP 9 and 10 project and other unrestored mining pits to serve as control sites. The monitoring will be used to document the effects of restoration on predation efficiency as well as the effectiveness of flow management in spatially separating predators from juvenile salmon. Monitoring will be conducted during the spring period of salmon outmigration, and will take place twice during the 2008–2011 study period: either in the same year or in different years, depending on flow conditions. Monitoring will be timed to ensure river flows are in the range suitable to test spatial segregation Hypothesis in SRP 9 and riffle control sites (<500 and >300 cfs) and in unrestored SRPs (>2,500 cfs). The study flows will be provided for up to ten consecutive calendar days at each flow. The high flow will be provided in conjunction with VAMP study flows and/or flood management flows, as available through spring 2011. The study period may be extended through spring 2016 if the high flow is not available through spring 2011. Preferred methods will entail predator capture by boat electrofishing during lower flows and angling during higher flows. Stomach content analysis of predators will be used to determine predation rate. Acoustic tracking of bass and salmon smolts with both mobile and stationary monitors will be used to document habitat use and spatial separation of predators and salmon. The use of electrofishing will be contingent on the acquisition of permits from CDFG and NMFS. In the event electrofishing is not permitted, angling and seining will be used to capture predators and salmon.

2) Direct Predator Sampling. Hypothesis 2 will be tested using stomach content analysis of predators to document predation rate under a range of flow and turbidity conditions. Predators in the downstream portions of the river (i.e., mining reach, sand-bedded reach) will be captured by angling or electrofishing during both managed pulse flow releases and flood control releases to allow predation rate to be examined for a range of flow, temperature, and turbidity conditions. Sampling will be conducted during the winter to examine predation on the fry life-stage as well as during the spring period of salmon outmigration. Surveys will be conducted over three weeks in each of two years during the 2008–2011 study period: either in the same year or in different years, depending on suitable turbidity and flow conditions. As a means of testing whether concurrent gravel cleaning or other turbidity enhancements could reduce predation rates, predation rates will be compared during periods and locations with naturally higher and lower turbidity. Predator capture methods will be the same as those described under (1) above but may include point sampling (Beechie et al. 2005) in areas that are unsuitable for block netting, and the majority of the sampling to test turbidity effects can be performed concurrently with restoration project monitoring. For comparative purposes, predation rate will also be documented in the same reach during low flows (typical winter/spring base flows) using the same methods.

3) Predator Removal. To test Hypothesis 3, the Districts propose to remove sportfish predators at sites within approximately RM 25-35 in the lower Tuolumne River during one-week each year, 2008–2011, during the Spring to Fall period. Methods may include electrofishing, gill-netting, or angling/fishing tournaments as approved by fishery agencies. Removal will target sportfish over a minimum size necessary for piscivory The

catch obtained will be released alive in Turlock Lake, Modesto Reservoir, or Don Pedro Reservoir, or other nearby public angling impoundments, depending on an approved program plan with CDFG.

4) Paired Rotary Screw Trapping. To test Hypothesis 5, data from paired RST monitoring described under Instream Flows, together with annual escapement counts, will be used to compare fry and smolt movement in response to flow and turbidity levels in the river. Continued monitoring of water temperature and turbidity throughout the lower river during the outmigration period will provide data to help validate hypothesized relationships between these parameters and predator efficiency under each of the pulse flows and water year types encountered.

Table 5 Summary of methods, metrics, and schedule to examine Predator Control issue

Approach	Methods	Metrics	Schedule	Report Progress/Product
1. Predator and Smolt Tracking Studies within Restored and Unrestored Mining Pits	Combination of electrofishing or angling followed by acoustic-tracking to document habitat use by predators. Predation rate by stomach content analysis. Surveys will test flows between 300–500 cfs with opportunistic surveys at flows in excess of 2,500 cfs	1. Predator habitat use, density, No. of salmonids in diet and proportion by weight. 2. Comparison of actual distribution of predators and prey with River2D modeling results.	Ten days during spring in each of two years during the period 2008–2011, but may be extended through spring 2016 if water not available for high flow.	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
2. Direct Predator Sampling	Collect predators by electrofishing or angling from representative habitats within mining and sand bedded reaches. Stomach content from predators to document predation rate on salmonids under a range of flow and turbidity.	Predator habitat use, density, No. of salmonids in diet and proportion by weight.	Three weeks during winter and spring in each of two years between 2008–2011.	Data reports and preliminary analysis with annual FERC reports (2008–2011). Complete analysis by 7/1/2012.
3. Predator Removal	Removal of predators and re-planting in Turlock Lake, Modesto Reservoir, and Don Pedro Reservoir	Numbers and sizes of predators captured in each year, catch per unit effort estimates	One week annually within Spring to Fall during 2008–2011	Data reports and preliminary analysis with annual FERC reports (2008–2011). Complete analysis by 7/1/2012.
4. Paired Rotary Screw Trap Monitoring	Deploy and monitor RSTs near Grayson (RM 5) and Waterford (RM 29) between January and early June.	Daily fry counts to compare fry and smolt movement in response to flow and turbidity levels in the river.	January to May/June for the period 2007–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.

VI. RIVER TEMPERATURE

Identified FERC Issues:
The FERC Letter requests an assessment of the effect of project operation on river temperatures and the resulting effects on fisheries resources in the lower Tuolumne River, the development of a temperature model to determine flow-temperature relationships, and an analysis of how conditions in the Delta might affect the success of any measures taken to improve temperature conditions in the Tuolumne River.

Districts' Issue Assessment:
The Districts believe the identified temperature issue is best addressed by continued use of the 11 temperature monitoring stations (9 in the Tuolumne River and 2 in the San Joaquin River) and existing temperature models. In addition to use of the Tuolumne River temperature model (Apps 18 and 19 TID/MID 1992), the Districts will also continue to collaborate with the current temperature modeling efforts in the wider San Joaquin basin being conducted under CALFED Grant ERP-02-P28 to address downstream conditions of the San Joaquin River into the south Delta.

Concerns over summer water temperatures led to the development of the increased flow schedules under Article 37 of the 1996 FERC Order. As stated in the 2005 Ten Year Summary Report, the Districts have met instream flow requirements under the Order and have monitored temperatures in accordance with Article 58 as a means of determining temperature relationships with juvenile salmonid distribution. Instream flow and temperature simulations using a combination of SNTEMP temperature model (Theurer et al. 1984) results and the PHABSIM model results for the lower Tuolumne River (USFWS 1995) were provided to the TRTAC on March 17, 2003 and subsequently sent to FERC on October 13, 2003 to provide an estimate of the existing relationship between river operations and summer flows. The simulations and corresponding field data show that river water temperatures typically reach equilibrium with ambient air temperatures within several miles below La Grange Dam in summer. With regards to influencing Delta water temperatures, the existing model shows that increases in Tuolumne River flow would have no significant effect in lowering water temperatures in the warmer San Joaquin River and South Delta. During this new study period, the U.S. Bureau of Reclamation's Friant Dam is scheduled to begin making restoration flows for salmon and steelhead from the Upper San Joaquin River. Because of the long travel time between Friant Dam and the mouth of the Tuolumne River, it is possible that those Friant flows could increase early springtime water temperatures in the lower San Joaquin River.

Hypotheses:
The following hypotheses relate the habitat needs of Tuolumne River salmonids to instream flows provided under the current required FERC flow schedule:

> Hypothesis 1: Water temperature relates to suitable habitat for over-summering or rearing Tuolumne River salmonids.
>
> Hypothesis 2: Delta water temperatures from late May through September are determined by ambient air (meteorology) and not influenced by upstream water releases.

The Districts began monitoring water temperatures at five locations on a continuous basis in the spring of 1987 and an additional six locations were added in the years between 1996 and the

present (TID/MID 2005a). Summer flow studies conducted over three years (1988–1990) documenting the distribution of resident salmonids and invertebrates during low flow conditions (Apps 27 and 28, TID/MID 1992), the development of a predictive Tuolumne River temperature model (Apps 18 and 19 of TID/MID 1992) and more recent temperature and snorkel survey data (TID/MID 2005a) all serve to meet the request for an assessment of project operations on river temperatures and fishery resources.

As described under Instream Flows and IV. Steelhead Presence/Protection, Hypothesis No.1 is well supported by existing data that show increased summer flows for resident life stages of Tuolumne River salmonids has resulted in increased summertime distribution of suitable habitat for *O. mykiss* (TID/MID 2005a). Following the August 28, 2002 Flow Schedule meeting by TRTAC members in Stockton, a number of model simulation runs were made using the existing Tuolumne River SNTEMP model (Apps 18 and 19 TID/MID 1992) to evaluate the extent of suitable water temperatures on both a year-round basis as well as more detailed evaluations at summer and autumn flows under the current FERC flow schedule. These simulations were used to provide a basis for a cooperative effort to re-allocate carry-over water that occurred due to a late-season change in water year classification during May 2003, resulting in a temporary variable summer flow schedule (Report 2003-4 TID/MID 2004).

Recommended Approach and Methods:
The Districts believe that the current assessments and modeling efforts developed to date are sufficient to describe the existing relationship between river operations and summer flows. Below the Districts describe the analyses to be used to address the identified hypotheses:

1) Continue Temperature Monitoring. The Districts will continue to maintain the current water temperature monitoring network as provided in past annual FERC Reports (TID/MID 2005a). Under the 3-year river-wide monitoring program developed by the TRTAC (CDFG Grant No. ERP-04-S04), seine and snorkel surveys will be used to build upon existing temperature and fish survey data to relate instream flows, river temperatures and fishery resources.

2) Synthesize Results of Existing and Ongoing Studies by 2012. By July 1, 2012, the Districts will synthesize the results of existing and ongoing studies to compare actual versus modeled temperatures, as well as fish distribution in relation to river flows and instream temperatures.

3) Delta Temperature Evaluation. The Districts will request use of the San Joaquin basin temperature model currently under development to examine the influence of upstream operations on San Joaquin and south Delta temperatures during the smolt outmigration and fall up-migration periods.

Table 6 Summary of methods, metrics, and schedule to examine River Temperature issue

Approach	Methods	Metrics	Schedule	Report Progress/Product
1. Continue Temperature Monitoring	Continue to maintain the current water temperature data logger monitoring network.	Mean, maximum, minimum water temperature in addition to temperature metrics (e.g., MWAT) by RM	Annual deployment and retrieval between 2007–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
2. Synthesize Results of Existing and Ongoing Studies by 2011	Compare actual versus modeled temperatures, as well as fish distribution in relation to river flows and instream temperatures	Fish habitat use by RM in relation to temperature and flow.	2007–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
3. Delta Temperature Evaluation	Use San Joaquin temperature model to examine the influence of upstream operations on Delta temperatures during smolt and adult migration periods	Mean, maximum, minimum water temperature in addition to temperature metrics (e.g., MWAT) by RM. Comparisons to published habitat suitability criteria and agency fish monitoring data.	One time study covering observed water conditions and fish monitoring data collected by agencies between 2007–2011	Complete analysis by 7/1/2012.

REPORTING AND COORDINATION

A summary report of the Tuolumne River Fisheries Management Program for the period of 2005–2012 will be submitted to the Commission by July 1, 2013. The Districts will continue filing an Annual Article 58 Report with the Commission by April 1 of each year that includes (1) a summary of monitoring, restoration, and TRTAC activities, (2) review of status of spawning runs, Delta salmon survival and salvage, and ocean salmon harvest, (3) hydrology, flow, temperature, and flow schedule information, and (4) individual technical reports. Coordination will continue through TRTAC meetings, e-mail exchange, and website.

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