Figure A1-6
September Delta Exports

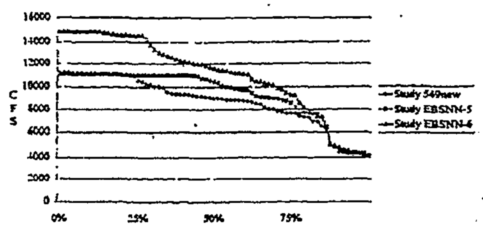


Figure A1-7
September Export-Inflow Ratio

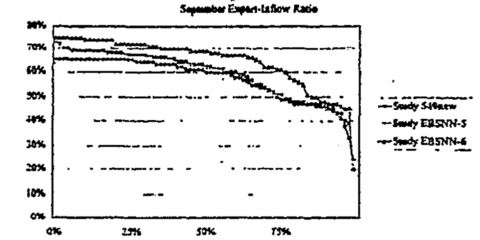


Figure A1-8
Critical Year Average X2 Position

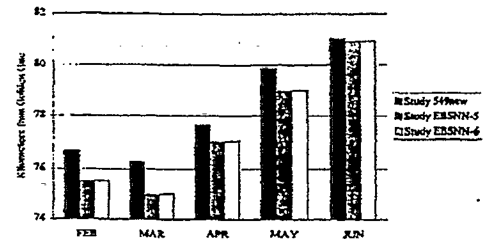
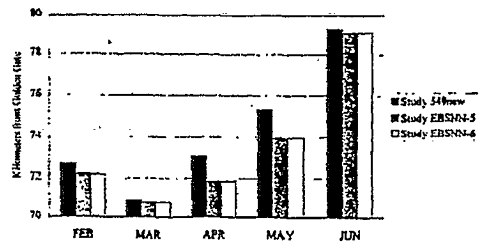


Figure A1-9
Dry Year Average X2 Position



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Natural Heritage Institute

114 Sansome Street, Suite 1200
San Francisco, CA 94104
Tel. (415) 288-0550/Fax (415)288-0666
e-mail: nhi@n-h-i.org

Lester A. Snow
Executive Director
CALFED Bay-Delta Program
1416 9th Street, Suite 1155
Sacramento, CA 95814

September 22, 1999

Dear Lester:

Please consider this letter and the attached comments and documents as NHI's comments to the CALFED programmatic EIR/EIS document.

NHI's primary concern is that the document fails to explore an adequate range of feasible alternatives for several components of the plan. Alternatives that would better achieve all four of the specified objectives of the CALFED Program are described in these comments. NHI's report, "An Environmentally Optimal Alternative for the Bay-Delta Ecosystem: A Response to the CALFED Program" outlines a far more expansive vision of the actions necessary to achieve all of CALFED's objectives. We are submitting a copy of the EOA as part of our comments to the EIR/EIS. In addition, we are resubmitting our comments to the initial draft of the ERPP from 1997 as comments to the EIR/EIS since they are still relevant. CR5 IA-2.1-7 IA-2.4-8 ERP 0-81

In several places, we have delineated *questions in italics.* Please ask your staff to respond to these questions in the final EIR/EIS.

Thank you for consideration of these comments. We are committed to the success of this Program and *trust you will find our critique constructive and helpful in advancing that goal.*

Yours sincerely,

Gregory A. Thomas

1199(2)

Natural Heritage Institute

114 Sansome Street, Suite 1200
San Francisco, CA 94104
Tel. (415) 288-0550/Fax (415)288-0666
e-mail: nhi@n-h-i.org

COMMENTS OF THE NATURAL HERITAGE INSTITUTE TO THE CALFED PROGRAMATIC EIR/EIS

September 22, 1999

Table of Contents:

A. Long-Term Levee Protection Plan LS-2.5.2-2

The organization, clarity, and substance of the levee protection plan are a tremendous improvement over previous drafts. NHI staff commends CALFED staff for this progress. Nevertheless, NHI remains concerned that the Levee Protection Plan underestimates both the magnitude of the seismic risk problem and the opportunity for solving this problem through subsidence reversal programs. Our most fundamental concern at this juncture is that CALFED has not quantified the costs and benefits of various levee program alternatives, including the costs to California's economy, environment and water supply from catastrophic levee failure. It is possible to determine the most cost-effective and reliable means of reducing levee system vulnerability or to select the preferred alternative until this analysis is completed. LS-2.3.5-1 LS-1.4-3

Executive Summary LS-2.5.2-3

In the Executive Summary of the levee section (ES-5) and two other places in the document (Pg 2-17; pg; pg. xx) CALFED incorrectly misquotes and misrepresents the seismic team report with the following quote: "Significant seismic risk is present; however, improved preparedness can reduce the potential damage." *What is the basis for this conclusion?* It is true that the study opines that significant improvements in emergency response capability would increase the number of failures that could be withstood and repaired within a given time-frame (e.g. within six month, or within a given water season). But this does not eliminate a high probability of catastrophic failure of the delta levee system from seismic events with the next few decades. The Executive Summary and levee plan simply ignores the alarming conclusion that:

> "Simple levee upgrades currently being considered to improve static stability (e.g. PL84-99 upgrades) are largely ineffective at reducing seismic fragility. These types of "static" upgrades will do very little to reduce the risk of levee failures associated with soil liquefaction, and are unlikely to reduce the exposure levels shown in Figures 5-2 and 5-3 by more than about 10% (almost no change in seismic exposure)" (Pg. 30).

Figure 5-3 illustrates that there is a 35% probability of an earthquake causing 10 or more levee breaches in the next in the next 50 years. The study team leader, Dr. Raymond Seed of the University of California at Berkeley, has informed us that 6-12 levee breaches in a single event would probably overwhelm the feasible level of standby emergency capabilities such that key western Delta islands (Seed, pers. com. 1999) would be inundated for an indefinite period of time, effectively compromising the Delta as a water delivery system. With regard to emergency preparedness, the report states (pg. 31) that "at the present time, the ability to respond to more than a limited number of levee failures following a seismic event is probably very limited."

To illustrate, consider the following scenario:

30 years from today, a moderate earthquake in the Delta region causes 10 simultaneous levee breaches (a 20% probability). Assume that each levee breach is an average of 500 feet long, 200 feet wide, and 50 feet deep (including scour) with a volume of 5,000,000 cubic feet (185,000 cubic yards). Together, the ten breaches 1,850,000 cubic yards of fill in a short period of time (3-6 months or less) would be necessary to repair the breaches[1]. A comparison of this number to historical dredging rates reveals the true magnitude of this number. For instance, according to a report by Philip Williams and Associates (table attached) Delta dredging to upland disposal averaged 500,000 cubic *yards per year between 1975 and 1987.* Thus, an emergency response effort would have to move nearly 4 times the annual average in a quarter to half the time (3-6 months). This would presumably require 8 to 16 times the number of barges and other equipment *and labor that were available during the 1975-1987* period. *This does not* include the considerable resources that will be simultaneously required to repair damaged levees in danger of imminent failure. *Where will CALFED assemble these resources? Does CALFED intend to maintain a fleet of barges for the indefinite future? How much will this cost and how does it compare to the costs of reversing subsidence on key Western Delta islands.* LS-2.5.2-1

CALFED's Executive Summary ignores these alarming conclusions and downplays the seismic risk to the levees and levee dependent systems. If the levee system fails,

[1] The backside of the levees could erode beyond repair in less than 3-6 months unless extraordinary measures are taken to line the backside of the levees with plastic. Even these measures may not be sufficient in the event of high winds common in the Delta. In reality, 1-2 months is a more conservative window for repair.

CALFED fails. This EIS/EIR will remain unsatisfactory on this issue until it does two things:

1) Acknowledges and quantifies the full dimensions and consequences of the seismic risk and analyzes its implications for the choice of the other CALFED program elements, including delta conveyance alternatives, levee plan, water quality proposal, and ecosystem restoration strategy. LS-2.5.2-2

2) Seriously explore and describe a program for reducing or eliminating the seismic risks through subsidence reversal techniques. Specifically, we propose that CALFED commit to expend no less on learning how and where to reverse subsidence than it is planning to spend on levee maintenance over the life of the plan. LS-2.3.5-1

Specific Questions:

CALFED claims in the subsidence section (pg. xix) that the Delta must remain in its current configuration if CALFED is to achieve its objectives for water quality, ecosystem restoration, and levee system integrity. *What analysis has CALFED performed to support this assertion? How does CALFED define the current configuration of the Delta? Does CALFED consider the subsided configuration of the Delta islands desirable? Is it possible that some cut-off and set-back levees that would change the configuration are desirable? Did CALFED analyze the impacts of other Delta configuration alternatives on water quality, ecosystem restoration, and levee system integrity? How does CALFED define "current configuration?"* LS-1.4-1

Page xix states, "over the last 25 years, the existing levee program has demonstrated that levees in the Delta can be stabilized." Over the past 20 years, more than 25 levee failures have occurred on at least 15 Delta Islands and tracts.[2] The seismic report (appendix g) *estimates a 25% probability of 10 simultaneous levee breaches in the next 50 years,* and concludes that CALFED plans to upgrade all Delta levees to PL84-99 standard would not significantly reduce levee vulnerability." As few as 6-12 levee breaches may result in *irreparable damage to the Delta Levee system* (Seed, pers. com. 1999). *Does CALFED consider a levee system with a 25% chance of irreparable failure stable? Does CALFED have a plan for reducing the probability of delta levees from the dynamic loads created by seismic shaking?* LS-2.5.2-2

Page xix states, "In most cases, however, subsidence reversal is not implementable – due to excessive costs, right-of-way acquisition, land use conversion, and political concerns." *Has CALFED staff conducted any analysis or produced any documents regarding the cost or feasibility of subsidence reversal? If so, did these analyses compare the cost of subsidence reversal to the costs of catastrophic levee failure?* NHI has conducted and published analysis regarding the issues of cost, right-of-way acquisition, land use conversion, and political concerns associated with subsidence reversal. These analyses LS-2.3.5-1

[2] DWR, Delta Atlas, pg. 48.

are included in the attached report, "An Environmentally Optimal Alternative for the Bay-Delta Ecosystem: A Response to the CALFED Program" (NHI 1998). Briefly, the report concludes the best place to focus subsidence reversal is in the Western Delta where levees and water supply are most vulnerable to seismic failure. Most of the Western Delta Islands are already in public ownership (Sherman, Twitchell, and Jersey Island) or are owned by private parties who intend to convert them in a manner consistent with subsidence reversal activities (Webb and Holland Tract). The remaining island, Bradford, is categorized as mostly idle with some pasture by DWR, and its owners are *reputedly in financial distress and eager to sell. Most of the Western Delta islands* (excluding Bethel) are utilized for low value agriculture such as pasture, hay, and corn. NHI and representative from the Delta protection commission and Delta water agencies developed a map of low conflict (political) restoration opportunities that includes most of the western Delta. Subsidence reversal will undoubtedly be expensive, but these costs will probably less than the cost to the California economy if the Delta islands fail (NHI 1999). In conclusion, both the land acquisition and conversion costs and local political opposition to subsidence reversal on the western Delta islands are minimal.

Chapter 4, Ecosystem Restoration Program/Levee Program Coordination: This section needs more work. Despite years of document preparation, CALFED has generated less than two pages on opportunities for integrating the ecosystem restoration program and the levee protection plan. ERP 0-62

Section 4.2 includes numerous assertions that vegetation on levee surfaces either compromises levee stability, maintenance, and emergency repair. *Are these assertions based on scientific studies? Has CALFED reviewed the peer reviewed scientific literature on the interaction between vegetation and levees? If so, what sources were reviewed?* LS-4.2-3

The levee cross sections depicted in figure 6 do not increase the area or linear footage of tidal marsh habitat. Rather, they suffer on of the same drawbacks of existing levee designs, a preponderance of rip-rap along the water land interface. Nearly all the wetland vegetation is depicted as being significantly above mean sea level. CALFED should consider additional cross section designs that attempt to increase the amount of vegetation along the water/land interface. In particular, they should explore designs with a gentler slope to the water that is planted with wetland vegetation from approximately 3 feet below mean lower low water to mean higher, high water. LS-4.2-2

The plan fails to analyze the opportunities for cut-off and set back levees on mineral soils. There are an abundance of areas throughout the Delta, even in the central and western Delta, where bands of mineral soil are available to serve as foundation material for new or cut-off levees. LS-2.1.2-9

NHI welcomes the inclusion of appendix H detailing the maps of ecosystem restoration opportunities that NHI developed in collaboration with the Delta Protection Commission, representatives from the North, Central, and South Delta, Water Agencies. We must clarify, however, that these maps depict opportunities for ecosystem restoration – not

necessarily opportunities for integrating ecosystem restoration and the levee program as is stated on page 4-3.

B. Impact Analysis

Programmatic EIR/EIS

The probability of multiple levee failures that would overwhelm the best emergency response capabilities is approximately 10% over the next 20 years.[3] Such catastrophic levee failure would have major adverse impacts on the water supply, ecosystem, and water quality objectives of the program, yet there is no discussion of the risk and consequences of catastrophic levee failure for any of the alternative analyses. Pg. 6.1.36 claims erroneously claims that the Levee System Integrity Program would reduce the risk to the ecosystem of catastrophic breaching of Delta levees by maintaining and improving the integrity of the Delta Ecosystem. Alternative 3, and to a lesser extent alternative 2, would reduce much of the water supply and export water quality impacts of catastrophic levee failure, but none of the three alternatives would reduce the severe ecological and local water quality impacts that catastrophic levee failure would have on the Delta. The programmatic EIR/EIS should evaluate the risk and impact of multiple levee failures on water supply, Delta water quality, and the ecosystem health for all alternatives including the no action alternative. IA-2.0.0-13 IA-2.0.0-14

Section 7.1 estimates that 151,800 acres of important farmlands could be converted out of agriculture as a result of the ecosystem restoration program. This is less then one quarter of one percent the 6,834,594 acres of important farmland identified in the ERP. When compared to the amount of farmland that is currently being converted to urban uses, this number is insignificant. Moreover, these numbers appear to greatly overestimate the amount of farmland that would be converted, particularly in the Delta. 33,500 acres of Delta lands are delineated as idle in DWR's land use survey while another 75,000 acres of lands are delineated as native. If ecosystem restoration occurs mostly on these lands, losses to agriculture will be small. IA-7.1.7-8

Section 7.1,7.2, and 7.3 fail to adequately consider the agricultural impacts of the no-action alternative. Without the CALFED program, particularly the levee program, 100,000 – 200,000 acres of agricultural land and corresponding jobs could be lost due to catastrophic levee failure. Another 100,000 – 200,000 acres would be idled due to the local water quality impacts of catastrophic levee failure. The EIR should consider these scenarios when evaluating the no-action alternative. IA-7.1.6-1

[3] These probabilities vary depending on how many simultaneous levee breaches would cause irreparable destruction of the levee system. 6-12 levee breaches may be irreparable (Ray Seed, Pers. Com 1999). The probability of 6-12 levee breaches in the next 20 years is approximately 10%.

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Section 7.2 estimates that gross revenue losses would range from $500 to $1,500 per acre. Since majority of the land is in the Delta, and most of the other lands targeted for acquisition are riparian and wetland prone to flooding, it is unlikely that average revenues are above $500 per acre (from DWR land use statistics). As stated above, approximately 110,000 acres in the Delta, 16% of the legal Delta lands, are currently classified as idle or native. If a significant amount of restoration occurs on these lands, as is anticipated, than the average revenue loss per acre would decrease substantially. Another 56% of the Delta is classified as field crops (primarily corn), pasture, grain and hay (from DWR land use statistics). *According to table 7.1-2 the gross revenue per acre for these commodities* range from $108 to $570 per acre with a weighted average of $350 per acre. Most of the lands currently target for restoration are planted to these lower value uses, and the higher price of lands in other crops such as orchards will largely direct the restoration program away from higher value lands. Considering that 56% of the Delta acreage yields an average $350 per acre while another 16% of the Delta averages $0 per acre, the estimated range of revenue losses $500 to $1,500 is exaggerated. A more realistic figure would be $0 to $500 per acre. $500 to $1,500 per acre revenue loss estimates for the Sacramento and San Joaquin River regions also seems excessive. Considering that nearly half of Sacramento Valley land is in grain, alfalfa, field crops, or pasture with a gross revenue that ranges from $100 to $525 per acre, it is impossible that the average revenue loss per acre could reach an average of $1,500 per acre even if the other half of the lands were in orchard with a revenue of $2181 per acre (which they are not). Rather we estimate that an average revenue loss of $350 to $1,000 per acre is more accurate. Again the ecosystem program is going to be more likely to spend its money on low value land rather than high value orchards, resulting in a disproportionate amount of low value land being taken out of production. IA-7.2.2-2

7.3–13 uses number of up to 167 million revenue losses from agricultural conversion in the Delta. This number is based on an average revenue loss of $1,500 per acre which is two high based on the analysis presented above for section 7.2. Utilizing a more realistic figure such as $350 per acre would generate an estimated of $39 million in revenue losses per year. This section estimates a loss of approximately 11,000 jobs due to agricultural land conversion resulting from the combined restoration and levee programs, but does not consider the increase in jobs that would result from the $2-3 billion investment in these programs. IA-7.3.7-3

C. Water Transfer Program Plan:

P. 1-3: states "It is important to note that water transfers are simply mechanisms to move water and not sources of water." This is not entirely correct. To the transferee, water transfers are indeed a source of water. Indeed, for some urban water supply agencies and for some agricultural water agencies on the west side of the San Joaquin River, water transfers are now regarded as a component of their base annual supply. Perhaps the point the document seeks to make is that water transfers reallocate existing supplies; they do not make new water available to the system. Even this is not correct in two important respects: WT-1.2-4

- Water transfers can provide an important economic incentive against over-application of irrigation water. When that reduces evaporative losses or deep percolation of water to unusable groundwater basins (e.g., the drainage-impacted lands on the west side of the San Joaquin) or salt sinks (e.g., tail water losses to the *Salton Sea* from the Imperial Irrigation District), those saving represent water that would not otherwise we available for beneficial uses. This is important to acknowledge. Avoiding flows to salt sinks also have important water quality benefits. Facilitation of water transfers was a key mechanism cited by the interagency San Joaquin Valley Drainage Program (the "Rainbow Report") for reducing drainage problems at their source. WT-1.2-4
- Water transfers are also a key component of conjunctive use/groundwater banking programs, which do produce new water. One of the unexamined issues in the *EIR/EIS* is how water transfers can be improved for this purpose. We suggest that this issue be examined in the Integrated Storage Investigation. WT-1.2-4 IA-5.1-ST-29

P. 1-3: states "Water transfers . . . may encourage more efficient use of water . . ." Our empirical work on agricultural water conservation in the Central Valley confirms this statement. Indeed, it demonstrates why water transfers and other economic inducements like *tiered* pricing *may* be the best or only *mechanism* for *improving* efficiency of agricultural water use in the economic sense (i.e., a reduction in the amount of water consumed per unit of agricultural profit realized). This realization suggests that the facilitation of water transfers warrants greater prominence than it has received so far in *the CALFED* program. WT-1.2-5

P. 1-3: states "It is not a CalFed objective to increase the economic efficiency of water in the sense of causing water to move from relatively lower value uses to relatively higher values uses per unit of water ..." But it is a CALFED objective to improve water supply reliability. The role of water transfers in accomplishing that objective—in part by moving water from lower value uses to relatively higher value uses per unit of water—is not analyzed in the EIR/EIS. Yet, conservation options of this sort will need to be part of the Integrated Resource Plan (of which the ISI is a only a part) to satisfy the requirements of NEPA/CEQA/CWA §404 for consideration of a reasonable range of alternatives. What if half of the 20% of irrigation water that now produces only 4% of farm product were transferred to meet supply deficiencies in high valued crops, urban supply systems and instream flows? That could result in a substantial increase in supply reliability for every sector, including agriculture. How could a water transfer system that could tap that potential be put in place? No such scenarios have been generated or examined so far by the CALFED Program. WT-1.2-5

P. 1-5: states "water transfers can provide financial incentives for efficiency improvements, which can generate transferable water in some instances. For example, . . . back in production." Indeed. Yet, this paragraph hides a big problem in generating transferrable water: that is, in most areas of the Central Valley, the most readily available methods for conserving water—on-farm conservation measures and lining of canals—will not generate transferrable water. In the areas where excess irrigation applications return WT3.4.1-1

to usable surface or groundwater systems, it appears that the only ways to generate transferrable water are by fallowing land (which is not desired by agriculture), by reducing evaporation losses (e.g., shifting from sprinkler to drip irrigation) or by shifting to crops with lower applied water requirements. Eliminating deep percolation or recapturing tail water will not give rise to marketable water, at least under the CVPIA *water transfer rules.*

This "consumptive water" or "no injury" limitation to water transfers is a sound result where the source of the water and the place of application are hydrologically connected. *But the result is not sound where the water is "imported" into the area of application.*[4] See the next comment for an elaboration of this point.

P. 3-9: states "The other view argues that . . . groundwater basin results": As a proponent of "the other view", we should clarify our position. We propose integrating groundwater management into the surface water management system. We argue that "imported" irrigation water that percolates to usable groundwater, as contrasted to "native" or "area of origin" water, should be transferrable on either a short-term or long-term basis. This is because state common law recognizes that an importer of water retains the right to recapture the deep percolation or return flow. Thus, an importer does not lose control of imported water to other water users, but can take measures to recapture and reuse that water or transfer it to others. The federal water transfer rules, however, abrogate this distinction and treat imported water as though it were native water for purposes of the "consumptive use" and "no injury" limitations on water transfers. This is ironic since the very purpose of the CVP is to make water available in service areas where it would not otherwise be. WT3.4.1-1

At present, groundwater users who are pumping within the service areas of the federal and state projects are obtaining a "windfall" in *the form of groundwater recharge from irrigation applications. They receive this developed water* without charge and *to the* detriment of potential transferees of that same water. Stated another way, groundwater pumpers who have enjoyed the benefit of incidental groundwater recharge from the over-application of imported irrigation water by the CVP or SWP are not "legal users" of that *water in the event that the importer (the projects or their contractors) undertake measures* to reduce that incidental recharge. Those farmers or water districts that implement irrigation improvements or water conservation measures in these areas should be allowed to market the saved water. Indeed, unless they can do so, it is hard to see why they would incur the costs of implementing those measures.

How would the water supply reliability picture change if this incidental groundwater recharge were instead reallocated to willing buyers either within or outside of those service areas? Under that scenario, groundwater pumpers would not necessarily lose the

[4] The functionally relevant meaning of "imported water" is water that would not otherwise have been hydrologically available at the point of extraction. It does not mean only water that has been diverted from one drainage basin to another. Thus, water released from Shasta for storage in the Yolo Basin is probably "imported water".

use of the incidental recharge water from the state and federal projects, but they would have to pay for it like the surface water users do. That increase in cost would induce and justify larger investments in water conservation measures by these users and reduce the draw on aquifer supplies in drier years when that water is most needed by other users in the system. This type of integration of surface and groundwater uses is exemplified by the Arvin Water Storage District in Kern County.

We think the CALFED program should look seriously at these relationships between water transfers, groundwater management and water conservation and how they relate to the (dry year) water reliability objective of the CALFED program. That inquiry is central to the potential role of water transfers within the CalFed solution set. The final PEIS/EIR should consider this water management alternative, including an analysis of how changing the federal rules to allow transfer of recaptured deep percolation and return flow would improve incentives to conserve water for other uses. WT4.5.1-1

P. 2-5: states "The federal . . . to any other California water user": As noted above, this summary of law should analyze how the limitations on transferrable water in the CVPIA limit the usefulness of water transfers in accomplishing the objectives of the CALFED program. Specifically, the inability to transfer salvaged deep percolation water may be a problem. This summary of the law should also discuss the distinction between native and imported water as it affects water transfers. WT-2.1-1

P. 4-8: states "4.4.3 Solution Process . . . Issues": Legislation to create an instream flow registry to protect environmental water transfers was developed by NHI in 1995 with the support of ACWA and MWD. That bill was twice passed and twice vetoed by Governor Wilson. The Governor supported the measure but vetoed the bill because the cost of administering the program by the SWRCB was not in the Governor's budget requests. Please include NHI in the proposed discussions among "stakeholder representatives and CALFED agency representatives" on this issue "during the months prior to a Record of Decision". We have accumulated substantial experience on this problem and the options for dealing with it. WT4.4.3-2

D. Water Use Efficiency Program

NHI supports the intent of CALFED to invest in urban and agricultural efficiency as part of its program to meet multiple needs, and we find this section to be much improved. However, three conceptual problems remain. First, CALFED must assure that efficiency investments assist in meeting CALFED goals. Subsidies for water conservation initiatives that are not linked to a tangible benefit for the CALFED program are likely to be ineffectual and wasteful. Second, CALFED limits the potential for agricultural efficiency improvements by defining efficiency in purely physical rather than economic terms. Third, CALFED fails to appreciate the larger role that water conservation can play in improving dry year water supply reliability when it is coupled to inter-annual storage arrangements such as groundwater banking. WUE 2.2-4

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Moving from subsidies to investments: Linking payments for water conservation to tangible water supply and water quality benefits requires CALFED to create market incentives for water conservation initiatives.' This can be done in two ways. To the extent that CALFED "enters the market" to purchase water for environmental purposes (through the EWA), the market value of water will be increase. This makes it worthwhile for local water users and suppliers to spend more to conserve or recycle water that would otherwise be lost to beneficial uses. As a second technique, CALFED can enter into ventures or joint ventures to actually invest in conservation or recycle projects in exchange *for all or a portion of the water that will be generated.*

As a prime example, consider what could happen if CALFED were to fund efficiency programs in urban southern California. If CALFED simply hands out subsidies for efficiency improvements in the hope that benefits will flow to the ecosystem via reduced diversions, it will be disappointed. Instead, as a result of SWP contract rules, the saved water would largely flow to other contractors. In effect, a public investment in efficiency would have been converted into a water subsidy for other SWP contractors. IPF 5.4.4-5 WUE 2.2-4

For this reason, it would be far preferable for CALFED to use its efficiency funds as investments rather than subsidies in return for an assurance of public benefits. Thus, for example, CALFED could invest in a reclamation project or toilet retrofit in southern California for a share of the saved water to be delivered to the EWA.

There is another benefit to looking at CALFED efficiency investments as market transactions. CALFED's current approach is to fund only efficiency improvements that are not cost effective at the local level. That is CALFED will exclusively fund the most expensive efficiency programs. But under a market paradigm, CALFED could fund any project, provided that the benefit stream to CALFED justifies the cost. This shift in emphasis would allow CALFED to get more benefits at less cost without being accused of providing public funds for local benefits. IPF 5.4.4-5 WUE 2.2-4

CALFED should consider agricultural water conservation alternatives predicated upon an economic definition of efficiency. In the PEIS/EIR, CALFED defines irrigation efficiency solely in terms of the fraction of water that is "beneficially used". Consequently, the conservation potential is limited to reduction in losses to salt sinks, inaccessible or degraded aquifers, or the atmosphere. But efficiency can also be understood as a measure of economic performance. From that vantage point, agricultural water use efficiency is defined as **the volume of irrigation water consumed, divided by the market value of the farm products derived from that water (or, more pertinently, by the farm *profits*).** Thus defined, the potential for efficiency improvements in the use of water in agriculture becomes quite large because the field of water conservation practices enlarges to include moving water from low value applications to higher value applications. This is illustrated by the fact that 20% of agricultural water use is applied to crops that provide only 4% of annual crop value. Stated another way, a vigorous agricultural water conservation program could be constructed under a guarantee to California agriculture that its current level of profitability would be maintained while allowing some fraction of water now used to WUE-2.2-1

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produce that profit to become available for unmet needs in other sectors, including the environment.

This alternative scenario for improving agricultural efficiency should be analyzed in the final EIS/EIR. Presumably, the water supply reliability strategy adopted in the Record of Decision will be the product of analyses of both supply and conservation alternatives. It is hard to see how the imperative under NEPA/CEQA/CWA § 404 to compare a range of reasonable alternatives can be satisfied without considering an agricultural water conservation alternative defined in terms of improvements in the economic efficiency of water use in that sector. It is possible that comparison of that alternative with the current one would lead to its rejection as impractical or undesirable. That would be justified as long as that rejection is based on technically sound analysis. What is not justifiable under the NEPA/CEQA/CWA § 404 processes is rejection based on unexamined preconceptions.

CALFED fails to consider alternatives for increasing dry year water supplies by linking water conservation to storage. While this document recognizes the potential of using recovered losses to improve water supply reliability in drier years, it fails to analyze that potential. Water tends to be more valuable in most sectors and for most purposes in drier years than in wetter years. Over-application of irrigation water that recharges usable groundwater may represent a recoverable loss. But the time to recharge aquifers is during years of relative abundance, not years of relative scarcity when that water is needed for immediate consumptive uses or to maintain minimum stream flows. There are substantial potential water supply reliability benefits to conservation measures that reduce losses in dry years. But, most such conservation measures cannot be readily switched on or off depending on the water year type. Rather, water conservation measures should be implemented on farms and in conveyance system in all year types. In drier years, that conserved water can be used to meet otherwise unmet needs. In wetter years, the conserved water can be stored (e.g., banked in groundwater storage sites) for recovery in drier years when it can provide the greatest value. What we suggest here is a purposeful, *time-sensitive groundwater recharge program, rather than an accidental one.* IA-2.0.0-19 CR5

The same analysis applies to all other incidental beneficiaries of recoverable losses, such as downstream water users and aquatic environments. In most cases, that water is more valuable to such users in drier years than in wetter years. Conservation tied to storage should provide a net improvement in water supply reliability for all users. CalFed has not analyzed the water supply reliability benefits of this kind of water conservation program linked to groundwater banking. IA-5.1-ST-82

E. Delta Storage

The CALFED DNCT has postulated the existence of a particular Delta storage configuration during its simulation exercises. In particular, the DNCT has looked at:

- The creation of storage within Bacon, Woodward, and Victoria Islands.
- The installation of high volume diversion facilities on one or more of these islands.

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- A direct physical connection between these islands and Clifton Court Forebay and/or the Tracy pumping plant.

We are concerned that the existing description on storage and diversion alternatives may not include this scenario within its envelope. Since the creation of this kind of diversion/storage complex is a reasonably likely outcome of the CALFED Program, the FEIS should describe these options and their impacts with enough detail to avoid the need for additional programmatic work at a later date.

F. Environmental Water Account PH2:3.6.6-47

NHI is very supportive of the EWA concept. However, the value of that concept will be determined by the manner in which the EWA is implemented. CALFED should consider the following points as it moves toward EWA implementation:

- EWA operations cannot and should not be divorced from:
  - The ERP water purchase program.
  - The CALFED habitat improvement program.
  - The CVPIA b(1), b(2), and b(3) programs.
- This implies that: PH2:3.6.6-48
  - A single institution (once called the Delta Ecosystem Restoration Authority *within CALFED) should manage both the flow and non flow parts of the* ecosystem program
  - Funding should be able to move either from the habitat measures to the flow program or vice versa in order to allow investments in ecosystem restoration to pay the highest returns.
  - CVPIA water must effectively be managed as part of the EWA (either through a transfer of assets or through tight coordination).
  - Any expansion of infrastructure to allow greater water deliveries to water users is likely both to have intrinsic environmental impacts and to reduce the utility of any given level of EWA assets. This implies that the EWA must grow as system infrastructure grows. Without this kind of feedback loop, the ability of the EWA to provide environmental enhancement will decline over time. PH2:3.6.6-49
  - The EWA funding stream must be predictable if it is to take on debt, purchase options, invest in infrastructure, or invest in efficiency. This implies that EWA funding cannot depend upon annual appropriations from the legislature and Congress. Either the EWA must be given an adequate endowment to allow a predictable annual income, or funding must be based upon some sort of user fee. PH2:3.6.6-50

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G. Ecosystem Restoration Plan ERPIII 0-3

The Ecosystem Restoration Plan remains disorganized and lacks scientific justification, over a year and a half after the criticisms of the independent scientific review panel. The document still fails to satisfactorily adopt the six basic recommendations of that panel. The stakeholder-initiated Strategic Plan represents the only significant progress since the initial draft of the ERPP. CALFED has even marred that signal example of successful stakeholder engagement by simply editing the original version of the strategic plan and then simply ignoring it in Volumes I and II of the ERPP. This makes a mockery of stakeholder participation and leaves this central element of the CALFED plan seriously flawed. NHI suggests that CALFED either adopt the original version of the Strategic Plan as drafted by the Core Team or retain the Core Team to consider whatever revisions the CALFED staff wish to propose. *If CALFED is unwilling to take either of these steps, we believe the final EIS/EIR must explain the rationale for substituting the revised Strategic Plan for the original version (September 1998), which was drafted by six of California's most respected ecosystem scientists and planners.*

Muddle of Objectives ERPIII 4.1-1

The core team of scientists that developed the strategic plan developed a clear set of goals and measurable objectives to guide the priorities of the restoration program. Although not sufficiently comprehensive, the list of objectives was clear and the strategic plan articulated a logical path for refining them and specifying additional objectives over time. CALFED staff has unfortunately mixed the strategic plan objectives with many vague or less important objectives. As a result, by one count the program now has over 140 objectives. Many of the objectives are confusingly redundant, uselessly vague or comparatively unimportant. This creates a muddle of "strategic objectives, strategic sub-objectives, and long-term and short term objectives." *CALFED should simply reduce* the number of redundant objective statements and then list all objectives under each of the six goal statements in an executive summary section.

The ERPP must specify criteria and a process for selecting and prioritizing restoration *opportunities and Stage 1 Actions* ERPIII 10-3

As we stated in our comments to the original version of the ERPP (November 1997), the ERPP does not the describe criteria and a process for selecting and prioritizing restoration opportunities. The original unedited draft of the Strategic Plan (September 1998) by the core team of independent scientists emphasized the importance of utilizing selection criteria for nominating, evaluating, and selecting ERP actions for stage 1 implementation. The core team stated that it is important to: "(1) introduce new criteria designed to help make Stage I ecosystem-based and adaptive, and (2) suggest a process for further evaluating both previously proposed and newly proposed actions". To our knowledge, CALFED never developed explicit criteria to screen or prioritize the universe of potential restoration projects. Rather, it seems that CALFED staff simply selected a list of projects and then attempted to rationalize them. Although some stage 1 projects appear misguided to NHI, the focus of our criticism is directed at the lack of process for

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selecting the actions rather than the actions themselves. Many of the proposed actions are worthwhile, but many other worthwhile projects were not included. It is not apparent that these were considered or evaluated according to a rationale selection process or criteria. More detailed comments on stage 1 actions are provided in the Delta section of our comments.

Even with a large budget, the list of desired restoration activities will far outstrip the available financial resources. To be useful, the plan must provide a basis for winnowing the more essential from the less essential, and, since the ERPP cannot undertake every winner simultaneously, a process for sequencing and prioritizing. The selection and prioritization principles around which a working consensus might coalesce might include the following obvious ones: ERPIII 5.0-3

- **Learning potential:** Projects should be designed specifically to address critical knowledge gaps pertinent to broader application of restoration techniques.
- **Fungibility:** The restoration program should invest in ecosystem assets (land, water) that can be exchanged as priorities evolve.
- **Reversibility/Conservation:** Projects that prevent relatively irreversible changes to the *landscape* such as urbanization, *fragmentation*, exotic species invasions, or conversion to perennial crops should be prioritized.
- **Comparative Cost Effectiveness:** Projects should yield the greatest benefits per unit of investment in achieving the restoration goals and objectives.
- **Restorability:** Restorability: Projects that truly restore or protect natural process, functions or character, or come close should be favored.
- **Feasibility/Ripeness:** Projects that can be achieved in the near term without countervailing adverse consequences should be favored.
- **Sustainability:** Projects that are self-sustaining should be preferred over those that require significant maintenance.
- **Leverage:** *Projects* that have the potential to leverage an initial public investment into a larger effort for ecosystem benefits are desired.

<u>Volume I and II of the ERP should be viewed as Illustrative rather than Definitive</u> ERPII 0-4

The ecosystem targets and actions described in Volumes I & II as well as the stage I plan were generally not selected according to the methodical scientific process recommended by the independent scientific review panel and described in the strategic plan. As a result, many of the actions described in Volume I and II are not scientifically based and may ultimately limit the scope of the restoration program to a set of ineffective actions.

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In fact, the original unedited version of the strategic plan states, "none of the proposed actions contained in Volumes I and II of the Ecosystem Restoration Program Plan were evaluated within the context of the adaptive management approach recommended for the ERP." This statement is still accurate since very little of Volumes I and II were substantially redrafted since the strategic plan was initially released.

The strategic plan provides a reasonably clear explanation of the process by which targets and actions will be changed over the life of the project as our understanding of the ecosystem improves over time. But it is unclear whether target and actions described in Volume I & II limit the scope of future restoration actions or are simply examples of the types of that the restoration program will include. As currently drafted, it appears that Volume I & II constitute the full scope or "book ends" of the restoration program. This is a problem, because there is no assurance or scientific basis for assuming that the actions described in Volumes I & II will actually achieve the goals and objectives of the ERPP. *Does CALFED consider the specific targets listed in the ERPP as "bookends" or limits on the scope and area of restoration actions?* ERPII 0-5 ERPII 0-6

<u>The ERPP's restoration targets are too modest</u> ERPII 0-6 ERPII 16.12-3

The independent scientific review panel recognized that water and land restoration must be the key elements of CALFED's ecosystem restoration program, yet CALFED proposes to restore less than 150,000 acres of land – less than two percent of the 6,835,000 acres of farmland in the primary solution area. The ERPP's anemic proposal for restoring less than 6,000 acres out of 3,750,000, 0.16% of farmland in the San Joaquin River region is particularly scant. We fail to understand how CALFED will achieve any meaningful restoration objectives with such anemic restoration proposals. In light of the fact that land restoration must be a key element of the restoration program, NHI suggests that CALFED considerably expand land acquisition program. We expect that significantly expanding the proposed land restoration targets will not significantly alter CALFED's land use and agricultural impact analysis (see impact analysis comments and previous section).

In many cases, ERPP targets are already required by existing laws or already being implemented by pre-existing programs. For example, the flow restoration Targets for the Tuolumne River are already mandated by FERC while the flow targets specified for the Merced River are below those required by Davis Grunsky. The entire premise of the *CALFED ecosystem restoration program is to identify restorative* actions above and beyond existing law in order to reduce the conflicts imposed on the water system by endangered species.

The ERPP's vision for restoration of the Delta is also disappointingly modest and limiting. Over 95% of the Delta's riparian and wetland habitats have been destroyed or fragmented. The ERPP acknowledges that the Delta is the ecological hub of the Central Valley bioregion, yet it proposes to restore less than 10% of the Delta to tidal marsh habitat types over the next 25 years. This is not going to be enough to secure the long-term survival of many native species needing contiguous habitat areas. The Delta is the ERPII 4.0-2

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only place where large contiguous areas of aquatic, marsh, and riparian habitat types can be restored. In the Delta, the low land values, lack of urbanization, large parcel sizes, continued flooding, subsidence problems, and proximity to endangered species present a unique opportunity for restoring vast areas over the next 25 years.

To the extent one can infer any rationale for the paltry target here proposed, it seems an entirely unscientific one. *Basically, we are given to understand that only about 12% of the tidally influenced lands in the Delta are considered worthy of restoration to tidal marsh* because a 1906 map of the Delta shows about this percentage of marsh remaining and, at that time, when the fishery was in reasonably good shape. Thus, the logic goes, if we restore to the 1906 marker, the fish will come back. Why 1906 is thought to be the optimal marker, rather than 1956 or 1856 is not explained. Apparently, there is no better reason than that a map of that date happens to be in the possession of the CALFED staff. In the intervening decades, of course, the hydrodynamics and species composition of Delta has been utterly transformed by human actions. Since the clock is not to be turned back on these alternations, there is no good reason to think that this extent of marsh restoration will produce a 1906 level of fishery benefits. ERPII 4.0-3

But the problem with the analysis is much more fundamental. Clearly, as the independent scientific review panel stated, where habitat is concerned, more is always better than less. The real constraints on how much tidal marsh to reconstruct in the Delta and where are not a function of some historical marker or some preconceptions as to how many fish are enough. They are set by the wholly practical considerations such as where and how much of the subsided lands can be elevated to near sea level and at what cost, how much and where the levee system is most vulnerable to catastrophic failure due to seismic events, how much and where the full costs of levee maintenance and fish screening make continuation of present land uses unsustainable, how much and where habitat benefits can be obtained for favored species, and the extent to which and where there are willing sellers of the private lands in the Delta. In short, the EIS/EIR should present an *ERPP that specifies the restoration targets on the basis of analysis of costs* and opportunities rather than just some arbitrary historic period. Rather than consider these factors, the ERPP simply assumes that it will be impossible to restore subsided lands to tidal marsh or shallow water habitat. ERPII 4.0-4

The real explanation for the ERPP's modest tidal marsh target may well be the concern that the private landowners in the Delta would object to a more ambitious restoration program. NHI also believes that a feasible Delta restoration program must be acceptable to the Delta landowners. Indeed, we think the best restoration program would be one that is home grown–developed by the Delta residents and the environmental beneficiaries together. We have been working to this end. The key point here is that the extent to which private lands will be converted to habitat is entirely within the control of these private landowners and this will remain so. What the ERPP needs to do is develop a program of incentives that makes it attractive to these owners to embrace, and indeed initiate, restoration projects on as broad a scale as practicable. Of course, one of those *practical constraints is the opportunity costs at various levels of restoration effort, just as* is the case for all other restoration options. (See comment # 2 above). But starting with ERPII 4.7-4

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arbitrary limits based upon some unarticulated political premise simply undermines the ERPP as a serious effort.

The map of low conflict restoration opportunities that we developed along with the Delta Protection Commission and representatives from local Delta Water Agencies (figure 12, in the Environmental Optimal, and Appendix H of the Long Term Levee Protection Plan) *should be included in the ERPP. It delineates 165,000 acres of land considered suitable* for habitat restoration not including tens of thousands of acres of other lands that are suitable for wildlife friendly agriculture. Despite the large geographic area of low conflict restoration opportunities depicted in the map, the map was viewed by both NHI and Delta interests as near-term low conflict restoration opportunities – not a recommendation on the scope and magnitude of the final restoration program after 30 years. Indeed, it is not possible to specify optimum long-term plan for habitat restoration at this time. Rather CALFED should embrace a flexible approach that allows them to expand or constrain the program over time as science and social preference dictate. ERPII 4.7-5

<u>Restoration Targets and Actions Are Arbitrary and Overly Limiting</u> ERPII 0-7

In our comments to the initial EIR, NHI emphasized that the **ERPP should place more emphasis on the restoration planning process and less emphasis on specific *restoration targets and actions.*** In recognition of the tremendous uncertainty regarding actions necessary to improve ecosystem elements, CALFED has correctly embraced the adaptive management planning process. Unfortunately, the ERPP does not articulate an adaptive management process. Rather, CALFED has ignored the real level of uncertainty about how to restore the ecosystem and simply identified several unsubstantiated and seemingly arbitrary restoration targets and actions. Our specific comments regarding the *East San Joaquin Tributaries* ecological zone demonstrate the *folly of specifying* overly narrow and often arbitrary targets and actions. CALFED should delete specific targets unless there is a strong scientific basis for them and replace the target with a broader *range of potential restoration actions.*

We suspect that that CALFED has prematurely identified specific targets and actions in order to produce an environmental document that would comply with CEQA and NEPA. ERPP is intended to be a programmatic document, and it is not possible or wise to develop highly specific targets at this level. For the purposes of quantifying the relative costs and benefits of the ERPP, CALFED should identify the broad range of effort potentially necessary to achieve implementation objectives. For example, to achieve the implementation objective associated with stream flows on the Stanislaus River, the ERPP should estimate a range of potential target flows necessary to mobilize gravel such as "an average release of between 6,000 and 12,000 c.f.s. for a 10 day period." ERPP should qualify this statement with the caveat that the exact flow necessary to mobilize the bed will be determined through an adaptive management program. The final cost/benefit analysis can then be based on the costs and benefits that would accrue at the lower, middle, and upper end of the range of targets. The purpose of this exercise is to provide *an analysis of costs and benefits over a broad range of effort.* There is ample precedent for using this approach in programmatic environmental documents. Rather than

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specifying narrow ranges of targets such as "create between 43 and 60 miles of riparian vegetation in the Delta ecozone" that may preclude achieving restoration objectives, CALFED should establish broader targets that give the program the leeway necessary to *implement whatever reasonable level of action is necessary to achieve program* objectives such as "create between 50 and 200 miles of riparian vegetation."

Significantly expanding restoration targets will not significantly alter the impact analysis or require significant new analysis. CALFED impact analysis is very general, as it should be for a programmatic EIR. In many cases, CALFED has only identified the direction of impact, not the magnitude of impact. Since expanding the range of targets upward will not effect the direction of impact, it will not affect the magnitude. In cases where CALFED has crudely attempted to quantify the magnitude of impact, such as agricultural land conservation a doubling or tripling of targets will be insignificant since the initial targets are so modest – less than one quarter of one percent of all agricultural land in the region.

In many cases, an identification of a range of targets and actions is the only defensible means of describing the level of effort necessary to achieve a particular implementation objective, because many objectives can only be achieved by actions that exceed a critical threshold, and those thresholds cannot be practicably determined at the programmatic level. For example, periodic pulse flows capable of mobilizing the bed of the river are necessary to achieve the implementation objective associated with stream flows, but the actual flow necessary to mobilize the bed can only be determined through further analysis. The ERPP should estimate a range of potential target flows necessary to mobilize gravel such as "an average release of between 4,000 and 8,000 c.f.s. for a 10 day period on the Stanislaus River," and qualify this statement with the caveat that the *exact flow necessary to mobilize the bed will be determined through additional analysis.* The final cost/benefit analysis can then be based on the costs and benefits that would accrue at the lower, middle, and upper end of the range of targets. The purpose of this *exercise is to provide an analysis of costs and benefits over a broad range of effort.* There is ample precedent for using this approach in programmatic environmental documents. CALFED should avoid wasting time and money by identifying narrow ranges of targets such as "create between 43 and 60 miles of riparian vegetation in the Delta ecozone." ERPII 0-8

Are CVPIA and Other Restoration Programs Included in ERP?

It is unclear whether the ERP encompasses CVPIA and other major restoration programs such as the Sacramento River Area Conservation Program or is in addition to those programs. If indeed, the ERP targets represent the cumulative total of CALFED, CVPIA restoration targets, and other restoration targets, then the scope of the ERP is unacceptably small. CVPIA alternatives alone contemplate retiring between 57,000 and 200,000 acres of 'agricultural' land – more than the number of acres targeted for restoration in the ERPP. The Sacramento River Area Program includes another 10,000 acres. If the ERP targets include targets adopted by other programs, then the ERP would do nothing more than implement existing programs and laws. Surely, this was not the intent of the last 5 years of CALFED planning. *Please respond and let us know whether* ERP 0-73 ERP 0-74 ERPII 0-9

the ERP restoration targets are above and beyond CVPIA and other program targets (additive) or whether the ERP targets include all restoration actions contemplated in these other programs?

Delta Restoration Vision and Stage 1 Actions ERPIII 10-4

One of the greatest threats to the Delta is urbanization from nearly all-surrounding communities – Sacramento, Stockton, Lathrop, Manteca, Tracy, Brentwood, and Oakley. Many lands on the periphery of the Delta are at imminent risk of urbanization. We agree with CALFED's plan to work with farmers to protect wildlife friendly agricultural lands, but we think that this activity should be elevated to a stage 1 action and concentrated in the Delta Secondary zone. If CALFED does not elevate this activity to a stage 1 action, many lands along the periphery of the Delta will be urbanized, and ecosystem restoration opportunities will be irreversibly lost.

It is obvious for reviewing the stage 1 actions that CALFED has not consulted the necessary experts to identify and explain priority actions. In several cases CALFED has simply missed worthwhile stage 1 actions. For example, action 1 in the Delta Section (D-4) calls for increasing the *duration* of flooding in the Yolo Bypass in winter and spring. Although increasing the duration of flooding may be worthwhile, it is probably more important to increase the *frequency* of flooding particularly in dry years, because prolonged periods without inundation may leave the endangered Sacramento splittail with no place to spawn. The splittail only needs flooded conditions for six weeks in January and February – not during spring months as described in the stage 1 actions. Action 3 for the Delta (D-5) recommends widening the Tule Canal/Toe Drain. Why does the toe drain need to be widened? Is there any evidence that the width of the toe drain limits migration of fish? Our understanding is that the toe drain can already convey 10,000 c.f.s. (Ted Sommer, pers com 1999). If anything, the toe drain conveyance capacity should be reduced to increase overbank flooding favored by many native fishes. ERPIII 10-5

Pg. D-5 Actions 6, 8, and 9 propose wetland restoration on Little Holland Tract, Liberty Island, and the lower Yolo Bypass respectively. These areas have recently been identified as mercury hot spots by the U.C. Davis study funded by CALFED. Creation of wetlands could reopen biological pathway for methylated mercury – causing significant adverse impacts for the North Delta ecosystem. While these actions represent some of the easiest opportunities for large scale restoration, the most prudent course of action would be to delay these actions in favor of some other actions that are more pressing. ERPIII 10-6 WQ-4.4.2-2

All of these proposed actions are located in the Yolo bypass, a dedicated floodway that will never be developed. CALFED can be assured that the opportunity for restoring these areas will not be diminished by time. In other areas of the Delta, restoration opportunities will be lost in the near future due to the pace of urbanization. ERPIII 10-7

One of the best examples of a restoration opportunity that may soon be lost to urbanization is tidal marsh restoration on the southern shore of Big Break in North East

Contra Costa County. Numerous scientists and restoration planners have visited the site and affirmed its high potential for tidal marsh restoration, yet CALFED never considered including it on the stage 1 list[5]. This is particularly disappointing since CALFED has claimed that it will utilize the north delta sites to study the relationship between salinity gradients, salinity variability, and physical habitat – a research need identified by the Core Team. Salinity gradients and variability are very small or non-existent in the north Delta. The western delta is the best place to study the effects of salinity variability and Big Break is one of the few sites where short-term restoration is possible in the West Delta. ERPIII 10-8

Central and West Delta Stage 1 actions: Action 1 proposes restoring a mosaic of habitat types on Franks Tract using clean dredged materials. This may be a worthwhile project, but it will require very large volumes of dredged material that may be more efficiently used elsewhere. The idea of restoring already inundated habitat to tidal marsh is sound, but why is Franks tract the only site under evaluation? It may be possible to restore more productive wetlands with less fill and for less money at Big Break. Before CALFED implements this action on Franks Tract, it should comparatively evaluate it against the benefits and costs of other opportunities for restoring tidal marsh at other open water areas such as Big Break. ERPIII 10-9

East San Joaquin Basin

Pg. 433: The flow regimes specified for the East San Joaquin Tributaries are an example of the inconsistent and poorly reasoned approach that was apparently utilized to outline the restoration program described in the ERP. Although the Tuolumne (1.95 maf) is significantly larger than the Stanislaus (1.2 maf) and Merced (1.02) rivers, the three systems share similar geology, watersheds, hydrology, and aquatic species yet the flow recommendations for each river (which are nothing more than existing law on the Tuolumne and less than existing law on the Merced[6]) vary widely. Table X below depicts the CALFED flow recommendations for these three rivers for above average-wet years. Presumably, the recommended flows are intended to meet strategic ecological objectives such as restoring salmon populations, yet there is no explanation why 25 c.f.s. *on the Merced is an adequate summer flow while 300-1,500 is deemed necessary* on the Stanislaus. ERPII 16.12-3

The recommended spring peak flows for each river are more consistent, but there is no scientific basis for *determining whether they are adequate for achieving objectives* associated with high flows such as maintaining dynamic channel processes, channel complexity, bed sediment quality, and natural riparian habitats. The rationale statements claim that these "pulse" flows would help to restore natural stream processes; gravel

[5] NHI has identified the Big Break site as a prime restoration opportunity and invited CALFED staff to visit the site on numerous occasions, but CALFED staff have declined.
[6] The ERP Volume 2, pg. 432 states that the Davis-Grunsky contract requires Merced Irrigation District to maintain a continuous flow of between 180cfs and 220 cfs in the lower Merced River from November 1 through April 1, yet pg. 434 of the ERP recommends minimum flows in normal years of "25 cfs from June through October 15, 60 cfs from October 15, 75 cfs from October 16 through October 31 and January through May and 100 cfs in November and December.

recruitment, cleaning, and transport; and riparian vegetation development and survival. But it is obvious, for example, that dry year pulse flows of 1,000 to 1,500 c.f.s will not transport, recruit, or clean gravel. As we said in our comments to the initial ERP draft (November 1997) achieving these geomorphic objectives generally requires a threshold flow necessary to mobilize the channel bed. Peak flows below this threshold do nothing to achieve stated geomorphic objectives and may even be a harmful waste of water. Our understanding of these systems suggest that even the maximum recommended flows of 4,000 – 6,000 c.f.s on these rivers are not sufficient to meet the needs of maintaining a healthy riparian ecosystem[7]. Rather flows closer to the natural mean annual flood (10,000 – 14,000) c.f.s may be necessary to achieve stated geomorphic objectives on these rivers. Furthermore, peak flows of 4,000-6,000 c.f.s that do not go overbank may perpetuate channel incision and reduce channel complexity overtime.

Table 1: Flow Recommendations for East San Joaquin Tributaries

	Merced (normal to wet) (c.f.s.)	Tuolumne (normal to wet) (c.f.s.)	Stanislaus (normal to wet) (c.f.s.)
OCT 1-15	25	300	300-400
OCT 16-31	75	696.6667	300-400
NOV	100	300	300-400
DEC	100	300	300-400
JAN	75	300	300-400
FEB	75	300	300-400
MAR	75	300	300-400
APR	75	2297	1,500
MAY	75	1296	1,500
JUN	25	250	800-1,500
JUL	25	250	300-400
AUG	25	250	300-400
SEPT	25	250	300-400
Spring Peak	3,000-4,000		3,000-4,000

The flow regimes specified for the Tuolumne and Merced Rivers are already required by law. If the CALFED plan for flows on the Tuolumne and Merced River is to do nothing more than existing law, then they should simply state that CALFED plans to do nothing to augment flows on the Tuolumne and Merced rivers.

[7] On page 439, the ERP acknowledges that "the present channel capacity of the Tuolumne River is about 9,000 cfs which is not large enough to meet the needs of maintaining a healthy alluvial river ecosystem.

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The diversity year classification for stream flow restoration targets (depicted in table 2) is indicative of the inconsistent and arbitrary approach apparently utilized by CALFED to select restoration targets and actions. *Why are multiple year class selections utilized on different tributaries to identify flow restoration targets?* ERPII 16.12-3 ERPII 16.12-4

Table 2: Inconsistent Year Classifications for East San Joaquin Tributaries

Stanislaus	Tuolumne	Merced
• Critical, dry, and below normal • Above-normal • wet	• critical and below • median critical dry • intermediate critical dry • median dry • intermediate dry-below normal • median below normal • all other year types (intermediate below normal/above normal, median above normal, intermediate above normal-wet, and median wet/maximum years	• dry years • normal years

Pg. 437 Coarse Sediment Supply: Target ERP 16.12-5

The stated rationale for coarse sediment supply actions states that incorrectly states "gravel transport is the process whereby flows carry away finer sediments that fill gravel interstices (spaces between cobbles. Gravel cleansing is the process whereby flows transport, grade and scour gravel." In actuality gravel transport is the process whereby flows transport, grade and scour gravel. It is important to recognize that it is generally impossible to clean fine sediments from the gravel interstices without actually mobilizing the gravel (Kondolf and Wilcock, 1998). Even though the definition of gravel transport explicitly involves flows transporting water and changing water flows (i.e. large peak flow releases) is identified as an opportunity for restoring gravel conditions necessary for spawning, actual changes in flows are not listed as a programmatic action for improving coarse sediment supply. Rather the only actions listed are studies for evaluating whether gravel augmentation programs to improve spawning habitat below major dams are necessary. Gravel augmentation may be necessary, but in the absence of restoring flows sufficient to transport gravel, it does not constitute restoration of ecological processes.

Pg. 438 Stream Meander: The target for preserving and expanding stream meander belts on the East Side San Joaquin Tributaries – adding a cumulative total of 1,000 acres on all 3 tributaries – is probably insufficient to achieve the stream meander objective. We suggest increasing the target to a range of 1,000 – 10,000 acres on all 3 tributaries. ERP 16.12-6

Programmatic action 1B proposes establishing a mechanism through which property owners would be reimbursed for lands lost to natural meander processes. We support this approach but our concerned that such a program may end up compensating private interests for the acquisition of property already controlled or owned by the state. The state holds fee title to the beds of all navigable rivers and holds a public trust easement on their banks. Any land that becomes part of the bed or bank of the river through natural meander migration becomes the property of the state. *Does CAFED intend to purchase riparian lands that are already owned by the state? If not, what mechanism will CALFED utilize to ensure that CALFED funds are not used to incorrectly compensate private parties for the acquisition of lands already owned or controlled by the state?* ERPII 16.12-7

Pg. 440 Central Valley Stream Temperatures: The temperature targets seem unnatural. The target calls for spring temperatures that are five degrees warmer than summer temperatures. Summer temperatures on those streams probably exceeded 60 degrees in the summer months and were certainly greater than pre settlement springtime water temperatures. The diversity of the aquatic community is shaped by natural variation in stream temperatures. Unnatural variation in stream temperatures proposed by CALFED and the Fish and Game Code may be harmful or unnecessarily expensive to attain. ERPII 16.12-13

Pg. 442, water diversions: .The target for this section is to screen 50% of the water volume diverted in the basin. The rationale section states that entrainment losses at pumps are unknown. Screens are expensive to maintain and install. *Why does CALFED plan to screen 50% of the diversions if the entrainment losses at those diversions are unknown? Has CALFED considered alternatives to screening? If so, what type of alternatives have they considered?* ERPII 16.12-8

San Joaquin River Mainstem Restoration PH2:3.6.6-60

The revised phase two report states that "CALFED will give consideration to restoring salmon runs below Friant Dam on the San Joaquin River as a means of attaining ERP goal. CALFED will evaluate fishery restoration in the mainstem San Joaquin River as a part of the ERP, while keeping in mind the specific hydrological and water management considerations in the San Joaquin Basin." NHI applauds CALFED for agreeing to consider restoring salmon to the San Joaquin River, and we urge CALFED to go a step further and commit to restoring salmon to the river. *What are the specific hydrological and water management considerations in the San Joaquin Basin that CALFED refers to on page 39 of the revised phase II document?*

Although the phase II document commits to considering opportunities for salmon restoration below Friant Dam, the ERP chapter on the mainstem San Joaquin seems to ignore opportunities for restoring salmon. On page 386, "the vision for the Mendota Pool ERPII 15.5-1

to Gravelly Ford Ecological Management Unit includes no significant tributary inflow." Since this reach is often dry during the spawning immigration season, it will be possible to restore salmon without a significant increase of instream flows in this reach. *Does CALFED plan to evaluate opportunities for rewatering this reach? If so what actions will they take to evaluate these opportunities?*

Many of the restoration targets are incorrectly or inappropriately limited to downstream of the Merced River, even though many of the actions described are upstream of the Merced River. CALFED should expend the geographic scope of these targets to include the entire river from Vernalis to Friant Dam rather than just Vernalis to the mouth of the Merced. ERPII 15.0-3

Pg. 398,Stream Meander: The target for this section reads "restore and maintain a defined stream-meander zone on the San Joaquin River between Vernalis and the mouth of the Merced River," but action 1b "establish a river meander corridor between the Chowchilla Bypass and Mendota Pool" is significantly upstream of the Merced River

Pg. 398, Natural Floodplain and Flood Processes: The geographic scope of the target is limited to the area downstream of the Merced River, yet the second paragraph of the rationale section describes the West Bear Creek Floodplain Restoration project upstream of the Merced as an example. The third paragraph of the rationale cites opportunities described in a study of the river upstream of the Merced River conducted by the San Joaquin River Riparian Habitat Restoration Program. Obviously, there are many excellent opportunities for attaining floodplain and flood process objectives upstream of the Merced River. CALFED should expand the geographic scope of this target to include the entire river from Vernalis to Friant Dam rather than just Vernalis to the mouth of the Merced.

Pg. 399, Central Valley Stream Temperatures: Again the geographic scope of the target is limited to areas downstream of the Merced River, but there are many actions that could be taken upstream of the Merced River to lower water temperatures downstream of the Merced. CALFED should expand the geographic scope of this target to include the entire river from Vernalis to Friant Dam rather than just Vernalis to the mouth of the Merced.

Pg. 402, Water diversions, programmatic action 2A: This action should be considered an interim action until suitable salmon migration and spawning conditions are restored on the San Joaquin River below Friant Dam. The Department of Fish and Game has been installing a temporary barrier at Hills Ferry, just upstream of the Merced, of and on since 1949. This program is clearly an ongoing program and should not be funded by CALFED. *Does CALFED intend to divert ERP dollars to fund existing state programs such as the Hill Ferry Salmon Barrier on the San Joaquin River?*

Pg. 402, Levees, Bridges, and Bank Protection: Again the ERP limits the geographic scope of this target to the area downstream of the Merced River, yet the rationale for this action relies heavily on project descriptions and studies from upstream of the Merced

River. CALFED should expand the geographic scope of this target to include the entire river from Vernalis to Friant Dam rather than just Vernalis to the mouth of the Merced.

Pg. 397, Coarse Sediment Supply: We applaud CALFED for protecting committing to protect coarse sediment supplies below Friant Dam. This is essential for maintaining the opportunity to restore anadromous fish to that reach. CALFED says that it will develop a cooperative incentive program to relocate gravel mining from the active floodplain. *What does CALFED mean by active floodplain?* Friant Dam has greatly diminished the frequency of floods and in many cases gravel mining has caused channel incision, preventing the historical mean annual flood from inundating the flood plain. Even though those surfaces are rarely inundated, gravel mining upon them adjacent to the stream could be harmful to the long-term restoration of the system. CALFED should define the active floodplain as the present day 100-year floodplain. ERPII 15.6-2

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Attachment A 1199

Natural Heritage Institute

ory A. Thomas
President

114 SANSOME STREET, SUITE 1200
SAN FRANCISCO, CA 94104
TEL: (415) 288-0550/FAX: (415) 288-0555
e-mail: nhi@igc.apc.org

Non-Profit Law and Consulting in Conservation of Natural Resources and the Global Environment

COMMENTS OF THE NATURAL HERITAGE INSTITUTE REGARDING THE CALFED BAY-DELTA PROGRAM DRAFT ECOSYSTEM RESTORATION PROGRAM PLAN

November 21, 1997

Prepared by:

John R. Cain
Gregory A. Thomas

Contributors:

Peter B. Moyle Ph.D.
Wim Kimmerer Ph.D.
William J. Trush Ph.D.

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Introduction

These comments elaborate on the summary points submitted on October 13. They were developed by NHI staff in collaboration with Drs. Peter Moyle, Wim Kimmerer and William Trush. In these comments, we underscore four main methodological issues and associated substantive points with specific recommendations for producing the next iteration of the Ecosystem Restoration Program Plan (ERPP).[1]

On the timing of the next iteration, we feel compelled to add a process recommendation up front: it would be a tragic mistake if the quality and substance of the CALFED restoration plan were compromised by the unrealistic, wholly arbitrary and politically motivated timeline that is driving the entire CALFED Bay-Delta Program. It would be far more satisfactory to take the time needed to do the ERPP right, rather than rush to judgment. And it will take time. At this point, CALFED has not even assembled the scientific and technical expertise needed to factor the recommendations of the scientific review panel into the ERPP process. We have more to say on this point later in these comments. The CALFED staff and consultants have performed yeoman's labor trying to be all things to all people in producing this first iteration. The shortcomings, while very significant, are a product of limitations in available time, resources and information, not a lack of effort. Correcting them will require an additional investment in time and resources. The success of the entire CALFED program depends upon doing this step right.

If CALFED is compelled to finalize this document by January 15, we urge that it add a strategic plan to the existing ERPP volumes that will serve as a road map for implementing and improving the ERPP in the months and years ahead.

In our view, there are five major deficiencies in this iteration of the ERPP:

1. The program must be designed around specified ecosystem goals which reflect social values and preferences

To figure out how to restore or reconstruct the estuary, the ERPP must first specify what kind of an ecosystem is desired. The current draft pretends that this is obvious, which it is not; can be derived from science, which it cannot; or is defined by terms like "ecosystem health" or "ecosystem integrity" or "improved ecological processes", which don't help.[2] All ecosystems, however transformed, continue to function in some fashion and are healthy for the organisms they support. The ERPP is rife with "visions" for zones, species, habitats, but explicit goals underlying these visions are nowhere disclosed.

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[1] In general, NHI subscribes to the comments developed by the scientific review panel and by the Nature Conservancy and will not reiterate these important points here.

[2] Problems with the term "ecosystem health" are described in Appendix I.

For example, the goal statement on page 1 of Volume I does not provide any explicit guidance to the ERPP. It states that:

> The goal for ecosystem quality is to improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species.

Terrestrial and aquatic habitats are very vague terms. Habitat for what – native species, invasive organisms, agricultural crops? The term "ecological functions" is even more vague. Many favorable and unfavorable phenomena are associated with ecological functions. Excessive nutrient loading and subsequent eutrophication may enhance food supply for some organisms and has been associated with increasing fish production, but can also result in reduced oxygen concentrations and nuisance algal blooms. Arundo donax, an invasive riparian plant, performs the ecological function of reducing bank erosion. Obviously, these are not the type of functions the ERPP intends to restore, but the example illustrates the wide latitude for interpretation of general terms such as "ecological function" and "ecosystem health." The last clause, "to support sustainable populations of diverse and valuable plant and animal species" is more specific, but it could describe an ecosystem composed entirely of exotic species. In fact, it could even justify the introduction of additional non-native species. Many of the species that have decimated California's native fauna such as the bull frog were intentionally introduced because they were considered "valuable." It is time for CALFED staff and stakeholders to sit down and agree on what we value most – on what type of ecosystem we want to achieve with the ERPP.

The plan needs to be explicit about its ecosystem goals or the process through which these normative preferences will be established. The scientific review panel recognized the pitfalls of vague subjective goals such as ecological health and thus recommended that CALFED simplify and focus its goals with "explicit, quantifiable, and attainable" goal statements. CALFED attempts to specify the purpose of the ERPP by identifying implementation objectives for every ecosystem element in the ERPP, but these objectives are simply too numerous and varying to focus the program. The scientific review panel referred to this undifferentiated assortment of objectives, targets, and actions as a collection of Christmas ornaments with no tree to hang them on. Clarification of measurable implementation objectives would be extremely useful, but NHI cautions that this exercise is no substitute for articulating clear normative goals and priorities.

In the end, the specification of ecosystem goals involves social choices. An estuary dominated by exotics works fine if those species are desired. An estuary devoid of currently endangered species also works fine if those species are not desired. Some of these social preferences are already enshrined in laws, such as recovery of endangered species and doubling of natural production of anadromous fish. Some of these are controversial, e.g. doubling of production of non-native anadromous fish, especially if they compete with the natives. Some goals are derived from ecological considerations, such as maintenance of the food chain, others may be desired largely for their aesthetic values, such as large expanses of tidal wetlands attractive to waterfowl.

NHI convened a workshop along with the CALFED agencies in 1995 as a first step toward specifying achievable goals for improvement or restoration of environmental conditions[3]. Several goals relating toward estuarine biota are listed below:

- Restore populations of indigenous species to levels not likely to result in extinction.
- Maintain populations of fish and waterfowl that can be eaten safely.
- Provide anglers with a reasonable chance of catching sport fish.
- Increase naturally-produced populations of anadromous fish.
- Maintain sediment contamination at least below levels seen in 1950.
- Prevent conditions that result in water column anoxia, including harmful and nuisance algal blooms.
- Restrict additional introductions of exotic species.
- Enhance aesthetic values.
- Sustain natural evolution of baylands.

The plan should also be explicit about the planning horizon over which these goals are to be achieved. Some of the most important, like restoration of the Delta islands, will take decades to accomplish. The timeline of this plan should be long enough to make these goals realistic. NHI fully supports the recommendation of the scientific review panel to articulate clear 10 and 20 year plans early on in the planning process.

To be sure, a process for selecting ecosystem goals may initially produce a list that includes something for everyone in order to garner the broadest possible support for the plan--sport fish for the anglers, salmon for the commercial fishermen, restoration of endangered species for the biodiversity enthusiasts, a profusion of wetlands for the waterfowl photographers and nature aesthetes. Rather quickly, however, the conflicts and tradeoffs among goals will become apparent.

As the scientific review panel recommended, it is essential for the ERPP to acknowledge these conflicts and explain how they are to be resolved. For instance, the panel quickly pointed out that the objective of increasing striped bass and other non-native fishes directly conflicts with, or at least dilutes, the goal of restoring native species.[4] CALFED can not simply ignore these conflicts. Striped bass require extra water late in the spring that will usually not have large benefits to other species, and the stated objective of 2-3 million large piscivorous bass assumes an estuarine ecosystem totally dominated by striped bass. This clearly conflicts with other recovery goals.

Under this view, striped bass should not be exterminated, but neither should increasing their abundance be a goal of the ERPP. Under the contrasting view, striped bass are a valuable sport game, about which much data have been gathered, and entitled to protection under existing law. The important point here is that this is one of many preference issues that must be resolved before real progress can be made in developing an ERPP. It is indispensable that the ERPP and ultimately the EIR/EIS grapple with these foundational issues in an open, forthright and analytical manner; not ignore or obscure the them as the ERPP does now.

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[3] An unabridged findings of the workshop are attached as Appendix 1.

[4] More detail on the conflicts between striped bass and other species are included in Section III.

Once the goals are specified--and not before--it becomes possible to determine the habitat conditions or ecosystem processes or functions that need to be maintained or restored to achieve those goals. Once these habitat conditions or processes or functions are specified--and not before--it becomes possible to identify the particular actions that need to be taken to achieve them and the performance indicators that need to be monitored. In following this chain of logic, however, it would be a mistake for the plan to demand more of the state of the science than it can deliver. For instance, the fact that not a lot is known about how population levels of a given species will respond to various increases in tidal wetland habitat should not serve as an excuse for not increasing that habitat. More habitat is always better than less habitat and the plan should strive to maximize all desired habitats, not limit them to arbitrary targets, as discussed below.

2. The ERPP must specify criteria and a process for selecting and prioritizing restoration opportunities

As noted above, in the absence of specific ecosystem goals, the ERPP is really nothing more than an undifferentiated wish list. Goal specification will help bring some definition to this list. Even after a goal-driven plan is articulated, however, the list of desired restoration activities will far outstrip the available financial resources. To be useful, the plan must provide a basis for winnowing the more essential from the less essential, and, since the ERPP cannot undertake every winner simultaneously, a process for sequencing and prioritizing. The selection and prioritization principles around which a working consensus might coalesce might include the following obvious ones:

- Favor native over introduced species (e.g., manage for salmon rather than stripers or shad)
- Favor natural processes over artificial ones (e.g., provide smolt survival flows rather than construct hatcheries)
- Favor low maintenance solutions over high maintenance solutions (e.g., convert farmlands to habitat where diversions would require installation of fish screens)
- Favor less expensive options over more expensive options (e.g., favor capture of naturally occurring sediment to raise Delta islands over trucking dredge spoils from San Francisco Bay)
- Favor prevention over rescue (e.g., prevent species introductions from ballast water rather than dedicating large blocks of water to salinity repulsion to limit propagation up the estuary)
- Favor projects providing multiple benefits over those providing few (e.g., favor restoration of tidal marsh to restoration of diked marsh)
- Favor actions that benefit endangered species over species with stable populations.
- Favor actions that are reversible.
- Favor actions that provide benefits across a large area over actions with site specific benefits (e.g. releasing water from a dam benefits the entire river while planting cottonwood trees in one location will only benefit a small portion of the river)

But the list of principles should also include the following less obvious ones:

- Invest in learning: give a priority for funding to pilot projects that will illuminate the best techniques for broader application such as projects to demonstrate how to most effectively reverse subsidence and raise the landforms in the Delta.

- Invest in convertible and non-depreciating restoration assets such as interests in lands and waters whenever there is an appreciable likelihood that these assets will eventually be valuable for restoration purposes or where their acquisition will prevent adverse development such as urban development. These assets create options rather than foreclosing options. There are no opportunity costs associated with this use of funds because these assets can be exchanged for more valuable ones should better options become apparent in the future. For example, opportunities to purchase Delta islands from willing sellers should be pursued even before it is clear whether it will be feasible to convert them to tidal marsh. If not, these lands can be resold or leased to finance other restoration opportunities.

3. The ERPP's restoration targets are often arbitrary and too modest

Here we join the chorus of commentators who have criticized the ERPP for failing to justify its proposed restoration targets or for relying on a justification that simply makes no sense.

The ERPP's anemic proposals for habitat restoration in the Delta are the most notable example of CALFED's lack of vision. The ERPP acknowledges that the Delta is the ecological hub of the Central Valley bioregion, yet it proposes to restore less than 10% of the Delta to natural habitat types over the next 25 years. This is not going to be enough. Over 95% of riparian and wetland habitats have been destroyed or fragmented. Long-term survival of many native species will require large-scale restoration of contiguous habitat areas. The Delta is the only place where large contiguous areas of aquatic, marsh, and riparian habitat types can be restored. Furthermore, the low land values, lack of urbanization, large parcel sizes, continued flooding and subsidence problems, and proximity to endangered species are a unique opportunity for restoring vast areas over the next 25 years.

To the extent one can infer any rationale for the paltry target here proposed, it seems an entirely unscientific one. Basically, we are given to understand that only about 12% of the tidally influenced lands in the Delta are considered worthy of restoration to tidal marsh because a 1906 map of the Delta shows about this percentage of marsh remaining and, at that time, the fishery was in reasonably good shape. Thus, the logic goes, if we restore to the 1906 marker, the fish will come back. Why 1906 is thought to be the optimal marker, rather than 1956 or 1856 is not explained. Apparently, there is no better reason than that a map of that date happens to be in the possession of the CALFED staff. In the intervening decades, of course, the hydrodynamics and species composition of Delta has been utterly transformed by human actions. Since the clock is not to be turned back on these alternations, there is no good reason to think that this extent of marsh restoration will produce a 1906 level of fishery benefits.

But the problem with the analysis is much more fundamental. Clearly, where habitat is concerned, more is always better than less. The real constraints on how much tidal marsh to reconstruct in the Delta and where are not a function of some historical marker or by preconceptions as to how many fish are enough. They are set by the wholly practical considerations such as where and how much of the subsided lands can be elevated to near sea level and at what cost, how much and where the levee system is most vulnerable to catastrophic failure due to seismic events, how much and where the full costs of levee maintenance and fish screening make continuation of present land uses unsustainable, how much and where habitat benefits can be obtained for favored species, and the extent to which and where there are willing sellers of the private lands in the Delta. In short, let's have an ERPP that specifies the restoration targets on the basis of analysis of costs and opportunities rather than just some arbitrary preconception. Rather than deal with these issues, the ERPP simply assumes that it will be impossible to restore subsided lands to tidal marsh or shallow water habitat.

The real explanation for the ERPP's modest tidal marsh target may well be the concern that the private landowners in the Delta would object to a more ambitious restoration program. NHI also believes that a feasible Delta restoration program must be acceptable to the Delta landowners. Indeed, we think the best restoration program would be one that is home grown--developed by the Delta residents and the environmental beneficiaries together. We have been working to this end. The key point here is that the extent to which private lands will be converted to habitat is entirely within the control of these private landowners and this will remain so. What the ERPP needs to do is develop a program of incentives that make it attractive to these owners to embrace, and indeed initiate, restoration projects on as broad a scale as practicable. Of course, one of those practical constraints is the opportunity costs at various levels of restoration effort, just as is the case for all other restoration options. (See comment # 2 above). But starting with arbitrary limits based upon some unarticulated political premise simply undermines the ERPP as a serious effort.

The modest restoration targets in the ERPP may also be an artifact of the unfortunate decision which was made by CALFED at the scoping phase--and in the face of strenuous objections by NHI--to analyze and consider only one restoration alternative and to make that generic to all Delta facility options. As we stated at the time, that course might be permissible under the federal and state environmental planning statutes if the single alternative were the environmentally optimal one--which the ERPP clearly is not--and if the restoration potential were invariable with the facility options being developed--which is also clearly not the case. This scoping mistake can still be rectified, however, by analyzing in the next iteration of the ERPP and in the EIR/EIS a range of levels of effort in the restoration targets. That would be particularly important to do in the case of tidal marsh restoration in the Delta. We suggest a range from the 47,000 acres proposed in the ERPP draft up to 200,000 acres for the purpose of ascertaining within that range the optimal target for a 50 year timeline, in view of the practical constraints described herein and with the understanding that the Delta landowners themselves will be the ultimate arbiters of the extent to which an environmentally optimal program will be implemented.

In many cases, an identification of a range of targets and actions is the only defensible means of describing the level of effort necessary to achieve a particular implementation objective, because many objectives can only be achieved by actions that exceed a critical threshold, and those thresholds cannot be practicably determined at the programmatic level. For example, periodic pulse flows capable of mobilizing the bed of the river are necessary to achieve the implementation objective associated with streamflows, but the actual flow necessary to mobilize the bed can only be determined through further analysis. The ERPP should estimate a range of potential target flows necessary to mobilize gravel such as "an average release of between 4,000 and 8,000 c.f.s. for a 10 day period on the Stanislaus River," and qualify this statement with the caveat that the exact flow necessary to mobilize the bed will be determined through additional analysis. The final cost/benefit analysis can then be based on the costs and benefits that would accrue at the lower, middle, and upper end of the range of targets. The purpose of this exercise is to provide an analysis of costs and benefits over a broad range of effort. There is ample precedent for using this approach in programmatic environmental documents. CALFED should avoid wasting time and money by identifying narrow ranges of targets such as "create between 43 and 60 miles of riparian vegetation in the Delta ecozone."

There are numerous other opportunities that the ERPP appears to have disregarded for political reasons. For example:

- The ERPP fails to consider opportunities for restoring both fall run and spring run salmon on the upper San Joaquin River. Yet restoring the upper San Joaquin River may be the single biggest restoration opportunity in the entire valley. There may be political and economic constraints that ultimately prevent this action, but it may be possible to overcome these constraints with some sort of creative water reallocation that could satisfy the needs of the Friant water users.
- Another opportunity for expanding the range of spring run Chinook salmon, steelhead, and other native fish is removal of Englebright Dam. Englebright does not currently serve any significant water supply function and thus would not diminish the water supply.
- Similarly, removal of Nimbus Dam would restore 12 miles of salmon and steelhead spawning habitat without affecting water supply or flood control. Power operations of Folsom Dam could be shifted from peaking load to base load operations or a new reregulation dam could be built closer to Folsom Dam.
- The ERPP has also neglected opportunities to restore winter run on Battle Creek. Winter-run salmon once utilized Battle creek but have been blocked PG&E hydro dams and barriers at the Coleman fish hatchery. The dire state of the winter run may be the most significant factor currently constraining restoration of the Sacramento River. Furthermore, the reduction of their range to a single reach of the Sacramento renders them very vulnerable to a catastrophic event. For these reasons, expansion of the winter run, wherever possible, should be a major priority. CALFED, however, appears to have ignored this opportunity/priority in deference to the status quo at Coleman fish hatchery and PG&E.

As the above discussion and examples make clear, the ERPP consistently avoids the analysis of promising restoration opportunities, whenever there is the likelihood of major controversy. Its vision of what can be done to rehabilitate and restore fisheries and habitats is very limited.

4. CALFED has failed to marshal the requisite technical expertise in the development of the ERPP

Upgrading the expertise brought to bear in developing the ERPP program is the most obvious, urgent and critical change that can be made to improve the document. Dick Daniel and his staff have admirably and successfully constructed the framework for an enormously complex plan, but it is now time to reach out and consult the best expertise possible to flesh out the detailed components of the plan. This is necessary now to improve the next iteration of the ERPP and in the long-term to ensure successful implementation of the ERPP.

Our plea for marshaling additional expertise should not be viewed as a criticism of the existing CALFED ecosystem team. It is simply a consequence of the fact that the ERPP addresses numerous highly technical subjects from estuarine hydrodynamics and fluvial geomorphology to yellow-billed cuckoos and red-legged frogs. Adequate and defensible treatment of these subjects requires consulting the scientists who specialize in these highly specific fields.

It is not enough, however, to hire the best scientists in various fields to improve specific elements of the plan. Rather, CALFED must establish framework for incorporating technical expertise into the planning and implementation of the ERPP over the long term. Two of the six recommendations proffered by the scientific review panel involved the appropriate consultation of scientists. We concur wholeheartedly with these recommendations and hope that the next version of the ERPP will include a "science plan" that describes how the expertise of agency scientists, stakeholder scientists, independent scientists and outside scientific review will be incorporated into the planning and implementation process.

Science and scientists can seldom prove anything. As a result, science based planning is dependent on developing a consensus among scientists on the most difficult issues. A facilitated workshop format similar to the one developed for the scientific review panel could provide a non-adversarial forum for developing consensus on complex technical issues. It is imperative that these workshops be reserved for discussion among scientists with demonstrated expertise in their field. Policy experts and others should be allowed to observe the technical dialogue and offer comments during pre-scheduled comment periods, but they should not be allowed to dominate the discussion. The proliferation of ecosystem panels and workgroups populated by policy wonks should serve as adequate warning to avoid less structured formats.

If CALFED is not willing to consult the experts before proceeding, it is not worth proceeding with the ERPP. Allocating restoration funds on the basis of sub-standard information increases the risk of failure, and tarnishes the promise of restoration. Ineffectual restoration programs will erode public support for restoration programs. If we are going to invest billions of dollars in restoration, we should marshal the best expertise to help plan the restoration actions before we lunge ahead.

5. The ERPP has failed to describe a workable adaptive managment program

In light of the real uncertainty regarding the Bay-Delta Ecosystem, the ERPP must define an adaptive management program that can reduce the risk of irretrievably expending scarce resources on ineffective treatments. Adaptive management is a response to uncertainty intended to limit the probability of wasting limited monies on ineffective treatments. An article in science regarding uncertainty and resource management (Ludwig et al. 1993) clearly stated the following strategy for dealing with uncertainty:

> Confront uncertainty . . . Most principles of decision-making under uncertainty are common sense. We must consider a variety of plausible hypotheses about the world; consider a variety of possible strategies; favor actions that are robust to uncertainties; hedge; favor actions that are informative; probe and experiment; monitor results; update assessments and modify policy accordingly; and favor actions that are reversible.

The preceding quote addresses not only the scientific method for dealing with uncertainty, but also the common sense strategies necessary to avoid irretrievably expending finite resources on ineffective treatments. The scientific review panel and the Nature Conservancy have articulately described the essential scientific components of an adaptive management strategy, and a draft paper by John Williams[5] appended in this document provides the best overview we have seen to date on science, planning, and adaptive management. Although the scientific components of adaptive management are critical, NHI emphasized the seldom considered but equally important strategic investment dimensions of a holistic adaptive management strategy.

ERPP is an investment in the future of the Bay-Delta ecosystem, California's water supply, and the future of California. We have a limited amount of capital to invest and our expectation of future returns is high. If we invest our money poorly, we will have little to show for it in 25 years. If we are astute, we will develop an investment plan to guide the implementation of ERPP. CALFED needs to design an investment strategy that will help prioritize the actions that will maximize their returns over the next 25 years.

Like any investor, CalFed must favor projects where there is some certainty that they can recoup their investment at a latter date if necessary. This dictates that CalFed invest in fungible assets that are likely to appreciate in value over time. Specifically, they should invest heavily, particularly in the earlier years of the program, in land and water. If they overbuy or buy in the wrong place, they can always sell or trade these resources for land and water elsewhere or for investment in non-fungible activities such as levee set-backs. This strategy is entirely consistent with the scientific review pannel's observation that acquisition of water and land for habitat are the most prudent measures to pursue in the face of uncertainty.

Many restoration improvements will only be attained through irretrievably committing resources to specific actions such as building a fish screen or setting back a levee. In these cases, CALFED should favor actions that are likely to serve multiple objectives such as levee setbacks over fish screens. Fish screens may reduce fish mortality more than levee setbacks (in fact levee setbacks may increase mortality by stranding), but a levee set back could serve multiple objectives including flood control, riparian vegetation, flood plain species, and increased nutrient cycling. Furthermore, an expensive fish screen could be wiped out the year after it was constructed. As a result $20 million on a levee set back may be more cost effective then $5 million dollars on a fish screen.

The principal of favoring actions that are reversible applies equally to both actions taken and foregone. A failure to act today may mean irretrievably loosing the opportunity to act in the future. A prime example of this is urbanizing areas of the Delta region. There are many lands well suited for long-term tidal marsh restoration along the periphery of the Delta, but if CalFed does not act soon to acquire interest in these lands, they will be urbanized, permanently precluding restoration of tidal marsh. Urbanization and conversion to perennial crops poses similar threats to river corridors, migration corridors, and other wildlands throughout the CalFed solution area. We can always

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[5] "Notes on Adaptive Management," a draft paper prepared for the Ag-Urban Ecosystem Restoration Team has been included as Appendix 3 of this document. This paper has not been officially endorsed by the Ag-Urban Ecosystem group or the Ag-Urban policy group.

construct a new fish screen or plant vegetation, but we can't be assured of always being able to create a meander corridor.

Not preventing invasion of exotics is another irreversible action. Once exotics become established, it will be impossible to eradicate them. On the other hand, a lot of money could be irretrievably committed to an ineffective exotic control program. In this case, CalFed must balance between irreversibly committing its resources to a program and irreversibly opting not to address the problem.

The whole notion of favoring reversible actions may be the most important step for insuring the success of an adaptive management program. Adaptive management is predicated on the notion that management decisions can and should be modified periodically if they are determined to be misdirected. It is a lot easier for a manager to admit that a particular action was wrong if the resources previously expended on that action could be redirected into a new action.

I. Comments on ERPP Volume 1: Ecosystem Elements and Stressors

I.1 Implementation Objectives for Ecosystem Elements

The implementation objectives should be more specific. For example, the streamflow implementation objective is "to restore basic hydraulic conditions to reactivate and maintain ecological processes that create and sustain habitat required for healthy fish, wildlife, and plant populations." What ecological processes are necessary to create and sustain habitat and what specific hydraulic conditions need to be reactivated? Different processes will require different hydraulic conditions. On the other hand, attaining a specific measurable component of the streamflow implementation objective such as "mobilizing the channel bed every year" is a simple engineering question of determining the discharge necessary to create shear forces capable of mobilizing the bed. Table I lists some specific measurable components of implementation objectives.

In most cases it will be impossible to identify targets, let alone actions, until the implementation objectives have been specified. How can a numerical flow target be specified to achieve the streamflow implementation objective capable of attracting adult salmon spawners unless you have identified attracting spawners as a specific implementation objective of stream flow. In some cases the appropriate target is dependent on achieving a specific threshold. For example, channel bed mobilization will not occur until enough water is released to mobilize the channel. No amount of water less than that necessary to mobilize the channel will achieve the implementation objective. Thus, the target will be determined by the minimum amount necessary to mobilize the channel. Unfortunately, the ERPP has not conducted, let alone explained, the type of analysis necessary to identify these thresholds. It may not be possible to identify the threshold in the programmatic level, but the ERPP should at least state that moving the bed is necessary. Some examples of implementation objective components are listed below. This issue is addressed in more detailed NHI comments prepared by William Trush Ph.D.

Table I: Examples of Measurable Implementation Objective Components

Natural Processes	Implementation Objective Component	Target
1. Natural Sediment Supply	• Natural input from watershed • Gravel recruitment from banks • Artificial replenishment rate • Amount removed by mining	X tons from watershed per year X tons from bank erosion X tons from artificial replenish. X tons removed from mining
1. Streamflows	• Average monthly flows • Frequency of peak flows • Magnitude of peak flows • Duration of peak flows • Seasonal distribution of flows • Intra-seasonal variability of flows • Fall base flows	X % of unimpaired Number of flows over X c.f.s./year % of unimpaired $Q_{1.5}$ Annual sediment transport capacity relative to sediment supply Percent of total per month
8. Stream Meander Corridors	• Migration of bank per year. • Sinuosity • Planform complexity	X feet per year in x reach X width to meander ratio in x reach X number of secondary channels per reach

CalFed Stressor	Implementation Objective Component	Target (examples)
1. Levees and Bank Protection	• Number of miles of levees • Number of miles of rip-rapped banks. • Number of structures protected by levees or rip-rap	X number of miles of levee between points Z and Y.

CalFed Habitat	Implementation Objective Component	Target
• Emergent tidal marsh habitat	• Area of tidal marsh habitat • Distribution of tidal marsh habitat • Flora species composition and richness • Patch size • Proximity to SRA habitat	X numbers X% in x location,

CalFed Species	Implementation Objective Component	Target
• Striped Bass	• Number of Striped Bass	No target (i.e. no restoration actions targeted on s. bass)
• Delta Smelt	• Average number • Inter-annual population variability	
• Red legged frog	• Number of frogs • Number of distinct and protected populations • Eradication of bull frog and green sunfish in red-legged frog refugia.	X number A least 6 sites, 3 in the Sacramento Valley and 3 in the San Joaquin.

I.2 Ecosystem Process Visions

I.2.1 Streamflows, Flood Plains, Sediment Supply, and Stream Meander Corridor

The ERPP's stated emphasis on restoration of the ecological processes associated with streamflow is correct, but it is obvious that the CalFed staff who authored these sections are not adequately knowledgeable about hydrology and geomorphology. The ERPP properly divided the ecological processes associated with streamflow into four categories, but the ERPP should better explain the relationship between these four processes. NHI suggests the concept of "alluvial rivers" as the overarching theme that integrates these four processes. For more detail on alluvial river processes, see the attached comments authored by William Trush for NHI.

The ERPP has correctly recognized that an adequate sediment supply is essential to restoring channel form and associated habitat. Sediment supply is sharply limited by dams and gravel mining. If CalFed is not going to remove dams, they must do something about gravel mining. On several rivers, particularly in the San Joaquin Valley, the effect of gravel mining on sediment supply has been an order of magnitude or more greater than the effect of upstream reservoirs (Kondolf et. al., 1996, Cain, 1997). The current paradigm for restoring spawning gravel habitat and the one CalFed seem to embrace is excavating gravel from instream or floodplain pits and redepositing the gravels in another reach of the channel. This is an unsustainable waste of public funds.

Limiting excavation of gravel to off channel, floodplain pits is not acceptable. Isolating floodplain pits from the channel requires undesirable levees and bank protection, but is no guarantee that the channel will not "capture" the pits during inevitable flood events. If these pits are excavated below the thalweg, pit capture will cause channel incision and degradation of aquatic habitats upstream and downstream of the captured pits. Furthermore, levees and armored banks designed to prevent capture of floodplain pits by definition prevent channel migration and associated benefits, an ERPP implementation objective. Finally, excavation of floodplain pits exploits a scarce, non-renewable resource, the coarse sediment still remaining below dams. Gravel excavated will simply not be available for gravel recruitment by channel migration below the dam.

If restoration is to succeed on dammed rivers, gravel mining in the channel or floodplain below the dams must be prohibited. Please see NHI's specific comments on gravel mining for more detail gravel mining regulation, management, and alternatives.

The ecological process described as stream meander corridors should be renamed channel form and migration. Corridors are not processes. They are planning tools necessary to allow channel migration and important ecological processes associated with channel migration. Furthermore, not all channels meander, and channel meanders are not the only channel forms valuable to biota. Steeper stream reaches, particularly those used for spawning, are often characterized by channel braiding or branching while some low gradient streams branch out into multiple distribution channels that nourish and water wetland complexes. Reestablishing meanders in degraded reaches where meanders never existed would be misguided. Rather, corridors should be established to allow all of the diversity of channel forms and processes historically present in the solution area, not just meandering.

I.2.2 Bay-Delta Hydraulics

This chapter is short, but contains some major errors. The best example is at the bottom of p.51-top of p. 52: "Because the water [this apparently refers to water in the south Delta] has a short residence time, the food supply is generally poor for those fish drawn into or residing in the central and southern Delta." Although this sentence contains elements that appear to be based on informed speculation about the role of residence time in Delta productivity, it is otherwise completely unsubstantiated, yet stated as fact. The food supply (as zooplankton) these days is in fact better in the Delta than in Suisun Bay.

The "vision" for this section is pretty unclear. When were hydraulic conditions in the Delta satisfactory? The only documented major changes in the Delta since the mid-60's have been increases in exports as the SWP came on line, some increases in upstream impoundments, and a few droughts. Export pumping has relatively little effect on flow patterns in the northern Delta. Most of the big changes in Delta hydraulics happened much earlier. It is also possible that erosion in edge and shallow water habitat by boat wakes, dredging activities and time have modified Delta hydraulics, but this has not been documented. A simple aerial photo analysis could determine whether the area of shallow edge habitats along island margins has changed since 1960. We find this omission odd given the emphasis CalFed places on habitat and flow conditions in the Delta.

The last paragraph in this section is just an introduction for an isolated or dual facility. If CalFed thinks that such a facility will solve a lot of fishery (and hydraulic) problems in the Delta, they should explain on what basis they think that is the case. This should be done in the context of a scientific document written by people who actually know and work in the relevant fields. Trying to slide the PC by on the basis of such weak and unsubstantiated arguments as this is asking for trouble.

I.2.3 Bay-Delta Aquatic Food Web

This chapter is absolutely riddled with speculation and statements that are just not true. Much of this chapter seems to be based on a very superficial knowledge of some recent developments. We doubt that the authors ever even spoke to the relevant experts on these topics - none of the ones we know have been contacted.

p. 54 top of second column claims that decaying plant material provides a "dependable, time-released form of food". This seems to be a misinterpretation of some recent results. Bacteria in the entrapment zone probably subsist on organic matter from phytoplankton produced in the Delta. There is almost no information on bacteria in the Delta, but there is a fairly extensive literature on this topic from other estuaries that CalFed has ignored completely. There is no information from this estuary on the importance of bacteria to higher trophic levels.

p. 55 top of second column. "low chlorophyll levels.... may be a factor in the poor survival of young Delta smelt and striped bass..." According to what? Survival of striped bass is a function of flow (or X2) and exports, but has not declined in the last ca. 30 years. Oddly, of all the species CalFed could have picked, these two seem to have been particularly unaffected by the decline in primary production in the late 80's (other species that have responded are not mentioned here).

p. 55 col. 2 para. 3 "..some algae... are washed downstream into the wider expanses of San Pablo Bay...". This demonstrates a remarkably poor understanding of the effect of hydrodynamics in the Delta on transport of materials. Recent work by Jon Burau shows that stratification is rare in Suisun Bay, so freshwater flow can have no direct effect on lower bays except in the most extreme flood events. How can plant materials be washed downstream into San Pablo and San Francisco Bays by freshwater flow? They are transported tidally.

Next paragraph "Aquatic invertebrate population trends followed those of algae.." This is way over-simplistic. Rotifers and some cladocerans decreased in the Delta, and *Eurytemora* and *Neomysis* decreased in the entrapment zone, more-or-less in synchrony with declines in phytoplankton. Other taxonomic groups have shown different trends.

Later in the same paragraph: "populations of many bottom-dwelling invertebrates, most notably Asian clams, have increased." Only one species of clam, *P. amurensis,* has increased. Other benthic organisms have been pretty much wiped out from Suisun Bay.

p. 56 end of first column: "Research indicates that survival and growth of fish larvae generally increase with increased concentration of zooplankton." This is misleading. Only recently has anybody tried to compare growth rates of fish with zooplankton abundance, and then only indirectly. Although this statement is probably true for most populations some of the time, we do not have any good information on food limitation of young fish in this estuary. Coincident declines (and they are not all that coincident anyway) are insufficient evidence. Furthermore, "modifying the ...ecosystem in ways that will lead to increased algae and zooplankton..." is a pretty tall order. How will that be done? How will the effect of *P. amurensis* be eliminated, or the decline in organic inputs due to sewage treatment be "fixed"?

p. 56 first full paragraph of second column. We doubt if anything in this paragraph is true, let alone supported by any data. The claim is made that in some areas of the Bay-Delta, hydraulic conditions cause an accumulation of food resources in the water column. We have no idea what this is supposed to mean. What about the hydraulic conditions of the western Delta causes them to be characterized as "benign"? High zooplankton populations no longer develop in Suisun Bay. "Horizontal salinity stratification" doesn't really mean anything. The salinity front is not referred to as "X2", which is the daily average distance of the 2 psu isohaline from the Golden Gate.

p. 56 next paragraph. The claim that crop residue, leaf litter, and other vascular plant detritus is important organic carbon for the estuary is pure speculation. Vascular plant detritus is notoriously refractory material; bacterial production in the brackish estuary is more likely based on labile forms such as phytoplankton lysing on entering brackish water (again, note that we know virtually nothing about the bacteria of the rivers and freshwater Delta).

p. 57 first 4 paragraphs discuss nutrients and phytoplankton biomass in the rivers and the Delta. Is there a citation for this, and is this based on current conditions or conditions before *P. amurensis* (flux of phytoplankton to Suisun Bay is probably much higher than before *P. amurensis*)? Freshwater flow does not move organic matter to San Pablo or Central Bay unless that material floats; even then, it is residual circulation that moves surface water seaward, not the river flow itself.

p. 57 column 2 top, last sentence. "...even though flows early in the dry season have been managed to maximize the frequency with which saltwater and freshwater converge in the bay." No matter how many "just say no to commingling" pamphlets you put out, that naughty salt water will always be up there converging with the poor innocent freshwater. It just can't be helped, no matter how much you like to think you can manage things. Somewhere in the estuary, freshwater will meet salt, every day, all the time.

p. 58 para. 2. "Improving outflow... will stimulate primary and secondary productivity..." Primary and secondary productivity can both be thought of as the product of biomass and specific growth rate of phytoplankton or zooplankton respectively. Biomass of phytoplankton is being estimated and that of zooplankton can be estimated from abundance data. Neither responds strongly to flow. Growth rates of phytoplankton are generally light-limited in this estuary, so increasing flow may reduce primary productivity. Growth rates of zooplankton probably do not respond to flow, and in the handful of measurements made in Suisun Bay there was little variation at all. The idea that primary and secondary production can be stimulated is therefore flawed in two respects: first, nobody is measuring either of these variables so their variability cannot be assessed; and second, there is no evidence that either productivity variable responds to flow.

p. 58 paragraph before "Integration": Even in the unlikely event that primary and secondary production could be increased, there is little evidence that this would increase production of striped bass, Delta smelt, salmon, sturgeon, or anchovy. There is limited evidence that longfin smelt and Pacific herring declined in abundance after *Potamocorbula amurensis* was introduced, and a reasonable assumption is that this is due to a decrease in food abundance, but it is a huge step to go from that to the claim that fish production will be increased if foodweb production goes up.

p. 59 Implementation Objective, Targets, and Programmatic actions. This section contains a lot of inaccuracies and wishful thinking. For example, para. 1 states that increasing nutrient concentration will provide for a "sustainable level of foodweb productivity." First of all, primary production is light limited nearly all the time and nutrient limited only during large blooms; although there may be species-specific effects of nutrient concentration these have not been demonstrated. Second, the productivity of the foodweb is now and has always been "sustainable"; if it were not, the foodweb would have gone away. This is buzzwordology, not science.

p. 60 para. 1 and 2 claim that targets will be restoring chlorophyll and zooplankton to levels in the 1960's and early 1970's. This is pure fantasy, in that it would require getting rid of *P. amurensis* and possibly increasing the input of sewage to the estuary.

"General programmatic actions" are also apparently based on speculation. The first action is to increase freshwater inflow in spring of drier years, but no relationship is presented to support this. Increasing residence time in the Delta holds some promise, although again the basis for this should be presented. Reducing concentrations of contaminants is useful on general principles, but don't count on any response in the lower trophic levels of the estuary. Reducing losses to diversions, similarly, would have an unknown effect on the foodweb; chlorophyll might increase with longer residence time but the same may not be true for zooplankton. Again, the issue of organic matter input is so poorly understood that making it a "programmatic action" seems speculative at best.

I.3 Species Visions

Most of the visions for aquatic species are flawed and unrealistic. We recommend that these sections be discarded and new visions written that take into account recent scientific findings and incorporate realistic objectives for management and restoration.

Delta smelt: This section is remarkably optimistic, given that nobody knows why Delta smelt are down, and nobody knows how to restore them. One possible reason for low Delta smelt abundance that has been raised but not investigated (because not funded yet) is predation by inland silversides. This is not mentioned. The relationship of Delta smelt to freshwater flow is weak at best, so the statements about improving flow conditions for Delta smelt do not seem to be based on anything more than wishful thinking. The statements about low-salinity habitat moving from the "productive" regions of Suisun Bay to the "less productive" Delta are dogmatic and not based on current scientific knowledge. The idea of creating physical habitat for Delta smelt, in the absence of any knowledge of what that habitat should be, is weak.

Longfin smelt: This section too is full of misstatements. For example, what evidence is there that reproductive rates of longfin smelt depend on diversions, and what is the mechanism for such an effect? The ERPP states a need to achieve "consistently high production" in normal and wetter years. Since in all such previous years production has been high, this seems a safe bet, but the ERPP goes further by claiming that somehow the system will be made better for longfin smelt. There is no indication that this can actually be done. For example, how would foodweb productivity be stimulated?

Splittail: At least this is something that we know reasonably well, but the case for splittail should have been made by reference to recent work by DWR and DFG scientists who actually have a pretty good handle on this species (at least compared to others). Surprisingly, the manuscript recently completed by Ted Sommer is not mentioned; this paper describes how resilient splittail are and how they respond strongly to high-flow events.

Pacific lamprey and other species of lamprey: One of the most serious omissions from the ERPP and from most of the recovery plans for anadromous fish has been concern for pacific lamprey (*Lampetra* *tridentata*). This species should at least be mentioned as a species worthy of recovery in all the various "ecological zones." It is in decline, although evidence is purely anecdotal (Moyle, pers. com. 1997). It has requirements similar to Chinook salmon except it spends 5-7 years in the larval stage, so it needs permanent, cool water. Research on this species is badly needed, starting with a status report. The lack of information, combined with the lack of interest has kept this species out of reports. Even worse is our lack of information on the river lamprey (*Lampetra ayersi*) which spawns in local rivers in small numbers.

Resident native fishes: Native resident species are barely mentioned in most sections of the report. At the very least, the plan should assess opportunities for improving conditions for native resident fishes. Deer Creek is a particularly good opportunity for protecting native fish assemblages (Tehama Co). It has the full complement of native fishes together in intact assemblages, along with native frogs, turtles, and, presumably invertebrates. It is truly remarkable in this regard since most places have exotic species mixed in, or the amphibians absent. This is also true for nearby drainages.

Sturgeon: In most places in the report, the two sturgeon species are lumped together. They should be treated separately in all places because they are quite different in their life history requirements, the green sturgeon is a species of special concern, and the white sturgeon is a major game fish.

There is some discussion about transporting larvae to productive rearing habitat. This sounds dubious, since nobody has caught any larvae, nor do they know where they rear. If CalFed knows more than DFG about this, they should cite their sources.

Salmon: "...salmon populations will remain stable or increase..." CalFed is really setting itself up with this one. Whatever actions are taken, however well-advised, nobody can predict what *will* happen. This is another example of CalFed stating speculation as if it were fact.

Vision for Chinook salmon: This is a summary of general statements unencumbered by any representation of scientific findings. There is a lot of hubris here as well, but many of the actions suggested might actually have the desired effect (but the initial criticism still holds, that this is an undocumented opinion piece, and we can't even tell whose opinion).

p. 143 col. 2 para. 2 CalFed seems pretty confident in stating as fact a commonly made *supposition* that habitat in the Delta needs to be improved to support rearing of salmon fry. Nobody knows where young salmon rear when they leave their natal streams before smolting, so it is difficult to know whether adding tidal habitat will improve things for them. It may be true, but if it is in fact speculation it should be identified as such.

p. 143 last para. "The ERPP anticipates a highly compatible relationship between restoring ecological processes and harvest management recommendations." This is vague and unclear. Explain or delete.

p. 145 col. 2 para. 2. "ERPP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0...." Increasing the cohort replacement rate above 1.0 is exactly the same as saying you are going to make the stock increase, so this section presents a circular argument. The real issue is how to do that and how to tell if you have done that.

p. 146 para. 2. Marking all hatchery fish might be a good idea, although attention needs to be paid to the probably high shaker mortality in the ocean recreational fishery, which we understand to have shifted largely from trolling to mooching (which injures fish more than trolling). It may not be possible to protect wild stocks unless that changes.

Marine/estuarine fishes: The focus is on more flow. That is appropriate given the fish-X2 relationships, but presumably CalFed was supposed to be coming up with alternatives to flow. Also, freshwater flow does not transport fish through the estuary, but sets up the salinity patterns and influences the circulation patterns to which they respond. This is a subtle distinction but important.

Bay-Delta aquatic foodweb organisms: Much of this is a rehash of the earlier chapter on the foodweb, emphasizing the point that this is an unnecessarily flabby document. However, many of the statements in here are either not true or unsubstantiated.

The ERPP claims that plankton growth would have to be "enhanced." Since nobody is measuring growth rate of planktonic organisms, it is hard to imagine how to increase it or how to tell if it has increased. Per-capita growth rates of most planktonic organisms most of the time will be indistinguishable from maximum rates. Enhancing growth is not only nearly irrelevant to the purposes of CalFed, it may not be possible. Increasing shallow-water habitat will certainly do little for the growth of zooplankton (it may contribute to increasing mean growth rate of phytoplankton), and in fact shallow areas are probably poor habitat for zooplankton because of the abundance of planktivorous fish there.

Page 168 col. 2 para. 2. "...algae are generally small, easily transported, and highly nutritious. Phytoplankton are somewhat larger than algae..." Whoever wrote this needs to go read some elementary book on aquatic life, or at least scan the glossary.

On the plus side, at least this section has a few references sprinkled in it, although not nearly enough to qualify it as any sort of scientific review of the subject. It is also clear that even the references that were cited were not read in any depth.

Aquatic Amphibians and Reptiles: Ideally, ecozone visions should have at least a paragraph on riparian frogs (more than just red legged frog, which is largely extirpated from the valley floor). In most places, native riparian amphibians are gone or rare but there is enough information so that comments could be made for each ecological zone. The Sierra Nevada Ecosystem Project Report is a good source of information and Mark Jennnings, who wrote the amphibian section there, could easily produce short paragraphs for each zone.

If CalFed is serious about protecting and restoring native, aquatic amphibians and reptiles, it must identify and protect the last refugia of these species, particularly in the San Joaquin Valley. Many of these refugia are distant from the mainstem rivers that the ERPP emphasizes. For example, the last populations of red-legged frog in the San Joaquin Valley are largely isolated to perennial springs and ponds in the interior watersheds of the Coast range (Mark Jennings, pers. com. 1997). The largest and most sustainable population of Western Pond Turtle in the San Joaquin Valley is on Jose Creek a tributary of the San Joaquin River upstream of Friant Dam (Dan Holland, pers. com. 1997). If

CalFed does not intend to protect these last remote refugia, they should remove these species from their target list.

Invertebrates: It would also be desirable to have a comment in each section about aquatic invertebrates, especially larger species, such as native clams. Unfortunately, our ignorance is profound and it probably cannot be easily done. This would be a good area for research.

Striped Bass: The ERPP erroneously contends that striped bass will benefit from late winter flows. Striped bass: "...benefit from increased inflows in late winter and spring..."we don't know what late winter has to do with it, since striped bass don't spawn until the water gets warm. The last sentence in this paragraph about the reproductive capacity of bass bespeaks substantial ignorance about the life history of this species. If this were true, the D1485 actions to protect striped bass should already have caused them to increase. Furthermore, there is a flurry of research going on right now that is shedding considerable light on the decline in striped bass. Although none of this is published yet, it is widely enough known and we are sure the authors would have been glad to provide details.

I.4 Ecosystem Stressor Visions

I.3.1 Gravel Mining

The name of this stressor should be changed from gravel mining to aggregate mining. Aggregate mining refers to the excavation of both sand and gravel. Although gravel is particularly important for salmonid habitat, sand is also important for benthic habitat and channel forming processes associated with floodplain deposition, channel complexity, and seral succession of riparian vegetation.

Aggregate mining in the floodplain and channel, particularly excavations below the elevation of the channel thalweg, are inconsistent with ecosystem restoration. The description of gravel mining in the ERPP is generally accurate, but it understates the manner in which gravel mining disrupts geomorphic equilibrium and the entire riverine ecosystem established on that equilibrium. Riverine ecosystems exist within a geomorphic framework and abrupt changes in that framework can devastate a riverine ecosystem.

Instream gravel mining or capture of flood plain gravel mines causes incision of the channel both upstream and downstream of the gravel mine. Incision upstream of the pits is caused by head cutting while incision downstream of the pits is caused from sediment starved "hungry water" that occurs when the pit capture all bedload moving down river. Incision lowers the water table, reduces flooding, reduces channel complexity, and increases water velocity.

Combined, these consequences of incision devastate the riverine ecosystem. Lower water tables strand and often desiccate riparian vegetation and wetlands. Reduced flooding further desiccates riparian vegetation, reduces nutrient cycling between the channel and floodplain. Reduced complexity combined with increased water velocities degrades conditions for native aquatic species, particularly those dependent on slow water refuge habitat (virtually all species at some stage in their life cycle). Finally, and worst of all, increased velocities often result in further incision, perpetuating the vicious cycle of channel incision.

The ERPP vision for gravel mining is flawed. It proposes: "reducing or eliminating instream gravel operations to alluvial deposits outside active stream channels and introducing gravel in deficient areas in streams until natural processes are restored to a level that will provide sufficient quantities (of gravel)."

Reducing gravel mining in stream channels is not enough. Gravel mining in stream channels does not simply have local, deleterious effects, but widespread effects to the channel morphology and riverine ecosystem. Gravel mining in the active channel, particularly below dams, must be prohibited.

What does CalFed mean when they refer to the "active channel?" The "active channel" is a term of art that generally refers to the area inundated by the "dominant" discharge. The dominant discharge is the peak flow with a recurrence interval of 1.5 to 2 years. (Leopold, 1964) The active channel is very different than the low flow channel. Identification of the active channel on dammed rivers is confounded by the effect of damming on the frequency of the historical dominant discharge. Incision below dams can further confound the relationship between pre-dam dominant discharge, post dam discharge with a recurrence interval of every 1.5 to 2 years, and bankfull discharge. In some cases such as the Merced River, the frequency and duration of peak flows have been so diminished and altered that the concept of a dominant discharge and thus an "active channel" is no longer applicable.

The ERPP should clarify its definition of the active channel and propose prohibition of gravel mining from the pre-dam active channel as defined by Leopold. The historical active channel is easy to map from pre-dam aerial photographs, and is a reasonable approximation of the probable floodway (as opposed to floodplain) during infrequent, post-dam flood events.

Excavation of aggregate from floodplain pits is also inconsistent with ecosystem restoration. In many cases the only source of coarse sediment available for recruitment into the channel is coarse sediment underlying the floodplain. If this material is excavated, the channel is left with no source of coarse sediment. Therefore, CalFed should also move to prohibit aggregate mining from the floodplain. If aggregate mining is allowed to proceed on the floodplain, it should never be allowed deeper than the elevation of the channel thalweg, because river capture of pits deeper than the thalweg results in channel incision.

Excavation of former flood plains or terraces may be acceptable and even beneficial, but should never be allowed to occur below the thalweg. Excavation of abandoned floodplains to a lower elevation could be employed as a strategy to accelerate the restoration of floodplains along incised channels.

The second part of the gravel mining vision referred to above proposes introducing gravels into deficient areas. Where is this gravel going to come from? Will it be mined from existing channel and floodplain pits? Present gravel replenishment programs operated by public agencies purchase gravel mined from one stream reach for introduction into another stream or reach (Kondolf, et. al., 1996) This is a waste of public funds and should not be perpetuated by the ERPP.

Aggregate is necessary for both ecological restoration and continued urban growth in California, but current aggregate mining activities are incompatible with ecological restoration. The ERPP vision proposes to identify alternative sources of aggregate. This is an essential, but difficult step. Alternate aggregate supplies are more expensive and will not be exploited without legislation that prohibits excavation of river aggregate and provides incentives to mine alternative aggregate sources.

CalFed and the stakeholders must work with county governments and the state legislature to develop a regional aggregate production plan that does not rely on aggregate extraction from river channel and flood plains. Currently aggregate miners are governed by the surface mining and reclamation act (SMARL) which is irregularly enforced by county governments. The concept of reclamation embodied in SNARL is not applicable to river channel mining and counties have little incentive to comply with the provisions of SMARL. SMARL must be reformed to prohibit gravel mining in rivers and floodplains and to develop incentives for developing off river sources of aggregate. In the meantime or in the absence of prohibition of aggregate extraction from the channel, CalFed must purchase mineral rights from current and potential gravel mining operations.

I.3.2 Invasive Species

A serious weakness of the ERPP is the way in which it minimizes the impact of invasive species. It cannot be overstated that a single invasive species can undo millions of dollars of restoration efforts. The estuarine ecosystem is changing profoundly and rapidly in response to new invasions and it is critical that these invasions be stopped.

Ballast water is singled out as the major source of invaders, which is appropriate, but there needs to be mention of other sources as well: unauthorized deliberate introductions (e.g., northern pike, white bass), releases from bait buckets, releases from aquaria, and releases from aquaculture operations. The latter three are related to industries in California that need to be more tightly regulated and made responsible for any organisms that get loose in our waterways. Better education and better law enforcement are needed for unauthorized introductions. Two suggestions for addition to action items (e.g., vol. 2, p. 56):

1. Introductions by ballast water should be halted by the year 2010. As an immediate step in that direction, state and federal laws in regard to regulation of ballast water should come into conformity with the federal law governing the discharge of ballast water in the Great Lakes. The shipping industry needs to be forced to take responsibility for solving this problem; voluntary efforts have not worked.

2. An Exotic Species Emergency Response Team should be formed, with authorization, training, and funds to treat outbreaks of new, potentially harmful species. Perhaps it could be connected to the oil spill emergency response team.

II. Comments on ERPP Volume II: Ecozone Visions

II.1 General Comments

There are many good ideas about restoring ecological processes described in Volume I, but few of them are consistently embodied in the visions and actions described in Volume II. Thus, despite all of the appropriate emphasis on restoration of ecosystem processes, many of the actions in Volume

II are narrowly focused, species specific actions. CalFed should review every action described in Volume II for consistency with the implementation objectives described in Volume I.

Many of the actions described in Volume II are no different than actions already mandated or proposed under separate laws and programs such as the Anadromous Fish Restoration Plan developed pursuant to the Central Valley Improvement Act. NHI realizes that CalFed should integrate restoration projects currently being implemented under other laws and programs, but the ERPP must be a significant effort above and beyond these programs. As currently drafted, ERPP is little more than programs already mandated by law.

II.2 The Delta

The ERPP's passive approach to Delta habitat restoration is discussed above in the introduction. What follows is additional discussion on the consequences of failing to deal with Delta island subsidence and the feasibility of reversing that subsidence.

II.2.1 Restoration of Subsided Lands

A subsidence reversal program would have significant ecological benefits over the life of the ERPP and well beyond, but the vision for the Delta ecozone has no implementation objectives for subsidence reversal. Without restoration of island elevations there are two scenarios for the future -- neither of them attractive:

- Continued maintenance of Delta islands
    - Islands continue to subside at 2-3 inches per year. The cost of continued levee maintenance and the cost of pumping out and repairing flooded levees will grow higher and higher over time.
    - The risk and consequences of catastrophic levee failure will increase.
    - The time required for and cost of restoration of island elevations will increase.

- Abandonment of the Delta islands where the cost of maintenance becomes untenable
    - Tens of thousands of existing acres of existing habitat will be permanently lost as islands flood.
    - The opportunity to connect Suisun Marsh and habitats created in the eastern Delta will be lost.
    - Increased salinity intrusion as a result of permanent island flooding will diminish the value of existing habitats in Suisun Bay and Marsh and will make farming in the eastern Delta problematic.
    - The quality of water diverted from the Delta will decline.

By contrast, new technical information appears to confirm the viability of programs designed to restore island elevations. The most promising method of reversing subsidence would be to cultivate tules and other wetland vegetation. Recent field experiments determined that tule cultivation could accrete up to 6 inches of organic material a year. Such a program would simultaneously provide significant benefits to target species.

Other techniques which also need to be applied to the problem of island elevation restoration are the use of dredged materials and the capture of natural sediment.

The ERPP fails to mention the beneficial re-use of dredged materials in their implementation objectives for reducing the stressors associated with dredging and sediment disposal. Yet beneficial reuse is a way to convert a stressor into a benefit. Several federal and state agencies participating in the Long Term Management Strategy (LTMS) program have strongly endorsed projects to beneficially re-use dredged materials for the creation of tidal marsh and other habitats. The implementation objective for dredging and sediment disposal appears to be the status quo. A comprehensive dredging and sediment disposal program that could truly improve conditions for target species would manage dredging within the context of the Delta's overall sediment supply.

Similarly, the Delta vision does not mention sediment supply as a critical ecological process. The Delta islands were formed by the annual deposition of sediment on Delta marshes over the last 6,000 years. Restoration of this process is essential to creating and maintaining shallow water habitat over the next two decades. Unfortunately, the ERPP does not identify the data needed to evaluate the current sediment deposition and transport processes in the Delta. A recent unpublished study by EDF and the Bay Institute indicates that current sediment inflow to the Delta is greater then pre-settlement rates. If this is true then it may be possible to capture this sediment and utilize it to build subsided islands. From conversations with Delta farmers, NHI staff has learned that operation of irrigation siphons during high flow events sometimes results in bedload deposition on Delta Islands. This is an exciting opportunity to reverse subsidence. The wholesale omission of a sediment supply vision for the Delta speaks volumes about the need for CalFed to hire geomorphologists and hydrologists.

II.2.2 Delta Habitat Types and Targets

The distinction between tidal perennial aquatic habitat, dead end sloughs, and freshwater emergent mash is ambiguous and confusing. Tidal perennial aquatic habitat (TPAH) is most specifically defined as areas less than 9 feet deep at mean high tide. Fresh emergent wetlands appear to include both tidal and non-tidal wetlands. Sloughs are tidal channels through marshes. Most slough habitat and freshwater emergent tidal marsh are types of TPAH since they are largely confined to the area within 9 vertical feet of the mean high tide. The ERPP needs to clearly distinguish between these habitat types. Are Delta sloughs and tidal freshwater emergent tidal marsh a subset of tidal perennial aquatic habitat?

Grouping non-tidal and tidal freshwater emergent habitats into one category is very problematic. Ecological processes associated with tidal and non-tidal marsh are significantly different, and presumably tidal wetlands will be far more beneficial to fish. As written, table 6 assumes that restoration of non-tidal and tidal fresh emergent wetlands will both have equal benefit to fish. Furthermore, restoration of tidal marsh is far more difficult than restoration of non-tidal marsh because of the extent of subsided lands in the Delta.

CalFed must distinguish between tidal and non-tidal freshwater emergent marsh. The area of tidal freshwater marsh in California has been decimated, largely due to reclamation of Delta Islands. Restoration of freshwater tidal marsh in the Delta is the only opportunity for large-scale restoration of this habitat in California. Restoration of non-tidal freshwater marsh is not a substitute for restoration of tidal marsh.

Targets for restoration of tidal wetlands seem to be arbitrarily based on 1906 conditions. The restoration target for tidal emergent marsh are intended to restore 30 to 50 percent of the tidal marsh lost since 1906. This target is an arbitrary percentage of an arbitrary historic marker. Analysis of the 1906 maps may be useful for documenting changes to the Delta landscape, but 1906 conditions are not a valid basis for restoration activities. According to the ERPP, two thirds of the natural tidal marsh had already been converted to agricultural land by 1906.

The ERPP targets and actions need to be more specific for this section. Acreage numbers associated with various Delta regions or Delta actions should be at least estimated, and the ERPP should lay out a timeline for achieving those actions. Some tidal marsh can and should be converted immediately from farmland currently near sea level to provide ecological benefits in the next decade. Restoration of subsided lands to tidal marsh will take time, and thus should commence immediately. No subsided peat islands should be abandoned or ignored. Rather, efforts should be made to prevent additional subsidence of peat soils throughout the Delta, and trial projects to build island surface elevations should be implemented immediately. Over the next 25 years the goal should be to build as much subsided land to sea level as possible.

The specific target for tidal perennial aquatic habitats is paltry. The 1,500 acre target for the north Delta is barely more than the acreage currently planned and being developed on Prospect Island, Liberty Island, and Little Holland Tract. According the Laurie Lou at USACE, the Prospect Island project is expected to develop approximately 1,200 acres of tidal perennial aquatic habitat. TPAH on liberty alone will exceed 1,000 acres. Discrepancies between ERPP numbers and USACE numbers could be a result of different definitions of TPAH, but this only underscores the need to better define TPAH. It is important to note that mean low tide near the mouths of the Sacramento and San Joaquin rivers is actually above sea level. As a result lands above sea level can be restored to TPAH.

Why has the ERPP limited itself to projects already on the drawing board east of Cache slough? The Cache and Lindsey slough area west of Cahce slough is an excellent place for tidal marsh restoration. Lindsey slough is thought to be one of the most important spawning areas for Delta smelt (Herbold, pers. com. 1997). Restoration of tidal marsh south of Lindsey slough and on Hastings tract could add 3,000 to 5,000 acres of TPAH. Restoration of these areas would create a unique corridor between the Delta and the Jepson Prairie.

The ERPP calls for restoration of 2,500 acres of TPAH in the central and western Delta. DWR, USGS, and NHI have already submitted a credible proposal to restore 1,000 acres of TPAH on portions of Bradford and Twitchell Islands. Far more restoration is necessary in the Central and Western Delta to establish corridors of suitable shallow water habitat between the Delta perimeter and Suisun Bay. Restoration 2,500 acres will not create continuous habitat from rivers to bay.

Programmatic actions 1C, 1D and 1E refer to restoration of TPAH in the south and east Delta, but limit restoration to lands between 5 and 9 feet below mean sea level. This implies that lands above 5 feet below mean sea level are not suitable for TPAH. Table 6, however, defines TPAH as lands 9 feet below mean high tide. Since mean high tide is at least two feet above sea level in the Delta, then lands 9 feet below mean sea level are too deep and lands between mean high tide and 5 feet below sea level are ideally suited for TPAH restoration. Why have lands between mean high tide and 5 feet below sea level been excluded from potential restoration areas?

The vision for the South Delta Ecological Unit states that restoration of interior slough complexes of Old and Middle River would depend on the water supply conveyance alternative ultimately selected, presumably because restoration of channels near the existing pumps would increase entrainment of juvenile fish. This is an example of CalFed treating speculation as established knowledge. It is true that many biologists believe that enhancing shallow water habitats and marsh in the vicinity of the Delta pumps would lull endangered fish into an attractive nuisance. Other reputable biologists, however, have speculated that enhancing habitat in the vicinity of the pumps would increase recruitment and reduce entrainment of endangered species. Thus we are confronted with two competing hypotheses. Adaptive management protocols dictate that we test both hypotheses before making a long-term management decision. CalFed should conduct studies to determine whether increasing habitat near the pumps would be beneficial or detrimental to juvenile fish before abandoning the possibility of simultaneously maintaining the existing conveyance system and restoring large areas of Old and Middle River.

Targets for non-tidal emergent marsh are similarly paltry. On page 29 ERPP states that 30,000 acres of subsided islands in the Central and West Delta are appropriate for development of non-tidal fresh emergent wetland, but the restoration target for this area is only 11,000 acres. This target could be exceeded by nearly 2,500 acres by converting Sherman and Twitchell Islands alone. This is not unrealistic since DWR has already acquired the majority of these Islands for the express intent of creating wildlife habitat. Furthermore, Delta Wetlands Inc has a longstanding proposal to convert 15,000 acres of Delta Islands in this zone to non-tidal fresh water emergent marsh and seasonal marsh. An additional 5,000 acres is planned for a reservoir site. Again, the ERPP target is not different than plans already proposed.

There is over 1,000 miles of levees in the Delta, yet the ERPP calls for riparian habitat restoration on a maximum of 65 miles of levees. The vision for reducing stressors caused by levees on page 52 also address riparian vegetation restoration and management. It includes a target of changing vegetation management practices on 50 to 175 miles of levees to reestablish "natural vegetation." Is this target in addition to the previously mentioned riparian vegetation target? Assuming that it is, ERPP's maximum total targets are for increasing linear miles of riparian vegetation by 240 miles, less than a quarter of total Delta levees.

The potential for expanding riparian vegetation in the Delta is enormous. According to Earl Cooley who manages a mitigation bank on Medford Island, reestablishing cottonwood and willow vegetation is relatively easy in the Delta because the water table is high and the growth rate of this vegetation is very rapid. The largest constraint to restoring riparian vegetation is flood control, but the ERPP has not adequately addressed this constraint. The levees section, simply states that vegetation will be managed in accordance with flood protection needs and new levee vegetation management guidelines approved by Reclamation Board. What are the new guidelines? If the past is an indicator, managing vegetation in accordance with flood protection consists of removing vegetation. Between 1986 and 1991, 12,000 linear feet of riparian habitat was lost in the Delta under the levee subventions program (Ed Littrel, pers. com. 1997) despite state laws that mandate a no net loss in habitat associated with levee repair. How will the ERPP interface with the Board of Reclamation and the CalFed levee group develop strategies that simultaneous allow increased vegetation and improved flood control? If those strategies have already been identified, describe them or provide a citation.

ERPP repeatedly uses the word "restore" to refer to activities intended to create large non-tidal freshwater emergent wetland types on subsided islands. This habitat type was never present in large areas in the historical Delta so it is inappropriate to describe creating this habitat as restoration. It may be appropriate to create this habitat, but this activity should be properly described as habitat creation.

II.2.3 A More Expansive Approach to Delta Restoration

It may be unrealistic to specify today the amounts of locations of habitat restoration that can be accomplished within the Delta over the lifetime of the ERPP or thereafter. The program should proceed incrementally, restoring as opportunities present themselves, and taking aggressive steps to create the conditions where restoration becomes possible. An incremental and opportunistic approach can be guided by a few established facts and general principles:

Facts:

- Over 97% of natural habitats in the Delta have been lost.
- Existing habitat in the Delta is highly fragmented in small patches.
- The patch size of habitat is directly proportionate to its ecological value.
- Connectivity between habitat areas greatly enhance their value.
- Current land uses in many parts of the Delta are unsustainable
- In general, landowners in the Delta are not hostile to the use of their land for habitat purposes, provided that they do not suffer economically.

Principles:

- Voluntary transactions. Land or easements could be purchased from willing sellers for habitat. Alternatively, existing landowners could be paid to produce new "crops", that is, paid to manage their land to promote the goals of the CalFed program. Thus, farmers might convert all or part of their land over to tule marshes, or various types of wetland and riparian habitat. Similarly, they might be paid for their cooperation in discharge management programs or entrainment reduction programs. In this way, a local economy based upon unsustainable practices might be converted into a sustainable economy without major local opposition.
- Risk of urbanization: Easements or fee interest should be immediately acquired on historical Delta lands that our at elevations of less than 5 feet above mean sea level and subject to urbanization or conversion to perennial crops.
- Proximity to sea level: A significant acreage of land between 9 feet below mean high tide and 2 feet above mean high tide should acquired and converted to tidal marsh as soon as possible. (Note that the elevation of mean high tide varies throughout the Delta).
- Public ownership: Land currently under public ownership should be immediately converted to habitat or otherwise used for habitat restoration. Subsided publicly owned lands should

be immediately converted to non-tidal emergent marsh to halt further subsidence and increase habitat for target species.

- Peat Soils: All lands with peat soils at risk of continued subsidence should be managed to prevent additional subsidence. In some cases this will entail conversion of unsaturated lands to wetlands. In other cases continued farming with wetland rotations may be possible.
- Land use: Idle lands, poor quality agricultural lands, or lands used for low value crops should be targeted for immediate acquisition and restoration.
- Proximity to sediment sources: Lands located adjacent to natural or dredged sediment are ideal candidates for accelerated subsidence reversal efforts. These lands should be identified and acquired as soon as possible.
- Proximity to documented occurrences of target species: Lands with restoration potential adjacent to target species habitat should be given priority for acquisition.
- Risk of levee failure: Areas most vulnerable to levee failure may be the best place to invest in levee setbacks. Lands on the waterside of setback levees should be converted to TPAH, tidal marsh, and shaded riverine aquatic habitat types.
- Current harm to fish and wildlife: Agricultural areas or specific land uses most harmful to fish and wildlife should be targeted for acquisition and the land use modified appropriately.
- Migration corridors: To the extent possible, create a continuous corridor of TPAH, tidal marsh, and shaded riverine aquatic habitat between the Suisun Marsh and upland and the tributaries to the Delta.

NHI is currently conducting a GIS assisted analysis of the Delta region to help identify the best locations for restoration based on locations where these criteria overlap. We are eager to share are information with CalFed and hope that CalFed will do the same.

II.3 River Systems

II.3.1 The San Joaquin River

Restoring the San Joaquin may be the single biggest restoration opportunity in the entire valley. There may be overwhelming political and economic constraints that ultimately prevent this action, but it may be possible to overcome these constraints with some sort of creative water reallocation that could satisfy the needs of the Friant water users.

If the ERPP is going to be consistent, it should state that the goal is the recovery of spring run Chinook, fall run Chinook, and Pacific lamprey to the San Joaquin River between Friant Dam and the Merced River. Unfortunately, the ERPP goal in relation to anadromous fish in the San Joaquin mainstem is only to study the possibility of recovery. We know it is possible to restore fall and spring run salmon (Moyle, pers. com. 1997), it is just expensive in terms of water. But such water would also contribute to increased flows in the lower San Joaquin River, which would help in salmon recovery on the tributaries. Right now, water users in the Merced, Tuolumne, and Stanislaus bear the full burden of recovering salmon in the San Joaquin River system, when formerly the San Joaquin River proper, upstream, was a major contributor of salmon and lampreys.

Reestablishing flow and restoring a riparian corridor along the San Joaquin between Friant Dam and the Merced River would greatly enhance the ecological value and sustainability of the Grasslands ecological area and Mendota State Wildlife Refuge. Currently, these refuges are isolated other important ecological resources upstream and downstream on the San Joaquin by adjacent land and water resource practices. Restoration of the San Joaquin would create a continuous corridor from the Sierra to the Delta through Mendota Refuge and the vast Grasslands ecological area.

II.3.2 East San Joaquin Ecological Zone

The myopic focus on salmon in this section is puzzling, given that the document purports to be an ecosystem restoration plan. There is hardly any discussion regarding riparian habitat conditions and other species.

Certainly, the spawning reaches of these streams our important, but restoration of the lower reaches of these streams near their confluences with the San Joaquin are important not only to salmon but many other species as well. There is no discussion regarding the confluences of these rivers with the main-stem San Joaquin. Confluences are important backwater floodplain areas ideal for riparian habitat restoration. Where the tributaries join the mainstem, water backs-up and floods adjacent lands. This could be ideal habitat for western pond turtles and giant garter snakes. Unfortunately, this is largely precluded, particularly on the Stanislaus, because of levees. Setting-back levees and improving habitat at the confluences could provide important nursery habitat for juvenile salmon. The confluences of the Tuolumne and Stanislaus are particularly important because of their proximity to the San Joaquin National Wildlife Refuge.

The omission of Caswell State Park and the potential link with the San Joaquin National wildlife refuge is indicative of the myopic, species specific orientation of this section. Caswell is the best example of Great Valley Riparian in the San Joaquin Valley (Cosumnes excepted) and one of the best examples in the entire Central Valley. Caswell was the last San Joaquin Valley nesting site for Yellow Billed Cuckoo. It is one of the few places on the San Joaquin or its tributaries that still supports the once abundant western pond turtle (Tim Ford, pers. com. 1997), which has been decimated in the lowland San Joaquin Valley (Dan Holland, pers. Com. 1997).

Caswell and other good patches of riparian along the tributaries are examples of the types of riverine ecosystems we should be restoring, not just salmon spawning habitat. As mitigation for New Melones, the Corps acquired multiple lands and easements along the river. Unfortunately, these lands and easements have not been properly managed to maximize ecological values. The ERPP should describe these resources and develop a plan to expand and link these lands into a continuous riparian corridor between Tulloch Dam and the San Joaquin River.

Conservation of Western pond turtles and restoration of yellow billed cuckoo and giant Garter snake should also be included as a goal. Yellow billed cuckoo has been extirpated from the San Joaquin Valley but was last extant in the valley at Caswell State Park. Restoration of cottonwood galley forests around Caswell State Park and the San Joaquin National wildlife refuge may be an excellent opportunity for expanding the range of this endangered species. Giant Garter snake may be extirpated from this area and the once abundant western pond turtle is declining at an alarming rate throughout the San Joaquin valley (Holland, pers. com. 1997). Restoration of floodplain along the lower portions of the tributaries particularly near the confluences is essential for the recovery of these two species.

The recovery of native resident fishes along with recovery of pacific lamprey should be added as a goal for this ecozone. These species have been particularly hard hit by development in the San Joaquin Valley (Moyle and Brown, 1993). According to Larry Brown (pers. com. 1997), the Stanislaus has the most native species including hitch, hardhead, lamprey, etc and the Dry Creek tributary to the Tuolumne is one of the few streams in the San Joaquin Valley where hitch are the dominant species.

Steelhead should be dropped from the goals of this section. With the possible exception of the Stanislaus River, there does not appear to be habitat for steelhead spawning & rearing in these rivers (Moyle, pers. com. 1997). Recovery of steelhead in these rivers would almost certainly involve hatchery fish, which would prey on wild Chinook salmon juveniles. Thus, the somewhat hopeful goal of restoring steelhead may be in conflict with the real potential for restoring the southernmost runs of Chinook salmon.

The Ecological Zone Description should discuss the major changes in geomorphology hydrology and the implications for restoring natural processes. This analysis should compare existing and pre-dam and post-dam instantaneous peak flows as well as average monthly flows. The discussion for the Tuolumne and Merced should detail the location and impact of gravel mining operations.

The numerous debatable statements in the description of the ecological zones and fisheries is not supported by citations. Pg. 373 first full paragraph states that "The (Merced) hatchery has been valuable in augmenting and sustaining salmon runs in the lower Merced River and in the Stanislaus and Tuolumne Rivers . . ." What is the basis of this statement? Have there been any peer-reviewed studies? This section is replete with similar unsupported statements. These statements should be properly supported with citations or qualified to indicate that they are not substantiated.

Pg. 373 top of second column states that "Preliminary surveys on the Merced River indicate that the major needs for salmon habitat improvement include rehabilitating riffle areas, constructing or repairing levees and channels to isolate mining pit areas from the active stream channel, and modifying diversion structures." This is not "ecosystem restoration." It is the same old single species management. If these actions provide benefits to other species, explain them.

On page 375, the second full paragraph begins "The vision for the Stanislaus River includes reactivating and maintaining important ecological processes that create and sustain habitats for salmon and steelhead." Does this sound like ecosystem restoration? The paragraph goes on about specific measures for these species with no mention of how key ecological processes will be restored Page 1 of volume 1 says that the foundation of the ERPP is restoration of ecological processes . . ." Why are the visions so inconsistent? The vision for Tuolumne and the Merced at least start out with a reference to restoring streamflow, gravel recruitment, etc. Why is the Stanislaus vision so species specific.

Programmatic action 1A for the Stanislaus: 2,000 to 4,000 c.f.s. is almost certainly not enough to recruit gravel, transport sediment, cleanse spawning gravel, etc. as they say under the rationale on the bottom of 385 and the top of 386.

The vision for the Merced is still lacking, but it is a lot better than the Stanislaus vision. For example, in bullets on page 372 the ERPP specifically mentions restoring natural channel configurations, restoring gravel recruitment, transport, etc. In the second to last paragraph of page 377 the ERPP states that a spring flow event would be released that would emulate a natural pulse flow that would normally occur if flows were unimpaired. This is a necessary step in the right direction

Action 1A,B, and C basically involve construction of spawning gravel habitat. This is not a restoration strategy that relies on ecological processes. In fact, this proposed action is inconsistent with the implementation objective, target, and rationale. If additional gravel is needed, it is reasonable to add it to the stream, but only in conjunction with high flows capable of transporting and depositing it. The concept of "renovating" spawning habitat is very problematic. A recent study (Kondolf, et. al., 1996) described the pitfalls of attempting to build spawning habitat without regard for the underlying physical processes that transport gravel and maintain habitat in natural riverine systems.

A priority action for this eco-zone is to phase out gravel mining as quickly as possible. This may require acquisition of lands and mineral rights.

II.3.3 Cache Creek

Cache Creek is one of the few large streams in the Central Valley without a terminal storage reservoir. As a result the natural hydrologic sediment regimes have not been irreversibly altered.

Unfortunately, the ERPP misses the rare opportunity for reestablishing a nearly natural stream on Cache Creek and instead opts for the band aid approach to restoration. ERPP proposals to add spawning gravels to Cache Creek is a prime example of this misguided approach. Anyone who has ever walked along Cache Creek knows that there is no shortage of gravel on the Creek. Cache Creek is the largest single source of gravel in the entire Central Valley today. This example illustrates two alarming points about the entire ERPP: 1) in many cases the authors are obviously ignorant of the ecozones or natural processes they are purporting to restore, and 2) the ERPP is not an ecosystem restoration plan but rather a laundry list of boiler plate restoration actions.

II.3.4 Battle Creek

The ERPP has also neglected opportunities to restore winter run on Battle Creek. Winter-run salmon once utilized Battle creek but have been blocked PG&E hydro dams and barriers at the Coleman fish hatchery. The dire state of the winter run may be the most significant factor currently constraining restoration of the Sacramento River. Furthermore, the reduction of their range to a single reach of the Sacramento renders them very vulnerable to a catastrophic event. For these reasons, expansion of the winter run, wherever possible, should be a major priority. CALFED, however, appears to have ignored this opportunity/priority in deference to the status quo at Coleman fish hatchery and PG&E.

III. Commnts on ERPP Volume III: Vision for Adaptive Management

III.1 Overview

This section is poorly developed and clearly an afterthought. Adaptive management is not a trial and error approach where actions are reevaluated based on success or failure (as depicted in the diagram on page eight). NHI would hope that any resource management would be reevaluated based on success or failure. Adaptive is distinguished from traditional management by an intent to design actions, at least in part, to provide information about the ecosystem. A paper by Volkman and McConnah (1993) clarifies the difference between traditional management and adaptive management:

> With traditional management, action is based on existing knowledge and established modes of operation. The course is altered if it appears unproductive, but information is not sought aggressively or strategically, and when it is gathered, it is drawn from a relatively narrow range of conditions. In contrast, adaptive management implies an active search for key hypotheses and a commitment to test them.

Adaptive management should not be limited to research and actions taken after CalFed implements physical restoration treatments. Rather adaptive management should be an integral part of the restoration program from the first step of the program, analyzing the problem, to the last step of evaluating success. As stated previously in these comments, CalFed must define adaptive management and properly integrate it into Volumes I and II.

In light of the uncertainty regarding the Bay-Delta ecosystem and the finite funds available for restoration, NHI urges a risk averse adaptive management strategy to avoid irretrievably committing scarce resources to ineffective treatments. The cornerstone of such a strategy would be to heavily invest initial restoration funds in fungible assets that are likely to appreciate in value over time such as land and water. This is an important component of adaptive management because unnecessary or misguided actions can easily be reversed without forfeiting restoration funds.

NHI hopes that the body of our comments will help integrate the adaptive management concept throughout the entire text. Additionally, NHI suggests that you review the literature on adaptive management and experts in the field such as John Williams who recently completed a summary of literature on adaptive management (attached).

III.2 Implementation Priorities and First Level Species

Striped bass is listed has a first level priority species along with winter-run Chinook and Delta smelt. Striped bass should be removed from either the 1st, 2nd or 3rd priority list for the following reasons:

1. It is an exotic species that is doing fine in its native range.

2. It is showing signs now that is it in fact poorly adapted to the Sacramento-San Joaquin estuary and that factors effecting its population may be out of our control:

a. Bill Bennett's analysis indicates that the bass, especially large fecund females, are leaving the estuary in ENSO years (which are increasingly frequent) and not coming back..

b. Their spawning peaks later in the season than any native species, indicating that conditions during their successful colonization may have been unusual. There may be a connection with hydraulic mining here as well.

3. Maintaining conditions for striped bass spawning will require extra water in May that will usually not have large benefits to other species. This water would be better spent improving conditions for native species.

4. Striped bass are piscivores with high metabolic rates. While they seem to eat mainly each other, they also consume salmon, splittail, and other species. If their populations are enhanced, it is likely that they may suppress the recovery of other species, especially salmon.

5. The goal of 2-3 million large piscivorous bass is very high and assumes an estuarine ecosystem totally dominated by striped bass. This would seem to contradict other recovery goals.

6. The temptation to try to enhance striped bass through artificial propagation will be almost irresistible and if it works may actually increase predation on other species and prevent full recovery. Volume II states artificial propagation of striped bass may be needed but will be tried only if there are "healthy populations" of the other species what ever that means. A population can be healthy without being especially large. It is also interesting to note that artificial propagation is not listed as an alternative for most other species, such as splittail.

7. The focus on striped bass detracts from native fish that support fisheries: Chinook salmon, steelhead, white sturgeon, green sturgeon, and splittail.

8. Without a special management focus, striped bass will not go extinct in the estuary. In fact, if environmental conditions are right, there should be periodic strong year classes of bass, which will support a fishery. The large fisheries for striped bass in the past can be regarded as a fluke, related in part to the wetter climate and degraded conditions that favored bass and did not favor other sport fish.

Furthermore, all mention of American shad as any kind of priority/management species should be deleted from the ERPP as well. They have persisted as a largely unmanaged species in the past and will continue to do so in the future.

The three species listed as first tier priorities in Volume III or the ERPP is not very meaningful, especially when one is striped bass. The Delta Native Fishes Recovery Plan targets a wide spectrum of declining native species: Delta smelt, longfin smelt, green sturgeon, splittail, spring run chinook, late-fall-run chinook, and San Joaquin fall-run chinook, plus winter-run chinook (for which there is a separate recovery plan). A broader list of native target species would be more likely to result in true ecosystem restoration rather than the failed single species plans of the past. If a short list were needed for first priority, NHI would recommend including the following species for the reasons indicated:

1. Delta smelt - listed species, confined to estuary, seems to have unique responses to estuarine conditions.
2. Chinook salmon - all runs. It is just one species but the four runs and numerous subpopulations should be maintained for the sake of diversity and for fisheries. We need to maintain favorable conditions for salmon throughout the year somewhere in the system.
3. Longfin smelt - salt-water oriented, with a straight-forward numerical and perhaps reproductive response to outflows.
4. White sturgeon - important native sport fish that is largely confined to estuary, except when spawning.

III.3 Ecosystem monitoring

(p. 35-36). The ERPP seems very unclear on the value of adaptive management and the purpose of monitoring in that context. First, adaptive management is specifically designed as a way to manage a system in which the responses are *not* understood; thus it cannot require "...that the mechanisms behind observed ecosystem responses are understood".

Second, the ERPP makes the usual mistake about assuming one can monitor to "measure the response of the Bay-Delta system to restoration actions..." You can measure changes in the system over time. Whether you can interpret these as responses depends on the size of the response, the size of the action, and how creative you are at data interpretation. Convincing somebody else is a different matter. We are not arguing against monitoring, but the "action-specific" monitoring must be adequate, and must be accompanied by research to see why the system responds in certain ways or does not.

Third, the ERPP states that the monitoring program should "... measure all, to the extent possible, ecosystem variables that are likely to significantly affect the response of the indicator(s)..." Suppose an indicator is the number of Delta smelt. According to the ERPP, we would have to measure abundance of smelt, their reproductive, growth, and mortality rates, predation by all their major predators by time of day and season, the degree of food limitation at all life stages, cannibalism, disease, viruses, and parasites, losses to exports, emigration, and probably a lot of other things we do not know about that affect their response. Although some or even many of these variables should be measured for scientific purposes, this degree of effort is impractical for the purposes of CalFed restoration.

p. 36 para. 3 "...bring all relevant data into a data base system to facilitate integrated analysis." Good analysis, which is always "integrated", whatever that means, is not usually limited by the availability of data in one place. A creative, capable researcher can usually find the data needed; furthermore, IEP, SFEI, and USGS are doing a fine job of making data available. The limiting factors are analytical talent and money. Much more monitoring is being done than can be accommodated by the existing analytical effort.

p. 39 Estuary zooplankton. "...zooplankton species generally respond rapidly..and can be used as an early indication of the effects of some restoration actions.." Wim Kimmerer has spent a lot of time analyzing data on zooplankton, and has no idea how one would do what CalFed says. Zooplankton usually respond rapidly, but not necessarily to stimuli we know about. Later in the same paragraph the statement is made that data on zooplankton is important in interpreting growth and survival of fish. Nobody is measuring growth or survival of most species, so there is nothing to interpret.

Estuary benthos: As far as we know, nobody is currently monitoring benthos in San Pablo, Central, or South Bay on a routine basis.

The sections on monitoring of flow and estuarine fish are generally OK.

Salmonids: This section is very ambitious. Nobody is now monitoring abundance of juvenile stages of salmonids, nor does there seem to be a consensus on how to do that. We suppose somebody at CalFed has an idea and look forward to hearing it.

III.4 Indicators

As stated by one member of the scientific review panel, the indicators, as a group, are both too general and too specific. Restoration of ecosystem processes is purportedly the foundation of the ERPP, but indicators for ecosystem process are either vague or unhelpful (see attached comments by William Trush for more specifics comments on indicators of ecosystem processes). Indicators for species are nothing more than highly specific numerical targets for each species. They are not an indicator, they are a direct measure of the number of a particular species. Indicators should not be a laundry list of measures of every ecosystem component, but rather a limited group of ecosystem elements that indicate whether the program is achieving its goals.

The problem with this discussion of indicators is that there is no discussion of what makes good or poor indicators, and what they should indicate. That seems an essential underpinning to this exercise. Indicators should be presented as a hierarchy, with indicators of fundamental, human-controlled activities at the bottom (e.g. flow conditions, exports, toxic discharges, habitat construction), and abundance of things we care about at the top.

Page 46: This section is extremely fluffy. Table 4, for example, is just a vague laundry list of poorly developed ideas. For instance, nutrient budget and cycling is listed opposite a bunch of habitat types, with a "stressor" listed: levees, bridges, and bank protection. What does this have to do with nutrients? In the same table, what does "food web support" mean?

Page 49, "The broader indicators of overall ecological health..." For the aquatic ecosystem of San Francisco Bay, the "ecological health" metaphor is intellectually bankrupt. There is no temperature one can take, no suite of indicators corresponding to heart rate, blood pressure, and white cell count that clearly and uncontroversial demonstrate good or poor health. NHI put on a workshop on this topic and concluded that ecosystem "services" provided a more useful framework for setting restoration goals. Results were presented to CalFed: where are they?

Pp. 63-68 - Numerical Indicators/Goals: Tying recovery goals to specific numbers at a specific time is tricky and often not very satisfactory. The best way of doing is exemplified by Loo Botsford's work in the Winter Run Chinook Recovery Plan, which was at least partly adopted in the ERPP. He ties measurement of recovery not only on actual numbers but on rates of increase, which are difficult to determine precisely. The less precise the estimate, by his criteria, the more time you need before you declare a species recovered, because you need to account for uncertainty. This actually is a brilliant concept but we suspect makes water managers etc rather unhappy because precise measurements are very hard to obtain, so long recovery periods become more or less mandatory.

Furthermore, using just numbers of individuals etc is tricky because such numbers are likely to be so variable and it takes a long time for a trend to be significant. Thus, measures of habitat recovery need to be in place. This is the approach was used in the Putah Creek trial, advocating the use of habitat (=flow regime) as a short-term surrogate for abundance estimates of each species.

p. 55 aquatic food webs. This entire section should just be excised. There is nothing in here worth keeping. For example, para. 1: "..objective...is to maintain, improve or restore the amount of basic nutrients... to provide a sustainable level of food web productivity." This reads as if written by an expert in marketing. First off, nobody knows if "basic nutrients" need to be maintained or improved or even whether they are in short supply in general. The high concentrations of these nutrients in the bay certainly do not bespeak shortage. Furthermore, unless you kill the entire system, there will always be "a sustainable level of food web productivity", although it may not sustain the things you want (see comments above about ecosystem services).

The indicators in this section are weak. Primary production measured by "traditional light and dark bottle methodology" would be neither an efficient nor an effective way of determining if enough food were being produced for the food web. Organic carbon *concentrations* are easily measured, but obviously CalFed has never tried to measure organic carbon *fluxes*, or they would not even dream of using them as indicators. The same is true of gut fullness of fishes, which it is asserted can "provide evidence of the importance of trophic dynamics on higher trophic levels." No, actually, it will tell you some of the things they eat and give you a *rough* idea of how often they eat or how much.

Here are some indicators that would actually work for the aquatic food web (and it would have to vary depending on location):

Indicators of habitat:

- X2: General index of the physical response of the estuary to outflow.
- Inflow: Useful indicator for habitat of upstream species and possibly for migration rates.
- Export flow: Indicator of risk of entrainment.
- Water clarity: Indicator of growth conditions for phytoplankton

Indicators of response:

- Chlorophyll: Measure of phytoplankton biomass; include size fractionated chlorophyll (i.e. larger than 10 μm) as an indicator of food supply for zooplankton.
- Abundance of diatoms: Generally good food.

- Abundance of nuisance species: harmful algal blooms, aquatic weeds.
- Abundance of common zooplankton species: indicate food available to fish.
- Bacterial biomass or production: probably important source of food to some higher trophic level organisms.

There are good reasons to measure primary production, egg ratios, etc., but only in the context of research, not as indicators to be used in monitoring.

III.5 Focused Research

Focused research (p. 77): This section clearly indicates a lack of understanding of what scientific research actually is. Who does unfocused research? Focused as opposed to what? The ERPP defines this buzzphrase as "The use of the experimental method to answer specific questions." Instead of answering general questions, or using this method just for the hell of it? "The experimental method" is a commonly held misconception among non-scientists: there is no standard method that applies in all cases. Scientific research is a creative process in which one uses all the tools available: modeling, monitoring, intuition, literature review, inspiration, experiment, discussion, and thought. It is not some cut-and-dried process in which one knows the outcome in advance. If it were, most of us would have got bored and would be doing something else.

Apparently this chapter is based on a survey returned by 13 people, and two documents prepared by SFEI and the Estuarine Ecology Team. That is a pretty shallow method for determining what research would best support the needs of CalFed. It further points up the problem we noted from the outset: this is a flabby, unfocused, vague document with no central theme and no method for getting from one point to another. The result of this is that the list of research topics is merely a laundry list of potential topics, presented without regard to how they fit together.

The research needs must take into account what is already known. For example, some of the best research in the world on factors affecting estuarine primary production has been done in this estuary by Cloern and colleagues, so new research must go beyond merely asking what these factors are.

Most of the research questions on ecosystem productivity are too general or vague to be of any use. One exception is to determine what mechanisms cause covariation of abundance of estuarine-resident species with X2. This one is essential for trying to figure out what to do about all these estuarine-resident species. Note that this is a *big* research topic, and may take decades and millions of dollars to complete. we suspect that none of the research proposals submitted to CalFed recently addressed this topic.

Examples of focused research on ecosystem productivity are neither focused nor, in some cases, research. The first one is to "Measure the production of phytoplankton... to better understand how the system functions". Measuring production is insufficient for understanding the system. You actually have to formulate theories about how it functions, then develop hypotheses based on those theories, then go test the hypotheses. This paragraph describes monitoring, which is not the same as research.

"Study the importance of organic matter's input to the estuary..." This is too broadly and vaguely stated to be of any use in designing research.

"Create a food web model..." Much better. This is an action, it is research, it might yield interesting insights into how the food web works. However, "[u]sing the food web model results... [to] determine how productivity of the estuary has changed..." is not an appropriate use for the food web model, which should be viewed solely as a research tool until much further down the road.

"Determine effects (of) exchanges between channels and shoals..." Yes, this is a good one, but we don't really know why it is listed. We think it is important, but why does CalFed? What is the logical sequence of steps leading to that conclusion?

Introduced species: Question 1, "What kinds of levels of disturbance... favor exotic species..." is not a research topic that will provide useful input to management any time soon. It is interesting to argue about, and maybe some useful models can be developed, but that's about it.

Estuary model development, item 1. The existing conceptual models are about as clear as they can be for our current state of knowledge. Although they could and should be refined, it is time to go out and start testing some of the assumptions and beliefs embodied in these models.

Item 2, "Create mechanistic models that accurately simulate and predict any of the numerous physical, chemical, or biological processes of the estuary." There are no biological models of this system that can accurately predict anything very useful, and there will not be any for a long time. This is wishful thinking.

Appendix 1

Goals for Restoring a Healthy Estuary

Report on Results of a Workshop of Estuarine Scientists

GOALS FOR RESTORING A HEALTHY ESTUARY

Report on Results of a Workshop of Estuarine Scientists

October 2, 1995
Tiburon, California

Introduction

On October 2, 1995, fourteen CalFed agencies and stakeholders convened a workshop of scientists with particular expertise in estuarine fishery biology and hydrology and wetlands ecology *to specify achievable goals for the restoration of a "healthy" Bay-Delta estuary*. Lists of the sponsoring organizations and expert participants are attached to this report. We undertook this task because existing specifications of goals for the estuary (e.g., those set forth in the Comprehensive Conservation and Management Plan) are too broad to define appropriate restoration actions for the CalFed process. The discussion was confined mainly to technical aspects of ecosystem evaluation and goal-setting, although known societal preferences were taken into consideration in recommending restoration goals.

This report summarizes the consensus of the group. The Appendix contains the white papers by Wim Kimmerer and Josh Collins prepared to stimulate thinking by the participants.

The geographic scope of the discussion was the tidal reaches of the estuary and its associated marshes, including areas that could be returned to tidal action, with an understanding that cause-effect relationships crossing these boundaries would be included in the scope. Much of the emphasis in the workshop was on goals for open-water habitats, partly because of the expertise represented, but also because extensive efforts are underway to develop goals for baylands. The work ongoing on baylands at the San Francisco Estuary Institute may be of particular value to the CalFed process.

Meaning of ecosystem health

Participants agreed that while concepts like "ecosystem health" and "ecosystem integrity" are appealing, they are of limited use in setting ecosystem restoration goals because they cannot be precisely defined in terms of measurable ecosystem functions, processes, or other properties. The participants favored defining ecosystem restoration goals in terms of a system's capacity to provide the full range of ecosystem "services" important to society. Creating and sustaining these services, of course, requires certain ecosystem structures and functions. The extent to which an ecosystem's services to society meet societal expectations is a measure of the health of that system.

Ecosystem services include all of the uses that society expects to obtain from the ecosystem. These can be inferred from current use of the ecosystem, and from legal and regulatory statements of purpose such as the Clean Water Act or Endangered Species Act. Obvious desired services include water supply of a quality suitable for drinking or irrigation; provision of edible (i.e., non-toxic) fish and shellfish; maintenance of endangered species; safe passage for anadromous fish; water sports; navigation; absorption of wastes; birdwatching and aesthetic enjoyment.

Goals for restoring the estuarine ecosystem to "health" can either address these services directly, or the processes or functions of the ecosystem necessary to support these services. Ecosystem processes or functions that support more than one service may appropriately be considered goals in themselves.

Partial list of goals for the estuarine ecosystem

The following are goals that the group believed were related to ecosystem services for which society had expressed a priority. The goals listed here include only those relating directly to estuarine biota. The group briefly discussed, but did not resolve, whether to include goals related to other services such as clean water for human consumption or agriculture, disposal of sewage, or arable land.

Goals unanimously endorsed:

Restore populations of indigenous species to levels not likely to result in extinction. The group recognized that extinction is a natural process, but that the current rate of extinction is far higher than before human settlement. Therefore, the possibility of extinction is allowed, but at a rate more like that which would have occurred over evolutionary time. Because evolutionary time is very slow compared to the time horizon pertinent to the CalFed planning process, the practical goal is to prevent any appreciable risk of extinction of, at least, all vertebrate species.

Maintain populations of fish and waterfowl that can be eaten safely. There are several sources of contamination resulting in warnings to restrict consumption of fish; most of these are relatively old sources of material with long residence times, such as DDT and mercury.

Provide anglers with a reasonable chance of catching sport fish. Population levels of these species need to be increased.

Increase naturally-produced populations of anadromous fish. This goal is explicit in the

Central Valley Project Improvement Act.

Maintain sediment contamination at least below levels seen in 1950. The public responds unfavorably to reports of sediments contaminated by industrial or other activity, whether or not the levels of contamination interfere with the provision of other ecosystem services. The year 1950 was selected as a baseline before which the level of industrial activity in the bay watershed was low, although the influence of hydraulic mining in the last century cannot be discounted.

Prevent conditions that result in water column anoxia, including harmful and nuisance algal blooms. Advanced treatment of sewage discharge has eliminated the high organic loading that once resulted in anoxic conditions and foul odors over nearly the entire estuary. This progress should not be reversed. A further problem is the continuing occurrence of nuisance blooms in the Delta and along the open coast.

Restrict additional introductions of exotic species. The rate of successful introduction of exotic species is higher in the Bay/Delta estuary than in most other estuaries. This has led to the replacement of many species of indigenous fish, benthos, and plankton with introduced species and alteration of trophic structure.

Enhance aesthetic values. Although aesthetic values are highly subjective, the high level of use of areas such as marshes for non-consumptive recreation (hiking, bird-watching) is a clear indication of public preference for attractive marsh and other habitats.

Sustain natural evolution of baylands. Most of the bay's wetlands have been either converted permanently to other use (e.g. urban development) or diked and drained for use as farms or managed wetlands for hunting. Only a very small fraction of the bay's wetlands remain under the influence of the tides, and therefore subjected to natural development. Marshes have a broad range of functions, some related to other goals above, and should be protected and expanded to support those functions.

Goals that are more equivocal with respect to desired ecosystem services:

Establish a viable commercial fishery in San Francisco Bay that provides fish or shellfish for consumption This was suggested as a way of ensuring that the ecosystem could support a large population of fish or shellfish that were safe to eat. Based on post-workshop consultations, this is apparently a controversial issue due to the historic conflicts between sport and commercial fishing interests in San Francisco Bay associated with the pressure that commercial harvesting has sometimes placed on fisheries. Whether this concern is amenable to a regulatory solution was not discussed.

Decrease turbidity of the water and increase seagrass habitat. Extensive seagrass habitat has been mostly lost from the bay. The cause of this loss is probably high turbidity of the water. Reducing turbidity might solve that problem, providing better habitat for some fish; however, reducing turbidity could also increase phytoplankton primary productivity, increasing the use of the large amount of available nutrients in the water, and resulting in an increased incidence of nuisance blooms.

Goals posited but not addressed:

Provide a greater "sense of place" for Californians with respect to the Bay-Delta. People who live in the Chesapeake Bay region probably feel stronger ties to their estuary as an ecosystem than people in the San Francisco Bay region do to theirs. This goal seems to incorporate a number of others, and may be redundant.

Maintain sustaining to increasing populations of ecologically important species. "Ecologically important species" refers to forage species for higher trophic levels. It was not decided whether this should be a goal in itself or an objective for support of other services.

Proposed actions for progress toward the goals

The group was not convened to recommend specific actions to achieve the goals listed above. Much of that discussion has taken place, and some continues to take place, in other forums (e.g. the CALFED Bay/Delta process, bayland goal-setting process, species recovery teams). The group instead recommended focused programs to establish specific objectives related to the processes and functions requisite to the goals and related to robust measures of progress toward the goals. The development of goals and initiation of actions to achieve them need to be better integrated between open-water habitats and marshes, for which a greater effort for setting objectives has taken place.

Many of the recommended programs include the use of focused workshops to address these difficult problems. Some guidelines on structure and process to make these "downstream" workshops most productive were enumerated. These workshops should be preceded by meetings of core groups that would establish and conduct the preliminary analyses necessary to ensure the effectiveness of the workshops. The workshops would then be convened to examine the evidence developed, recommend actions to be taken, and assess the need for further analysis. The experts should come together first in a plenary session to agree on the scope, objectives and process, and then break into concurrent work groups concentrating specific expertise on specific problems. "Vertically integrated" white papers, that treat a narrow theme in considerable depth, should be prepared as background and to sharpen the issues for each specialty work group session. The results should be communicated back to the plenary for synthesis into a final product that "horizontally integrates" across the disciplines and specialty groups. Workshops should span two or more days.

The following section briefly discusses limiting factors, which are the key to increasing abundance of populations. The next sections describe briefly some of the topic areas that might be suitable candidates for focused workshops.

Limiting factors

Limiting factors are poorly known for resident species of the bay/delta. The factors limiting indigenous populations of fish and invertebrates may include:

- Habitat availability
- Freshwater flow
- Entrainment
- Food supply
- Toxic substances
- Fishing

Determining the relative importance of these factors is crucial to deciding what actions would provide protection and enhancement of these populations. Some of these are discussed below. However, it is important to keep in mind that all biological populations must have some (generally unknown) compensatory mechanisms to constrain abundance toward environmental carrying capacity. Actions that increase carrying capacity may be more effective at achieving goals for populations than actions that reduce non-compensatory mortality.

Habitat for open-water species

The CALFED Bay/Delta Program has proposed that providing habitat is the most efficacious means of protecting species occupying that habitat. This conclusion is based partly on the relationships between X_2 and abundance or survival of many estuarine-dependent species. However, these relationships could also arise through other causes related to flow, such as entrainment. Therefore, before the CALFED process goes too far in developing planning alternatives for habitat restoration, the scientific basis for relating habitat to species abundance needs to be further examined. Also, it is notable that the interactions between open-water habitat and tidal wetlands have been poorly studied in this estuary.

We recommend that one or more workshops be held on the benefits of new open-water and marginal habitat. These workshops should examine evidence, prepared in advance, for the relationship between habitat and abundance of estuarine species. Proposed habitat restoration actions (e.g. flooding a portion of Prospect Island) should be set up as case studies with appropriate recommendations for monitoring and research into the success of these actions in enhancing population size.

Entrainment

The role of entrainment in the delta, including its effects on indigenous species and ecosystem functions, is perhaps the most significant unknown. Entrainment at the major pumping plants is believed to be a cause of declines in at least some species resident in the estuary; entrainment onto Delta islands is poorly known but believed to be important. If these effects are unacceptable, mitigation will require construction of facilities which may be quite expensive and may alter the system in unpredictable ways. Therefore a top priority for managing the bay/delta ecosystem is to assess the importance of entrainment relative to other factors. This assessment would require multiple approaches with an emphasis on modeling and on scientific and statistical rigor.

Exotic species

Participants strongly recommended that regulations to prevent the introduction of additional exotic species be reviewed, strengthened if necessary, and vigorously enforced. The evidence for the frequency of exotic introductions and their effects is being assembled, and CALFED and other agencies should disseminate this information. Research should be conducted into the vulnerability of the ecosystem to invasion, but this should not delay management actions.

Contaminant effects

There are many potential problems with contaminant effects in the Bay/Delta, but no known population-level effects. A group should be formed to investigate to what extent contaminants may interfere with ecosystem functions (this group might be the Contaminant Project Work Team being established by the Interagency Ecological Program, although the San Francisco Estuarine Institute has been holding workshops on toxic indicators). A small workshop should be convened to summarize what we know and don't know and to recommend priority research topics and monitoring programs to provide diagnostic indicators of contaminants. To provide a unifying framework, efforts should include the construction of mass balances and the incorporation of contaminant effects into numerical models.

GOALS FOR RESTORING A HEALTHY ESTUARY

Wim Kimmerer

September 25, 1995

Introduction

A workshop on restoration goals for the San Francisco Bay-Delta Estuary will be held in Tiburon on 2 October 1995. The purpose of the workshop is to begin to resolve technical issues regarding achievable goals for the restoration of a "healthy" estuary. Participants will include many of the scientists most active in research and management activities in the Bay-Delta. Output of the workshop will be presented for use in the CALFED process under the assumption that to achieve restoration of the ecosystem requires a clear statement of restoration goals.

This white paper has been prepared to summarize some of the technical issues regarding restoration goals and ecosystem health. The concept of ecosystem "health" is more than mere "ecobabble" and, as discussed below, understanding the concepts is essential for setting achievable goals. This paper is my attempt to set the stage for the discussion at the workshop; I hope that it will stimulate critical thinking of the conceptual and practical bases of goals for the ecosystem. This paper is necessarily subjective, and incorporates my biases: for example, my ignorance and therefore neglect of how these concepts apply to wetlands.

A great deal of effort has been expended by a variety of agencies and individuals in attempting to protect, restore, enhance, and analyze the San Francisco Bay-Delta estuarine ecosystem. The ultimate goals of all this activity have never been stated very clearly. Most of the planning and regulatory documents on restoration activities give goals that are either quite concrete but limited (e.g. to reverse the decline in abundance of certain species of fish) or rather vague. Terms such as "ecosystem health", "ecosystem integrity", "ecosystem function", "biodiversity", and "balanced indigenous ecosystem" are used frequently in written material on ecosystem restoration; none of these terms is sufficiently well-defined for this ecosystem to be useful in setting achievable goals.

To establish a clear direction for restoration of the Bay-Delta ecosystem, clear goals are necessary. The principal purpose of this workshop is to provide the technical basis for those goals, and for indicators or "performance measures" that can be used to determine progress toward these goals..

We must keep in mind that bringing the estuary to some desired state in the future cannot be the same as restoring it to some near-pristine condition in terms of species composition or structure: the estuary has already be irreversibly altered. Instead we need to define what we, as biologists, think the desired state or set of states should be, and what should or should not be included in a description of those states. In future workshops, other societal values will presumably be added to the definition. For example, a vision of the estuary constructed by biologists may include its use for rearing by large numbers of juvenile chinook salmon, while a vision created by a another group may not include rearing juvenile salmon at all. Since it will be possible to have a "healthy, functioning" ecosystem either way, the pathways to defining the desirable estuarine state(s) will necessarily involve difficult choices based as much on aesthetics or human use as on science.

Problem statement When we use the term "ecosystem health", what do we mean? The underlying problem is largely semantic, resulting from the extension of the concept of health from an individual to an ecosystem. Human health is fairly unambiguous and, in the twentieth century, based on a clear body of theory about the homeostatic properties of an organism. Ecosystem theory is not nearly as well developed, nor does it include a mechanism for homeostasis. Instead of a homeostatic mechanism, an ecosystem is believed to have one or possibly many alternative set points or region (i.e. sets of values of all state variables) toward which it moves, even as the set points themselves change because of changing physical conditions. This differs from homeostasis in that there is no ideal or target set point; instead, the set point is a consequence of the various interacting feedbacks in the system.

Although the concept of ecosystem health is not yet well defined, most ecologists would agree on the relative health of, say, the East River and Tomales Bay. Most of us would define a "healthy" estuary as one in which a full complement of estuarine species flourishes, with thriving, diverse wetlands, clear water, plenty of oxygen, numerous fish of many species and a variety of sizes, and if there is a significant human population nearby, thriving commercial and recreational fisheries supported by natural production.

In an attempt to cut through semantic problems, I assume that the goal of restoration is a "healthy", "functioning" ecosystem with plenty of "integrity", a "balanced, indigenous community", and an appropriate degree of "biodiversity". These various terms about the status of the ecosystem are made synonymous with each other and with restoration goals. In addition, "restoration" is used here to mean restoration of the ecosystem to a healthy state, not to some previous state. Hereafter I use the term "ecosystem health" to mean the status of the Bay-Delta ecosystem along a continuum with our ultimately desired ecosystem as an endpoint (or one of a number of interchangeable endpoints) toward which we hope to move the current, less than desirable, ecosystem. The other endpoint need not be defined.

Tenets for the workshop

1. Time moves in one direction only: therefore, many of the changes that have occurred in the estuary are either irreversible (e.g. introduced species) or practically so (e.g. dams).

2. Therefore, past states of the ecosystem will not be used as goals for restoration of the estuary; but rather as a guide to system response

3. Natural change in an ecosystem is not oriented toward a goal

4. The ecosystem under consideration comprises the San Francisco Bay-Delta estuary from approximately the Golden Gate to the upper limit of tidal action, including its open waters and tidal marshes.

Questions for the workshop

The principal issues to be addressed at the workshops are:

1. What should be the scientific basis for goals and objectives for restoration of the estuary?
2. What are the most useful indicators of ecosystem health for this estuary?
3. How do indicators of ecosystem health vary between wetlands and open water?
4. Are there any properties of the whole ecosystem (as opposed to populations or physical or chemical variables) that can be used to describe ecosystem health in a scientifically defensible way?
5. Are specific numerical objectives for population abundance or other variables warranted on a technical basis?

Secondary issues include:

6. Should goals be set in terms of habitat explicitly, or in terms of the populations expected to occupy that habitat (more a concern for open water than for wetlands)?
7. How should we account for future risks to the ecosystem such as sea level rise or the increasing human population and attendant increase in demands?

I anticipate that these issues will be addressed using a triage approach, in which we sort the issues into:

1. Issues on which consensus is or has been achieved

2. Issues that are not amendable to consensus because data are lacking, the issue is intractable, or interpretations are too divergent.

3. Issues for which consensus could be achieved following a well-structured program of investigation

Existing Information

There is a serious risk in this workshop of "re-inventing the wheel". Many people have addressed the issue of ecosystem health, some as it applies to estuaries. In this section I examine some of these efforts to glean from them ideas useful in our effort.

A brief literature review Ecology is considered a young science; the sub-discipline that addresses ecosystem health is in its infancy and growing rapidly. As with any young science, much of the literature concerns definitions. Here I review briefly the general tone of this literature as it relates to the San Francisco Bay-Delta estuary. Key references are in the Bibliography.

The literature on ecosystem health mostly falls into two categories: discussions of what constitutes ecosystem health and how one might measure it, and scientific articles analyzing human influences on ecosystems that result in specific instances of degradation (e.g. metal pollution). The latter class of articles does not offer much in terms of definition. Many articles in the former class suffer from excessive generality, or they offer indicators of ecosystem health that cannot be applied to this estuary, mostly because they are not pertinent to the problems faced here.

The analogy to human health is weak, as discussed above. There is no optimum state for the ecosystem, so goals must be subjective. Therefore, how can the status of the ecosystem be interpreted as either healthy or unhealthy? Several common themes run through the literature on ecosystem health or integrity; these are listed below at the beginning of each paragraph in italics.

Use of poorly defined terminology. The terminology of this branch of ecology is rather weak and poorly defined. Terms such as "balanced ecosystem" tend to be used without definition or critical appraisal. Using the terminology suggested above should prevent difficulties with semantics.

The concept of ecosystem integrity. Ecosystem "integrity" is closely related to (or indistinguishable from) that of "health". Regier (1993) listed about 40 attributes of an ecosystem with integrity, based on discussions in a conference on that topic (Woodley et al. 1993). With only one exception, these attributes could apply equally well (or poorly) to an ecosystem in any state, however degraded. For example, an ecosystem with integrity ...

- "has as its primary nexus a set of living organisms, each unique but always changing, within adapting populations of different evolving species or taxa...
- is a self-organizing dissipative system which may represent a compromise between the thermodynamic imperative of energy destruction...and the biological imperative of survival." (Regier 1993)

The sole exception is that an ecosystem with integrity is said to contain "some relatively large, longer-lived plant and animal organisms..." with various functions. Thus, despite the growing literature on this topic, this concept appears to have little to offer for developing a working definition of ecosystem health.

The concept of sustainability. Much of the literature on this topic uses terms like "self-sustaining" as an indicator of health. However, any ecosystem is self-sustaining provided its energy supply is adequate and conditions do not preclude life. What this term apparently means is that ecosystem components *desired by humans* occur in self-sustaining populations.

Presented this way, this attribute of ecosystem health is redundant to the general description of a healthy ecosystem given above. A related topic is the sustainability of human use of an ecosystem for harvest, recreation, or other purposes. The ecosystem need not sustain such uses without intervention; genetic considerations aside, using hatcheries to support a major fishery does not necessarily impair the attributes that make the ecosystem otherwise healthy.

Anthropogenic disturbance contrasted with "natural" disturbance. The literature generally distinguishes anthropogenic disturbance from the "natural" ebb and flow of events in an ecosystem. This distinction under-represents the capacity of nature for catastrophe. Natural disturbances of a severity equal to the most severe human interference have occurred in geological time if not in historical time. Anthropogenic effects differ from natural disturbance less in their severity than in their frequency and therefore capacity for cumulative effects, although some anthropogenic insults have no close parallel in nature.

"Holistic" approaches. The recent trend toward solutions of problems in ecosystems instead of populations extends into the concept of ecosystem health. The idea of examining the entire ecosystem has attractive parallels in medicine. However, it is not clear that there are emergent properties of ecosystems that can be used in such a way. Furthermore, ecologists construct ecosystems from their observed parts: for example, measures of ecosystem properties like diversity or energy flow can only be determined by detailed sampling of individual components. Interestingly, the use of the "fish-X2" relationships to support a management measure for the Bay-Delta is a rare example in of applying a remedy to many parts of an ecosystem at once. Note that in this case the mechanisms behind the relationships are not well understood, recalling the analogy to early medicine in which physiological understanding was lacking.

Goals of restoration vs. indicator variables. If the goal of restoration is to produce a "healthy" estuarine ecosystem, then the objectives of restoration actions should be to improve the status of the ecosystem in terms of indicators of "health". Therefore these indicators need to be attributes that are measurable, scientifically defensible, and interpretable. This may seem obvious, but many proposed measures of ecosystem health do not meet some or all of these criteria.

Comparison of reference and stressed systems. Most of the recommendations for measures of ecosystem health include comparisons with more-or-less pristine reference sites. This works reasonably well for the ecosystems discussed by the existing literature, which include terrestrial sites, lakes, and rivers, but only rarely estuaries. Comparison among large numbers of systems differing in relatively few ways is the basis for the EPA's Environmental Management and Assessment Program (EMAP), which has been applied to estuaries of the east and Gulf coasts (see below). It is not clear that Pacific coast estuaries can be similarly compared, given tremendous difference in size, watersheds, topography, flow, tides, and other characteristics. However, this comparative technique might be possible for tidal wetlands, for which at least functional (if not structural) comparisons might be useful (e.g. primary production).

Use of relative abundance of sensitive and tolerant species. Sensitive species can be used as indicators of stressed conditions if the identity of the species and its response to the particular stress under consideration are reasonably certain. Estuarine and marine systems, because of their open exchange with the sea, may be inappropriate systems for the application of this approach. For example, the marine polychaete *Capitella capitata* has long been considered an indicator of sewage stress, but recently it has been shown to be a complex of perhaps 10 or so species with different degrees of tolerance for organic enrichment. To use the differential response of sensitive and tolerant species as an index of stress requires either certainty about these species' relative tolerances to the relevant stress, or comparison between stressed and unstressed locations.

Parallel efforts in this estuary There are several efforts now underway in the form of other workshops and activities aimed at defining goals or ecosystem health. Important activities include:

1. The Bay Area Wetlands Ecosystem Goals Project, which will hold a meeting of its Resource Managers Group on Monday, September 25.

2. A workshop on "Creating Sustainable Landscapes in the San Francisco Bay Region" to be held on September 30 by the Institute for Ecological Health, San Francisco State University

Although the purposes of these activities and the mix of disciplines is different from those of the October 2 workshop, useful outputs of these workshops should be incorporated to the greatest extent possible.

EMAP The EPA's Environmental Management and Assessment Program (EMAP) is intended to assess the status of the nation's ecosystems. Emphasis has been on estuarine ecosystems on the Gulf and east coasts. This program is designed to examine populations of ecosystems rather than individual systems, so the overall approach is different from ours. However, the underlying goals should be similar. Material on EMAP was obtained from various Internet sites.

Identifying values and the associated questions is an important first step in the EMAP process. Values desired for ecological resources typically fall into three categories:

1. *Sustainability*: maintaining the desired uses of these resources over time.
2. *Productivity*: net accumulation of plant and animal matter, for example, food, timber, natural production.
3. *Aesthetics*: retaining the natural beauty of the landscape.

Examples of questions to be addressed by EMAP:

- What proportion of estuarine area in large estuaries, tidal rivers, and small estuaries

has fish with gross pathologies?
- What proportion of lakes are eutrophic, mesotrophic, and oligotrophic?
- What proportion of wetlands have less than the expected number and composition of native plant species?
- What proportion of forests have vegetative structure and functions to sustain forest biodiversity?
- What proportion of the surficial sediments in harbors and embayments are toxic to aquatic organisms?

Indicators for EMAP are chosen using societal values as a basis. These indicators fall into two classes: *condition* indicators, which provide a quantitative estimate of the state of a resource, and *stressor* indicators, which display the magnitude of an anthropogenic or natural stressor, provided these stressors are believed to affect ecosystem condition. For estuaries, the indicators being used are:

- Dissolved oxygen
- Quantity of marine debris
- Water clarity
- Sediments: toxicity, quality
- Benthos: condition, abundance, diversity
- Fish: condition, abundance, diversity

EMAP is based on a comparison among numerous sites, so these indicators can be used in a comparative sense. However, some of them (e.g. percent saturation of dissolved oxygen) can be used as absolute measures. The biological indicators are based on the Index of Biotic Integrity (IBI; Karr et al. 1986), which is determined from samples of the species composition of fish in lakes. Metrics included in the IBI include the numbers of species and individuals, number in several different taxonomic groups, percent in various trophic groups, percent tolerant and intolerant species, percent hybrids, and percent with disease. Use of this index requires comparison among various sites, so it is suitable only where a large number of stressed and unstressed sites are available for comparison.

Biodiversity initiatives Numerous initiatives are aimed at maintaining or otherwise addressing biodiversity. This term is not generally very clearly defined or differentiated from the more traditional term "diversity". For example, biodiversity is "...defined as the collection of genomes, species, and ecosystems occurring in a geographically defined region" (Ocean Studies Board 1995). This definition is a generalization of the traditional term, which refers to some measure of the number of species within a larger taxonomic or functional grouping, and the degree to which the species composition is dominated by one or a few species. Thus, "biodiversity" by this definition is vaguer and therefore less useful for measurement, regardless of its utility as a rallying point for reducing the global rate of extinction.

CALFED requirements CALFED (a consortium of California and Federal resource agencies) is attempting to identify the problems in the estuary and the tradeoffs that need to be made to reduce the impacts of water development. They have developed a problem statement that explicitly shifts the definition of the problems of the Bay-Delta ecosystem from variables of societal interest (i.e. abundance of species of recreational or commercial value or whose existence is in jeopardy) to their habitat, stating "...better habitat generally leads to more abundance of species." However, the indicators selected by CALFED are described as "the health and sustainability of individual species and species communities...[1]. The terms "health" and "sustainability" are not defined in the document.

Characteristics of health indicators

This section describes several characteristics that might apply to health indicators. The next section lists a variety of potential indicators and discusses their characteristics. These and other characteristics are discussed in detail by Cairns et al. (1993). The characteristics are given numerical scores between 1 and 5: a score of 1 means that the indicator is most useful from the perspective of that characteristic, and 5 means that it has severe weaknesses. Scores of 3 would not eliminate an indicator if it were useful on the basis of other considerations. Some of the characteristics have a maximum of 3.

Primary or derived Health indicators can be primary or derived, where primary indicators are monotonically related to an ecosystem property that most scientists would agree is "good" or "valuable", and derived indicators are variables that are assumed to be related to some primary indicator that itself may not be measurable or interpretable.

1. Primary:
   Abundance of an endangered or recreationally important species
3. Derived
   Quantity of certain kinds of habitat (e.g. shallow-water low-salinity)

Interpretable Some indices of "health" may be as readily interpretable as is body temperature for human health (at least in principle). Others require value judgments as to what value of the index is enough and what is too little. Still others may be completely uninterpretable, in that the direction of change going from an "unhealthy" to a "healthy" ecosystem is unclear, or knowledge of the topic is insufficient to form a basis for interpretation. The interpretation is made on the basis of relevance to ecological considerations or societal values:

1. Interpretable
   Oxygen percent saturation
3. Require value judgments
   Abundance indices of ecologically important species

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[1] CALFED Problem Definition Package, draft of 1 September 1995. Sacramento.

5. Uninterpretable
   Species diversity in open waters

Measurable or conceptual A health index can be measured directly, or (more frequently) calculated from a series of other measurements, subjectively determined, or conceptual. Conceptual indices could be determined in an experimental setting but are not generally measurable in the whole system.

1. Directly measurable or observable (no controversial assumptions needed to calculate a summary value such as an area-wide mean):
   Oxygen percent saturation
2. Calculable (assumptions must be made such as method of averaging or interpolation, or about quantities that are not measured directly)
   Abundance indices of fish
4. Subjectively determined:
   Natural beauty
5. Conceptual:
   Resilience

Quantitative vs. Qualitative Health measures could be quantitative, binary, or qualitative:

1. Quantitative:
   Diversity or species richness (perhaps more useful in marshes)
2. Binary:
   Presence or absence of toxic concentration of pollutants
3. Qualitative:
   Quality of marsh or open-water habitat

Historically based Health indicators are interpretable either by comparison between stressed and unstressed locales, or through historical trends. Indicators with a long historical record are likely to be more useful than others. This is a qualitative index, with 1 indicating the presence of long data record, 2 indicating some historical data, and 3 indicating very little or no data.

Indicators for the San Francisco Bay-Delta Estuary

Table 1 lists indicators gleaned from the literature, from discussions with colleagues, or through consideration of the meaning(s) of ecosystem health. These indicators are grouped according to the variables to be measured, and rated according to the characteristics listed above.

Relatively few of the indicators rate well on all of the characteristics listed above. Most of the indicators that might be associated with "health" in a theoretical sense (e.g. resistance to invasion) rate low on most of the characteristics; thus these are not valuable indicators of ecosystem health. Many of the indicators that are measurable and quantitative require considerable interpretation or value judgements before they can be used (e.g. abundance of recreationally important species).

Many of the indicators may be more valuable in marshes, where emphasis is on habitat (in the form of physical structure and plant life) rather than on the animals inhabiting the marsh. For example, plant species diversity may be related to the diversity of animal habitat. In open water, it is not clear that high diversity of plant life makes much difference.

No doubt there are indicators I have missed, and probably there would be disagreement over the classifications of many of those in Table 1. This forms the starting point for discussions at the October 2 workshop.

The section below briefly discusses each of these indices by groups and suggests ones that might be more or less useful as indicators.

Abundance Several groups of species are considered depending on societal interpretations of their value. Species that are threatened or endangered, or those that support a fishery, are given greater consideration than those that are environmentally sensitive or ecologically important. Only two of these indicators do not require a value judgement. The abundance of a threatened or endangered species can be interpreted (at least in principle) in terms of the numbers required to eliminate danger of extinction. The existence of a commercial fishery is evidence of sufficiency of stock size if stocks are not declining. All of these indicators might be useful to the extent that the necessary interpretations of numerical goals can be made. Abundance of sensitive species may be less desirable as an indicator because of the difficulty in defining them. For example, longfin smelt appear to be more sensitive than delta smelt to freshwater outflow, but are also in less danger of extinction, judging from the listing of delta smelt, but not longfin smelt, as threatened.

Species composition Diversity is probably not a useful indicator for open water because it is difficult to interpret, but diversity of marsh plants may be more helpful. The rate of extinction of species appears valuable based on the rankings, but is rather low and may require comparison with other ecosystems. Genetic diversity and the frequency of hybridization seem also to be difficult to interpret. The frequency of introductions or, conversely, resistance to invasion, is often cited as a measure of ecosystem health but again interpretation is problematic. Presence of undesirable species seems like a useful indicator but there may be little that can be done about it: for example, there seems to be little chance of eliminating the greatest nuisance species in the Great Lakes, the zebra mussel.

Population characteristics Several characteristics of populations have been suggested, including age and trophic structure, and morphology or behavior of individuals in populations. These share the drawback that it is unclear which direction a "healthy" population should go from the existing situation. Resilience of populations (as distinct from resilience of ecosystems) is informative about the potential effects of restoration but may not be controllable.

Energy flow "Productivity" carries sufficient baggage to have a positive connotation when it is applied to ecosystems; yet, high primary production in an estuary may be a result of eutrophication. High secondary production or biomass of consumers (of desirable species) is probably useful as an indicator except that values must be selected, and there is very little historical basis. The same is true of growth rates in populations. The production: respiration ratio has been suggested as a measure of health, but many estuaries are probably net oxidizers of carbon except where primary production is stimulated by anthropogenic nutrient inputs.

Water quality The amount of debris per unit area of bottom or marsh is a useful indicator of the aesthetic value of the ecosystem more than its function; nevertheless it is easy to measure. Percent saturation of oxygen is probably the most commonly used indicator for estuaries, but since the reduction of sewage input with the Clean Water Act, oxygen concentration is not reduced except in the Stockton Ship Channel in late summer. Water clarity is also often cited as an indicator; it is very low in the Bay-Delta estuary because of retention of fine sediments produced by hydraulic mining in the last century. There may be opportunities for control of sediments over the long run, so this is a useful index. The size distribution of organic matter appears to be related to eutrophication in lakes, but is probably not useful here. Similarly, nutrients are rarely limiting in the Bay-Delta, so their loading rates are not of much use.

Toxicity and disease Several indicators relating to the physical health of aquatic organisms or humans are useful. It would be very desirable to have fish with a low incidence of lesions, tumors, or disease, and that can safely be consumed by people. In addition, concentrations of pollutants exceeding known thresholds for toxic effects, or bioassay results indicating toxic concentrations in water or sediments, are clear indicators that ecosystem health is degraded even in the absence of observable effects on populations. The amount of toxic material being discharged is more suitable as a means of controlling inputs than as an indicator of the status of the ecosystem.

Physical habitat The definition of habitat for open-water species is not necessarily clear, in that most species are known only from sampling in a subset of available habitat. In marshes, however, restoration efforts are directed at habitat (i.e. the marsh itself) rather than the animals that inhabit it. This fundamental difference means that aspects of marsh habitat such as fragmentation, heterogeneity, and the shape and physical structure of banks should be considered outright as indicators of health. For example, a marsh with little vegetation, lots of open mudflat, and straight channels would not be considered very healthy. Similarly, vegetative cover along river or slough channels is part of the natural landscape of these areas and can be valued without regard to the use of those areas by animals.

Flow variables All of the flow-related variables listed have been used either as standards for estuarine protection or as independent variables in analyses of abundance or survival patterns of valued species. Thus, these are useful in limiting operations to protect the ecosystem, but may not themselves be measures of ecosystem health.

Other characteristics Natural beauty, though subject to interpretation, underlies much of what people take as ecosystem "health" and should be included as an indicator in spite of its subjectivity. Resilience is an important property of ecosystems, but more useful in a theoretical context than in management because it is impossible to measure or interpret in a real ecosystem. Self-sustainability, as discussed above, is a property of any ecosystem and therefore suffers from the same problems as resilience.

Recommendations

The following indicators are suggested as the most useful.

Little or no interpretation required:

Abundance of threatened or endangered species
Existence of a viable commercial fishery
Percentage of native fishes with stable (or increasing) populations
Abundance of debris
High oxygen percent saturation
Water clarity
Frequency of tumors or disease in fish
Frequency of toxic effects
Suitability of fish and invertebrates as food for humans
Quantity of marsh habitat

Interpretation or additional information required:

Abundance of other species (native estuarine-dependent fish and crustaceans)
Abundance of striped bass
Abundance of undesirable species (e.g. water hyacinth)
Production of invertebrates and fish
Amount of open-water habitat (with appropriate characteristics)
Marsh habitat heterogeneity, channel fractal dimension
Riparian cover
Natural beauty

Table 1. Potential indicators of ecosystem health grouped according to variables included, and ranked according to characteristics defined in the text

Indicator	Primary	Interp table	Measu-rable	Quanti-tative	Historic
Abundance					
Abundance of a species qualifying as threatened or endangered	1	1	2	1	1
Abundance or indices of environmentally sensitive species	1	3	2	1	1
Abundance or indices of recreationally important fish	1	3	2	1	1
Existence of a viable commercial fishery	1	1	1	2	1
Abundance or indices of ecologically important species	1	3	2	1	1
Long-term declines in abundance of species	1	3	2	1	1
Percentage of native species with stable populations	1	1	1	1	1
Species composition					
Diversity or species richness (open water)	3	5	2	1	2
Diversity or species richness (marsh)	3	3	2	1	2
Community trophic structure	3	3	2	3	2
Rate of extinction	1	1	1	1	2
Frequency of introductions	3	3	1	1	1
Resistance to invasion	3	3	5	3	1
Degree of genetic diversity within populations	3	3	1	1	3
Frequency of hybridization	3	3	1	1	3
Presence of undesirable species	1	1	1	2	1
Noxious algal blooms	1	1	1	2	1
Abundance of opportunistic species	3	3	2	1	2
Population characteristics					
Population age structure	3	3	1	1	2
Gross morphology	3	1	2	3	2
Population resilience	1	3	2	1	2
Behavior	3	3	2	3	3
Energy flow					
Primary production (open water)	3	5	2	1	2
Fish or invertebrate biomass (mass)	1	3	2	1	2
Fish or invertebrate production (mass/time)	1	3	2	1	3
Growth rates	3	3	1	1	2

Production:respiration ratio	3	3	1	1	3
Water quality					
Abundance of debris	1	1	1	1	3
Oxygen percent saturation in water or sediment	1	1	1	1	1
Water clarity	1	3	1	1	1
Size distribution of organic matter	3	5	1	1	3
Frequency or intensity of nutrient loading	3	3	2	1	2
Toxicity and disease					
Frequency of lesions, tumors, or disease in aquatic organisms	1	3	1	1	2
Suitability of fish for consumption	1	1	1	1	2
Concentrations of pollutants in reference to thresholds	1	1	2	1	2
Frequency or intensity of toxicant discharge	3	3	2	1	2
Results of toxicity bioassays indicative of pollutant effects	1	1	2	1	2
Physical habitat					
Quantity of certain kinds of habitat	1	3	2	1	2
Quality of marsh or open-water habitat	1	1	2	3	2
Instream/riparian cover	1	3	2	1	1
Habitat fragmentation or linkage	3	3	2	1	2
Habitat heterogeneity	3	3	1	1	2
Channel sinuosity	3	3	1	1	1
Fractal dimension of banks	3	3	1	1	2
Physical stability of substrate and banks	3	3	1	3	2
Flow variables					
X2	3	3	2	1	1
Net delta outflow	3	3	2	1	1
Variability of freshwater flow	3	3	1	1	1
Percent freshwater flow diverted	3	3	2	1	1
Diversion flow or frequency	3	3	2	1	1
Other characteristics					
Natural beauty	1	3	4	3	1
Resilience	3	5	5	3	3

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A Practical View of Ecosystem Health And the Role of Science

Joshua N. Collins, Ph.D

23 September 1995

The concept of Ecosystem health is problematic for me as a scientist. Both parts of the concept, ecosystems and health, are neither arbitrary nor obvious. While they are certainly more than convenient constructs, they cannot be exactly defined or quantified. Neither defines the other. And putting them together seems to more than double the amount of scientific uncertainty. Why?

Part of the explanation is that the concept of ecosystem health evokes a mixture of theories, models, and practices from two very different kinds of science, theoretical ecology and medicine.

Consider medical science. It is steeped in empirical study of the human organism, depends upon practical applications, and has abundant relationships with human value systems. Medical science helps shape our personal expectations, relative to our infirmities. Human health seems to be a notion or gestalt informed by science but relying also upon careful judgement. How do we know we are heathy? My physician scans a clip-board full of scientific measurements that more or less relate to each other and to me, puts a finger to her forehead, and says, "you can go home tomorrow." Even as we age, it seems our health can be restored.

Now consider ecological science. It is steeped in theory about complex interactions within and among species and their habitats, and is relatively independent of human value systems. As the body of ecological theory has been advanced, the ecosystem concept has moved farther from the practical arena of management. While managers might appreciate the ecosystem concept, they can find it difficult to use as a practical template for managing our natural resources. How does a manager budget for travel around a complex adaptive pulsed system that seems to defy geographic coordinates? The forest supervisor retreats from a scientific presentation on forest ecology and mutters to me over a styrene cup of cold coffee, "I want to manage the forest ecosystem, but I can't figure out where it is and where it isn't, or how much it will cost."

Part of the explanation is also that the emerging concept of ecosystem health has not been designed by scientists, rather it is being forced by public pressure to reverse a perceived chronic decline in natural resource availability. Simply stated, the public, and therefore also the government, want to use science to restore, and perhaps increase, some functions of ecosystems.

The internal conflict within the concept of ecological health is often evident as a semantic debate about ecological restoration. The concerned public who wants to regain ecological functions that have apparently been lost are confronted by scientists who understand that time goes in one direction, and ecosystems can't go backward.

This situation is sociological, in part because our open society does not permit natural resource managers to escape public sentiment. It suggests that neither the problem nor the solution is entirely scientific. Having accepted that, I propose the following definitions to bring the concepts of ecosystem and health together in a practical, useful way.

> **Ecosystem Health:** *the state or trend of our ecosystem relative to our shared goals. The sum of ecosystem goals represents ecological wellness, or ecosystem good health.*

Based upon these simple definitions, the central questions about ecosystem health and the role of science become self-evident. The central questions are: *what is the practical ecosystem, and what do we want it to do?* The role of science is not necessarily to answer these questions, but to advance public debate toward the answers.

Why shared goals? Because ecosystem health care is public business. It requires consensus, coordination, and cooperation that cannot be achieved without a common vision or sense of purpose. The goals must be shared by the agencies of government that have major regulatory or operational interests in ecosystem health.

Who sets the goals? People who understand the problem and can anticipate the consequences if the problem isn't solved. Scientific thinking should comprise the core of any effort to develop ecosystem goals. For example, scientists should provide information about ecological resources, past and present, including perhaps which ones are ecologically more important, and scientists should try to explain ecological change. Furthermore, scientists can and should recommend the boundaries of what is achievable, in the context of natural and human controls on ecological functions. But scientists cannot and should not make final judgements about how much of what kinds of ecological functions is enough. Science can describe process and function, but it cannot define good or bad, right or wrong. Such judgements are a matter of policy.

What are the goals? They are quantitative statements of the desired level of ecosystem performance or affordable risk. They can be compliance standards, historical performance levels, or levels of performance that are unprecedented but patently desirable.

After goals are set, then a scientific process of observation and experimentation is required to help set a course of action to achieve the goals, measure progress toward the goals, minimize uncertainty, assess the risks that the goals will not be achieved, and help revise the goals for new understanding. Indicators of performance and risk must minimize the chance of falsely inferring health or illness. The need to prevent the false diagnosis of good health is especially important because it helps protect the ecosystem, and therefore us, from wrong programs and policies. More rigor is required to monitor and assess the ecosystem than to establish ecosystem goals.

The emerging model for ecological health care is elegant: establish scientifically valid ecosystem goals in the context of public expectations and policy; turn government programs into tools to achieve the goals; and monitor progress. According to this model, ecosystem health is the state or trend of the ecosystem relative to our shared goals. Everything that is done to achieve the goals is therefore ecological restoration, meaning the restoration of ecosystem good health.

Appendix 2

Fluvial Geomorphic Process and Ecological Restoration: A Critical Review of the CALFED Ecosystem Restoration Program Plan.

Prepared by William J. Trush Ph.D. for NHI and other Environmental Groups with Funds from the John Krautkraemer Memorial Fund

A CRITICAL REVIEW OF THE CALFED ECOSYSTEM RESTORATION PROGRAM PLAN

Prepared for:

The Bay Institute
Environmental Defense Fund
Natural Heritage Institute
Nature Conservancy

Prepared by:

William J. Trush, Ph.D.
McBain and Trush
P.O. Box 663
Arcata, CA 95521

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The intent of the ERPP is to achieve ecosystem health.
Vol. I, p. 5

INTRODUCTION

The Ecosystem Restoration Program Plan (ERPP) adopted five primary physical elements for achieving river ecosystem health. An ecosystem element (Vol. I, p.4) is: "... a basic component or function which, when combined with other ecosystem elements, make up an ecosystem. An ecosystem element can be categorized as a process, habitat, species, species community, or stressor." All other elements are directly or indirectly dependent on these first five physical elements and their implementation objectives, defined as (Vol. I, p.5): "... the most specific and detailed description of what the ERPP strives to maintain or achieve for an ecosystem element."

- **Central Valley Streamflows:**
"... to restore basic hydraulic conditions to reactivate and maintain ecological processes that create and sustain habitat required for healthy fish, wildlife, and plant populations." Vol. I, p.26

- **Natural Sediment Supply:**

"... [to] provide sufficient quantities to reactivate and maintain ecological processes that create and sustain habitat required for healthy fish, wildlife, and plant populations." Vol. I, p.32

- **Stream Meander Corridors:**

"... to maintain, improve, or restore natural stream meander processes to allow the natural recruitment of sediments, create habitats, and promote riparian succession." Vol. I, p.36

- **Natural Floodplains and Flood Processes:**

"... to modify channel and basin configurations in order to improve floodplain function along Central Valley rivers and the Bay-Delta." Vol. I, p.43

- **Central Valley Stream Temperatures:**

"... to maintain, improve, and restore water temperature regimes in order to meet life history needs of aquatic organisms." Vol. I, p.49

Achieving river ecosystem health, no matter how ecosystem health may be defined, hinges on these five elements. The purpose of this review is to examine whether the physical ecosystem elements are being adequately stated, evaluated, quantified, and monitored in the ERPP Review Draft, June 13, 1997.

RECOVERING ALLUVIAL RIVER FUNCTIONS

These physically based implementation objectives are highly inter-dependent processes that can create a naturally functioning alluvial river. By definition, alluvial rivers (as opposed to bedrock dominated rivers) continually reshape their bed and banks in response to fluctuating flows and sediment supply. Today, most reaches of Central Valley rivers are no longer alluvial. Instead, human perturbation dominates channel processes. Levees, aggregate mining, urbanization, and riparian encroachment have encased most river miles in a straightjacket preventing natural alluvial function. Dams and flow diversions have greatly reduced annual flow variation and sediment supply. Combined, these changes have degraded habitat for native species. Incision, channel straightening, and floodplain isolation have increased velocities and decreased habitat complexity. Recovery of river ecosystem integrity can be accomplished by recovering alluvial processes and morphology, but the Plan does not convey this bigger perspective or reach for the opportunity to establish a broad, but testable, hypothesis.

The fundamental building block of alluvial river channel morphology is the alternate bar sequence (Figure 1). Without frequent scour and replacement, dynamic alternate bars cannot exist. For most Central Valley mainstems, this alternate bar morphology has been lost, or "fossilized" with riparian vegetation that encroached onto the bar surfaces, preventing bar mobilization. Formation and maintenance of alternate bar sequences indicate many fundamental alluvial processes, such as channelbed surface mobilization and bedload continuity, are functioning. Also called alternating point bars or riffle/pool/run sequences, these depositional features are easily identifiable in the field and distinguishable on aerial photographs. However, alternate bars in pre-dam aerial photographs on Central Valley rivers are much more complex than idealized bar sequences shown in Figure 1. Depending on channel slope, bed particle size distribution, and channel forming discharge, the morphology of these alternate bars varies from low sinuosity, alternate bars in gravel bed reaches nearer the foothills, to highly tortuous meanders in lower gradient, sand-bedded reaches near the delta. These alternate bars provided more complex habitats than illustrated in Figure 1, including side-channels, multiple channels, and abandoned channels (oxbows).

Dynamic alternate bar sequences provide the complex channel morphology utilized as high quality habitat by aquatic vertebrates, macrobenthic invertebrates, and riparian plant species (Figures 1 and 2). In most Central Valley rivers with large storage reservoirs, the reduced flow variability and magnitude, combined with riparian encroachment and bar fossilization, allow alternate bars to become fossilized. Moderate, but infrequent, high flow releases eventually remove or coarsen remaining alluvial deposits downstream of a reservoir. The channel assumes a rectangular cross section with mature riparian vegetation up to the low water surface.

Dynamic alluvial bars provide complex habitat for most species over broad ranges of flow. An alternate bar provides habitat for all life stages of salmonids: spawning habitat in pool tails and juvenile rearing habitat on point bar faces, side channels, and alcoves, and undercut banks. Additionally, these habitats are available over a wide range of flows. In contrast, the riparian encroached, simplified rectangular channel of most Central Valley rivers provide poorer habitat over narrow flow ranges. The rectangular channel may not impair adult spawning, but may greatly limit juvenile rearing habitat.

The Plan does not convey a bigger perspective or hypothesis, that river ecosystem health can be attained by making Central Valley rivers alluvial again. The emphasis of the ecosystem elements, given their broad definition in the Plan, must be on process. Alluvial rivers are not

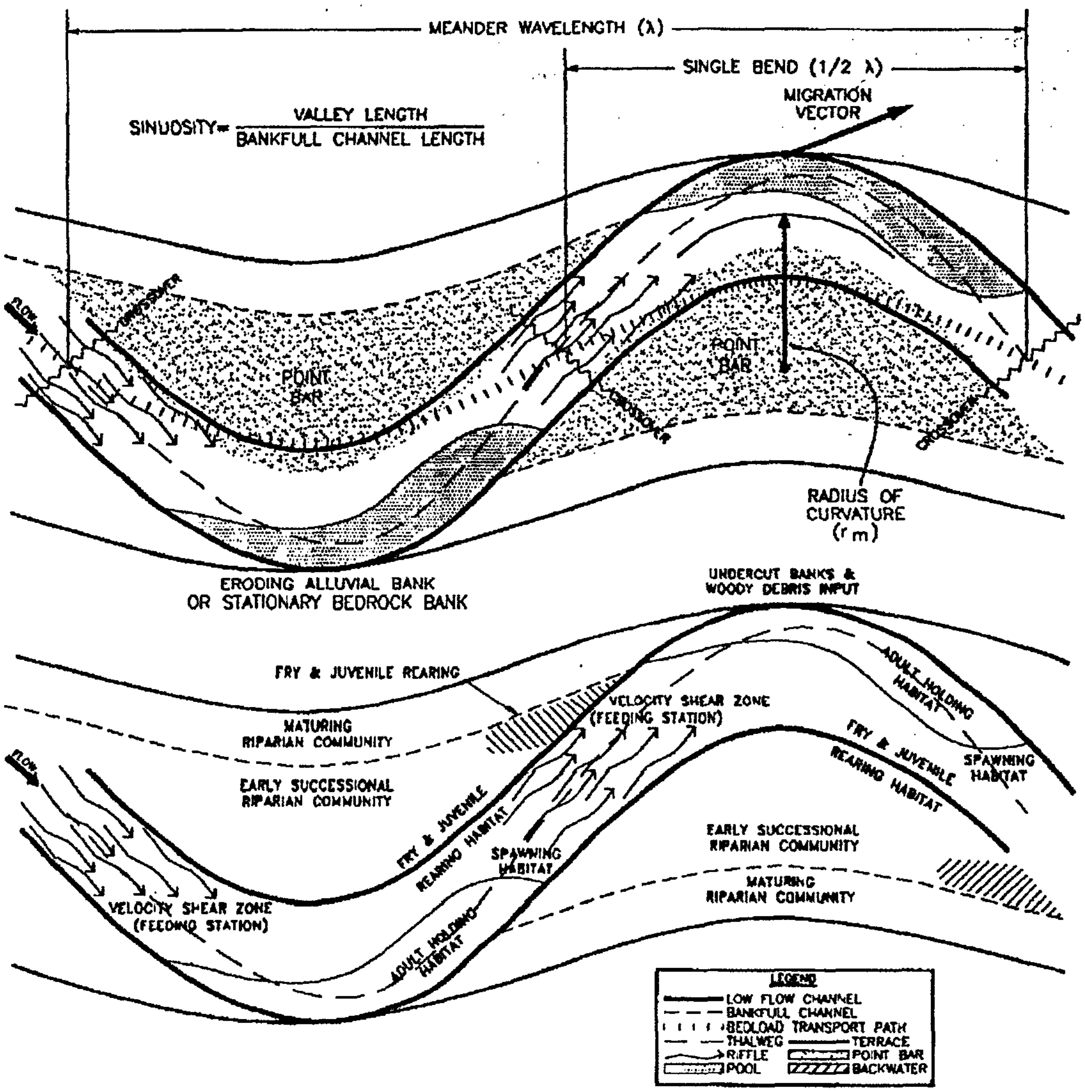

Figure 1. An idealized alternate bar sequence in an alluvial river and associated habitat.

simply willed by human intervention, but rather must be allowed to create themselves. This will require providing sufficient space and ingredients (e.g., sufficient bedload supply), as well as flows needed to achieve critical fluvial and riparian processes. Important processes include: initial mobilization of the channelbed surface, bedload transport, floodplain deposition, bar inundation to prevent woody riparian germination, alternate bar mobilization, channel avulsion, and bank erosion.

The morphology and dynamics of contemporary alluvial rivers can be used to identify important processes as ecosystem elements in future restoration. This effectively circumvents the common problem of having insufficient historical background data on channel morphology or fish habitat. Data on most alluvial channel processes are generally nonexistent; no one was

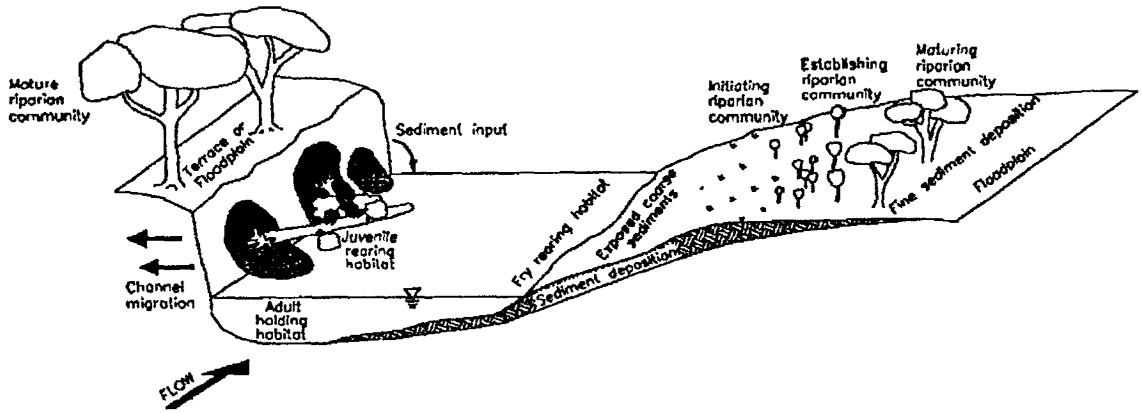

Figure 2. Habitat across a point bar.

monitoring channelbed mobility or bedload routing prior to regulation. Historical analyses of aerial photographs provide necessary estimates of meander migration rates, extent of floodplain development, and alternate bar morphology. However, quantitative relationships between flow/sediment and morphology cannot be inferred from these photographs. Implementation objectives with quantifiable goals will require analyses of historical conditions, application of accepted concepts for contemporary alluvial morphology and processes, and monitoring reference channels.

INADEQUATE HYDROLOGIC PERSPECTIVE

Although flow variability creates these processes, the Plan never clearly explains how ecological processes depend on the annual hydrograph. The Plan assesses the Central Valley streamflows implementation objective (Vol. I. p. 21) in, "The ability to restore natural streamflows is limited. Constraints include the extreme variability in flows (hydrologic variations), water management practices, upper watershed conditions, and previous water supply allocation (water rights and contracts). Emulating natural runoff patterns will provide the greatest potential for improving the ecological functions that are dependent on streamflow." What were, and are, these runoff patterns? How did (do) these patterns change with water year type? The reader is provided with only mean monthly unregulated and regulated discharges, perhaps the least appropriate way to account for runoff patterns. Four primary flow characteristics of annual hydrographs, duration-magnitude-frequency-timing, each serve important ecological functions; monthly average flows camouflage all four.

For example, the Plan states (Vol. II, p. 329), "Recommended flow events for the Mokelumne and Calaveras rivers respond to the need to restore late winter and spring streamflows, at least for a short time, to levels that are similar to natural levels." The Mokelumne River Target for Wet years is 2,000 cfs to 3,000 cfs with an unspecified duration; for Normal years the Target is 1,000 cfs to 2,000 cfs. The Normal Target is considerably below the mean monthly flow of 2,500 cfs presented on p.316 at Pardee. Unfortunately mean monthly flows bear no resemblance to the actual annual peak discharges representing "natural levels." A quick survey of peak daily average discharges (cfs) prior to regulation below Comanche Dam (USGS gaging station 11-3235) for water years 1905 to 1925 (before Pardee Reservoir in 1929, Salt Springs Reservoir in 1931, and Comanche Reservoir in 1964) shows: 4940, 9000, 23000, 3020, 12600, 7200, 16700, 4920, 3840, 11100, 7750, 8040, 7550, 6940, 7060, 5500, 7350, 7970, 5430, 1770, 9700 cfs (Jorgensen et al. 1971, *California Streamflow Characteristics*, USGS Open File Report). In only 1 of 21 unregulated water years (1924) was the peak daily average discharge less than 2000 cfs. While a more sophisticated analysis could be offered, the overall conclusion would remain: mean monthly flow analyses are not appropriate for an ecosystem-based restoration strategy (see discussion of physical thresholds below).

Hydrograph components represent different portions of the annual hydrograph. Common hydrograph components are summer and winter baseflows, winter storms, peak spring snowmelt, and snowmelt recession into the summer (Figure 3). Each component had different functions in the unregulated river ecosystem, and was influenced by whether the watershed was rainfall or snowmelt dominated (Figure 3). Pre-regulated annual hydrographs should be compared to post-regulated hydrographs to identify differences in hydrograph components and differences in physical and riparian processes. This cannot be analyzed by classic statistical hydrologic methods of daily average flow duration curves or annual maximum flood frequency curves (and certainly not monthly average discharge). Instead, each hydrograph component should be analyzed separately (within water year classes) for differences in magnitude, duration, frequency, and timing.

The water year classification system in the Plan does not consider Extremely Wet years, but does consider Extremely Dry years. The very wettest years produce annual hydrographs significantly different than water years considered "wet", with major flood peaks often critical to maintaining spatial diversity in the channel, scouring riparian vegetation, increasing sediment

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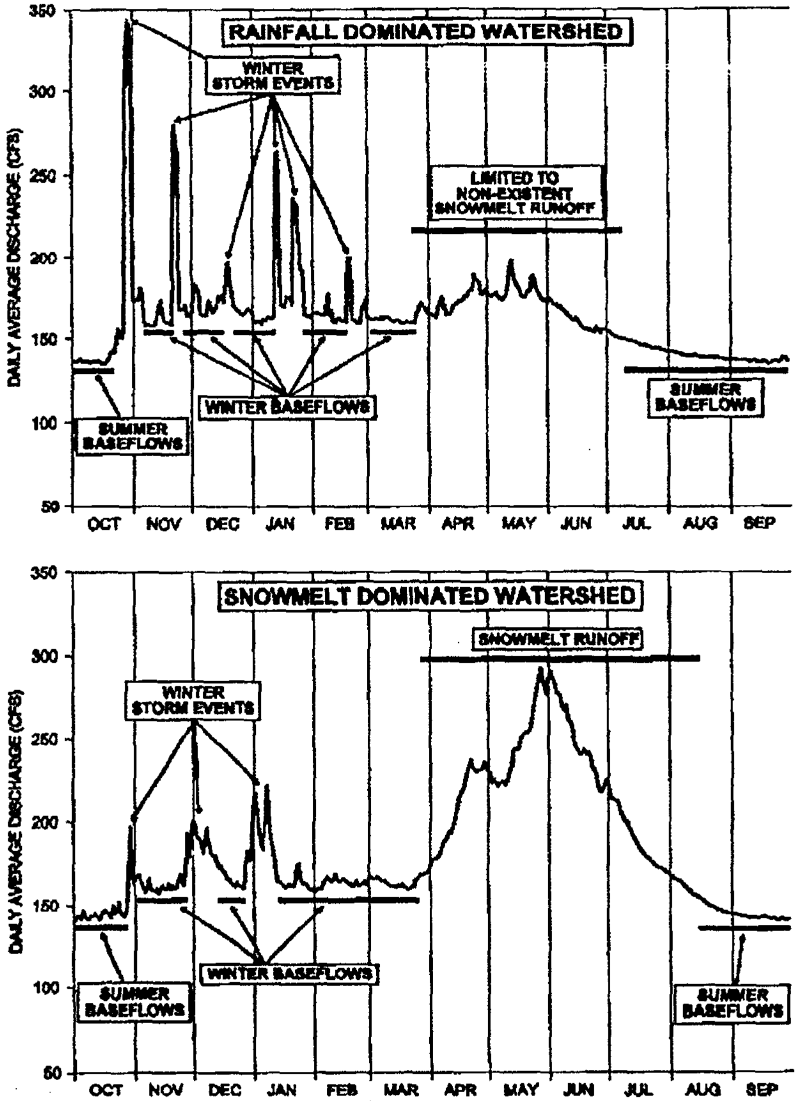

Figure 3. Hydrograph components for typical snowmelt and rainfall dominated watersheds.

supply, and routing bedload. Currently dams are operated to prevent these events except during uncontrolled flooding. An Extremely Wet water year classification would recognize these important ecological roles and provide more management flexibility to water agencies responsible for flood protection and levee design.

UNREALISTIC EXPECTATIONS

Implementation objectives for the five physical elements have critical roles in restoring alluvial

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function and river ecosystem health. A reader unfamiliar with Central Valley river dynamics is provided no insight as to whether the targets in Volume II are sufficient/realistic for accomplishing each implementation objective because no justifications are provided. Why are 1,200 to 2,500 cubic yards of gravel introduction recommended annually below Comanche Dam (Vol. II, p. 29)? Why not 4,000 cubic yards? Does this gravel volume equal the transport capacity of proposed spring releases (p.327)? How will 2,500 cubic yards of annually introduced gravels "maintain quality spawning areas and replace gravel that is transported downstream"? If gravel deposits were depleted downstream of the dam, many years of gravel introduction would be required to replenish depleted sediment storage in the mainstem channel. Only then would gravel introduction at a constant annual rate "replace gravel that is transported downstream." Should gravel introduction, at first, be accelerated to satisfy sediment storage in depleted mainstem reaches?

For a reader familiar with Central Valley river dynamics, the quantified targets are mostly unfounded. For example, a vision statement for the East San Joaquin Basin Ecological Zone asserts (Vol. II, p. 376), "Restoring a diverse, self-sustaining riparian and stream channel corridor will be an essential element in the ecosystem restoration plan." The Plan describes the function of high flows as (p.386), "The spring flow will also mobilize, clean, and transport spawning gravels; create point bars and other instream habitat types; and contribute to a natural channel meandering pattern and riparian scrub and woodland habitat development and maintenance." But the recommended high flows in the Targets (pp. 384 to 387) are inadequate to initiate critical fluvial geomorphic processes required to restore a self-sustaining stream channel. Proposed spring releases (in Wet water years) for the Stanislaus River cannot mobilize the surface layer of the channelbed. Yet the Plan attributes many physical processes to these spring releases that will require flows considerably higher than is needed to simply mobilize the channelbed surface. These CDFG recommended flows were based on salmonid life history requirements, and have nothing to do with channelbed dynamics and a river ecosystem perspective. How did the plan's authors determine these flows could realistically accomplish the stated implementation objectives?

The Natural Sediment supply implementation objective has unrealistic expectations. The reworking of floodplain and terrace deposits is important as a sediment source, but cannot be considered capable of restoring natural sediment supply on rivers that are now dammed. Given that the high flows recommended in Volume II are insufficient to initiate and sustain meandering, river corridor widths are never specified, and proposed levee setbacks probably will extend only a few hundred feet (and probably less, the Plan doesn't specify), where will bedload supply come from? Few tributaries enter the mainstems once leaving the mountains. Availability of mine tailings for future introduction back into the mainstems should be an important implementation objective that is not addressed in the Plan. These mine-tailing areas also provide excellent sites for floodplain reconstruction on a scale capable of supporting riparian forests (rather than strands of trees in levee setbacks).

Natural sediment supply needs more quantification. Is natural supply desired? With regulated flows, peak events are reduced (in magnitude, duration, and frequency) and therefore have much less bedload transport capacity. To maintain a favorable sediment budget, bedload transport capacity should be kept in balance with bedload supply. This is never explored in the Plan, yet should form the framework for ascertaining whether sufficient bedload supply can be provided to maintain critical fluvial processes, e.g., maintaining an alternate bar morphology.

The Plan also states (Vol. I, p.39) that: "Floodplains capture and store sediment, build soil, and reduce the need for dredging channels downstream and in the Delta." If the Plan is striving for a dynamic equilibrium, then reduction of sedimentation downstream is an unrealistic expectation. Though sediment may be deposited on some surfaces, other surfaces will be eroded away, creating no net gain in sediment storage. Some net sediment retention should occur prior to establishing an equilibrium, but this would probably be impossible to substantiate as a measurable benefit to the Delta.

PHYSICAL THRESHOLDS ARE NOT CONSIDERED

Some implementation objectives have physical thresholds dependent on flows that cannot be manipulated. Mobilizing the surface layer of the channelbed requires a certain minimum flow. No arbitration can make the channelbed mobilize with a lower flow magnitude (perhaps if sediment supply is increased, channelbed particle size may be reduced, thereby lowering the required flow magnitude). Overbank deposition, alternate bar scour, and inundation are all floodplain processes with flow thresholds. Spring releases only capable of occasionally mobilizing spawning gravel deposits (the popular "flushing flows") do not have the capability to develop a new meander sequence, prevent riparian encroachment, scour pools, or even transport gravel from one riffle crest to the next separated by a deep pool (bedload transport continuity).

Implementation objectives that are thresholds must be identified and quantified because these can become limiting factors for achieving ecosystem health. Three critical thresholds are: (1) frequent incipient motion of the channelbed surface, (2) less frequent mobilization of alluvial features such as alternate bar sequences, and (3) maintenance of bedload transport continuity (especially for Central Valley rivers with past gravel extraction pits in the active channel.). All three can be relatively easily measured and monitored. Their frequency and duration may be altered (from what occurred prior to flow/sediment regulation) without significant harm to the ecological health goal (i.e., *hypotheses for adaptive management monitoring*), but the flow magnitude cannot be lowered.

Thresholds may exist for other flow characteristics besides magnitude, such as duration, frequency, and timing. For example, to encourage riparian vegetation recovery on floodplains and discourage riparian encroachment on bars within the active channel, the timing and frequency of flows can be a critical factor. A spatial threshold would be a minimum river corridor width to allow channel migration. These spatial and flow-related thresholds are not addressed by the Plan's targets or proposed monitoring strategies.

MOST TARGETS HAVE NO QUANTITATIVE GOALS

A Target is defined and qualified by (Vol. I, p. 5): "... is a qualitative or quantitative statement of an implementation objective" and " Targets are to be set based upon realistic expectations, must be balanced against other resource needs and must be reasonable, affordable, cost effective, and practicably achievable." Again, the scope of the Plan is huge. No one can expect detailed Target quantification, e.g., what should be the river corridor width for a certain segment of river channel. But in some instances quantification is provided, but with no clue as to its origin (e.g., targeted riparian acreage for certain rivers in Vol. I).

Many Targets are not quantified, though only a quantitative evaluation, even a very general one, will provide the reader minimum insight as to whether this Plan has a chance of achieving its intent of river ecosystem restoration. Here are a few examples:

- What flows would be necessary for inundating floodplains?
- What would be the new wavelength and amplitude of meandering channels?
- How wide a migration corridor will be needed?
- How many acres of riparian habitat are needed to restore riparian functions?

If a dam controls over half a watershed's drainage area and an even greater percentage of downstream sediment supply, what should bankfull discharge be? What should incipient floodplain inundation be? Should the magnitude of the unregulated bankfull flood be recommended? Wouldn't the bedload transport capacity of this flood exceed present-day sediment supply? What is the target for determining how much floodplain is enough? Should a few surfaces be re-shaped in levee set back areas to flood with an annual frequency using the present-day high flow releases (as the Plan infers)? If so, would these be legitimate floodplains?

Most unsettling for a reviewer has been the Plan's lack of explaining how these targets were quantified, or can be quantified. For example, Target 1 (Vol. II, p.388) states: "Preserve and expand the stream meander belts in the Stanislaus, Tuolumne, and Merced rivers by adding a cumulative total of 1,000 acres of riparian lands in the meander zones." Show the reader, perhaps as a flowchart, how 1,000 acres of riparian lands were determined sufficient for restoring river meander belts.

UNCERTAIN FEEDBACK FROM ADAPTIVE MANAGEMENT MONITORING

The proposed adaptive management monitoring protocols and indicators have the following problems:

1) The proposed monitoring in Volume III needs to be hypothesis driven. The monitoring component does not propose to evaluate whether the channels are becoming more alluvial (or perhaps as important, whether specific channels can be expected to become more alluvial). Mostly habitat improvements are proposed for monitoring (e.g., more spawning gravel). There is no overall quantifiable goal for channel restoration.

2) Most of the proposed monitoring is incapable of relating morphological change, or changing processes, with specific characteristics of the flow regime. Very few proposed indicators provide specific reference to flow characteristics of hydrograph components. We want to measure desired processes as a function of flow, otherwise how can flows be adjusted to improve performance of our desired processes. This monitoring plan will be incapable of evaluating present-day flow regimes and/or recommending specific flow changes in the future.

3) The monitoring is not directed at determining what successful restoration should be, only documenting indicator changes with time. No quantitative vision is being refined and/or offered. In summary, there is little that will be adaptive in this proposed adaptive management monitoring plan.

Among the five primary physical ecosystem elements to be monitored (streamflow, natural sediment supply, meander formation, floodplain processes, temperature), only the following proposed indicators are adaptive (can be related to specific flow characteristics): the frequency and duration of floodplain inundation (p. 53) and reduced incidence of flooding at given river flows (p. 53). Another, Central Valley temperature (p. 54). could be related to the duration, magnitude, and seasonal timing of flow releases.

The others are not. The presence, distribution, and quality of pool/riffle/run sequences (the dependent variable) can be plotted as a function of time, but not of a specific flow characteristic (the independent variable)(Figure 4). The same can be concluded for meander lengths, channel sinuosity (essentially the same as meander lengths), riparian seral stage proportions, and spawning gravel abundance. If these indicators were monitored 20 years, the trends would be of interest but would represent the cumulative effect of 20 annual flow regimes. There would be no way of evaluating the effectiveness, or lack thereof, of specific flow release characteristics, stream corridor width, or gravel volume introduction rates. What aspects of the annual hydrographs in Figure 4 are responsible for changes in channel width?

River process monitoring can reduce the response time between management recommendations. If a recommendation does not work, why wait many years for time trend monitoring to indicate so? If channel width maintenance on an alluvial river was desired,

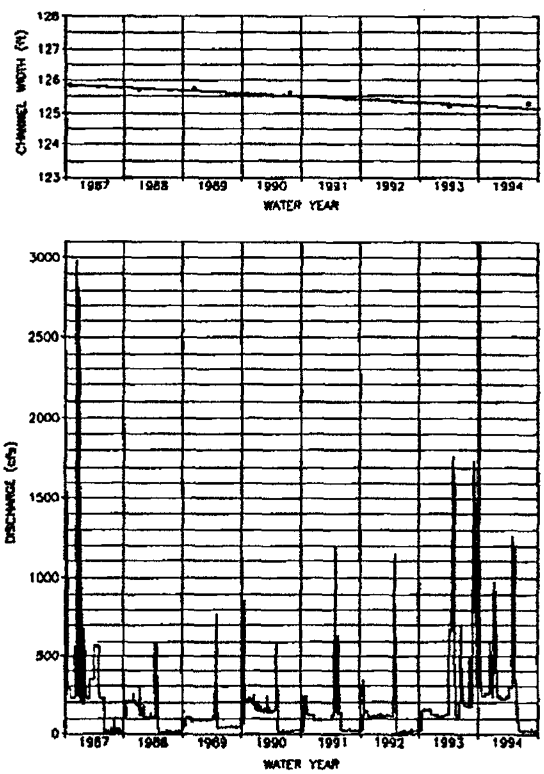

Figure 4. Hypothetical trend in channel width and annual hydrographs during eight water years.

comparing migration rate on outer channel banks with floodplain construction rate on inner banks, both as functions of flow regime, would allow peak flow recommendations in a few years rather than waiting for many using time-trends. Using Figure 5 as an example, peak discharges below 3,000 cfs would widen the channel whereas flows above 3,000 cfs would decrease channel width (overbank flows beginning at approximately 400 cfs).

Annual flow recommendations based on water year class would combine a range of flows, from frequent "widening" flows below 3,000 cfs to less common "narrowing" flow peaks above 3,000 cfs. Creating Figure 5 would require careful monitoring of bank retreat and advancement during individual floods, as well as estimating water surface slope and vertical velocity profiles if a model was desired. The work of Dr. Eric Larsen at U. C. Davis could be instrumental in developing an appropriate monitoring protocol.

PROCESSES CAN BE RESTORATION GOALS

Most indicators are response variables, gauging the results of interacting physical and riparian

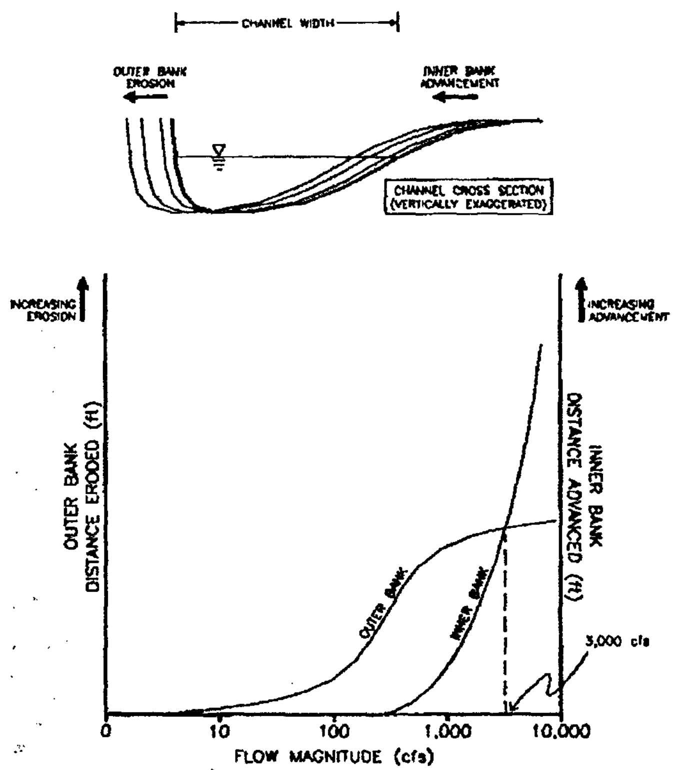

Figure 5. One theoretical relationship between bank erosion and bank advancement as a function of flood magnitude.

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processes. These may be important at the policy-level for demonstrating restoration program success (especially given the economic and social importance of restoring anadromous salmonid habitat), but they are inadequate for practicing adaptive management. Indicator variables that relate back to a specific management action, have an anticipated response, and are based on a solid rationale are almost entirely missing for the five elements, except as noted above.

The following physical processes are critical to developing and sustaining an alluvial river channel:

- Frequent mobilization of the channelbed surface (every 2 of 3 years)
- Periodic scour of alternate bars several surface layers deep (every 3 to 5 years)
- Occasional mobilization of bars (every 10 to 20 years)
- Bedload transport continuity
- Balanced coarse and fine sediment budgets

Physical processes can be measured in the field and quantitatively related back to recommended flow and sediment management practices. These provide timely adaptive management through clear hypothesis testing and can be modeled to predict future morphological trends and forecast a restoration timeline. Rather than selecting response indicators as restoration goals (targets), these processes can be the goals for recovering alluvial channel function and recovering ecosystem health.

An understanding of these processes will help predict primary responses, i.e., desired effects of restoration. These include diverse riparian communities, significant meander migration, floodplain formation, changes in meander wavelength and amplitude induced by new flow and sediment regimes, and natural groundwater dynamics. Many have been considered in the Plan, but the detail is lacking.

SUMMARY

The five proposed physically based ecosystem Elements in the Ecosystem Restoration Program Plan will be critical for restoring river ecosystem health. Their inclusion to a restoration plan represents a significant improvement over past plans that have focused on single species management. However the Plan needs revision, if these Elements and their respective Implementation Objectives and Targets are to be achieved. The following were noted and recommended:

1) An overall goal, and working hypothesis, for restoring river ecosystem health is having self-maintaining alluvial rivers. This goal uni fies the five ecosystem elements and allows the formulation of specific, quantifiable goals and monitoring strategies even if historical data are limited.

2) The Plan does not incorporate annual flow variation into the Target recommendations. Although recommendations vary by water year class, only mean monthly flows are evaluated. ERPP should analyze other hydrograph components such as winter baseflows, spring snowmelt peaks, winter flood peaks, and snowmelt recession. This analysis is essential for establishing the relationship of hydrologic variation with river and riparian processes.

3) The ERPP should include an Extremely Wet water year classification to accommodate the ecological roles of infrequent large floods.

4) Flow-related physical thresholds are not recognized as potential limiting factors in the restoration plan. Unrealistic expectations regarding the role of flows initiating critical fluvial processes were common among quantified Targets. Flow targets should be based on minima necessary to activate critical hydraulic processes such as mobilization of the channelbed surface, bedload transport, floodplain deposition, bar inundation to prevent woody riparian encroachment, alternate bar formation and maintenance, channel avulsions, and channelbank migration.

5) No quantitative reasoning is presented for recommended Targets. Due to the Plan's extensive scope, a quantitative decision tree or flowchart would be difficult for all targets, but selected examples for several key elements are feasible and necessary. This would require the authors to present their quantitative interpretation of river ecosystem health, something conspicuously missing from the Plan.

6) An unacceptable flaw in the monitoring plan is the overall sampling strategy of collecting and interpreting most monitoring data as a function of time rather than flow or another physical variable (such as corridor width). This prevents timely feedback necessary to practice adaptive management and to improve the quantification of Targets for Implementation Objectives.

7) Make physical processes, as well as response indicators that are physically based, the basis for evaluating project success and practicing adaptive management.

Appendix 3

Notes on Adaptive Management: A Draft Paper Prepared by John G. Williams Ph.D. for the Ag-Urban Ecosystem Restoration Team.

NOTES ON ADAPTIVE MANAGEMENT

John G. Williams
jgwill@dcn.davis.ca.us

Draft Prepared for the Ag-Urban Ecosystem Restoration Team

"What's in a name. That which we call a rose
by any other name would smell as sweet"

"Adaptive management" has entered California hydrospeak. Whatever it means, it sounds good. After all, who would want to practice nonadaptive or maladaptive management? Unfortunately, the meaning of the term has been diluted in proportion to its popularity, so some have questioned whether any useful meaning remains, and a term that means different things to different people can only lead to misunderstandings. We argue that the term does have an important meaning, so either that meaning must be resurrected for adaptive management, or a new term must be devised.

If "adaptive management" means anything, then it must distinguish one kind of management from other kinds. We propose that adaptive management has two essential attributes: (1) it is a response to uncertainty about the system being managed, and (2) actions are designed, at least in part, to provide new information about the system. Other attributes can and should vary according to the system being managed and its political context.

This definition distinguishes adaptive management from "real-time" management, or management with a flexible, trial and error approach, although many people use the term with just those meanings. It also distinguishes a narrow meaning of adaptive management from an elaboration of the concept known as "Adaptive Environmental Assessment and Management," or AEAM, that involves a particular approach to implementing adaptive management. AEAM seems appropriate for the Bay/Delta, so it is tempting simply to call it adaptive management, and indeed the two terms are sometimes used interchangeably in the literature (e.g. Holling 1978; Walters 1986, 1997). However, we think the importance of maintaining a focus on uncertainty justifies distinguishing the two and introducing yet another term. The distinction is well explained in an excellent article by Volkman and McConnaha (1993), describing the application of adaptive management to the Columbia River:

> In 1984, Professor Kai Lee, then a member of the [Pacific Power Planning] Council, suggested that the [Columbia River salmon] problem lent itself to the idea of adaptive management: the notion that fish and wildlife measures should be seen as a series of experiments, with formal experimental designs to help answer critical questions about the interactions of humans and the ecosystem. By structuring salmon recovery measures as experiments, the Council could acknowledge scientific uncertainty, act on reasonable hypotheses, and learn from the results.

> Adaptive management can be a radical doctrine. With traditional management, action is based on existing knowledge and established modes of operation. The course is altered if it appears unproductive, but information is not sought aggressively or strategically, and when it is gathered, it is drawn from a relatively narrow range of conditions. In contrast, adaptive management implies an active search for key hypotheses and a commitment to test them. In fisheries, adaptive management has been developed and applied largely within the harvest arena. Populations might be deliberately over- or under-harvested, for example, to examine the population's response to harvest pressures.
>
> In principle, the need to learn more about the effects of other human activities on salmon recovery seemed no less compelling. It was apparent, however, that the Council could not apply an unadorned form of adaptive management even to the most critical uncertainties involved in salmon recovery. Applying the theory on a smaller scale, to harvest problems, is difficult; but it is at least limited to a single constituency (harvesters) and distinct population groups (chinook salmon off the coast of British Columbia, for example). The idea of extending the concept to an ecosystem, particularly an intensively-developed ecosystem such as the Columbia River Basin, promised a mare's nest of controversies.
>
> ...
>
> The solution proposed by Dr. Lee was based on a modification of adaptive management called Adaptive Environmental Assessment and Management (AEAM), developed by C.S. Holling and his colleagues (Holling 1978). Holling's notion stressed explicit integration of scientific, economic, and social concerns into efforts addressing resource problems. Computer modeling and simulation would demonstrate the potential effects of alternative management actions and scientific uncertainty. Scientists, managers, policy makers, and the public, all bringing their own political, economic, and cultural concerns, would come together in an analytical process aimed at identifying appropriate cases for scientific probing. No one would be forced to pretend that she lives in a world where science alone matters. To the austere principles of adaptive management, then, Holling added a *social* process -- a group conversation conducted with the help of computer models, focusing on data, but mindful that dogma is not far behind.

The Importance of Uncertainty:
The concept of adaptive management of living resources developed through the application of ideas from engineering and decision theory, particularly to the regulation of salmon harvest in the Pacific Northwest. As described by Walters and Hilborn (1976) in a seminal paper, "Adaptive control of fishing systems:"

> This paper addresses the question of how harvesting decisions should be modified to take account of statistical uncertainty. In seeking a formal framework for dealing with this question, we have been drawn to the literature on control system theory, where the problem is addressed under the heading of "adaptive" or "dual" control (citation omitted).

Harvest management typically involves one or a few species. However, CALFED proposes the more difficult task of managing an ecosystem, involving a greater order of uncertainty.

Healey (1997), citing O'Neil et al. (1986), points out that there is an inherent unpredictability about ecosystems because they are "medium number" systems, made up of too many interacting subsytems to deal with analytically, but of too few subsystems of deal with in terms of averages. Healey also notes that ecosystems may even behave chaotically in the mathematical sense, whereby very small differences in initial conditions and lead to very large differences in eventual outcomes. In consequence:

> The "unknowable" character of rivers and river basins is part of their fascination as ecosystems. But their "unknowableness" also means it is not possible to predict their behavior the way behavior of structural materials in a bridge or the airfoil of a jet plane can be predicted. Fortunately this does not mean that the goal of ecosystem management must be abandoned. What It does mean is that approaches to the management of ecosystems must differ from approaches the management of traffic on highways or the exploitation of individual fish populations. In the latter two instances, management is based on simple analytic models that predict quantities (e.g., vehicles, fish) that can be accommodated or harvested in a specified period of time. Such quantitative statements about ecosystem behavior may never be possible. ...

Mangel et al. (1966) express a similar view:

> By identifying things that are critical to a given ecosystem (such as nutrient dynamics, life history parameters of critical species, need for migratory pathways, and/or major external threats or opportunities) one can design a management plan that accommodates a wide variety of human uses while preserving that which is most critical for the continued viability of the ecosystem. But a distinction must be made between managing a living resource with an ecosystem approach and managing an ecosystem. An individual species or population as a resource may be managed while taking into account its interactions with other elements of its ecosystem. This is resource management with an ecosystem approach. Managing ecosystems, on the other hand, means managing the entire system by integration of ecological, economic, and social factors to control the biological and physical systems (Wood 1994). Currently, this is difficult to do as an informed activity (Slocombe 1993) because the concepts are ill defined, great uncertainty exists about most ecosystems, and methods are just developing. ...

The increasing recognition of the inherent uncertainty associated with ecosystems is described in Appendix I of Mangel et al. (1996):

> The first is a change in the way ecosystems are perceived. Some call this "the new ecological paradigm." It should be emphasized that although the facts have been known by some ecologists, other scientists, and managers for many years, it is only recently that there is more widespread recognition of the knowledge. Formerly, the dominant paradigm was that of an ecosystem that was stable, closed, and internally regulated and behaved in a deterministic manner. The new paradigm is of a much more open system, one that is in a constant state of flux, usually without long-term stability, and affected by a series of human and other, often stochastic factors, many originating outside of the ecosystem itself. As a result the ecosystem is recognized as probabilistic and multi-causal rather than

deterministic and homeostatic; it is characterized by uncertainty rather than the opposite.

The importance of uncertainty has been recognized by courts as well as scientists. After reviewing the evidence on the flows needed to protect salmon and other public trust resources of the American River, Judge Hodge (1990) wrote that:

> ... As with the water quality issue, it is the fact of uncertainty which is left with the Court. There is simply no basis in the evidence for a reasoned selection among various of the competing positions. This represents not an abdication of court responsibility, but, rather, a recognition of existing scientific reality.

An important essay in Science, "Uncertainty, resource exploitation and conservation, lessons from history" (Ludwig et al. 1993), listed five attributes of effective resource management, culminating with:

> 5) Confront uncertainty. ... Most principles of decision-making under uncertainty are common sense. We must consider a variety of plausible hypotheses about the world; consider a variety of possible strategies; favor actions that are robust to uncertainties; hedge; favor actions that are informative; probe and experiment; monitor results; update assessments and modify policy accordingly; and favor actions that are reversible.

More recently, Castleberry et al. (1996) noted that the basic arguments of the Ludwig et al. paper apply to instream flow assessments, and emphasized the importance of acknowledging uncertainty:

> At an April 1955 workshop in Davis, all 12 participants agreed that currently no scientifically defensible method exists for defining the instream flows need to protect particular species of fish or ecosystems (citation omitted). We also agreed that acknowledging this fact is an essential step in dealing rationally and effectively with the problem.

Similarly, we argue that acknowledging the fundamental uncertainties about the Bay/Delta ecosystem is an essential step in dealing rationally and effectively with its restoration. The uncertainty problem is like a drinking problem; you have to admit that you have it in order to deal with it.

Uncertainty and the Need to Act:
Uncertainty is a two-edged sword. Historically, uncertainty about the causes of environmental problems worked to the benefit of the status quo. However, experience showed that the failure to act until the signal from specific causes could be clearly distinguished from the noise of ecological uncertainty put the environment at too great a risk. In the language of statistics, traditional policy emphasized the risk of acting on an incorrect hypothesis about the cause of a problem, a "Type I" error, but underemphasized the risk of failing to act on a correct hypothesis, a "Type II" error (McAllister and Peterman 1992).

Because adaptive management recognizes ecological uncertainty, it highlights the need to balance Type I and Type II errors. As a practical matter, this means acting despite uncertainty, as noted in the third of five principles of adaptive management that are commonly recognized, although they do not all follow as strict logical consequences of the definition given above. As stated succinctly by Hennessey (1994):

> 1. The purpose of adaptive management is the protection and restoration of living resources.
> 2. Projects are experiments; the choice is to make them good ones or bad ones. Some will fail; others will succeed.
> 3. Action is overdue. We do not delay action until enough is known.
> 4. Information has value, not only as a basis for action, but as a product of action.
> 5. Protection measures may be limited, but management is forever. (Lee and Lawrence 1986; Holling 1978; Walters 1986)

Similarly, the first of attribute of effective management given by Ludwig et al. (1993) is "Act before scientific consensus is achieved."

Management as Experiments:
Adaptive management treats management actions or projects as experiments, and experiments require hypotheses to be tested. As stated by McAllister and Peterman (1992):

> Hurlbert (1984) identified the components of an experiment a (1) hypothesis, (2) experimental design, (3) execution of experiment, (4) data analysis, (5) interpretation of results. In this paper we are primarily concerned with experimental design. Advocates of experimental management emphasize that before management actions are taken, hypotheses should be clearly stated, possible biological models should be described mathematically, and experimental designs should be carefully chosen (Walters and Hilbron 1978; Walters 1986; Sainsbury 1988). Good experimental design is crucial to distinguish among alternative hypotheses (Hurlbert 1984).

Designing good experiments is a major challenge, so treating management actions as experiments increases rather than decreases the need for careful and creative thinking. Treating actions as experiments also means that managers should be held accountable for the design and execution of their actions, and not just for the results, since the results are assumed to be uncertain (Mangel et al. 1996).

Although adaptive management treats management actions as experiments, there can be more or less uncertainty about the results of a project or action. For example, there was not much uncertainty about the effect of Friant Dam on the San Joaquin River spring-run chinook salmon. Where there is not much uncertainty, not much can be learned by treating an action as an experiment. Moreover, all information is not equally useful, so not all experiments are worth conducting, and a bad idea cast as an experiment is still a bad idea.

Adaptive Environmental Assessment and Management:
The process of Adaptive Environmental Assessment and Management (AEAM) is founded on the realization that "The value of modeling in fields like biology has not been to make precise predictions, but rather to provide clear caricatures of nature against which to test and expand experiences" (Walters 1986, p. 45). In consequence, the greatest benefit from

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models in biology comes from what is learned in the modeling process, and AEAM is a way to involve diverse people in the modeling process, creating the "group process conducted with the help of computer models" described by Volkman and McConnaha (1993). Holling, Carl Walters, and others developed a workshop process for this purpose that has had considerable use, and is described at some length in Walters (1986). As described briefly by Walters (1997) [although he uses the term adaptive management instead of AEAM]:

> ... we generally use the term today to refer to a structured process of "learning by doing" that involves much more than simply better ecological monitoring and response to unexpected management impacts. In particular, it has been repeatedly argued (Holling 1978; Van Winkle et al. 1997; Walters 1986) that [AEAM] should begin with a concerted attempt to integrate existing interdisciplinary experience and scientific information into dynamic models that attempt to make predictions about the impacts of alternative policies. This modeling step is intended to serve three functions: (1) problem clarification and enhanced communication among scientists, managers, and other stakeholders; (2) policy screening to eliminate options that are most likely incapable of doing much good due to inadequate scale or type of impact; and (3) identification of key knowledge gaps that make model predictions suspect. Most often the knowledge gaps involve biophysical processes and relationships that have defied traditional methods of scientific investigation for various reasons, and most often it becomes apparent in the modeling process that the quickest, most effective way to fill the gaps would be through focused, large scale "management experiments" that directly reveal process impacts at the space-time scales where future management will actually take place. The design of management experiments then becomes a key second step in the adaptive management process, and a whole new set of management issues arises about how to deal with the costs and risks of large-scale experimentation (Walters and green 1996). Indeed, AEAM modeling so regularly leads to recommendations for management experiments that practitioners like Walters (Univ. of British Columbia, pers. comm.) have come to use the terms "adaptive management" and "experimental management" as synonymous. In short, the modeling steps in [AEAM] planning allows us, at least in principle, to replace management learning by trial and error (an evolutionary process) with learning by careful tests (a process of directed selection).

From one point of view, anyone who thinks that he or she understands how something work has a model of it. Mathematical modeling has the virtues described by Walters because it makes people be explicit about they way they that think things work, and the numerical results of running the resulting model provide a check on the reasonableness or importance of the ideas. AEAM seems particularly attractive for management directed at specific species or ecosystem functions. However, as Healey points out, complete ecosystems are so complicated that developing models that are useful "clear caricatures" for the whole system may not be possible. It may be more appropriate to use different models for investigating different aspects of the ecosystem, within a conceptual framework that reminds us that each is incomplete.

Active and Passive Adaptive Management:
Walters and Holling (1990) distinguish three types of management that can be considered

adaptive in any sense:

> (1) evolutionary or "trial and error," in which early choices are essentially haphazard, while later choices are made from a subset that gives better results; (2) passive adaptive, where historical data available at any time are used to construct a single best estimate or model for response, and the decision choice is based on assuming this model is correct; or (3) active adaptive, where data available at each time are used to structure a range of alternative response models, and a policy choice is made that reflects some computed balance between expected short-term performance and the long-term value of knowing which alternative model (if any) is correct.

From a scientific or information-gathering point of view, there are good reasons to favor an active adaptive approach, which typically involves some deliberate change in the management of the system that is large enough to be informative. However, such large changes may be politically infeasible, and small changes may produce little information despite being economically disruptive.

This point is perhaps best explained by the example of harvest management. Traditionally, management of salmon harvest was based on the idea that the number of young salmon "recruited" to the fishery is related to the number of spawners by some non-linear curve that reflects density-dependent mortality. With the classic Ricker (1954) model, the curve is dome-shaped, such that some number of spawners maximizes the number of recruits, and either more or fewer spawners produces fewer recruits. With the Beverton-Holt model, which makes different assumptions about the nature of the density-dependent processes that affect survival, the number of recruits levels off as the number of spawners increases, so beyond some number additional spawners are in effect "excess," but do not result in an absolute decrease in the number of recruits.

The obvious objective of harvest management is to provide the optimum number of spawners; however, this is generally an uncertain number. The number of recruits is affected by many other factors besides the number of spawners, and estimates of numbers are often of dubious accurately, so inevitably a plot of recruits over spawners shows a great deal of scatter. Accordingly, there is uncertainty regarding which of various spawner-recruit relations best describes the population of salmon in question, and there is also uncertainty about the proper values of the parameters of the various curves.

A straight-forward approach is to select the curve and parameter values that best fit the available data on numbers of spawners and recruits, and calculate a "best guess" optimum number of spawners. Then, harvest can be managed to keep the number of spawners close to the estimated optimism, and the numbers of spawners and recruits can be monitored and used to refine the estimate of the optimum number of spawners. This is what Walters and Holling call a passive adaptive approach.

However, this approach gives rise to a dilemma. If harvest is managed to keep the number of spawners close to the original estimated optimum, then subsequent data points will be affected mainly by other variables and measurement errors, and will provide little additional information about the optimum number of spawners. An original bad guess may remain unrecognized, particularly if the estimated optimum is too low, with a resulting loss of part of the productive potential of the habitat. Managing the harvest to provide for small changes in the number of spawners will not help much, either. On the other hand, managing the harvest to allow some substantially different number of spawners will entail large loses if the original estimate is close to correct, and these loses must be weighed against the potential value of the information gained by the experimental harvest

Presumably, this dilemma generalizes from the relatively simple case of harvest management to more complex questions of ecosystem management. However, doing the balancing for harvest management is complicated enough (see Walters and Hilborn 1976), and it is not clear that it is even possible for other situations except by essentially political decisions. For such reasons, there is a strong temptation to try passive rather than active adaptive management.

There may be an escape from this dilemma when there is significant natural variation in the system of interest. For example, there is substantial year to year variation in Delta outflow, regardless of management. There is inconvenience, expense and delay associated with monitoring the system over a long enough period for uncontrolled variation to cover a range of conditions, and there is more danger that study results will be confounded by co-variation among variables, or by long-term changes in the environment. However, these disadvantages may be small compared to the problems associated with deliberate major changes in management.

Monitoring for Adaptive Management:
For management actions to be treated as experiments, there must be a way to measure the response of the system being managed: a monitoring program. Good monitoring is more difficult and more expensive than many people realize. Many questions of interest concern small organisms in large and often muddy rivers, and there is no easy way t answer them. As noted in Appendix I of Mangel et al. (1996):

> Two types of uncertainty are involved in living resource conservation. The first could be considered "ecological uncertainty," which refers to the probabilistic nature of biological systems discussed in the previous paragraph. [Quoted above.] The second type is uncertainty in the estimation of parameters such as abundance, birth and death rates, etc.: this is measurement "uncertainty." Both of these types of uncertainty are central concerns to any model or management regime, and there is often confusion between them when uncertainty is discussed.

Accordingly, it is important to consider carefully how well proposed monitoring programs can be expected to detect the response of the system to experimental management, which can often be done by computer simulations (Ludwig and Walters 1985). If responses can be detected only if they are very large, or after many years, then the "experimental design" of the proposed management should be reconsidered.

Good monitoring in adaptive management is also important for three other reasons. First, unsuccessful but politically attractive measures may be repeated if failures are not recognized (Kondolf et al. 1996). Second, as noted above, randomization and replication are ordinarily impossible in adaptive management experiments, so it is important to monitor potential confounding factors. The Vernalis Adaptive Management Program, for example, will test the effect of different flow and export rates on the survival of juvenile chinook salmon in the San Joaquin River. Survival will be measured by releases of coded-wire tagged hatchery smolts. However, it seems sensible also to monitor potential confounding factors such as water temperature, measures of the condition of the smolts at release and at recapture, indicators of exposure to toxics, etc. Besides reducing uncertainty in the interpretation of the results of the main experiment, such data can also be useful for testing hypotheses about the mechanisms by which the alternative management regimes effect smolt survival. Third, science advances by observations, as well as by experiments, and observations often provide the inspiration for experiments (Power et al., in press).

Scientific Difficulties with Adaptive Management:
Doing good experiments is difficult even in the controlled conditions of a laboratory, and it is much more difficult in the field. Writing about ecological studies generally, Hilborn and Mangel (1997) point out that:

> ... the following attributes of ecological systems often make experiments difficult:
>
> -- Long time scales: Many ecological systems have times scales of years of decades
> -- Poor replication: Many ecological systems are difficult to replicate, and replicates are rarely, if ever, perfect
> -- Inability to control: One can rarely, if ever, control all aspects of an ecological experiment
>
> Because of these factors it is often harder to get clear, unambiguous results in ecological experiments (cf. Shradder-Frechette and McCoy 1992).

The same difficulties apply, usually more strongly, to adaptive management experiments. Management experiments that involve only part of a system or a short period of time may fail to detect or recognize unanticipated factors that can render the experiment not just invalid but also misleading. For example, many biologists now believe that the survival rate of salmon in the ocean varies over a timescale of decades (Pearcy 1997). Experimental management of freshwater habitat during a period of changing ocean survival could easily give misleading results if the experiment were monitored only in terms of numbers of adults. Field experiments with small spatial scales can give similarly misleading results (Peterman 1991; Walters 1997).

Replication is also a problem. There is only one Stanislaus River, so it is not possible to replicate experimental management of Stanislaus. Experimental management of the Toulumne and the Merced rivers could be useful approximations to such replication, but would not be the real thing, and although it might be the best that can be done, the meaning of the results of such experimental management will be to some degree compromised. Measurement uncertainty adds to the difficulties.

There is no easy solution to these problems, so it is not reasonable to expect adaptive management experiments to produce unambiguous results within a few years. On the positive side, analytical and statistical methods have been developed or applied in ecology (e.g. Hilborn and Mangel 1997) that could be applied as well to adaptive management. However, these methods, such as Bayesian statistics, are unfamiliar to most scientists working on Bay/Delta issues.

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Political Difficulties with Adaptive Management:
Resource management is complicated by social as well as scientific uncertainty (Halbert 1993), and even in the context of fisheries, adaptive management can fail through unanticipated social responses to management experiments. As noted by Volkman and McCannaha (1993), applying adaptive management to ecosystems promises "a mare's nest of controversies:"

> The notion that we are willing to take dramatic steps in order to learn -- to create control cases, and then to depart sharply from them -- can, in a high-stakes setting like the Columbia River, be exceedingly problematic. It is difficult to convince people of the wisdom of investing public funds, or risking harm to a species on the brink of extinction, while embracing the scientific method's root principle that failure is not only possible, but likely, and may be necessary in order to learn.
>
> The notion that we place a high value on leaning ignores the fact that in some instances, ignorance has values. As long as key questions are open, parties remain free to take political positions. In the long term, the truth may set us free, but in the short term, it can reduce our room to maneuver. "Good science" becomes that which supports one's position.
>
> The supposition that we are willing to wait patiently for answers that may take decades to determine, runs against the grain of politics. If salmon are declining, the political impulse is to change course, regardless of whether we understand the problem.
>
> Good science can run into equity considerations. Is it fair to ask Indian tribes, whose harvest has been in sharp decline for decades, to go slow on hatchery technology that has fueled non-Indian harvest for decades because we need to explore the long-term effects on salmon populations.
>
> All of these factors point to a simple, but very hard lesson: adaptive management does not take these decisions out of the political arena. Decision makers still have to gain political support to test important hypotheses. All of the aversion to risk and expense, the impatience with slow answers, the uses of ignorance, the bureaucratic inertia from all quarters, and the fear of failure still come into play. Adaptive management does not allow us to escape unscientific pressures.

Conclusions:
Adaptive management as described here is a bitter pill, and despite its therapeutic benefits is accordingly difficult to implement. On the one hand, scientists must acknowledge that in some sense they do not know what is going on, and managers must acknowledge that in a similar sense they do not know what they are doing; on the other hand, those subject to management actions must acknowledge that uncertainty does not justify inaction. All must accept that progress will be slow, and that substantial sums must be allocated to monitoring and evaluation, probably at the expense of additional restoration efforts. Only the alternatives are less palatable.

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