REBUTTAL EXPERT REPORT OF PROFESSOR PETER B. MOYLE, PH.D.

This rebuttal report primarily responds to the August 2005 expert report of Dr. Charles Hanson (which I shall refer to as the Hanson statement), although it secondarily deals with the August 2005 expert reports of Messrs. Stalnaker, Whittler, Bender, Kubitschek, Brown, and Donahue.

The Hanson statement sets up an artificially high goal for flow releases, ignores past successes in restoring flows and habitat for fish, and discounts the resilience of Chinook salmon. The result is that the Hanson statement paints an exaggerated picture of the difficulty of restoring the San Joaquin River as habitat for salmon and other fishes. The conclusions that the Hanson statement draws are based on a number of rather arbitrary assumptions, including the following:

1. Restoration of the San Joaquin River[1] means returning the river to pre-dam conditions.
2. Restoration of the San Joaquin River should be based solely on restoring spring-run Chinook salmon.
3. A spawning population of 7,500 salmon is required for restoration to be successful.
4. Salmon will use 1only 30% of available spawning habitat.
5. Flows approximating about half of the pre-dam flows on the river are required for restoration of spring-run Chinook salmon.
6. All potential impediments to migration of juvenile and adult salmon in the San Joaquin River between Friant Dam and the Merced River have to be removed before the target salmon population can be restored.
7. Temperatures have to be in the optimal range for all life history stages of salmon at all times to achieve the target salmon populations.
8. Restoration of fish in good condition involves so many uncertainties and is so complicated that it cannot be done without many more years of study.

While my August 2005 expert report (which I shall refer to as "my statement"), combined with those of Drs. Deas and Kondolf, already shows that these assumptions are incorrect or not justified, I will briefly respond further here.

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[1] Throughout this report, when I refer to the San Joaquin River, unless otherwise noted I am referring to the stretch of the San Joaquin River from Friant Dam to the confluence with the Merced River.

1. THE SAN JOAQUIN RIVER DOES NOT HAVE TO BE RETURNED TO PRE-DAM CONDITIONS TO SUPPORT A DIVERSE FISH FAUNA THAT INCLUDES CHINOOK SALMON.

The Hanson statement (and others in the defendants' portfolio) implies that we must *restore* the river to some legendary natural state for the river to again support fish in good condition. Dr. Hanson starts with the premise that restoration is only possible with an allocation of about half of the average annual flows (a premise I discuss further, below) and then further assumes that unless conditions for salmon are optimal at all times and places, restoration of his target, self-sustaining population of salmon is not possible.

In contrast, my vision of an achievable goal for the San Joaquin River is characterized by the concept of *reconciliation*[2]. Realistically, most of the water is going to be taken from the San Joaquin River for human use, the channel will continue to be heavily modified, and humans will be a major component of the river's ecosystem. As I note in my own, August 2005 statement, a reconciled river reflects these realities while using the best science available to find ways to create a living river that supports fish in good condition.

Contrary to what Dr. Hanson and others state, we know a great deal about how to achieve these goals from studies of the San Joaquin River and other rivers, and we are learning more at a rapid rate. For the reasons set out in my August 2005 statement and in this rebuttal report, it is my opinion that the goal of a San Joaquin River that supports fish in good condition can be accomplished in a realistic manner. This is illustrated by efforts on Putah Creek, the Tuolumne

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[2] Reconciliation ecology is "the science of inventing, establishing, and maintaining new habitats to conserve species diversity is places where people live, work, and play (Rosenzweig 2003 p.7)". It explicitly recognizes that returning most land and waterscapes to something approaching historic 'natural' conditions is not likely. Restoration ecology, on the other hand, has as its implied goal returning areas to their natural condition, although that condition is often hard to define. Rehabilitation ecology is sometimes used more or less synonymously with restoration ecology.

River, and other streams. Using a flexible approach (adaptive management) and a long-term commitment to monitoring the impacts of management actions, fish can be restored to the San Joaquin River *without* the stringent flow conditions and habitat improvements that Dr. Hanson claims are necessary.

2. RESTORATION OF FISH IN GOOD CONDITION ON THE SAN JOAQUIN RIVER SHOULD BE BASED ON MULTIPLE SPECIES, NOT JUST ON SPRING-RUN CHINOOK SALMON

The Hanson statement bases all its recommendations solely on a goal of restoring spring-run Chinook salmon. This is an overly simplistic approach and provides only one criterion for success.

In contrast, my approach is based on bringing back ("in good condition") spring-run Chinook salmon, fall-run Chinook salmon, and other native fishes, as well as improving the warm-water fishery for non-native species. I focus on the two salmon runs because they have the most stringent requirements. However, aspects of the strategy I recommend (e.g., summer flows) are based on the needs of other fishes as well. The Hanson statement, for the most part, does not mention other fishes at all. To the extent Dr. Hanson discusses fall-run Chinook salmon, he considers them as being unworthy of consideration. According to Dr. Hanson, this is because fall-run Chinook "had been reduced to a remnant run prior to the construction of Friant Dam for reasons unrelated to the construction of Friant Dam" and their restoration was not possible due to a lack of suitable water temperatures, potential hybridization with spring-run Chinook salmon, and superimposition of their redds on those of spring-run Chinook salmon. No evidence is provided for Dr. Hanson's assertions regarding fall-run Chinook.

In my opinion, a remnant fall run is still a run and, as I indicated in my August 2005 statement, it was the diversion of water from the river as the result of Friant Dam that was the final blow to the fall-run's persistence in the San Joaquin River below Friant Dam and above the Merced. It is worth noting that the numbers of fall-run Chinook salmon on the Tuolumne and Merced Rivers reached levels (<200 fish) similar to pre-dam, 1940s runs in the San Joaquin River, but those populations have increased since then at least partly in response to restoration efforts (Yoshiyama et al. 2001). Moreover, as indicated in my August 2005 statement, I do not share Dr. Hanson's apparent view that fall-run cannot be restored to the San Joaquin River.

For these reasons, Dr. Hanson's consideration of only spring-run Chinook salmon is not appropriate when evaluating how to bring back fish in good condition to the San Joaquin River.

3. A SPAWNING POPULATION OF 7500 SPRING-RUN CHINOOK SALMON IS NOT REQUIRED TO MEET THE OBJECTIVE OF FISH IN GOOD CONDITION

The Hanson statement indicates that the mean of his rough numbers of spring-run Chinook salmon estimated in the San Joaquin River in 1939-50 (7500 fish, range 3000 to 30,000) is the appropriate objective that must be reached, on average, for success (although he does not define *why* this is the appropriate measure of success). There is no biological basis for this number as a goal.

As I discussed in my earlier statement, theoretical considerations suggest that a minimum run of 500 returning salmon per year (i.e., fluctuating between 500 and a higher number) is a reasonable place to start in re-establishing a naturally-reproducing, self-sustaining run of Chinook salmon in good condition. In my own statement, therefore, I basically propose to start low and work up to higher numbers as the system improves as the result of the cumulative effects of management for salmon and other fish. Certainly, higher numbers are desirable to support fisheries as well as for ecosystem and aesthetic considerations. However, a population of precisely 7500 fish has no biological relevance to the goal of fish in good condition.

4. DR. HANSON’S ASSESSMENT OF THE LIMITS OF EXISTING GRAVEL IS INACCURATE

Starting with an assumption that there must be enough spawning habitat to support 7500 spring-run Chinook salmon, Dr. Hanson’s statement calculates that there is now only sufficient gravel on the San Joaquin River to support somewhere between 400 and 1500 female spawners (800-3000 fish, assuming a 1:1 male:female ratio). His estimates are based on the premise that all salmon would be spawning simultaneously, so that redds would be perfectly spaced and non-overlapping, and that even under crowded conditions only 30% of the available space would be used. This estimate is not supported by the very study upon which Dr. Hanson relies.

Dr. Hanson’s statement that spawning salmon will use only 30% of available spawning habitat appears to be based, not on real world observations, but on a modeling study for the upstream end of a reservoir on the Columbia River with limited spawning habitat (Hanrahan et al. 2004, cited by Hanson). The spawning habitat modeled in that study was very different (e.g., deeper) from that in the San Joaquin River, rendering its conclusions suspect if applied directly to the San Joaquin River. Even if Hanrahan’s model was directly applicable, however, Dr. Hanson has misapplied the model. Hanrahan et al. (2004) estimated that each redd in the area modeled represents 6-10 spawning adults, presumably accounting for multiple users of the same site and jack males that spawn with ‘regular’ salmon. Dr. Hanson, by contrast, assumes only 1 spawning female per redd. If the 6-10 spawning adults-per-redd number had been used in Dr. Hanson’s calculations, then the number of potential spawners using existing gravel on the San Joaquin River would have been calculated to range from 2,400 to 15,000 fish. Even if we assume just two salmon per redd (as Dr. Hanson has done), Dr. Hanson’s estimates regarding available spawning habitat are sufficient for the ‘starter’ population that, in my opinion, is needed to have fish in good condition. (Again, I emphasize that our plan features self-sustaining populations of multiple species, not just spring-run Chinook salmon, so there will be multiple criteria for success.)

5. FLOWS APPROXIMATING PRE-DAM FLOWS ON THE SAN JOAQUIN RIVER ARE NOT REQUIRED TO RESTORE FISH IN GOOD CONDITION

The Hanson statement presents hydrographs that indicate that 33% of the average wet-year annual flow is needed for restoration in wet years, 41% of the average normal-wet year flow is need in normal-wet years, 55% of the average normal-dry year flow is needed in normal dry years, and 66% of the average dry-year flow is needed in dry years, for an overall average of about half the average annual flow.[3] Unfortunately, Dr. Hanson does not tell us how he determined these flows, nor how these flows will achieve the needs of each life history stage of the salmon. This is in marked contrast to the strategy the Moyle-Kondolf-Deas team used to develop a flow regime based on what the fish need. Dr. Hanson instead seems to rely on 'rules of thumb' and general extrapolations from various methodologies. The Hanson flows therefore seem to be largely based on theoretical considerations from various models, while our flow recommendations are based on looking closely at what the fish need (appropriate to the stated goals) in the San Joaquin River as it exists today.

To respond more specifically to the information Dr Hanson used to develop his flow regime, I have divided the studies he cites into (1) rules of thumb, (2) the papers by Brian Richter and his colleagues on the Range of Variability approach, (3) the Tennant Method, and (4) IFIM studies.

Rules of thumb. The Hanson statement "identifies" a "general approach of 60% of the annual San Joaquin River flow" as "one of the preliminary estimates of flow allocation for salmonid restoration" (although his own hydrographs average about 50% across year types). Just how Dr. Hanson identified this 60% preliminary figure is not clear, although he does cite a number of studies and other documents for what he seems to suggest are "rules of thumb" about the

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[3] These figures are derived by dividing the total flow recommended for each year type in Dr. Hanson's August 2005 statement by the total average annual unimpaired flow for that year type that Dr. Hanson identifies in his Jan. 21, 2004, declaration.

percentage of stream flow required for fishery purposes. Dr. Hanson does not elaborate on why flows reported or recommended in these other documents, for different rivers, with potentially very different objectives, can appropriately be applied to the goal of supporting fish in good condition on the San Joaquin River below Friant Dam.

The various studies to which Dr. Hanson points for the proportion of natural flow that restoration of a river supposedly requires have all sorts of figures that vary from 30 to 70% of the average annual flow. One of the highest of these figures is Jones (2002), a two-page article in an Australian newsletter for Australian streams, which suggests a "greater than two-thirds" rule for a rather vague "percentage of natural flow" in order to sustain (not restore) a "healthy working river." This article does not appear to have been peer reviewed and does not discuss salmon. Its use in this context is inappropriate.

Dr. Hanson also cites a Trinity River report, a river on which he states that restoration flows for salmon are pegged at an average of 51%. On that river, however, the goal is quite different, because the federal government has a strong obligation to maintain salmon *fisheries* for Native American tribes.

Dr. Hanson next cites to a 1997 SWRCB staff recommendation for Russian River flows. Dr. Hanson says that this document recommends that a bypass flow of "60% of the annual average flow" be provided to support salmon and steelhead habitat. Dr. Hanson is incorrect. The 60% of average annual flow in this report is recommended for small tributaries to the Russian River, for spawning of coho salmon and steelhead during winter months (Dec. 15-March 31). It is designed to set an upper limit on the amount of water that can be diverted during the high flow periods of these tributaries. The Hanson statement indicates that the recommendation is for the Russian River itself, but it is not. The flows of the main river are largely determined by releases from two large reservoirs, for a variety of purposes.

A more realistic comparison would look at restoration flows for the Tuolumne and Merced Rivers, which are less than 20% of annual flow (see Figure 8 in Kondolf statement) and currently support Chinook salmon and native fishes.

The Hanson approach is also in contrast to the flow regime for the San Joaquin River recommended by the Moyle-Kondolf-Deas team. We used the general pattern of the historic flow regime, but not the volume, recognizing that fish can be returned in good condition to a river of smaller size than the historic river. We also assume that in extremely dry years, the flow regime will reflect a “share the pain” philosophy so that measures beyond water will be used to keep fish populations sustained through hard times. Dr. Hanson actually recommends a hydrograph that uses the *highest* percent of flows during these same dry years.

Range of variability. Dr. Hanson claims in addition to rely on the “range of variability” approach described by Richter et al. The Richter approach is really best applied to (1) rivers without major modifications for which modifications are planned, as a means of maintaining an existing ecosystem as fully functioning, or (2) to rivers which have been mainly dammed for flood control and/or power production, so most of the water is still available for flows. The San Joaquin River, of course, fits neither of these categories.

The basic goal of flow regimes developed under the Richter approach is to retain a full range of ecological function in the stream. This follows Poff et al. (1997, cited by Hanson) who argue that maintaining a natural flow regime is most likely to protect ecosystem integrity. In other words, the Richter approach seeks to ensure something more than “fish in good condition,” including non-fish ecological benefits. I have understood the question at issue here is “what flows are required to restore fish in good condition?” As discussed in Dr. Kondolf’s rebuttal statement, strict application of *calculations* based on the Richter approach to the more limited goals at issue here is not appropriate.

In addition, the rivers for which Richter developed his model, as reported in his papers, are rivers that, although dammed for hydropower or flood control, were not dammed for large scale diversions. In other words, all or most of the natural flow would be released to the river and the only question was mainly the timing of releases. This condition is not true of the San Joaquin River or most other rivers in California. A key difference from my way of using the RAV/natural flow regime concept and the way Dr. Hanson uses it, is that I assume we are starting from scratch and recreating a functioning river, while Dr. Hanson's method of analysis seems to begin with hypothesizing a fully functioning river and then reducing flows without reducing the full range of ecological function. By contrast I assume that the recreated river will have many characteristics in common with the pre-dam river – including diverse assemblages of native fishes – but will not be identical to it.

Richter's range of variability approach reflects a departure from prior approaches (such as the Tennant method) that calculated a fixed percentage of stream flow without concern for inter-annual or intra-annual variation. Richter thus emphasizes the ecological importance of a "range of variation" in the timing, duration, frequency, and magnitude of flows. I generally agree with this natural flow regime concept but apply it to the San Joaquin River differently than does Dr. Hanson, whose apparent goal is to achieve pre-dam, or near-pre-dam conditions. In particular, while variation in timing, duration, frequency, and magnitude of flows is important, the full natural magnitude of flows is demonstrably not necessary to maintaining diverse native fish populations, including salmon, in good condition.

For example, I applied the concept of natural variability to Putah Creek in developing a flow regime that tracked the historic flow regime in terms of variability, with one major exception – I recommended flows at much lower levels than the historic flows (except during natural spills from the dam, which serve processes which require large amounts of water). Native fish, including Chinook salmon, have returned to Putah Creek under this flow regime. The natural variability concept also influenced the design of the flow regime I propose, in collaboration with

Drs. Kondolf and Deas, for the San Joaquin River but, again, I have worked to develop a hydrograph that will support fish in good condition while assuming that most of the river's flow will still be diverted for human use.

Tennant Method. Dr. Hanson also cites to the Tennant method, an early instream flow methodology developed for small Montana trout streams in order to give local fisheries biologists a means of recommending flows when all they had to work with was a hydrograph and personal knowledge of what key fish species (trout) needed. The problems were mainly direct diversions for irrigation from the streams. The "optimum" range for flows under this method was estimated to start at 60% of the mean annual flow, but "good" conditions were estimated to be maintained with 30% of the flow. This approach does not take into account the different conditions or goals of very different rivers, let alone the specific conditions and goals of the San Joaquin River.

The Tennant method is not an appropriate method for developing a flow regime for the San Joaquin River. It is just too simplistic, not accommodating, for example, the need for variability in flows. The San Joaquin River is far bigger than the streams for which Tennant developed his method and we have more complex information available, obviating the need for such a method. In short, the Tennant method just requires too many simplifying assumptions to be valid for the San Joaquin River, as has been demonstrated for other rivers (Tharme 2003).

IFIM. Dr. Hanson also points to the Instream Flow Incremental Methodology (IFIM), a rather mechanistic approach to designing instream flow regimes. The IFIM assumes that appropriate flows can be developed if we know how key fish species (usually trout) at each life history stage select velocities, depths, and substrates. Like the Tennant method, it has a hard time dealing with complexity (e.g., multiple species) and the need for variability in flows for stream processes. Because of its simplifications, the closer a stream is to a cement ditch containing rainbow trout in summer, the better the IFIM models (PHABSIM) work. A serious flaw, especially for big rivers, is that the methodology uses a relatively small number of transects to characterize complex hydrologic phenomena (Castleberry et al. 1996; Williams 1996)[4]

Dr. Hanson states that he used regression equations from Hatfield and Bruce (2000), developed though a meta-analysis of 127 IFIM studies, to produce his basic flow recommendations for different life history stages of Chinook salmon. The equations of Hatfield and Bruce relate mean annual discharge to '*optimum*' flow. Dr. Hanson developed his 'optimum' flows using the "range of base flows in the river prior to the construction of Friant Dam." As I have already pointed out, using the historic magnitude of flows is not necessary to bring back fish in good condition to the San Joaquin River. Thus the Hanson optimum flows bear no relationship to the flows necessary for the more limited goal relevant here.

Beyond this basic problem, other problems with the IFIM are reflected in Dr. Hanson's recommendations for minimum summer flows for holding of adult spring run Chinook salmon. Using the regression equations of Hatfield and Bruce for adult *steelhead* (rather than empirical data on spring run Chinook salmon from places in California where they over-summer), Dr Hanson concluded that optimal summer flows for the salmon would be 884 cfs! This result does not hold up in view of the actual, on the ground reality of other Central Valley streams that support spring-run Chinook salmon. For example, in Butte, Deer, and Mill creeks (Sacramento Valley), large numbers of spring-run Chinook hold at summer flows of 50-150 cfs. What is most important for these fish to hold are large deep pools and cool temperatures, both of which are present below Friant Dam at flows far below 884 cfs.

Dr. Hanson did arbitrarily modify his hydrograph at least to reflect the reduced need for high summer flows in river, using a range of 385-580 cfs depending on year type. The flow

[4] Moyle and Baltz (1985) point out the difficulties of applying IFIM methodologies to California streams with multiple fish species and age classes. Tharme (2003) provides references to the numerous critiques of the method. See also the Kondolf rebuttal statement.

recommendations I developed in conjunction with Drs. Kondolf and Deas provide minimum summer flows of 350 to 400 cfs, based on a variety of factors (see my statement), with much lower flows during critically dry years. These flows are adequate for holding adult spring run Chinook salmon.

The problems with the IFIM approach are further reflected in the calculation by Dr. Hanson of three different optimum flows for three different life history stages of Chinook salmon. All three of these life history stages can be present in the river simultaneously. Which flow should be chosen in preference to others is not stated and Dr. Hanson provides no explanation for choosing among them.

As Hatfield and Bruce (2000, p 1013) state *"Some resource managers will be tempted to use our equations uncritically because so little information or effort is required to complete the calculations. We stress, however, that considerable statistical and ecological uncertainty would remain after such a calculation. …fluvial systems are complex and many factors determine a healthy river. Natural resources cannot be managed without acknowledging and planning for uncertainty… To do otherwise is to risk implementing faulty management decisions."*

Which flows to use? A major difference in the hydrographs we propose vs. those Dr Hanson proposes are in the ramping up and down of flows. The Hanson flows attempt to follow the mean of the historic hydrograph (for each year type) as closely as possible except in July-September, resulting in extended high flows in winter, spring, and summer. Dr. Hanson assumes that such flows are necessary for *every* juvenile and adult Chinook salmon to make it down and up the river at a leisurely pace, without looking at what these fish actually need to be maintained in good condition. (Of course, use of the mean historic hydrograph means that very significant fluctuations from that mean that occur in any given year are smoothed out.)

The flows developed by me, Dr. Kondolf, and Dr. Deas, on the other hand, are designed to allow Chinook salmon to move up and down the river fairly quickly during the normal peak times of migration, urged on with pulse flows where needed. I expect that some salmon will be left behind by these flows, but that most will make it through. As discussed in my statement, I am relying on the flexible behavior of salmon, the fact that salmon are capable of rapid migration, and their ability to adapt to altered flow regimes as they have elsewhere. Not every juvenile salmon has to survive this period (and many certainly will not) for fish to be in good condition.

6. MIGRATION OF JUVENILE AND ADULT SALMON IN THE SAN JOAQUIN RIVER BETWEEN FRIANT DAM AND THE MERCED RIVER IS POSSIBLE WITH MINIMAL CHANGES TO IMPEDIMENTS TO MIGRATION

The Hanson statement essentially concludes that salmon cannot return without first fixing dozens of problems with the San Joaquin River that might inhibit passage of migratory fish -- presumably at huge expense and time. Dr. Hanson summarizes factors likely to cause mortality to salmon in the San Joaquin River, but of course some of these factors (e.g., predation) are likely to cause mortality of salmon on *any* river. Despite these factors, salmon survive on other rivers. What makes the San Joaquin River fundamentally different today is that it is dry.

Dr. Hanson's claim that all impediments to salmon migration must be fixed rests on four assumptions: (1) the minimum number of spring-run Chinook needed for restoration is 7,500 fish, (2) optimal conditions must exist at all times for salmon to migrate up and down the river, (3) cumulative mortality during migration, caused by channel problems, will make it impossible for the run to persist, and (4) no fixes can take place without major changes to the river channel.

Assumption 1 is not true, as discussed above. Assumptions 2 and 3 are also not supported. We know, for example, that runs of salmon persisted through the 1940s, when most of the problems mentioned were already in place and some (such as poaching) were worse than they are today. Those impediments that appeared subsequently (e.g., gravel pits) have been survived by salmon elsewhere (e.g., Tuolumne River), as Dr. Kondolf shows in his statement. As I indicate in my statement, the non-functioning fish ladder at Mendota Dam is the principal obstacle that may need to be fixed for salmon to migrate successfully. That fish ladder presumably has fallen into neglect because of the absence of salmon and other known migratory fish from the river.

Even in nearly pristine conditions, salmon frequently face less-than-optimal conditions and significant migratory barriers, yet they survive. In my opinion, runs of salmon and populations of other native fish can be re-established on the San Joaquin River mainly just by providing the modest amounts water indicated in my and Dr. Kondolf's statements. As Dr. Kondolf indicates in his statement, there are no impediments to migration at the present time that cannot be surmounted using techniques that have been successful on other rivers. Obviously, fixes for impediments in addition to the Mendota Dam fish ladder (as indicated by Dr. Kondolf and Dr. Hanson) would presumably improve fish survival during migration, but such fixes are not essential for fish recovery.

Dr. Hanson and Mr. Donahue, in their reports, also rather uncritically accept the idea that all diversions must be screened. This assumption gives Mr. Donahue license to sketch out a Cadillac version of a screening program, piling up expenses. I am responding to this particular part of their statements because I have recently evaluated existing information on the value to fish populations of screening diversions in the Central Valley (Moyle and Israel 2005) and currently serve on the Interagency Fish Screen Committee (a committee on which I am the only non-agency member). My research has found that (1) most diversions, mainly small ones, are not screened in the Central Valley, (2) it is likely that most small diversions do not need to be screened to protect salmon (or other fish) populations, and (3) diversions with the most impact are those that take a substantial percentage of the flow of the stream they are on. Diversion timing, of course, is highly seasonal and does not have much impact on salmon at times of year when salmon are not present. Diversions also have less impact when flows are high.

The only diversions for which some kind of device for reducing entrainment may be needed are the Arroyo Canal behind Sack Dam and the diversion canals above Mendota Dam. The Arroyo Canal has the potential to take large portions of the flow when juvenile salmon are migrating downstream so probably should be screened, at least seasonally. As discussed in Dr. Kondolf's rebuttal statement the potential problem with losing juvenile salmon in the Mendota diversions could be dealt with in ways other than conventional fish screening, such as building a by-pass around the dam for fish or using innovative new technology such as permeable curtain barriers. It is worth noting, however, that both runs of salmon did manage to persist in the river when the Arroyo Canal and Mendota diversions were operating in the past.

In contrast, the Donahue report lists about 150 potential diversions, most with a *maximum* diversion potential of less than 5 cfs and suggests indirectly that they all need to be screened. However, the report does not present enough information (e.g., location, season of operation, whether they are functional, how much water each actually diverts in relation to flow, and other factors which make a difference to fish populations) to support a conclusion that these smaller diversions are a problem at all. The same basic questions apply to the larger facilities that the Donahue report says need to be screened; no evaluation is provided as to *why* each one needs to be screened aside from the fact they will divert water and therefore, presumably some fish. For example, Donahue and Hansen insist that openings into flood by-pass channels must be screened, providing no justification. Yet studies of my former graduate student Ted Sommer on the Yolo By-pass indicate that it may actually be good for fish to be in properly managed bypass channels (see statement of August 2005).

It is important to keep in mind that fish, and salmon in particular, are not particles drifting helplessly downstream but are capable of actively avoiding unfavorable situations. Indeed, when Dr. Hanson himself conducted a study of a 290 cfs diversion on the Sacramento River (much larger than the diversions listed by Mr. Donahue), Dr. Hanson found that only 0.05 to 0.08% of hatchery Chinook salmon released above the diversion were actually captured by it (Hanson 2001).

My experience on other rivers suggests that once salmon runs become re-established on the San Joaquin River, there will be a strong motivation by agencies and local people to improve conditions for fish survival. Such improvements can often reduce water costs even further, by reducing water costs for fish survival. For example, if necessary, gravel for spawning could be added to the stream from local sources on a gradual basis, with more added as fish numbers improve. There will be costs involved in improving the system, but, as Dr. Kondolf indicates in his statement, they are likely to be incurred over a long span of time and minimized by careful evaluation of alternatives.

7. DR. HANSON OVER-SIMPLIFIES THE TEMPERATURE REQUIREMENTS FOR CHINOOK SALMON

The temperatures that the Hanson statement says the water of the San Joaquin River "should not exceed" are all in the optimal range for various life history stages of Chinook salmon (see Table 1 in my statement). Optimal temperatures are typically defined under laboratory conditions as those in which physiological processes operate at the least energetic cost, so growth and survival are both high and predictable. The reality of wild Chinook salmon in the Central Valley is that they often experience temperatures higher than "optimal" yet still have high growth and survival. For example, Dr. Hanson indicates that for juvenile Chinook rearing "the seven day average of daily maximum temperatures should not exceed 16ºC (61º F)" while I put optimal conditions for rearing in the range of 13-20º C (55-68ºF), temperatures which are based on an exhaustive USEPA report (McCullough 1999). It would not at all be unusual to find juvenile Chinook salmon growing rapidly at daytime maxima of 20ºC (68ºF), with temperatures at night dropping to 15-16ºC (60-61ºF). I also point out that juvenile Chinook can survive exposure to temperatures of 24º C (75ºF), depending on their thermal history, availability of refuges in cooler water, and night-time temperatures. While seven-day single temperature averages such as Dr. Hanson recommends as standards not-to-be-exceeded are often used because of the simplicity of doing so, they do not reflect the temperatures that juvenile Chinook salmon regularly experience in Central Valley streams at some times of the year. For example, the most productive spring-run

Chinook salmon stream left in California, Butte Creek, can experience daily maxima up to 24ºC (75ºF) with minima of 18-20ºF (65-68º F) for short periods of time in pools where juveniles are rearing and adults are holding (Ward et al. 2003).

It is thus possible for Chinook salmon to maintain populations even when they experience periods of suboptimal or even near-lethal conditions. They are also capable of finding, through behavioral means, temperature refuges (where cooler water is present due to ground water seeps, shady areas, and other factors). The bottom line is that Chinook salmon do not have to experience (and usually do not) temperatures that are continuously in the temperature ranges that the Hanson statement says are necessary.   In fact, it is this flexibility that has made Chinook salmon so successful in the Central Valley and to thrive where less temperature tolerant salmonids (e.g., coho salmon) cannot.

Another temperature problem that the Hanson statement identifies is potential exhaustion of cold water from Millerton Reservoir in the fall months, resulting in water that is too warm for salmon survival to flow through the reaches immediately below the dam, based on the analysis of Dr. Brown (using the high flows recommended by Dr. Hanson). In contrast, the analysis of Dr. Deas using our flow regime suggests that this is rarely likely to be a problem and presents methods by which temperatures can be manipulated during critical periods to protect the salmon. For example, Dr. Deas shows that under conditions of reduced storage in a dry-normal year, the maximum temperatures of water released from the dam under our proposed release schedule would be between 58 and 59º F (ca. 15ºC), well within the optimal range for most life stages if salmon.   This could result in some mortality of eggs incubating in the gravel (these temperatures are in the suboptimal range for incubation) but it is likely that, given the time of year (November) the high release temperatures are likely to occur (when air temperatures are cool), exposure time (if any) to the 15ºC temperatures would be short. Even under the Hanson flows, which would result in a reservoir substantially depleted of its water, the maximum temperatures of the released water would still be 61ºF (16ºC), still within the survival limits of incubating eggs.

Once again, I would like to emphasize that our proposed flow regime is not just about spring-run Chinook salmon. Conditions that might be stressful for some life stage of this fish will still be beneficial to other native fish and fisheries.

8. RESTORATION OF FISH IN GOOD CONDITION CAN START IMMEDIATELY

The theme of the last several pages of the Hanson statement, as well as of the statements by Mssrs. Stalnaker, Whittler, Bender, and Kubitschek, is the supposed impossibility of river restoration without years of additional study. All these authors seem to ignore the years of study on the San Joaquin River that have already occurred, the numerous studies done on other rivers (including San Joaquin River tributaries), and the huge amount of information we now have on salmon biology (summarized in Quinn 2005). In my opinion there is plenty of information to begin the process of reestablishing fish in good condition, as outlined in my statement, and as indicated by the statements of Drs. Kondolf and Deas.

Part of the perceived problem is dealing with uncertainty. Dr. Hanson suggests that uncertainty must be nearly eliminated if we are to use adaptive management. In fact, as Dr. Kondolf indicates, the reason to use adaptive management is *because* of uncertainty. If everything were known, then adaptive management would not be necessary.

There are always going to be uncertainties in dealing with difficult restoration issues, such as bringing a nearly-dead river back to life, but we know enough so that a restoration/rehabilitation/reconciliation program for the San Joaquin River can begin with a high probability that salmon and other native fishes will return to the river within a few years. The best way to eliminate uncertainty is to get the reconciliation process going and monitor how the system, and fish, respond. For example, in the first year (or two) of the program, it is easy to envision the following first steps: (1) bringing spring-run Chinook salmon embryos to the Friant Hatchery for rearing in both the hatchery and the river, (2) appointing a technical advisory committee for the program, made up of scientists who really do understand adaptive management, (3) creating a functional fish ladder at Mendota Dam, (4) starting other channel improvements , (5) continuing annual monitoring of fish in the river, currently being done by DFG, (6) identify sources of native fishes such as hardhead for the middle reaches of the river, and (7) evaluate methods for most rapidly improving fisheries in the lower most sections of the river . In the second year, the new flow release schedule (as outlined in my statement) would begin. More data collection and modeling do not need to be done to get this kind of program started with a reasonable probability of success.

CONCLUSIONS

The Hanson statement takes a top-down approach to restoration, starting with broad assumptions that result in high water and habitat restoration costs and low likelihood of success in restoring fish to good condition below Friant Dam. These assumptions do not hold up under close inspection. By focusing solely on spring-run Chinook salmon, Dr. Hanson and his colleagues are able to emphasize and exaggerate uncertainties. The approach of the Moyle-Kondolf- Deas team has been just the opposite; it is a practical, bottom-up approach that starts with goals and objectives for the fish and then figures out how those goals and objectives can be achieved while accommodating the realities of the highly altered San Joaquin River.

Despite statements to the contrary, there is plenty of information available to carry out a successful reconciliation program for San Joaquin River and its fishes. In fact, there is no uncertainty that a wide array of fish and fisheries will benefit by turning the river back into a living stream for its entire length

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