A River in the Balance:
Benefits and Costs of Restoring Natural Water Flows to the Eel River

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Dan Ihara
Humboldt County
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EXECUTIVE SUMMARY

INTRODUCTION

The complex of facilities (including dams, reservoirs, tunnel and machinery) used to store water and generate electricity located on the main stem of the Eel River is known collectively as "The Potter Valley Project" (PVP). Since 1908 the PVP has diverted water from the Eel River to run its electrical generators and then "abandons" the water to the East Fork of the Russian River.

In regard to the relationship between natural water flows and dams Raphals points out,

> The natural flow regime represents perhaps the most important driving force in a river ecosystem because it sustains key natural processes. For example, natural flows maintain the dynamic geomorphology of the channel and surrounding terrestrial areas during floods, sustain the quality of water on which native organisms depend, facilitate nutrient flows along the river corridor and between the river and upland areas, and help regulate the life cycles of river organisms (Raphals, 2001, p. 37).

And furthermore,

> Dams are intended to alter the natural distribution and timing of stream flows. As such, they also alter essential processes for river ecosystems. By changing the pattern of downstream flow (i.e., intensity, timing and frequency), they modify sediment and nutrient regimes and alter water temperature and chemistry. These parameters are the basic building blocks of freshwater ecosystems and when these change, many species, habitats and functions that depend directly or indirectly on these forces decline or disappear *(ibid)*.

Considering the option of removing PVP dams and restoring natural water flows to the Eel River is warranted for several reasons. In addition to basic ecosystem and public trust reasons, removing PVP dams is warranted due to specific institutional circumstances of the license to operate the PVP, the possibility of the transfer of ownership, and the proposed increase in Sonoma County Water Agency (SCWA) diversion of water from the Russian River.

This report examines the several components of benefits and costs of restoring natural water flows to the Eel River.

BENEFITS

<u>FISHING:</u> The Eel River salmonid fishery has precipitously declined from pre-PVP annual runs of over half a million fish: the value of such a fishery could exceed $50 million dollars annually today. But over the last century most of that value has been lost.

It is difficult to imagine now, but: "In the early 1900s the Eel River supported runs of salmon and steelhead trout that were estimated to exceed one-half million fish" (California Fish and Game 2001). The value of a fishery that size could exceed $50 million dollars annually. Over the last century most of that value has been lost.

PVP plays key roles in this loss.

- PVP, to the detriment of fish populations, greatly diverts the water that would otherwise naturally flow into the Eel River. For example, between 1911 and 2000 the average July water flow released into the main stem of the Eel from Van Arsdale reservoir was 12% of the "unimpaired" flow. In other words, for these years the PVP dams diverted 88% of the water that would have flowed in July naturally without the PVP dams. In some years the percentage taken from the Eel in a late-summer month is higher than this average.
- PVP dams block over 100 miles of salmon and steelhead habitat on the Eel River.
- The invasive pikeminnow was introduced into a PVP reservoir, Lake Pillsbury. This predator, which continues to breed in Lake Pillsbury, has spread through the Eel River system feeding voraciously on juvenile fish that are native to the Eel River basin.

To appreciate the economic value of commercial and sports fishing, the following is useful to note:

- Smoked salmon's wholesale price is $6 - $8 per pound. For a fish yielding ten pounds of smoked salmon, that would be $60 - $80 per fish.
- A study on recreational fishing in the Central Valley found that the average expenditure per fish is about $106-108.
- River guides charge $300 per day.

<u>RAFTING:</u> Restoring natural water flows to the Eel River would increase and enhance recreational opportunities on the Eel and has the potential of adding millions of dollars per year to the local economy.

Rafting alone has the potential for generating over two million dollars of revenue annually through increased river rafting operations on the main stem of the Eel. The natural water flow of the Eel River would extend the current rafting and kayaking season by approximately 6 weeks. For example, using a conservative estimate of the number of rafting parties that could commence on the river each day, the expenditures on the rafting trip alone would total $2.3 million dollars. Combined with other expenditures rafters would make in the area, the total expenditures increase to $2.875 million. This does not include the indirect or multiplier effects of these expenditures on the local economy.

MARKET VALUES LOST:

The study shows how the Eel River basin may suffer market-valued losses due to the PVP of more than $5 million annually. Over the ninety-four years since the start of the PVP, the present value of the cumulative losses totals in the hundreds of millions of dollars. Although pre-development-sized runs may not be seen again, potential market-valued benefits from restoration of natural water flows to the Eel are still very significant. In addition to increases in sustainable commercial fish harvests, sports fishing and rafting possess great and increasing future market values that are compatible with a naturally flowing river.

"INTRINSIC" OR NON-MARKET VALUE OF FISH: Non-market or "intrinsic" values are recognized by economists as significant when considering the value of salmon.

As economist Ernie Niemi of EcoNorthwest puts it, "A person doesn't have to eat a fish to value it." He notes that a carefully conducted survey of the residents of Washington and Oregon found that, on average, they are willing to pay $30-97 per household per year to protect salmon (over and above what they would pay to consume fish individually). If Californians' willingness to pay for actions to protect salmon is at the low end of what was found in Washington and Oregon—$30 per household per year—then multiplying this amount times 5 million households in northern California suggests a total intrinsic value placed by residents of the region on protecting and rebuilding salmon populations of $150 million per year."

"The Eel River likely supports the largest remaining native coho salmon population in California" (California Department of Fish and Game 2001) and would therefore be a significant portion of total intrinsic value of salmon to all residents of California.

RESOURCES OF VALUE TO NATIVE AMERICAN TRIBES:

California Indian Legal Services (CILS) stated in their 1999 comments to FERC that "The [Federal Energy Regulatory] Commission must protect resources of value to the Tribes, such as the Eel River fishery on which the Tribe relies for the exercise of statutory and federally reserved fishing rights." The Round Valley Indian Tribes have stated that "FERC has already allowed PG&E to do tremendous damage to the Eel River fishery and has squandered the opportunity to help reverse that damaging trend by allowing PG&E to conduct a study to examine its own impact on the fishery" (comment on Draft Environmental Impact Statement). Native American opportunities for fishing have been greatly diminished, for example, by the above-mentioned loss of spawning habitat.

To highlight the importance of salmon, it is worth keeping in mind economist Philip Meyer's comment that "Indian elders link the survival of salmon with survival of their tribe as a people." Moreover, traditional elders value water (along with the air, the sun and the land) as one of the four life-givers on which all living things—all humans, all plants and all animals—depend. Although placing a dollar amount on resources of value to tribes (including spiritual values related to salmon and water) is inappropriate and inadequate, such resources are, nonetheless, real values that need to be fully recognized and acknowledged.

"COSTS"

<u>ELECTRICITY:</u> The PVP hydroelectric facility, which PG&E is attempting to auction off, may not be an economically feasible operation and as such would have a zero asset value.

The Sonoma County Water Agency's report *Allocation of Water Supply Benefits of the Potter Valley Project* states, "…the project is not economic as a hydroelectric project." This statement is consistent with a comparison of estimates of the PVP's operation expenditures and its revenue from sale of electricity. In other words, if the PVP were closed, then the money spent on efficient generators of electricity or on energy-conservation measures would be a net gain, not a net loss to society.

<u>CURTAILED ACCESS BY SOME TO SUBSIDIZED WATER:</u>

Many Russian River area users pay nothing to get diverted Eel River water. Others may pay a fee to a water wholesaler, but for the most part this charge is for transmission, treatment and operating costs, not for the water itself. Water in the Eel River, however, has real economic value. Hence, those who pay nothing for it are being subsidized. Furthermore, allowing water users to pay nothing for their use of the Eel River's water has promoted over-consumption and socially inefficient use. For purposes of illustration, payment of as small a price as $30 per acre-foot for acquisition of water diverted from the Eel River could exceed $5 million per year.

Rather than there being a cost from ceasing to divert water from the Eel to the Russian River, water diverted from the Eel River can be considered as having been subsidized for almost 100 years. Russian River area users of Eel River water have not had to pay the externalized environmental and other costs associated with diversion of Eel River water.

<u>ALTERNATIVE WATER SUPPY:</u> Alternative water supply exists that can supply water to the Russian River basin to replace Eel River water.

Professional geologist Robert Curry has detailed in testimony prepared for FOER that "several groups of options for meeting the [Russian River basin] water demands [exist] in lieu of the Potter Valley diversions…The most promising for upstream sites as well as some Middle Reach sites is increased use of groundwater. The next largest source of untapped water is Lake Sonoma…At present, nearly 1.1 million acre-feet of water in the Russian River system is untapped, and most passes to the sea in the winter."

Though development costs of such water supplies may be lower than some might expect, such development still requires expenditures. As noted above, the level of these expenditures, rather than a new or additional cost, can be viewed as what the Russian River area would have paid had they not gotten free Eel River water. Consequently the level of expenditures to develop alternative water supply can be seen as a reflection of the level of subsidy that the Russian River area has received. In other words, each year the PVP operates as it has, the Russian River area receives free water that allows it to delay expenditures on an alternative water source. ***Ironically, the larger the expenditure to develop an alternative to free Eel River water is, the larger is the subsidy the Russian River area has received and continues to receive.***

BENEFITS TO RUSSIAN RIVER FISHERIES:

Restoring the natural water flow regimes to the Russian River may have benefits to the Russian River area. For example, not adding water diverted from the Eel River to the Russian River would reduce rainy season flooding. Russian River natural water flows are better for spawning of anadromous fish than augmented water flows to the Russian River.

CONCLUSIONS

In the distant past it may have appeared to make economic sense to some people to dam the Eel River and divert water to the Russian River basin. Such a view is not tenable today. Now there is no economic sense in extending the operation of out-of-date electric generators and the subsidies to some users of scarce, valuable water.

In the final analysis, the issue is not between benefits to the Eel River system and “costs” to the Russian River system. For nearly 100 years, in *both* these two river systems, “human-constructed capital," ranging from irrigated orchards to housing developments, has been promoted while the “natural capital” values of *both* river basins have been degraded. Similar processes have been occurring worldwide. There is growing scientific evidence that ecosystems, which are under increasing stress throughout the world, are susceptible to relatively sudden collapse. Restoring natural water flows to rivers is part of the larger necessity of restoring humans to balance with the natural world on which all life depends.

A RIVER IN THE BALANCE:
THE BENEFITS AND COSTS OF
RESTORING NATURAL WATER FLOWS TO THE EEL RIVER

I. Introduction

A. Basic Background Regarding the PVP

Though the mouth of the Eel River, the third-largest river in California, is nearly two hundred miles north of the mouth of the Russian River, at their closest point in their headwaters regions only two miles naturally separates the upper Eel River from the East Branch of the Russian River (see Figure 1). In 1908 humans breached that separation. In that year a 5,826-foot tunnel was completed linking the two river systems. Eel River water travels through this tunnel to turn turbines to generate electricity. After being used for this purpose, Eel River water is released to flow into the East Branch of the Russian River. The complex of facilities (including dams, reservoirs, tunnel, and machinery) used to store water and generate electricity is currently owned by PG&E and is known collectively as the "Potter Valley Project" (PVP). Scott Dam forms the 80,000-acre-ft Lake Pillsbury. Twelve miles downstream Cape Horn Dam (also called Van Arsdale Dam) creates the 700-acre-ft Van Arsdale Reservoir. Water from the Eel River is diverted at Van Arsdale Dam through the above-mentioned tunnel to the PVP powerhouse facilities located at the headwaters of the East Branch of the Russian River (see Appendix A for basic information about the PVP, the Eel River, and conversion of units of measure).

B. Why Consider the Option of Removing the Potter Valley Project Dams and Restoring Natural Water Flows to the Eel River?

Before beginning our examination of benefits and costs, let us first address the question: why consider the option of removing the Potter Valley Project dams and restoring natural water flows to the Eel River at all? There are several reasons.

1. Natural Flow Reasons

First let us consider the importance of the complex of conditions and patterns expressed in the term "natural flow regime." As Raphals points out,

> The natural flow regime represents perhaps the most important driving force in a river ecosystem because it sustains key natural processes. For example, natural flows maintain the dynamic geomorphology of the channel and surrounding terrestrial areas during floods, sustain the quality of water on which native organisms depend, facilitate nutrient flows along the river corridor and between the river and upland areas, and help regulate the life cycles of river organisms (Raphals, 2001, p. 37).

And furthermore,

> Dams are intended to alter the natural distribution and timing of stream flows. As such, they also alter essential processes for river ecosystems. By changing the pattern of downstream flow (i.e., intensity, timing and frequency), they modify sediment and nutrient regimes and alter water temperature and chemistry. These parameters are the basic building blocks of freshwater ecosystems and when these change, many species, habitats and functions that depend directly or indirectly on these forces decline or disappear *(ibid).*

2. Threatened Species Reasons

It has been noted that the "Eel River likely supports the largest remaining native coho salmon population in California" (Department Fish and Game 2001, 1997; Moyle *et al.* 1994). Furthermore, "At its April 21, 2001, meeting the California Fish and Game Commission voted to accept a petition to list the coho salmon north of San Francisco as an endangered species pursuant to the California Endangered Species Act (CESA)."

Furthermore,

> Coho salmon occurred in the upper mainstem Eel River drainage as far up as Indian Creek and Tomki Creek and several of its tributary streams. Coho salmon presently occur in the upper mainstem Eel drainage as far up as Outlet Creek drainage (representing the longest run of coho salmon in California)…since 1947 (Mullin 1995, p. 2, citied in California Trout, 1996, p. 20).

Figure 1
Map


Eureka
HUMBOLDT
Fortuna
Van Duzen River
Eel River
South Fork Eel
Ft. Seward
North Fork Eel River
Garberville
Benbow
Eel River
Trinity Co.
Middle Fork Eel River
S. Fork Eel River
Covelo
Laytonville
Dos Rios
Fort Bragg
Lake Pillsbury
Van Arsdale
MENDOCINO
The Diversion Tunnel
Ukiah
Russian River
SONOMA
Healdsburg
Santa Rosa
Pacific Ocean
MARIN
San Francisco
Cape Horn Dam (1908)
forms Van Arsdale Reservoir with a surface area of 106 AF; this reservoir is shallow and now filled with sediment but acts as a bay for the diversionary tunnel.
Scott Dam (1922)
130' high, forms Lake Pillsbury, which holds 80,560 AF of water.

Since dams affect the natural timing and flow of streams, and since this may directly or indirectly result in the decline or disappearance of endangered or threatened species, and since coho and other salmonids may be affected by the disturbance of natural flow regimes by the Potter Valley Project dams, it is reasonable to at least consider dam decommissioning as an option.

3. Public Trust Reasons

There may also be public trust reasons for considering the removal of Potter Valley Project dams and the restoration of natural water flows to the Eel River. As the California Water Resources Control Board has stated:

> Under the public trust doctrine, certain resources are held to be the property of all citizens and subject to continuing supervision by the state…[and since then] the courts have broadened the definition to include recreational and ecological values (Water Resources Control Board).

4. Institutional-related Reasons

In addition to the above ecosystem and public trust reasons for considering the option of removing the Potter Valley Project dams and restoring natural water flows to the Eel River, there are several specific, more institutionally related reasons for considering such an option.

First, operation of the PVP is allowed under license issued by the Federal Energy Regulatory Commission (FERC). The initial 50-year license was issued by the Federal Power Commission to Pacific Gas and Electric (PG&E) in 1922. From 1972 through 1982 PVP continued to operate under annual licenses. PG&E was issued a new hydropower license in 1983 that authorized PVP operations through April 2022 (FERC 2000, xxix), subject to a number of conditions. Project operation under the new license was based on a 1978 EIS and a 1983 settlement agreement between PG&E and other parties (*ibid.,* p.1.4) Article 39 of the license required a 10-year study of project flow on anadromous salmonids and a final report containing "licensee recommendations for modifying operations" *(ibid).* One purpose of this modification was "the protection and maintenance of fishery resources in the Eel River and the East Branch of the Russian River" (*ibid.,* p. A-1). Insofar as the protection and maintenance of fishery resources in the Eel River and the East Branch of the Russian River may depend on restoration of natural water flows, consideration of restoration of natural water flows as an option appears reasonable.

The fact that FERC decisions on operation of the PVP are not yet fully resolved is another reason why the option of removal of PVP dams and restoration of water flows to the Eel River should be considered. Yet even if the FERC decision on the existing license were completely resolved, the current license will expire in 2022, only twenty years from now. It is timely to begin serious consideration of removal of PVP dams and restoration of water flows to the Eel River in the advent that a new hydropower license is not issued twenty years from now.

Second, in May 1998 PG&E applied to the California Public Utilities Commission (CPUC) to dispose of its hydroelectric assets, including the PVP. The sale of the PVP has not occurred for a variety of reasons including PG&E's bankruptcy proceedings. The American Society of Civil Engineers noted:

> It may be appropriate to consider retirement options [for dams and hydroelectric facilities] at various project life cycle milestones such as capital investment, relicensing, or transfer of ownership (American Society of Civil Engineers 1997, p. 7).

So even setting aside re-licensing issues, the possible transfer of ownership suggests that consideration of the "retirement" or decommissioning or removal option regarding PVP dams and hydroelectric facilities may be appropriate.

Third, Sonoma County Water Agency (SCWA) has proposed to increase greatly the amount of water it diverts from the Russian River. Such an increase could preclude future restoration of natural water flows to the Eel River and thereby preclude future protection and maintenance of Eel River fishery resources. Consideration of the benefits and costs of restoration of natural water flows to the Eel River is germane to understanding the environmental impacts and implications of the proposed SCWA expansion.

In summary, the option of removing PVP dams and restoring natural water flows to the Eel River is warranted for several reasons: for basic ecosystem, public trust, and institutional-related reasons. The latter include the specific institutional circumstances of the license to operate the PVP, the possibility of the transfer of ownership of the PVP, and the proposed increase in SCWA diversion of water from the Russian River.

II. What Are the Benefits and Costs of Removing Potter Valley Project Dams to Restore Natural Flows to the Eel River?

The following is an overview of the benefits and costs of removing the Potter Valley Dams to restore natural flows to the Eel River. It is beyond the scope of this report to consider such benefits and costs comprehensively or in depth. Such an examination should properly be part of a full environmental impact statement that formally considers "decommissioning" as a project alternative. This report is intended to suggest some of the dimensions, issues, and approaches that such a complete analysis should include. (For further discussion of a somewhat more formal model of benefits and costs, see Appendix B.)

A. Eel River Benefits

1. Market Valuation of Eel River Fisheries

a. Calculation of Fish Populations

The following is presented to give some sense of the pre-development Eel River salmonid populations and the subsequent history of the river's fishery.

It has been noted that, "In the early 1900s, the Eel River supported runs of salmon and steelhead trout that were estimated to exceed one-half million fish" (Dept. Fish and Game 2001, p. 57).

Another way to estimate pre-development (pre-European contact) Eel River salmonid populations is to make comparisons with the areas of other relevant river basins. For example, the total Eel River basin comprises 3,684 sq. miles (DFG 1997, p. 4). The Klamath River basin comprises 9,691 sq. miles (Institute for Fisheries 1998, p. 14). The Eel River basin is thus 38% the size of the Klamath basin. An estimate of the pre-development runs of salmon and steelhead in the Klamath River basin is 0.66 to 1.1 million fish (Institute for Fisheries, p. 14). Assuming the abundance of fish in the Eel was the same as in the Klamath, 38% of this is 250,000 to 420,000 fish. The mid-point of this range is 335,000 fish.

Similarly, prior to development, the Columbia River system contained 163,000 sq. miles of salmon and steelhead habitat and drained a watershed of 260,000 sq. miles (Institute of Fisheries). The estimate of the Columbia's pre-development salmon and steelhead populations range from 10 to 16 million fish. The Eel basin is between 1.4% and 2.3% the size of the Columbia basin, and these percentages of the Columbia River fish population quoted above result in 140,000 to 370,000 fish. The mid-point of this range is approximately 250,000 fish.

The average of the midpoints of these two ranges is 290,000 fish. This estimate does not seem excessive when one considers the above-noted estimate of more than 500,000 fish in 1900 (DFG, Oct. 2001, p. 57).

"Estimates based upon cannery records indicate the salmon *harvest* averaged roughly 93,000 fish per year between 1857 and 1921" [emphasis added] (Humboldt County Public Works 1991, quoted in Steiner 1996, p. 3.1-1). The Eel River fishing industry "peaked from 1884 to 1913 when as many as eight seining operations and seven canneries were operational at a single time" (Humboldt County Public Works, 1979, quoted in Steiner 1996, p. 3.1-1). However, "…there was no noticeable decline in the commercial fisheries by the late 1800s" *(ibid).*

"In 1964, the Department [of Fish and Game] estimated the annual spawning escapement in the entire Eel River System at approximately 82,000 steelhead trout, 23,000 coho salmon, and 56,000 chinook salmon" (DFG quoted in DFG 2001, p. 57) for a total of 161,000 fish. The number of fish harvested in relation to the number escaping to return and spawn is termed the "catch/escapement ratio." As reported in Smith (1977), this ratio for chinook salmon was estimated to range from 2 to 1 to 7 to 1. Smith uses a ratio of 5 to 1, which would imply a catch of over 250,000 chinook and a total population of over 300,000. So annual pre-development runs of over 500,000 total salmonids do not appear unreasonable.

"The most recent estimate of the average annual salmon and steelhead trout spawning populations in the Eel River system was made in the late 1980s and indicated that steelhead trout had declined to 20,000 fish, chinook salmon to 10,000 fish, and coho salmon to 1,000 fish" (DFG 1997 quoted in *ibid*). This total is 31,000 fish. This "reflects at least an 80% decline in salmon and steelhead trout populations from early 1960s levels" (and is also "supported by anecdotal accounts") *(ibid).* Recent surveys at the Van Arsdale fish ladder reveal more. In the 2000-2001 winter season, the count of fish arriving in the upper river was 303 chinook, 651 steelhead, and 1 coho. In 2001-2002, the count was 955 chinook, 311 steelhead, and 4 coho. For a discussion of estimation of fish population, see Appendix C.

Despite the above-described declines, "the Eel River is the third-largest producer of salmon and steelhead in California (DFG, Eel River Action Plan, 1997, p. iii), and "The Eel River likely supports the largest remaining native coho salmon population in California" (DFG 1997, quoted in DFG 2001, p. 57).

b. Market Valuation of the Entire Eel River Fishery

An Institute for Fisheries Resources study estimated the total sustainable economic value of a pre-development-sized Klamath fishery at $137.4 million/year (in 1996 dollars) (Institute for Fisheries Resources 1998). The Eel River basin is 38% the size of the Klamath basin (*ibid.* and DFG 1997). For purposes of comparison, 38% of $137.4 million/year is $52 million/year (in 1996 dollars) or $57 million/year in 2002 dollars.

A 1977 study by Humboldt County Public Works estimated the annual value to the local economy of historic fishery conditions on the main stem of the Eel River at $28,440,000 (1977 dollars). Adjusting for inflation, this would be $69 million in 2002 dollars.

For purposes of illustration, given the above estimates, if 90% of the pre-development Eel River fisheries value has been lost, the net annual loss would exceed 50 million dollars annually. The following sections address how the PVP has in several ways contributed to the overall decline of the Eel River fisheries.

c. Effects of PVP on Eel River Fisheries - Fish Impacts Above Cape Horn Dam: Loss of spawning habitat and water temperature changes

The two PVP dams directly affect Eel River fisheries by blocking salmonid access to miles of spawning habitat. Several estimates have been given:

In testimony prepared for FOER, Humboldt State University fisheries professor Dr. Terry Roelofs refers to "the potential fisheries resource of the upper Eel River above Scott Dam [is] estimated to include over 100 miles of historic spawning and rearing habitat for anadromous salmonids" (USDA Forest Service 1995).

California Indian Legal Services (CILS) in their 1999 comments to the FERC Environmental Impact Study referred to a loss of over 35 miles of chinook salmon spawning habitat because of Scott Dam, and an additional 22 miles of habitat lost to steelhead.

Scott Dam, 12 miles upriver from Cape Horn, "blocked access to 75 miles of spawning habitat in the Upper Eel and its tributaries" (DFG 2001, p. 56). "The reduction in habitat resulted in an estimated loss of 3,000 steelhead trout and 2,500 chinook salmon (Steiner 1998 in DFG 2001, p. 56). In any case the two PVP dams continue to block access to extensive spawning habitat.

In addition:

> "…regulated flow releases from Lake Pillsbury changed the temperature regime between Scott and Cape Horn dams. Water temperatures became cooler in summer and warmer in winter. The change in water temperature enhances summer rearing for steelhead trout, but can delay juvenile chinook salmon downstream, seaward migrations" (DFG 2001, p. 56).

d. Effects of PVP on Eel River Fisheries - Fish Impacts Below Cape Horn Dam

i. Eel River Water Flows

The focus of this study is the economic impact of decommissioning the Potter Valley Project and thereby restoring natural water flows to the Eel River. The following two questions need to be addressed first: What are the natural or "unimpaired" water flows to the Eel? How much water is diverted through the PVP?

The first Eel River water flow to consider is the natural or unimpaired flow on the main stem of the Eel River, below Cape Horn Dam out of Van Arsdale Reservoir (this is as far downstream as the Potter Valley Project extends). This average annual unimpaired flow was estimated to be 450,300 ac-ft (DWR 1969, quoted in Week, Oct. 23, 2001). The historical average annual diversion is given as 160,000 ac-ft (FEIS, p. 3-58). Based on this, Week gives the diversion at Van Arsdale as 36%.

The average amount diverted each month varies significantly from this yearly average (see Figure 2). For example, over the 91 years from 1910 to 2000 (for which data have been published), the PVP diverted 88% of the unimpaired flow to the Eel River at Van Arsdale during July, 81% of the unimpaired flows during June, and 69% and 64% of the unimpaired flows for the months of August and September, respectively. During the peak flow months of January, February, and March only 6%, 20%, and 15% of unimpaired flows have been diverted over this 91-year period. In other words, the PVP diverts from 67% to almost 90% of the unimpaired flows during the driest months, and less than 20% during the months of highest flows (for a further discussion of water flow issues, see Appendix D).

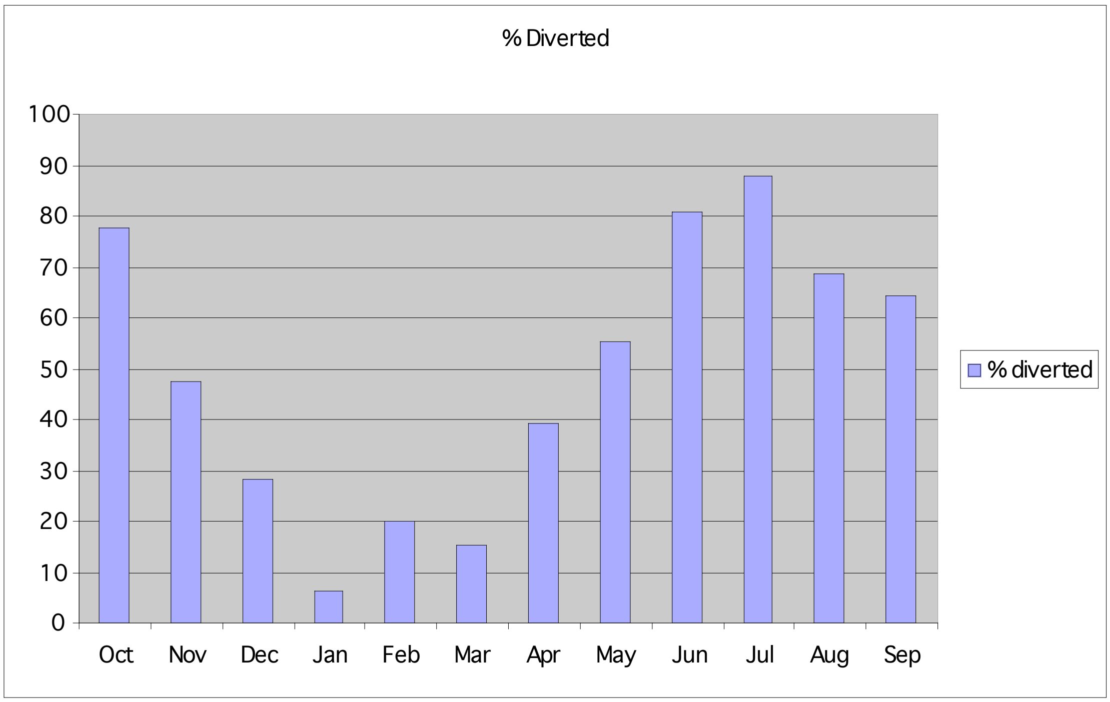

Figure 2
% of Monthly Unimpaired Flows Diverted from Eel River at Van Arsdale

ii. Salmonid Life History and Effect of Changes in Natural Flow

In order to assess the impacts of PVP diversion of water from the Eel River, it is necessary also to consider the life history of salmonids.

Salmonids go through several life cycle stages in the following order: upstream migration, spawning, incubation, emergence, rearing, and emigration.

Specifically in reference to the Eel River, from the period 1985-1996, "Anecdotal reports of the first Chinook in the mainstem below Cape Horn Dam are as early as October 18 …and as late as December 28…" (PG&E, Steiner, p. 5.3.5). It is possible that runs could begin as early as mid-September and extend through mid-January (personal communication, Pat Higgins). In January redds (nests of salmon eggs) are in danger of "de-watering" during dry years. June through September are critical months for juvenile salmonids (Higgins, personal communication). From December through March salmonids go through incubation and emergence, followed by emigration from February through May. Rearing occurs throughout the year (PG&E Interim report 1/12/2001, p. I-3, I-5). Consequently, one or more of these stages occurs throughout the year. For coho as many as five of these stages can be taking place during a single month.

It is important to consider how flows that diverge from natural flow patterns affect each of the life cycle stages of salmonids. Salmonids have evolved over millions of years in response to the ecosystems in which they live, including the rainfall patterns. How do the changes in the natural pattern of Eel River water flows affect the health and abundance of salmonid populations?

Consider the following:

> "Upstream movement [of chinook] can be delayed by inadequate flows in the mainstem. In this case chinook hold in large pools below limiting riffles awaiting storm-induced flow changes. During periods of low flow salmon are very susceptible to predation and angler harvest. In years without significant precipitation, the run may be limited to lower portions of the drainage" (PG&E 1996).
>
> "In years with abundant water, fish move higher into tributaries to spawn. Conversely, in years with extended periods of low flows chinook are often limited to spawning in lower mainstem portions…" *(ibid).*
>
> The positive response of fish to pulse flows has been well documented. Goodson (1969) stated that "even with sufficient streamflow for migration it may be necessary to provide stimuli to induce upstream migration."

A succession of storms naturally creates "pulse flows." Storage of water in reservoirs during rainy months and diversion of water both contribute to altering natural "pulse flows."

> "The pulses which do occur (during significant releases from the dams) are often out-of-synch with the natural occurrence of pulses…in undisturbed waterways and thus confuse the migratory behavior of the salmonids. In winter 1995, for example, artificial peaks—associated not with storm events but with mismanagement and technical problems at the PVP…misled large numbers of chinook salmon (seeking their natural spawning grounds in Tomki and Outlet Creeks) to the Van Arsdale ladder" (CalTrout 1996, p. 13).

On the other hand,

> "Spawning below [PVP] may put chinook eggs and fry in greater risk of injury during high flows" (PG&E, 1996).
>
> "Reduced minimum flows in January could adversely impact the spawning success of chinook by dewatering redds" *(ibid).*

Consequently, lower flows and other alterations from natural flow patterns would tend to exacerbate the tendency for fish to spawn in lower portions of the river. If such lower flows persisted, such lower flows would reduce spawning habitat. If, in addition, habitat in these lower portions of the river were degraded or destroyed, habitat for spawning would be even further reduced.

Overall, in addition to lower Eel River water flows, changes in the *pattern* of flows also can affect salmonids throughout the year.

In answer to the question "How well can a regulated water release regime mimic natural flows?" fisheries biologist Patrick Higgins' answer is "It can't."

Many of the impacts on fish during their different life cycle stages below the PVP dams arise from both reduction in water flow and changes in the patterns of water flow compared to the quantity and pattern of natural or unimpaired water flows to the main stem of the Eel River.

In addition to these impacts, "Headwater riparian zones need to be protected, so that when debris slides and flows occur they contain large wood and boulders necessary for creating habitat further downstream" (FEMA 1993, p. V-29). The PVP dams have blocked the natural movement of materials of different types and sizes from passage below the dams. Removal of these dams would allow for the eventual restoration of this natural movement of materials.

The above-mentioned change in temperature between Scott and Cape Horn dams and "delay in juvenile chinook salmon downstream, seaward migrations" have implications for fish below Cape Horn dam.

> "The delay may result in juvenile chinook salmon encountering marginal or lethal water temperature as they migrate through downstream reaches of the Eel towards the ocean. Over half the mainstem and tributary channels can be considered thermally lethal during some portion of the summer (Kubicek 1977), however prior to cumulative human impacts, large populations of anadromous salmonids flourished in the Eel River" (DFG 2001, p. 56).

iii. Pikeminnow *(Ptychocheilus grandis*, Sacramento squawfish)

"*Ptychocheilus grandis* (also commonly known as Sacramento squawfish) may pose a significant risk to the salmon and steelhead resources of the Eel River" (Brown and Moyle, in Steiner). *P. grandis*, a large predatory minnow native to the Sacramento-San Joaquin and Russian River systems (Moyle 1976 in Steiner 1996), was probably introduced to Lake Pillsbury in the late 1970s, with juveniles first being captured at the Potter Valley powerhouse in 1980 (VTN 1982, in Steiner 1996, p 5.11.1).

"*P. grandis* prefers large pools in low-velocity riverine habit, but will also inhabit reservoirs" (Cech *et al.* in Steiner, *ibid).*

Steiner describes the extent of the pikeminnow problem, noting that:

> "Conditions in many main channel reaches of all forks [of] the Eel River appear to favor *P. grandis* over salmonids during certain periods of the year…The rapid establishment of *P. grandis* is believed responsible for a significant decline in steelhead rearing densities in the mainstem Eel River between Cape Horn…and Scott dams, a condition which likely effects [sic] adult escapements." (Steiner 1996)

> "Predation is likely to pose the greatest risk to the salmonids during years with lower spring flows, warmer water temperature, and low adult salmonid escapements." *(Ibid.)*

> "At the Potter Valley project, both Lake Pillsbury and the Eel River between Scott and Cape Horn dams provide favorable habitat for *P. grandis*. Prior to the introduction of *P. grandis*, these locations both provided important salmonid habitat. Now, both areas have demonstrated significant salmonid declines, and Lake Pillsbury is believed to provide a continuing source of juvenile *P. grandis* to the river below." *(ibid.)*

According to fisheries biologist Pat Higgins, if the PVP dams were removed and natural flows restored, the Eel River system could equilibrate to a condition in which pikeminnow would be a reduced threat to Eel River fish populations.

e. Overall Contribution of the PVP to Loss of Fishery Resources

The part of the Eel River most immediately affected by the PVP, from Outlet Creek to Lake Pillsbury, drains 528 square miles, which is 14.3% of the entire Eel River watershed. Considering, as noted above, that over 100 miles of spawning habitat have been lost due to PVP, that an average of 36% of natural water flows has been diverted from this area over a 94-year period, that the monthly average diverted approaches 90% in July, that water temperature and flow conditions detrimental to spawning have been created, and that the PVP has been the source for introduction of the invasive pikeminnow which has depleted native fish populations, PVP's contribution to the loss of value of Eel River fishery may be proportional to the area of the Eel River immediately affected by PVP, i.e. 14%. Applying this 14% to the Institute for Fisheries Resources estimate of the value for the entire Eel River fishery results in an annual value exceeding $5 million. This amount is consistent with the Humboldt County Natural Resources Department 1977 estimate (expressed in 2002 dollars) of annual losses due to the PVP.

f. Some Relevant Fish Prices

To appreciate the economic value of commercial and sports fishing, the following is useful to note:

- Smoked salmon's wholesale price is $60-$80 per pound. For a fish yielding ten pounds of smoked salmon, that would be $60-$80 per fish (for further discussion of fish prices see Appendices E and F).
- Ocean sports fishing boats charge $60 per person per 5- to 6-hour trip.
- A study on recreational fishing in the Central Valley found that the average expenditure per fish is about $106-108.
- River guides charge $300 per day.

The decline in the market value of the Eel River fisheries can be seen in the great reductions in sports fishing on the Eel and in both ocean sport and commercial fishing of salmon off the California coast. For example, coho, as a listed threatened species, cannot be taken in the Eel, i.e. the "bag limit" of coho on the Eel is zero, leaving only catch and release possibilities. In particular, if the PVP dams were decommissioned, sports fishing opportunities below the current Cape Horn dam and between the Cape Horn and Scott dams would be enhanced. In general, opening up of spawning habitat and an increase in salmonid populations would contribute to restoring sports and commercial fishing opportunities throughout the Eel River system as well as off the north coast of California. Also it should be noted that in addition to fees paid to river guides and other direct expenditures by those from outside the Eel River basin who sport-fish, there are additional "multiplier" effects. I.e., for every additional dollar spent by a non-resident of the Eel River basin, there could be cumulatively 25 cents more added as that additional "injection" of income circulates through the local economy (based on California Trade and Commerce Agency multipliers for fishing and lodging in Humboldt County).

2. Other Market Values — Rafting

Boaters on the Eel River

Regular commercial rafting trips on the main stem of the Eel below Cape Horn Dam began over fifteen years ago (unless indicated otherwise the following information is based on personal communication with Jaimie O'Donnel, Aurora rafting company). A rafting party of 25 people for four days generates revenues of $10,000. Rafting trips are limited by the mainstem Eel River water flow. Trips can be conducted when water at the confluence of the Middle Fork and main stem of the Eel is above 600 cubic feet per second (cfs). Flows can drop below 500 cfs during May and June. Prior to May, weather conditions for commercial rafting trips are not suitable for most people's preferences. It should be noted that some people will raft in inclement weather and that rafting trips are conducted in the Grand Canyon even in the winter. Restoration of natural flows at Cape Horn Dam to the main stem of the Eel, i.e., average monthly flows of 426 cfs instead of 189 cfs in May, and 153 cfs compared to 29 cfs in June, would tend to ensure flows of greater than 600 cfs at the confluence of the Middle Fork and the mainstem and thereby allow rafting trips through mid-June. Although the average flow in June is only 29 cfs, flows decline during the month of June, so the flows during the first half of June are higher than 29 cfs. This improved reliability of rafting would greatly reduce the possibility of trip cancellation and thereby improve the attractiveness of rafting on the main stem of the Eel River. Consequently, rafting could be consistently offered from the beginning of May through mid-June.

There is a 46-day period from May 1 through June 15. It is estimated that as many as 10 rafting parties could be started each day without congestion. If so, the maximum number of rafting party trips during this period that could be supplied without congestion would be 460.

On the demand side, it is useful to note that commercial rafting on the Trinity River increased eight-fold within a decade (from 500 river days to 4000 river days). Rafting trips on the main stem of the Eel River begin at a point which is approximately half the distance from the San

Francisco Bay area compared to rafting trips on the Trinity River. In addition, the main stem of the Eel River is within 100 miles of large populations in Mendocino, Sonoma, Napa, and Marin counties, whereas Trinity River rafting has no similar-sized populations situated so close. The potential for rafting on the Eel River may be better compared to a river closer than the Trinity to an urban center—for example, the Rogue River, which is relatively easily accessible to the Portland metropolitan area. The above observations are a basis for expecting that the number of rafting trips *demanded* on the main stem Eel River could eventually equal the maximum rafting trips that could be supplied at the current price.

A conservative estimate of only five additional 25-person rafting parties commencing each day implies 230 additional rafting trips during this 46-day period, generating $2,300,000 dollars in rafting trip revenue. Two hundred and thirty rafting trips with 25 people each equals 5,750 people. If, on average, each person stayed an additional day in the Eel River region and spent a total of $100 per day on food, lodging, and other expenses, these expenditures would equal $575,000. Combined with the rafting trip expenditures, this results in a total of $2,875,000. Using a regional multiplier of 1.25, the total impact on the local economy would be $3,593,750. For 10 trips commencing a day, the total economic impact would be double this or $7,187,500 a year. These estimates are for an extended period of 46 additional reliable rafting days; growth of Eel River rafting to this level during this May–June period would likely increase the amount of rafting in the earlier months as well.

Finally it is worth noting that river rafting has increased greatly over the past two decades. Although rafting on the main stem Eel River has also grown during this period, its growth has been constrained by the reliability of flows during May and June, which are better suited for rafting than the preceding months. Had reliable flows existed over the past two decades, it is likely that rafting on the Eel could have grown faster and to a much higher level. Consequently, not having reliable flows has depressed rafting trip revenues to the Eel River area over the past two decades.

3. Market Values Lost

Currently the Eel River basin may suffer economic market-valued losses of more than $5 million annually, not including losses in consumer surplus (for further discussion of consumer surplus, see Appendix G). Over the ninety-four years since the start of the PVP, the present value of the cumulative losses totals in the hundreds of millions of dollars (for further discussion of present value considerations, see also Appendix G). Although pre-development-sized runs may not be seen again, potential market-valued benefits from restoration of natural water flows to the Eel are still very significant. In addition to increases in sustainable commercial fish harvests, sports fishing and rafting possess great and increasing market values, which are compatible with a naturally flowing river.

4. Intrinsic or Non-market Values

As economist Ernie Niemi of EcoNorthwest puts it, “A person doesn’t have to eat a fish to value it.” In a report included here as Appendix F, Niemi explains:

> “One carefully conducted survey of the residents of Washington and Oregon found that they place a substantial value on restoring and maintaining healthy salmon populations,

saying that, on average, they are willing to pay about $30–97 per household, per year, to protect salmon. Although some percentage of this expression of value reflects a desire to secure salmon for the commercial and recreational fisheries, a considerable portion is linked to a desire to protect salmon for their intrinsic characteristics.

"At first glance, it may seem that these amounts are beyond what Californians would be willing to pay to protect this state's salmon. On reflection, however, they appear more reasonable. Californians have been national leaders in recognizing the economic value of protecting the state's natural treasures, and they repeatedly have backed up their words with actions demonstrating their willingness to bear the costs of protecting parklands and other components of the environment.

"Perhaps their willingness to pay for actions to protect salmon is at the low end of what was found in Washington and Oregon—$30 per household per year. If so, multiplying this amount times 5 million households in northern California suggests a total intrinsic value placed by residents of the region on protecting and rebuilding salmon populations of $150 million per year."

"The Eel River likely supports the largest remaining native coho salmon population in California" (California Department of Fish and Game 2001). Because of this and the listing of coho salmon under both federal and California endangered species laws, it would seem reasonable that Eel River salmon would make up a significant portion of the total intrinsic value of salmon for all residents of California. (For further discussion of intrinsic value, see Appendix H.)

5. Resources of Value to Native American Tribes

California Indian Legal Services (CILS) stated in their 1999 comments to FERC that "The [Federal Energy Regulatory] Commission must protect resources of value to the [Round Valley] Tribes, such as the Eel River fishery on which the Tribe relies for the exercise of statutory and federally reserved fishing rights." The Round Valley Indian Tribes have stated that "FERC has already allowed PG&E to do tremendous damage to the Eel River fishery and has squandered the opportunity to help reverse that damaging trend by allowing PG&E to conduct a study to examine its own impact on the fishery" (comment on Draft Environmental Impact Statement).

CILS in their comments also argued that the "no-project" option or natural flow of the Eel River is the baseline for measuring the impact of the Potter Valley Project's diversion of water from the Eel. Native American opportunities for fishing have been greatly diminished, for example, by the above-mentioned loss of over 35 miles of chinook salmon spawning habitat because of Scott Dam, and over 55 miles of habitat lost to steelhead. "Because the PVP blocked passage of salmon to the upper watershed, [Native American] tribal members were no longer able to secure their sustenance from the Eel River's once-abundant salmonid fishery" (Volker 1999).

Economist Philip Meyer notes that "Indian elders link the survival of salmon with survival of their tribe as a people." Moreover, traditional elders value water, air, sun, and land as the four life-givers on which all living things—all humans, all plants, and all animals—depend. Although placing a dollar amount on resources of value to tribes (including spiritual values related to salmon and water) is inappropriate and inadequate, such resources are, nonetheless, real values that need to be fully recognized and acknowledged.

B. Russian River Costs and Benefits

1. PVP Hydroelectric Power Generation

Reports indicate that the power plant has generated as much 9.5 megawatts (MW) at 337 cubic feet per second (cfs). The diversion tunnel in 1950 was modified to allow diversion of 400 cfs, but in practice the maximum diversion has been approximately 360 cfs. "Typically [the PVP power plant]…produces 9.2 MW at a flow of 325 cfs (Steiner 1996). Though this level is near the maximum electrical production possible from this facility, due to restrictions on water flow available to the power plant, it does not operate continually at peak capacity. For example, during the exceptionally dry 12 months from Oct. 1, 2000, to September 30, 2001, the gross generation by the Potter Valley powerhouse was 26.4 MW. This is only 32% of the maximum capacity of the facility (if the facility were operated at peak capacity continually for a year, i.e., 9.5 MW x 24 hrs x 365).

The average PVP powerhouse water flow for the water years 1990 to 2000 was 172,195 cfs or 60% of the flow associated with peak electrical generation. If annual flow is linearly proportional at a 1 to 1 ratio to annual power generation, i.e., if 1/3 of the flow associated with peak electrical generation results in generating 1/3 of peak capacity annually, and if 1/2 of the flow is associated with generating 1/2 of peak capacity annually and so on, then with the 1990 to 2000 average flow, these calculations suggest that the PVP operated during this period at approximately 60% of maximum capacity and produced 48,264,247 kilowatt hours (kwh) of electricity.

If electricity can be sold wholesale at \$.07 a kwh, then the above amount of electricity could be sold for \$3,378,497 (see Appendix I for discussion of current and future wholesale price of electricity).

The minutes of the August 18, 1998, Joint Study Session with the Board of Public Utilities and the City of Santa Rosa state that

> "Mr. [Miles] Ferris [Board of Public Utilities staff member] discussed the impacts of PG&E getting out of the power production business… He states that between now and the year 2023 the project will require a large sum of money…The project costs between \$200,000 to \$400,000 a month to operate. Those costs do not include capital funds."

Multiplying \$200,000 to \$400,000 per month by 12 months equals \$2.4 million to \$4.8 million per year with a mid-point of \$3.6 million, which as indicated above does not include capital funds. Repair and maintenance costs of the PVP tunnel and the extensive fish ladder equipment are significant. In any case, the above mid-point estimate for costs of \$3.6 million exceeds the above \$3.4 million estimate for benefits, suggesting a net annual loss for the PVP hydroelectric facilities.

The above revenue and cost estimates support the statement made in the Sonoma County Water Agency's *Allocation of Water Supply Benefits of the Potter Valley Project* Report: "…the project is not economic as a hydroelectric project" (SCWA, 2000, p. 1).

The economic value of the PVP hydroelectric operation would be the amount that a fully informed rational operator would pay to acquire it. If the operation had annual total costs in excess of annual total revenues, no rational operator would agree to acquire it, even at a zero price, and its economic value as a hydroelectric operation would be zero.

2. Benefits and Costs of Water Diverted from the Eel River for Use in the Russian River Basin

Estimation of benefits and costs of water diverted from the Eel River for use in the Russian River basin implies a baseline or reference point. Following are summaries of three different attempts at estimating benefits and costs associated with water diverted from the Eel River for use in the Russian River basin:

i. the Sonoma County Water Agency (SCWA) *Apportionment of Benefits from Eel River Water;*

ii. the FERC FEIS estimate of costs associated with different minimum water flow alternatives; and

iii. the Input-Output Analysis performed by Northwest Associates for SCWA regarding minimum water flow alternatives. Following these summaries is a discussion of a more comprehensive approach to estimating such benefits and costs.

a. Review of Some Previous Approaches

i. SCWA Apportionment of Benefits from Eel River Water

Although many entities and individuals derive their water supply from the Russian River, those that directly benefit from water diverted from the Eel River by the PVP have been categorized into three groups by the SCWA (SCWA, 2000):

1) Potter Valley Irrigation District (PVID);
2) Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCID); and
3) Sonoma County interests including the Alexander Valley and the Sonoma County Water Agency (SCWA) Water Transmission System.

This SCWA study concludes that PVID, MCID, and Sonoma County interests each receive one-third of the water supply benefits of PVP. Furthermore, it concludes that one-third of the Sonoma County water supply benefits go to the Alexander Valley (or 1/9th of the total benefits) and the remaining two-thirds or two-ninths of the total benefits are enjoyed by SCWA.

For the three categories of users described above, the main impact of removal of the PVP dams would be a reduction of water availability during drier months, approximately April 1 to mid-November, with the greatest impact usually occurring in the later portion of this period, particularly during years of below-normal rainfall. (For further discussion of water use in the Russian River basin, see Appendix J.)

Each of these three categories is described in more detail below.

Potter Valley Irrigation District

PVID is a special district formed in 1952. Its five-member elected board, which meets monthly, governs the district. It employs three permanent employees and usually four additional seasonal employees during the summer. The district consists of sixteen miles of canal, 85 main control gates, and 700 service gates to private properties (Grand Jury Report, 1999). During the most recent election, elected PVID directors received approximately 100 votes.

PVID is a "small district" providing irrigation for "6,000 acres," "about half in pastures and the rest in viticulture and orchards." The district has 300 customers. "Last year it used 18,000 acre-feet of water" and is "contracted for 19,000 acre-feet with up to 23,000 acre-feet possible." It has a license for 50 cfs of water from April to November 15 for irrigation and stock watering. It charges its customers $4.50 per acre-foot, billed annually. PVID buys its water from PG&E at $1.20 per acre-foot (personal communication with Steve Elliot, Superintendent PVID, Nov. 29, 2001). Thus it costs PVID $22,800 for the 19,000 acre-feet it purchases from PG&E. PVID sells this water to customers for $85,500, leaving $66,700 for operating costs, maintenance, and capital expenditures.

Mendocino County and Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCID)

Water supply and water rights in Mendocino County appear to be complex. "There are 45 purveyors of water in Mendocino County, 14 of whom are county or city water districts. Of the remainder two are California water districts, while the other[s] are private water companies, mostly formed to serve specific land development projects" (Mendocino General Plan).

According to Paula Whealen, a water rights specialist, in a presentation to the Ukiah City Council on January 16, 2002, " …at the time Lake Mendocino was constructed…8,000 acre-feet of the water behind Lake Mendocino was reserved for uses in Mendocino County. Part of that water is for the uses of the City of Ukiah…[and other entities who] are diverting water that is the natural flow of the Russian River and are probably diverting some of the Eel River import."

"[Redwood County Water District also] obtains water from Lake Mendocino through an agreement with the Mendocino County Russian River Flood Control and Water Conservation Improvement District, however the agreement limits Redwood Valley to surplus water, which may not exist during dry years." (Mendocino County General Plan)

Sonoma County interests

Alexander Valley

The Alexander Valley is the long and relatively narrow valley in Sonoma County extending northeast from Healdsburg toward Cloverdale and the Sonoma-Mendocino county line. Many vineyards and wineries are located in the Alexander Valley. Alexander Valley's benefit is one-ninth of the total benefit.

Sonoma County Water Agency

SCWA…is a special district created…[in] 1949 and operates under the direction of a Board of Directors composed of the members of the Sonoma County Board of Supervisors. SCWA "is the primary provider of potable water for approximately 325,000 people in Sonoma County and northern Marin County. The Agency also provides supplemental potable water to another 170,000 people in the Marin Municipal Water District (MMWD) service area." "[SCWA] contractors consist of the cities of Cotati, Petaluma, Rohnert Park, Santa Rosa, and Sonoma; and the Forestville Water District, the North Marin Water District, and the Valley of the Moon Water District."

"The average annual demand on the aqueduct system for the three fiscal years ending June 30, 2001, was 61,646 acre-ft (this excludes 377 acre-ft/yr of sales of surplus water and 2,500 acre-ft per year of assumed aqueduct system losses). In FY 2001 aqueduct deliveries to all customers total 62,023 acre-ft." (SCWA 2001, Q&A)

ii. The FERC FEIS Approach to Costs of Minimum Flow Alternatives

The FERC Final Environmental Impact Statement (FEIS) analyzes the costs to agriculture of different proposed minimum flow alternatives: the no action, Sonoma County Water Agency (SCWA), Round Valley Indian Tribes (Tribes), Department of Interior (DOI), and Potter Valley Irrigation District (PVID) alternatives. The analysis used the Russian River System Model developed by SCWA. This model simulated the different minimum flow alternatives for the actual rain patterns over a 21-year period covering 1975 to 1995 (FERC 2000, p. 4-95). Also a "critically dry" year was modeled, as was a "year 2020 scenario" in which water use requirements were increased and sedimentation conditions changed in the reservoirs. The cost estimates generated were based on the amount of water curtailed, the response of crop yield to water for irrigation, the number of acres for different categories of crop, and the price per ton of these crops. An array of costs was estimated for the four different locations considered--the East Fork, West Fork, Upper, and Middle Russian River--under the different minimum flow alternatives and the different simulations. For the "Proposed Action" alternative, "For users in the Upper Russian and Redwood Valley, crop losses are approximately $110,000 (0.2% of modeled crop value) over and above the modeled losses under no action. For the critically dry year (1977), there are no modeled crop losses relative to no action" (FERC, 2000, p. 4-110). The FEIS notes that there is

> …no mitigation assumed in the analysis (i.e., no change in irrigation practices to deal with curtailment, no change in the types of crops grown or acreage under irrigation, no use of groundwater to offset curtailment, and no change in management practice to mitigate reduced

irrigation deliveries). Because no mitigation is assumed, the calculated crop losses may tend to overstate the actual or realized losses in crops. (FERC 2000, p. 4-101)

iii. SCWA – Northwest Associates Input-Output Approach to Estimating Costs

SCWA analyzes regional economic and employment impacts of flow regimes through use of a particular input-output model, IMPLAN used by Northwest Economic Associates of Vancouver, WA. Impacts estimated are for a "one-year change in water supplies and in the outputs which are affected directly by that change….it is not possible to state whether the total impacts after a second year of reduced water supplies would be more than, less than, or equal to the initial year total output impact. The reason is the dynamic nature of the economy and the adjustments which occur over time as the economy responds to changing conditions." (Northwest Economic Associates 1998, p. 62)

The limitations of this Input-Output approach to estimating are discussed further by Niemi (2002). He notes that:

> The report (1) fails to consider the economy's ability to adjust to a change in stream flows; (2) ignores the positive impacts on the economy resulting from the change in stream flows, (3) fails to consider non-market responses (especially those related to self-supplied recreation and quality of life) to the change in stream flows, and (4) fails to anticipate the applicability of economic trends and tools that could mitigate the negative impacts of any actual reduction in the supply of water for irrigation and other uses. (See Appendix K.)

b. A More Comprehensive Approach to Understanding Benefits and Costs of Water Diverted from the Eel River for Use in the Russian River Basin

A basic problem with the use of water diverted from the Eel River is that it is obtained essentially at a zero acquisition price. PVID pays PG&E $1.20 per acre-foot for its annual 19,000 ac-feet of water. Other beneficiaries pay no price for *acquisition* of water diverted from the Eel River. Beneficiaries may pay a price to a water supplier, but since that price (except for PVID) does include a price for acquiring the water per se, any charge for water obtained presumably equals only the costs connected with delivering the water to the purchaser.

In economic terms, in the case of water diverted from the Eel River, property rights are not clearly defined and there is a "missing market": in other words, there appears no initial "owner" of Eel River water who has a property right to that water and who can sell that water, if it chooses, to a willing buyer. If such a property right to Eel River water were defined, then those who wished to use water diverted from the Eel River would have to pay a price for the water used.

This situation is further complicated by the fact that water utilities generally are considered natural monopolies and

> …to prevent monopoly pricing, price regulation has generally been applied. However, this regulation tends to generate several forms of resource misallocation or inefficiency. These include: 1) allocative inefficiency caused by poorly designed rates; 2) cost inefficiency caused by the lack of incentives to minimize water provision costs; and 3) regulatory

inefficiency caused by failure to weigh costs against benefits in allocating regulatory resources (Mann 1993, p. 2).

Had any prices paid for water by users of water diverted from the Eel River included all the environmental and other costs of this diverted water--for example, to Eel River fisheries and Humboldt County--economic theory indicates that less water would have been used and the water used would have been used more efficiently.

Externalities, though, are not considered in the pricing of water diverted from the Eel River. If the water were owned by those affected by these externalities, the acquisition price would allow for the externalities to be internalized. Since externalized costs are not internalized into a water acquisition price, water diverted from the Eel River through PVP has been underpriced and in many cases proved "free" (of acquisition price) to users. Consequently, in this case, well-established economic theory recognizes that there will be "over-consumption" from the viewpoint of society. Because of this over-consumption, the size of operations that use this water will be too large and the methods by which the water is used will be socially inefficient. In addition, the type or mix of uses will tend to diverge from what is socially desirable.

In a sense Russian River basin users of Eel River water can be seen as having had their use of Eel River water subsidized for almost 100 years. Individual enterprises and the Russian River regional economy have developed based on such subsidized water. ***The cessation of such subsidized water would not be a cost, but rather a removal of an unwarranted benefit.*** It might be argued that individuals and enterprises in the Russian River basin could have purchased assets such as land with the assumption that continued use of water diverted from the Eel River came with those assets. But access to that water is contingent on FERC licensing, and that licensing is constrained by the objective of protecting and maintaining Eel River fisheries. FERC also reserves the right to require changes in the project works or operations that may be necessary to protect and enhance the environmental resources and values of the project area. And also FERC may modify or terminate the license in light of final disposition of litigation (FERC 2001, p. A7). So though individuals or enterprises may have assumed such continued availability of water diverted from the Eel River, given the contingent nature of FERC licensing there is no necessary reason for that assumption to hold in all cases.

One way the benefits of water diverted from the Eel River could be estimated is to compare the current economy of the relevant Russian River basin with what that economy would have been like without Eel River water. The difference could be taken as the cumulative benefit of water diverted from the Eel River to the Russian River basin. If the cost of alternative sources of water to substitute for Eel River water were high, then the cumulative benefits of Eel River water would be high for the ninety-plus years that Eel River water has been diverted to the Russian River.

But even the above comparison between Eel River and Russian River benefits neglects a key aspect of the situation. To focus on this neglected aspect, consider the case where a person "appropriates" the use of a neighbor's car for a considerable time. It would be inappropriate to simply compare the benefits to the original owner had the car not been appropriated to the benefits gained by the person appropriating the car. Conceivably the person appropriating the car might have even gotten more use from the car than the original owner; this, though, would not diminish the need for the "appropriator" to compensate the original owner.

In addition, if the car were appropriated for a long time, say for several years, the appropriator might have made decisions based on the "freely acquired" car; the appropriator might drive more and might, for example, even relocate further from work, or take an extra vacation by car. The appropriator having to give up these benefits if the car is returned would not be the basis for over-ruling the return of the car to the original owner and/or denying compensation for loss of use. The purpose of raising this particular analogy is to focus on how analysis of the benefits and costs involved in this case is not simply a matter of comparing the benefits lost to the Eel River basin to the benefits gained by the Russian River basin from use of Eel River water.

c. Alternative Water Sources

Professional geologist Robert Curry has detailed "several groups of options for meeting the [Russian River basin] water demands in lieu of the Potter Valley Diversions" (Curry 1999, p 9). "The most promising for upstream sites as well as some Middle Reach sites is increased use of groundwater. The next largest source of untapped water is Lake Sonoma…" *(ibid.)* Specifically regarding groundwater development Curry notes:

> At present, nearly 1.1 million ac-feet of water in the Russian River system is untapped, and most passes to the sea in the winter. In the past before the incision of the Russian River in the Ukiah, Alexander Valley, and Middle Reach areas, less water would have been "lost" from the system because more would have recharged groundwater during winter flood periods…Today, winter flow peaks are higher than in the past, due primarily to the inability of the River to access its flood plains to store winter flows and to recharge groundwater. *(ibid.)*

Furthermore, Curry notes:

> I have concluded a preliminary analysis of the volumes of water that could be restored to beneficial use and that could enhance anadromous salmonid habitats in the Russian River. If the Potter Valley Project were to be decommissioned, one source of water to provide for the missing summer diversions in the Russian River Valley would be this restored groundwater. Costs of such a project would be substantial but the benefits to long-term fishery sustainability, local economic sustainability, and availability of water to supply the needs projected by the SCWA for dry-year conditions through the year 2015 are also substantial.

If the alternative water supply sources that Curry proposes are the least costly alternatives, the difference between their cost and the cost to users of water diverted from the Eel River can be considered the amount that Eel River water users have been subsidized over the ninety-plus years the PVP has been in operation.

Another way to estimate benefits and costs is to consider the difference between what is currently charged to users of water diverted from the Eel River and what that charge might be if it reflected a cost for acquiring that water. For example, the Metropolitan Water District of Southern California charges $431 per acre-foot for treated water, while SCWA charges less than $400 per acre-foot. Assume for the sake of illustration that $30 were the cost per acre-foot for acquiring water diverted from the Eel River. Then, with this illustration ***the historic 160,000 acre-feet diverted from the Eel per year would have a total acquisition cost of $4,800,000 per year.***

For purposes of comparison it may be useful to note that:

In 1983 Warm Springs Dam and Lake Sonoma were completed for a cost of $360 million. Operation and maintenance were $1.1 million per year in 1995. Cost of operation and maintenance of fish hatchery and campgrounds is $2 million per year. Debt service will reach $6.3 million per year by 2007, and the debt runs to 2035. In 1993 SCWA contracted with United States for construction of the Warm Springs Dam Project for $99,427,000 plus interest in annual payments between 1993 and 2034 for the reimbursable costs of the water storage element of the project. In regard to Coyote Dam/Santa Rosa Aqueduct, under 1955 Water Transmission Bonds A thru F the total payments by 1994/5 total $24,413,292. (Environmental Center of Sonoma County)

The above suggests that the Russian River area has been willing and able to commit to multi-million-dollar water projects. Why has a major groundwater management strategy not been implemented? One stumbling block appears to be the lack of adjudicated water rights in the Russian River basin. A public water agency that incurred capital expenses in increasing groundwater resources would need to be able to charge others who might make use of such increased groundwater resources. Such an ability to charge is essential for the revenue bonds that would be needed to finance such groundwater management improvements. That this stumbling block may exist at present is no reason, though, to assume that it will always exist or that it is a justification for not pursuing economically-efficient alternative sources to replace water currently diverted from the Eel River.

In 1998 an appraisal authorized by Congress suggested that raising Coyote Dam for increased water supply and flood protection was economically feasible. "The current interest in this raising comes from the Mendocino County Russian River Flood Control District." In 1998 Congress authorized $100,000 for a Reconnaissance Study of this issue (http://www.spn.usace.army.mi l/projects/mendocinoo&m.pdf). Further research into this subject could reveal the amount water supply would be increased through this project and estimates for the cost. Such information could be used to estimate avoided costs to the Russian River basin due to operation of PVP.

d. Some Benefits of Restoring Natural Water Flows to the Russian River

Currently a significant portion, approximately 10%, of Russian River water results from diversion of water from the Eel River (DEIS, p. 3-598). Prior to 1908, the Russian River typically was dry during summer months. Somewhat counter-intuitively, though, diversion of Eel River water to the Russian River may have adversely affected Russian River salmonid populations.

> Russian River water management and habitat disturbance have worked in concert with the introduction of exotic species to cause major shifts or declines in fish populations throughout the [Russian River] basin. Possibly the most critical feature of the altered hydrograph is the increased summer flows....After the Eel River diversion and the

> construction of the Coyote Dam, mainstem [Russian River] summer flows increased 15 to 20 times. Contrary to expectations, increased summer flows actually decreased salmonid rearing habitat [in the Russian River] by inundating cover and increasing water velocities. (Steiner 1996, p. 3.3-1)

As noted earlier, "Today, winter flow peaks are higher than in the past, due primarily to the inability of the River to access its flood plains to store winter flows and to recharge groundwater." It is important to emphasize that "This creates great social cost to lower Russian River residents who are flooded far more than in the historic past, and to individual water users along the river valley throughout the watershed who have less groundwater that must be pumped from deeper levels with decreased water quality." (Curry 1999, p. 10)

> To achieve the increased bank and overbank storage of groundwater derived from the Russian River and to increase the retention of winter rainfall recharge in the valley-bottom areas, it will be necessary to restore the historic Russian River channel bed elevations. By increasing overbank recharge into the floodplain, we also increase the summer base flow that is derived from natural river banks through percolation through a well-watered riparian community that is supported by this process. This enhances summer recreational use and replicates natural flow regimes that support anadromous fish reproduction and movement. (*Ibid.,* p. 11.)

Flooding in the lower Russian River area, it is argued, is partially attributable to the augmentation of Russian flows by Eel water (California Trout 1996).

The point of the above is that developing water supply alternatives and ceasing augmentation of Russian River flows by Eel River water may have benefits, such as reducing flooding, increasing the quantity and improving the ease in pumping groundwater, enhancing summer recreational use, and benefiting anadromous fish populations by replicating Russian River natural flow regimes.

C. Other Costs and Benefits

Decommissioning of the PVP dams would entail expenditures. The accumulated silt in the reservoirs would need to be managed to minimize damage to the river below if the dams are removed. Terracing and a 20- to 30-year transition period have been suggested. Exactly who will bear financial responsibility associated with this aspect of decommissioning is not known; financial responsibility could, for example, reside in the current or a future owner of the FERC license. These issues need to be clarified and resolved. In any case the current FERC license expires in 20 years and the option of decommission is clearly one of the possible options and as such warrants further study and consideration. (For a listing of suggestions for further research, see Appendix L.)

Summary

This preliminary draft explores some of the dimensions of the benefits and costs of restoring natural water flows to the Eel River, including:

- How the Eel River salmonid fishery has precipitously declined from pre-PVP annual runs of over half a million, and how the annual value of such a fishery reaches into the tens of millions of dollars.
- How restoration of natural water flows to the Eel River has the potential of adding over $2,000,000 to the Humboldt County economy annually through increasing river rafting operations on the main stem of the Eel River.
- How economic losses or potential annual gains to the Eel River basin could be over $5,000,000 a year in relation to fisheries alone.
- How cumulative economic losses to the Eel River basin over the 94 years since construction of the PVP are in the hundreds of millions of dollars.
- How non-market values are recognized by economists as significant when considering the value of salmon.
- How resources of value to Native American tribes are real values that need to be fully recognized and acknowledged, whether or not a dollar value is attached.
- How the PVP hydroelectric facility may not be an economically feasible operation and as such would have a zero asset value.
- How water diverted from the Eel River has been obtained largely at a zero acquisition price and how this has promoted over-consumption and socially inefficient use.
- How water diverted from the Eel River can also be considered as having been subsidized because of the externalized environmental and other costs associated with diversion of Eel River water.
- How payment as small as a $30 per ac-foot charge for acquisition of water diverted from the Eel River would total nearly $5,000,000 per year.
- How alternative water supply to the Russian River basin exists that can substitute for Eel River water.
- How restoring natural water flow regimes to the Russian River may have benefits, such as reducing flooding, increasing the quantity and improving the ease in pumping groundwater, enhancing summer recreational use, and benefiting anadromous fish.

When taken together the above suggests how the benefits of restoring natural flows to the Eel River may outweigh any "costs" of restoring such natural flows. A fuller and more conclusive quantitative analysis is beyond the scope of this preliminary study. This should be the focus of a full Environmental Impact Statement formally considering decommissioning, i.e., removal of the PVP dams from the main stem of the Eel River, as a legitimate option.

In the distant past, it may have appeared to make economic sense to some people to dam the Eel River and divert water to the Russian River basin. But such a view is not tenable today. Now,

there is ***no economic sense in extending the operation of out-of-date electric generators and the subsidies to some users of scarce, valuable water.***

In the final analysis the issue is not between benefits to the Eel River system and costs to the Russian River system. For nearly 100 years in both these two river systems, "human-constructed" capital values ranging from irrigated orchards to housing developments have been promoted while the "natural capital" values of both river basins have been degraded. Similar processes have been occurring worldwide. There is growing scientific evidence that ecosystems, which are under increasing stress throughout the world, are susceptible to relatively sudden collapse (Scheffer *et al.,* 2001). Society is faced with crucial choices regarding the PVP; the fate of the Eel River and the life it supports hangs in the balance. In a larger sense, though, restoring natural water flows to rivers is part of the larger necessity of restoring humans themselves to balance with the natural world on which all life depends.

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APPENDIX A: BASIC INFORMATION

Eel River

The Eel River Basin comprises 3,684 sq. miles (DFG, 1997)

The Eel River is the third largest river in California

The Eel River "likely one of the largest remaining native coho salmon population in California" (DFG 1997 quoted in DFT 2001)

Potter Valley Project (PVP)

PVP is a 9.4 MegaWatt hydroelectric project

The historic annual diversion by the project is approximately 160,000 acre-feet per year.

PG & E was issued a new hydropower licence in 1983 that authorized PVP operations through April 2022

Total reservoir capacity of Lake Pillsbury is 80,650 ac-ft (1983 estimate). Lake Pillsbury is created by Scott Dam.

Total reservoir capacity of Van Arsdale Reservoir is 700 ac-ft (1983 estimate). Van Arsdale Reservoir is created by Cape Horn Dam (sometimes referred to as Van Arsdale Dam).

Maximum surface area of Lake Pillsbury is 2,003 acres

Maximum surface area of Van Arsdale Reservoir is 163 acres

Conversion Factors:

1 acre = 43,560 sq. feet
1 sq. ft = 7.48052 gallons
1 acre foot = 325,851 gallons

1 cfs for one minute = 448.8 gallons/minute
1 cfs for one hour = 26,930 gallons/hour
1 cfs for one day = 646,320 gallons/day
1 cfs for one day = 1.983 ac-ft/day or approximately 2 ac-ft/day

APPENDIX B:
ECONOMIC MODEL –
BENEFITS AND COSTS OF NATURAL WATER FLOWS TO THE EEL RIVER

In order to understand the benefits and costs of natural water flows to the Eel River it is useful to consider this subject more formally in terms of a basic economic model. First some terms and concepts will be defined and then the basic relationships expressed as an equation.

DEFINITIONS:

Potter Valley Project (PVP) – the complex of facilities begun in 1908 with the construction of the Cape Horn Dam and the Van Arsdale Reservoir and now including Scott Dam and Lake Pillsbury and all the facilities related to the diversion of water from the main stem of the Eel River to the East Fork of the Russian River for the purpose of generating hydroelectric power.

Natural Flows - By natural flows is meant the unimpaired pattern of flows that would have resulted had the Potter Valley Project not been constructed.

Eel River Basin – all the area from which water naturally flows into the Eel River.

Russian River Basin – all the area from which water naturally flows into the Russian River.

Market values – all the values represented by prices or determinable from the functioning of a market.

Intrinsic (or non-market) values – all the values that are not normally or conventionally represented by prices and market transactions. Intrinsic values include what are termed, existence, option, and bequest values (see Appendix H) and also include values related to Native American tribes.

The basic relationship is:

$$N = E - R$$

where:

N = Net benefits from natural flows to the Eel River in the absence of the PVP

E = Net benefits gained in the Eel River Basin from natural flows to the Eel River in the absence of the PVP

R = Net benefits lost in the Russian River Basin from natural flows to the Eel River in the absence of the PVP

In turn:

$$E = M + I$$

where:

M = Net Market values from natural flows to the Eel River in the absence of the PVP

I = Intrinsic (or non) market values from natural flows to the Eel River in the absence of the PVP

In turn:

$$M = F + K$$

where:

F = net market fisheries values

K = net benefits of non-fishing recreation values such as kayaking and rafting

Net market fisheries values can be expressed as:

$$F = (V_u - V_c) P$$

where:

V_u is the total value of Eel River fisheries had the PVP not been built
V_c is the total current value of Eel River fisheries and
P is the fraction or proportion of the loss in Eel River fisheries attributable to the PVP.

Alternatively F can be defined as

$$F = S + C$$

where:

S = net benefits of sport fishing

C = net benefits of commercial fishing

In turn:

$$S = O + I$$

where:

O = net benefits of ocean recreational or angler fishing

A = net benefits of river angler fishing.

In either case R can be defined as

$$R = H + W + A$$

where:

> H = the net benefits of hydroelectric power generated by PVP
>
> W = the net benefits to the Russian River area of water diverted from the Eel River
>
> A = additional or other net benefits to the Russian River basin of water diverted from the Eel River

The above are defined as "net benefits", meaning the net benefit to the Eel or Russian River Basin economies. For example, the value of electricity generated by PVP would need to be subtracted from PVP operating costs.

The entire relationship then can be expressed as:

$$N = ((V_u - V_c) P + K + I) - (H + W + M)$$

$$F + K + I - R$$

$$M + I - R$$

$$E - R$$

The above in outline form is

Net Benefits from diversion of Eel River water to the Russian River Basin

- I. Eel River Basin net benefits (E)
  - a. Market net benefits (M)
    - i. Market fishing net benefits (F)
    - ii. Rafting, kayaking and other non-fishing recreational net benefits (K)
  - b. Intrinsic (or non-market) net benefits (I)
- II. Russian River Basin net benefits (R)
  - a. PVP Hydroelectric Power net benefits (H)
  - b. Russian River Basin net benefits from diversion of Eel River water (W)
  - c. Other net benefits to Russian River Basin from diversion of Eel River water (M)

The basic relationships expressed in N = B – R can be considered as annual net benefit or annual value for a particular year, such as the current year. Where quantifiable these net benefits for a year can be summed for a total net benefit for a year.. Then, each year since the beginning of the PVP can be considered. The dollar values for each of these previous years would be less due to inflation, but this would tend to be offset when these values are converted to a present value using a discount rate. For example, a pound of salmon sold for only a few cents 90 years ago, when adjusted for inflation and converted to a present value using a discount rate would be closer to the current value of a pound of salmon, than the small price of 90 years ago might suggest . Also economic markets and conditions have changed greatly since 1908, wild salmon were not faced with the competition from "farmed" or "ranched" that they face today, and a commercial river rafting industry came into being only over the past few decades. In any case, once each annual net benefit is converted to a present value, these values, can be summed to create a total net benefit.

The sections of the main text of the report discuss each of the above variables. Briefly, here, the following should be noted:

- the total market fisheries benefits of the Eel River are, possibly over $50 million dollars a year.
- most of that value has been lost, i.e. the current total value of the Eel River fisheries is very low.
- the PVP has a significant role in the loss of this total fisheries, due to its being 14% of the basin in area, to its blocking over 100 miles of spawning habitat, due to it greatly reducing both the quantity and altering the timing of water flows to the Eel River, due to PVP role in the introduction and spread of the invasive pike minnow which feeds voraciously on juvenile salmonids.
- commercial rafting opportunities are significantly curtailed by the PVP. In the absence of the PVP, annual economic benefits could exceed $3 million dollars.
- the intrinsic value of fish and rivers to Californians may exceed $100 million dollars annually and the Eel River possesses significant fish and river values for California
- Native American values associated with the Eel River are significant and real and, even if not quantifiable, they need to be fully recognized and acknowledged.
- PVP has been characterized as "not economic as a hydroelectric facility". If so, it may be a zero (or negative) net benefit.
- Almost exclusively the Russian River Basin accesses water diverted from the Eel River at a zero acquisition cost, consequently the Russian River Basin's use of Eel River water is distorted by what can be seen as an almost complete subsidy. So rather than seeing loss of the use of water diverted from the Eel River as a loss, it can be viewed as subsidy for which the Eel River has not been compensated.
- Increased flows to the Russian River has hurt Russian River salmonid populations. Consequently "loss" of such flows, could actually benefit Russian River ecosystems and the native species it supports.

The main text discusses how given the above the current annual loss to the Eel River Basin from PVP may exceed $5 million. The annual present value of losses to the Eel River Basin over the 94 years since the PVP began total in the hundreds of millions of dollars. On top of this are the significant intrinsic fish and river values of California residents and native American tribes. On the other hand, there may be no current net benefits from the PVP hydroelectric operation, diversion of Eel River water to the Russian River can be seen as an hidden subsidy, and the Russian River ecosystem might actually have been better off had Eel River water not been diverted to the Russian River in the first place.

The situation looking backward regarding benefits had the PVP not been built is not symmetric to the situation looking forward to the potential benefits from PVP being de-commissioned and from natural water flows being restored. First fish populations would not recover in the reverse pattern of their decline. Also fish populations of pre-development magnitudes are not likely to be seen within a century. On the other hand, if natural water flows were restored, commercial rafting might realize its potential in a relatively short period of time. Also the value of both river and ocean sports fishing may exceed what those values had been in the past. The main text suggests that potential annual benefits to the Eel River basin may reach or exceed $5 million annually if natural flows to the Eel River were restored.

The preceding has been a sketch of a somewhat more formal formulation of the issue of benefits and costs of restoring natural water flows to the Eel River. In every of the items mentioned there is a need for further research. For example, a comprehensive in-depth estimation of the current annual value of the Eel River fisheries would assist in estimating the annual net benefits related to natural water flows. Appendix L, suggests further research lists and describes specific items of a larger research program which can build on the framework and initial analysis begun in this Study.

APPENDIX C:
ESTIMATION OF FISH POPULATIONS

Estimating the population of salmon has some distinctive features.

First "the size of a salmon population – measured in numbers of individuals, not in weight…-- is a function of the number of spawners, from the previous period…This number, called escapement, can…be considered to be equal to the original stock (i.e. recruits) minus the catch by [humans] (Anderson, 1986).

There appears to be some ambiquity regarding the term "run". "Run" usually refers to the number of fish that enter a river system. This would not include fish already caught by humans in the ocean. Consequently it is worth keeping in mind that the escapement equals the original stock minus both the ocean catch and the in-river catch.

Some estimates of the value of salmon fisheries are calculated per 1,000 spawners (e.g. Smith). Since spawners are a fraction of the entire stock, the catch, both in-river sport, and ocean sport and commercial, may exceed 1,000 fish. Estimates of value per spawner, should not be confused with estimates of value per fish caught.

APPENDIX D:
CALCULATION OF WATER FLOWS

Basically Eel River water from Van Arsdale reservoir is either allowed to flow through Cape Horn dam into the Eel River or Eel River water is diverted from Van Arsdale reservoir to flow through the intake at Potter hydroelectric facility to be abandoned into the Russian River. An estimate of the total unimpaired annual flow to the Eel River at Cape Horn dam can be approximated by adding the annual flow of water that flows past Cape Horn Dam into the Eel River to the annual flow of water that is diverted at Potter Valley intake into the Russian River. The difference between this unimpaired flow and the amount actually allowed to flow past Cape Horn, is the amount of water diverted from the Eel River. This amount expressed as a percentage of the estimated unimpaired flow is the percent of water annually diverted from the Eel.

The above approach does not take into account evaporation from Lake Pillsbury or from Van Arsdale. A comparison of the annual estimate generated by the above method for the years 1911 to 1960, is less than 2% higher than the unimpaired flow estimate cited by Weeks.

One cannot simply add the monthly flow at Cape Horn to the monthly flow at PV intake to estimate the average unimpaired flow for a month. The reason for this is that during months of heavy rainfall Eel River water accumulates in Lake Pillsbury above Scott Dam. This water is released during dry months to Van Arsdale Reservoir. From Van Arsdale during dry months most of this water is diverted to run the PVP hydroelectric operation with the remainder released to the main stem of the Eel below Cape Horn Dam. Consequently the amount of water flowing into Van Arsdale in any given month will tend to differ from the unimpaired flow for that month.

Week citing Anderson and Vestal 1972, gives unimpaired monthly flows for a 50 year period 1911 to 1960. For this *River in the Balance* study rainfall reported to the U.S. Weather service at Ukiah for this period was compared with rainfall in the 1960 to 2000 period as a whole and by decade. There was no significant difference in the rainfall averages between the latter period and the earlier 1911 – 1960 period, which suggested that the unimpaired monthly flows would approximate unimpaired flows in the latter period .

APPENDIX E:
MARKET VALUATION OF FISH

There are, of course, many complexities and refinements related to estimating the market value of a fishery. One of these involves net market benefit. This study focuses on the net benefit of salmon to the Eel River basin. As such it is concerned with the net benefit of salmon to the Eel River basin economy. The relevant factors here are the value added per fish and whether this value is purchased by a non-resident of the Eel River basin. For example, a river guide charging $300 a day for a single person sports fishing, incurs some costs for equipment, possibly for food and fuel. Expenditures for these, for the most part would be "leakages" from the local economy. The value added by the river guide would be the $300 minus these costs. If the person paying the river guide were from outside of the Eel River basin, then this net value added would be an "injection" to the local economy. In addition that person would make other purchases such as other lodging and food purchases during their visit to the region. In addition to these direct expenditures, there are indirect "multiplier" effects, which cumulatively could add 25 cents per dollar injected into a local economy.

Although the upper main stem of the Eel, might itself may not see great increases in sports fishing, increases in spawning habitat and salmonid populations would help lessen restrictions on river sports fishing generally and result in increased economic benefits. Craig Bell of the Northern California Sports Fishing Guide Association estimates that as recently as 5 years ago there were 25 – 30 sports fishing guides locally, leading as many as 60 guided trips annually. Jim Childs of the North Coast Sports Fishing News notes how sports fishing on the South Fork of the Eel River has declined greatly recently: currently coho and Chinook salmon and steelhead cannot be taken.

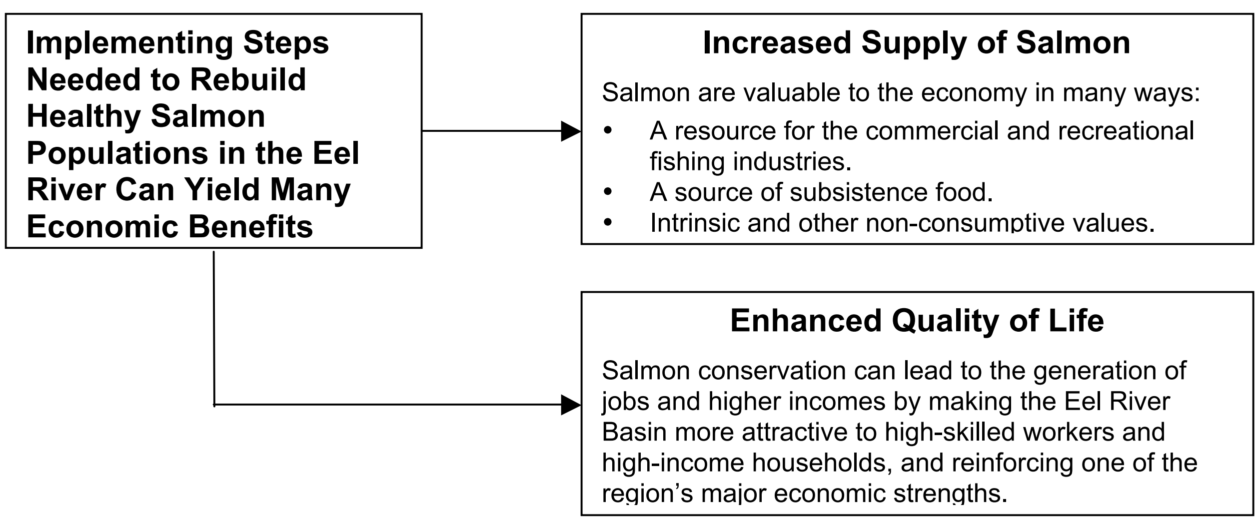
Each of the market-related values of salmonids can be analyzed in terms of net benefits, "injections" into the local economy and multiplier effects. For example, the value added from smoked salmon could be estimated, i.e. the sale price of a pound of smoked salmon, minus costs that "go out of the area", such as the cost of packaging materials. Another example would be the value added by an ocean fishing trip. Canned salmon can be sold retail for $7.50 for a 6.5 ounce can. Can and processing costs are about $1 per can, so this is a net of $6.50 for 6.5 ounces or $16 per pound. Although local salmon canneries do not now exist, they did at one time and economic valuation of salmon for canning may be estimated using the above example.

APPENDIX F
THE POTENTIAL ECONOMIC BENEFITS OF
REBUILDING HEALTHY SALMON POPULATIONS IN THE EEL RIVER
Ernest Niemi – ECONorthwest

Salmon have economic value insofar as they contribute to the well-being of humans, both nearby residents as well as those living farther away. These contributions to well-being are often called the economic benefits derived from salmon, and the larger the benefits, the larger the economic value. In economics parlance, the size of the value reflects humans' willingness to pay to acquire these benefits or, if they already have been acquired, their willingness to accept a payment to relinquish them.

Insights into the economic value of salmon can be acquired by looking at how the economic benefits might increase if salmon populations in the Eel River were to increase. Rebuilding healthy salmon populations in the Eel River can generate economic benefits in the two major ways, which we illustrate in Figure 1 and discuss in the following pages.

Figure 1: Potential Economic Benefits from Rebuilding Healthy Salmon Populations in the Eel River



Rebuilding healthy salmon populations in the Eel River can produce other, significant economic benefits by reinforcing efforts to accomplish other important community goals. For example, re-establishing a free-flowing river would improve water quality in the river, and a comprehensive effort to maintain healthy salmon populations probably would entail programs to reduce the use of pesticides that can have harmful effects on people as well as on salmon.

ECONOMIC BENEFITS ASSOCIATED WITH THE INCREASED SUPPLY OF SALMON

Salmon, themselves, have economic value. They can serve as the basis for a commercial fishery or the foundation for a recreational fishery; they can provide subsistence food for low-income families; and they have important intrinsic value, including their spiritual value for tribal members.

VALUES ASSOCIATED WITH COMMERCIAL AND RECREATIONAL FISHERIES.

Salmon have long had economic value as the basis for a Pacific Coast commercial fishery and as the target of recreational anglers.

Commercial-Fishing Values. Estimating the value of increasing the supply of fish to the commercial fishing industry is made difficult by many factors, including the deep disruption of the industry for more than a decade by closures of fishing seasons because of declining fish populations. These disruptions complicate further an industry already made complicated because fish are caught far from the streams where they were spawned and, hence, individual fishing boats may be regulated by multiple authorities. Increasing competition from farmed salmon operations adds another layer of complexity.

Against this backdrop, the past provides an unclear picture of what to expect in the future, and there is no single measure of value in the commercial fishing industry. Each estimate is dependent on powerful assumptions about market conditions, and how fishers will respond to the reopening of fishing seasons. To illustrate the possibilities, though, Table 1 shows estimates of the potential value of salmon, if they were produced by the Eel River and subsequently caught by the commercial fishery.

Because there are no data specific to Eel River salmon, the data in Table 1 report estimates drawn from two separate, but related fisheries: those north and south of the Eel River. The data in the top portion of Table 1 represent the commercial fishery to the north and specifically studies related to the Klamath and Columbia rivers. The estimates indicate that increased supplies of fish to the commercial fishing industry would be worth about $5–70 per fish, depending on the species and method of harvest.[1] The data in the bottom portion of Table 1 represent the southern commercial fishery and come from a study of the potential value of an increase in salmon populations in the California Central Valley. These data indicate that increased supplies of fish to the commercial fishing industry would be worth about $10–30 per fish.

[1] Ex-vessel prices represent the gross value of commercially-caught fish. The net benefit to the national economy of an increase in the supply of fish for the commercial fishery would be the gross value minus the costs of catching the fish and bringing them to market.

Table 1: Representative Estimates of the Potential Commercial Value of Salmon that Might Be Produced in the Eel River Basin

Species	Avg. Weight per fish (pounds)	Price ($ per pound)	Average Value per Fish[a]
Estimates Derived from Studies to the North of the Eel River[b]			
Chinook	15	$1.07 – 3.48	$15 – 70
Coho	9	1.07	10
Steelhead	8.5	0.64	5
Estimates Derived from Studies to the South of the Eel River[b]			
Chinook	10.3	2.85	$30
Coho	5.7	2.19	$10

[a] Values rounded to nearest dollar

[b] Estimates derived from Institute for Fisheries Resources. 1996. *The Cost of Doing Nothing: The Economic Burden of Salmon Declines in the Columbia River Basin*.; and Institute for Fisheries Resources. 1998. *The Cost of Doing Nothing: The Economic Burden of Salmon Declines in the Klamath Basin*. Weights representative of salmon in the Klamath Basin. Prices derived from an analysis of salmon runs in the Columbia River (Radtke, H.D. and S.W. Davis. 1995. *An Estimate of the Asset Value for Historic Columbia River Salmon Runs*. The Institute for Fisheries Resources. December).

[c] Estimates from Meyer Resources Inc. 1997. *Potential Economic Benefits of a Commercial Catch of 1000 California Central Valley Salmonids*. Meyer Resources, Inc. July. Weights represent low-bound of range for chinook and average for coho caught off California coast. Prices

Recreational-Fishing Values. Salmon are valuable recreational resources. If efforts to rebuild salmon populations in the Eel River are effective, more fish will be available to anglers. This behavioral response was demonstrated in the past couple of years, as fish runs in the Sacramento and other basins rebounded, eliciting a significant increase in recreational fishing, but the phenomenon seems unlikely to persist. With more fish available, the catch per angler will rise, inducing more people to go fishing. As with the commercial fishery, it is difficult to estimate the value of future increases in fish populations to the recreational fishery. Since most past studies of recreational values have been conducted during periods when salmon populations have been declining, they provide little direct insight into how anglers are likely to respond after a prolonged hiatus in fishing. As fish populations dropped in recent years, so too did catch rates, and many anglers cut back or stopped completely.

Past studies of the recreational fishery do, however, support some general conclusions. One of the most important is that the value of salmon (especially steelhead) to the recreational fishery substantially exceeds their value to the commercial fishery. One study of the economic value of salmon, for example, concluded that with conditions existing a decade a "conservative" estimate of the average recreational value per fish can be obtained by multiplying the average ex-vessel price of commercially-caught fish by three.[i]

The total value of fish to the recreational fishery is the amount anglers are willing to pay to fish for them. Economists typically break the total value into two parts. One is the amount anglers actually spend to fish. In most cases, though, anglers are willing to spend more than they actually do. The difference, which economists call the consumer surplus, is the amount the angler's willingness to pay exceeds what she actually pays. Consumer surplus is important because it represents a real gain in overall economic well-being, i.e., anglers obtain something (the recreational enjoyment of fishing and catching fish) that is worth more than they pay for it (their actual expenditures). Conceptually, consumer surplus is analogous to the net value (gross value minus harvesting costs) of fish caught by the commercial fishery.

The data and recent studies of recreational salmon fisheries associated with the Columbia River, included in an extensive review by the Bonneville Power Administration and other agencies, support the conclusion that, in recent years, the average consumer surplus (in 1998 dollars) per fish caught has been about $109.[ii] They also show that anglers' fishing expenditures averaged $80 per fish caught. Thus, the anglers' total willingness to pay—the sum of their expenditures plus their consumer surplus—to catch a salmon in recent years has been about $190 per fish.[2]

These findings are reinforced and expanded by another review of the literature, in the context of potential increases in the recreational fishery in California's Central Valley.[iii] It found that the average expenditure per fish is about $106-108, and the average consumer surplus is $103 for chinook and coho, and $306 for steelhead.

These estimates provides a general backdrop for weighing the potential benefits that would accrue if there were an increase in the supply of salmon produced by the Eel River for the recreational fishery. The estimates draw on some specific assumptions—the agencies assumed, for example, the Columbia River study assumed a 40:60 distribution of fish between those caught in the ocean and those caught in the river. Furthermore, the estimates reflect average values that prevailed about a decade ago. Since then the region's human population has increased, as have incomes, and the supply of fish for the recreational fishery has declined. Economic theory indicates that all these factors have pushed the value per fish higher.

As these trends continue, the value per fish should increase even further. Thus, if proposed actions to rebuild salmon populations in the Eel River are successful, the value per fish, at least initially, should be higher than $200 per fish, and perhaps in excess of $400 per fish. If the increase in supply grows large enough, however, the value per fish eventually should decline. For now, though, it seems reasonable to conclude that future increases in the supply to the recreational fishery of fish resulting from logging restrictions will have a gross value worth at least $200 per fish.

These estimates of recreational value apply to anglers who go fishing for salmon. Many people, however, derive recreational value from salmon without fishing for them. Where salmon populations are large enough, it is not uncommon for crowds to gather to watch salmon swimming in deep pools, leap waterfalls or spawn. Observation areas, where one can see salmon swimming up fish ladders, often are destination points for recreational trips.

Insight into the overall recreational value of salmon populations comes from surveys conducted in Oregon and Washington by federal agencies responsible for restoring salmon populations in the Columbia River. Their studies found that two-thirds of the region's residents participate in water-related recreation. Of these, 40 percent stated that "good fishing", and 75 percent stated that "high environmental quality" associated with healthy fish populations is "very important" to their recreational experience. In other words, about 25–50 percent of the total population indicated that that the actions necessary to rebuild and sustain healthy fish populations is very important to their lives.

[2] The sum of recreational expenditures and consumer surplus represents the gross value of fish available to the recreational fishery. The net benefit to the national economy of increasing the supply of fish to the recreational fishery generally is measured differently: the incremental increase in consumer surplus as anglers catch more fish per trip or shift to fishing from another recreational activity.

SUBSISTENCE VALUES

In the past, catching salmon was an important source of subsistence nourishment for many residents of northern California. It could again be important in the future, if salmon populations are large enough. Catching fish to put food on the table has a long history as a way for low-income families to increase their standard of living, and even to survive. The potential subsistence value of salmon seems particularly important to Tribal families, but not exclusively so.

We know of no study estimating the potential subsistence value that might materialize if efforts to rebuild salmon populations in the Eel River are successful. Nonetheless, we identify subsistence values to identify that they are real, potentially important benefits that might materialize from such restrictions.

INTRINSIC AND OTHER NON-CONSUMPTIVE VALUES

People don't have to catch salmon to value them. Salmon have been and are an integral part of an extensive ecosystem that includes the Eel River Basin, much of northern California, and a large part of the Pacific Coast of North America. As such, salmon are intrinsically important to everyone who places a value on ensuring that this ecosystem is healthy and productive. They are especially important to the region's Indian communities. Others, inside and outside the region, also see salmon as an icon for the region's heritage and way of life. For many, there is something inspirational in the salmon's arduous journey, linking the ocean with the mountains and spanning several years and hundreds of miles.

Measuring intrinsic values is difficult; some even say it is conceptually wrong and practically impossible. Nonetheless, some economists have striven to acquire at least a general sense of the value the American public places on protecting the intrinsic values embodied in salmon. Again, much of the research on this matter comes from the Pacific Northwest. One carefully conducted survey of the residents of Washington and Oregon found that they place a substantial value on restoring and maintaining healthy salmon populations, saying that, on average, they are willing to pay about $30–97 per household, per year to protect salmon.[iv] Although some percentage of this expression of value reflects a desire to secure salmon for the commercial and recreational fisheries, a considerable portion is linked to a desire to protect salmon for their intrinsic characteristics.

At first glance, it may seem that these amounts are beyond what Californians would be willing to pay to protect this state's salmon. On reflection, however, they appear more reasonable. Californians have been national leaders in recognizing the economic value of protecting the state's natural treasures, and they repeatedly have backed up the words with actions demonstrating their willingness to bear the costs of protecting parklands and other components of the environment.

Perhaps their willingness to pay for actions to protect salmon is at the low end of what was found in Washington and Oregon—$30 per household per year. If so, then multiplying this amount times the 5 million households in northern California, indicates that the total intrinsic value residents of the region would place on protecting and rebuilding salmon populations is about $150 million per year.[v]

QUALITY-OF-LIFE VALUES

In the distant past, the prosperity of northern California's communities was determined largely by the ability of resource-intensive industries—mining, agriculture, and logging—to convert natural resources into commodities and the raw materials for further manufacturing. Often, the activities of these industries had a negative impact on the environment and the region's families and communities had to choose: they could have a healthy economy or a healthy environment, but not both.

Today, things are much different. Having a healthy natural environment increasingly is a prerequisite for having a healthy economy. This change reflects fundamental changes in the economy: resource-intensive industries now constitute a small part of the overall economy; service industries are more important; and both firms and workers are highly mobile. In this setting the prosperity of communities and entire regions is increasingly being determined by their ability to attract and retain high-skilled workers and high-income families. Having a healthy environment is important in this context because, throughout the western U.S., places with a high-quality of life, and especially with a high-quality natural environment, are the ones with the greatest growth in jobs, incomes, and prosperity.

Numerous studies have documented the important role the environment plays in economic-development process. Surveys of adults who've recently moved to Oregon, for example, indicate that about 44 percent did so primarily to take advantage of its quality of life.vi Furthermore, these new residents tended to have higher levels of education than current residents and they often were willing to accept a reduced earnings to live in the Pacific Northwest.vii Other studies from throughout the West have found that counties containing or adjacent to unroaded areas, state parks, and wilderness areas are experiencing above-average growth in jobs and incomes.[viii]

Outdoor recreation is an important component of quality of life for many Americans. Fishing is especially important. Recent studies of federal lands, for example, found that, on a per-acre basis, the economic value of fishing exceeds the value of all other recreation activities.[ix] Free-flowing, wild-and-scenic streams also are important.[x]

In 1995 more than 60 economists, primarily from the Pacific Coast, endorsed a report that summarized these findings on the relationship between the economy and environmental protection.xi One of the report's central findings states, "In short, the Pacific Northwest does not have to choose between jobs and the environment. Quite the opposite: a healthy environment is a major stimulus for a healthy economy."

Despite all this general evidence, however, the task of estimating the specific quality-of-life benefits that would materialize if salmon populations were restored in the Eel River remains a tricky one. To date, the exercise has not been undertaken. Thus, the best conclusion is that the restoration could yield substantial quality-of-life benefits that could support significant increases in jobs and incomes in the immediate area and throughout the region, but the actual size of those benefits remains unknown.

[i] Alkire, C. 1993. The Living Landscape: Volume 1: Wild Salmon As Natural Capital: Accounting for Sustainable Use. The Wilderness Society. August.
[ii] Bonneville Power Administration, U.S. Army Corps of Engineers, and Bureau of Reclamation. 1994. *Columbia River System Operation Review: Draft Environmental Impact Statement: Appendix O: Economic and Social Impact*. DOE/EIS-0170. July.

[iii] Meyer Resources Inc. 1997. *Potential Economic Benefits of a Commercial Catch of 1000 California Central Valley Salmonids*. Meyer Resources, Inc. July.

[iv] Niemi, E., E. Whitelaw, M. Gall, and A. Fifield. 1999. *Salmon, Timber, and the Economy*. ECONorthwest for Pacific Rivers Council. October.

[v] Washington Department of Fish and Wildlife. 1996. *Opinion Survey*. Washington Department of Fish and Wildlife.

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Number of households from U.S. Department of Commerce, Bureau of the Census. 1998. *Statistical Abstract of the United States, 1998,* 118th Edition. Washington, D.C.: National Technical Information Services.

[vi] Helvoigt, Ted. 1999. "1998 In-Migration Study: Quality of Life." *Oregon Labor Trends* (March): 11-12.

[vii] Judson, D.H., S. Reynolds-Scanlon, and C.L. Popoff. 1999. "Migrants to Oregon in the 1990's: Working Age, Near-Retirees, and Retirees Make Different Destination Choices." *Rural Development Perspectives* 14 (2): 24-31.

[viii] Cromartie, John and John Wardwell. 1999. "Migrants Settling Far and Wide in the Rural West." *Rural Development Perspectives* 14 (2): 2-8; Rudzitis, Gundars. 1999. "AmenIties Increasingly Draw People to the Rural West." *Rural Development Perspectives* 14 (2): 9-13; and Southwick Associates. 2000. *Historical Economic Performance of Oregon and Eastern Counties Associated with Roadless and Wilderness Areas*. Oregon Natural Resources Council and World Wildlife Fund. August 15.
[ix] Forest Ecosystem Management Assessment Team. 1993. *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment*. Forest Service, Fish and Wildlife Service, National Marine Fisheries Service, National Park Service, Bureau of Land Management, and Environmental Protection Agency. 794-478. July.

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[x] Brown, T.C. and T.C. Daniel. 1991. "Landscape Aesthetics of Riparian Environments: Relationship of Flow Quantity to Scenic Quality Along a Wild and Scenic River." *Water Resources Research* 27 (8): 1787-1795.

[xixi] Power, T.M. and others. 1995. *Economic Well-Being and Environmental Protection in the Pacific Northwest*. Economics Department, University of Montana. December.

APPENDIX G:
MARKET VALUE TOPICS –
CONSUMER SUPLUS AND PRESENT VALUE

Consumer Surplus:

Economists recognize a concept termed "consumer surplus". Consumer surplus is based on the observation that a consumer normally pays less for a commodity than the maximum amount that consumer is willing to pay. The difference between the maximum they are willing to pay and the price they actually pay is called "consumer surplus". For example, one person might be willing to pay a maximum of $10 to see a particular movie, even though the ticket price (market price) is only $8. In this case this particular person receives $2 of consumer surplus. Economists have various techniques for quantifying the total consumer surplus for a particular good or service. This is used in a variety of cases, for example in analyzing the net benefits of a reduction in a tariff. For purposes of illustration say 100 units of a good are sold at $5 which includes a $1 tariff. If the price of reduced to $4, say 120 units are sold. The additional 20 units sold, which would not have been purchased at a price of $5, are receiving some consumer surplus. This amount defined by the downward sloping demand curve for this good between the price of $5 and $4, would be approximately $10 of consumer surplus.

Analysis of consumer surplus is important, particularly for non-priced or under-priced goods and services. Suppose there was no fee for hiking in a wilderness area and 100 people a season hiked there. Now suppose a fee of $10 were imposed and hikes fell to 90 people. One could safely conclude that there was at least $900 of consumer surplus received by the original 100 hikers. Using a rate of return of 3%, if would take an investment of 30,000 to generate a stream of benefits worth $900 a year, so the capitalized value of this wilderness hiking opportunity would be in excess of $30,000. A similar sort of analysis could be applied to recreational values associated with fishing. The fact that a particular person fly fishing pays no or a small fee to fly fish, does not mean that the value they receive for fishing is non-existent or is a small value. Economists can use actual travel costs to estimate a demand curve for a good or service and then use this demand curve to estimate total consumer surplus (see also Hackett). Such techniques could be applied to sports fishing to yield a more complete estimation of sports fishing as an economic resource. In any case, though often over-looked, consumer surplus is recognized by economists as part of the value of a good or service.

Present Value:

When considering economic values over time two important adjustments to make are for inflation and for the "time value of money" or the "discount rate". Though inflation is easily understood, the "time value of money" may seem puzzling. Simply, even at a zero inflation rate, one dollar today is more valuable than one dollar one year from today. In fact if the real interest rate is, say 3%, then one dollar today could be said to be equivalent to $1.03 and we could use .03 as the "discount rate". Similarly $1 today would be equivalent to $1/1.03 or approximately 97 cents one year ago (since 97 cents x 1.03 = $1.00).

Estimating losses over a 94 year time span from 1908 to present involves taking into account both inflation and the time value of money. If on average inflation and the discount rate totaled 5% a year, then $1 in 1908 would be worth $98.12 today. In 1902 – 1904 the average opening (beginning of season) price of a pound of canned salmon was 12 cents a pound. Converting this to a 2002 present value works out to $11.77 roughly the same magnitude as the current price. Given the preceding, a one dollar loss in 1908 could be converted to a 2002 present by multiplying by (1.05)^94 or 98.12, a 1909 dollar converted by multiplying by (1.05)^93 and so on.

Loss of fishery values did not have occurred all at once in 1908. Losses may have declined somewhat gradually at first and then more sharply, or may have declined sharply at first and then tapered off, or may be decline linearly over the entire period, or may be fluctuated widely with (or without) any of the above as a general trend. If losses declined exactly linearly, then the cumulative losses would equal _ of the current annual loss multiplied by 94. If the current annual loss was $5 million, then the cumulative present value of losses would be $5 x 1/2 x 94 = 235 million dollars. The main point is that cumulative losses would be in order of hundreds of millions of dollars.

APPENDIX H:
CONTINGENT VALUATION

"Use" values are the values for a direct use, for example the market values connected with commercial or sports fishing or with river rafting. Economists recognize that there are other non-marketed values. For example, people value the existence of pandas or tropical rainforests, even though they will never have a use for them. Such "existence value" can be estimated through a technique called "contingent valuation" (CV). In the contingent valuation approach, a representative sample of a population is asked what they are willing to pay to have a specified condition or situation occur. These responses are used as a basis for estimating the value of this condition or situation to the entire population. There is a large and growing literature of carefully conducted contingent valuation studies. It has been found that contingent valuation does not overstate or present biased valuations.

A contingent valuation study (Loomis, 1987) used the contingent valuation method

> to determine the public trust values of Mono Lake at alternative lake levels. Loomis found that the economic benefit to California residents of preserving Mono Lake could conservatively be estimated at $1.5 billion annually. Purchase of replacement water and power would cost Los Angeles $26.2 million per year. Thus on efficiency grounds the reallocation of water for maintenance of public trust values in Mono Lake could be warranted. (in Hackett, 1998, p. 111-112).

Loomis (1996) also estimated the willingness to pay for removing two dams on the Elwha River in Washington State. The mean annual value per Washington State household was approximately $70 for a total of $93 million. Overall the study suggested that the general public would be willing to pay to remove old dams that block salmon migration (Loomis, 1996).

In theElwha contingent valuation study, meetings were held with scientists working for the National Park Service and Bureau of Reclamation and the Lower S'Klallam Tribe. Meetings with focus groups of residents were also conducted to develop questions. The complete survey was pre-tested before a final sample of 900 Washington state households was surveyed. A similar contingent valuation process could be conducted to develop questions and survey households on non-use values related to the removal of PVP dams on the Eel River.

In regard to criticism of the contingent valuation method, it has been noted that "when contingent valuation is compared to actual spending, say with user fees, CV's generally are vey close to the actual spending level, and CV method referendum "yes" rates have been found to be slightly lower than when the issue was actually placed on the ballot (Carson et al 1986 in Hackett, 1998, p. 114).

In addition to existence values, economists recognize "option values" and "bequest values".

"Option value" is the value of keeping open an option for something. Take the case of the option of purchasing a stock at a pre-set price, say at $50, even when the market price of that stock exceeds that pre-set price. At any point in time such an option has a real monetary value which is a function of the stream of expected changes in the future price of the stock. In environmental situations

"…option value is prominent when (1) there is uncertainty over the ultimate environmental impact of a given activity that (2) is irreversible. The classic example is large-scale tropical rain forest destruction where thousands of species of plants and animals are made extinct before people even understand them and their possible beneficial role in medicine, foodstuffs, and so forth. Preservation has option value – it gives us time to learn about the possible services that are provided to people by the rainforest." (in Hackett, 1998, p. 109).

Similarly the option of there being a viable, healthy Eel River coho population could be precluded if this population became extinct. Keeping open the option, or retaining the possibility for such a coho population, has a value.

Bequest value involves the value of being able to "bequest" to the next and succeeding generations a condition or situation: the value of being able to give to future generations the experience of wild and scenic rivers. Again, this bequest value is separate from any direct use by the person or generation that makes the bequest.

All of the above non-market values could be estimated using contingent valuation techniques.

APPENDIX I:
WHOLESALE PRICE OF ELECTRICITY

The U. S. Department of Energy/Energy Information Agency's *Annual Energy Outlook with Projections to 2020* states that "[a]verage electricity prices are projected to decline from 6.9 cents per kilowatt hour in 2000 to 6.5 cents per kilowatt hour in 2020." The wholesale price for electricity in California, though high and erratic during the first part of 2001, had fallen to 7 cents per kilowatt hour by the end of October, 2001 (California Department of Water Resources). Given these fact, a wholesale price of 7 cents per kilowatt seems justifiable for calculating the PVP hydroelectric gross revenues.

The wholesale price for electricity varies greatly with the peak rate occurring afternoons during summer months. During the summer the amount of water the PVP can release to its powerhouse is greatly reduced and consequently the amount of electricity it can sell at peak prices is also limited.

APPENDIX J:
RUSSIAN RIVER BASIN USE OF EEL RIVER WATER

On average 160,000 ac-ft are diverted annually to the Russian River from the Eel River. (DEIS 2000). Although this is only 10% of the total water that flows through the Russian River each year, the role Eel River water plays is larger than this 10% figure might suggest. During the year an average 1,490,000 ac-ft of Russian River water is unappropriated. Only, about 112,000 ac-ft from the Russian River are used for crop irrigation and municipal uses throughout the year. "In a normal year, inflows [to Lake Mendocino] include about 110,000 ac-ft as runoff from the Russian River watershed into the lake and 140,000 ac-ft from the Potter Valley Project, excluding about 20,000 ac-ft taken by the PVID [Potter Valley Irrigation District]" (DEIS 2000). In other words more than half of the water available to Lake Mendocino comes from the PVP.

APPENDIX K: COMMENTS ON THE APPLICATION OF INPUT-OUTPUT ANALYSIS TO THE POTTER VALLEY

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20 February 2002
TO: Dan Ihara
FROM: Ernie Niemi
SUBJECT: Comments on the Application of Input-Output Analysis to the Potter Valley Project

You asked me to review and comment on Northwest Economic Associates. 1998. "Chapter 4: Regional Economic and Employment Impacts of Flow Regimes." *Analysis of the Socioeconomic Impacts of Changes in the Potter Valley Project Flow Release Schedule*: *Interim Report.* Prepared for the Sonoma County Water Agency (SCWA). Here are my initial findings, based on a short review of the report itself. I have not reviewed other, related documents that would place the report in context, compare its findings with related studies, and provide greater insight into its strengths and weaknesses. I am confident, however, that such an expanded review would not alter the basic elements of my findings; instead, it would enrich them.

In the introduction to Chapter 4, the authors explain they are employing an input-output model to estimate the changes in revenue, earnings, and employment in Mendocino and Sonoma Counties that would result from a one-year change in stream flow. Their subsequent analysis applies the model and estimates the potential impacts associated with changes in agriculture, recreation, and power generation in Mendocino County, and with changes in agriculture in Sonoma County.

The authors justify their use of the input-output model, saying it "is a commonly used method of quantifying regional economic changes." The frequency of its use, however, says nothing about its accuracy. In fact, the model embodies some fundamental flaws and weaknesses that inhibit its ability to provide an accurate, thorough description of how the economy would actually respond to a change in stream flows.

In this instance, the application of the input-output model exhibits four fundamental errors. The report (1) fails to consider the economy's ability to adjust to a change in stream flows; (2) ignores the positive impacts on the economy resulting from the change in stream flows, (3) fails to consider non-market responses (especially those related to self-supplied recreation and quality of life) to the change in stream flows, and (4) fails to anticipate the applicability of economic trends and tools that could mitigate the negative impacts of any actual reduction in the supply of water for irrigation and other uses.

The report fails to consider the economy's ability to adjust to a change in stream flows.

As I understand the model used in Chapter 4, it estimates the total impacts on employment, incomes, and output from a reduction in output from the irrigated-agriculture sector of the two counties, plus reductions in output of the recreation and hydropower sectors of Mendocino County. The analysis first adopts the 1995 IMPLAN model's depiction of the transactional relationships among different sectors of the economy, then assumes that this structure would remain fixed as the economy responded to the change in stream flows. Thus, it assumes that a reduction of X percent in irrigation would lead to an X percent reduction in agricultural output, which would ripple through the economy in the same fixed proportions as depicted in the 1995 IMPLAN model.

One consequence of this approach is that the model is static. That is, it assumes all participants in the economy are mindless automatons, unable to take appropriate actions to attenuate the negative impacts of the change in stream flows and enhance the positive impacts. Thus, according to the model:

- Those who lost their jobs as a result would never work again in the respective county, but also would not move and find replacement employment elsewhere.
- The local and regional establishments that would have sold goods and services to those who lost their jobs permanently would lose that business and obtain no replacement business (and also would not move).
- Those enterprises in each county that would have used the output of the original job-losers would obtain no replacement inputs from elsewhere (and also would not move).
- All throughout this chain who would lose their jobs would act exactly the same way as the original job losers, in that they never would work again and stay put.
- There would be no replacement sources of income, e.g., general public assistance, such as unemployment insurance, or private assistance.
- Affected farms, firms, and households would not sustain expenditures during any period of reduced earnings or unemployment by drawing down their capital stock or borrowing capital from others. Farms and firms would not sustain spending by selling assets, or acquiring additional capital through the sale of equity or borrowing. Households would not sustain expenditures by drawing down savings, selling assets, or borrowing.

To the extent that the model reported in Chapter 4 behaves this way then the model overestimates the negative impacts of the reduced output in the designated sectors, for, in reality, adaptability is one of the economy's greatest strengths. When farms and firms see that their costs of production will increase, they find ways to reduce the impacts, or reallocate their capital to produce alternative products. When households face an increased risk of unemployment, they find ways to get through the period of lost wages and search for replacement jobs. Participants throughout the economy have access to private or public to help them survive transitions.

Hence, the negative economic impacts on the local economy estimated in Chapter 4 would be mitigated by the adaptability of the affected economy. This adaptability would manifest itself in many ways; among them these, which apply to irrigated agriculture (but similar factors apply to the other sectors):

(1) Future reductions in irrigation might be spread over many farms, with each reducing production on small acreage, and no farms would cease operations. Alternatively, the irrigation reductions might be concentrated among those farms that have exhibited the least efficiency in their operations. At the extreme, the irrigation reductions might be concentrated among those farms that otherwise would exhibit negative earnings and, hence, any closure of operations triggered by the irrigation reductions could represent improvements in the sector's net productivity.

(2) Each farmer would adjust in her or his way. Farmers are among the most innovative of U.S. business managers in adapting to changing conditions and it is reasonable to anticipate that, with an X percent reduction in irrigation, the impacts on production, employment, and income would be less than X percent.

(3) Displaced workers would find new jobs. The analysis in Chapter 4 implies that workers would be permanently unemployed when job opportunities are closed in respoinse to a reduction in the supply of irrigation water. National statistics, however, indicate that most workers displaced from jobs would find replacement jobs within a few months, although some might have to relocate to another county to do so. If the economy is as robust as it was at the end of the 1990s, pay levels at many replacement jobs would exceed the pay levels at the jobs that were lost (Helwig, R.T. 2001. "Worker Displacement in a Strong Labor Market." Monthly Labor Review 124 (6): 13-28).

(4) Displaced farmers would find new ways of making a living. Potential reductions in the supply of water is not the only source of stress on farmers irrigating with Eel River water, and farmers will continue to feel stress regardless of what decisions are made concerning the water's management. Evidence from the Midwest, however, indicates that farmers and their families who exit from farming after a prolonged period of financial stress experience increases in income, decreases in stress, and improvements in their overall quality of life (Lorenz, Frederick, Glen Elder, Wan-Ning Boa, K.A.S. Wickrama, and Rand Conger. 2000. "After Farming: Emotional Health Trajectories of Farm, Nonfarm, and Displaced Farm Couples." Rural Sociology 65 (1): 50-71).

(6) Most of the business activity indirectly affected by a curtailment of irrigation would adjust quickly. Especially during a period when the farm sector is contracting nationally, many vendors selling to farms are looking to diversify their business. As the local and regional economies experience growth, the growth may offset and overwhelm the impacts a reduction in irrigated farming might have on retail and service sectors.

Given these and other opportunities to adapt to the proposal to increase flows in the Eel River, it is reasonable to anticipate that, if the assumed level of irrigation curtailment occurred, the overall, negative economic effects rippling through the local economy would be smaller—perhaps markedly smaller—than those indicated in Chapter 4. The same is true of Chapter 4's estimates of negative impacts associated with recreation and hydropower.

The report fails to consider positive economic consequences from the change in stream flows.

Chapter 4 focuses solely on the negative impacts associated with three groups—farmers in the two counties and the recreational and hydropower sectors in Mendocino County. It fails to consider the positive impacts on the economy resulting from higher stream flows in the Eel River, lower flows in the Russian River, and changes in the patterns of water use. The potential benefits include, but are not limited to:

- Spiritual and other intrinsic benefits accruing to tribal members as higher flows in the Eel river increase the likelihood that the populations of fish and other resources important to their culture will not decline further. Similar intangible, but not unimportant, benefits could be generated for others, e.g., those who place an intrinsic value on protecting and restoring native ecosystems and species at risk of extinction.
- The promise of more tangible benefits in the future for tribal members to the extent that higher stream flows in the Eel River would increase the likelihood that populations of fish and other species will expand sufficiently to support traditional economic activities. Similar benefits might materialize for individuals and firms associated with the recreational and commercial fishing industries (extending from the Eel River to communities along the California coast).
- Improvements in water quality in the Eel River, plus the promise that improvements would extend into the future if the higher flows were to be sustained. Water-quality improvements can increase recreational and aesthetic values, reduce health risks to recreationists and others, and can stimulate sectors of the economy linked to natural-resource amenities.
- Higher profits for those agricultural producers—in Sonoma and Mendocino Counties as well as and elsewhere—who compete with farmers receiving water from the Sonoma County Water Agency and, therefore, would benefit insofar as curtailed supplies of water to farms by SCWA would reduce the demand for production inputs and the supply of farm products.
- Higher profits for firms that would provide additional services and goods because of the adjustment to changes in stream flows. For example, reduced availability of irrigation water from the Eel River might trigger additional investments, unforeseen in the input-output model, by firms providing services in well-drilling and water conservation.
- Overall expansion in the local, regional, and national economies, as a change in water allocations to increase stream flows in the Eel River would reduce the wasteful use of water, labor, capital and/or other scarce resources. Currently, most users of the water diverted from the Eel River pay nothing for the water, only for the costs of conveyance. If there were appropriate market-like mechanisms governing water use, these water users would have to pay more and, consequently, some water users would decide to reduce their use, allowing the water to remain in the stream. Overall, the water would be used more efficiently and output of the total economy would rise. The proposed changes in water use would bring about a similar outcome.
- Reductions in the risk of damage from flooding in the Russian River.
- Reductions in negative environmental externalities associated with current use of Eel River water. For example, a reduced supply of irrigation water might result in a smaller amount of polluted runoff from farms and urbanized lands, improving water quality in the Russian River. The improvements in water quality might yield economic benefits by reducing

pollution-related, adverse impacts on human health, fish populations, and the aesthetics of stream flows in the Russian River.

The analysis makes no mention of these and other positive economic outcomes that might result from the proposed change in water use. The next section describes some additional, positive impacts that might be expected.

The report fails to consider non-market responses to the change in stream flows.

The analysis in Chapter 4 is limited to those impacts that can be traced through buy-sell transactions among different sectors of the economy, i.e., through organized markets. Many of the economy's responses to changes in natural-resource-management policy, however, materialize through non-market mechanisms.

I have listed above some of the non-market responses ignored in Chapter 4. Some additional, potentially important responses include increases in self-supplied recreation associated with higher stream flows in the Eel River, and related impacts on household-location decisions. Currently, recreational opportunities associated with stream flows on the lower Eel River are limited, even non-existent in some places at some times. Restoring higher stream flows could open up significant new opportunities along a long reach of the river. Stream-related recreation often has a higher value to recreationists than other forms of recreation. This higher value, however, often does not appear in the economic data underlying Chapter 4 because recreationists seize the opportunities themselves, without visible transactions involving vendors of recreational goods and services (such as occurs with reservoir-related recreation, where recreational opportunities often are concentrated). Thus, if there were more opportunities to fish, swim, boat, in the Eel River, or simply just to enjoy the aesthetics of a free-flowing stream, people would take advantage on their own, walking, riding , or driving to the river with no visible appearance in the IMPLAN data used in the analysis reported in Chapter 4.

Indeed, the possibilities for new recreational opportunities illustrate a fundamental flaw in the input-output model used in Chapter 4. It is impossible for the input-output model used in Chapter 4 to show—even to recognize—new economic activities created by a change in water use. The model can only show the expansion or contraction of existing economic activities. If Eel River stream flows were so low that there was no river-related recreation in 1995, when the data for Chapter 4 were collected, then there would be no way for the model to show the establishment of new recreational behavior.[3]

The analysis in Chapter 4 similarly fails to recognize how higher stream flows in the Eel River could influence household location and induce ripple effects throughout the adjacent economy. Many households decide where to locate based largely on the quality of life available in different areas. Quality of life can mean different things to different households, but, to many households, the aesthetics of the natural landscape and the availability of outdoor recreational opportunities figures prominently. Thus, if the proposed increase in stream flows for the Eel River were seen as a signal that future flows would be permanently higher than they have been, it is possible that some—perhaps many—households would have responded to the signal and moved nearer the Eel River. Others already living nearby might have stayed put, anticipating that higher stream

[3] The same is true if the proposed change in water use were, say, to trigger the development of a new industry devoted to developing and installing water- and electricity-conservation devices for farms, homes, and businesses.

flows would enhance not just the river-related aspects of the quality of life but also the overall health of the local economy.

The net effect would translate higher streamflows into economic growth. Numerous studies have documented the important influence high-quality, natural-resource amenities exert on the vitality of nearby economies. By diverting water from Eel River, the surrounding area has been starved of this source of vitality. The models and analytical approach applied in Chapter 4 totally overlook this connection between the river and the economy.

The report fails to anticipate the applicability of economic trends and tools that could mitigate the negative impacts of any actual reduction in the supply of water for irrigation and other uses.

The analysis in Chapter 4 focuses on a potential one-year change in water-use patterns. It speculates that, if the change lasted longer, the negative impacts (remember, the analysis examines only the negative impacts) could be higher or lower, and observes that a longer reduction in the supply of irrigation water from the Eel River might cause some lands to be withdrawn from irrigated farming.

Although this conclusion might seem plausible on its face, a closer examination reveals that the potential outcome is more ambiguous. Reductions in the supply of water need not result in fewer irrigated acres. Consider, for example, the experience of Westlands Water District, in the San Joaquin Valley. It initiated a water-conservation program in 1972, and has expanded the program to include the installation of water meters, development of information about irrigation scheduling, and incentives to encourage water-conservation investments by individual farmers. As a result, water-use efficiency has increased to 83 percent, and irrigation using only flood techniques has declined from 60 percent of lands in 1985 to 28 percent in 2000. These actions have yielded significant economic benefits, including these: increased crop yields; improved quality of crops; and reduced costs for water, energy, labor, and fertilizers, and other on-farm factors of production.[4]

The discussion in Chapter 4 does not reveal the extent to which irrigators using water from the Eel River have taken similar steps to promote water conservation, but it appears that they lag far behind the Westlands Water District. To the extent this is so, then there may be significant opportunities for these irrigators to realize similar, significant economic benefits from reducing their use of water from the Eel River. As long as they have essentially free access to the water, however, they have dampened incentive to pursue these options.

Similar opportunities may exist with regard for other economic tools to reduce the environmental damage from farming. One of the most prominent tools is the conservation easement, with which a farmer agrees not to manage the land in an environmentally-harmful way in exchange for monetary or other compensation. Other tools include water markets, water banks, and other schemes, such as insurance, that allow farmers to receive remuneration when they leave water in streams.

The analysis in Chapter 4 overlooks all of these alternatives and, instead, assumes that reductions in the supply of Eel River water for irrigation has a simple, unyielding, and singularly negative

[4] http://www.westlandswater.org/WtrCon.htm

impact on the economy. The actual impacts will be far more complex. There will be positive as well as negative impacts. There will be many different ways in which affected households, farms, firms, and communities can reduce the negative impacts and expand the positive ones. Given the long history, in which irrigators and others have evaded the discipline of market-like mechanisms (using water for free, without regard for their impacts on competing demands) it is almost certain that pulling some—perhaps all—of this water back into the Eel River would have beneficial economic impacts. The models and analysis in Chapter 4 are oblivious to this possibility.

APPENDIX L:
SUGGESTIONS FOR FURTHER RESEARCH

Any component of any of the individual variables in the economic model set forth in Appendix B warrants further research.

Some areas for further research include:

- Refining estimates of the pre-development population of salmonids;
- A more precise estimation of the current value of Eel River fisheries would be useful.
- Quantification of the impact of Pike minnow on salmonid populations could help refine the estimation of the impact of the PVP on the Eel River fishery.
- Friends of the Eel River could help systematically obtain and categorize information regarding each of the components of the variables contained in the economic model described in Appendix B.
- A complete series of actual power generation data or correlating water flows at Potter Valley intake to available actual power generation data would improve the estimate of the PVP hydroelectric revenue.
- Access to any PVP operating and maintenance costs that are not proprietary data would also be of use.
- Information about the growth of rafting on the Rogue River in Oregon over the past two decades could serve as a useful benchmark for the future potential for growth of rafting on the Eel if natural flows were restored.
- Estimates for the cost of raising Coyote Dam and for improving ground water sources in the Russian River Basin would also be of interest.
- Managing accumulated silt, and the costs of doing so, in cases where dams have already been decommissioned would be useful to know.
- Many research questions could lend themselves to study by Humboldt State University economics students, ranging from the demand and supply of guided river fishing trips to the market price for acquiring an acre foot of water.

The above gives some indication of the wide range of topics, in fact, of an entire research agenda, that could improve understanding of the benefits and costs of restoring natural water flows to the Eel River.