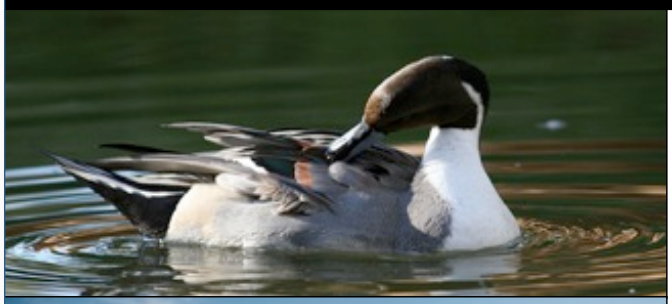
Bay-Delta Water

Economics of Choice



January 11, 2013

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ECONorthwest specializes in economics, planning, and finance. Founded in 1974, we're one of the oldest independent economic consulting firms in the Pacific Northwest. ECONorthwest has extensive experience applying rigorous analytical methods to examine the benefits, costs, and other economic effects of environmental and natural resource topics for a diverse array of public and private clients throughout the United States and across the globe.

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SECTION 1: CONTEXT AND ASSIGNMENT

Water flows from the Sierra Nevada into the Sacramento and San Joaquin Rivers, which in turn flow into the San Francisco Bay-Delta, and from the Delta Bay into the Pacific Ocean. In 2009, the California state legislature enacted the Delta Reform Act. As part of that legislation the California State Water Resources Control Board (State Water Board) was instructed to report to the Delta Stewardship Council (Council) the Board's view of what flows would be necessary to protect the Delta ecosystem. In its August 2010 report, *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem* (*Flow Report*)[1], the State Water Board expressed its concerns about the Bay-Delta flows.[2] It concluded that the Bay-Delta flows are inadequate. They threaten native fish[3], and thereby violate California's obligations under the public-trust doctrine.[4] According to the *Flow Report*, changing flow conditions in ways that would support native fish species requires improving the Bay-Delta flows throughout the year.

If we understand the Council's role correctly, then to allocate the Bay-Delta flows well, the Council would seek to balance its obligations to protect public-trust use of the Bay-Delta flows with its obligations to support the dual coequal goals of i) habitat conservation and management, and ii) improving reliability of water supplies. This balancing task includes:

a. Developing alternatives to increase the efficiency and equity of allocating the Bay-Delta flows among the competing instream and consumptive demands[5]

b. Describing the economic, biophysical[6] and other effects of the alternatives

c. Selecting what it regards as the best of the alternatives and enforcing the efficient allocation of the imputed flow conditions.

Economics, at its core, is the science of choice[7] or, as it is defined frequently in introductory textbooks, the study of the allocation of scarce[8] resources among competing

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[3] These species include Chinook Salmon, Delta Smelt, and Bay Shrimp. *Flow Report*, p. 5 and 8.

[4] *Flow Report*, p.1-7; *Flow Report*, p.12: "The purpose of the public trust is to protect commerce, navigation, fisheries, recreation, ecological values, and fish and wildlife habitat. Under the public trust doctrine, the State of California has sovereign authority to exercise continuous supervision and control over the navigable waters of the state and the lands underlying those waters. [citation omitted] A variant of the public trust doctrine also applies to activities that harm a fishery in non-navigable waters. [citation omitted]"

[5] Instream demands are water uses that can be carried out without removing the water from its source, such as in navigation and recreation. Consumptive demands are water uses which lessen the amount of water available for other uses, such as in manufacturing, agriculture, and food preparation. [U.S. Bureau of Reclammation. *Glossary*. January 5, 2011. Retrieved June 24, 2011, from http://www.usbr.gov/library/glossary/.]

[6] By 'biophysical,' we mean the biological effects (e.g., on plants and animals), ecological effects (e.g., on ecological systems), and physical effects, e.g., on water, land and air). We do not mean the interdisciplinary science of biophysics that, as Wikipedia tells us, 'uses the methods of physics and physical chemistry to study biological systems.' We apologize for any confusion, and plead only expedience for our lack of precision. [2011. *Biophysics*. May 16. Retrieved June 27, 2011, from en.wikipedia.org/wiki/Biophysical].

demands.[9] The State's balancing decision, whether good or bad, would include such an allocation among competing demands. Michael Jackson, an attorney working with Bay-Delta stakeholders, asked ECONorthwest to describe economic issues relevant to the State's balancing of competing demands for Bay-Delta flows. We at ECONorthwest recognize the diverse group of people interested in the Bay-Delta Flows, and have sought to write an accessible yet technically sound report rooted in established economic practices and theory. To that end, we have prepared this report.

[7] See, for example, <http://www.google.com/search?sclient=psy&hl=en&site=&source=hp&q=economics+science+choice&btnG=Search>

[8] By "scarcity," we mean situations in which the resources available for producing output are insufficient to satisfy wants. This is different to saying that they are insufficient to satisfy demand since demand relates to an expression of want backed by money. This concept of relative scarcity in relation to wants is widely held to define the central conflict of economics since, otherwise, there would be no need to think about the 'best' allocation of resources. [Pearce, D.W. 1992. *The MIT Dictionary of Economics*, 4th edition. Cambridge, MA: The MIT Press.]

[9] See, for example, <http://www.google.com/search?sclient=psy&hl=en&site=&source=hp&q=economics+allocation+scarce+resources+competing+demands&btnG=Search>; Field, B.C. 1997. *Environmental Economics*, Second Edition. San Francisco: McGraw-Hill Company, Inc.; Gramlich, E.M. 1990. *A Guide to Benefit-Cost Analysis*. Englewood Cliffs, New Jersey: Prentice Hall.; Harberger, A. and G. Jenkins, eds. 2002. *Cost-Benefit Analysis*. The International Library of Critical Writings in Economics: 152. Northampton, Massachusetts: Edward Elgar Publishers.; and U.S. Environmental Protection Agency. 2010. *Guidelines for Preparing Economic Analyses*. December.

SECTION 2: ECONOMICS AND THE CHOICES CALIFORNIA FACES

If the waters flowing from the Sierra Nevada to the San Francisco Bay-Delta had conditions of abundance, the State might not have felt compelled to prepare the *Flow Report*. But scarcity rules the waters and causes fierce competition. The consequences of the competition for these scarce waters lies at the heart of the State Water Board's *Flow Report*.[10]

Instream uses of the Bay-Delta flows compete with what the State Water Board describes as "other beneficial uses" of water.[11] These *other beneficial uses* include municipal, industrial, and agricultural uses.[12] If, once again, we understand the State role correctly, then in allocating the Bay-Delta flows the State would seek to balance its obligations to protect public-trust use of the Bay-Delta flows, with its obligations to support the "other uses" of the Bay-Delta flows.

To balance its obligations effectively, the State would, as we state in Section 1, seek to develop alternatives to improve the Bay-Delta flows, describe the economic, biophysical and other effects of these alternatives, and then select the best of the alternatives. To serve these ends, a necessary step for the State would be to describe how each alternative would affect economic well-being, power production, human health and welfare, the sustainability of natural resources, habitats and species, and possibly other factors.[13] Economists have developed tools for describing such effects.

Among the tools economics offers for comparing competing alternatives, the most widely known and frequently used in environmental and natural resource matters is benefit-cost analysis (BCA).[14] As applied in this case by the State, a properly conducted BCA would describe differences in net economic values—economic benefits minus economic costs—across the alternatives. In our experience, stakeholders and decision makers frequently care about other types of economic consequences besides changes in economic values. They want to know how policy alternatives will affect things like jobs and income, which economists describe as economic impacts, and the distribution of changes in economic values and impacts among stakeholders and households, which

[10] For a description and explanation of the economic consequences of a shift from abundance to scarcity in an ecological system, e.g., a watershed, see Courant, P., E. Niemi, and E. Whitelaw. 1997. *The Ecosystem-Economy Relationship: Insights from Six Forested LTER Sites*. Grant No. DEB-9416809. National Science Foundation. November.; Hulse, D., G. Gordon, and E. Niemi. 2001. *Establishing Correlations Between Upland Forest Management Practices and the Economic Consequences of Stream Turbidity in Municipal Supply Watersheds*. EPA Grant No. R825822. Environmental Protection Agency. September.

[11] In the rest of the report, we will italicize the phrase "other beneficial uses" to signal that these are not all other uses but only those specified by the State Water Board.

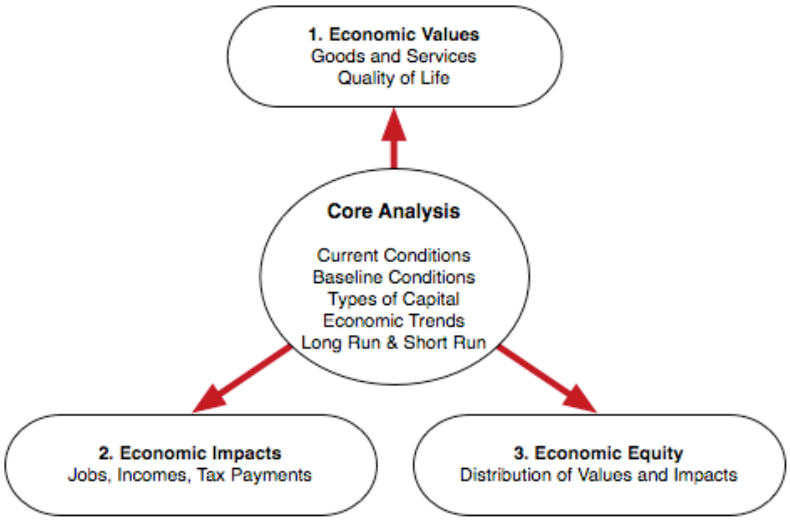
[12] *Flow Report*, p.1-7.

[13] *Flow Report*, p.2-3.

[14] Mishan, E.J. *Elements of Cost-Benefit Analysis*, 3rd Edition. 1972. p.11-13; Turner, R., D. Pearce, and I. Bateman. 1993. *Environmental Economics*, p.93-4; Teitenberg, T. and L. Lewis. *Environmental and Resource Economics*, 8th Edition. 2008. p.28.

economists generally address as economic equity. Thus, a comprehensive economic assessment from alternative Bay-Delta flows would describe economic consequences that include changes in economic values, changes in economic impacts, and the distributional outcomes for each alternative. Figure 1 shows the three categories of economic effects each alternative would cause.

Figure 1. Categories of Economic Effects



Source: ECONorthwest

The first category, Economic Values, represents *changes in the values of goods and services* available to Californians that result from the market and non-market activities associated with each alternative. Such effects include changes in economic benefits, costs or both, as well as changes in the quality of life. The second category, Economic Impacts, represents changes in jobs and incomes for workers, costs or revenues for private firms, and expenditures or tax revenues for governments. These impacts occur directly, as workers are employed on construction, deconstruction, and restoration, for example, and indirectly, as dollars are spent locally on goods and services, dollars which multiply through the local economy, supporting additional jobs and incomes. The third category, Economic Equity, represents the distribution of the other two categories of effects, Economic Values and Economic Impacts, across income brackets of households, across ethnicities, and across geographic areas. These changes are particularly challenging to describe and evaluate when, say, groups of households who enjoy the benefits, jobs, and incomes, differ from those who bear the costs.

The center of Figure 1—the Core Analysis—shows the analyses common to characterizing or calculating all three categories of economic effects.

1. By describing the Current Conditions and Baseline Conditions for each alternative, the analyst can describe the gap between the two. The larger the gap, the larger the problem.
2. By describing the four basic forms of capital (physical capital, human capital, social capital and natural capital)[15] under both Current and Baseline Conditions for each alternative, the analyst can, for example, measure the effects of the alternative on the stocks of economic assets and thereby on the flows of services from those assets.[16]
3. By taking economic trends into account, the analyst can apply a with-versus-without approach, which isolates the economic effects (values, impacts, equity) caused by the alternatives from changes that will likely occur unrelated to the alternatives.
4. By addressing both the short- and long-term effects, the analyst can avoid errors of omission and commission through confusing today and tomorrow. The literal differences in effects between today and tomorrow would be trivial. But since the relevant period of time may stretch to a century, the figurative differences would likely be huge.

In 1983, the California Supreme Court issued its opinion in the case of *National Audubon Society et al. v. The Superior Court of Alpine County, et al*.[17] That ruling, commonly called the "Mono Lake decision," (*Mono Lake*) clarified the extent of the State's public-trust obligation to protect water resources. In general, the Court ruled that protecting water resources takes precedence over consumptive water use. The Court's ruling relied in part on economic analyses of the competing demands for Mono Lake water.

The State's analysis of the economic effects of its balancing decision can benefit from applying the widely accepted professional standards applicable to economic analyses in this type of matter, and the precedents set by the *Mono Lake* decision. In this report we examine the relevant professional standards and the *Mono Lake* decision and describe their implications for the State as it seeks a balance.

In the next section, Section 3, we present an economic perspective of the Supreme Court's decision.

[15] These four types of capital affect local economic productivity, which in turn is the source of economic growth in, say, California. Examples of physical capital are private and public machines, buildings, roads, and water and sewage systems. Examples of natural capital are rivers and streams, mountains and valleys, and grasslands and forests. Examples of human capital are workers of all types and their knowledge and skills. Examples of social capital are social networks and the norms, laws, and judicial and political systems.

[16] O'Sullivan, A. 2008. *Urban Economics*, 7th Edition. p.90-91.

[17] Broussard, J. 1983. *National Audubon Society et al., Petitioners, v. The Superior Court of Alpine County, Respondent; Department of Water and Power of the City of Los Angeles et al., Real Parties in Interest*. 33 Cal.3d 419. S.F. No. 24368. Supreme Court of California. February 17.

SECTION 3: ECONOMICS AND THE STATE WATER BOARD'S BALANCING DECISION IN *MONO LAKE*

In *Mono Lake*, the State Water Board faced a classic public-policy choice, a choice resembling the choice it faces with Bay-Delta flows: allocating a scarce and valuable natural resource—Mono Lake—among competing demands. The State can therefore look to its own history for guidance on balancing its public-trust obligation to protect Bay-Delta flows with the demands from other beneficial uses, and the role that economic information can play in the deliberations. As it balanced competing interests and reached its decision in *Mono Lake*, the State Water Board described the biological significance of the water at issue, developed economic measures of the relevant costs and benefits of alternative water allocations, and considered measures that could mitigate negative economic outcomes.[18] It should take similar steps as it sets criteria for the Bay-Delta flows.

In *Mono Lake*, the State Water Board considered the consequences of the City of Los Angeles (City)— acting through the Los Angeles Department of Water and Power (LADWP)—exercising its right to draw water from Mono Lake for urban-consumption uses, and the resulting impacts on the lake's ecological habitats and affected species. The State Water Board began by considering the biophysical aspects of its decision. It first identified the ecological uses of trust resources at issue and their biological requirements, e.g., the species that depend on Mono Lake and their water requirements. Next, it studied the relationship between water flows out of Mono Lake and the impacts on ecological uses. It then compared the costs of the City acquiring water from sources other than Mono Lake with the economic benefits of protecting the ecological uses of the lake's affected public-trust resources.[19]

Dr. John Loomis, a natural-resource economist,[20] helped quantify the economic benefits in the State Water Board's analysis. Dr. Loomis surveyed California residents and calculated their willingness to pay to protect Mono Lake's habitats and affected species. Based on this information, Dr. Loomis calculated the economic benefits of protecting the ecological uses of the lake's water at $1.5 billion to $3.5 billion annually. This amount significantly exceeded the estimated cost, $26.5 million per year, of finding alternative sources of water for the City.[21]

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[18] Koehler, C.J. 1995. "Water Rights and the Public Trust Doctrine: Resolution of the Mono Lake Controversey." *Ecology Law Quarterly* 22: 451.; Casey, E. 1984. "Water Law—Public Trust Doctrine," *Natural Resources Journal* 24: 809-825.

[19] Koehler, 1995; Casey, 1984.

[20] Dr. Loomis conducted this research while at the Department of Agricultural Economics at the Davis campus of the University of California.

[21] Loomis, J. 1987. "Balancing Public Trust Resources of Mono Lake and Los Angeles' Water Right: An Economic Approach." *Water Resources Research* 23: 1449-1456. August; Loomis, J. 1997. Use of Non-Market Valuation Studies in Water Resource Management Assessments. Colorado State University; Duffield, J. 2010. *Valuing Ecosystem Services in River and Lake Systems: Methods and Western U.S. Case Studies*. Presentation, Salt Lake City, April 28.

Dr. Loomis conducted his analysis as independent research that was not part of the State Water Board's balancing decision. The State Water Board, however, took notice of Dr. Loomis' work and directed the consultant performing the economic portion of the Environmental Impact Statement for the balancing analysis to adopt and implement Dr. Loomis' approach. The consultant's assessment reached the same conclusion: the economic benefits of protecting the ecological uses of trust resources in Mono Lake significantly exceeded the cost of supplying the City with water from alternative sources. The State Water Board considered other factors along with these economic results and ultimately reduced by half the amount of water that the LADWP could divert from Mono Lake.[22]

The State Water Board's *Mono Lake* experience can help inform current deliberations on the relevant economic aspects of balancing competing uses of Bay-Delta flows. Analytical factors from the *Mono Lake* analysis that have relevance to the Delta Stewardship Council's planning decision include:

- *Conduct economic analyses in the context of the biophysical requirements of the ecological uses of public-trust resources*. The State Water Board identified the ecological uses of public-trust resources at issue in *Mono Lake* and the water requirements that support these uses *before* considering the costs and benefits of allocation scenarios. That is, the State Water Board acknowledged its obligation to protect the ecological uses of public-trust resources, and then considered reasonable methods of satisfying this obligation.[23]

- *Account for all relevant economic, legal, and other forces and trends*. The LADWP proposed that the State Water Board make its decision based on a worst-case scenario of future water supplies for the City. Such an approach ignored current trends in water policy at the local, state and federal level. For example, the worst-case approach ignored the fact that trends in state and federal water law at the time encouraged water transfers between and among entities. Such transfers meant that LADWP could tap sources other than Mono Lake for future demands. On this point the State Water Board noted, "[T]he LADWP analysis assumes that insufficient replacement water will be available thereby causing high water shortage costs to be imposed on water users in Los Angeles. This assumption does not appear to be realistic in light of the evidence…." The State Water Board took the current trends in water transfers into account when making its decision.[24]

- *Consider likely mitigating circumstances*. LADWP also asked that the State Water Board assume that the City would take no actions to mitigate the impacts of reduced flows from Mono Lake. That is, the LADWP asked that the State Water Board base its decision on a *static analysis* that assumed conditions would remain fixed over the foreseeable future. The State Water Board, instead, based its decision on a *dynamic analysis*, which assumed the City and others would take appropriate actions, such as

[22] Loomis, 1997; Duffield, 2010.

[23] Koehler, 1995; Casey, 1984.

[24] Koehler, 1995; Casey, 1984.

doing more to conserve water, to mitigate the initial effects of a reduction in water supplied from Mono Lake. More broadly, this dynamic analysis took into account relevant economic and other forces and trends, as noted above.

- *Account fully for both values reflected in market prices and values that are not.* In reaching its *Mono Lake* decision, the State Water Board considered estimates of the City's potential costs to acquire water from another source. These estimates derived from data on the prices at which water was bought and sold in the region. No such prices and data existed for the economic value of protecting the ecological uses of public-trust resources. The State Water Board recognized, however, that the absence of prices did not mean that protecting these uses had little or no value, but, instead, that market prices are not an appropriate tool for measuring the value. Hence, the State Water Board looked to the results of research that employed non-market techniques for estimating the value.[25] We address this point in more detail in the next section.

[25] Loomis, 1987; Loomis, 1997; Duffield, 2010.

SECTION 4: THE EVOLUTION OF THE ECOLOGICAL USES OF PUBLIC-TRUST RESOURCES AND ECONOMIC METHODS

Stakeholders in the *Mono Lake* case litigated to clarify the relationship between the City's water rights and the State's public-trust obligation to protect water resources. The Supreme Court of California ultimately ruled that, in general, the State's public-trust obligations have precedence over the City's water rights. This ruling helped inform the State Water Board's balancing decision in that case. The Supreme Court's decision emphasized that stakeholders and decision makers should consider public-trust obligations as dynamic and evolving over time, rather than fixed and based exclusively on historical conditions. What constitutes a protected use of public-trust resources can evolve along with changes in understanding of the natural environment and its relationship to the well being of human society.

Methods of describing the economic effects of public policies on ecological uses of water resources have also evolved. Markets do not exist for many of these uses and so economists calculate their economic significance using non-market valuation methods. Years ago, economists and public-policy analysts could reasonably debate the analytical veracity of these methods. Not so today. Analytical methods continue evolving, and areas of legitimate disagreement still exist, however, detailed descriptions of these analytical methods appear in economic textbooks, articles in academic journals, undergraduate and graduate economics courses, and reports by federal and state natural-resource agencies in the U.S. Economists in Europe, Asia and elsewhere also regularly use these methods.

In this section we describe the evolution of thinking on ecological uses of California's public-trust resources. We then summarize methods of describing the economic significance of ecological uses of trust resources, especially those that provide society with ecosystem-services for which markets do not exist. The information in this section provides a context for the sections that follow, in which we describe in more detail the analytical principles relevant to describing the economic effects of the State's balancing decision regarding the Bay-Delta flows.

A. Ecological Uses of Public-Trust Resources

Implementing the public-trust doctrine in California has evolved over time. Early in the state's history, the doctrine protected the public's access to, and use of, tidelands for navigation, commerce and fisheries. More recent court decisions recognized the changing nature of the use of trust resources and expanded the list of protected uses to include recreational uses and ecological uses that support habitats and species. Litigation related to the State Water Board's *Mono Lake* decision help clarify the responsibilities of the State as administrator of the public-trust resources. The Supreme Court of California ruled that the State Water Board must take impacts of allocation decisions on uses of trust resources into account when administering water rights.[26]

[26] Koehler, 1995; Casey, 1984.

The Court's ruling also emphasized a flexible definition of use, one that responds to changing public needs. The Court also identified ecological resources as one of "the most important" uses of trust resources.[27]

"[W]e stated that '[t]he public uses to which tidelands are subject are sufficiently flexible to encompass changing public needs. In administering the trust the state is not burdened with an outmoded classification favoring one mode of utilization over another. [citation omitted] There is a growing public recognition that one of the most important public uses of the tidelands—a use encompassed within the tidelands trust—is the preservation of those lands in their natural state, so that they may serve as ecological units for scientific study, as open space, and as environments which provide food and habitat for birds and marine life, and which favorable affect the scenery and climate of the area.'"[28]

Preservation of water-based natural resources "in their natural state" can affect a wide range of ecosystem services that trust resources provide. An illustrative, though incomplete, list of these ecosystem services includes flood mitigation and groundwater recharge, water filtration, sediment capture, nutrient cycling, gas regulation, provision of habitat for economically important fish and wildlife, and scenic and amenity values. While the natural resources at issue exist independent of human society, ecosystem services only exist insofar as there is human demand for their supply, at a particular place and time, and their value reflects the specific context within which the demand exists. Ecological uses of trust resources are not traded in markets, however, and so we must look to non-market valuation methods for measures of their values. We describe these methods in the next subsection.

B. Evolution of Economic Methods

Methods of measuring the economic effects of water allocation decisions on what the California Supreme Court described as one of the most important uses of public-trust resources—uses by aquatic resources that provide ecosystem services—have evolved over time. In the remainder of this section, we illustrate the evolution of these economic methods using reports by federal and California state agencies. We picked these sources because they help guide federal and state public policies, and because they often incorporate analytical principles or methods only after they have been subject to peer review and debate in academic and professional forums. We begin with federal guidelines.

1. Federal Guidelines

a. Principles and Guidelines

In 1983, the U.S. Water Resources Council published, *The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*P&G*).

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[27] Broussard, J. 1983. *National Audubon Society et al., Petitioners, v. The Superior Court of Alpine County, Respondent; Department of Water and Power of the City of Los Angeles et al., Real Parties in Interest.* 33 Cal.3d 419. S.F. No. 24368. Supreme Court of California. February 17.

[28] Broussard, 1983.

This report helps federal agencies, including the Corps of Engineers and Bureau of Reclamation, plan water-related projects. The *P&G* have not been updated since they were introduced. Recently, the National Research Council (NRC) of the National Academies, reviewed proposed changes to the *P&G*. The NRC's review begins by describing some of the significant changes in water-resources planning since the publication of the *P&G* in 1983.

"Since the early 1980s there have been may changes in the national water resources planning landscape. For example, … [s]cientific understanding and appreciation of the natural functions of aquatic ecosystems have increased, and environmental protection and ecosystem restoration have become primary planning objectives for some projects ... Many national water planning challenges involve balancing decisions and resources among a greater number of water resource users and interests."[29]

"For the Corps of Engineers, new missions have been added … especially aquatic ecosystem restoration."[30]

"[Other water-planning issues] such as design of ecosystem restoration projects, reallocating water from traditional users to rapidly growing cities or ecosystem restoration purposes, and controlling nonpoint source pollution reflect more recent changes and needs. Many of today's key national water management issues lie largely outside the missions of the agencies for which the *P&G* was written."[31]

"In light of these developments, many groups—including committees of the National Research Council—have recommended that the P&G be reviewed and modernized.[32]

The NRC concluded, however, that the proposed changes did not adequately address the many deficiencies in the outdated *P&G*. The proposed revisions "lacked clarity and consistency,"[33] which precluded the NRC from offering specific suggested changes. The NRC did comment on a few areas for improvement.

"…[T]he 2007 Water Resources Development Act requires that the P&G revision ensure the use of best available economic principles and analytical techniques. However, the proposed revisions contain concepts, advice, and language that are carryovers from historical practices and documents and are not fully consistent with contemporary best practices in decision science and economics. This relates

[29] National Research Council of the National Academies. 2010. *A Review of the Proposed Revisions to the Federal Principles and Guidelines Water Resources Planning Document*. Committee on Improving Principles and Guidelines for Federal Water Resources Project Planning, Water Science and Technology Board, Division on Earth and Life Studies. p.1.

[30] National Research Council, 2010, p.5.

[31] National Research Council, 2010, p.6.

[32] National Research Council, 2010, p.1.

[33] National Research Council, 2010, p.2.

to both how analysis is conducted and the role that it plays informing decisions."[34]

For example, the NRC noted that limiting an economic analysis of an environmental policy to costs and benefits would not satisfy current professional standards. An adequate analysis will look beyond costs and benefits to describe all relevant impacts and tradeoffs that affect jobs, income, competitiveness, etc. The *P&G* also separated the analysis of economic effects of environmental changes, which are described qualitatively, from the analysis of economic-development changes, which are described quantitatively. The NRC characterized this approach as a "residue" from the 1983 *P&G* that is inconsistent with current best practices.[35]

The NRC described the *P&G* as outdated and not representative of current best economic practices. This is especially true for analyses of the economic effects of public policies on environmental resources and ecosystem services. Given the significance of public-trust resources that support ecological habitats and ecosystem services that the Bay-Delta flows support, and given the deficiencies in the *P&G*, this report can offer the State Water Board little useful guidance on economic aspects balancing Bay-Delta flows.

b. EPA Guidelines on Economic Analyses

In December of 2010, the Environmental Protection Agency (EPA) released *Guidelines for Preparing Economic Analyses (Guidelines)*. The 2010 edition of the *Guidelines* represents the third update since the first edition was released in 1983. Unlike the *P&G*, which remain unchanged since first introduced in 1983, EPA anticipated periodically revising the *Guidelines* to account for "new literature published since the last revision" and the "growth and development of economic tools and practices."[36] These revisions and updates help keep the *Guidelines* more consistent with current best economic practices than do the *P&G*.

The 2010 edition includes a number of updates that help make the document a useful planning tool in general, and specifically for the State's balancing decision in the Delta. These updates include:[37]

- More detailed recommendations on identifying and describing baseline conditions that would exist without a proposed policy revision or regulation.
- An expanded description of methods of defining and valuing ecological benefits of projects and policies that protect natural resources.

[34] National Research Council, 2010, p.12.

[35] National Research Council, 2010, p.11-12.

[36] National Center for Environmental Economics. 2010. *Guidelines for Preparing Economic Analyses. U.S. Environmental Protection Agency*. EPA 240-R-10-001. December. p.1-1.

[37] National Center for Environmental Economics, 2010, p.1-1.

- A revised and updated description of methods of discounting costs and benefits that occur at different times in the future.

- Directions on presenting the results of benefit-cost studies, including effects that cannot be quantified or expressed in dollar amounts.

c. EPA Guidelines on Valuing Ecological Services

EPA's Science Advisory Board (SAB) released a report titled, *Valuing the Protection of Ecological Systems and Services* in May of 2009. As the name implies, the report describes methods of identifying and describing the economic significance of natural resources and associated ecosystem services affected by policies or projects. The SAB noted the importance of valuing ecosystem services using up-to-date economic methods, and promoting collaboration among social scientists and biophysical scientists.[38]

"This report describes and illustrates how EPA can use an 'expanded and integrated approach' to ecological valuation. The proposed approach is 'expanded' in seeking to assess and quantify a broader range of values than EPA has historically addressed and through consideration of a larger suite of valuation methods. The proposed approach is 'integrated' in encouraging greater collaboration among a wide range of disciplines, including ecologists, economists, and other social and behavioral scientists, at each step of the valuation process."[39]

The report describes a number of recommendations that facilitate the "expanded and integrated approach." Many of the recommendations have relevance to assessing the economic effects of water allocations in the Delta. These include:[40]

- Identifying and describing the critical relationships between biophysical aspects of affected natural resources and ecosystem services, and analyses of the economic effects of policies that impact resources and services.

- Choosing appropriate valuation methods.

- Identifying and describing sources of uncertainty in analyses of the economic significance of ecosystem services.

2. Guidelines by the California Department of Water Resources

The California Department of Water Resources (Department) recently produced guidelines for economic analyses of public policies that affect water resources. We describe two of these works in this subsection. The first, a four-part study published in 2005, describes the importance of considering the full range of economic costs and

[38] Environmental Protectation Agency (EPA) Science Advisory Board. 2009. Valuing the Protection of Ecological Systems and Services. EPA-SAB-09-012. May. p.2.

[39] EPA, 2009, p.2.

[40] EPA, 2009, p.1-7.

benefits of public policies that affect aquatic resources. The Department refers to this as a "multi-objective approach" to floodplain management because it takes into account objectives besides flood mitigation (a single objective) to consider consequences on habitats, water quality, society, etc. The second is a guidebook on conducting economic analysis published by the Department in 2008.

a. Multi-Objective Approach to Floodplain Management

1. Ecosystem Valuation Methods

The first of the four reports in the multi-objective approach, *Ecosystem Valuation Methods* (*Methods*), describes a number of up-do-date methods of valuing aquatic-based ecosystem services.[41] The report summarizes ten analytical methods and their advantages and disadvantages. The floodplain focus and the up-to-date descriptions of analytical methods in this and the other three reports, have relevance to, and can help inform, the State's assessment of the economic significance of ecological uses of the Bay-Delta flows.

2. Natural Floodplain Functions and Societal Values

The second report, *Natural Floodplain Functions and Societal Values* (*Functions*), describes biophysical aspects of floodplain habitats and examples of economic values of the ecosystem services that floodplains provide.[42] The report provides background information on floodplain habitats and the biological and human services they provide, and the importance of considering this information when making decisions that affect floodplains. The report describes economic values of ecosystem services including managing flows, maintaining natural channel processes, water supply, water quality, soil quality, and plant and wildlife habitat. The staff conducting the study applied some of the analytical methods described in the *Methods* report.

3. Middle Creek Restoration Project Case Study: Benefit and Cost Analysis

The third report, *Middle Creek Flood Ecosystem Restoration Project Case Study: Benefit and Cost Analysis* (*Case Study*), describes the results of a case study of applying analytical methods and data described in the *Methods* and *Functions* reports to a floodplain restoration project.[43] The Middle Creek Ecosystem Restoration Project restored damaged floodplain structure, habitats and functions in the Clear Lake watershed.

The analysis compared the benefits and costs of a no-action alternative and four restoration alternatives. The five alternatives described land use scenarios including maintaining current agricultural and rural-residential uses and flood protection,

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[41] California Department of Water. 2005A. *Ecosystem Valuation Methods. Revised Draft*. Multi-Objective Approaches to Floodplain Management on a Watershed Basis. May.

[42] California Department of Water Resources. 2005B. *Natural Floodplain Functions and Societal Values Revised Draft*. Multi-Objective Approaches to Floodplain Management on a Watershed Basis. May.

[43] California Department of Water Resources. 2005C. *Middle Creek Flood Ecosystem Restoration Project Case Study: Benefit and Cost Analysis*. Multi-Objective Approaches to Floodplain Management on a Watershed Basis. May.

restoring portions of the floodplain, and providing increased flood protection for existing uses and enhanced agricultural production.

4. Floodplain Management Benefit and Cost Framework

The fourth report, *Floodplain Management Benefit and Cost Analysis Framework* (*Framework*), describes a framework for analyses of ecological, social and economic consequences of policy decisions that affect aquatic resources. [44] It emphasizes the importance of including information on ecological consequences in decision-making. The report cites sources that are somewhat dated, though more current than those referenced in the 1983 *P&G*. In spite of this drawback, the document describes analytical concepts relevant to the State's balancing decision on the Bay-Delta flows. These concepts include the following.

- Incorporate environmental and social consequences into management decisions.[45]
- Measure the economic effects of policies on ecosystem services that have value to humans using non-market valuation techniques. The report references the *Methods* report for information on valuation techniques.[46]
- Not all economic effects of management decisions will occur over the same geography and time. Take these differences into account.[47]
- Select the appropriate discount rate for economic effects that will occur in the future.[48]
- Account for analytical uncertainty and risk. The report describes four methods of doing so.[49]
- Consider ecological, social and economic effects of policy decisions on a broad watershed scale. Do not limit economic analyses to the geographic boundaries of an individual project.[50]

State water projects that have a federal nexus must conduct economic analyses using the 1983 *P&G*. The *Framework* notes some of the limitations of the *P&G* and describes analytical principles that will produce more comprehensive assessments of ecological, social and economic effects of management decisions.

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[44] California Department of Water Resources. 2005D. *Floodplain Management Benefits and Cost Analysis Framework. Revised Draft*. Multi-Objective Approaches to Floodplain Management on a Watershed Basis. June.

[45] California Department of Water, 2005D, p.2.

[46] California Department of Water, 2005D, p.11-12.

[47] California Department of Water, 2005D, p.12.

[48] California Department of Water, 2005D, p.14.

[49] California Department of Water, 2005D, p.15-17.

[50] California Department of Water, 2005D, p.22-24.

"Local agencies seeking federal cost-sharing assistance for multi-objective projects with the [Army] Corps [of Engineers] will still be subject to the [P&G] However, if the local agencies are able to perform an economic analysis following the framework presented [in this report], they will not only have generated the information necessary to do the Corp's analysis, but more importantly, they will also have developed the information necessary to make a more informed decision about proposed floodplain management projects."[51]

b. Economic Analysis Guidebook

Economic analyses conducted by the Department must conform to the Federal *P&G* because of the significant amount of interactions and partnerships between the Department and Federal agencies. The Department recognized, however, that the outdated *P&G* could not adequately address the complex nature of water-management challenges that the Department faces. Department staff, therefore, developed the *Economic Analysis Guidebook* (*Guidebook)* in 2008, to address deficiencies in the *P&G*, help Department economists conduct economic analyses using up-to-date methods, and describe economic concepts and analyses to non-economists Department staff. [52]

"It is … DWR [Department] policy to adopt, maintain, and periodically update its own *Economics Analysis Guidebook*, which is consistent with the *P&G* but can also incorporate innovative methods and tools when appropriate. This policy is necessary because (a) the *P&G* has not been updated for more than 20 years, (b) federal and State economic analyses sometimes have different regional analysis perspectives, and (c) water management projects and programs have become more complex."[53]

"Water resource projects are increasingly becoming more complex, requiring more difficult economic analyses. Projects now tend to have multiple purposes and affect many diverse stakeholders. … [T]raditional methods of performing economic analysis often do not provide reliable means for quantifying important categories of benefits that these projects may provide (such as, ecosystem restoration)."[54]

The *Guidebook* describes economics as "critical" to describing the environmental consequences, social effects, and costs and benefits of water-management alternatives. Environmental issues include the tradeoffs between "natural" and "human" demands on water resources and should take into account the economic effects of water uses that benefit the natural environment, even if this use adversely impacts agricultural and urban water users. Economics can also help describe effects on social equity or

[51] California Department of Water, 2005D, p.35-36.

[52] California Department of Water Resources (CDWR). 2008. *Economic Analysis Guidebook*. The State of California. January.

[53] CDWR (2008), p.vii.

[54] CDWR (2008), p.1.

environmental justice. Economic costs and benefits include monetary and non-monetary effects. [55]

Methods of economic analysis described in the *Guidebook* include cost-effectiveness, benefit-cost, and socioeconomic-impact analysis. As the name implies, cost-effectiveness analyses identify the least-cost option of achieving a given goal. A benefit-cost analysis compares changes in costs to society with changes in benefit and calculates the net change, or net benefits of a proposal or proposals. A socioeconomic-impact analysis describes how a policy change affects factors such as population, employment, income, etc.

[55] CDWR (2008), p.viii.

SECTION 5: THE PRINCIPLES OF BENEFIT-COST ANALYSIS

In Section 1 of this report, we summarize our understanding of the State's objective to find a balance between the public-trust use of the Bay-Delta flows and, namely, the other beneficial uses of the Bay-Delta flows. In Section 2, we identify benefit-cost analysis (BCA) as the most widely used tool for evaluating alternative approaches to such a balance. In this section, Section 5, we focus on the principles by which the State should calculate and report the benefits and costs of these alternative approaches.[56]

A. Identify the Alternatives

At its most basic level, BCA is simply a tool for comparing alternatives. Whether one is already using one of the alternatives—in which case that alternative serves as the gauge or standard—or not, applying the principles remains the same. One begins by identifying all the alternatives and describing all the elements of each alternative.[57]

Today, the State does not seem to suffer too few alternatives. Rather, its challenge lies in identifying and clarifying the elements of each alternative. That said, prudence dictates ensuring the list of alternatives avoids errors of omission, because the alternatives selected for the BCA could affect the outcome of the analysis. By the same token, elements omitted from the description of an alternative could affect its ranking among the alternatives State evaluates.

B. Identify the Relevant Scope

At the beginning of any BCA, the State should identify the relevant scope of the analysis. That is, the analyst should specify which benefits and costs matter, to whom, over what geography and over what period of time.

> "Before you conduct an economic analysis, it is necessary to define its scope (i.e., identify who and what should be included in the analysis and who and what should be excluded)."[58]

Once the State has identified the relevant scope, it then should maintain each of the scope's dimensions throughout the BCA.

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[56] For portions of this Section 5, we relied on material Ed Whitelaw and others at ECONorthwest prepared in a matter involving Methanex Corporation, Claimant/Investor, and the United States of America, Respondent/Party; *In the Arbitration Under Chapter 11 of the North American Free Trade Agreement and the UNCITRAL Arbitration Rules Between Methanex Corporation and United States of America*. The arbitration occurred in 2004.

[57] Field, B.C. 1997. *Environmental Economics*, 2nd Edition. San Francisco: McGraw-Hill Company, Inc. p.116-117; U.S. Environmental Protection Agency (EPA). 2010. *Guidelines for Preparing Economic Analyses*. Report No. EPA-240-R-10-001. December. p.A-8.

[58] U.S. Environmental Protection Agency (EPA). 1993. *Guide for Cost-Effectiveness and Cost-Benefit Analysis of State and Local Ground Water Protection Programs*. U.S. Environmental Protection Agency, Office of Water, and Office of Ground Water and Drinking Water. April. p.11.

C. Assemble Information and Account for Risk and Uncertainty

Given the relevant scope, the analyst should assemble information on the full range of costs and benefits. Even on topics for which extensive research exists, the published findings would still reflect different levels of understanding. Researchers have grouped these different levels into risk, uncertainty, and ignorance. Risk refers to conditions under which the range of possible outcomes and their probabilities are known. Uncertainty refers to conditions under which the range of possible outcomes is known, but their probabilities are not.[59] Ignorance applies when we do not know the possible outcomes.

The more that analysts differ on estimates or ranges of important categories of costs and benefits, the more the State should account for the uncertainty clearly and consistently.[60]

> "Estimates of costs, benefits and other economic impacts should be accompanied by indications of the most important sources of uncertainty embodied in the estimates, and, if possible, a quantitative assessment of their importance… Ideally, an economic analysis would present results in the form of probability distributions that reflect the cumulative impact of all underlying sources of uncertainty. When this is impossible, due to time or resource constraints, results should be qualified with descriptions of major sources of uncertainty."[61]

In interpreting the benefits and costs associated with those elements of the various alternatives that affect environmental assets and ecosystem services, the State should not assume Californians would perceive numerically equal upside and downside risks neutrally. That is, when it comes to environmental matters, individuals tend to exhibit risk aversion.

> "…it seems reasonable to advocate that environmental policymakers approach their decisions in a risk-averse manner."[62]

> "If people are risk averse, then we should expect them to give extra weight to measures that avoid environmental disasters … It seems sensible to many people to take measures today to avoid the possibility of catastrophe in the future, even if the worst-case scenario has a relatively low probability."[63]

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[59] Knight, F.H. 1921. *Risk, Uncertainty and Profit*. New York, NY: Sentry Press.; Integrated Risk Information System. 2011. *IRIS Glossary*. U.S. Environmental Protection Agency. May 16. Retrieved July 27, 2011, from http://www.epa.gov/risk_assessment/glossary.htm#u.; Camerer, C. and M. Weber. 1992. "Recent Developments in Modeling Preferences: Uncertainty and Ambiguity." *Journal of Risk and Uncertainty* 5: 325-370.

[60] U.S. Environmental Protection Agency (EPA). 2000. *Guidelines for Preparing Economic Analyses*. September. p.27.

[61] EPA, 2010, p.11-12.

[62] Lesser, J.A., D.E. Dodds, and R.O. Zerbe, Jr.. 1997. *Environmental Economics and Policy*. p.406.

[63] Goodstein, 1999. E.S. *Economics and the Environment*. p.150.

> "There are many cases in environmental pollution control where risk-aversion is undoubtedly the best policy …"[64]

For the State to consider such risk aversion makes economic sense. It should request that in the displays of the usual ranges and probability distributions of the elements of the alternatives, the analysts present not only the expected values or, in the jargon, the central tendencies, but also the downside and upside risks.

> "[An evaluation of benefits and costs should] reflect the full probability distribution of potential consequences. Where possible, present probability distributions of benefits and costs and include the upper and lower bound estimates as complements to central tendency and other estimates."[65]

Often, sufficient data simply are not available for fully quantifying certain categories of the costs and benefits of the alternatives. Accepted principles of benefit-cost analysis also prescribe that analysts take into account non-monetized costs and benefits.[66] In such cases, the analyst should identify the likely sign and size of the effect. For natural assets for which the professional literature offers no direct calculations of value, economics offers the benefit-transfer technique.[67] With benefit-transfer, the analyst, with appropriate adjustments, imputes to the subject asset values calculable for other assets.

If the information on which the calculation of costs and benefits depends is faulty, then, of course, the calculation itself is faulty. In the best cases, the academic and professional communities reach consensus on the direction and magnitude of a policy's impacts. In the worst cases, they do not, because the information available and the analyst's interpretations of it are faulty or still evolving. Under these conditions, high uncertainty persists. In such cases, the value of BCA is limited, and the analyst has an obligation to report this limitation prominently and the uncertainty causing it.

> "When important benefits and costs cannot be expressed in monetary units, BCA is less useful, and it can even be misleading, because the calculation of net benefits in such cases does not provide a full evaluation of all relevant benefits and costs. You should exercise professional judgment in identifying the importance of non-quantified factors and assess as best you can how they might change the ranking of the alternatives based on your estimated net benefits. If the non-quantified benefits and costs are likely to be important, you should recommend which of the non-quantified factors are of sufficient importance to justify consideration in the regulatory decision. This discussion should also include a clear explanation that support[s] designating these non-quantified factors as important. In this case, you should also consider conducting a threshold analysis to help decision makers and

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[64] Field, B.C. 1994. *Environmental Economics*. p.129.

[65] Office of Management and Budget (OMB). 2003. *Regulatory Analysis*. Circular No. A-4. October. p.18.

[66] See, Moore, J.L. 1995. *Cost-Benefit Analysis: Issues in Its Use in Regulation*. CRS Report for Congress 95-760 ENR. June 28. Retrieved July 22, 2011, from http://www.cnie.org/nle/crsreports/risk/rsk-4.cfm.; EPA, 2010, p.7-57.

[67] EPA, 2010. p.7-51.

other users of the analysis to understand the potential significance of these factors to the overall analysis."[68]

D. Best Practices for BCA

In preparing this Section 5 on the principles of BCA, we found we had accumulated various techniques or practices that, while perhaps not qualifying as general principles, have proved useful over the years. We view this list as illustrative, not exhaustive.

1. Compare conditions with the alternative to conditions without the alternative: A good BCA avoids comparing conditions before the alternative to conditions after the alternative.

   "Calculation of net present value should be based on incremental benefits and costs. Sunk costs and realized benefits should be ignored. Past experience is relevant only in helping to estimate what the value of future benefits and costs might be."[69]

   By comparing the conditions with each of the State's alternatives to the conditions without that alternative, the analyst can isolate the effects of the alternative alone and thereby increase the accuracy of the comparison among all the State Water Board's alternatives.

2. Report and Document Methods, Information, and Assumptions: A good BCA should rely on transparent assumptions and allow for straightforward replication by a third-party analyst.[70]

3. Apply Methods and Assumptions Consistently: the analyst should remain consistent throughout the analysis.[71] For example, the analyst should not account for the possibility of uncertainty in underlying assumptions in one aspect of the BCA and ignore it in another.

4. Economic Impacts and Economic Equity Are Complements to BCA: In Section 2, regarding Figure 1, we describe the three categories of economic effects each of the State's alternatives would cause, economic values (for which the primary tool of analysis is BCA), economic impacts and economic equity. The State should keep in mind that the second and third categories can serve as complements to BCA, but not as substitutes for it. Consider, for example, EPA's guidance.

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[68] Office of Management and Budget (OMB). 2003. *Informing Regulatory Decisions: 2003 Report to Congress on the Costs and Benfits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities*. Office of Information and Regulatory Affairs. February. p127

[69] Office of Management and Budget (OMB). 1992. *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*. Circular A-94. October. p.6.

[70] OMB, *Informing Regulatory Decisions*, 2003, p.134.

[71] Rossi, P. and H. Freeman. 1982. *Economics*, 13th Edition. New York: McGraw-Hill Book Company. p.275.

> "Counting the number of jobs lost (or gained) as a result of a regulation generally has no meaning in the context of benefit-cost analysis."[72]

Each of the three categories of economic effects plays a distinct role in a comprehensive economic description and evaluation of the alternatives for improving the Bay-Delta flows. These roles should remain distinct.

5. Address externalities explicitly: In a market transaction, consider the buyer as the first party and the seller as the second party. A good BCA accounts the effects of the transaction on third parties, i.e., those who did not agree to experience the costs or benefits of the transaction.

> "Identify the expected undesirable side-effects and ancillary benefits of the proposed regulatory action and the alternatives. These should be added to the direct benefits and costs as appropriate[73]."

[72] EPA, 2010, p.8-8. See also, OMB, 1994, p.6-7.

[73] OMB, *Regulatory Analysis*, 2003, p.3.

SECTION 6: OBSERVATIONS ON THE BURGEONING LITERATURE ON BAY-DELTA FLOWS

In preparing this report, we reviewed roughly 100 studies that address the economic issues associated with managing Bay-Delta flows. There are plenty more studies out there and the number is increasing. In this Section 6, we have chosen to draw the State's attention to some of the salient points raised in or illustrated by 12 of the studies.

We do not claim that the studies we have not yet reviewed are any worse or better than the ones we managed to acquire and review. Furthermore, we do not claim that the 12 studies on which we have based our observations represent the entire 100 studies. We do claim, however, that our observations help illustrate, though not exhaust, the challenges the State will face as it seeks a balance between the public-trust uses and the *other beneficial uses* and must choose among the proffered alternative approaches to managing the Bay-Delta flows.

A. BCA without Adequate Data Would Suffer Fatal Flaws

A widespread lack of basic data on California's water resources constrains the extent to which scientists, stakeholders and decision makers can develop fact-based water plans. Specific to the Board's benefit-cost analysis, describing the economic consequences of changing Bay-Delta flows would be much more challenging without baseline data on the Bay-Delta flows. The less adequate the data, the greater the uncertainty of benefit-cost analyses of the management alternatives.

The Delta Stewardship Council staff (Council Staff) propose achieving the Delta Plan's coequal goals of improving the quantity and quality of the water resources using the best available science.

> "Coequal goals means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem."[74]

> "The Council is required by law to use the best available science … as the basis for the Delta Plan. The Delta Plan must include 'a science-based, transparent, and formal adaptive management strategy for ongoing ecosystem restoration and water management decisions.' [citation omitted]"[75]

The Council Staff acknowledge, however, that the body of scientific information on the Bay Delta lacks adequate data on water resources. Council Staff, and others, also acknowledge that this lack hampers water-planning efforts for the Bay Delta Plan.

[74] Delta Stewardship Council Staff (Council Staff). 2011. *Fourth Staff Draft Delta Plan*. Delta Stewardship Council. June 13. p.3.

[75] Council Staff, 2011, p.19.

> "The Delta plan requires the development and submission of water use data and other data that are currently unavailable or inaccessible."[76]

The Public Policy Institute of California (PPIC) recently concluded the same.

> "Beyond an almost entirely non-technical California Water Plan Update developed by the Department of Water Resources every five years or so, there is little to no statewide organization, prioritization, and synthesis of technical and scientific activity applied to water problems."[77]

> "The state's fragmented water rights system has contributed to serious gaps in water measurement and accounting. Most groundwater users have not been required to report water use to the state. Although riparian and pre-1914 appropriative rights holders are required to report their diversions, there was no legal sanction for failure to file an annual statement of diversion and use until the legislature amended the Water Code in 2009 … Many did not report, and those who did tended to substantially overstate their diversions and use. These gaps have led to difficulties in tracking water use trends, and they impede more effective management of water resources for economic and environmental purposes [citation omitted]."

> "As water becomes increasingly scarce, it will become ever more important to measure and keep track of physical stocks and flows and their uses."[78]

> "California is almost unique among western states in not collecting information on such diversions. California also lacks water quality information on many of its aquifers and waterways."

> "To aid analysis and enforcement, greater and more systematic state efforts are essential to assemble data from local, state, and federal agencies within a coherent framework."[79]

> "[W]ithout better reporting, California's water accounting and water rights enforcement will remain approximate at best—an increasingly difficult handicap for policy discussions and water management in a water-scarce state."[80]

Other stakeholders in the Bay Delta agree. For example, the California Roundtable on Water and Food Supply recently reported,

> "A clear picture of the factors affecting water distribution and use in California is important to decision-making at the policy and farm levels, but is currently lacking.

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[76] Council Staff, 2011, p.19.

[77] Hanak, E., et al. (PPIC). 2011. *Managing California's Water from Conflict to Reconciliation*. Public Policy Insistute of California. p.128.

[78] PPIC, 2011, p.330.

[79] PPIC, 2011, p.353-54.

[80] PPIC, 2011, p.87.

> There is a need for better data collection and demonstration of water supply and distribution at basin scale, and better baseline data on water use to guide decision-making."[81]

Developing science-based water-management plans in the Bay Delta without the missing data on water resources would be challenging. The recent review of the scientific support for the Draft Bay Delta Conservation Plan (BDCP) by the National Research Council of the National Academies (Research Council) illustrates this point. The Research Council criticized the Draft BDCP for lacking basic information on affected water volumes. The Research Council described this as a "major shortcoming" of the Draft BDCP.

> "The lack of clarity concerning the volumes of water to be diverted is a major shortcoming of the BDCP. In addition, the BDCP provides little or no information about the reliability of supply for such a diversion or the different reliabilities associated with diversions of different volumes. There is no indication of how the amount of water to be diverted and its associated reliability are to be determined. It is nearly impossible to evaluate the BDCP without a clear specification of the volume(s) of water to be diverted, whose negative impacts the BDCP is intended to mitigate."[82]

The missing information impedes well-informed planning and management decisions, and scientists and policy makers would have difficulty developing a science-based Delta Plan without the missing data. This lack of fundamental data on water resources would also likely increase the uncertainty of analytical results from benefit-cost analyses of water-management alternatives.

B. Assessing the Analytical Veracity of Past Studies of Conveyance Structures

The literature on economic analyses of management alternatives for the Bay Delta includes a number of assessments of conveyance structures, such as a peripheral canal or tunnel. Among the most widely cited works in this literature are those by the PPIC. This literature, however, does not include a full benefit-cost analysis of conveyance structures or their alternatives. Most studies focus on certain costs and do not include many of the relevant benefits. In spite of these conditions, these studies illustrate the challenge the Board would face should they conduct a benefit-cost analysis of conveyance structures. We give two examples.

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[81] The California Roundtable on Water and Food Supply. 2011. *Agricultural Water Stewardship: Recommendations to Optimize Outcomes for Specialty Crop Growers and the Public in California*. June. p.3.

[82] National Research Council of the National Academies (Research Council). 2011. *A Review of the Use of Science and Adaptive Management in California's Draft Bay Delta Conservation Plan*. The National. In the PPIC report, *Comparing Futures*, the authors concluded that a peripheral canal would be the least-cost option for maintaining water exports out of the Delta, and that ending exports would have the highest probability of saving threatened or endangered fish in the Bay Delta.[82] Academies Press: Washington, D.C. May 5, page 4.

In the PPIC report, *Comparing Futures*, the authors concluded that a peripheral canal would be the least-cost option for maintaining water exports from the Bay Delta, and that ending exports would have the highest probability of saving threatened and endangered fish.[83] They estimated that the peripheral canal had an average annual cost of between $0.25billion and $0.85billion. The three other alternatives—1) continuing through-Delta exports; 2) dual conveyance of peripheral canal and through-Delta exports; or, 3) no exports—all had higher economic costs. The no-export option had the highest likelihood of achieving viable populations of delta smelt and fall-run Chinook.[84]

Dr. Jeffrey Michael of the University of the Pacific, critiqued some of the major assumptions, data and conclusions described in *Comparing Futures*.[85]

- Regarding the use of discount rates, PPIC did not "… utilize the conventional, scientifically accepted present discounted value approach …"[86]
- PPIC ignored the market and non-market values of affected fishery species. (In a later report, the PPIC described the importance of including non-market values—or as they describe, the values of ecosystem benefits—in benefit-cost analyses.[87])
- PPIC relied on out-dated and second-best estimates of population growth, which overestimated population growth and water demand over the time of the analysis (through 2050).
- PPIC also overestimated the costs of water recycling and ignored recent trends in water conservation.
- PPIC did not conduct their analysis in the context of water scarcity. They assumed no advances in water-conservation or desalination technology over the next 40 years. That is, the PPIC assumed a static analysis of an economy with fixed technology rather than a dynamic analysis of an economy that responds to price signals.
- The PPIC results are highly sensitive to analytical assumptions, and thus are not robust.

In another critique, the Research Council had harsh criticism for the quality of the biophysical information in the Draft BDCP in support of a peripheral canal. The Research Council concluded that the analysis underlying the Draft BDCP relied on incomplete or unsupported data, unrealistic assumptions, ignored relevant trends, and, like the PPIC's analysis, the underlying analysis ignored the concept of water scarcity.

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[83] Lund, Jay, aet al. 2008 (PPIC 2008). *Comparing Futures for the Sacramento-San Joaquin Delta*. Public Policy Institute of California. Chapter 6 and p.ix.

[84] PPIC, 2008, Table S.1, p.ix.

[85] Michael, Jeffrey. 2011. *First Administrative Draft Economic Sustainability Plan for the Sacramento-San Joaquin Delta*. Submitted to the Delta Protection Commission. June 16; Michael, Jeffrey. 2008. *The Economics of Ending Delta Water Exports Versus the Peripheral Canal: Checking the Data of the PPIC*. University of the Pacific. December 15.

[86] Michael, 2011, p.65.

[87] Hanak, Ellen, et al. (PPIC). 2011. *Managing California's Water From Conflict to Reconciliation*. Public Policy Institute of California. Pages 99 and 207.

> "The BDCP cannot be properly evaluated if is does not clearly specify the volume of water deliveries whose negative impacts are to be mitigated. The draft BDCP suggests that the water requirements are based on the amount of acreage and crops that contractors have grown, or on the maximum deliveries specified by the SWP [State Water Project] contracts … There is no mention that quantities diverted may be constrained by various provisions of California water law, by possible changes in the extent of irrigated agriculture south of the Delta, and by potential changes in cropping patterns fueled by globalizing forces of supply and demand for food. The draft BDCP also fails to identify and integrate demand management actions with other proposed mitigation actions. A conservation plan should address issues of water use efficiency and should account for future trends in other variables that drive the demand for agricultural and urban water supplied. … The BDCP's lack of attention to these issues constitutes a significant omission, given the intensifying scarcity of water in California."[88]

> "The lack of an appropriate structure creates the impression that the entire effort is little more than a post-hoc rationalization of a previously selected group of facilities, including an isolated conveyance facility [peripheral canal] …"[89]

A peripheral canal or tunnel has proponents and detractors. Some of the critiques to date, however, raise serious concerns regarding the veracity of analyses that support a canal or tunnel as the preferred management alternative. Any new analyses of a conveyance structure's benefit and costs would likely be considered incomplete if they do not address the analytical deficiencies raised by these analyses.

C. Addressing Environmental Justice Consequences of Water-Management Alternatives

Past planning efforts in the Bay Delta have not effectively dealt with environmental justice (EJ) aspects of water use and distribution in California's Central Valley. The Delta Plan is an opportunity to change this. Informational resources exist that can help analysts address EJ issues in benefit-cost analyses in meaningful ways so that they go beyond the typically superficial treatment of EJ issues in past analyses.

The Bay Delta Conservation Plan describes EJ as,

> "The fair treatment and meaningful involvement of all people regardless of race, color, national origin, educational level, or income with respect to the development, implementation, and enforcement of environmental laws. EJ seeks to ensure that minority and low-income communities have access to public information relating to human health and environmental planning, regulations, and enforcement. EJ ensures that no population, especially the elderly and children, are forced to shoulder a disproportionate burden of the negative human health and environmental impacts of pollution or other environmental hazard."[90]

[88] Research Council, 2011, p.31-32.

[89] Research Council, 2011, p.43.

[90] California Natural Resources Agency. 2010. *Highlights of the Bay Delta Conservation Plan*. December. p.84.

As described by the California Natural Resources Agency, EJ communities in the Central Valley share a number of characteristics and conditions including:[91]

- Mostly minority and low-income households
- Excluded from environmental policy setting
- Subject to disproportionate impacts from environmental hazards
- Residents experience disparate implementation of environmental regulations, requirements, practices and attributes.

A study published in July of 2008, by OxFam America and the Rockefeller Foundation, reported that the 20th U.S. Congressional District, which encompasses Westlands and the southwestern side of the San Joaquin Valley, was the poorest congressional district in U.S.[92] EJ communities in the San Joaquin Valley face challenges including unsafe drinking water, poor air quality and high incidence of childhood asthma.[93] The *Fourth Staff Draft Delta Plan* reported that nitrates and other pollutants contaminate drinking water supplies from groundwater for many low-income communities in the San Joaquin Valley.

> "The high cost of accessing water from alternative sources, coupled with the low earnings of these households, often makes safe drinking water in these communities unaffordable [citation omitted]."[94]

A recent report by the Pacific Institute concluded the same.

> "Despite the acute health effects of nitrate contamination, some communities in the state have been waiting for more than a decade for measures to restore the safety of their drinking water. … These communities … tend to be low-income and have a high percentage of Latino households. Although costs to community water systems and the households they serve are significant and directly tied to nitrate contamination of groundwater, public policy and regulatory programs have to-date failed to incorporate those costs in their policy and regulatory programs."[95]

As described in the Pacific Institute report, the high costs of addressing nitrate contamination and limited available funds means a significant backlog of unfunded

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[91] California Natural Resources Agency. 2003. *Environmental Justice Policy.* www.resources.ca.gov/environmental_justice_policy_20031030.pdf.

[92] Burd-Sharps, S., K. Lewis, and E. Borgess Martins. 2008. *The Measure of America: American Human Development Report 2008-2009*. OxFam America and the Rockefeller Foundation.

[93] Pacific Institute. 2011. *The Human Costs of Nitrate-Contaminated Drinking Water in the San Joaquin Valley*; Carger, Lloyd. 2010. *Reaping Riches in a Wretched Region: Subsidized Industrial Farming and Its Link to Perpetual Poverty*, 3 Golden Gate U. Envtl L.J., http://digitalcommons.law.ggu.edu/cgi/viewcontent.cgi?article=1033$context=ggueli.

[94] Delta Stewardship Council Staff. 2011. *Fourth Staff Drat Delta Plan.* June 13. p.111.

[95] Moore, E. and E. Matalon. 2011. *The Human Costs of Nitrate-contaminated Drinking Water in the San Joaquin Valley*. Pacific Institute. March. p.7.

projects. The California Department of Public Health currently has a waiting list of 100 community water projects, with a total cost of $150 million.[96]

A number of benefit-cost experts describe methods of combining EJ objectives including equity considerations with the economic-efficiency objectives of a benefit-cost analysis.[97] Such an approach in the Bay Delta could help avoid negative EJ impacts of water-management decisions and promote more equitable distribution of environmental benefits to communities that currently suffer from inequitable distribution of contaminated water resources.

D. Describing the Relevant Economies as Dynamic, Not Static

Economies are dynamic. They grow, develop, change and react over time in response to local, regional, national and international forces and trends. Consumers, workers and business owners make decisions based on how these forces and trends affect them. For example, as gas prices increase, consumers change their driving habits, purchases more fuel-efficient cars, or take mass transit. As the price of apples increases, some consumers will switch to other, less expensive fruits.

The dynamic nature of economies is important to the State Water Board's benefit-cost analysis of their balancing decision for two reasons. The first is because the affected economies will change for reasons unrelated to the new management alternatives. Attributing economic consequences from outside forces to the Bay Delta management alternatives would yield inaccurate results and mask the true consequences of the alternatives.

Recent reports on the Bay Delta describe some of the relevant outside forces likely to affect the region's economy. The PPIC report, *Managing California's Water*, lists what the authors describe as "drivers of change," which will affect future water supply and demand. These drivers include environmental, economic and demographic changes.[98]

- Rising sea levels will cause seawater intrusions into coastal aquifers.
- Climate-change induced warming will reduce snowpacks, increase winter runoff, decrease spring and summer runoff, and increase stream temperatures.[99]
- New urban developments will likely use less water per capita than existing homes.
- Urbanization will increase discharges of urban runoff.[100]

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[96] Moore and Matalon 2011, p.8.

[97] See for example, Banzhaf, H. S. 2010. *Regulatory Impact Analyses of Environmental Justice Effects*. National Center for Environmental Economics. Working Paper # 10-08. U.S. Environmental Protection Agency. August; Haveman, Robert. 1965. *Water Resources Investment and the Public Interest*. Nashville: Vanderbilt University Press; and Johansson-Stenman, Olof. 2005. "Distributional Weights in Cost-Benefit Analysis—Should we Forget About Them?," *Land Economics*, Vol. 81.

[98] PPIC, 2011, p.135-136.

[99] PPIC, 2011, p.135-136.

- Urbanization of agricultural lands will reduce agricultural water use.[101]
- Population growth has been, and is expected to continue as, the most important demographic driver of water demand.[102]
- Continued reduction in agriculture's share of the state's economy.[103]
- California's agricultural producers will continue shifting to more permanent and higher-valued tree and vine crops in response to global market forces.[104]

Anticipated changes in local and state regulations will also affect future water supply and demand. For example, a recent report by the California Department of Water Resources describes an upcoming change that will affect urban water use. Beginning in 2016, water suppliers must comply with water conservation requirements established by the Water Conservation Bill of 2009 to be eligible for State water grants or loans.[105]

One of the challenges of conducting a benefit-cost analysis of Bay Delta management alternatives will be controlling for the economic consequences attributed to the types of biophysical, economic and other forces and trends described above that are unrelated to the management alternatives.

The second reason why the dynamic nature of economies is important to a benefit-cost analysis of Bay-Delta alternatives is that the affected economies will likely respond to the management alternatives. That is, the analysts should not assume a static economy, frozen in time and technology. The management alternatives will affect different sectors of the state's economy differently. Some sectors may experience higher costs, others may have increased employment or revenues. Consumers, workers and business owners will respond to these first-round changes. For example, in response to an alternative that reduces irrigation flows, some growers may idle their land. Others, however, will likely continue producing by switching to less water-intensive crops, increasing irrigation efficiency, engaging in water trades, or all three.

Authors of a recent retrospective analysis of the economic impacts of reduced flows to the San Joaquin Valley describe such reactive behavior.[106] The analysis focused on the changes in agricultural production in response to reduced water supplies from the Bay Delta caused by drought and restrictions on pumping due to environmental concerns.

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[100] PPIC, 2011, p.164.

[101] PPIC, 2011, p.137.

[102] PPIC, 2011, p.164.

[103] PPIC, 2011, p.137.

[104] PPIC, 2011, p.166.

[105] Pezzetti, Tonianne. 2011. *Guidebook to Assist Urban Water Supplirs to Prepare A 2010 Urban Water Management Plan*. State of California, Natural Resources Agency, Department of Water Resources. March. p.xiii.

[106] Michael, J., et al. 2010. *A Retrospective Estimate of the Economic Impacts of Reduced Water Supplis to the San Joaquin Valley in 2009*. September 28. p.1-3.

The authors report that growers reacted to the water reductions by engaging in water trades and changing their growing practices.

> "[A] significant increase in the amount of water transfers was critically important to reducing the negative impacts of water scarcity. … Building on these successful transfers will be important in minimizing the losses from future water shortages."[107]

> "Across the entire San Joaquin Valley, virtually the entire decline in net harvested acreage was in lower-value field and seed crops as farmers rationally directed more of their scarce water resources to protecting high value fruit and nut orchards."[108]

Water scarcity in California is not a new phenomenon. Water users react to this scarcity by adjusting their use and adopting new technologies and practices. This trend is expected to continue. A benefit-cost analysis that assumes a static economy, frozen in time and fixed in technology would not reflect the reality of how local and regional economies in the Bay Delta function.

E. Describing the Complex Competition for Bay Delta Water Resources

Much of the debate over Bay-Delta water resources pits in-stream or habitat use against agricultural or municipal use. Some describe this as the "jobs vs. fish" argument. Implicit in this characterization is the assumption that consumptive use of water—water use that supports "jobs"—is more important or has greater economic value than in-stream use—water for "fish." As the PPIC describe in their recent report, *Myths of California Water – Implications and Reality*, the competition for Bay-Delta water resources is much more complex.[109]

> "Healthy ecosystems provide significant value to California's economy, partially and sometimes fully offsetting their costs to traditional economic sectors. Direct benefits include improvements in recreation, commercial fishing, and drinking and agricultural water quality, and indirect benefits include improvement in the quality of life in California."[110]

In most times and places there are insufficient resources to satisfy all the demands for all of the goods and services provided by Bay-Delta water resources. Hence, there is competition for the water and, when it is used to produce one set of goods and services, the demands for others go unmet. The characteristics of this competition provide useful insights into the economic consequences of current and future decision-making for Bay-Delta water resources.

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[107] Michael et al., 2010, p.1-2.

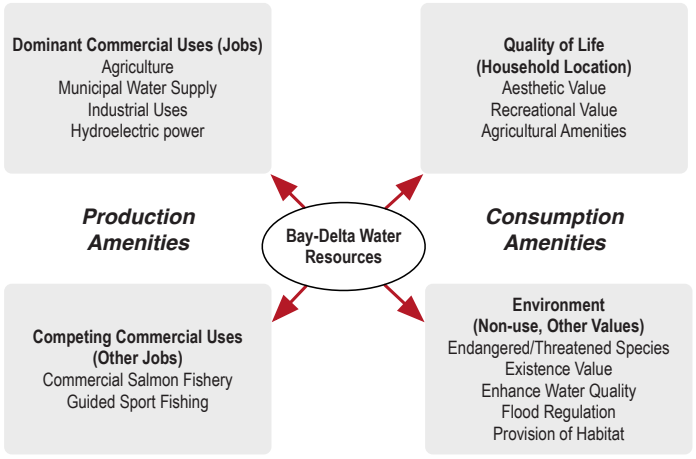
[108] Michael et al., 2010, p.3.

[109] Hanak, Ellen et al. 2010 (PPIC 2010). "Myths of California Water—Implications and Reality." *West-Northwest*, Vol. 16, No. 1, Winter. p.20-22.

[110] PPIC, 2010, p.21.

One could categorize the competition any number of ways, but we employ a taxonomy that distinguishes among four types of demand, as illustrated in Figure 2. Two of these are called demands for production amenities, i.e., those goods and services that are, or could be, inputs to processes that produce other goods and services. The other two represent demands for consumption amenities, i.e., those goods and services that directly enhance the well being of consumers.

Figure 2. The Competing Demands for Bay-Delta Water Resources



Source: ECONorthwest

Competition for Production Amenities. Demand for Bay-Delta agricultural, municipal, industrial, and hydroelectric production, represented on the left side of Figure 2, comes from private and public enterprises, as well as households, that rely on water resources to conduct commercial activities. We separate the demands for production amenities into two groups—dominant and competing demands—to show that, sometimes, negative effects on other commercial sectors, which are represented in the bottom left of Figure 2, can offset the positive consequences arising from others. Using water for commercial production of crops may, for example, prevent it from being used to support guided sport fishing.

Competition Directly from Consumers. On the left side of Figure 2, water resources are economically important because they are inputs in the production of other things, notably crops and livestock, that consumers want to have. On the right side, the connection to consumers is more direct. Here, consumers consider Bay-Delta water resources economically important for how they directly contribute to their well-being. In economic parlance, these are known as consumption amenities.

Some ecosystem goods and services, such as recreational opportunities and scenic vistas, contribute directly to the well-being of people who have access to them. Their

contribution to consumers' well-being makes them economically important in their own right, but they have additional economic importance when they also influence the location decisions of households and firms. We show the demands for consumption amenities that influence location decisions of households sensitive to spatial variation in the quality of life, in the upper right portion of Figure 2. In general, the nearer people live to amenities, the lower their cost of using them. Thus, consumers can increase their economic well-being by living in a place that offers recreational opportunities, pleasant scenery, wildlife viewing, and other amenities they consider important.

Quality-of-life values can be powerful. All else equal, if the Bay-Delta's consumption amenities improve, some people already here would tend to stay and additional people would tend to move in. Degradation would have the reverse impacts. One consequence is that the amenities lead to higher demand for housing and consumer-oriented commercial products. The higher demand raises land value for these uses higher than otherwise would exist.[111] Differences in quality of life also explain about half the interstate variation in job growth during periods of economic growth.[112] This relationship also has been found at sub-national perspectives.[113] Some in the Bay-Delta undoubtedly could enjoy higher earnings living elsewhere, but choose not to do so because their overall economic welfare—the sum of their earnings plus quality of life—is higher here. Some aspects of this quality of life—the strength of communities, schools, and churches, for example—are not directly related to water resources, but others are: scenic views, ways of life, and opportunities for fishing and boating, to mention a few.

The lower right portion of Figure 2 represents demands associated with economic values that do not necessarily entail a conscious, explicit use of ecosystem goods and services. We call these environmental values. There are two general categories: non-use values and values of goods and services that generally go unrecognized. Non-use values arise whenever people place a value on maintaining some aspect of the environment, even though they do not use it and have no intention to do so. Research has documented non-use values for maintaining salmon populations, for example, whose survival in the Bay-Delta depends on adequate water flows. Studies have shown that regardless of direct interaction with salmon populations, many Californians hold a positive willingness to pay to ensure the long-term survival of salmon.[114]

Environmental values also can be important when water resources provide valuable services that people generally consume without being aware of them. Some of these are part of the so-called web of life. Others, such as the ability of wetlands to purify water

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[111] Roback, J. 1982. "Wages, Rents, and the Quality of Life." *Journal of Political Economy* 90: 1257-1278; 1988. "Wages, Rents, and Amenities: Differences among Workers and Regions." *Economic Inquiry* 26: 23-41.

[112] Partridge, M. and D. Rickman. 2003. "The Waxing and Waning of Regional Economies: The Chicken-Egg Question of Jobs Versus People." *Journal of Urban Economics* 53: 76-97.

[113] For a more thorough discussion of relevant research, *see,* for example, Power, T.M. and R.N. Barrett. 2001. *Post-Cowboy Economics: Pay and Prosperity in the New American West*. Island Press, and Kim, K.-K., D.W. Marcouiller, and S.C. Deller. 2005. "Natural Amenities and Rural Development: Understanding Spatial and Distributional Attributes." *Growth and Change* 36 (2): 273-297.

[114] Loomis, J., T. Brown, and J. Bergstrom. 2007. "Defining, Valuing, and Providing Ecosystem Goods and Services," *Natural Resources Journal* 47: 329-376.

and mitigate flood damage, have a more direct link to the well-being of California's residents. For example, San Francisco, which receives its water from the pristine Hetch Hetchy watershed, saves tens of millions of dollars per year in avoided water treatment costs.[115] Some scientists and economists believe many services have great economic value, even though people generally are unaware of their importance.[116] Environmental values typically increase as people learn more about the environment, the services it provides, and environmental degradation.[117] Many people today, for example, consciously consider the economic values associated with the services produced by the global climate in ways that were unknown, even to scientists, just a few years ago.

The demands associated with the consumer amenities represented on the right side of Figure 2 are typically harder to measure, or even to observe, than the commercial demands shown on the left side of the diagram. This difficulty does not diminish their value or impact on jobs and incomes, however. Instead, it merely reflects the lack of tools for measuring them.

As described in the PPIC Report, one of the goals and challenges of the Board's benefit-cost analysis of its balancing decision will be identifying and describing the full range of benefits and costs of the competing demands for Bay-Delta water resources.

> "California must find ways to manage water jointly for environmental and commercial benefits. Better accounting of water use and its economic and environmental benefits and costs can help guide policies for watershed management."[118]

[115] Null, S. and J. R. Lund. 2006. "Re-assembling Hetch Hetchy: Water Supply Implications of Removing O'Shaughnessy Dam," *Journal of the American Water Resources Association* 42 (4): 395-408.

[116] Daily, G.C. (ed). 1997. *Nature's Services: Societal Dependence on Natural Ecosystems*. Washington, D.C.: Island Press.

[117] Blomquist, G.C. and D.R. Johnson. 1998. "Resource Quality Information and Validity of Willingness to Pay in Contingent Valuation." *Resource and Energy Economics* 20:179-196.

[118] PPIC, 2010, p.21.