John G. Williams, Ph.D.
Environmental Hydrology

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Ms. Diane Riddle
Division of Water Rights
State Water Resources Control Board
P.O. Box 2000
Sacramento, CA 95812-2000
driddle@waterboards.ca.gov

Dear Ms. Riddle:

Here are my comments on the Revised Draft Environmental Impact Report (RDEIR), Consideration of Modifications to the U.S. Bureau of Reclamation's Water Right Permits 11308 and 11310 (Applications 11331 and 11332) to Protect Public Trust Values and Downstream Water Rights on the Santa Ynez River below Bradbury Dam (Cachuma Reservoir), dated July 2007. The RDEIR modifies and updates the State Water Resources Control Board's August 2003 Draft Environmental Impact Report. Changes include eliminating previously identified alternatives and adding two alternatives (5B and 5C). My review of the RDEIR focuses on the newly identified alternatives.

My qualifications for this review are detailed in the attached *c.v*. Briefly, I have worked on instream flow issues for many years, especially since I was appointed in 1990 as Special Master to supervise the court's continuing jurisdiction in *EDF v. EBMUD*, a case concerning the American River in which the instream flow needs of Chinook salmon and steelhead featured prominently. I have published several scholarly articles on methods for assessing instream flow needs, as well as a monograph on Chinook salmon and steelhead in the Central Valley that was commissioned by CALFED. I also served on the NMFS Central Valley Technical Recovery Team for listed salmonids, and on a panel that reviewed the Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan. I am also co-author of an article concerning stream-aquifer interactions, and have graduate training and publications in energy balance climatology. I am familiar with water-related modeling in general and with water system operations models from my years as Executive Director of the Bay-Delta Modeling Forum and from direct professional experience. Having served for seven years as an elected member of the Board of Directors of the Monterey Peninsula Water Management District, I am generally familiar with water management issues and CEQA.

After reviewing the RDEIR, with particular attention to its treatment of the instream flow and migration requirements of the population of steelhead (*Oncorhynchus mykiss*) in the Santa Ynez River, I have two main conclusions:

1) **The RDEIR does not provide an adequate basis for comparing or selecting among the new range of alternatives considered; and**

2) **The RDEIR does not provide an adequate basis for concluding that any of the new range of alternatives considered will meet the stated objective of the project.**

875 Linden Lane, Davis, CA 95616
530 753 7081 (voice) 530 756 3784 (fax)
jgwill@dcn.davis.ca.us

I have also concluded that:

The RDEIR fails to provide clear and meaningful descriptions of the alternatives;
The RDEIR alternatives are too similar to be meaningful choices;
The RDEIR fails to consider a large body of relevant science;
The method used in the RDEIR for analyzing and scoring flow-related impacts is fundamentally flawed;
The RDEIR ignores evidence considered in another EIR;
The analysis of water temperature in the RDEIR is deficient;
The RDEIR provides a disjointed and simplistic analysis of the condition of steelhead and other public trust resources that are affected by the project;
The RDEIR fails to analyze the effects of water rights releases on steelhead;
The RDEIR fails to analyze the effects of water quality in the mainstem Santa Ynez River on the success of incubating O. mykiss embryos and alevins;
The RDEIR fails to show that the steelhead population in the Santa Ynez River will be viable under any of the alternatives considered;
The RDEIR fails to show that fish below the dam will be in good condition under any of the alternatives considered.

The basis for these conclusions in presented below. I have also offered suggestions for improving the analyses.

In reaching these conclusions, I have considered not just the information provided or referenced in the RDEIR, but also information from the scientific literature, and from agency reports concerning recovery planning for various species of Pacific salmon, as well as various documents regarding the Santa Ynez River that have been submitted to the SWRCB previously. There is also a large literature dealing with methods for assessing the instream flow needs of fishes, and especially salmonids, to which I have contributed; reviews of this literature include Korman et al. 1994, EPRI (2000) and Annear et al. (2004). The RDEIR should, but does not, place the assessment method it adopts in the context of the methods generally used. I try to do this below, but in short, the method used by the RDEIR is remarkably simplistic, and the literature provides no support for any claim that it is adequate to support an assessment of the alternatives considered in the RDEIR. There is also a substantial and highly relevant literature dealing with analysis and recovery planning for evolutionarily significant units (ESUs) or "distinct population segments[1]" of Pacific salmon in Washington, Oregon, and California listed as threatened or endangered under the federal Endangered Species Act (e.g., Beechie et al. 2003;Good et al. 2005, Lindley et al. 2007; Boughton et al. 2007). In addition, NMFS has recruited a panel of very highly qualified scientists, the Recovery Science Review Panel (RSRP), to provide scientific oversight and guidance for the recovery planning process. One of the reports of this panel, RSRP (2004), is particularly relevant to the Santa Ynez steelhead.

[1] Usage by NMFS apparently is in flux, but out of habit I use the term ESU, without intending any distinction from "distinct population segment."

From a scientific perspective, however, and particularly from an ecological perspective, existing methods for assessing instream flows are unsatisfactory[2] (Castleberry et al. 1996; Anderson et al. 2006). Anderson et al. (2006) provide a good critique of common methods for assessing instream flow needs, as well as a discussion of the kinds of concepts that are needed for better assessment methods. There is considerable overlap between the ideas developed in various salmon recovery documents and in articles such as Anderson et al. (2006).

Of course, instream flow decisions cannot wait on the development of better methods for assessing instream flow needs. The appropriate response to this situation is set forth in Castleberry et al. (1996:20), who cited the decision in *EDF v. EBMUD* as exemplary:

> First, conservative (i.e., protective) interim standards should be set based on whatever information is available, but with explicit recognition of its deficiencies. The standards should prescribe a reasonable annual hydrograph as well as minimum flows. Such standards should try to satisfy the objective of conserving the fishery resource, the first principle of adaptive management (Lee and Lawrence 1986).
>
> Second, a monitoring program should be established and should be of adequate quality to permit the interim standards to serve as experiments. Active manipulation of flows, including temporary imposition of flows expected to be harmful, may be necessary for the same purpose. This element embodies the adaptive management principles that management programs should be experiments and that information should both motivate and result from management action. Often, it also will be necessary to fund ancillary scientific work to allow more robust interpretation of the monitoring results.
>
> Third, an effective procedure must be established whereby the interim standards can be revised in light of new information. Interim commitments of water that are in practice irrevocable must be avoided.

It should be noted that many of the authors of Castleberry et al. (1996) are highly distinguished. For example, Michael Healey is the interim Chief Scientist for CALFED, and Jennifer Nielsen is the past president of the American Fisheries Society. Below, I discuss the application of this approach to the Santa Ynez River.

The RDEIR does not provide an adequate basis for comparing or selecting among the alternatives considered.

The RDEIR fails to provide clear and meaningful descriptions of the alternatives

The descriptions of the new range of alternatives assessed in the RDEIR are difficult to interpret in physically meaningful terms. The problem is most easily explained by a counter-example, the description at p. 3-14 of an alternative that was assessed in the 1995 Cachuma Contract Renewal EIR/EIS:

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[2] I refer here to methods for assessing instream flows in advance of their implementation; instream flow regimes can be assessed by implementing them in a program of adaptive (i.e., experimental) management.

Alternative 3A2 involves operation of Lake Cachuma with releases to maintain the following minimum streamflows at selected locations downstream of the dam in order to improve steelhead habitat and general aquatic and riparian habitat conditions.

- 48 cfs 15 February to 14 April, then
- 20 cfs to 1 June, then
- 25 cfs for one week, then
- Ramp releases to 10 cfs by 30 June, then
- Hold at 10 cfs to 1 October, then
- 5 cfs for the rest of the year.

Under this alternative, the above flows are to be maintained at both San Lucas and Alisal bridges. These flows would be created by both natural streamflow and releases from the dam.

In contrast, the RDEIR describes alternatives in terms of the Biological Opinion or similar non-physical terms, for example, at p. 3-6:

4B. Operations under the Biological Opinion assuming Reclamation achieves a 3.0-foot surcharge and the discharge of SWP water to the river near Lompoc in exchange for water available for groundwater recharge in the Below Narrows Account established by Order WR 73-37, as amended by Order WR 89-18.

5B. Operations under the proposed CalTrout Alternative 3A2 during wet and above-normal water year types, with operations under the Biological Opinion during below-normal, dry and critical water year types, assuming Reclamation achieves a 3.0-foot surcharge, except that releases for fish rearing and passage will be provided with a 1.8-foot surcharge.

Even in the technical appendices, flows are described mainly in terms of exceedence curves, which are of limited utility for assessing instream flows, since they convey no information about the order in which flows occur. Hydrographs are much more informative for instream flow assessment.

The RDEIR alternatives are too similar

With respect to steelhead, the alternatives considered in the RDEIR are too similar to allow the SWRCB to make choices among alternatives that make a difference to the fish in most years; meaningful differences occur only in wetter years. For example, sufficient access to the ocean is a key requirement for steelhead. However, the average number of "passage days" estimated for the various alternatives (other than the no project alternative) ranges only from 34 for 4B to 38 for 5B and 5C, and the percentage of years with 14 or more passage days ranges only from 62% for 4B to 65% for 5B and 5C (Table 2A in Stetson Draft Technical Memorandum No. 6). Similarly, the median flows for January to April (50% exceedence) from Bradbury Dam to Highway 154 for these alternatives range only from 5.5 cfs for 3B, 3C, 4B and 5B to 5.8 cfs for 5C; from Highway 154 to Refugio Road they are identical (5.0 cfs); and from Refugio Road to Alisal Road they range only from 4.5 cfs for 3B and 3C to 4.8 cfs for 5B and 5C (Table 1 in Stetson Draft Technical Memorandum No. 6).

There is somewhat more contrast with respect to rearing, but in effect there are really only two alternatives. For the Bradbury Dam to Highway 154 reach for July through September the median flows for the alternatives (other than the no project alternative) are 11.7, 11.7, 11.2, 18.3 and 18.3 cfs (Table 1 in Stetson Draft Technical Memorandum No. 6).

The lack of adequate contrast among the new range of alternatives evidently results from concern about the potential effects of instream flow releases on water supplies (RDEIR, p. 3-14):

> The new Alternatives 5B and 5C are based on a variation of CalTrout Alternative 3A2 Adjusted for Dry Years. These alternatives would operate under two different sets of hydrologic conditions for releases of water from Cachuma Lake for fish. In wet or above-normal years, the criteria for fish water releases would be based on the proposed CalTrout Alternative 3A2, which would entail the increased stream flows outlined in that alternative. In below-normal, dry, or critical years, the criteria for fish water releases would be under the long-term Biological Opinion. The idea is to attempt to reduce impacts to water supplies by switching to the long-term Biological Opinion operating criteria in years of below-normal,[3] dry, and critical runoff conditions.

The CEQA process would have been better served if the RDEIR had assessed CalTrout Alternative 3A2 with the dry year adjustment (20% of the years) proposed by CalTrout. This would have provided a more meaningful range of alternatives for the SWRCB to consider. Decisions whether and how to reduce impacts on water supplies should come at the end of the process, not at the beginning.

The RDEIR fails to consider a large body of relevant science

Most species and ESUs of Pacific salmon (genus *Oncorhynchus*) are in decline in California, Oregon, and Washington, and many are listed as threatened or endangered under the federal Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) has organized a coast-wide process for planning the recovery of these species, and in the process has summarized much information about salmon and has developed useful concepts such as the Viable Salmonid Population (VSP) concept. Much of this material, including material published after the 2003 SWRCB hearing on the Santa Ynez River, is relevant for assessing the alternatives in the RDEIR, as discussed below, and all of it has been ignored by the RDEIR. Essentially, the RDEIR ignores all of the science and recovery planning that NMFS has generated since the 2000 Biological Opinion.

The method for analyzing and scoring flow-related impacts is fundamentally flawed.

At p. 4-51, the RDEIR states that:

> To provide an objective basis for comparing flow-related impacts among alternatives, a scoring system was developed to compare the effects of different flow regimes on fish habitat in the lower Santa Ynez and in Cachuma Lake using modeled flow. A scoring system to allow for comparison of the alternatives was set up on a relative scale of 0 to 5, with a score of 0 indicating little or no habitat value and a score of 5 indicating the higher habitat value."

[3] It is widely known that in Lake Wobegon, all the children are above average. Somewhat similarly, according to the RDEIR, on the Santa Ynez River, 60% of water years are below normal. See Figure 2, Stetson Draft Tech. Memo. No. 5.

Such a scoring system is not "objective." In reality, the RDEIR simply assigns ranks, based on the subjective judgment of the authors; each of the rankings could as well be bad, poor, ok, better, good. As shown below, the subjective judgment of the RDEIR authors is also biased in favor of water users and against the survival of steelhead. However, there is also a fatal technical deficiency with the rating system itself.

Besides using subjective rankings, the RDEIR misuses the rankings, by treating them as numbers from an interval scale, rather than as numbers from an ordinal scale. To understand this problem, consider other uses of numbers from an ordinal scale, such as the numbering of chapters in a book or the naming of kings. The numbers tell us the order in which the chapters or kings appear, but that is all, and it is obvious nonsense to talk about Chapter 3.5 or Charles the 3.5th. Similarly, the scoring system used in the RDEIR, for example in Table 4-41 (inserted below), tells us how the authors have ranked the associated conditions in nature, on a scale from worse to better. However, there can be no credible claim that conditions that score 3 are better than conditions that score 2 to just the same degree that conditions that score 5 are better than conditions that score 4. For example, Table 4-41 ranks 6 days of passage flows the same as 4 days, but 7 days is better than 6 days (Figure 1 shows this graphically). Therefore, the ratings cannot be manipulated by arithmetic, for example by taking averages. Unfortunately, this is what the RDEIR does, for example in the right-most column of Table 4-2 (inserted below), in an attempt to compare the alternatives. Looking at Table 4-2, we see that Alternatives 4B and 5B are given average scores of 3.5. However, talking about a score of 3.5 makes no more sense than talking about Charles the 3.5th. By reference to Table 4-1 or Figure 1, we can see that there are no conditions in nature that correspond to a score of 3.5 (the data here are the output of a computer model, which does not compute partial days). The number is essentially meaningless, and cannot serve to compare the alternatives. To the extent that the rankings are meaningful, they are only so within categories (e.g., passage). That alternatives are given the same average score is not evidence that they are equivalent, and that one alternative has a higher average score than another is not evidence that it is better.

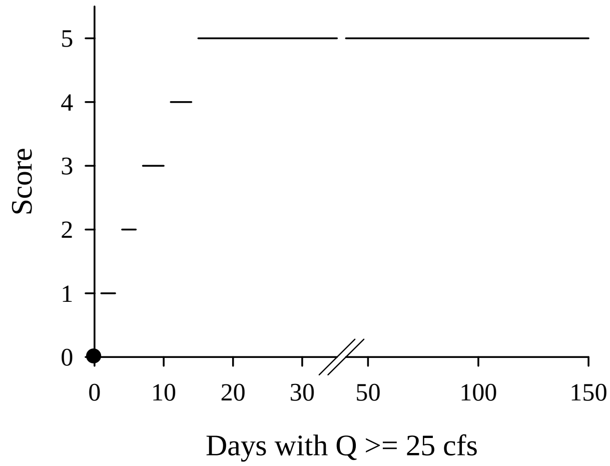
Table 4-41
Scoring Criteria For Steelhead Habitat

Life Stage	Flow Location	Months Considered	Scores					
			← better			worse →		
			(5)	(4)	(3)	(2)	(1)	(0)
Passage	Alisal Road	January - April	> 14 days*	11 to 14 days	7 to 10 days	4 to 6 days	1 to 3 days	0 days
Spawning	Highway 154	February – May	> 30 cfs	> 15 to ≤ 30 cfs	> 10 to ≤ 15 cfs	> 5 to ≤ 10 cfs	> 2.5 to ≤ 5 cfs	≤ 2.5 cfs
Fry Rearing	Highway 154	April - August	≥ 10 cfs	≥ 5 to < 10 cfs	≥ 2.5 to < 5 cfs	≥ 1.5 to < 2.5 cfs	> 0 to < 1.5 cfs	0 cfs
Juvenile Rearing	Highway 154	January - December	≥ 10 cfs	≥ 5 to < 10 cfs	≥ 2.5 to < 5 cfs	≥ 1.5 to < 2.5 cfs	> 0 to < 1.5 cfs	0 cfs

* A 'passage day' is defined as a flow of ≥ 25 cfs at the Alisal Road Bridge.

Frequency of Scores							
Alternatives	← better			worse →			
	(5)	(4)	(3)	(2)	(1)	(0)	(AVG)
2	21	4	2	5	5	15	2.7
3B	31	6	0	2	1	12	3.5
3C	31	6	0	2	1	12	3.5
4B	31	4	2	2	2	11	3.5
5B	33	2	1	3	2	11	3.5
5C	33	2	1	3	2	11	3.5

Figure 1: Graphical depiction of the RDEIR ranking for steelhead migration. Note that the ranking does not distinguish years with 14 days >= 25 cfs from days with 100 or more such days.



Besides being subjective, the RDEIR scoring system is biologically unsound. The scoring system is perhaps most deficient for steelhead migration (Figure 1), since it is based on a misreading of NMFS (2000) (hereafter also called the Biological Opinion) regarding the subject. At pp. 4-64 and 4-65, the RDEIR states that:

> Travel times for salmonids are not well defined in the literature. NMFS cites several studies of salmonid travel times which range from 8 to 31 miles per day (Groot and Margolis 1991, cited in NMFS 2000) to 1.85 to 18.4 miles per day (average of 4.6 miles per day) for steelhead in the Carmel River (Dettman and Kelly 1986, cited in NMFS 2000). NMFS also considered an analysis of recession curves derived from the Los Laureles gage (located above Cachuma Lake), which demonstrated that the recession from 150 cfs to baseflow took 14 days. Based on these studies, NMFS considered 14 days of passage in a particular year to provide adequate passage opportunities (NMFS 2000). A score of 5 was equated with years in which the number of passage days exceeded this threshold (Table 4-41; Figure 1). A score of 0 was equated to years that provide no passage opportunity. The remaining scores were assigned passage days by dividing the remaining passage days evenly amongst the scores. This reflects that, given the uncertainty and variability in steelhead travel times, passage opportunities to portions of the mainstem may be provided even with smaller numbers of passage days.

Contrary to the claim in the RDEIR, NMFS (2000) did not consider 14 days with flows of 25 cfs at Alisal Bridge to provide adequate opportunity for migration. Rather, at p. 36, NMFS (2000) states that “Based on the limited information available, it is NMFS’s best professional judgment that 14 days of *consecutive* migration ability is likely to significantly increase successful migration of steelhead in the Santa Ynez River” (emphasis added).[4] This does not say that 14 days is “adequate,” especially if the days are not consecutive, and in any event, for “adequate” to have any meaning, the RDEIR would have to specify what the 14 days would be adequate for. Does it mean adequate for some steelhead to migrate, or adequate to allow enough migration for the population to persist in the long term? The first meaning might be correct, but neither NMFS (2000) nor the RDEIR provide any evidence to support the second.

[4] The failure to consider whether the days are consecutive probably results from using exceedence curves instead of hydrographs for the analysis.

Moreover, in context, it is clear that NMFS is referring to situations where the 14 *consecutive* days begin with a peak of 150 or more cfs, usually when a natural flow peak is supplemented; in the same paragraph, NMFS (2000) states that "As the supplementation will provide a storm flow tail out that starts at 150 cfs, NMFS concludes that the proposal will ensure steelhead passage ... during supplementation." However, NMFS (2000:8) proposed that "The first storm [flow > 25 cfs] of the season not be supplemented, as it is considered a recharge storm to saturate the groundwater in the lower watershed for further releases." The scoring system does not account for this, and for this reason as well does not accurately reflect the Biological Opinion. Further, at p. 35, NMFS (2000) states that "In the opinion of the NMFS fishery biologists and hydraulic engineers, these criteria [e.g. 25 cfs at Alisal Bridge] are close to the minimums at which passage is possible, not water depth and width that produce good migration habitat" (emphasis in original). Finally, the RDEIR scoring does not take into account whether the mouth of the river would be open, which is clearly necessary for the flows to provide an opportunity for migration to anadromous fish.

Additionally, the RDEIR does not mention language in NMFS (2000) that the rate of flow is an important determinant of the rate of steelhead migration (p. 35); that is, the fish tend to migrate faster in higher flows. Thus, while extending the duration of flows of 25 cfs or more after a period of higher flow might allow successful migration, 25 cfs for 14 days without a higher peak might well not, especially if the days are not consecutive. Moreover, the tendency of fish to migrate more slowly when flows are low undercuts the rationale for the scores for years with fewer than 14 days with flows of 25 or more cfs. In particular, returning to the point about scales, there is no basis for assuming that a year with 10 days with flow of 25 or more cfs is sixty percent as good as a year with several months of such flows; for this to be true, the scoring system would need to be a ratio scale, not just an interval scale.

Thus, the scoring system gives its highest score to conditions that are best described as marginal. This matters, because it means that the system cannot distinguish between an alternative or year that provides marginal conditions for migration, and one that provides better than marginal conditions. For example, it does not distinguish between a year such as 1967, with over 90 days with simulated flow greater than 25 cfs, and years with 14 such days. Similarly, it does not distinguish between the migration flows of 48 cfs for two months provided in some years by Alternatives 5B and 5C and the lower migration flows of shorter duration provided by other alternatives. Since it cannot make such distinctions, the scoring system does not provide a rational basis for distinguishing among alternatives. At the very least, if a scoring system is to be used it should be based on biological reality, so that the highest score for passage, for example, would only be given to years that are unquestionably good for steelhead, such as 1967.

The scoring systems for spawning and for fry and juvenile rearing are similarly flawed. According to the RDEIR (p. 4-66), "The minimum, long-term rearing target flow level established by the Biological Opinion is 2.5 cfs. This flow was equated with a score of "3," which falls in the middle of the scoring range. Conditions without flow were scored "0." A score of "5" was given to flows greater than 10 cfs because this is the maximum rearing flow required in the Biological Opinion for habitat maintenance." In fact, a flow of 10 cfs in years with spills greater than 20,000 acre feet was simply part of the Bureau's proposed action, not a flow recommendation independently developed by NMFS. (In the "reasonable and prudent measures" section, the Biological Opinion states that "In addition to meeting the interim and long term flow targets described in the Description of the Proposed Action section, …", and then goes on to consider other measures.) NMFS (2000) offers relatively little analysis of the flow targets. The main point considered was that the proposed target flows would have higher exceedence values than existing conditions or historical flows (Table 1). However, nothing in NMFS (2000) suggests that habitat would not continue to increase as flows increase above 10 cfs. To the contrary, in discussing the water rights releases, the Biological Opinion (p. 45) states that "Thus available rearing habitat in water rights release years, including the area and depth of riffles, runs, and pools, will be temporarily increased while water rights releases occur." Again, the analysis in the RDEIR cannot distinguish flows that provide some habitat and flows that provide more habitat. In particular, the scoring system is blind to the flows greater than 10 cfs that are provided in 40% of years by Alternatives 5B and 5C.

Flow Cfs	% exceedence			
	Highway 154		Alisal Road	
	Target	Historical	Target	Historical
10	**40%**	**32%**	**34%**	**30%**
5	**78%**	**54%**	**40%**	**35%**
2.5	**98%**	**65%**	**45%**	**38%**

Table 1: Estimated percent exceedence at different minimum flows, copied from Table 11 in NMFS (2000).

The RDEIR also inappropriately supports the scoring of 5 for all flows greater than 10 cfs by considerations regarding the width of the stream; "In addition, the top-width versus flow relationships developed during the habitat analysis show that the rate of increase of habitat (i.e., top-width) typically declines above 10 cfs (SYRTAC 1999)." Effectively, this equates habitat with the width of the stream, which has little relationship to reality.[5] The analysis does not even consider the relation between flow and the length of channel with suitable habitat, so this approach does not even take account of the area of wetted habitat. Even on its face, the RDEIR does not say that habitat ceases to increase as flows go above 10 cfs, but rather only that the rate of increase declines.

The "top-width" method described by SYRTAC (1999) appears to be a simplification of the "wetted perimeter" method, but examination of the citations given indicates some confusion on the matter, and I have not found anything in the literature that provides significant support for the use of top-width as a measure of habitat quality. Even according to SYRTAC (1999:2-2):

> Generally, the greater the top width, the greater the amount of habitat. Changes in top width were considered from the standpoint of the absolute and relative change in top width from one flow to the next. Large changes in top width would indicate a large change in the amount of

[5] The analysis in SYRTAC (1999), to which the RDEIR refers, is not much better, although it considered width to depth ratios, maximum depth, and velocity at the thalweg at a relatively small number of transects in addition to width.

> potential living space available to steelhead. While top width is not the same as suitable habitat, it has been used as an index of the amount of habitat available in the past (Swift 1976, Annear and Condor 1983, Nelson 1984). While top width can be used as an index of habitat quantity, it does not address habitat quality. For instance, a section of stream that is 100 feet wide and two inches deep provides less habitat for fish than a channel that is 20 feet wide and two feet deep.

The three citations given by SYRTAC (1999) are Swift (1976), (Annear and Condor 1983), and Nelson (1984). I have not been able to locate Nelson (1984), which is an unpublished report, but I have reviewed Swift (1976) and Annear and Condor (1983). I have also reviewed Annear et al. (2004), which among other things describes various methods for instream flow assessment. The title of Annear and Condor (1983) is "Relative bias of several fisheries instream flow methods." The methods considered were the Tenant method, wetted perimeter curves, habitat retentions models, and the physical habitat simulation system (PHABSIM). According to Annear and Condor (1983:534), "An unbiased [maintenance flow] was defined for each stream as the mean (plus 95% confidence interval) of all recommendations for that stream. The recommendation from each method for each stream was then compared to this unbiased range to determine its predictive tendency." Thus, the study only compared the methods to each other; no real biological evaluation was involved. However, Annear and Condor (1983:532) do provide a brief definition of the method:

> This [wetted perimeter] method assumes that a direct relationship between wetted perimeter and fish habitat exists in streams. By plotting the response of wetter perimeter to incremental changes in discharge, the investigator usually can identify an inflection in the resulting curve where small decreases in flow result in increasingly greater decreases in wetted perimeter. This point on the curve represents a flow at which the water surface recedes from the stream banks and fish habitat is lost at an accelerated rate. This flow is the instream flow estimate. …

Regarding the wetted perimeter method, Annear and Condor (1983) also reported that "None of the methods in this [wetted perimeter] category generated a significant number of unbiased [maintenance flow] estimates." That is, the recommendations were generally different from those of the other methods considered.

Annear and Condor (2004:163-164) give a similar description of the wetted perimeter method, and make the following observations:

> **Appropriate Scale:** River reach. Should only be applied to riffle mesohabitat types.
>
> …
>
> **Assumptions:** The method application assumes that the flow represented by the breakpoint will protect the food producing riffle habitats at a level sufficient to maintain the existing fish population at some acceptable level of sustained production. The method further assumes that the stream channel is stable and unchanging over time.
>
> …
>
> **Historical Development:** Initially the model was based on multiple measurements to develop empirical relations. It is now common to use computer programs to analyze cross sections and develop stage-discharge relations and wetted perimeter plots (Grant et al. 1992). Gippel and Stewardson (1996) critically evaluated the "inflection point" and noted that the determination of the breakpoint is highly error prone. The also presented a technique for mathematically defining the point of maximum curvature. Annear and Condor (1983) likewise found considerable variation in using inflection points for determining instream flow levels when

> compared to other methods. Early reports (Collings 1974) estimated that the discharge represented by the breakpoint protected 50-80% of the maximum available wetted perimeter. The Oregon Department of Fish and Wildlife recommended that at least 50% of available wetter perimeter be maintained (Ken Thompson, personal communication; Stalnaker and Arnette 1976), Tennant (1976b) found that discharges covering 50% of the wetted perimeter in Montana streams represented approximately 10% of the mean annual flow. Nelson (1980) attempted to demonstrate healthy standing crops of trout in Montana streams subject to flow flows defined by the wetted perimeter. Gippel and Stewardson (1996) found that the discharge represented by the wetted perimeter breakpoint in two high mountain streams in Australia was similar to the 95% exceedence flows. Dunbar et al. (1998) concluded that the discharge determined by the breakpoint still significantly reduced invertebrate production.

Thus, of the various studies cited, only Nelson (1980) and Dunbar et al. (1998) attempted any biological testing of the wetted perimeter method. It is not clear from Annear et al. (2004) what Nelson (1980) found (this is another unpublished report), and the findings of Dunbar et al. (1998) do not reflect well on the method, which is supposed to protect food producing riffle habitat. As noted by Annear et al. (2004), the method depends on an assumed relationship regarding invertebrate production, rather than empirical evidence. The method also assumes that the channel is stable. As is revealed by a quick examination of the Santa Ynez River on Google Satellite, the channel of the river is clearly not stable. In the 2003 SWRCB hearing, one of the biologists on the SYRTAC, Jean Baldridge, testified that “We ended up rejecting the PHABSIM in the reach below 154 because of the dynamic nature of the channel;” however, the same objection applies to the top-width method.

The other study cited by SYRTAC (1999) is Swift (1976). This describes a superficially similar but actually rather different method, which Annear et al. (2004) called the “Washington toe-of-bank width method.” According to Swift (1976:2):

> This report presents the results of studies made at 54 reaches on 18 streams in western Washington to (1) measure the stream discharges and spawnable areas corresponding to depths and velocities preferred by spawning steelhead, (2) measure the stream discharge and wetted perimeter of each stream channel corresponding to a water stage that covers the streambed but not the channel banks, as an evaluation of rearing conditions, and (3) develop equations relating the resulting stream discharges and wetted perimeters at the study reaches to drainage-basin and stream-channel parameters. Thus, estimates of discharges for the spawning and rearing characteristics preferred by steelhead trout can be derived from the equations presented herein. These equations, coupled with other requirements for steelhead propagation, can be used as a basis for allocating streamflows for steelhead at stream sites where measurements are not available.

In other words, Swift (1976) developed empirical relations from a set of streams in western Washington for application to other streams in the region. Swift (1976) used plots of average wetted perimeter over discharge to identify what he called “rearing discharge’, Qr, as shown one of his figures (copied below as Figure 2), but he did not describe Qr as the discharge producing optimal habitat or as the appropriate discharge for a flow standard. Rather, he described it as the discharge that “just covers the streambed,” and stated that flow standards should be higher than Qr (pp. 9-10):

> 4. Qr, the rearing discharge, is the discharge that provides water that just covers the streambed. It is related to the availability of aquatic insects serving as a food supply for fish. The rearing discharges determined in this report are much less than the spawning discharge, and flows of less than the rearing discharge would be critical at any time during the year. Thus, maintaining flows *in excess of* the rearing discharge would be of prime importance in allocating streamflow for steelhead rearing. (Emphasis added)

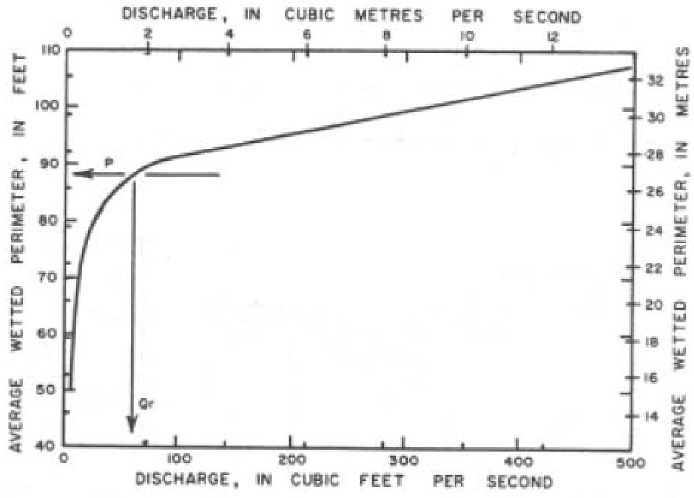


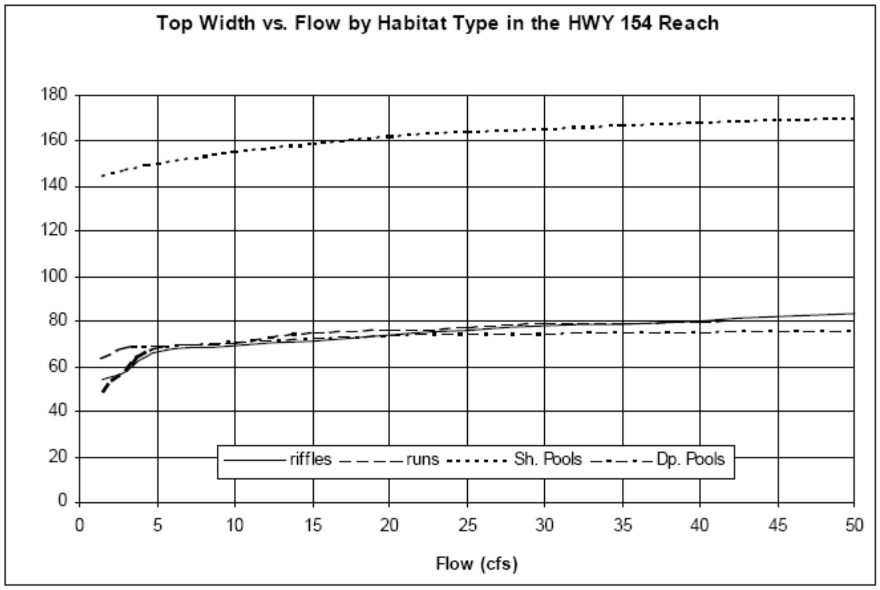
Figure 2. A figure from Swift (1976), showing the relation between average wetted perimeter and discharge, and identification of Qr. Copied from Swift (1976).

Although it is not discussed in the works cited above, it seems an implicit assumption of the wetted perimeter method that the river does not run out of water, that is, that the discharge in the stream is more or less constant through the study reach, so that that the width measured at transects more or less reflects the area of the stream. The Santa Ynez River in the summer is a losing stream that does run out of water, at least on the surface, so a more complex analysis is required to take account of the relation between flow released from the dam and the resulting area of habitat. The RDEIR does not provide such an analysis.

Additionally, the application of the top-width method by SYRTAC (1999a), like almost all of the instream flow literature, ignores basic statistical considerations. In particular, the curves of top width over flow are given without confidence intervals. The curves are estimated from data, either measured or modeled, and are therefore subject to error. The actual error is in general unknown, but the error can and should be estimated. The normal way to do this is to construct confidence intervals around the curves, which SYRTAC (1999a) did not do. In science, statistics are not an optional nicety; statistics is the science of collecting, analyzing, and presenting data. Studies that could but do not follow appropriate statistical procedures do not provide a suitable basis for management decisions.

Finally, the RDEIR does not describe the results of SYRTAC (1999) accurately. As noted above, the RDEIR states that "In addition, the top-width versus flow relationships developed during the habitat analysis show that the rate of increase of habitat (i.e., top-width) typically declines above 10 cfs (SYRTAC 1999)." Actually, to the extent that there is a "breakpoint" in the curves, it occurs around 5 cfs, rather than 10 cfs, as shown for the Highway 154 reach in Figure 4. Thus, the faulty top-width analysis contradicts, rather than supports, the 10 cfs flow target given in the Biological Opinion.

Figure 4: Top width v. flow in the Hwy 154 reach, copied from SYRTAC (1999).



In summary, the top-width or wetted perimeter method is a simple, first-cut approach for determining minimum flows that is based on an assumption regarding invertebrate production, rather than on fish habitat requirements. It has never been properly tested. As I explain below, better methods are available. In the RDEIR, the top-width method (1) is improperly applied to habitats other than riffles (2) is improperly applied to an unstable channel, (3) does not estimate habitat area for fish, and (4) does not meet ordinary scientific norms for statistical practice. It does not provide a rational basis for balancing the habitat needs of an endangered species against out of stream uses of water.

The RDEIR provides a disjointed and simplistic analysis of the condition of steelhead and other public trust resources

Analyzing the effects of water projects on aquatic species and ecosystems is extremely difficult, and completely satisfactory methods for doing so have not yet been developed (Castleberry et al. 1996; Anderson et al. 2006). Nevertheless, a basic principle is clear: analyses of effects on particular species must deal with their life cycles in an integrated fashion, in the context of the ecosystems in which they occur. The RDEIR notes that anadromous steelhead must pass through a life cycle that involves two migrations along the river as well as incubation and rearing. Fish that cannot complete any of these phases will not reproduce. However, the RDEIR analyzes conditions for these life history phases separately, without consideration that fish must pass through them sequentially. As an example, the analysis of migration does not consider whether the mouth of the lagoon is open. Similarly, the analysis of migration opportunity does not consider whether years with adequate opportunity for smolt migration are preceded by good conditions for rearing. Rather than simply counting the frequency with which suitable or unsuitable conditions occur for migration, spawning, rearing, etc., the RDEIR should consider the frequency and consistency with which conditions occur that will allow steelhead to complete their life cycle.

The shortcomings of this kind of analysis and methods such as the top-width approach are well known among fisheries biologists working on instream flow issues as well as among ecologists such as Anderson et al. (2006). According to Annear et al. (2004), in their book titled Instream Flows for Riverine Resource Stewardship, published by the Instream Flow Council (2004:4-5):

> During the late 1960s and 1970s, the science of instream flow began to develop as reflected by a proliferation of methods to assess instream flow needs (Osborn and Allman 1976). Some of the attempts to develop "better" methods resulted form hydrologic statistics or "rules-of-thumb." We now know that the resulting minimum flows for one life stage of one species, such as summer spawning, do not ensure that ecosystem functions, sustained aquatic communities, or adequate habitat protection will continue even for the species for which the minimum flow was established (Calow and Petts 1992, 1994). Increased access to computers in the 1970s and 1980s coupled with increased knowledge of aquatic system and organisms resulted in more sophisticated methods. However, even when approaches such as the Instream Flow Incremental Methodology (IFIM) were employed, the tendency was to focus on only one or a few river-dwelling species (usually sport fish), life stages, or habitat needs (Stalnaker 1993). A single species orientation remains the hallmark of instream flow analysis. Even methods such as the much used Physical Habitat Simulation System (PHABSIM) have often focused on assessing one species or setting one minimum flow (Stalnaker et al. 1995). … Many of the methods developed in the mid-1970s remain in use today, and, while they are not appropriate for identifying all the requirements for effective stewardship, some may be useful in situations such as project screening or feasibility assessment (Stalnaker 1990).

To try to improve on this situation, the National Instream Flow Program Assessment Committee, and later the Instream Flow Council (IFC), developed a conceptual model of the elements that are necessary for effecting instream flow protection (IFC 2004:5-6).

> The main principle of this [conceptual model developed by the IFC] is that the flow regime is the dominant variable in determining the form and function of a river. Factors such as the shape of the channel, abundance and diversity of its fish and other organisms, and sustainability are directly determined by flow patterns (Hynes 1970; Poff et al. 1997). Consequently, to maintain or rehabilitate the integrity of flowing water ecosystems, instream flow practitioners must recognize the importance of both inter- and intrannual streamflow patterns for maintaining natural processes in streams. Wherever possible, managers should base their decisions on the concept of natural flow variability and the need to balance sediment input with transport capacity. Thus, a true minimum flow to maintain riverine processes is a quantity of water rather than a single, continuous *rate* of flow distributed over time in varying amounts to maintain natural stream processes. …

The RDIER ignores evidence considered in other EIRs

As a practical matter, habitat assessment in the Santa Ynez River is complicated by the lack of access to a critical reach. The RDEIR states that "The Highway 154 Reach was selected as the index location for spawning and rearing habitat because it contains the best quality habitat available in the mainstem (SYRTAC 2000a). Much of this reach is located on private property and no additional data collection efforts have been undertaken except in the short reach near the dam." [6] The Department of Water Resources did have access to this area in the 1980s, however,

[6] It seems strange, methologically, to select as an index reach a part of the stream that is mostly inaccessible.

and in 1989 DWR produced a "Draft Santa Ynez River instream flow needs study." Data on stream depth and velocity at transects were collected for that study, and SYRTAC (1999) used these data for the now-inaccessible part of the reach. Presumably, the DWR report was the basis for the following discussion of the Santa Ynez River in Chapter 8 of the 1993 California Water Plan, California Dept. of Water Resources Bulletin 160-93.

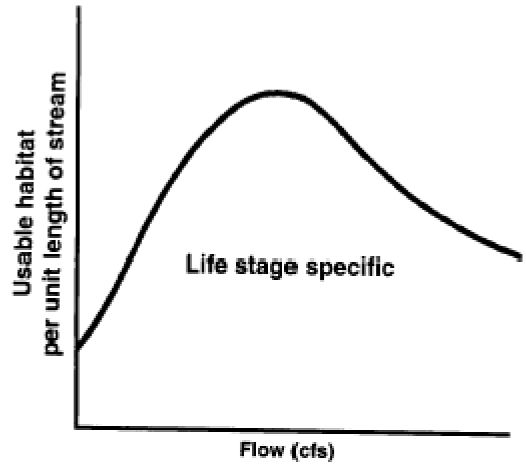
> **Santa Ynez River.**. The Santa Ynez River system historically supported the largest run of steelhead trout in Southern California. However, much of the main channel is now of poor quality or unsuitable for spawning and rearing due to low or nonexistent flows, high temperatures, passage barriers, and habitat degradation. A self-sustaining population of trout remains in one of the tributaries, Salsipuedes Creek, but numbers are low. Rearing habitat is especially limited in the creek and it appears that run size depends on the magnitude of winter storms.
>
> The river is regulated in its upper reaches by Juncal Dam and Gibralter Dam and downstream by Bradbury Dam and Lake Cachuma. There is presently [in 1993] no instream flow requirement for the river; Lake Cachuma is operated to fill the lower ground water basin and to protect downstream water users. Some information is available about the possible effect of different levels of instream flow from studies associated with the proposed enlargement of Lake Cachuma. Analyses show that if water quality is satisfactory and flows are constant, releases of 50 to 120 cfs are needed to provide optimal habitat between Bradbury Dam and Buellton. Maintaining flows in the reach between the ocean and the confluence with Salsipuedes Creek appears to be particularly important to allow steelhead to reach the highest-quality spawning habitat. Lower flows of from 6 to 50 cfs may also be beneficial if combined with habitat improvement.

If flows of anything like 50 to 120 cfs are needed to provide optimal habitat downstream from Bradbury Dam, then the scoring system used in the RDEIR, which gives no credit to flow increases above 10 cfs, seem hard to justify. The DWR study used PHABSIM, which I have criticized in the professional literature (e.g., Williams 1996; Williams et al. 1999; Kondolf et al. 2000; Williams 2006). Therefore, I do not endorse the report's findings, although PHABSIM is more credible than simply considering stream width. It seems strange, however, that the RDEIR does not even mention this study, or the analysis in the 1995 Cachuma Contract Renewal EIR/EIR that depended on it.

Moreover, on general grounds it seems highly likely that increases in flow beyond 10 cfs will increase the quality or quantity of habitat for juvenile steelhead. The usual assumption is that for a given species and life stage in a given channel there is some dome shaped relationship between flow and habitat, such as in Figure 3.1 in Gillilan and Brown (1997), copied here as Figure 4.[7] In general, the bigger the channel, the larger will be the flow at which habitat peaks. Thus, within the range considered by the RDEIR, the alternatives that provide higher flows, 5B and 5C (or 3A2 as modified by CalTrout), should provide better habitat conditions for steelhead.

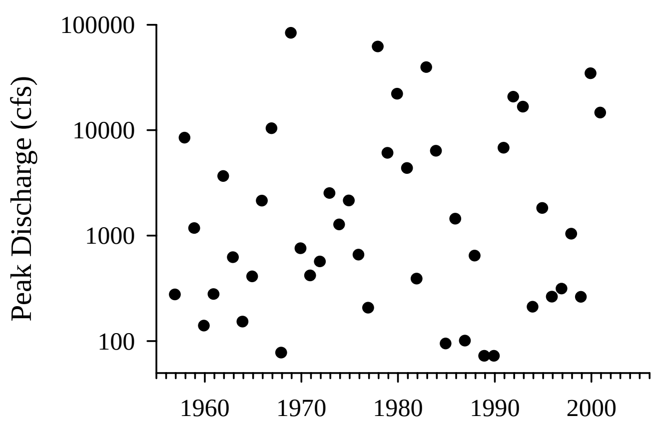
[7] This does not apply to situations where high flows spill onto a flood plain and provide rearing habitat there, but such situations are now uncommon in the USA, because of flood control measures.

Figure 4. A generalized relationship between flow and habitat for a given species and life-stage, in a given channel, copied from Gillilian and Brown (1997). This figure is from a discussion of PHABSIM, but the idea depicted of a domed shaped relationship between flow and habitat is more general.



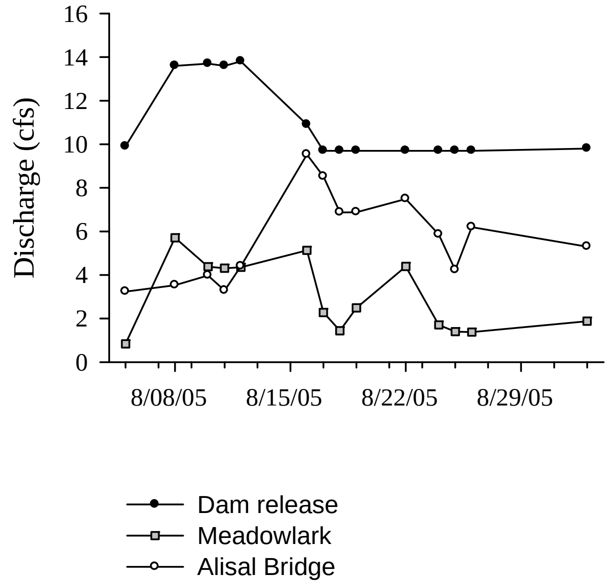
Peak flows greater than 10,000 cfs are common on the Santa Ynez River (Figure 5), and the channel can be expected to adjust to these flows, since the banks are generally non-cohesive. For a channel shaped by such large flows, it would be surprising if habitat did not continue to increase with flow well beyond 10 cfs.[8] Moreover, increased flows below Bradbury Dam should increase the longitudinal extent of suitable habitat, defined in terms of water quality, especially temperature, as well as the geometry of the channel. The potential effect of increased flows on the area of habitat can be seen in data from August 2005 (Figure 6). When releases from Bradbury Dam were increased from ~10 to ~13.7 cfs, flows farther downstream similarly increased, although with some time-delay. Note that the increase in releases resulted in more than a fourfold increase in discharge at Meadowlark, 5.4 miles below the dam. The RDEIR is deficient in not considering the longitudinal increase in potential habitat with increasing releases. Among other problems, this obscures the contrast between alternatives 5B and 5C and other alternatives that occur in simulated wet years.

Figure 5. Peak flows in the Santa Ynez River near Solvang; data from USGS gage 11128500.



[8] I have not visited the Santa Ynez River for some years, but my memory of the channel, reinforced by touring the river by Google Satellite, is consistent with habitat peaking at flows well above 10 cfs.

Figure 6. Flow in the Santa Ynez River, August, 2005, just below Bradbury dam (black circles), 5.4 miles downstream (gray squares), and 9.5 miles downstream (open circles). Data from summary of an August 23 Adaptive Management Committee conference call.



The analysis of water temperature in the RDEIR is deficient

The RDEIR includes a brief discussion of water temperature, but lacks data or analyses that are needs to assess the alternatives considered. The discussion of the effects of water temperature on steelhead habitat in the RDEIR is almost entirely limited to the following, at p. 4-70:

> Water temperature may also be a limiting factor for steelhead/rainbow trout in the mainstem of the Santa Ynez River. Water temperature increases longitudinally in distance from Bradbury Dam (SYRTAC 1997). The Highway 154 Reach is about the limit of where releases from Bradbury Dam can provide water temperatures in the preferred range for steelhead/rainbow trout. Even with larger releases of water, such as the WR 89-18 releases, water temperature tends to remain high as distance increases from the Bradbury Dam (SYRTAC 1997). For example, before the 1996 WR 89-18 release, water temperatures were 18.6 to 19.6°C at 7.8 miles from Bradbury Dam (Alisal Reach). After the release, water temperatures were 17.0 to 25.1°C (SYRTAC 1997). At 9.5 miles from Bradbury Dam, water temperatures were 19.4 to 22.5°C before the release and 17.0 to 27.1°C after the release at the bottom of a pool (SYRTAC 1997). Cool water refuges, caused by groundwater upwelling, have been found in several pools in the Refugio and Alisal reaches, creating cool pockets of water in these reaches. These thermal refuges play an important role during periods of warm temperatures for steelhead/rainbow trout rearing.

The statement that "The Highway 154 Reach is about the limit of where releases from Bradbury Dam can provide water temperatures in the preferred range for steelhead/rainbow trout" is not supported by any useful data or analysis. The Highway 154 reach is only 2.9 miles long. The anecdotal information provided about temperatures 4.9 and 6.6 miles farther downstream does not adequately support the statement.

As a generality, water in a stream has an equilibrium temperature with respect to given environmental conditions, especially air temperature. (Since environmental conditions vary diurnally, the equilibrium temperature will similarly vary, so for a stream such as the Santa Ynez River it is reasonable to think about an equilibrium temperature cycle, but the principle is the same. Deas and Lowney (2000) provide a recent review.) When water is released from a dam at a temperature lower than the equilibrium temperature, it will gain heat as it moves downstream, until it reaches the equilibrium temperature. How far downstream this occurs will be affected both by the mass of the water and by its velocity, as well as by the difference between the release temperature and the equilibrium temperature. Both the mass of the water and its velocity increase with discharge, so it is reasonable to expect that the length of habitat with suitable or at least tolerable water temperature will increase with discharge. For example, the higher spring flows in some years in Alternatives 5B and 5C (and especially in the 3A2 alternative proposed by CalTrout) should result in a greater length of river with suitable habitat in the late spring than other alternatives. This can be evaluated with modeling, as described by Deas and Lowney (2000). Exchange of water between the surface and subsurface components of the flow may complicate the situation, but in any event the subject deserves much more data and analysis than the RDEIR provides.

The RDEIR fails to analyze the effects of water rights releases on steelhead

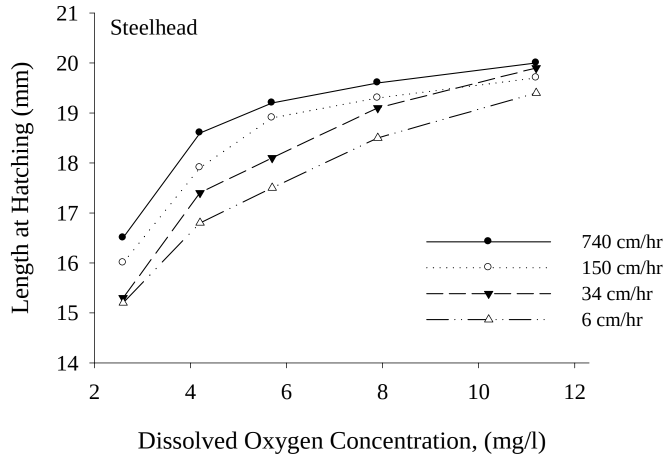
At p. 78, the Biological Opinion (2000) states that: "Water rights releases produce a number of adverse effects to steelhead attempting to rear in the mainstem, most notably to steelhead 3.5 to 10 miles downstream of Bradbury Dam. NMFS recommends Reclamation investigate and implement alternative means of providing water … that would avoid and/or minimize adverse effects …" More detail on the disruption of thermal stratification by the releases is provided at pp. 46-47 of the Biological Opinion. The RDEIR does not discuss this problem, nor does it consider alternatives that integrate the water rights releases with the instream flow releases, which it should.

The RDEIR fails to analyze the effects of water quality in the mainstem Santa Ynez River on the success of incubating steelheads embryos and alevins

The RDEIR provides very little information on dissolved oxygen generally. However, according to the Biological Opinion (NMFS 2000; 48). "In the spring, fall, and winter, cooler temperatures and increases in flows appear to raise dissolved oxygen levels to 7-8 ppm in most cases." The Biological Opinion further states that salmonids function normally at dissolved oxygen levels of 6-8 ppm. However, this is incorrect regarding embryos. The size of hatching steelhead is somewhat reduced at 7-8 mg/l,[9] compared to higher levels of dissolved oxygen (Figure 7), and dissolved oxygen in the redds will be lower than in the surface stream, likely by several mg/l, since dissolved oxygen is taken up by biological activity as it passes through the hyporheic (subsurface) zone (Hendricks and White 2000). Given the relatively low dissolved oxygen levels reported for the surface stream, dissolved oxygen in the hyporheic zone should be considered when assessing potential spawning habitat in the mainstem. Alternatives with higher flows during the incubation season for steelhead (i.e., 5B and 5C) should result in higher rates of hyporheic flow and better water quality in the hyporheic environment.

[9] Mg/l and ppm are essentially equivalent.

Figure 7. The relationship between dissolved oxygen concentration and the length of hatching steelhead, based on Silver et al. (1963). [Copied from Williams 2006]



The RDEIR does not provide an adequate basis for concluding that any of the new range of alternatives considered will meet the stated objectives of the project.

Besides failing to provide a rational basis for selecting among the alternatives considered, the RDEIR does not provide a reason for concluding that *any* of the alternatives considered will meet the stated objectives of the project. Moreover, a strong case can be made that measures to provide passage for steelhead around Lake Cachuma, not considered by the RDEIR, are necessary to meet the objectives.

The proposed project is, as defined at p. 1-1:

> Development of revised release requirements and other conditions, if any, in the Reclamation water rights permits (Applications 11331 and 11332) for the Cachuma Project. These release requirements will take into consideration the National Marine Fisheries Service's Biological Opinion and the draft Lower Santa Ynez River Fish Management Plan and other reports called for by Order WR 94-5. The revised release requirements are to provide appropriate public trust and downstream water rights protection. Protection of prior rights includes maintenance of percolation of water from the stream channel as such percolation would occur from unregulated flow, in order that the operation of the project shall not reduce natural recharge of groundwater from the Santa Ynez River below Bradbury Dam.

Assessing whether the proposed alternatives will "provide appropriate public trust … protection." requires some consideration of what level of protection for public trust resources is appropriate. Ultimately, this judgment must be made by the State Water Resources Control Board (SWRCB), but its discretion is guided by existing laws and public policy. In exploring this issue, I have used primarily two considerations, based in state and federal law. The first consideration is based in Fish and Game Code section 5937, which requires that enough water be released to keep fish below the dam in good condition. I have adopted and extended the definition of "good condition" described by Dr. Peter Moyle in Exhibit CT-70 and in greater detail in Moyle et al. (1998). The second consideration is based in the Endangered Species Act, which promotes the recovery of listed species and the protection of their environments. The Viable Salmonid Population (VSP) concept has been developed to assist in recover planning for Pacific salmon, including steelhead (McElhaney et al. 2000), and more recent documents discuss application of the VSP concept to steelhead, including southern California steelhead (Lindley et al. 2007; Boughton et al. 2007).

The RDEIR fails to provide reasonable evidence that the steelhead population in the Santa Ynez River will be viable under any of the alternatives considered

Whether a population is viable under the VSP concept depends on two tests. First, the population must be independent, in the sense that its population dynamics or its risk of extinction "over a 100-year time period are not substantially altered by exchanges of individuals with other populations (McElhany et al. 2000: xiii)." The second test is whether the population has a "negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes" over a period of 100 years. Whether a population is viable should be considered in terms of its abundance, growth rate, spatial structure, and diversity. In recognition of the diversity of situations in which the VSP concept will be applied, however, McElhany et al. (2000) provide guidelines rather than explicit rules by which the determination of viability should be made, leaving development of more explicit rules to the geographically specific technical recovery teams. Such rules have been developed for southern and south-central coast steelhead by Boughton et al. (2007), and for Central Valley Chinook and steelhead populations by Lindley et al. (2007). The Lindley et al. (2007) criteria are summarized in Figure 9, and I frame my discussion in terms of them because, as one of the et al., I am familiar with the thinking behind them. The RDEIR should have some analysis of this sort to determine whether the *O. mykiss* populations of the Santa Ynez River are viable.

	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	$>$ 20% within 20 years	$>$ 5% within 100 years	$<$ 5% within 100 years
	– or any ONE of –	– or any ONE of –	– or ALL of –
Population size[a]	$N_e \leq 50$	$50 < N_e \leq 500$	$N_e > 500$
	–or–	–or–	–or–
	$N \leq 250$	$250 < N \leq 2500$	$N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.

[b] Decline within last two generations to annual run size $\leq$ 500 spawners, or run size $>$ 500 but declining at $\geq$ 10% per year. Historically small but stable population not included.

[c] Run size has declined to $\leq$ 500, but now stable.

[d] Catastrophes occuring within the last 10 years.

[e] Decline $<$ 90% but biologically significant.

[f] See Figure 1 for assessing hatchery impacts.

Figure 9. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids. Overall risk is determined by the highest risk score for any category. (Modified from Allendorf et al. 1977) [copied from Lindley et al. 2007.]

Whatever specific criteria are employed for assessing population viability, population size is critically important. Recent population data on Santa Ynez steelhead are scant. Good et al. (2005:283), discussing the populations in various tributaries as well as the main stem, state that “Run sizes are unknown, but likely small (<100 adults total), implying the populations are not viable over the long run.” Data on redd observations from Robinson et al. (2007), summarized in

Table 2, are consistent with this estimate. These data need to be treated with caution, because not all redds would have been observed, on the one hand, and steelhead may dig more than one redd, on the other. However, for the five years with the most data, the number of redds observed averaged 48.6 for the mainstem and the tributaries combined, and Robinson et al. (2007) report that "The majority of redds observed appeared to be from resident rainbow trout inhabiting the basin (based on redd dimensions), particularly in dry and normal years."

Robinson et al. (2007) also report data from traps in Hilton Creek and Salsipuedes Creek (Figure 9). High flows and other problems can interfere with trapping, but the data show that pumping water from Lake Cachuma into Hilton Creek, which began in 2000 has been helpful. Nevertheless, since the efficiency of the traps is reported to be high, the data indicate that the number of fish in these creeks is small. As noted below, it is also apparent that predominantly resident or hatchery fish are using the improved conditions in Hilton Creek.

Table 2. Redd observations reported by Robinson et al. 2007. The habitat columns are for Hilton Creek (HC), lower Salsipuedes Creek (LSC), upper Salsipuedes Creek (USC), El Jaro Creek (EJC), Los Amole Creek (LAC), Nojoqui Creek (NC), Quiota Creek (QC), San Miguelito Creek (SMC), Hwy 154 Reach Santa Ynez River (154R), Refugio Reach Santa Ynez River (RR), Alisal Reach San Ynez River (AR), and Avenue of Flags Reach Santa Ynez River (AFR). See cautions in the text regarding interpretation of the data.

Year	Habitat											
	HC	LSC	USC	EJC	LAC	NC	QC	SMC	154R	RR	AR	AFR
1996	--	**7**	**0**	**6**	--	--	--	--	--	--	--	--
1997	**0**	**14**	**11**	**18**	--	--	--	**49**	**0**	**0**	**0**	**0**
1998	**0**	**0**	**3**	**0**	--	**0**	--	**1**	**0**	**0**	**0**	**0**
1999	**1**	**49**	**16**	**0**	--	**0**	--	**35**	**5**	**1**	**0**	**0**
2000	**0**	**5**	**14**	**0**	--	**0**	**1**	**0**	**0**	**0**	**0**	**6**
2001	**3**	**0**	**12**	**0**	--	**0**	**0**	--	**0**	**0**	**0**	**0**
2002	**0**	--	--	--	4	--	**3**	--	**2**	--	--	--
2003	**9**	7	--	**3**	--	--	**0**	--	--	**0**	0	--
2004	**15**	**0**	--	**0**	**1**	**0**	**0**	--	**0**	**0**	0	--
2005	**5**	--	--	--	--	--	--	--	--	--	--	--
2006	**10**	--	--	--	4	--	--	--	--	--	--	--
2007	**3**	--	--	--	--	--	**0**	--	--	--	--	--

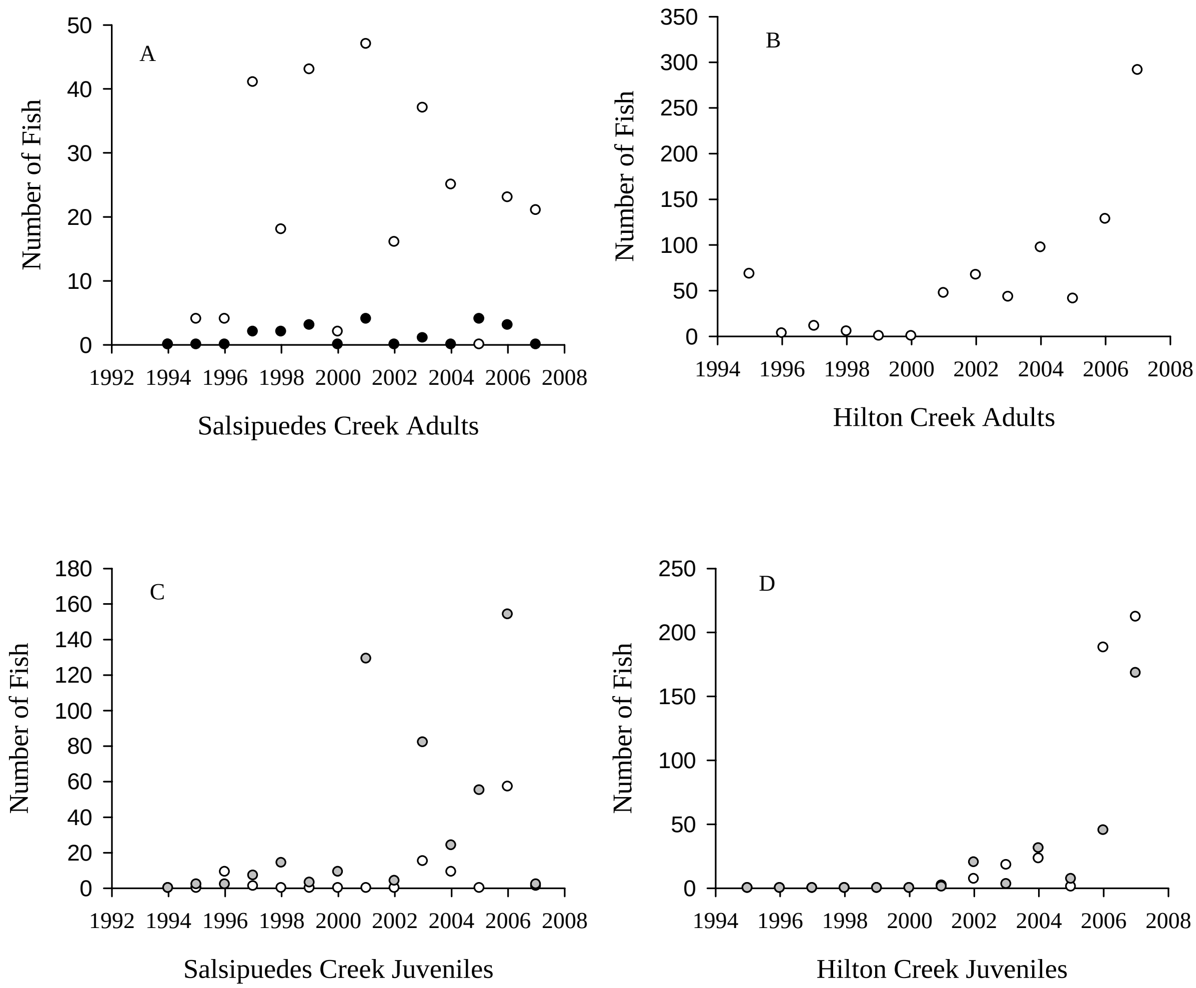


Figure 9. Fyke trap data from Robinson et al. (2007) for Salsipuedes Creek (A and C) and Hilton Creek (B and D). Traps were fished in pairs, with one facing upstream and one downstream. The text is unclear, but probably the adult data are from the downstream-facing trap, and juvenile data from the upstream-facing trap. Open symbols show adults between 100 and 525 mm, and juveniles < 100 mm fork length. Black symbols show adults > 525 mm (assumed anadromous), and gray symbols show “smolts.” Traps were fished from January through May, except for 1998 and 2000, when trapping began in late March. Trap efficiently is reported to be >95%.

Lindley et al. (2007) did not explicitly consider spatial structure and diversity in assessing population viability, but did do so indirectly in terms of vulnerability to catastrophic events such as toxic spills, large forest fires or volcanoes, since a broader geographical distribution reduces the risk from catastrophes. Steelhead in the Santa Ynez River are now restricted to a relatively small area of habitat below Bradbury Dam; their risk from catastrophes would be much reduced if they also had access to habitat above the dam.

Diversity in life history patterns is particularly important for steelhead. In the Santa Ynez River, as in other coastal streams, anadromous and resident life history forms are probably best regarded as a polymorphism; that is, the Santa Ynez populations probably includes individuals exhibiting both life history types.

A report of the NMFS Recovery Science Review Panel, RSRP (2004, attached as an appendix) provides a good discussion of current knowledge of this matter. RSRP (2004:11-12) states that:

> The collected evidence has important implications concerning the long-term viability of *O. mykiss* ESUs. In polymorphic populations, the occurrence of resident and anadromous life histories helps to buffer a population against fluctuating environmental conditions in fresh water and the ocean as well as variable access to the ocean from sandbars blocking estuaries. The loss of anadromous fitness in land-locked resident populations, and the unidirectional evolution from anadromous or polymorphic populations, clearly indicates that resident populations by themselves should not be relied upon to maintain long-term viability of an ESU. To be sure, a resident population *recently* created from an anadromous or polymorphic population will continue to produce anadromous fish that could, in principle, help to re-establish an anadromous run in the short term. However, the feasibility of re-reestablishing an anadromous from a resident population is expected to diminish rapidly in evolutionary time. If it could be done at all, it would be most easily accomplished within a few or perhaps several, but not many, generations after the extinction of a self-sustaining anadromous run.
>
> … We believe that recovery plans for *O. mykiss* ESUs … should place a high priority on the maintenance and restoration of naturally occurring life-history diversity …

The available data on the size of the anadromous fraction of the Santa Ynez population (e.g., Figure 9) are not encouraging. For example, it appears that the spawning fish taking advantage of improved conditions in Hilton Creek are resident rather than anadromous (Figure 9B), and no more than four anadromous adults have been captured in Salsipuedes Creek in any recent year (Figure 9A). It is not even clear that the anadromous fraction of the run is self-sustaining, and by comparison to historical runs, even those remaining after a large fraction of the upper watershed had been blocked by dams (Good et al. 2005), the existing anadromous run barely exists at all. This suggests that conditions below Bradbury Dam may be selecting against the anadromous life history pattern, in an evolutionary sense. Thus, considerations regarding both life history diversity and spatial distribution indicate that passage around Bradbury Dam will be necessary to restore a viable population of steelhead in the Santa Ynez River (NMFS 2007b: 36).

Recent estimates of small effective population size (N_e) for the populations in Hilton Creek (17-131) and Salsipuedes Creek (21-61) by Anthony Clemento of NMFS (Clemento 2007) also support the conclusion that this population is not viable. Thus, the existing Santa Ynez steelhead population does not rank as viable under the Lindley et al. (2007) criteria, nor would it rank as viable under the Boughton et al. (2007) criteria. The RDEIR provides no analysis showing that the population is likely to become viable under any of the alternatives considered.

The RDEIR fails to provide reasonable evidence that fish below the dam will be in good condition under any of the alternatives considered

To show that the proposed project will meet the requirement of Fish and Game Code sec. 5937, it must show that the project will leave the fish in "good condition." This issue has been addressed by Dr. Peter Moyle (Exhibit CT 70; Moyle et al. 1998): "condition" must be assessed at three levels: individual, population, and community. The RDEIR presents no such assessment, and does provide information by which the assessment could be made. From the discussion and data presented above, it is clear that steelhead in the San Ynez River are not now in good condition at the population level, and the RDEIR provides no reason to believe that any of the alternatives considered will make them so.

Recent developments in scientific understanding, moreover, show that evolution can occur within decades, that is, in a time-scale relevant to management (Hendry and Stearns 2004). This point is amplified in the quotation above from the RSRP (2004). Therefore, the condition of steelhead in the Santa Ynez River should also be considered at an evolutionary level as well. The historical record shows that the population had a strong anadromous component before Bradbury Dam blocked access to habitat farther up the watershed (Good et al. 2005). From the available data, it appears that the anadromous component is now very small. It seems likely that this reflects not just the decrease in the population size, but also selection for the resident life-history type. If this is so, then simply increasing the size of the population below the dam will not achieve "the maintenance and restoration of naturally occurring life-history diversity" in the population, the objective emphasized by the RSRP.

In my professional opinion, an alternative that provides for passage of steelhead around Bradbury Dam probably is necessary to meet the objectives of the project. Salsipuedes Creek and the other small tributaries below Bradbury Dam simply do not provide enough habitat to maintain a viable anadromous population, and conditions in the mainstem Santa Ynez River and Hilton Creek may select for the resident life history pattern, especially if opportunities for migration to and from the ocean continue to be marginal.

What analyses should the RDEIR have included?

Since I am criticizing the analyses of instream flow needs that have been done on the Santa Ynez, it is reasonable that I should explain how this could be done better.

Habitat as a function of flow

In my professional opinion, a structured "Demonstration Flow Assessment" is the best available approach for assessing habitat in the Santa Ynez River that can be implemented for an environmental impact report. An unpublished manuscript by Railsback et al., which is attached as an appendix, describes the application of such an approach on the Clackamas River, Oregon[10].

[10] "The Demonstration Flow Assessment (DFA) method for instream flow evaluation uses direct observation of river habitat conditions at several flows and expert judgement to rank the alternative flows. The DFA method has the advantage of allowing long river reaches to be assessed at relatively modest cost. However, past applications have

Low altitude aerial photography could be used to apply this approach to the inaccessible reach above Highway 154. This is far from ideal, but is probably the best that can be done in the circumstances. Successful application of the method depends upon having a balanced group of experts on steelhead or stream fishes involved in the assessment who are insulated from outside interference. It is also critical that the experts involved articulate the reasoning behind their assessments, in ways that allow the reasoning to be tested in a program of actual adaptive management (Williams 1998), or by reference to the scientific literature. The reasoning should incorporate the ecological and geomorphic considerations emphasized by Anderson et al. (2006) and Annear et al. (2004).

Useful information on water temperature in different areas of the lower Santa Ynez River and tributaries could be dealt with by modeling, as described in Deas and Lowney (2000), or perhaps by developing an empirical relationship if appropriate data exist.

Assessing dissolved oxygen and flow rates in the hyporheic zone should be dealt with by measurements, using a statistically valid sampling design. Kondolf et al. (In press) will provide guidance regarding the measurements.

Water rights releases

To comply with Article 10, section 2 of the California Constitution and with common sense, the water rights releases from BradburyDam should be integrated with the instream flow releases. It is hard to imagine why this should not be done, except for deference to past practice; certainly the RDEIR does not describe any such reason. This issue probably can best be addressed using latest version of the USGS Modflow model[11], which incorporates recent advances in modeling surface and groundwater interactions.

Analyzing whether alternatives will meet the objectives of the project

A conclusive affirmative answer to this question can only be provided by implementing one of the alternatives and demonstrating that it does support a viable population of steelhead with a substantial anadromous component. Therefore, the RDEIR cannot provide such an answer. However, the RDEIR could, and should, assess whether it is plausible that the alternatives will do so. This could best be done for steelhead using a suitable life cycle model, to assess whether the habitat conditions projected to exist under the alternative could plausibly support a viable steelhead population. Chapter 14 of Williams (2006), attached as an appendix, provides guidance

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often lacked procedures and documentation to assure that results are reproducible and reasonably free of uncertainty and bias…The procedures combine established concepts from stream ecology and decision analysis, and are general and adaptable to a variety of sites. Approaches are recommended for studies targeting both a few particular species or the general integrity of the aquatic community, and could be adapted for assessment of flow needs for other resources such as recreation and aesthetics. The procedures use habitat quantification: specific types of important habitat are defined and then quantified in the field during demonstration flows. The five major steps are: (1) Decision framing, establishing the fundamental assumptions, constraints, and expectations for the instream flow assessment; (2) Conceptual modeling developing high-level mechanistic, empirical, or theoretical/community models for how flow affects fish by affecting food production, feeding, mortality risks, or reproduction; (3) Metric development, defining specific, measurable habitat types to be quantified; (4) Field observations, quantifying the area of each habitat type at each demonstration flow, using visual estimation aided by detailed maps and other tools; and (5) Analysis, calculating the total area of each habitat type for each demonstration flows, then ranking flows according to habitat benefits and resource tradeoffs."[Railsback, et al., Unpublished]

[11] See http://water.usgs.gov/nrp/gwsoftware/modflow2005/modflow2005.html for documentation.

regarding the kind of model that would be appropriate for this inquiry. Hendry et al. (2004) provided a framework for assessing the evolutionary consequences of alternatives in terms of anadromy.

The Santa Ynez River steelhead issue has been before the SWRCB for 20 years; what should the SWRCB do immediately?

Instream flow conditions for steelhead below Bradbury Dam were brought to the attention of the SWRCB in 1987. Steelhead in the Santa Ynez River have since been listed as endangered, and recent population data (Figure 10A,B; Clemento 2007) are not encouraging. Prompt action is needed. The immediate problem for steelhead in the Santa Ynez River is the low population size and the small amount of suitable habitat below Bradbury Dam. Therefore, the SWRCB should follow the advice given by Castleberry et al. (1996), quoted above: implement protective interim instream flow standards, monitor the results within a framework of real adaptive management, and maintain the ability to make changes in the flow standards in light of new information.

In my professional judgment, the flow standard described in the RDEIR that best approximates a conservative (i.e., protective) standard with a reasonable annual hydrograph is the 3A2 alternative described but not assessed in the RDEIR, with the original adjustment for dry years proposed by CalTrout, rather than the extreme adjustment embodied in Alternatives 5B and 5C.

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