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Dear Ms. Williams:

This letter focuses on the written and digital material that you provided on the hydrology and temperature modeling of the Sacramento Municipal Utility District, Upper American River Project, FERC Project No. 2101. The specific questions I concentrate on are:

- How do the SMUD and agency/NGO alternative discharge proposals compare with respect to **minimum** flows during the *R. boylii,* the foothill yellow legged frog, reproductive season? Will the spring and summer water temperatures be adequate for warm water taxa such as hardhead and *R. boylii*?

- What has been the history of spill flows over Slab Creek Reservoir Dam and Camino dam, and what were the probable effects on *Rana boylii*?

- Are there any potential effects on *R. boylii* of the proposed agency/NGO white water boating flows on the Slab Creek reach?

Overview

I will preface my comments re the Upper American River Project (UARP) by summarizing recent research on the effects of flow fluctuations on *R. boylii*. Based on a review of current literature and many FERC-related study reports from other Sierran rivers (conducted by Drs. Amy Lind, Sarah Yarnell, and myself) egg masses are negatively affected by flow fluctuation via scouring if pulses occur during or after oviposition, and desiccation if oviposition occurs during prolonged spills and then water levels drop quickly prior to hatching. Tadpole stranding is also a concern.

To detect the effects of new license conditions on amphibian populations, we need to address the problem of incorporating lag times into the design and interpretation of monitoring. The numerical response in terms of breeding population size may be detected only years after the new discharge regimes have changed conditions for spawning and tadpole rearing. This is a common problem because many amphibian species have ≥2 years until sexual maturity (Petranka et al. 2003). In spite of the lag time, a monitoring regime focused on egg masses is desirable because other life stages are widely dispersed, mobile and cryptic. It will likely be more accurate to measure response by counting the life stages that are concentrated in space and time, i.e. number of reproducing adult females as measured during egg count censuses.

My monitoring of *R. boylii* in the unregulated S. Fk. Eel River over 15 years has shown that breeding season flow fluctuation is a key factor in the survival of eggs and small tadpoles. Interannual declines in the number of reproductive adult females were associated with spring pulse flow events 3 years prior. This three year lag time is consistent with the time it might take for an egg to become a breeding female. Population stability has likely been maintained because the inter-annual frequency of high mortality events has been relatively low, approximately 18%, and the multiyear intervals between events allowed for adequate recovery time. Timing and magnitude were also important. While large magnitude pulses decrease survival, smaller magnitude pulses also reduced recruitment if they occurred when egg masses were older and less resistant to scour, or after a large proportion of the population had already bred. Evaluation of the proposed minimum flow regimes and recreation flows for the UARP thus needs to include a discussion of whether vulnerable life stages will be exposed to aseasonal flow fluctuations with respect to magnitude and frequency of pulses.

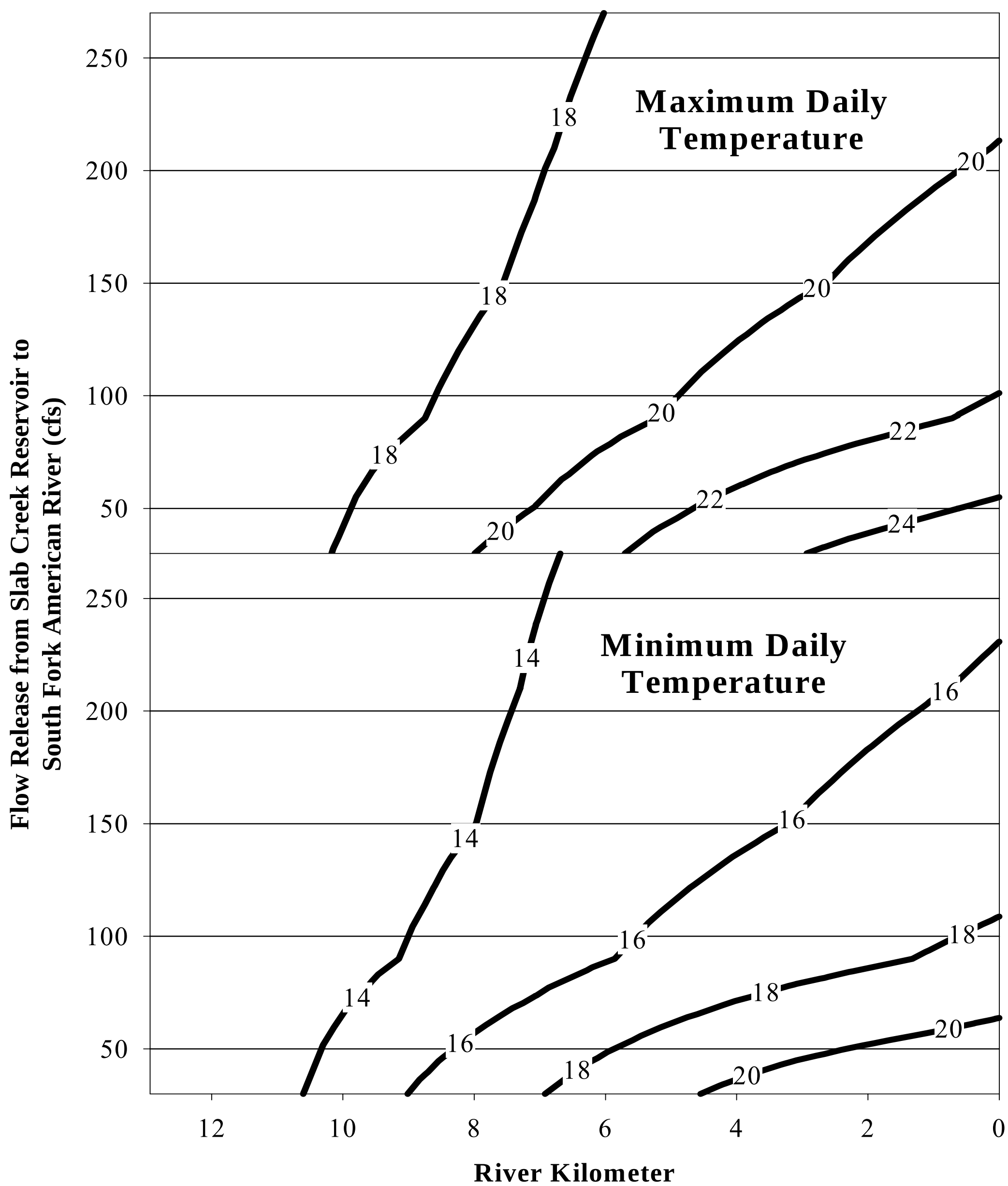
An important example illustrating the role of lag times and reference reaches in detecting the effects of flow regime changes comes from the N. Fk. Feather River. Recreational boating flows began in 2002 in the Cresta Reach but not in the Poe Reach. Although egg censuses were begun in 2002, the 2005 and 2006 egg counts were essentially the first sets of data which integrated the effects of the new flow regime over an appropriate time span. Prior to 2005, the population trajectories in both reaches were roughly parallel. In 2005 and 2006 the trajectories diverged, the breeding population in Poe rose, while Cresta declined. The hydrographs for 2002 and 2003 in Poe were conducive to hatching and rearing, consistent with the three year lag time pattern between non-pulse years and population growth at the SF Eel. Flows which eliminate occasional high recruitment years are detrimental because such "bonanza" years are a key characteristic of amphibian population dynamics in general and can sustain populations over the long term (Meyer et al. 1998, Daszak et al. 2005).

The new minimum flows will also influence the thermal regime. Thus, it will be difficult to separate frog population responses to changes in pulse timing and magnitude from responses to changes in temperature.

1. Temperature

1a. Slab Creek. There is a tradeoff between the potential benefits of higher minimum flows and the negative effects of cooler water on warm adapted taxa. The temperature model output is the information available for evaluating this tradeoff. However, the model focuses on thalweg temperatures, and its accuracy in predicting temperatures in the near shore environment of amphibians needs to be evaluated. It is possible that the temperatures will be too cold for timely larval *R. boylii* development. It is also possible that edgewater habitats where eggs and tadpoles usually reside may be warmer than the predicted temperatures, thus highlighting the need for monitoring under the new flow regime.

Figure 1. Simulated maximum and minimum daily water temperatures in the South Fork American River below Slab Creek Reservoir during the month of July 2002 for constant flow releases from Slab Creek Reservoir ranging from 30 to 270 cfs.



In the absence of data regarding edgewater temperatures, comparison of projected thalweg temperatures in the Slab Creek Reach to observed thalweg temperatures in the

Camino Reach can provide another basis for evaluating thermal impacts of higher minimum flows. For July, as shown in Fig. 1 (from R2 report dated Nov. 29 2004), daily max in the middle of the reach at 90 cfs will be 20ºC. In comparison, July maximum temperatures in Silver Ck, where *R. boylii* seem to be relatively more abundant, were approximately 24ºC in 2001 and 22ºC in 2002 and 21ºC in 2003 (based on visual inspection of water temperature record at SC1 (Unit 25) Draft plot dated 4/3/2006).

Projected temperatures may not be warm enough for hardhead. CDFG states in a précis on hardhead on their website that "most streams in which [hardhead] occur have summer temperatures in excess of 20 °C, and optimal temperatures for hardhead (as determined by laboratory choice experiments) appear to be 24-28 C." The monitoring component focused on hardhead will thus be very important for determining effects to their population.

Also, it is important to consider continuity and connectivity of appropriate thermal habitat to potential source populations of frogs. It currently appears that the population is more robust upstream in the direction of Silver Creek. If there is a several km long stretch in the upper portion of the Slab Ck. reach too cold for frogs, this will increase the distance between the two project reaches with *R. boylii*. Currently there are no data regarding whether reservoirs represent a dispersal barrier for this species. If Slab Creek Reservoir is impassable, as is assumed, the issue of connectivity is a moot point.

If the flows proposed for July were moved to June, I hypothesize that there would be a tradeoff between the positive effects of warmer temperatures and the potentially negative effects of rapid decline in river stage. I would recommend stepped decreases in discharge for June. If the stepped flows were moved to May, there might be a loss of the buffering effect of higher base flows in those years in which there are spills. In any of these cases it is important to monitor how the stepped flows influence inundation and dewatering of potential amphibian breeding areas, because each channel cross-section will have its own relationship between discharge and stage.

1b. Silver Creek. The three relevant figures I found among the UARP documents were: Predicted mean daily temperatures from the Water Temperature Technical Report, dated 10/19/2004, p. 14, Fig. 2 here, and an electronic file you sent UARPSNTEMP Analyses 111004 (R2 Resource Consultants, Inc., dated July23, 2004 page 3) presented as Fig. 3 here. I also reviewed the 2000-2003 observed temperatures at water temperature station SC1 in Silver Creek above the confluence with SF American River.

In the absence of data from experiments in which *Rana boylii* tadpoles have been reared under a range of thermal regimes, it is difficult to predict exactly how the higher minimum flows and concomitant reductions in mean temperatures will influence rates of tadpole development. We can assume that the 2003 temperatures measured in Silver Creek are conducive to timely tadpole development because early stages of metamorphosis were reached by mid August of that year. Observations were made on

8/7/03 of tadpoles with front limb emergence, Gosner Stage 42, in Silver Creek and of similarly developed tadpoles in the South Fork American below the confluence with Silver Creek on 8/16/03. June – Aug discharge for 2003 ranged between approximately 30 and 25 cfs. Thus, for critically dry and dry years the proposed flow regimes will not likely represent a change from the 2003 thermal regime.

To make educated guesses whether the proposed flows for Below Normal, Above Normal, and Wet years would create temperatures outside the range of natural variability in thermal regime experienced by a *Rana boylii* population I have analyzed temperature data from the SF Eel River where there are many years of temperature monitoring and the population is robust over the long term (Figs. 4 and 5). Granted this is a coastal location, not driven by snow melt, such that spring and early summer temperatures may be warmer. However, examining the range of natural variation is useful for evaluating the range of mean daily temperatures predicted by the models for the proposed flows.

The model output curves are for 5, 15, 30, 45, and 60 cfs. There are no outputs for discharges > 60cfs, so I cannot comment on temperatures for egg laying in May of Above Normal and Wet years when the agency alternative flows are 80 and 100 cfs, and June of Wet years with 87 cfs. For CD, Dry, and BN years it appears that the temperatures will likely be suitable for breeding to commence in May and June.

For the proposed flows that are within the range of the model output for the summer months, the ranges of mean daily temperatures seem comparable to those at the SF Eel River. For example, in July of a wet year the proposed flow is 52 cfs. Predicted mean daily temperature ranges for 45 cfs is 18-20 C and 17-19 for 60fs, which are around the middle of the range of July means at the SF Eel, although they would be cooler than the temperatures observed in Silver Creek in 2003. It should also be considered that tadpoles are mobile and can potentially thermoregulate by changing depth or moving into algal mats which warm to temperatures greater that the surrounding water. Thus it is difficult to predict if small changes in ambient water temperature would be beyond their ability to compensate behaviorally.

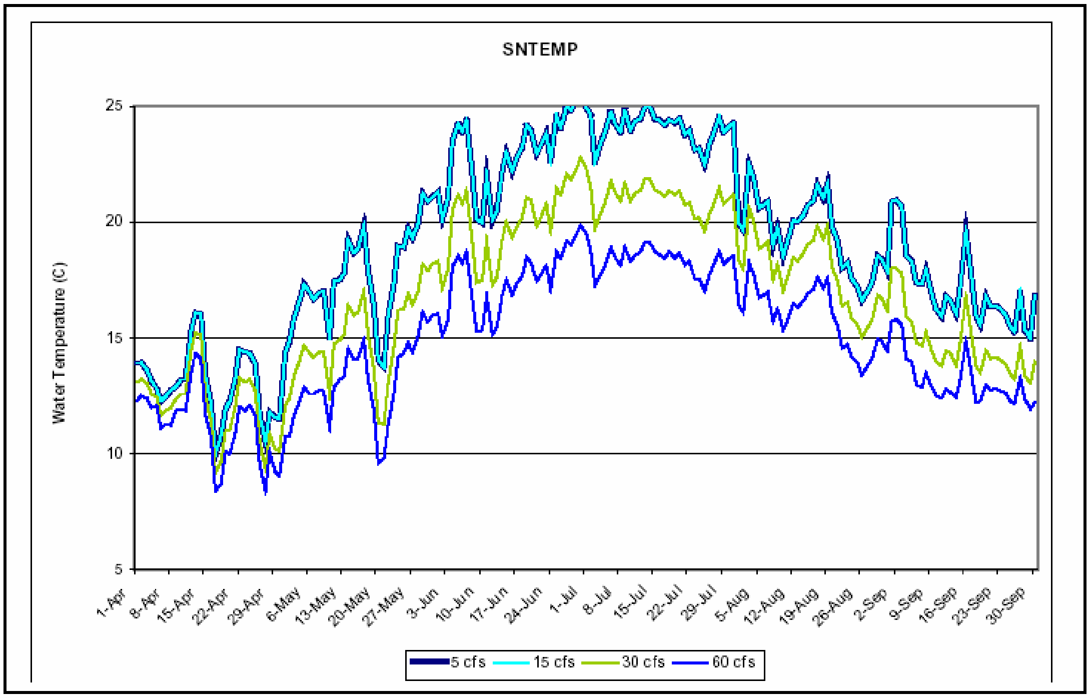


Figure 4.3-12. Predicted mean daily temperatures for Silver Creek upstream of confluence with S F American River (SC1) for variable flow release from Camino Dam.

Fig 2. Model output for Silver Creek, 60 cfs curve relevant to June temperatures in below normal and above normal years.

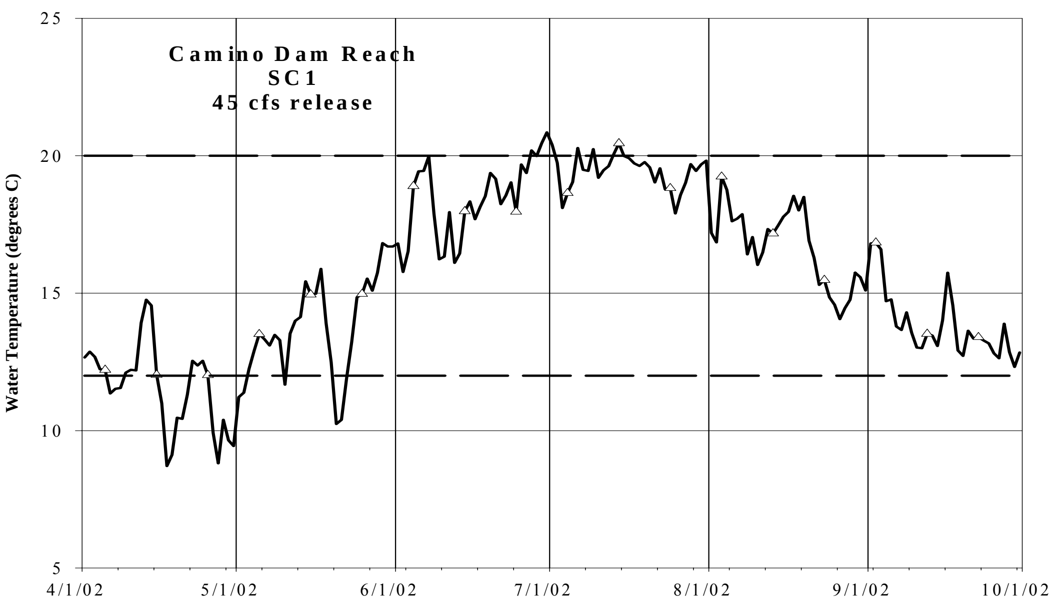


Fig. 3. Model output for Silver Creek, 45 cfs.

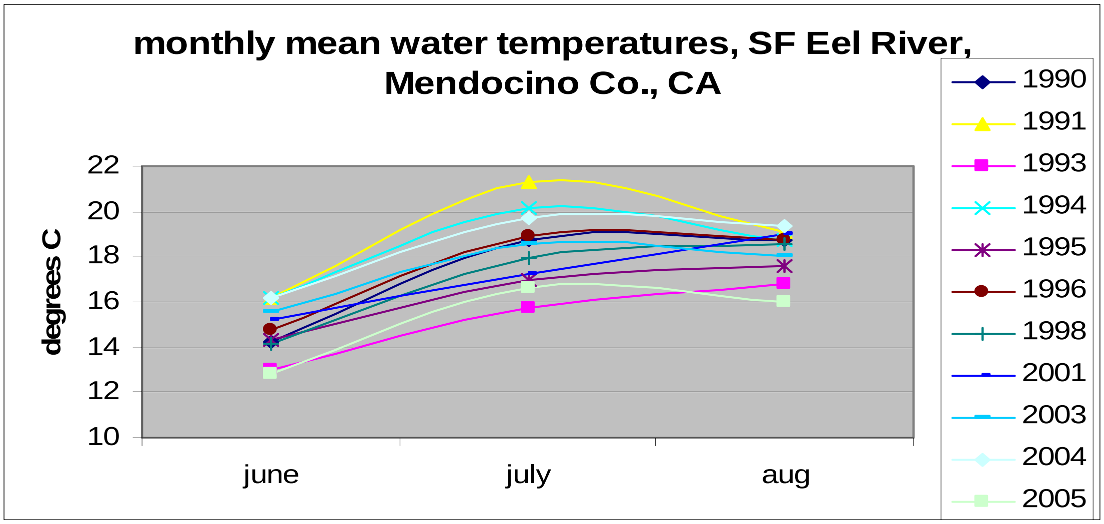


Fig. 4. Monthly mean water temperatures for eleven years at the Angelo Reserve, where *R. boylii* population numbers are relatively stable and abundant.

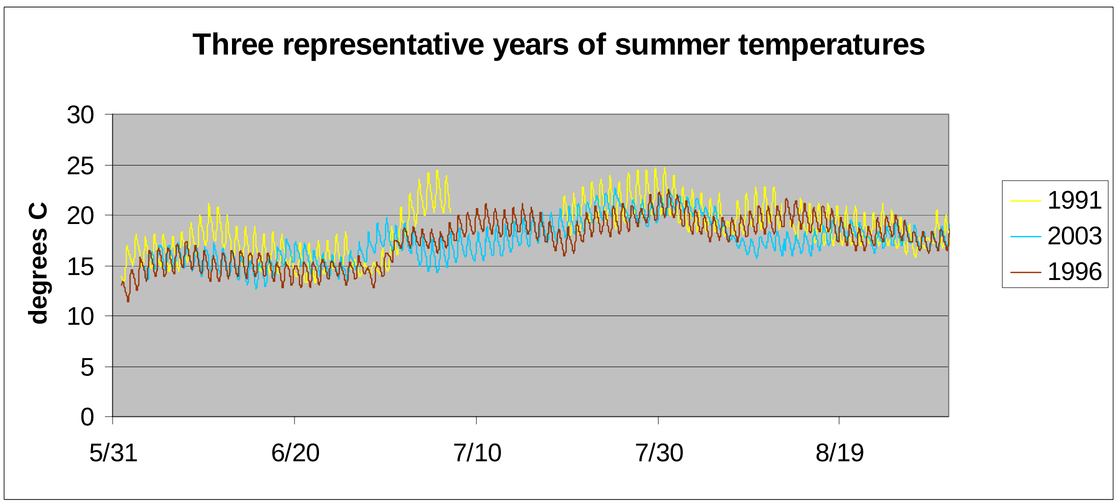


Fig. 5. Hourly readings of temperature from three representative years of the data summarized in Fig. 4.

2. Spill / Pulsed Flow Frequency Analysis for Slab Creek:

For the years 1975-2000 I plotted the flow data from the ResSim model, for the months bracketing the *R. boylii* breeding season, May 1 – Aug 1. Please see attached Excel file entitled "Slab Creek Reach Flow scenario Comparisons". Each plot has three modeled scenarios, unimpaired, regulated "base case", and the regulated "agency alternative", as well as the actual flows collected by the USGS at gaging station number 11443500. For each year, I examined the hydrograph to determine whether there were pulses or rapid increases in discharge (2-3x increase or greater) or large spills when the magnitude of discharge was in the thousands of cfs.

According to the USGS flow data ('75-'04), large magnitude spills occurred in 23% of the years: 1982,1983, and five consecutive years1995-1999 (the light blue line in all graphs). The ResSim model predicts that the flow regime proposed by SMUD would produce spills in an additional two years, 1975 and 1993 (pink line in all graphs). In all nine of these potential spill years the absolute magnitude, in terms of peak mean daily discharge, would be similar under the agency alternative scenario (the yellow line) but relative magnitude would be dampened, because of the smaller difference between the peak discharge and the higher minimum flows proposed by the agencies/NGO's.

In addition to the spills in the wet years, the ResSim model of the "base case" scenario predicts abrupt increases in discharge, from 10 to 36 cfs on the first day in June in another 32% of the years ('76, '77, '87, '88, '90, '91, '92, '94). Such flows actually occurred in '87, '88, '90, '91, '92, '94, and '01). These flows could pose a scouring threat if any clutches were laid in May. Presently we do not know about the timing of oviposition in the Slab Creek Reach but we can use the output of the Upper American River SNTEMP Model to estimate whether the water temperatures might be in the range when breeding initiates in other localities. By my reading of the May SNTEMP output (Fig. 6, copied from p.1 of R2 Consultants report to USFS dated Nov. 29, 2004), at 10 cfs temperatures begin to be appropriate starting at about river km 8 or 9. Under the agency alternative flow scenario the discharge during May of these years, there would not be any abrupt flow fluctuations and thus this threat of egg scour is mitigated. The level of discharge, ≥109 cfs, would produce temperatures unlikely for egg laying except at the downstream end of the reach beginning about river km 3 or 4. The proposed discharge throughout the rest of the summer, would also keep temperatures below levels observed during July and August in Silver Creek where the frog populations are relatively more robust.

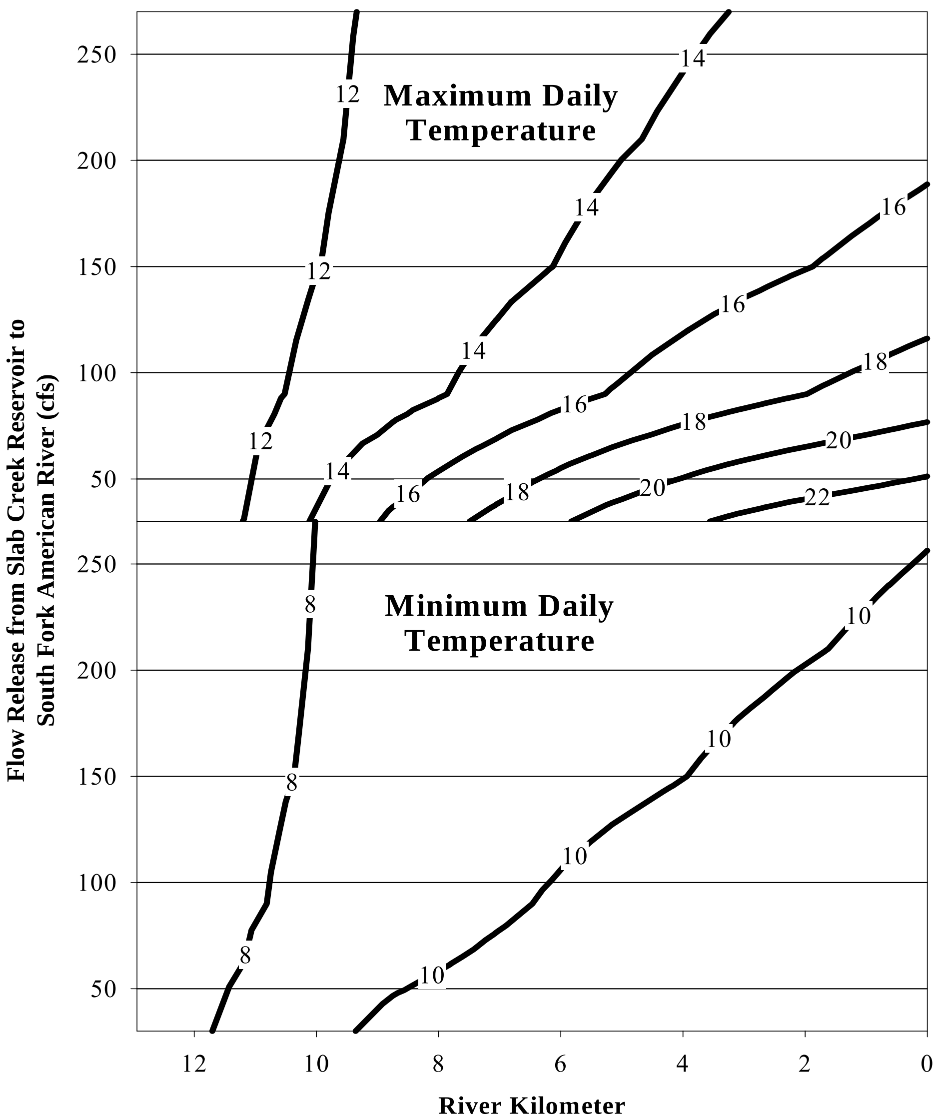


Figure 6. Simulated maximum and minimum daily water temperatures in the South Fork American River below Slab Creek Reservoir during the month of May 2002 for constant flow releases from Slab Creek Reservoir ranging from 30 to 270 cfs.

There are also years in which the agency alternative increases the inter-annual frequency of pulsed flows during May. Frequency is 23% (7 of 30 yrs) in the "base case" scenario and 62% of years reflecting the recreational stream flows in the agency alternative scenario. With respect to the intra-annual number of peaks and falls, I question whether the ResSim model output accurately represents what the actual discharges will be. The wording on pp. 89-96 of the Agency /NGO Alternative document delineates flows lasting 3-6 hours long. I would anticipate that the licensee will ramp back down to the base flow in between the boating hours, on back to back weekend days in order to minimize the loss of power generation.

Waiting until year 6 for October WWB will allow some time for studying how the cooler temperatures of the new higher minimum flows will affect the timing of reproduction and time to metamorphosis, but there are many questions that will require investigation during that period. It is likely that there will be a shift in the timing of breeding to later in the spring since the high flow releases are colder. Shifting metamorphosis later into the fall has at least two potential negative side effects which should be studied in years 1-5. First, tadpoles might still be present in October and thus vulnerable to the lethal and sub-lethal effects of increased flow velocity via downstream displacement, decreased growth rate, and increased predation risk. Preliminary results from laboratory swimming trials conducted by Dr. Amy Lind and myself indicate that larger tadpoles are still vulnerable to being swept out of rock crevices and flow refugia as current velocity increases. The second potential negative side effect is the impact of fall flows on emergence of aquatic insects. In the Rock Creek and Cresta reaches of the North Fork Feather River, recreational flows in the fall have caused large numbers of macroinvertebrates to enter the drift and be exported downstream. Thus, in addition to less time for metamorphs to grow in the fall, there will probably be less insect food available. The metamorph life stage is the stage we know the least about. We do not know what triggers the metamorphs to leave the river channel and move to tributaries, or how important ephemeral tributaries are as over-wintering refugia. We do not know how discharge events that are decoupled from rainfall and runoff which would inundate ephemeral tributaries will effect the movement of young of the year frogs through the landscape. How pronounced the timing shifts in frog breeding and rearing will be, is going to depend on the types of water years occurring during the initial 5 year study period. Thus it could take longer than the first five years to answer these questions if the new license term coincides with a multi-year dry period, and if the lag time between recruitment effects and numerical response in the adult breeding population is taken into account.

3. Spill / Pulsed Flow Frequency in Camino Reach of Silver Creek:

Similar to the methods outlined above, for the years 1975-2000 I plotted the flow data from the ResSim model, for the *R. boylii* breeding season, May 1 – Aug 1 (in attached Excel file "Silver Creek Reach Flow Scenario Comparisons"). Each plot has three modeled scenarios, unimpaired, regulated "base case", and the regulated "agency alternative", as well as the data from USGS gage station number 11441900. For each year, I examined the hydrograph to determine whether there were pulses or rapid increases in discharge (2-3x increase or greater) or large spills when the magnitude of discharge was in the hundreds or thousands of cfs. For spill years I compared how the magnitude of the events differed between the scenarios of different minimum flows.

In Silver Creek, the agency minimum flows attempt to mimic the slope of the descending limb of the unimpaired hydrograph. A potential effect, in terms of stranding, could occur if frogs spawned at the end of May, or early June when flows are at 87 cfs, it is possible that stranding could occur when flows drop to 52 cfs at the beginning of July (Fig. 7). A stepped decrease to 65 cfs during the third week of June could potentially allow tadpoles to follow the receding shoreline. Predicting whether these scenarios would actually occur is extremely difficult to evaluate *a priori*, because the amphibian test flow study increments were at 100 and 50 cfs. At the SFAR confluence site the eight polygons identified as suitable habitat at 100 cfs were not wet at the lower flows. Whether they would be inundated at 87 cfs needs to be investigated. If there was slow time to hatching and/or only limited dispersal of larvae prior to the transition to the lower discharge, it is possible that the reproductive output for that year could be lost. At the Camino Adit site a similar stranding situation is not likely because polygons that were identified at 100 cfs were within or contiguous to the wetted perimeter of the channel at 50 and 20 cfs (see Fig. 8 copied from Amphibian Test Flow Technical Report).

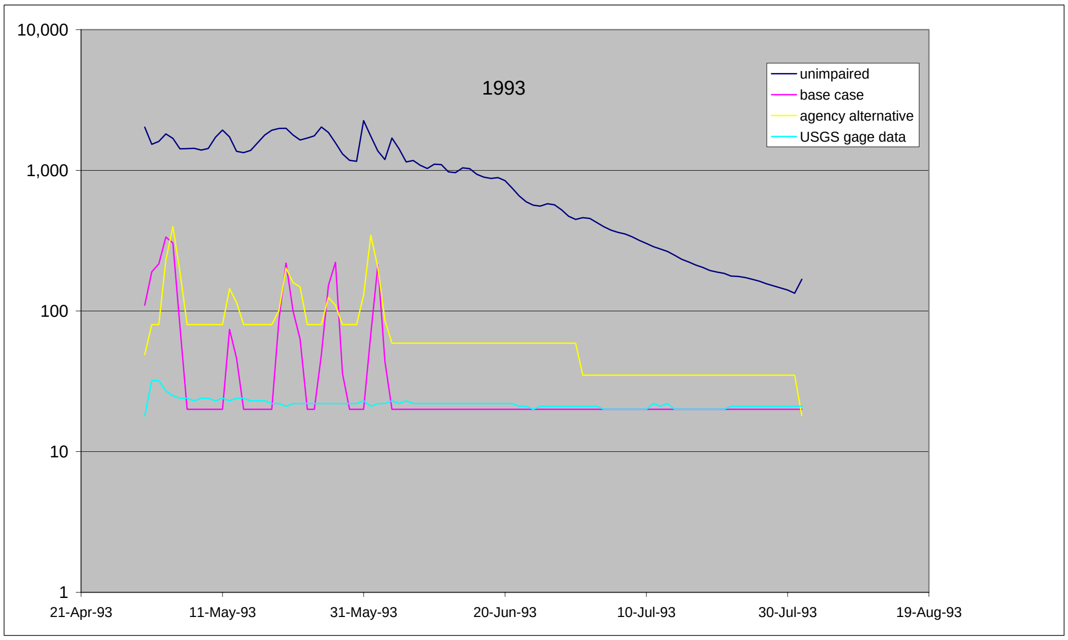


Fig. 7. Spring hydrograph for Silver Creek, when June to July transitions are from 87 to 52 cfs (similar years are ’78, ’80, ’84, ’86, ’93, ’97).

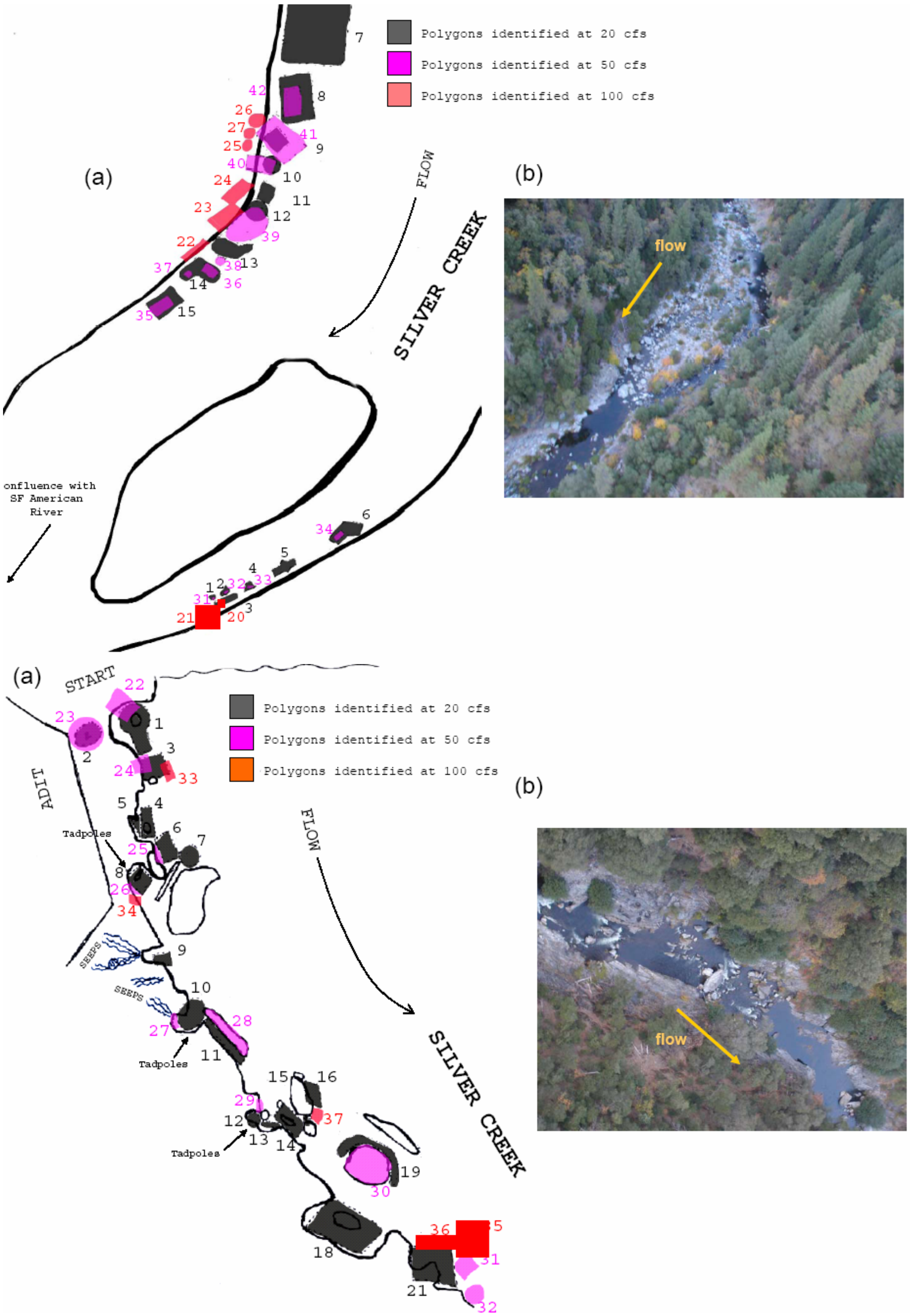


Fig. 8. FYLF sites in Silver Creek near the confluence (top) with SFAR and at Camino Adit (bottom).

From 1975 to 2004, spills during the breeding season occurred in 5 years ('82,'83,'95, '96, '98) or less than 6% of years. These years were likely difficult for successful recruitment, but the relatively low frequency and number of years since the last spill would have allowed for recovery. An example of a spill year is shown in Fig. 9. When comparing the proposed flow regimes, the agencies' higher minimum flows smoothes some of the "spikiness" of the impaired hydrograph, but the fall rate, or slope of the line, from late June to July, is for all three scenarios, is steeper than the unimpaired hydrograph. Under the proposed flow regimes there would be an additional three years '75, '93, and '99 in which pulses would occur during the breeding season (see Fig. 10). The agency alternative's higher minimum flow dampens the magnitude of the pulses, 59 to 270 cfs vs. 20 to 270 cfs, in this example. It is very difficult to predict whether such a difference will be biologically significant for frogs because there are too many unknown factors which contribute to a potential impact. Factors such as where on the cross section eggs are laid, the time since egg laying, the proportion of the population yet to lay their eggs, etc. would affect the outcome. The monitoring program will be important for assessing if the higher minimum flow will mitigate the effects of pulses in such years.

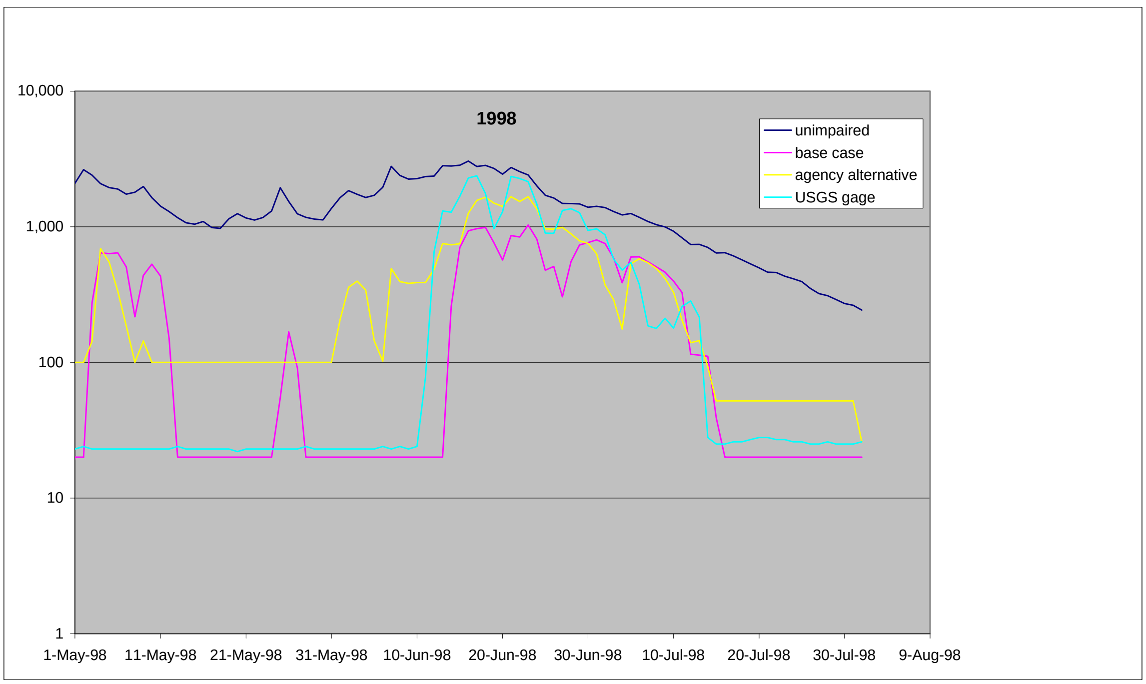


Fig. 9. Example of a spill year hydrograph for Silver Creek.

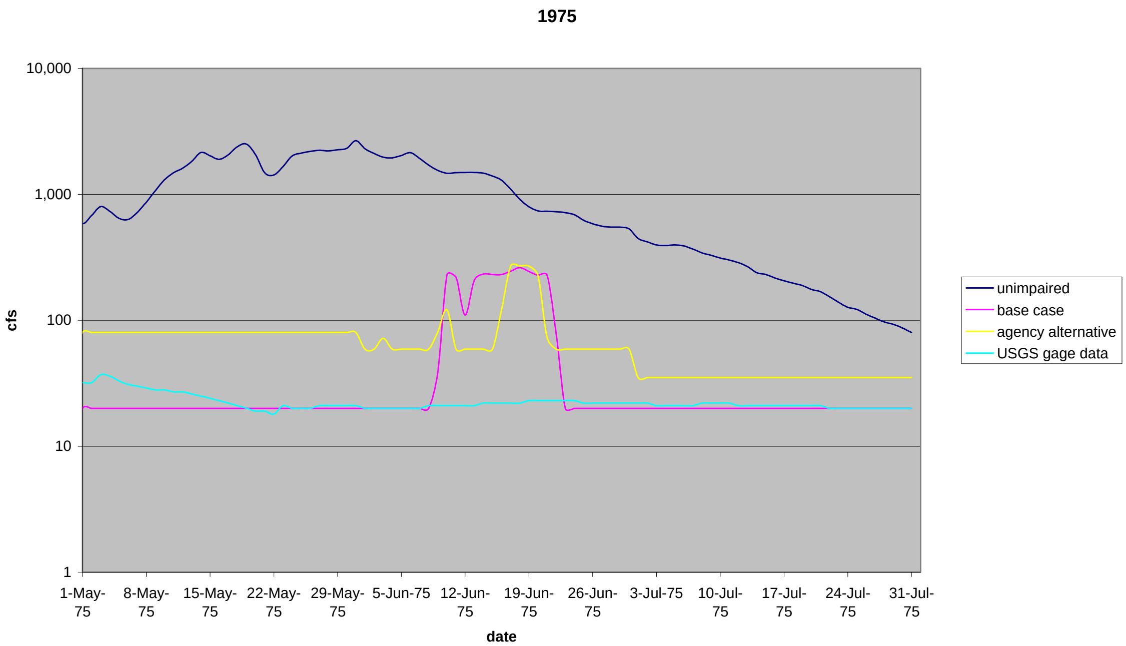


Fig. 10. Example of year in which proposed regimes would create pulsed flows during the potential breeding season (see also '93 and '99).

4. White water boating (WWB)

Surveys for *R. boylii* egg masses have not been conducted during May during the license application process (pers. comm. with Stillwater Sciences staff). The amphibian studies prepared by Stillwater and presented in the "Application for New License, July 2005" report that egg masses were found in June in 2003 and 2004, but it is possible that there were earlier clutches. Therefore we can not be sure that the WWB flows prior to Memorial Day will completely miss the breeding season**. When there will be boating flows in May, I recommend that there should be surveys or spot checks for clutches of eggs to make sure that breeding has not yet begun.** This spot check provision will help to achieve the goal identified on page 35 (Section 5) of the monitoring program: "Determination of presence and distribution of sensitive amphibian species and identification of breeding and larval periods are important in evaluating potential impacts resulting from streamflow modifications." It is interesting that the dates at which eggs were observed in 2003 and 2004 were when average water temps had already gone well past the 11-12 $^{\circ}$C mark, temperatures at which breeding has been observed to begin in other systems (Kupferberg 1996, Garcia and Associates, pers. comm.). It is possible that there is geographic variation in the temperatures at initiation of breeding. It is also possible that in regulated rivers where there is higher frequency of discharge fluctuation later into the spring there has been artificial selection for initiation of breeding at a higher temperature.

With regard to adaptive management of WWB, inclusion of the following wording is a welcome move in a cautionary direction. "If FS, CDFG, and SWRCB determine that unacceptable environmental impacts are occurring below Slab Creek Reservoir Dam due to October recreational streamflows based on amphibian monitoring described in Section 5, adaptive management measures may include but are not limited to cancellation of the October recreational streamflows". In my opinion, however, even greater caution in protecting ecosystem function, rather than just frog populations, is warranted. By ecosystem function I mean the flow of energy and carbon from the aquatic ecosystem to the terrestrial environment. This subsidy from the aquatic system is important to a wide range of consumers such as spiders, bats, birds, lizards, and others (Power et al. 2004). Also, there is a missing step in the logic which allows progression to a higher frequency of boating if impacts at the first level are "acceptable". If the ecosystem can tolerate the perturbation of the first increment of the recreational flow regime, there is no reason to assume that doubling the frequency of WWB flows will similarly not have a significant adverse impact. Although *R. boylii* are currently limited in their distribution in UARP, the general concerns about secondary production due to aseasonal pulsed flows are relevant for all the reaches with recreational WWB flows. I do not believe disruption of insect emergence would be detectable using the "aquatic health index" approach mentioned in the Monitoring Program Section 5.2 on p. 33. Dr. Vincent Resh, UC Berkeley, in consultation with the Ecological Resources Committee of the North Fork Feather River has suggested alternative metrics and thresholds that may be more appropriate for addressing these very same questions regarding aseasonal pulsed flow effects on macroinvertebrates. Late season life stages of aquatic insects in Mediterranean climates are adapted for low flow conditions where the predominant selective pressures are competition and predation rather than disturbance. Although there may be an occasional rainstorm in October, it is far outside the range of natural variability to have 8 storms that would cause large run-off events at a time of year when there is little antecedent soil moisture in the surrounding watershed. For these reasons, I reiterate that fall WWB flows are especially problematic.

With respect to adaptive management for spring WWB flows, the cancellation procedures require clarification. The 10 day notice period regarding temperature triggers would allow for a loophole if boating flows would continue as planned because of insufficient notification time. Notification should be as soon as possible. Given the high number of spring boating days, up to 28 after year 11, there potentially could be several pulsed flows before ten days are up.

5. Other comments on monitoring schedule

On page 34 of the Comprehensive Resource Agency / NGO Alternative the rationale for monitoring *R. boylii* each 5-year period is laid out. I anticipate that it will be necessary for the Forest Service and / or other agencies to invoke the option stated on p. 31 to "select an equal number of alternative years to ensure that surveys occur during a range of water year types." Due to the stochastic nature of the rainfall and snow pack variation, it is likely that the designated years will miss certain water year types. Because the discharge to stage and discharge to velocity relationships are site specific, it will be necessary to assess if the flow regimes associated with each water year type will achieve the stated goals of connecting egg laying habitat to larval rearing habitat as shoreline recedes. Similarly, to determine if there are cumulative effects of the new flow regime on *R. boylii* population dynamics, the lag time between effects on recruitment in one year and numerical response in the breeding population size some years later must also be taken into account when selection of years occurs.

Conclusion

My main concerns are about recreational flows and the changes in Slab Creek Reach with respect to the colder summer mean temperatures created by higher base flows. The precaution of assessing the effects of the cooler temperatures on *Rana boylii* prior to the consideration of fall recreational flows is well warranted. I would urge a similar precautionary approach with respect to understanding the relationships among discharge, temperature, and frog breeding in the spring. For years with May boating flows, especially Memorial Day weekend, there need to be spot checks to verify that breeding has not yet commenced. Clarification of the flow cancellation procedures is also needed.

Although I have been asked to comment specifically on *R. boylii*, because of my expertise with this species, I think it is important to conclude with a broader focus. To the extent that amphibians are indicator species, the foothill yellow legged frog's response to aseasonal pulsed flows in other northern California river systems illustrates the dangers of instituting a disturbance regime outside the evolutionary history of the organisms. Species inhabiting the rivers in California's Mediterranean climate have evolved life histories and traits for resisting disturbance that are synchronized with the predictable cycle of winter / spring floods and summer / fall drought. The higher minimum flows, and stepped reductions in spring flows in the agency/ NGO alternative proposal represent a return to a more natural shaped hydrograph in most years. Some of the recreational pulsed flows seem to be at cross purposes with the goal of mimicking the shape of the natural hydrograph. A cautionary approach is warranted.

Sincerely,

Sarah J. Kupferberg, PhD.

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