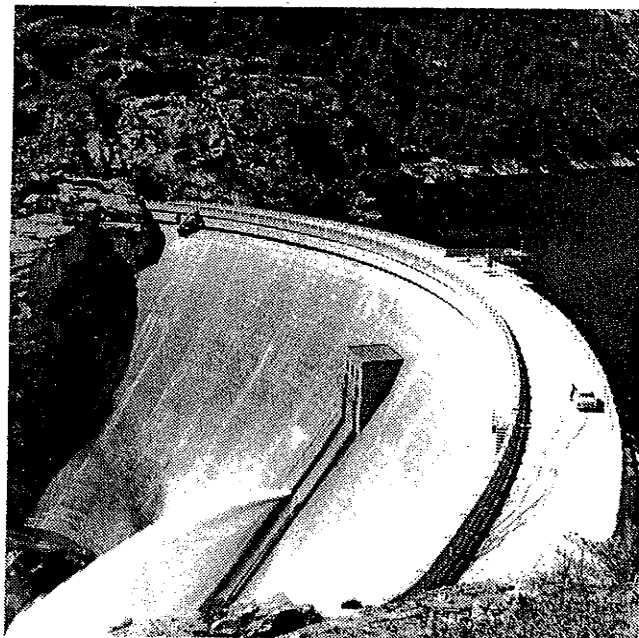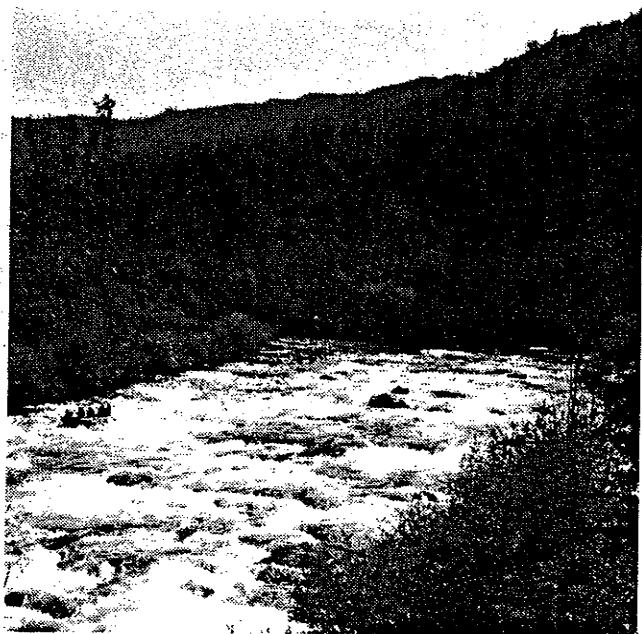# THE TUOLUMNE RIVER: PRESERVATION OR DEVELOPMENT?

An Economic Assessment

by

The Environmental Defense Fund

March 1984

THE TUOLUMNE RIVER:

PRESERVATION OR DEVELOPMENT?

AN ECONOMIC ASSESSMENT

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THE ENVIRONMENTAL DEFENSE FUND

Robert Stavins
Principal Author

With a Foreword by
William H. Desvousges

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ABOUT THE ENVIRONMENTAL DEFENSE FUND

The Environmental Defense Fund (EDF) is a not-for-profit, public interest environmental organization with over 7,000 members in California and more than 47,000 nationwide. Through participation in administrative proceedings, litigation, organizing efforts and lobbying, EDF's staff of scientists, economists and attorneys works to ensure long-term, rational use of natural resources consistent with the protection of environmental quality and public health.

In California, EDF is most active in issues associated with water and energy development and conservation and with the use and disposal of toxic substances, especially pesticides. Within the environmental movement, it has been among the first to advocate the use of economic incentives to further environmental protection. Rigorous scientific and economic research at EDF has repeatedly demonstrated that reasonable environmental protection is not only consistent with rational economic growth, but is indeed an essential element of a truly healthy economy and society. The subject of this study represents one further example of the compatibility of economic welfare with environmental protection.

PREFACE

Benefit-cost models developed for major public works projects such as new hydroelectric dams traditionally do not include direct consideration of environmental impacts. This study improves upon the conventional approach by developing a benefit-cost assessment model which provides for the partial quantification of at least some environmental costs, as an integral part of the overall assessment procedure. It thereby allows comprehensive assessment of a project's net contribution to national economic welfare.

The social benefit-cost model developed in this study is applied to the task of assessing a recent proposal for the development of additional hydroelectric facilities on the main stem of the Tuolumne River in California. In particular, the benefits and costs of the proposed Clavey-Wards Ferry (CWF) Project are analyzed, taking account of the substantial impacts which the Project would have on the recreational use of the River for fishing and whitewater rafting.

Based upon application of widely accepted economic methodologies, the analysis leads to the conclusion that construction of the CWF Project would result in a net loss to society of more than $26 million per year.

This finding lends support, from an economic perspective, for the inclusion of the Tuolumne River Canyon within the National Wilderness Preservation System and for the designation of the Tuolumne River as a component of the National Wild and Scenic Rivers System. The effect of such actions would be to protect the Tuolumne River and Canyon and prevent the development of additional hydroelectric facilities.

The research which underlies this report grew from not only an examination of all available, relevant documents, but also from information provided by a number of well informed persons. Thanks are due to all those individuals named in the list of personal communications at the end of the study. Without their cooperation, this research could not have been successfully completed.

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FOREWORD

by

William H. Desvousges*

The prospect of writing a foreword to this Environmental Defense Fund (EDF) study of the Tuolumne River is both pleasing and frightening. The fear stems from my inability to do justice to the task of preparing the reader for this excellent and important research; the pleasure is derived from having the opportunity to highlight the benefit-cost methodology employed in this study.

Before reviewing this study for EDF, I knew very little about the Tuolumne River or the multifaceted debate surrounding the decision to preserve or develop it. I have found, however, that in his thorough analysis, Robert Stavins has presented an excellent case for preserving the river. The EDF report estimates the annual social cost--that is, the foregone opportunities from preserving the Tuolumne River--to be $214 million. Development will result in only $188 million in annual benefits. In effect, society would receive $26 million a year less in benefits from development than it would from preservation of the river. It is clear, even by the standards of the parsimonious science of economics, that society's welfare would be diminished by the implementation of the Clavey-Wards Ferry project.

A singular advantage of this study is its use of the benefit-cost assessment methodology, formerly known as benefit-cost analysis. The Tuolumne River study is an excellent example of how benefit-cost assessment can work. In an assessment, benefits play a role equal to that of costs (in this case, benefits are measured based on an individual's willingness to pay for preserving the Tuolumne River) and include values based on a wide range of motives. The sensitivity of key assumptions is evaluated throughout the assessment to determine their plausability. The implications as to who wins and who loses are drawn clearly so that decision-makers can evaluate their importance. However, there is no magic decision-making rule: only a clear, consistent presentation of the information any decisionmaker would like to have.

Stavins' use of the benefit-cost assessment methodology is a boon to the reader/reviewer in that the competency or the incompetency of the research

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process is easily determined (a point critics often overlook). The Tuolumne River case study shows just how valuable the assessment methodology can be in competent hands. Furthermore, Stavins was able to complete his research in a relatively short time with modest resources by judiciously blending related research results and original data and analysis, which suggests that the methodology need not impose onerous financial costs.

It is particularly remarkable that this study is being published by an environmental advocacy organization, such as EDF. The study represents a significant departure from the position frequently maintained by environmentalists, who in the past have tended to denounce the use of benefit-cost assessment in any form. For example, the U.S. Environmental Protection Agency has been criticized repeatedly for using benefit-cost as a tool to scuttle environmental quality regulations. This criticism was so extensive in the case of the revised Water Quality Standards that the Administrator removed all traces of benefit-cost assessment from his newly proposed revisions. Yet these Standards for many river segments could have benefitted from the analytical scrutiny required by a benefit-cost assessment procedure.

In summary, this EDF economic assessment uses a rigorous methodology with solid economic footings to make a strong case for preserving the Tuolumne River. Moreover, it highlights the usefulness of benefit-cost assessment in evaluating public policy decisions.

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ABSTRACT

This study develops an economic model of hydroelectric development and environmental quality which evaluates the social merit of current hydroelectric development proposals for California's Tuolumne River.

Historically, environmental impacts of proposed hydroelectric projects have been evaluated qualitatively and separately from any quantitative economic analysis. This approach has led to the undervaluation of environmental concerns in licensing decisions by the Federal Energy Regulatory Commission. Advances in theoretical and applied economics, however, have made it possible to quantify and monetize at least some environmental values. Such an approach may in fact be mandated under law, in certain cases, in order to ensure objective and full consideration of environmental costs.

The model developed here is based upon such recent advances in theoretical and applied economics. It incorporates quantitative methodologies, endorsed by the U.S. Water Resources Council, for the evaluation of recreation effects of hydroelectric projects. The analysis includes two important environmental impacts of the proposed Project: (1) the virtual elimination of whitewater boating from an 18-mile stretch of the Tuolumne, considered to be one of the premiere rafting runs in the United States; and (2) the near-total degradation of one of California's best trout fisheries.

Based on conservative assumptions and using widely accepted methodologies, this analysis finds that the Clavey-Wards Ferry (CWF) Project would result in a net social loss of more than $26 million per year. With only two of its potential environmental costs internalized, the Project exhibits a social benefit-cost ratio of 0.877, indicating a total return of 88 cents to society for each dollar invested.

An empirical analysis of present and probable future use of the River, based upon a travel cost method (TCM) model of recreation demand, provides plausible estimates of user and intrinsic (option) values of the resource. If additional environmental impacts were internalized, or if less conservative assumptions were used, the Clavey-Wards Ferry Project benefit-cost ratio would fall below 0.877, as is demonstrated by sensitivity analysis.

There are numerous limitations to benefit-cost analysis as an aid in decision-making, and those limitations indicate that the benefit-cost criterion ought not to be used as either a necessary or a sufficient condition for project investment. Public-policy decisions regarding the use of the nation's scarce natural resources are ultimately political decisions, and should remain so.

INTRODUCTION:

THE TUOLUMNE RIVER --- A MULTIPLE PURPOSE RESOURCE

For over a half century, the Tuolumne River and its tributaries in the Sierra Nevada Mountains of California have provided San Francisco and several neighboring communities with electrical power and with almost all of the water they consume. The Tuolumne River system also provides electricity and agricultural irrigation water for towns and farms in Stanislaus and Merced Counties (Figure 1).

Although extensively developed with a series of hydroelectric projects, the Tuolumne still retains its wild and scenic character within a 30-mile stretch (of its 158-mile length) in Tuolumne Canyon downstream of Yosemite National Park. This reach of the River provides an important recreational resource for visitors from throughout California and the nation. Plans are underway, however, to develop this section of the River with a series of dams, diversions, reservoirs and hydroelectric powerhouses, known collectively as the Clavey-Wards Ferry Project.

Tuolumne Canyon is one of the major scenic river canyons of the world and is still largely in its natural state. The section of the River flowing through the Canyon contains one of the best whitewater rafting runs in the United States and supports an excellent trout fishery. In addition, the area supports a diverse mix of wildlife and provides a popular area for hikers and campers.

Electricity, water supply, flood control and a variety of recreational opportunities are some of the Tuolumne River's major uses. In the upper reaches of Tuolumne Canyon are O'Shaughnessy Dam and the Hetch Hetchy Reservoir, providing water and power to the City and County of San Francisco. Immediately downstream of the Canyon is the New Don Pedro Dam and Reservoir, which provides electricity and irrigation water to the Modesto and Turlock Irrigation Districts (Figure 1). Between O'Shaughnessy Dam and the headwaters of the New Don Pedro Reservoir is a stretch of the River which has particularly frequent use by fishermen, whitewater boaters, hikers and campers.

FIGURE 1: LOCATION OF THE TUOLUMNE
RIVER WATERSHED IN CALIFORNIA
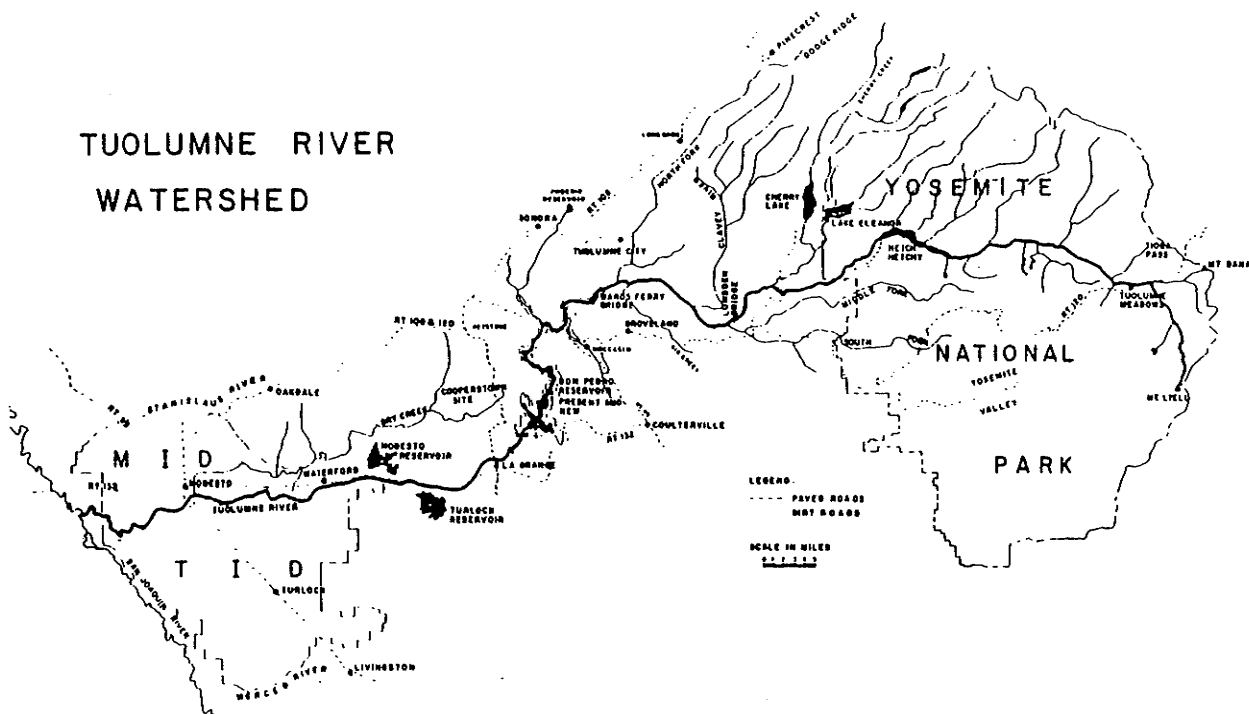
Ironically, it is the same features which create the scenic nature of this 30-mile stretch of the River that make the canyon an attractive site for a large-scale hydroelectric project. Due to the large volume of water flowing in this stretch of the Tuolumne River gradient, and due to the River's narrowness and the steepness of the canyon walls, this reach of the River lends itself to relatively easy conversion into a reservoir and source of hydropower.

In April of 1983, the U.S. Federal Energy Regulatory Commission granted the City and County of San Francisco, the Modesto Irrigation District and the Turlock Irrigation District a preliminary permit[1] to examine the feasibility of constructing three dams and related hydroelectric facilities within Tuolumne Canyon. The Clavey-Wards Ferry (CWF) Project would cost in excess of $1 billion (if completed in 1994) and would flood or dry up 27 miles of the Tuolumne and another 7 miles of the Clavey River, a Tuolumne tributary. Essentially a single-purpose, power-generating project, it would provide no flood control, virtually no recreation benefits and only a small increment of water supply.

The essential incompatibility between the development of this reach of the River for electrical power and its preservation in a relatively undisturbed state calls for a critical examination of the benefits and costs of these competing uses. What is required is an analysis which is sufficiently robust to consider alternative present and future uses of the River.

The central question is whether developing the remaining canyon reach is justified in relation to the recreational and environmental amenities which would be destroyed. In short, does the more valuable public interest lie in the proposed Clavey-Wards Ferry development, or in the preservation of this stretch of the River in its natural state?

A Comprehensive Economic Assessment

of Additional Hydroelectric Development of the Tuolumne River

The potential merits of proposed hydroelectric projects are frequently evaluated through a comparison of their expected economic benefits and costs. Traditionally, such benefit-cost analyses have failed to include consideration

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[1]U.S. Federal Energy Regulatory Commission. Order Issuing Preliminary Permit and Denying Competing Application. Project Nos. 2774-000 and 5642-000. Washington, D.C., April 6, 1983.

of environmental impacts. By omitting environmental amenities from the calculation of project benefits and costs, these important amenities are implicitly assigned a value of zero. In economic terms, environmental considerations thus remain "external" to the analysis.

This study considers environmental impacts within the context of a comprehensive economic assessment of further hydroelectric development on the Tuolumne. Unlike previous benefit-cost analyses of the proposed Clavey-Wards Ferry Project, this study uses an economic model which is capable of "internalizing" at least some of the "environmental externalities" which would be direct consequences of the Project.

Using state-of-the-art quantitative methods endorsed by the U.S. Water Resources Council (March 1983a), this social benefit-cost model includes monetary evaluations of whitewater boating and recreational fishing impacts of the proposed hydroelectric project.

The quantitative model developed in this study also includes the intrinsic values of a river. Traditionally, economics has concerned itself with only those uses of a resource which result in its consumption, whether through direct use or indirect use. Recent developments, in both theoretical and applied economics, however, now permit the consideration of the intrinsic values of an environmental resource to non-users. The interests of those persons who may be potential future users (option value) and those individuals who value a resource in situ (existence value) are at least partially evaluated here.

This analytical approach by no means internalizes all environmental effects. Nevertheless, it represents a significant improvement over some traditional benefit-cost models which have failed to provide for the calculation of social benefits and costs.

Preview of the Study

In order to make this study of hydroelectric development and environmental quality accessible to the widest possible audience, the text has been kept relatively brief. Where possible, technical information has been relegated to footnotes and appendices. In particular, mathematical specifications of the economic assessment model and detailed technical discussions, both generic and with regard to the model's application to the Clavey-Wards Ferry Project, are largely found in appendices.

The study is divided into six chapters. The immediately following section of Chapter I summarizes the major conclusions of the social benefit-cost assessment. Following this, the history and current status of hydroelectric development on the Tuolumne is briefly described, and the history of proposals for further development on the Tuolumne is documented. Next, the legal status of the proposed Clavey-Wards Ferry Project is reviewed. In the last section of Chapter I, the limitations of traditional benefit-cost methods are briefly described, and a more comprehensive approach to assessing the economics of hydroelectric projects is introduced.

Chapter II outlines the probable major impacts of the proposed CWF Project on the natural environment, including impacts on recreation, fisheries, wildlife, hydrology, water quality, vegetation, visual resources and archaeological and historical sites.

Chapter III provides an overview of conventional and improved approaches to evaluating the economic feasibility of hydroelectric projects with potential environmental impacts. First, conventional benefit-cost (B/C) analysis is defined, and its major limitations are described in some detail. Next, general theories of environmental economics are introduced, and their merger with traditional B/C methodologies is explained. Finally, legal and policy arguments which support a broad, social benefit-cost framework are briefly examined.

Chapter IV of the study presents a social benefit-cost model of hydroelectric development, in which recreational and fishery impacts are included as explicit factors in the B/C calculations. First, the critical parameters of the model are described. Included are discussions of alternative measures of the discount rate, alternative mechanisms to account for risk and the appropriate specification of the discount period.

The next major section of Chapter IV describes that part of the SBC model which considers the social costs of hydroelectric development. Considered here are both the private (internal) and the environmental (external) costs. Two separate and distinct methods are utilized for evaluating and internalizing two categories of environmental impacts, that of whitewater boating and that of recreational fishing.

In the first method, the whitewater boating impacts (benefits lost or foregone) are evaluated both for users and non-users. In the former case, a widely accepted technique, the "travel cost method" (TCM), is used to estimate the value of the site for whitewater rafting. Calculations are based upon detailed survey data of actual historical usage of the River. The so-called supply side benefits are also calculated. Next, intrinsic benefits to non-users are considered. In addition to the River's value for those persons who currently raft the Tuolumne, the River also has a value to those who do not currently utilize it but expect that they may wish to someday. The (option) value of the Tuolumne to such persons is considered as part of the social cost of development.

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In the second method of internalization, the impacts of the CWF Project on the recreational fisheries of the Tuolumne and the Clavey are considered. The approach here is one of mitigation for expected damages, i.e., the Project is assumed to be operated in such a manner as to be compatible with maintenance of the trout fishery (in accordance with guidelines prescribed by the California Department of Fish and Game).

A second major section of Chapter IV describes the other half of the social benefit-cost model, the estimation of the social benefits of a hydroelectric project. Included are the private (internal) benefits, namely the provision of electrical generation capacity and energy and incremental firm water yield, and the external benefits, such as flatwater recreational fishing and boating.

Finally, the model provides for the combination of total benefits and total costs in the form of a benefit-cost ratio. Such a ratio constitutes an investment criterion for a proposed hydroelectric project and provides one measure of the public merits of such proposed projects. As an alternative measure of the merits of a potential hydro project, the SBC model also calculates the net annual economic value of the proposed development.

Chapter V of the study consists of an application of the social benefit-cost model to an analysis of the proposed Clavey-Wards Ferry Project. Utilizing data and methodologies provided by the Project proponents themselves,[2] the internal, private costs of the CWF proposal are carefully developed. Following this, the TCM model of recreation demand is applied to an analysis of whitewater boating on the Tuolumne, and in keeping with the precedent from previous empirical economic research, the associated non-user value is estimated. Next, the impacts on recreational fishing are internalized in the model through modification of the flows which are available to pass through the CWF turbines. In this and in all other aspects of the analysis, conservative assumptions and rigorous procedures are consistently utilized.

The second half of Chapter V of the study presents an evaluation of the social benefits of hydroelectric development on the Tuolumne: energy generation, incremental water supply and provision for new flatwater recreation at Wards Ferry Reservoir. One frequently used approach for

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[2] The three project proponents, the City and County of San Francisco, the Modesto Irrigation District and the Turlock Irrigation District, have produced five major appraisals of the Clavey-Wards Ferry project: Clair A. Hill & Associates and R. W. Beck and Associates 1968; R. W. Beck and Associates 1976; R. W. Beck and Associates 1979; R. W. Beck and Associates 1980; and Sverdrup & Parcel and Associates, Inc. 1981. Full citations for these and all other sources are provided in the list of references at the end of the study.

evaluating the benefits of a proposed hydroelectric project is to estimate the avoided cost of the least expensive alternative method of meeting the same energy demands.[3] This approach, which the Project's proponents have used in their analyses and which is the approach used by the U.S. Federal Energy Regulatory Commission, is utilized here as well. The empirical results of the benefit and cost calculations are combined in a social benefit-cost ratio for the Clavey-Wards Ferry Project.[4] Lastly, a sensitivity analysis of the SBC model is provided, in which a set of ranges of the B/C ratio is developed, given various assumptions regarding interest rates and other parameters of the model.

The final chapter of the study, Chapter VI, briefly summarizes the major aspects of the analysis, develops its major conclusions, and presents the major policy implications of the study.

Major Conclusions of the Economic Assessment

of the Clavey-Wards Ferry Project

Because the Tuolumne River is a scarce resource with competing uses, it is necessary to examine the benefits and costs of additional hydroelectric development from a broad social perspective. This is particularly true because the U.S. Congress is considering protecting the affected reach of the River under the Wild and Scenic Rivers Act or through inclusion in the National Wilderness Preservation System.

Based upon an application of the SBC model, this study finds that the annual social benefits of the Clavey-Wards Ferry Project would be approximately $188 million, while the annual social costs would exceed $214 million. Thus, even with only two of the Project's environmental costs internalized, the result is a net annual loss to society of $26 million and a benefit-cost ratio of 0.877. This means that every dollar invested in the Clavey-Wards Ferry Project will return to society less than 88 cents.

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[3] Note that this avoided-cost measure implicitly assumes that the electricity which would be generated by the project will be demanded at prices consistent with those which are otherwise assumed.

[4] So that interested parties may follow our procedures every step of the way, detailed appendices provide complete documentation of the SBC computer model.

It is important to keep in mind that the analytical approach employed here by no means includes all environmental impacts of the CWF hydroelectric project. In this sense and with regard to most other assumptions, either explicit or implicit in the model, the results presented here may well overestimate the net social benefits of the project proposal. If additional environmental impacts were internalized in the calculations (or if less conservative assumptions were used in the analysis), the CWF benefit-cost ratio would be even less than the current value of 0.877.

California's Tuolumne River --- A Multiple-Use River

Targeted for Further Development

From within Yosemite National Park, the Tuolumne River's Hetch Hetchy Reservoir[5] (Figure 2) provides San Francisco's water supply of approximately 300 million gallons per day, while three powerhouses in the area provide nearly 300,000 kilowatts of electrical capacity for the San Francisco Public Utility Commission (Appendix 1). Hetch Hetchy Reservoir is impounded by O'Shaughnessy Dam, which was completed in 1923. With 455 square miles of drainage area, the Reservoir has a maximum storage capacity of more than 360,000 acre-feet (AF).[6] Additional reservoirs are Cherry Lake (Lake Lloyd) and Lake Eleanor (Figure 2).

Three powerhouses, Kirkwood (67.5 megawatts - MW), New Moccasin (90 MW) and Holm (135 MW), complete the system, which is owned by the City and County of San Francisco and operated by the Hetch Hetchy Water and Power Department. Power is sold to the municipal departments of the City, to the Modesto and Turlock Irrigation Districts and to industrial customers assigned by the

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[5]In the early 1900's, naturalist John Muir led the fight to prevent the damming of the Tuolumne and the flooding of Hetch Hetchy Valley in Yosemite National Park, an area which was comparable in its scenic beauty to Yosemite Valley. Muir lost the fight when the U.S. Congress passed the Raker Act of 1913 (38 Stat. 242), which permitted the City and County of San Francisco to construct six dams and reservoirs in the Tuolumne watershed. Although the battle was lost, one result of Muir's unsuccessful efforts on behalf of the Tuolumne was the emergence of the Sierra Club as a strong voice for environmental preservation.

[6]An acre-foot (AF) is the amount of water which would cover an area of one acre to a depth of one foot; it is equal to 325,851 gallons.

FIGURE 2:
TUOLUMNE RIVER AND THE PROPOSED CLAVEY-WARDS FERRY PROJECT
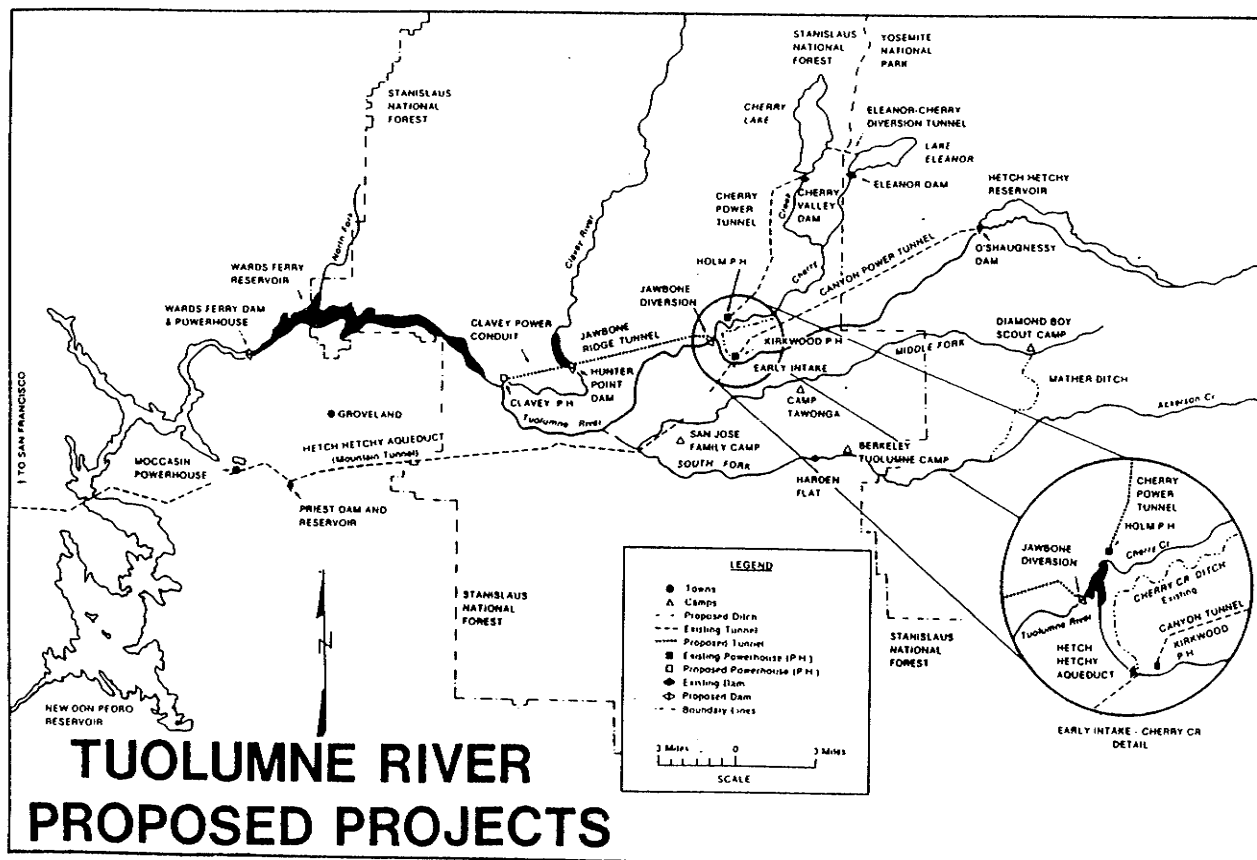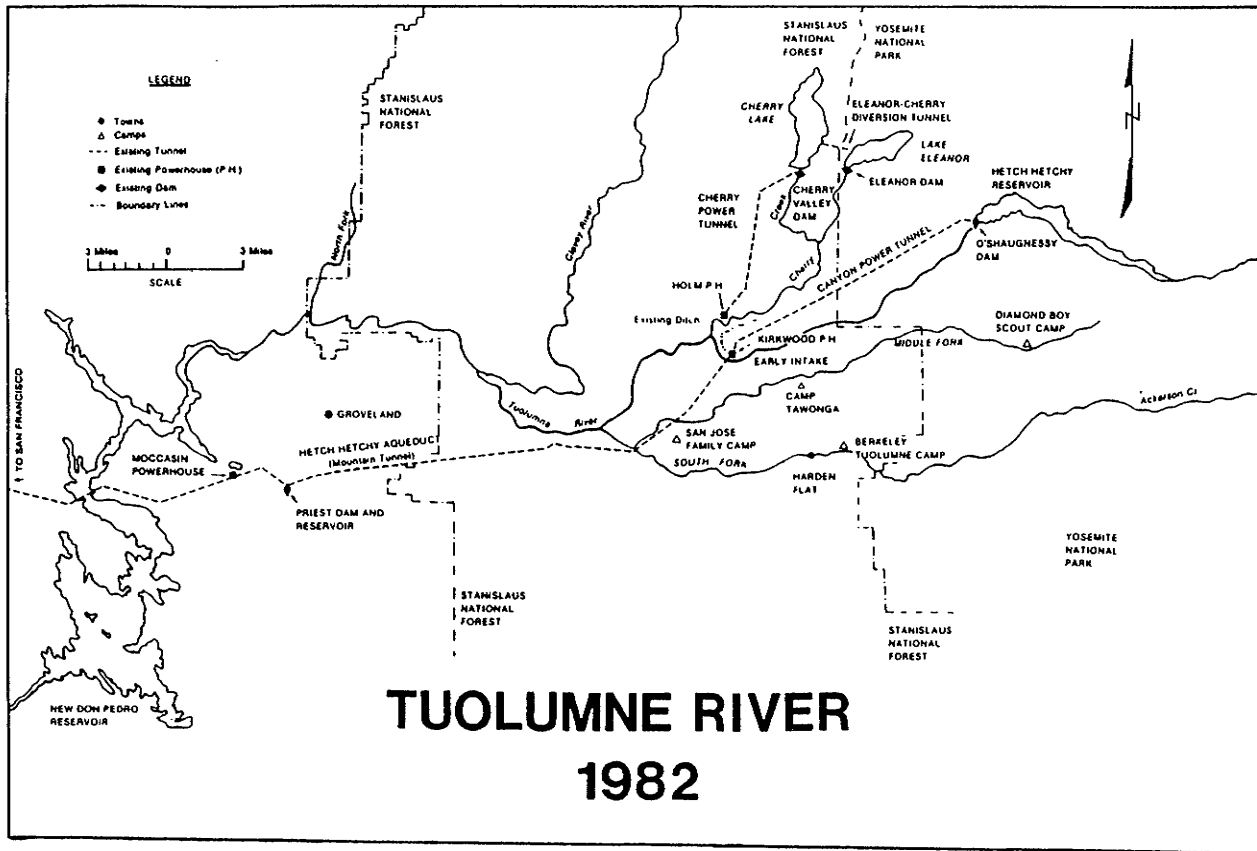
Pacific Gas & Electric Company (PG&E).

The 30-mile stretch of the River immediately below Yosemite Park provides for a variety of recreational benefits which account for nearly 35,000 annual user-days. The U.S. Army Corps of Engineers has described this reach of the Tuolumne as "one of the finest whitewater boating rivers in the Nation" (State of California 1982). The whitewater run is comparable to those of the Colorado River in the Grand Canyon and on the Salmon River in Idaho.

Even with current levels of development, the remaining relatively free-flowing stretch of the Tuolumne maintains an important trout fishery; indeed, the California Department of Fish and Game has designated the Clavey tributary as one of the streams to be managed for its wild trout fisheries.

The Canyon is a prime habitat for a diversity of wildlife species, including a number of endangered, threatened and rare animals, such as the bald eagle, the prairie falcon and the spotted owl. In terms of visual beauty, a Federal Wild and Scenic River Study found that compared with other rivers in the region, the Tuolumne possesses "outstanding, remarkable scenic values" (State of California 1982, p. 15).

Below this scenic area is the New Don Pedro Dam and Reservoir, owned and operated by the Modesto and Turlock Irrigation Districts. This project generates 150 megawatts (MW) of power and provides irrigation water for nearly 230,000 acres of farmland in the Central Valley (Modesto Irrigation District 1982; Turlock Irrigation District 1981a).

Thus, these three sections of the Tuolumne River --- the Hetch Hetchy Project in Yosemite National Park, the New Don Pedro Project in the Sierra foothills and the exceptionally scenic stretch of canyon and river in between --- combine to form a working river which is meeting the multiple-use demands of the State's and the region's population. Further hydroelectric construction on the Tuolumne would upset the balance that now exists between preservation and development.

Proposed Additions to the Hetch Hetchy Water and Power System:

The Clavey-Wards Ferry Project

As early as 1912, the potential for development of the Upper Tuolumne River Basin for water supply and hydroelectric power was identified and investigated by the City of San Francisco (Freeman 1912). Development of the River has included the Hetch Hetchy Project and the New Don Pedro Project. On January 17, 1967, by Resolution No. 67-0030, the San Francisco Public Utilities Commission retained a joint venture of Clair A. Hill & Associates and R. W. Beck and Associates to assess the potential for additional hydroelectric development of the Upper Tuolumne Basin, between the Dion R. Holm Powerhouse and the New Don Pedro Reservoir (Figure 2). The result was a

report, completed in 1968,[7] which recommended (as "Stage I") the development of new hydroelectric generation on the Tuolumne River near the mouth of the Clavey River and at Wards Ferry.[8] Thus was the proposal for the Clavey-Wards Ferry Project born.

In 1975, the Modesto[9] and Turlock[10] Irrigation Districts and the Hetch Hetchy Water and Power division of San Francisco's Public Utilities Commission[11] authorized an appraisal report to update the 1968 investigation of the Clavey-Wards Ferry Project. The resulting analysis used completely new cost estimates, and concluded that the proposed CWF Project was economically feasible (R. W. Beck and Associates 1976).[12]

Because of Congressional consideration of a Wild and Scenic River designation for the Tuolumne, R. W. Beck and Associates updated its benefit-cost analysis of the Clavey-Wards Ferry proposal in 1979. Construction costs for particular items had increased at different escalation rates since the 1976 study, so unit costs were reviewed and revised on an item by item basis (R. W. Beck and Associates 1979).

Due to continuing Congressional interest in the Tuolumne, the Project's proponents requested that R. W. Beck and Associates update its economic

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[7]Clair A. Hill & Associates and R. W. Beck and Associates. Report on Potential Additions to the Hetch Hetchy Power Supply System. Prepared for the Public Utilities Commission, City and County of San Francisco, January 1968.

[8]The land on which the Clavey-Wards Ferry project would be constructed is owned by the U.S. government and is supervised and administered by the Bureau of Land Management (U.S. Department of the Interior) and the U.S. Forest Service.

[9]For further information about the Modesto Irrigation District, see: Modesto Irrigation District, 1970 through 1982; and M-S-R Public Power Agency 1983.

[10]For further information about the Turlock Irrigation District, see: Turlock Irrigation District, 1970a through 1981a.

[11]For further information about the San Francisco Public Utilities Commission and its role in the proposed Clavey-Wards Ferry project, see: City and County of San Francisco, Public Utilities Commission, Hetch Hetchy Water and Power Department, 1970-71 through 1980-81; and City and County of San Francisco, Public Utilities Commission, San Francisco Water Department, 1970-71 through 1980-81.

[12]Hereafter referred to as the "Beck 1976" study.

analysis in 1980, specifically to take account of cost changes (in generic thermal alternatives) which would tend to enhance the Project economics (R. W. Beck and Associates 1980).

In 1981, the San Francisco Public Utilities Commission requested that Sverdrup & Parcel and Associates, Inc. (1981) update the construction cost and power benefit estimates of the Beck 1980 analysis, as an adjunct to a Hetch Hetchy Systemwide Power study which was then being conducted.

What all five of these studies had in common was that they were concerned only with internal costs and benefits of the CWF proposal; or in other words, whether or not the Project would make money for the three participants. No attempt was made to evaluate the economics of the Project from a broader societal perspective, taking into account significant economic externalities such as impacts upon the recreational fishery and whitewater boating.

Since R. W. Beck's 1976 analysis, the Clavey-Wards Ferry proposal has changed very little. As presently planned, the total installed capacity of the Project would be 400 MW, and the development would consist of two units, Clavey and Wards Ferry. The Clavey unit would divert water from the Tuolumne at a new dam, known as the Jawbone Diversion, located at the confluence of the Tuolumne and Cherry Creek (Figure 2). This concrete dam, 175 feet high and 255 feet long, would create Jawbone Reservoir. From here, the flow would be routed west to the new Clavey Reservoir via Jawbone Ridge Tunnel. On an annual basis, nearly 72 percent of the Tuolumne's flow would be diverted out of the River and into the Jawbone Ridge Tunnel; in some months, less than 5 percent of the River's natural flow would be left in the riverbed.

The Clavey Reservoir would be created by Hunter Point Dam, a 195-foot-high, 570-foot-long concrete arch dam located on the Clavey River. About 93 percent of the Clavey's average annual flow would be diverted from its streambed, and in dry periods of the year this diversion would exceed 98 percent of the Clavey's natural flow. Clavey Power Conduit, a concrete-lined pressure tunnel, would extend to Clavey Powerhouse, downstream from the confluence of the Tuolumne and Clavey Rivers. This powerhouse would contain two generating units with a total installed capacity of 300 MW.

The Wards Ferry unit would include Wards Ferry Dam, a 450-foot-high, 1,060-foot-long rockfill dam located on the Tuolumne River immediately upstream from the New Don Pedro Reservoir and creating Wards Ferry Reservoir (Figure 2). Wards Ferry Powerhouse would be located in the left abutment of Wards Ferry Dam and would contain two generating units, with a combined installed capacity of 100 MW. On average, approximately 86 percent of the Tuolumne's flow would be diverted through the turbines of the Wards Ferry Powerhouse.

The Legal Status of the Proposed Clavey-Wards Ferry Project

This section of the study briefly reviews three major aspects of the current legal status of the proposed CWF Project: (1) the proceedings to obtain a preliminary permit and license for the project from the Federal Energy Regulatory Commission (FERC); (2) pending Congressional legislation to protect the River from further development; and (3) State requirements likely to affect the Project's fate.

FERC Proceedings

Under the Federal Power Act (16 U.S.C. Sections 791(a) et seq.), the proponents of the Clavey-Wards Ferry Project must obtain a license from FERC before they can construct the Project. On April 6, 1983, FERC granted a preliminary permit to the Modesto and Turlock Irrigation Districts and to the City and County of San Francisco to conduct studies to obtain information required for the license application. Preliminary permits are issued for a maximum term of three years (18 C.F.R. 4.82), and give priority over all competing applicants.[13]

In acting on a license application, FERC is required under the Federal Power Act to weigh the Project's social benefits against its social costs, including the loss of environmental amenities. In addition, the National Environmental Policy Act (NEPA, 42 U.S.C. Sections 4321 et seq.) requires FERC to prepare an Environmental Impact Statement which assesses the environmental impact of the project. These requirements are discussed in more detail in Chapter III and Appendix 20.

In order to aid FERC in assessing the Project's environmental costs, the applicant must submit a detailed environmental report (18 C.F.R. 4.41(f)) and

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[13]The preliminary permit was issued approximately seven years after the districts filed an amended application for the Project. This delay was due in part to Congressional designation of the Tuolumne River for study for possible addition to the Wild and Scenic River System. During the three-year period of this study, which expired at the end of 1982, FERC was prohibited from issuing a permit (16 U.S.C. Section 1278(b)).

The Sierra Club, the County of Tuolumne and Tuolumne River Expeditions, Inc. filed for rehearing of the April 6 FERC order granting the preliminary permit. On July 29, 1983, FERC issued an order denying rehearing (FERC, Order Denying Rehearing, Mooting Request for stay, and Finding Jurisdiction to Act (Project Nos. 2774-001 and 5642-001; July 29, 1983)). The Sierra Club and Tuolumne River Expeditions, Inc. have a petition for review of FERC's order in the Ninth Circuit Court of Appeals which is still pending (Sierra Club, et al. v. FERC, Nos. 83-7584 and 83-7699).

must consult with appropriate Federal, State, and local resource agencies and include their recommendations in the report. In acting on the license application, FERC must take their recommendations into consideration.[14]

Pending Congressional Legislation

Legislation has been introduced in both the U.S. Senate and House of Representatives to protect the Tuolumne River under the Wild and Scenic Rivers Act (16 U.S.C. Sections 1271-87). Two bills, S. 142 (Cranston) and H.R. 2474 (Dellums) (98th Congress, 1st Session), provide for the designation of the Tuolumne River as a Wild and Scenic River from its sources on Mount Dana and Mount Lyell in Yosemite National Park to the headwaters of the New Don Pedro Reservoir. Under Section 7(a) of the Wild and Scenic Rivers Act, the enactment of either of these bills would prohibit the proposed Clavey-Wards Ferry Project (16 U.S.C. Section 1278(a)).

In addition, Senator Wilson has publicly announced his support of Wild and Scenic River designation for the Tuolumne River but has not yet introduced legislation (Los Angeles Times, February 13, 1984). SB 1515 (Wilson), however, could designate the Tuolumne River Canyon for inclusion in the National Wilderness Preservation System (16 U.S.C. 1131-36).

Eventual inclusion of the Tuolumne River Canyon within the National Wilderness Preservation System would accord a strong measure of protection to the area. While the law permits the President, under certain limited circumstances, to authorize hydroelectric power projects within wilderness areas in national forests (16 U.S.C. Section 1133(c)(4)), political pressure would make such an action unlikely.

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[14]Section 4(e) of the Federal Power Act provides

> [L]icenses . . . issued within any [Federal] reservation . . . shall be subject to and contain such conditions as the Secretary of the Department under whose supervision such reservation falls shall deem necessary for the adequate protection and utilization of such reservation.

> (16 U.S.C. Section 797(e) (1976)).

The Ninth Circuit Court of Appeals has held that a Secretary's recommendation is binding in FERC and not merely advisory. (Escondido Mutual Water Company, et al. v. FERC et al., 692 F. 2d 1223 (1982), rehearing denied with dissenting opinion 701 F. 2d 826 (9th Cir. 1983). Cert. granted 52 U.S.L.W. 3309 (October 17, 1983).

Since National Forests are Federal reservations, this ruling applies to recommendations by the U.S. Forest Service concerning hydroelectric development on the Tuolumne River within National Forest lands.

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State Requirements

Before the proponents of the Clavey-Wards Ferry Project can appropriate water for the project, they must have sufficient water rights under State law.[15] Unless they can establish sufficient existing rights they must obtain a water rights permit from the California State Water Resources Control Board (Board). As discussed more fully in Chapter III and Appendix 20, the Board must, in acting on a permit application, consider all beneficial uses of water, including recreation and preservation and enhancement of fish and wildlife (California Water Code Section 1257). The California Department of Fish and Game has the primary responsibility for recommending the amount of water required to preserve fish and wildlife resources (Water Code Section 1243). In addition, the Board must comply with the California Environmental Quality Act (CEQA, Pub. Res. Code Sections 21000 et seq.), which requires full consideration of the Project's environmental impacts. Even if the Board's permit process can be bypassed, the Project proponents would be required to comply with CEQA.

The Department of Fish and Game has already formally expressed opposition to the Clavey-Wards Ferry Project.[16] The Department has described the Tuolumne River as a prime trout stream and the Clavey River has been formally designated a "wild trout stream" to be preserved in its present state (California Department of Fish and Game 1977). State policy requires that all necessary actions, consistent with State law, be taken to prevent adverse impact of land or water development projects on designated wild trout waters. (California Fish and Game Commission 1975.)

A second major area of State concern is associated with the public trust doctrine, under which the State, as sovereign, holds title to all navigable waters in trust for the people of the State. The preservation of fish and wildlife, recreation, and scenic values is one of the more important purposes of the trust. In National Audubon Society v. Superior Court, 33 Cal.3d 419 (1983), the California Supreme Court made it clear that all State agencies, and the State courts, must give substantial weight to these values in decisions concerning the use of the State's water resources.

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[15]See Order Issuing Preliminary Permit and Denying Competing Application (FERC, April 6, 1983) at 4.

[16]The Department filed a Protest and Petition to Intervene in the FERC proceeding on the preliminary permit for the Clavey-Wards Ferry Project (California Department of Fish and Game 1977).

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<u>Preservation vs. Development:</u>

<u>Social Benefits and Costs of the Clavey-Wards Ferry Project</u>

Economic methodologies for assessing the feasibility of water projects are well established. A body of economic principles and analytical procedures has evolved over the past twenty-five years which can be used to provide reasonably good estimates of the (internal or private) benefits and costs of multiple-purpose water projects, designed to generate electrical power, reduce flood damages, improve navigation conditions, and provide irrigation and municipal water supplies.[17]

Benefit-cost analysis consists in principle of the systematic appraisal of all benefits and costs of a contemplated course of action (in comparison with alternative courses of action, defined to include "no action" as one alternative). Given the assumption that <u>all</u> benefits and <u>all</u> costs are considered, an economically rational decision criterion (the so-called benefit-cost criterion) for whether or not to undertake a specific course of action is to do so only if the resulting additional benefits exceed the corresponding additional costs.[18]

A benefit-cost analysis is a systematic evaluation of "the advantages and disadvantages of any actual or hypothetical change in society's production and consumption arrangements" (Seneca and Taussig 1979, p. 16). Thus, the benefit-cost criterion, whether expressed as a ratio of benefits to costs (B divided by C) or as the difference between the two (B minus C), is a rational, common-sense investment criterion. But in a broader sense, it provides neither a sufficient nor even a necessary condition for investment decisions. The reasoning behind this last statement is thoroughly developed in Chapter III.

When particular categories of benefits and/or costs are systematically excluded from an economic assessment, benefit-cost analysis loses its value as an aid to societal decision-making.[19] It is primarily for this reason that

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[17] The development of this body of economic principles and analytical procedures is exemplified by: Eckstein 1958; Krutilla and Eckstein 1959; Howe 1971; and Mishan 1982.

[18] In general, a benefit may be defined as the value of a good or service to a consumer; a cost is thus a foregone benefit. The private market system constantly performs numerous and complex, implicit benefit-cost analyses.

[19] For a discussion by an economist of the ethical limitations of benefit-cost analysis, see: Mishan 1982, pp. 162-168.

traditional B/C analysis has sometimes been attacked in the legal and policy literature as an inadequate basis for health, safety and environmental decisionmaking (Baram 1980; Sagoff 1980; and Swartzman, Liroff and Croke 1982).

From a broader, social benefit-cost perspective, however, other voices within the legal community have argued on behalf of the role which economic analysis may play in seeking solutions to environmental problems:

> I would argue that the proper role of the government in resource allocation and environmental protection is to define property rights, so that market exchanges can occur to enforce those bargains and protect property rights so defined; and to intervene in the economy when market failure produces external diseconomies such as water and air pollution (Meyers 1975, p. 453).

Indeed, it is when such external diseconomies occur, as with an environmentally disruptive hydroelectric project, that a social benefit-cost analysis which considers all possible uses of the resource is required.

A variety of Federal and State statutes, regulations and court decisions require that the environmental costs of a proposed hydro project be weighed against the more easily measured economic benefits in assessing the merit of a project. For example, FERC must balance the broad social costs and benefits of a proposed project under the Federal Powers Act (16 U.S.C. Sections 791 et seq.) and under NEPA (42 U.S.C. Sections 4321 et seq.) (See Udall v. Federal Power Commission, 387 U.S. 428 (1967)). Similarly, State water laws and the public trust doctrine require a weighing of the value of competing uses of a river in any decision on water appropriations for hydropower purposes (See, e.g., Water Code Section 1257; National Audubon Society, supra).

In only one case, however, has FERC, or its predecessor, the FPC, denied a permit for an economically feasible hydropower development project because the scenic and recreational qualities of the river (assessed qualitatively) were deemed of greater value than the electric energy which would have been produced (Namekagon Hydro Company, 12 F.P.C. 203(1953)). This suggests that the present method of evaluating environmental externalities on a descriptive or qualitative basis is inadequate.

Although Federal and State decision-makers are required to balance social (including environmental) costs with social benefits, there are few formulae for weighing the environmental aspects of the equation. Nevertheless, the U.S. Water Resources Council's recently promulgated Economic and Environmental Principles and Guidelines For Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 1983b) urges quantifying all benefits and costs which can be quantified: "National economic planning should

internalize all known direct beneficial and adverse effects" (U.S. Water Resources Council 1983b, p. 10257).

What is important is the concept of quantifying what _can_ be quantified. Certainly, it remains difficult or impossible to assign monetary measures to many environmental values. As the state of the art of economic analysis improves, however, more of these environmental externalities can "be brought into relation with the measuring rod of money" (Pigou 1932).

In many instances, private markets fail to account for the full benefits and costs of production or consumption decisions, frequently because of the public good nature of externalities (such as air pollution). In such cases, the allocation of resources is said to be economically inefficient. So too with benefit-cost analysis: "The measures of benefits and costs must be inclusive of _all_ relevant social values if the analysis is to avoid the pitfall of inefficient public resource allocation" (Seneca and Taussig 1979, p. 270). Thus, it is only by internalizing the expected environmental impacts of a proposed project that a benefit-cost assessment can provide socially valid guidance to investment decisions.

To meet the needs of policy-makers and to meet the legal mandates of the Federal Power Act and NEPA, it is essential to assess the economic merits of the proposed Clavey-Wards Ferry Project from a regional and national perspective, rather than simply from the single-minded viewpoint of its electric utility developers. Thus, it is necessary to internalize where possible all benefits and costs of the Project. The social benefit-cost analysis of this study, in keeping with current recommendations of the U.S. Water Resources Council, provides just such a comprehensive assessment of additional hydroelectric development in the Tuolumne River Canyon.

THE IMPACT OF THE PROPOSED CLAVEY-WARDS FERRY PROJECT

ON THE NATURAL ENVIRONMENT

Although the Tuolumne River is extensively developed throughout much of its 158-mile length with hydroelectric dams, diversions, reservoirs and powerhouses, it still retains its wild and scenic character within the 30-mile free-flowing reach below Yosemite National Park, where the proposed Clavey-Wards Ferry hydroelectric project would be constructed. By diverting up to 95 percent of the Tuolumne's present flow and up to 98 percent of the Clavey's natural flow out of their respective river beds, the Clavey unit would virtually dry up some fifteen miles of the Tuolumne and six miles of its Clavey tributary. Additionally, the Wards Ferry unit would inundate another twelve-mile stretch of Tuolumne Canyon under the reservoir created behind a new 450-foot-high earth-filled dam. These are the principal mechanisms through which the proposed Clavey-Wards Ferry (CWF) Project would significantly degrade the area's natural environment.

The quantitative economic analysis of Chapter V of this study internalizes only two of the many environmental impacts of the CWF Project. Therefore, it is the purpose of this chapter to provide a broad outline of the range of effects which the Project would have on the natural environment of Tuolumne Canyon. Environmental impacts are considered within eight major categories: fisheries, wildlife, recreation, hydrologic, water quality, vegetation and soils, visual resources, and archaeological and historical impacts.

Fisheries Impacts

The fisheries of the Tuolumne and Clavey Rivers would be severely damaged, if not destroyed, by the Clavey-Wards Ferry Project.[1] This is particularly serious from a Statewide perspective, considering that the Clavey River is managed by the Department of Fish and Game as a "Wild Trout Stream," and the Tuolumne is considered to be one of the finest cold-water trout fisheries in California (U.S. Department of Agriculture and U.S. Department of the Interior 1979).[2]

Wards Ferry Reservoir would inundate over 12 miles of the Tuolumne fishery, eliminating spawning beds and stream habitat. The Wards Ferry Dam would also block spawning runs necessary to perpetuate the New Don Pedro Reservoir trout (and possibly salmon) fisheries (U.S. Department of Agriculture and U.S. Department of the Interior 1979).

The likely consequences for the Clavey trout population are no less grim: If the project is built, it is probable that the wild trout fishery on the Clavey River would be totally lost" (California Department of Water Resources 1982b, p. 9). Clavey Reservoir would inundate more than a mile of stream habitat and would completely block the passage of fish. Average flows in the lower reach of the stream would be reduced to less than 7 percent of the pre-project average, far below what is generally assumed necessary for fishery protection (Appendix 2). In addition, the fragile native (non-trout) fish community in the lower Clavey would be damaged by flow changes and by the encroachment of exotic species from Wards Ferry Reservoir (Peter Moyle, personal communication, June 1983).

Jawbone Reservoir (Figure 2) would inundate almost two miles of the Tuolumne River and Cherry Creek and would drastically dewater the River below this point. The Project's planned flow releases of 35-75 cubic feet per second (cfs) are considered by the U.S. Fish and Wildlife Service to be inadequate even for the smaller stretch of the Tuolumne above Early Intake. U.S. Department of the Interior 1976.) The California Department of Water

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The adverse impact of the proposed Clavey-Wards Ferry Project on the recreational trout fishery of the Tuolumne and Clavey Rivers is one of the two environmental externalities which are internalized though the social benefit-cost (SBC) model utilized in this study. The development of the generic model is described in detail in Chapter IV and its application to the Tuolumne analysis is considered in Chapter V.

Much of the presentation in this chapter is based upon an analysis which was conducted jointly by the U.S. Forest Service and the National Park Service: U.S. Department of Agriculture and U.S. Department of the Interior. _Tuolumne Wild and Scenic River Study: Final Environmental Impact Statement and Study Report._ Forest Service/National Park Service. San Francisco, California, October 1979.

Resources has confirmed this judgment, stating that if the Clavey-Wards Ferry Project were constructed "it would be impossible to preserve this fishery" (California Department of Water Resources 1982b, p. 8).

The Tuolumne River below New Don Pedro Reservoir currently sustains a declining population of salmon. The California Department of Fish and Game has indicated that increased diversions may result in complete elimination of salmon from the River (U.S. Department of Agriculture and U.S. Department of the Interior 1979).

Additional adverse impacts on the fishery would likely occur with fish passage through hydroelectric turbines, water temperature and quality changes, water level fluctuations, habitat alterations and reductions of flushing flows (California Energy Commission 1981a).

Wildlife Impacts

Tuolumne River Canyon encompasses several ecological communities and provides a diverse habitat for wildlife. More than 200 species of terrestrial vertebrates, 200 species of birds and numerous fish species are represented in the area. Also present are six endangered, threatened or rare animal species (U.S. Department of Agriculture and U.S. Department of the Interior 1979).

The Southern Bald Eagle, an endangered species, would be adversely affected by construction of the Clavey-Wards Ferry Project (California Department of Water Resources 1982b). This detrimental impact would be caused by destruction of habitat, construction activities, erection of transmission lines and increased human presence in the area (California Energy Commission 1981a).

These same factors would also adversely affect other wildlife, including several deer herds which traverse the Canyon:

> The project's features would block several migration routes used by deer which summer in Yosemite National Park. Jawbone Reservoir could block the 300 or more deer which cross the Tuolumne River and Cherry Creek near their confluence. Wards Ferry Reservoir would block 200-300 deer which cross the Tuolumne River in that location. Hunter Point Reservoir could adversely affect the several hundred deer which use that area (California Department of Water Resources 1982b, p.9).

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Recreational Impacts

The 26-mile section of the Tuolumne River and Canyon which would be affected by the proposed Clavey-Wards Ferry Project currently provides a variety of recreational benefits, including rafting, fishing, hunting, hiking and camping. Together, recreational activities account for nearly 35,000 user-days per year.

Whitewater boating on the Tuolumne would be virtually eliminated by the CWF Project. Twelve miles of the eighteen-mile whitewater run between Lumsden and Wards Ferry would be inundated by Wards Ferry Reservoir, and flows in the remaining section would be severely depleted by diversions to Clavey Reservoir. Minimum Project flow releases have been scheduled at only 35-75 cfs, yet at least 1,000 cfs are needed for whitewater rafting (Steve Cutwright, personal communication, June 1983). Currently, approximately 6,500 whitewater boaters per year use this section of the River, which is considered to be one of the finest whitewater runs in the entire country. It is estimated that this number will more than double within a decade.[3]

Wards Ferry Reservoir would create the potential for additional flatwater recreation, but such added recreational opportunities would be extremely limited.[4] According to the CWF Project's own evaluation, the reservoir would be a long, narrow and deep lake with difficult access down steep canyon walls and would be sunless most of the time (R. W. Beck and Associates 1976). Furthermore, surface water levels would fluctuate by almost 100 feet, complicating access and seriously affecting scenic qualities. In addition, "considerably better opportunity for flatwater recreation exists at currently undeveloped sites on larger reservoirs nearby" (U.S. Department of Agriculture and U.S. Department of the Interior 1979, p. 63).

Approximately 22,000 visitor-days were recorded last year at the U.S. Forest Service Campgrounds on the Tuolumne River near Lumsden Bridge (William Lane, personal communication, July 1983). The area offers excellent fishing and scenic qualities, both of which would be adversely affected by the Project:

> The prime attraction is the flowing river which
> would disappear from the area if the project's
> diversion to Hunter Point Reservoir was allowed.
> Others come to the area to hunt, backpack, pan for

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[3]The impact of the Clavey-Wards Ferry Project upon whitewater rafting is the second major environmental externality which is explicitly considered in this study's social benefit-cost assessment.

[4]The flatwater (fishing and boating) recreational opportunities which would be a consequence of the development of the Wards Ferry Reservoir are also included in the social benefit-cost analysis of Chapters IV and V.

gold, swim and picnic (California Department of
Water Resources 1982b).

As was previously indicated, large sections of the stream fisheries of
the Tuolumne and Clavey Rivers would be replaced by reservoir fisheries, but
"reservoir fisheries are in abundance in the Sierra foothills, whereas river
trout fisheries of the quality of the Tuolumne are a rarity in the state"
(U.S. Department of Agriculture and U.S. Department of the Interior 1979, p.
65). A former California Department of Fish and Game biologist has estimated
that the Tuolumne River holds more than 1,000 pounds of fish per acre, whereas
Wards Ferry Reservoir would probably maintain less than 10 pounds per acre
(Gray 1976). Again, according to the Project proponents' analysis, "in view
of the expressed preferences of fishermen for flowing water, this replacement
(reservoir instead of stream), without offsetting compensation, would have to
be considered a recreation loss" (R. W. Beck and Associates 1976, p. BV-1).

The wildlife impacts previously described would adversely affect hunting
as well. Lastly, backpacking and hiking, recreational activities depending on
solitude and scenic values, would be severely curtailed by the construction
and presence of the proposed hydroelectric complex.

Hydrologic Impacts

Severe hydrologic impacts to the Tuolumne and Clavey Rivers would also
result from operation of the proposed Project. Flows would be reduced to a
fraction of historical levels, and the yearly distribution of flows would also
be altered. Other hydrologic impacts would be increased water-surface area
(and consequently increased evaporation), and construction-related changes in
overland flow patterns (California Energy Commission 1979a).

Water Quality Impacts

Water quality would be adversely affected by low-flow induced warming
trends related to Project operation (U.S. Department of Agriculture and U.S.
Department of the Interior 1979). Changes in water temperature and dissolved
oxygen content would result from water releases from different levels of the
reservoirs, upper level water generally being warmer and lower level water
being colder and containing less oxygen. Water passage through tunnels,
penstocks and turbines would also reduce oxygen levels (California Energy
Commission 1979a). Changes in turbidity and sediment transport would result
from river flow modifications and construction activities. All of thse water
quality impacts would, in turn, affect the Tuolumne's fishery resources.

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Vegetation and Soil Impacts

The diverse vegetative communities of the Tuolumne River Canyon would suffer from development of the proposed Project. About 1,500 acres of vegetation would be totally eliminated by inundation, and shoreline vegetation and soils would be damaged by water level fluctuations (U.S. Department of Agriculture and U.S. Department of the Interior 1979). Vegetation and soils would be damaged and in some cases eliminated by Project construction. Encroachment of riparian vegetation into the streambed would probably occur on reaches of the river with reduced streamflows.

Visual Impacts

The devastating impact of the proposed Project on the visual resources of Tuolumne Canyon was best described by the U.S. Departments of Agriculture and Interior:

> In general, the Tuolumne's steep slopes, vegetative variety, and free-flowing water, and the contrasts between north- and south-facing slopes and between rocks and water, give it a high esthetic rating. Adding to this the near natural condition of most of its 30 miles, the lower Tuolumne River was found to possess outstandingly remarkable scenic value compared with other rivers within the same physiographic province. . . . The considerable road building, dam construction, borrow pits, transmission facilities, switchyards, and related structures, would produce impacts both of a short-term and a long-term nature, and would constitute a significant detraction from the natural scene (U.S. Department of Agriculture and U.S. Department of the Interior 1979, pp. 18, 24).

Archaeological and Historical Impacts

The Tuolumne River area shows evidence of human presence dating back 4,000 years. Tuolumne and Stanislaus Canyons were inhabited by 2,700 Miwok Indians prior to about 1850. Gold rush history is also in evidence along the lower Tuolumne River: "In the lower 18 miles of the study reach, over 10 miles of which would be impacted by the proposed Wards Ferry Reservoir, there are 12 prehistoric sites and 11 historic features" (U.S. Department of Agriculture and U.S. Department of the Interior 1979, p. 67). With the recent inundation of the Stanislaus River Canyon, the Tuolumne sites have become especially important.

III

CONVENTIONAL AND IMPROVED APPROACHES TO EVALUATING

THE ECONOMIC FEASIBILITY OF HYDROELECTRIC PROJECTS

Conventional economic analyses of hydroelectric and other public investment projects have typically failed to include evaluation of the positive and negative externalities of such enterprises. In particular, environmental impacts rarely have been included in benefit-cost assessments of proposed developments. Recent advances in theoretical and applied economics, however, make it possible to develop quantitative models with which at least some environmental externalities can be evaluated together with the usual (internal or private) benefits and costs. Moreover, such inclusion of externalities within a benefit-cost assessment is expressly recommended by the U.S. Water Resources Council's (1983a) new "Principles and Guidelines."

This chapter begins with a general description of conventional benefit-cost (B/C) models and their use of the "discounting" process. Limitations of these traditional B/C models are considered in some detail. Next, general theories of environmental economics are introduced and their merger with traditional B/C methodologies is explained. Finally, legal and policy arguments which support a broad, social benefit-cost framework are briefly examined.

Evaluating Public Investment:
Conventional Benefit-Cost Analysis[1]

Major civil engineering projects such as hydroelectric developments typically have long lives and are usually characterized by substantial initial construction costs followed by continuous, but relatively low, operation and

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[1]For a discussion of the theoretical basis of benefit-cost analysis, see: Mishan 1982; and Eckstein 1958, pp. 19-46. For further examination of benefit-cost analysis in the context of water resource development, see Eckstein 1958, pp. 47-109; and for a description of benefit-cost assessments of hydroelectric projects, see Eckstein 1958, pp. 237-258.

maintenance costs. The benefits of such projects, however, tend to be more evenly distributed over their useful lives. But the decision of whether or not to undertake investment in such a project must be made in the present. Hence, a procedure is required whereby many future benefits and costs can be expressed in terms of their value today.

The simplest approach would of course be to add up all benefits from various future years and to do likewise for all future costs. But such a procedure would assume that the decision-maker, the individual who is considering the project investment, values present dollars equally with various future dollars. Irrespective of questions of general price inflation, such indifference with respect to present versus future income (or present versus future expenditures) is highly unusual, to say the least.[2]

Neither consumers nor corporations value a dollar today equally with a dollar in the future. Because "a bird in hand is worth two in the bush", consumers and corporations alike tend to decide (implicitly or explicitly) that they are indifferent between, for example, receiving (or paying) $1.00 today and receiving (or paying) $1.12 a year from now. The calculation might be based upon possible returns if today's one dollar were invested in some type of security for a year, or it might be based upon a willingness on behalf of consumers to postpone present consumption only on the condition that future consumption is increased. Either way, in the above example, the corporate investor or the consumer would have used a "discount rate" of 12% in determining the "present value" of $1.12 a year from now.

In order to compare alternative investment strategies which involve costs and benefits spread over different time periods, it is thus customary to discount all monetary amounts to a base year. This procedure of discounting simply converts all future monetary values into present values by adjusting future values downward by the equivalent of a compounded interest or discount rate factor. On the cost side, the present value may be thought of as an amount of money, which if invested at the present time at the project discount rate would provide a return precisely adequate to repay all project capital and operating costs during the operational life (or planning period) of the

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[2]The relationship between individuals' time preferences and those of a society acting collectively is hardly simple and direct. While of relevance to any empirical application of benefit-cost analysis, an examination of the issues associated with this relationship is beyond the scope of this study. For further discussion, see, for example, Marglin 1963a and 1963b.

project in question. On the benefit side, the present value may be thought of as an amount of money, which if invested at the present time at the project discount rate would provide a return precisely equal in size and timing to all future monetary benefits of the project.[3]

Returning now to the decision of whether or not to construct a new hydroelectric project, it is necessary to ask whether the benefits of the project will exceed its costs. Because the project's benefits and costs are spread out over a period of years, the question is best posed as whether or not the present value of all future project benefits exceeds the present value of all future project costs.[4]

By using these discounted present values, benefits[5] and costs[6] may be compared either as a benefit/cost ratio (benefits divided by costs) or as "net benefits" (benefits minus costs). In the first case, a simplest investment criterion might be that only if the benefit-cost ratio exceeds 1.0 should a project be considered.[7] In the second case, an investment criterion would

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[3]A mathematical version of this description of present value analysis is provided in Appendix 3.

[4]It is also possible to compare benefits and costs in terms of average annual values (annuities) spread over the life of a project. To do so, present values are levelized or annualized, using the so-called "annuity factor," which is mathematically specified in Appendix 3.

[5]Economics approaches the concept of "benefits" from a societal perspective, assigning values based on individuals' willingness to pay for particular products or services. A problem is that each person's willingness to pay is influenced by his or her income and/or wealth. In essence, economics implicitly assumes that individuals are themselves best suited to value the (effects) worth of a proposed water development project (Desvousges and Smith 1983).

[6]The economic perspective on "costs" tends to focus on "opportunity costs." Such opportunity costs measure the cost of any resource, whether labor, machinery or environmental amenities, in terms of its next best alternative use (Desvousges and Smith 1983). Thus, the value of foregone alternative uses of a resource provides the basis for estimating the cost of a specific use. Opportunity costs are concerned with tradeoffs --- how much of one good or service must be sacrificed in order to have more of another good or service.

[7]As is discussed later in this chapter, a finding of a benefit-cost ratio greater than 1.0 (or a finding of positive net benefits) should not be utilized as either a necessary or sufficient condition for project investment.

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uggest that only if net benefits are positive (greater than zero) should a
roject be considered[8] (Appendix 3).

Such conventional benefit-cost models have long been utilized by various
.gencies of the Federal government for the evaluation of proposed water
evelopment projects. In particular, benefit-cost assessments (which have
ypically ignored externalities, environmental or otherwise) have regularly
een carried out by the U.S. Corps of Engineers, the U.S. Bureau of
eclamation, the Tennessee Valley Authority and the Soil Conservation Service.
hese analyses have been conducted according to guidelines set down by the
ederal government, guidelines which formerly but no longer ignore the
nvironmental costs of hydroelectric and other water development projects.[9]

Limitations of Traditional Benefit-Cost Models

Economists have frequently pointed out the limitations of benefit-cost
nalysis as a decision-making rule. This section examines several of these
imitations.

xclusion of Externalities

Conventional benefit-cost (B/C) models have focused exclusively on the
nternal (private) benefits and costs of projects, i.e. those benefits which
he individual or entity considering the investment actually receives and
hose costs which that individual or entity incurs. External benefits and
osts (to other individuals or entities) are thus ignored. Such exclusion of

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[7] Although the benefit-cost ratio and positive net benefit (also known as net
resent value) criteria are numerically equivalent, they do not necessarily
esult in identical rankings of alternative projects.

[8] A sequence of Federal water policy and planning documents have enunciated the
ule that project benefits should exceed project costs: Congress first
equired a Federal agency (the U.S. Army Corps of Engineers) to demonstrate
ositive net benefits in the Flood Control Act of 1936, Sections 1 and 2 (33
.S.C. 701(a) and (b)). Other statements supporting this policy are found in:
he 1950 "Green Book" of the Federal Interagency River Basin Committee; U.S.
ffice of Management and Budget 1972, and 1976; and U.S. Water Resources
ouncil 1964, 1970a, 1970b, 1970c, 1973, 1979, 1980, 1983a and 1983b. The
1973-1980 Water Resources Council documents are the so-called "Principles and
tandards," and the 1983 documents are the new "Principles and Guidelines."

externalities destroys the usefulness of B/C analysis as a social decision-making tool. It is only by internalizing the expected (environmental and other) social impacts of a proposed project that a benefit-cost assessment can provide socially valid guidance to investment decisions.

Inability to Consider Intangible Benefits and Costs

Although many externalities can conceivably be internalized, many others cannot. "Merit goods" are particularly difficult to deal with: whereas such things as better health, improved education and increased recreational opportunities can be measured and (to varying degrees) evaluated in monetary terms, other social goods, such as increased civic participation, improved community relations and alleviation of poverty, are likely to elude attempts to translate them into monetary values (Mishan 1982).

Sensitivity to Discount Rate

For an economic model to be useful, it is important that its results be relatively insensitive with respect to any arbitrarily selected parameter values.[10] Yet, discount rates can have a substantial impact on the outcome of a B/C analysis.[11]

The Choice of a Discount Period and Questions of Intergenerational Equity

Because of the different distributions over time of benefits and costs of hydroelectric projects, the overall length of the discount period frequently can affect substantially the calculated B/C ratio.[12] In general, given the

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[10]It is for this reason that "sensitivity analyses" of the SBC model's discount rate and other parameters are included in Chapter V. The SBC model's results are relatively insensitive to changes in the assumed discount rate.

[11]Fox and Herfindahl (1964) examined the impact on the results of previous benefit-cost analyses of Federal water projects of varying the discount rate which was originally utilized, 2-5/8%. They found that fully 80% of the evaluations which had B/C ratios exceeding 1.0 using the original discount rate had B/C ratios less than 1.0 when an 8% discount rate was used. For further discussion of this issue, see: Just, Hueth and Schmitz 1982.

[12]The sensitivity analysis in Chapter V indicates that the SBC model's results are not significantly affected by the choice between a discount period of 50 and 100 years.

nature of the discounting process and because of questions of intergenerational equity, benefit-cost analysis is simply inappropriate (as normally practiced) for extremely long-term phenomena.[13]

Distributional Effects

The incidence on members of society of the benefits and the costs of an investment project (such as a large hydroelectric facility) frequently are different. Benefit-cost analysis, however, considers only aggregate effects: the benefit-cost ratio is an efficiency criterion, and is not suited for dealing with questions of equity.[14]

Inadequacy of B/C as a Decision Criterion

Only if unlimited funds are available (at some interest rate) is the "B/C > 1" criterion an appropriate decision rule. In the face of a capital constraint, however, many projects with B/C ratios greater than 1.0 cannot be undertaken; only those projects with the highest B/C ratios or the greatest net benefits (within the bounds set by the capital constraint) should be undertaken.

A related and important issue is associated with the typical method of evaluating the benefits of a proposed hydroelectric project. As is discussed in detail in Chapter IV, the frequently preferred evaluation method is to assume that the proposed project's benefits are equal to the (avoided) costs of otherwise providing the same incremental quantity of electrical capacity and energy. But all that the resulting B/C ratio can say is whether or not the hydroelectric project is economically superior to the alternative (say,

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[13]For an extensive discussion of the limitations of benefit-cost analysis for examining extremely long-term phenomena (such as nuclear waste storage) and of alternative models for such situations, see: Stavins and LeVeen 1982, pp. 32-36.

[14]In order to incorporate distributional and other non-temporal equity considerations into benefit-cost models, various weighting systems have been tried, but all are somewhat arbitrary and assume diminishing marginal utility of income. For further discussion of this issue, see: Mishan 1982, pp. 189-191. Failure to include equity considerations has frequently been cited as a primary failure of attempts to internalize environmental externalities into economic analyses. For a response to this criticism, see: Willey 1983.

steam) project (assuming that the benefits of both projects are identical).[15] The avoided-cost measure of project benefits leads to a B/C ratio which may be greater than 1.0 only because the unit cost of the alternative project is greater than the unit cost of the hydro project. In other words, the calculated B/C ratio may be greater than 1.0 simply because the hydroelectric project is better than the alternative steam project, even though both projects could result in a net loss.[16] That is, the marginal units of electricity provided may be worth less than the cost of either alternative.

The B/C Criterion Is Neither a Necessary Nor a Sufficient Condition

for Project Investment

The foregoing limitations of conventional benefit-cost analysis lead to the conclusion that the B/C criterion, whether expressed as a ratio or as a difference, ought not be regarded as either a necessary or sufficient condition for project investment, because:

(1) If externalities have been excluded, the calculated B/C ratio may exceed 1.0, while total (social) benefits are actually less than total (social) costs.

(2) Given a particularly long discount period and a positive discount rate, the B/C ratio may exceed 1.0 only because future consequences have been ignored.

(3) In general, B/C analysis only examines efficiency questions. A project may be socially efficient, but inequitable in terms of its distributional impacts.

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[15]Let the true ratio for the hydro project be B_h/C_h and the true ratio for the alternative technology (say, for steam, s) be B_s/C_s. Now, assume that the benefits of both projects are the same, that is, both produce identical outputs ($B_h = B_s$). If $C_s/C_h > 1$, then the true hydro project B/C ratio is greater than the true steam project B/C ratio. This is the justification behind the use of avoided costs as a measure of benefits. But, to say that the hydro project is economically superior to the steam project is not the same as saying that the hydro project is indeed economically justifiable. All that we know is that it is better than steam, but both projects may be economic "losers."

[16]See Chapter 5 for a discussion of the problems which arise when the "alternative project" is not appropriately identified.

(4) The avoided-cost measure of project benefits, leads to
     a B/C ratio which may be greater than 1.0 simply
     because <u>both</u> the hydro project and its alternative are
     economically undesirable, although the hydro project is
     less so.

A benefit-cost analysis should therefore be only the first step in
project assessment. If the project is found to have a B/C ratio less than
1.0, then serious questions exist regarding the economic feasibility of the
project. And if the ratio is greater than 1.0, other questions remain, such
as whether there are distributional effects, what they are and whether or not
they are desirable.[17]

A benefit-cost analysis can thus provide a useful initial investigation
and can be an effective tool for assimilating diverse information:

> In sum, a well-conducted cost-benefit study can be only
> a part, though an important part, of the data necessary
> for informed collective decisions (Mishan 1982, p.
> 199).

What is crucial to keep in mind is that the benefit-cost criterion should not
be used as an absolute decision rule.

Benefit-Cost Analysis of Projects with Environmental Impacts

Long before economists began to internalize environmental impacts into a
benefit-cost framework, a literature developed on the problem of
externalities. The relationship, however, between the natural environment and
the extractive use of natural resources was not explicitly considered during
the early stages of what has now come to be called, natural resource

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[17]Other types of economic models, may be appropriate for this next stage. One
alternative would be an input-output model of the regional economy affected by
the proposed project.

economics.[18]   By the 1970's, a large and rapidly growing literature had come
to focus on the environmental impacts of various forms of production and
consumption,[19] and economists had begun to acknowledge the significance of
failures to internalize environmental externalities when evaluating investment
decisions:[20]

> . . . when there are detrimental externalities of
> production . . . , private enterprise will perhaps
> overallocate resources (produce an excessive amount)
> because part of the cost of the operation is external
> to the firm --- it is borne by others (Baumol 1977, p.
> 520).

Thus, from an economic perspective, one possible route to a solution for
environmental problems would be to provide for the valuation and exchange of
environmental amenities in the marketplace, just as for other goods and

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[18]The problem of the optimal rate of depletion, as first rigorously formulated
by Hotelling (1931) and later extended by Gordon (1967), Cummings and Burt
(1969) and Solow (1974), assumed that a resource had value only when extracted
(or when regarded as a source of future extractions). Barnett and Morse
summarized in 1963 a vast body of empirical evidence which indicated that
direct costs of production based upon natural resources had been falling over
time. It was not until 1972, that Fisher, Krutilla and Cicchetti suggested in
a seminal article that whereas Barnett and Morse's findings regarding direct
costs might well be valid, it was likely that at least some of the negative
externalities associated with production from natural resources were actually
increasing.

[19]See Coase (1960) and Ruff (1970) for general treatments; and Mishan (1971)
for an extensive review of the post-war literature on externalities.

[20]For a theoretical treatment of negative externalities of production, see
Baumol 1977, pp. 517-520; for a more rigorous treatment, see Varian 1978, pp.
203-207; and, for a recent review of developments in economic theories of
externalities and their relation to analyses of resource use and environmental
impacts, see Dasgupta 1982.

services.[21]   But the marketplace is incapable of internalizing most
environmental impacts, because of the public good nature of environmental
amenities. It is, in fact, for this reason (among others) that benefit-cost
analyses are necessary for the evaluation of potential investment projects
which are likely to have significant environmental impacts:[22]

> We must, then, resign ourselves to the prospect of
> never being able to internalize these important
> environmental spillovers within the market economy;
> that is, of not being able to create a market for them
> --- which is, of course, one of the reasons why
> benefit-cost methods are required to evaluate them
> (Mishan 1982, p. 122).

This motivation for the internalization of environmental externalities within
benefit-cost models is repeatedly cited by the U.S. Water Resources Council
(1983a) in its new "Principles and Guidelines" for the assessment of
hydroelectric and other water development projects.[23]

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[21]Decisions regarding hydroelectric project investments frequently result in
irreversible impacts having uncertain consequences. This fact is crucial to
the estimation of the (intrinsic) values of environmental resources to non-
users, specifically the so-called option value and existence value. The
nature and empirical estimation of these intrinsic values is discussed in
Chapters IV and V. Also, for a review of the relevant literature, see Stavins
and LeVeen 1982, pp. 14-24.

[22]For a thorough development of the theory and the methods of internalizing
externalities, see Mishan 1982, pp. 111-153.

[23]In reference to adverse national economic development (NED) impacts, the new
"Principles and Guidelines" state: "If market prices reflect the full
economic value of a resource to society, they are to be used to determine NED
costs. If market prices do not reflect these values, then an estimate of the
other direct costs should be included in the NED costs" (U.S. Water Resources
Council 1983a, p. 10).

Legal and Policy Arguments

Supporting the Use of a Social

Benefit-Cost Analysis

The final section of this chapter will briefly summarize the applicable Federal and State laws which support the use of a social benefit-cost model such as that employed in this study. The discussion here is based on a more lengthy and detailed survey of the legal requirements that apply to the review of proposed hydroelectric projects presented in Appendix 20.

The two principal agencies with decision-making authority on the Clavey-Wards Ferry Project are the Federal Energy Regulatory Commission (FERC or Commission) and the California State Water Resources Control Board (Board). FERC must issue a license for the project under the Federal Power Act, 16 U.S.C. Section 791(a) et seq., before development may proceed. The Board has the authority to grant state water right permits required for the diversion and storage of water by the Project (Cal. Water Code Section 1252-1257).

Both agencies operate under legal mandates which allow them to approve a project only if its benefits to the public exceed its costs. The Federal Power Act requires that FERC determine a proposed project is in the "public interest" before it may issue a license, (16 U.S.C. Section 797(e); 16 U.S.C. Section 803(a)). FERC must also balance a project's economic and technical benefits against its environmental costs under the National Environmental Policy Act (NEPA), 42 U.S.C. Section 4321 et seq.

The Board, in considering whether to grant a water rights permit or to continue to allow the appropriation of water for hydroelectric purposes, must weigh the project's social benefits and costs, including the costs associated with the loss or degradation of the competing uses of a river. The consideration of social benefits and costs is required under four distinct doctrines: (i) the State constitutional requirements of reasonable use, Cal. Const. Art. X, Section 2, (adopted in 1928 as Art. XIV, Section 3; (ii) statutory requirements that the Board consider the impact of an appropriation on other uses, e.g., Cal. Water Code Section 1257; (iii) the California Environmental Quality Act (CEQA), the State counterpart of NEPA, Cal. Pub. Res. Code Sections 21000 et seq.; and (iv) the "public trust doctrine," which is integrated with the State's water rights system (National Audubon Society v. Superior Court, 33 Cal. 3d 419 (1983)).

Traditionally, FERC and the Board have assessed the environmental costs of a proposed project on a qualitative basis and then have weighed these costs against the more readily quantified and traditional economic benefits to the project developer. The result is a decision-making process which can often undervalue the loss of environmental amenities.

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FERC Review

FERC has repeatedly acknowledged its "public interest" obligation in reviewing license applications. For example, in one of its decisions, it states:

> Before any license can issue, the benefit to the public must be shown . . . The only purpose for which we may license the use of waterpower resources is to serve the public interest. No private individual, no private company, no municipality or State, no one other than the people of the United States has any right or claim to the use or benefit of these resources. A license under the Federal Power Act is a privilege conferred, not for the benefit of the licensee, but for the benefit of the public (Public Utility District No. 1 of Skamania County, Washington, Project No. 2199, 32 FPC 444, 446 (July 30, 1964)).

However, in only one reported case--decided over thirty years ago--has the Commission denied a license based on its assessment that the proposed project's environmental costs outweighed the economic benefits to the project developer (Namekagon Hydro Company, 12 FPC 203 (1953)).

FERC practice is to review the environmental impacts of a proposed project only after performing a formal benefit-cost analysis of the project's strictly internal benefits and costs to determine whether a project is "economically feasible." This practice internalizes the environmental costs of a project only to the limited extent that the costs of mitigation are borne by the project developer. The most common type of fixed mitigation is the establishment of minimum flows for fisheries maintenance which rarely fully protect that resource. Generally, fixed mitigation for the loss of recreation or other environmental amenitities is not included.

The remaining environmental costs (those not included as mitigation costs) are assessed on a qualitative basis by FERC based on environmental information submitted by the license applicant (18 CFR Chapter I, Part 2, App. A). The fact that FERC (and the FPC) has only once rejected an application on environmental grounds strongly suggests that its qualitative evaluation undervalues environmental costs. This conclusion is strengthened by FERC and FPC decisions which indicate that the Commission perceives its primary role as approving hydroelectric power projects and that it is "constrained" to license projects despite the environmental losses they occasion (Public Utility District No. 1 of Snohomish Co., 41 FPC 108, 116 (January 30, 1969); Monogehela Power Company, et al., 58 FPC 451 (April 21, 1977)).

One way for FERC to reduce the apparent pro-development bias in its evaluation of a project's environmental costs would be for the Commission to assess the public merit of a project using a social benefit-cost methodology, which would include quantification and internalization of all externalities

(including environmental amenities) to the extent possible. Such an approach would make the assessment of environmental costs less subjective and would require FERC to articulate clearly the assumptions underlying the evaluation of these costs. While some environmental costs likely cannot be quantified, and must still be considered on a qualitative basis, internalization of those environmental costs which can be quantified would help ensure that those costs are weighed on an equal basis with a project's more readily quantified traditional economic benefits.

Moreover, the use of methodologies for quantifying and valuing environmental costs may be required in appropriate cases to help ensure that FERC objectively considers environmental costs, as mandated by NEPA and the Federal Power Act. In a recent decision, a Federal Court of Appeals recognized that while NEPA does not in every case mandate a formal benefit-cost analysis, its use may be required if necessary to provide the decision-making agency and the public with the information needed to determine whether the project should proceed (Columbia Basin Land Protection Association v. Schlesinger, 643 F.2d 585 (9th Cir. 1981)).

The use of a social-benefit cost model also is consistent with the Federal "Principles and Guidelines" applicable to agencies which construct water projects with Federal funds (including the U.S. Bureau of Reclamation and the U.S. Army Corps of Engineers). These "Principles and Guidelines", while not binding on FERC, establish a clear Federal policy in favor of the use of a formal social-benefit cost analysis by requiring the quantification, monetization and internalization of all project impacts which can be measured, including the loss or degradation of environmental values.

State Water Resources Control Board Authority

In acting on a State water right permit application, the Board—under the State constitutional requirement of reasonable use and under specific statutory provisions—must weigh the benefits of a proposed appropriation for hydroelectric development against the loss or degradation of other beneficial uses of a waterway, including fish and wildlife and recreational uses, which would result from the project (Water Code Section 1257). Moreover, the Board has continuing authority over water appropriations under the reasonable use requirement and the "public trust" doctrine (discussed below). The Board must also balance the benefits of a project against its environmental costs under CEQA.

The Board generally does not perform a formal numerical benefit-cost analysis in evaluating the benefits and costs of a proposed hydroelectric development project. Like FERC, it assesses the environmental costs of the proposed development on a qualitative basis.

The Board may reject a permit application if it determines, after weighing the value of the competing beneficial uses, that the appropriation "would not best conserve the public interest" (Cal. Water Code Section 1255).

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However, its usual practice is to approve the appropriation with conditions and mitigation requirements, including minimum flow requirements, based on a recommendation by the California Department of Fish and Game (Cal. Water Code Section 1243). Like the case of mitigation in FERC licenses, these minimum flows and other conditions rarely fully protect the recreational, fish and wildlife, and other environmental values of a waterway, or pass the full cost of the loss or degradation of these values to the project developer.

The Board must also give great weight in its permit decisions to environmental, recreational, fish and wildlife, and other "public trust" values, and has a continuing obligation to protect these values. The "public trust" doctrine is integrated with the State's water right system and recognizes that the State holds its water resources in trust for the public at large and not for private benefit (National Audubon Society v. Superior Court, 33 Cal. 3d 419 (1983)).

Thus, in administering the State's water rights permit system, and carrying out its public trust duties, the Board must look beyond the internal benefits and costs to the project developers and must consider the broader social benefits and costs of a proposed appropriation. While the Board is not required to assess a project on a numerical benefit-cost basis, a social benefit-cost methodology, such as that proposed in this study, would help ensure the recreational and fish and wildlife costs of a project are fully addressed. For the same reasons as those discussed in the previous section on FERC practice, such an approach would greatly assist the Board in objectively determining the value of the competing uses of a river to the people of the state.

Conclusion

While there is no express requirement that either FERC or the Board use a social-benefit cost model, such as that proposed in this study, to evaluate the public merit of a proposed hydroelectric project, the use of such a methodology would further the purposes of these agencies mandates, and in some circumstances could be required. Historically, environmentalists and others have been suspicious of the use of benefit-cost analyses in the decision-making process on water projects largely because of their improper use to justify unmeritorious projects (e.g., Sierra Club v. Froehlke, 359 F. Supp. 1289 (S.D. Tex. 1973)).

However, the evidence suggests that the alternative process of qualitatively evaluating a project's environmental costs often undervalues those costs, especially if the decision-making agency has a pro-development bias. In the case of hydroelectric development, the use of a formal social benefit-cost analysis, if properly done, would ensure more objectivity in the decision-making process by requiring FERC and the Board to articulate the assumptions underlying their analysis and would better ensure that environmental costs and benefits are evaluated on an equal basis with more traditional economic costs and benefits.

IV

A SOCIAL BENEFIT-COST MODEL

OF HYDROELECTRIC DEVELOPMENT

Hydroelectric development projects frequently have significant, and often irreversible, impacts on the natural environment. Benefit-cost (B/C) models which fail to provide for the explicit inclusion of such environmental externalities cannot offer socially valid guidance to decision-makers. To provide such guidance, economic assessments of proposed hydroelectric projects should, where possible, incorporate environmental externalities.

This chapter develops the specification of one such social benefit-cost (SBC) model of hydroelectric investment. In order to make the presentation accessible to the widest possible audience, the text has been kept brief, and technical information has been relegated where possible to footnotes and appendices. This is particularly the case with mathematical specifications of the model's various segments. While the presentation is thus highly simplified from the perspective of the professional economist, parts of this chapter may nevertheless contain difficult passages for non-economists to understand on a single reading. Although an effort has been made to avoid unnecessary use of technical jargon, some unavoidably remains in the text.

The financial (internal benefit and cost) aspects of the SBC model parallel the private (internal) benefit-cost model developed by the Clavey-Wards Ferry Project's consultants (R. W. Beck and Associates 1976, 1979 and 1980; Sverdrup & Parcel and Associates, Inc. 1981). Those aspects of the SBC model which provide for the internalization of environmental externalities utilize economic methodologies which are fully consistent with the recommended procedures of the U.S. Water Resources Council's new "Principles and

Guidelines."[1]

In the immediately following section, issues associated with the major parameters of the SBC model are examined: alternative measures of the discount rate; alternative mechanisms to account for risk; and appropriate specification of the discount period.

The cost side of the SBC model is described in detail, beginning with the private cost segments. Next, external costs are considered. The model includes two separate and distinct methods for evaluating and internalizing environmental externalities.

First, a willingness-to-pay measure is used for recreation costs (benefits lost or foregone), both for users and non-users. Three alternative estimation methods are considered: contingent valuation, unit day values and the travel cost method (TCM). The last of these is fully developed to estimate the value (consumers' surplus) of the Project site for whitewater boating. The discussion in the text of the travel cost method is kept relatively brief, and a detailed description of the TCM model is provided as an appendix (including the econometric estimation of its parameters and the use of integral calculus for the determination of user values). Also internalized through the model are supply-side whitewater recreation impacts (producers' surplus) and intrinsic whitewater recreation benefits (option value).

The second method used for evaluating and internalizing environmental externalities is that of mitigation, and this approach is applied to impacts of a hydroelectric project on recreational fishing. The approach is one of modelling project operation so that it is consistent with fishery preservation, and adjusting project benefits accordingly.

After the SBC model's cost side is described, its benefit side is considered. Included are the private (internal) benefits (namely the provision of electrical generation capacity and energy and incremental firm water yield) and the external benefits (such as reservoir/flatwater fishing and boating).

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[1] The former Chairman of the U.S. Water Resources Council, then Secretary of the Interior, James G. Watt, stated in his "Foreword" to the "Principles and Guidelines" that "it contains the best currently available methods for calculating the benefits and costs of water resources development alternatives accurately and consistently, . . . I am confident that these Principles and Guidelines will enhance our ability to identify and recommend to the Congress economically and environmentally sound water project alternatives" (U.S. Water Resources Council 1983a, p. iii).

Finally, the SBC model provides for the combination of total benefits and total costs in the form of a social benefit/cost ratio. As an alternative measure of the merits of a potential hydro project, the SBC model also calculates the net annual economic value of the proposed development.

An Overview of the Social Benefit-Cost (SBC) Model

This evaluative model of potential hydroelectric development is based upon standard methods of present value analysis (Appendix 3), but is more comprehensive than conventional benefit-cost procedures. In particular, the SBC model permits the analyst to consider a broader range of benefits and costs of project development than are typically evaluated.

Figure 3 provides a pictorial representation of the broad spectrum of values which are associated with water resources. This spectrum of water resource values was developed in a recent study published by the U.S. Environmental Protection Agency (Desvousges, Smith and McGivney 1983). Both current user values and intrinsic values are considered. Current user values include both direct and indirect use. Note that conventional B/C models consider direct user values only; i.e., at best, the first five (of a total of thirteen) final categories in the right-hand column of Figure 3.

Direct uses are divided here into in-stream uses and those which require withdrawal of water from its natural course. Among the first group are recreational values (fishing, boating, swimming, rafting) and commercial values (fishing, navigation). Withdrawal uses include municipal (e.g., drinking water, landscape maintenance, waste disposal), agricultural (irrigation) and industrial/commercial (e.g., steam generation, waste disposal, cooling, process treatment). Indirect (near-stream, as opposed to in-stream or withdrawal) uses provide recreational values (hiking, picnicking, birdwatching, photography), relaxation values (viewing) and aesthetic values (enhancement of adjoining site amenities).

Intrinsic values are divided between those associated with potential use and those which are not associated with potential use. The former category includes the "option value" to individuals who are either near-term or long-term potential users of the water resource. Individuals who do not expect to use the resource, however, may also find value in its existence; hence, the phrase "existence value." Included here are stewardship (maintaining a good environment for everyone to enjoy, including future family use - bequest value), vicarious consumption (enjoyment from the knowledge that others are using the resource) and pure existence value.

Whereas this study's Social Benefit-Cost Model is more comprehensive than most previous hydroelectric B/C models, it is by no means exhaustive of all water resource values. Indeed, only four of the many categories found in

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FIGURE 3: A SPECTRUM OF WATER RESOURCE VALUES


```
                                              ┌ Recreational1
                              ┌ In Stream ────┤
                              │               └ Commercial1
              ┌ Direct Use ───┤               ┌ Municipal2
Current       │               │               │
User   ───────┤               └ Withdrawal ───┼ Agricultural
Values        │                               │
              │                               └ Industrial/3
              │                                 Commercial
              │                               ┌ Recreational
              │                               │
              └ Indirect Use ──── Near Stream ┼ Relaxation
                                              │
                                              └ Aesthetic


                                              ┌ Near-term
                                              │ potential use
              ┌ Potential Use ── Option Value4┤
Intrinsic     │                               │ Long-term
Values ───────┤                               └ potential use
              │                               ┌ Stewardship
              │                               │
              └ No Use ───────── Existence Value┼ Vicarious
                                              │ consumption
                                              │
                                              └ Pure existence
                                                value
```
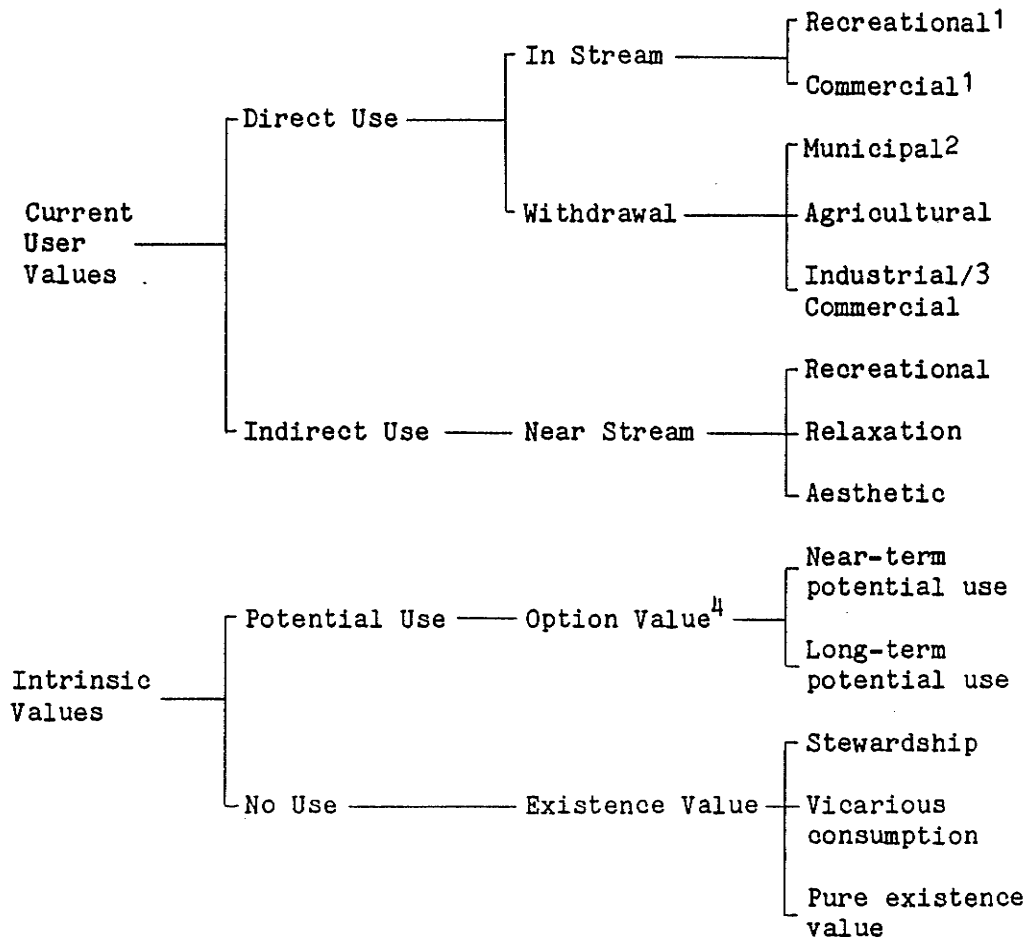
[1]Evaluated in this study: whitewater boating benefits foregone; degradation of trout fishery; flatwater boating benefits; and flatwater fishing benefits.

[2]Evaluated in this study: municipal water supply benefits.

[3]Evaluated in this study: hydroelectric power benefits.

[4]Evaluated in this study: option value associated with whitewater recreation benefits foregone.

SOURCE: Desvousges, William H. and V. Kerry Smith. Benefit-Cost Assessment Handbook for Water Programs, Volume I. Prepared for the U.S. Environmental Protection Agency. Research Triangle Park, North Carolina: Research Triangle Institute, April 1983, p. 3-2.

Figure 3 are internalized within the benefit-cost calculations:

(1) some in-stream recreational uses (whitewater boating, trout fishing, flatwater boating, flatwater fishing);

(2) withdrawal for municipal uses (incremental water supply);

(3) withdrawal for industrial/commercial uses (hydroelectric generation); and

(4) some potential uses (option value associated with whitewater recreation).

Furthermore, the broad range of probable environmental impacts documented in Chapter II are, for the most part, not internalized in the SBC Model.

Critical Parameters of the SBC Model

Three issues are briefly examined in the immediately following sections: (1) the choice of a discount rate; (2) alternative approaches to accounting for risk in the model; and (3) the choice of a discount period.

Alternative Discount Rates

The discount rate is an interest rate used to translate monetary measures of benefits and costs occurring in different years into a common unit, such as a present value. Note that this is independent from questions of general price inflation and differential price escalation.[2] Rather, the discount rate is positive because individuals (and organizations) tend to prefer some level of immediate consumption (profit) and the associated immediate satisfaction to

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[2]Discount rates can include general price inflation, in which case the discount rate is known as a "nominal rate." This is the procedure utilized in Chapter V when the SBC model is applied to an analysis of the Clavey-Wards Ferry Project. Alternatively, discount rates may be specified to be independent of inflation, in which case the rate is known as a "real rate". If treated consistently throughout an analysis, B/C results are insensitive to the use of a real or a nominal rate.

future consumption (profit) and corresponding future satisfaction.3

There is a long and continuing debate within the economics profession regarding the appropriate discount rate for public investment projects.4 Four alternative rates are usually considered: (1) the social rate of time preference; (2) the consumption rate of interest; (3) the marginal rate of return on investment in the private sector; and (4) the opportunity cost of capital (Appendix 4).

Although much of the debate over appropriate discount rates has been on an academic plane, one recent study looked at the ways in which public and private electrical utilities actually identify discount rates for their own investment analyses (Corey 1982). This survey, which covered nearly half of the electrical generation capacity in the United States, indicated that utilities tend to use a discount rate which is significantly higher than the marginal cost of capital they experience.

The official position of the Federal Energy Regulatory Commission, expressed in its guidelines for hydroelectric power evaluation, is that for non-Federal projects (such as Clavey-Wards Ferry), the overall cost of money to the project developers should be used as the discount rate (U.S. Department of Energy 1979). This overall cost of money includes whatever sources are actually used. In the case of a private utility, this includes long-term debt (bonds), preferred stock and common equity; in the case of a public utility (as in this study), only the cost of long-term debt is relevant.

Alternative Methods of Accounting for Risk

There are substantial amounts of risk and uncertainty associated with an investment in a new, large-scale hydroelectric project. This is because of physical factors, such as climatic variations, and because of economic and

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3This preference for satisfaction now rather than later --- a positive rate of time preference --- is demonstrated, for example, when someone purchases an automobile on a finance plan, and hence pays more than the actual one-time cost of the car.

4For a thorough discussion of the major alternative discount rates for hydroelectric project evaluation, see Eckstein 1968, pp. 94-104. For a detailed discussion of the social cost of federal financing of multiple purpose river development projects, see Krutilla and Eckstein 1969, pp. 78-135. A recent and comprehensive examination of the issues surrounding the discount rate and questions of risk and uncertainty is found in Lind 1982a, 1982b and 1982c.

social factors, such as the future supply of petroleum and the future demands for electricity and recreation opportunities.

From an economic perspective the risk of a new investment project is related to the degree to which variation in the outcome of the project will be related to variation in the payoff from the nation's total assets.[5] What is most important is not the variability in the returns of the project, but rather the correlation between the variability in returns to that project and the variability of national income in general (Desvousges and Smith 1983).

Five principal methods have been suggested for accounting for risk in project evaluations (Baumol 1973):

(1) limiting the planning period of the analysis, an unacceptable approach because of the bias which is introduced into the analysis;

(2) using a stochastic (probability) approach to the estimation of all benefits and costs;[6]

(3) employing sensitivity analysis after completion of the B/C calculations;

(4) using decision theory (von Neumann and Morgenstern 1947); and

(5) incorporating a "risk premium" into the project discount rate.

Although considered inappropriate on theoretical grounds, the last alternative approach, making a risk premium adjustment to the discount rate, has received the most frequent use in actual applications. Also, as is examined later in this chapter, although the use of such risk premiums has been criticized in the economic literature (Arrow and Lind 1970; Lind 1982b), when irreversible development of a valuable natural area is at stake, their use is essentially valid (Arrow and Fisher 1974; Fisher and Krutilla 1974; Lovett 1983).

As will be seen in the next chapter, this study accounts for risk in the project evaluation by employing a sensitivity analysis after completion of the B/C calculations.

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[5]For a full discussion of the Capital Asset Pricing Model (CAPM), "Beta Coefficients" of risk and related matters, see Lind 1982b, pp. 61-68.

[6]See Stavins and LeVeen 1982, pp. 24-26.

Conceptual Issues Associated with Identifying an Appropriate Discount Period

When a financial analysis of a potential investment project is being conducted, it is appropriate to use as the discount period for the analysis the period of time over which the project in question will be financed, for example the term of bonds which are marketed to cover construction costs (30 or 40 years for most hydro projects).

In the case of an economic analysis (particularly within a social B/C framework), however, it is appropriate to utilize a discount period (planning period) which is equal to the useful life of the facilities in question. In the case of a large-scale hydroelectric project, this might mean a planning period of 100 years or more, but problems also exist if too long a discount period is used. The problem and its solution (a 50-year period) is described by FERC:

> Financial analysis is generally limited to periods of time equal to an estimated overall project service life or to a period of 50 years, recognizing the practical impact of the 50 year licensing period for non-Federal projects and the realities of funding non-Federal projects beyond the licensing period or over periods longer than the estimated service life of the project (U.S. Department of Energy 1979, p. 4-3).

A reasonable approach for analyzing large-scale, non-Federal projects is thus to utilize a 50-year planning period, and to conduct a sensitivity analysis of the model's results for planning periods of up to 100 years.

Social Costs of Hydroelectric Development

The private or internal costs of a hydroelectric project, including construction, operation and maintenance costs, are calculated in the SBC model in a manner parallel to standard industry practice. Beck and Associates' (1976, 1979 and 1980) assessments of the Clavey-Wards Ferry Project were used as the prototype for this phase of the model. The general nature of the present value B/C model is set forth in Appendix 3, and the step-by-step calculations of all line-items in the internal cost segment of the analysis are described in Chapter V.

The SBC model also provides for the internalization of environmental externalities through two methods of evaluating the costs of recreational benefits lost or foregone. In the first of these, developed in the context of impacts on whitewater boating, benefits foregone by users and non-users are included as part of total project costs. In the second method, the impact on an environmental amenity, in this case recreational fishing, is internalized

by reducing project benefits to the extent necessary to offset the resulting environmental losses.

Evaluating Recreational User Benefits Foregone

The most simplistic approach to evaluating recreational impacts of a proposed hydroelectric project would be to count up the gross volume and monetary value of economic activity currently generated by recreational activities. But not all of the reported expenditures are actually a net benefit to the economy; most are simply redistributions, geographically or temporally. Such a gross expenditure measure would say nothing about the overall economic welfare implications of a project from a regional or national perspective.

Value-added estimates would meet some of these objections, but it is still the case that "these amounts are spent, not for the provision of the recreation opportunity as such, but for the provision of other services connected with the use of the recreation opportunity" (Clawson 1959, p. 9). What is required is a measure of the value of (lost) recreational opportunities, per se (i.e. the value of the recreation site), and in typical economic fashion, one approach is to examine individuals' willingness to pay for those opportunities.

Willingness-to-Pay and Consumers' Surplus

The U.S. Water Resources Council (1983a) endorses a willingness-to-pay (WTP) approach, stating that this is the preferred method to be used to evaluate the benefits (and "negative benefits" or costs) arising from recreation opportunities created by or eliminated by a project.[7] The same

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[7] The Water Resources Council states that "benefits may be positive or negative. Since reliable empirical methods for estimating willingness to accept compensation for losses have not been developed, measures of willingness to pay are used to value both gains and losses" (1983a, p. 67). Note, however, that willingness-to-pay provides only a lower bound estimate of willingness-to-accept-compensation (Desvousges, Smith and McGivney 1983). "Equivalent (variation) surplus" which is measured through this approach is necessarily less than "compensating (variation) surplus," which is the desirable measure of the value of an amenity, such as recreation on a river, which will be lost as a result of some contemplated action, such as the construction of a hydroelectric facility (Desvousges, Smith and McGivney 1983, p. 2-4).

document goes on to point out that "WTP includes entry and use fees actually paid for site use plus any unpaid value (surplus) enjoyed by consumers" (p. 67).[8]

What the Water Resources Council is referring to as a measure of willingness-to-pay and hence as a measure of recreational value is the so-called "consumers' surplus,"[9] which essentially is the net public benefit which results from use of the recreational facility, over and above any fees which may be paid for its use and any miscellaneous expenditures which are associated indirectly with its use.

The consumer's surplus is the difference between what the consumer would be willing to pay and what he actually pays, and as such is "a measure of the net benefit he derives from buying" the product or service in question (Henderson and Quandt 1971, p. 26).[10] In general, consumers' surplus results from the fact that a consumer typically pays the same price for all units of consumption of a good or service, but normally would be willing to pay more for his or her initial unit than the actual price charged.

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[8]The total willingness-to-pay (WTP) is represented by the area under the demand curve for recreation between the old and new supply, but the problem is that since most recreation is publicly provided, demand cannot be directly estimated from observed price-consumption data. Hence it becomes necessary to establish procedures for estimating WTP, which is what the travel cost model, within the SBC model, does. An alternative approach to estimating WTP is demonstrated for the Bryce Canyon National Park by Cuddington, Johnson and Knetsch (1980).

[9]The invention of the concept of consumers' surplus is credited to Dupuit (1844). The concept was developed further by Marshall (1920, p. 842). A thorough contemporary decription is provided by Mishan 1982, pp. 22-53; a comprehensive, descriptive treatment is found in Baumol 1977, pp. 497-500; and rigorous treatments are found in Henderson and Quandt 1971, p. 26, and Varian 1978, pp. 207-213. A simplified example, in terms of water conservation, is presented by Mansfield 1975, pp. 67-72.

[10]Consumers' surplus refers to the public benefit produced when a good or service is available at a price lower than the maximum price consumers would have been willing to pay (Lovett 1983). Note that certain forms of price discrimination (charging different prices to different consumers) enable the seller to capture some or all of the consumers' surplus.

Consumers' surplus is thus due to the downward sloping nature of a demand curve (Figure 4) plus the existence of an equilibrium price, where the demand curve relates the quantity of a good or service consumed to the price level.[11] Hence, the first step in measuring consumers' surplus of a recreation facility is the estimation of the demand curve for the particular recreation experience in question.

Alternative Methods of Estimating the (Consumers' Surplus) Value of Recreation

Three major methods[12] have frequently been used to estimate the user-value of recreational opportunities:

(1) unit day values;

(2) the contingent valuation (survey) method; and

(3) the travel cost method.

The first of these, unit day values, is the simplest method and usually relies on expert or informed opinion and judgment to approximate the average willingness-to-pay of users for recreational resources. The Water Resources Council suggests that it be used only if the other two methods are unavailable for use, or if specific criteria are met.[13]

With contingent valuation (survey) methods, recreational benefits are estimated directly by asking persons their willingness-to-pay for changes in recreational opportunities at a given site. In essence, this method consists of designing and using simulated markets to identify the value of recreation in much the same way as an actual market would, if it existed. A major limitation of this approach, however, is that it requires that primary data be

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[11]Theoretically, the consumers' surplus should be measured as the area under a Hicksian (compensated) demand function, but Willig (1976) argues that the error created by using a Marshallian (Walrasian) demand curve to measure consumers' surplus, as in the SBC and TCM models, will be small in most applications. This position was anticipated by Foster and Neuburger (1975). Randall and Stoll 1980 extend Willig's analysis to welfare changes in commodity (instead of price) space.

[12]Lovett (1983) discusses a total of seven alternative methods. For further discussion and a critique of these methods, see O'Connell 1977.

[13]For a detailed discussion of the unit day value method, see U.S. Water Resources Council 1983a, pp. 83-87. These criteria are also examined in Chapter 5 of the present study.

FIGURE 4: GEOMETRY OF CONSUMERS' SURPLUS
AND PRODUCERS' SURPLUS
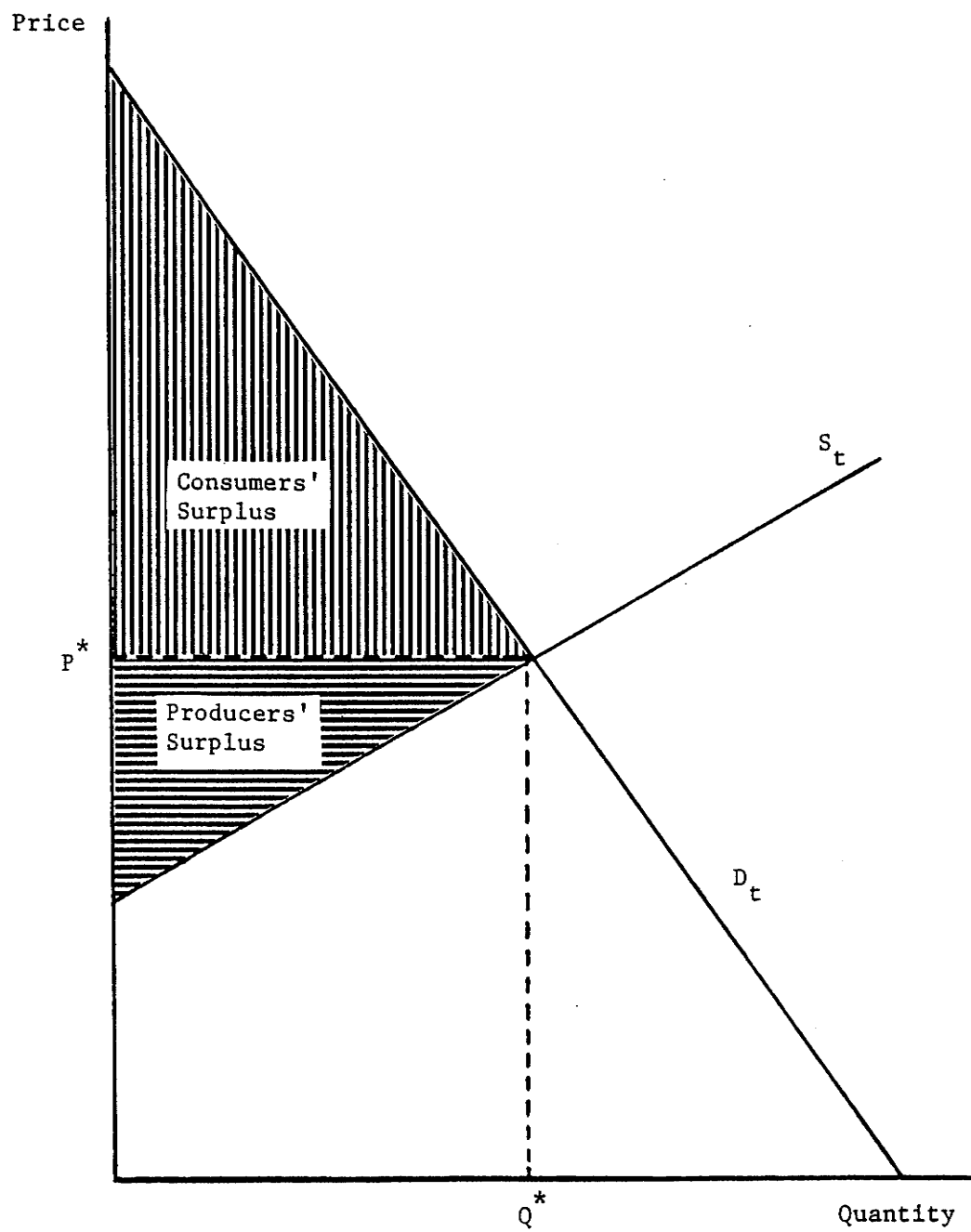
collected through a survey or sample of the individual users of a recreation site.[14]

The last of the three methods, and that recommended by the U.S. Water Resources Council, is the travel cost method. This approach consists of deriving a demand curve for a recreation site by using the variable costs of travel and the value of time as proxies for price. The basic premise which underlies this method of recreational benefit (value) estimation is that per capita use of a recreation site will decrease as out-of-pocket and time costs of traveling to the site increase, other variables being constant.[15]

The Travel Cost Method and Its Basic Assumptions

The travel cost method is usually credited to a suggestion made by Harold Hotelling (1947) in a letter to the Director of the National Park Service, in which it was suggested that demand curves could be derived by observing the rate of participation of population groups in outdoor recreation activities at recreation sites as a function of the costs required to transport them from their places of residence to the sites. Hotelling suggested further that the demand curves could then be used to estimate the economic value of the sites in question (Hotelling 1949; U.S. Department of the Interior 1949).

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[14]For a detailed description of the contingent valuation method, see U.S. Water Resources Council 1983a, pp. 79-83; for a discussion of the limitations of the approach, see Desvousges, Smith and McGivney 1983. Conceptual issues are examined in Bishop, Heberlein and Kealy 1983; and empirical aspects are discussed in Randall, Hoehn and Brookshire 1983.

[15]The lack of variation of entry fees at public, outdoor recreation sites rules out the possibility of utilizing such information for estimating a true site demand function, although an experiment with changing entry fees is discussed by Stroup, Copeland and Rucker (1976). Furthermore, Bowes and Loomis (1980) demonstrate that there is an exact theoretical relationship between valuation by the travel cost method and the desired measure of benefits based on individual site entry demand curves. Specifically, "except for the unusual case in which an individual would travel to a site but not enter, the consumer's surplus measured by the travel cost method is theoretically equivalent to that measured by entry prices" (quoted in Vaughan and Russell 1982).

The first empirical models to use the travel cost method (TCM) were developed by Clawson (1959), Trice and Wood (1958), and Clawson and Knetsch (1966). Since that time, the travel cost method has been widely used to analyze the demand for recreation and to estimate the value of recreation sites.[16] It is generally regarded as the most rigorous of available methods for estimating the value of recreational opportunities. Indeed, the new "Principles and Guidelines" identify the travel cost method as the preferred procedure for the evaluation of the recreational benefits (or costs) of a water development project and state that such procedures "reflect the current state of the art and if used with skill and judgment by the analyst should provide the best estimates that can be obtained" (U.S. Water Resources Council 1983b, p. 10257).

The major assumption of the travel cost method is that individuals would react to an increase in entry fees at a recreation site in the same manner as to an increase in the costs of traveling to and from that site. Hence the procedure is based upon the assumption that if individuals were charged more for site use, thereby raising their total trip costs, they would then participate at the same rate (i.e. visits per capita) as those persons located more distantly from the site who already faced that level of monetary trip costs. Use of the method implies acceptance of a number of additional assumptions,[17] the most important of which is that all factors which significantly affect individuals' decisions to use the recreation site are taken into account by the analyst.

A Regional Travel Cost Method (TCM) Model for the Evaluation of Recreation Demand[18]

The TCM model is described in detail in Appendix 5, and so this section provides only a very brief overview of the essential aspects of the model. Based upon empirical data on actual usage of the site by users coming from

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[16]For a comprehensive review of the (pre-1977) literature on empirical applications of the travel cost method, see Dwyer, Kelly and Bowes 1977. The method has previously been applied to white water recreation by Munley and Smith (1976) in their analysis of rafting on the Lehigh River in the Pocono Mountains of eastern Pennsylvania.

[17]Other assumptions of the method are treated in Appendix 5 to this study.

[18]The model developed in this study and described in Appendices 5 and 6 has been described as a "simple travel cost model." Three advanced variants and extensions of this model are: (i) own price/quality models; (ii) simultaneous demand systems; and (iii) hedonic travel cost models. For discussions of these more advanced approaches, see: Mendelsohn and Brown 1983.

various areas of origin, the TCM model provides for the estimation of a so-called participation function. Also included in the estimation of the participation function is information about transportation costs and opportunity costs of time.

The participation function is used to derive the (consumers' surplus) net economic value of the recreational opportunities of the site on a per capita basis for each area of origin. After conversion of the per capita figures to regional total values, the aggregate economic value is calculated.[19]

User Fees and Producers' Surplus

In addition to the demand-related recreational value, which is determined with the TCM model, it is also necessary to consider any actual fees which are paid for use of the recreation site (Clawson 1959; Vaughan and Russell 1982a) and the net supply-side recreational value. Clearly, the recreational use of a natural resource, such as a river (which is being considered for a hydroelectric project), produces certain economic benefits for the local and regional economy. Some of the money which is spent on recreational use of the resource flows through the community and has a concomitant impact on the creation of local job opportunities. But not every dollar spent locally should be treated as a net economic gain within a benefit-cost framework.

To be consistent, only the so-called "producers' surplus" (Figure 4) associated with recreational use should be considered as a net gain in the B/C calculations. This producers' surplus is the difference between the amounts people receive for their productive activities and the minimum amounts necessary to encourage them to produce.[20] Because producers' surplus is likely to be insignificant in comparison with consumers' surplus for most wilderness-type (i.e. relatively non-commercial) recreation actvities, a satisfactory approximation is the net profit of producers.[21]

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[19]In addition to the full description of the TCM model in Appendix 5, Chapter V of the study and Appendix 6 provide descriptions of the model's application to the analysis of the proposed Clavey-Wards Ferry Project on the Tuolumne River. Also, for a series of brief descriptions of highly simplified travel-cost-method models, see Dwyer, Kelly and Bowes 1977.

[20]For a broad treatment of the concept of producers' surplus in the context of benefit-cost analysis, see Mishan 1982, pp. 54-63. A descriptive development of the theory of producers' surplus is provided by Baumol (1977), pp. 497-500; and a more rigorous treatment is found in Varian 1978, pp. 213-214.

[21]See Varian 1978, p. 24.

Evaluating Intrinsic Recreational Benefits Foregone

In addition to the value of a resource to its users, many resources have intrinsic value to non-users as well. The classical welfare economics definition of a benefit follows the model of consumer behavior, whereby individuals acquire utility only through consuming goods or services. Such a definition is sometimes suitable for describing the user benefits of a resource, but it is now recognized that nonuser or intrinsic benefits may play a crucial role in the total value of certain environmental resources (Krutilla 1967).

Option Value and Existence Value

If uncertainty exists with regard to the demand for or supply of an environmental resource (such as whitewater for recreational boating) and if a contemplated investment decision will have irreversible consequences (as in the construction of a hydroelectric dam), then the uncertainty is itself something which consumers may be willing to pay to reduce or eliminate. This payment is described by economists as the option value of the environmental resource.[22] That is, the option value is the maximum amount (above any use value) that an individual would be willing to pay now for an option to ensure access to some public good, such as an environmental resource, at some designated future date (Fisher and Raucher 1983).[23]

One implication of option value in the context of a benefit-cost analysis is that in the presence of uncertainty and irreversibility, the conceptually valid decision rule is no longer simply that the B/C ratio be greater than unity, but rather that the ratio must be greater than 1.0 plus the option value divided by the total project cost (Arrow and Fisher 1974). A thorough examination of this finding is beyond the scope of this study and, in any event, this modified criterion is not utilized in the Tuolumne analysis of

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[22]Brief reviews of the literature on option value are provided by Bishop 1982 and Fisher and Raucher 1983.

[23]For a comprehensive and recent examination of intrinsic benefits, examining both the conceptual basis and tracing empirical investigations, see Fisher and Raucher 1983.

Chapter V. Nevertheless, Dasgupta's (1982) concise description of the implications of the theory is useful:

> When future costs and benefits are uncertain and when current investment decisions are irrevocable, such as that which often happens when environmental resources are exploited, current resource usage ought to be more 'conservative' than when decisions are not irrevocable. This is due to the fact that a more 'conservative' resource-exploitation policy enables the planner to maintain greater flexibility. In the field of resource exploitation there is very good reason for not doing today something that can be postponed until tomorrow: for tomorrow we shall know more (p. 200).

Some individuals can realize utility without direct consumption of a good or service or without any potential existing for future consumption. In this case the utility is realized through a notion of stewardship or through vicarious consumption (Figure 3), and the general concept of "existence value" covers both types of values. Existence value, then, can be defined as the willingness to pay for the knowledge that a particular good exists, regardless of a person's present or anticipated use (Fisher and Raucher 1983).[24] Mishan's (1982) description of existence value is helpful:

> . . . there is a non-participant (or disinterested) demand arising from the willingness to pay by all those people who are concerned simply that such goods be available to the nation or to humanity at large. They may not be concerned in the least with insuring themselves against future contingencies (option value), and they may well believe that they will never have occasion to enjoy the good in question (expected future consumers' surplus), but it gives them satisfaction to know it exists (p. 313).

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[24]For brief descriptions of option value and existence value, see Desvousges, Smith and McGivney 1983, and for a review of the literature, see Stavins and LeVeen 1982, pp. 14-24.

The common-sense basis of both concepts is straightforward. There are some individuals who value the Grand Canyon, for example, because of the current or expected future use of it (user value). Others are uncertain of whether they will ever visit the Grand Canyon, but if a development project were being considered which would result in irreversible damage to the Canyon, they would nevertheless value the retention of the option to someday visit the Canyon for themselves (option value). Lastly, there are others who may have no potential future use of the Grand Canyon; they are certain that they will never visit it. Yet many in this group would still place a high value on maintaining the Canyon in its present state (existence value), perhaps to take pleasure in the knowledge that others will enjoy it (vicarious consumption) or simply for the sake of maintaining a natural environment (stewardship).[25]

These concepts are more than theoretical abstracts; option value and existence value are real and are regularly experienced with regard to various goods and services, as the previously described example of the Grand Canyon indicates. Furthermore, empirical investigations have quantified option value and have begun to make estimates of existence value as well (Bishop 1982; Fisher and Raucher 1983; Desvousges, Smith and McGivney 1983).

Empirical Estimates of Intrinsic Values

Because intrinsic values of "environmental goods and services" are not traded in a conventional market setting, measuring such values is more difficult than for ordinary market goods. Various direct methods, however, do exist for estimating intrinsic values, notably the contingent valuation

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[25]Midway between option value and existence value is bequest value, where the interests of future generations may also play a role. Bequest values, a part of models of consumption/saving behavior (Ando and Modigliani 1963), are "arguably of particular importance when irreversible commitments of natural resources are proposed" (Lovett 1983, p. 514).

approach.[26]   Such methods have been used to measure both option value (Rae 1981a; Rae 1981b; Randall, Hoehn and Tolley 1981; Mitchell and Carson 1981; Desvousges, Smith and McGivney 1983) and existence value (Miller and Menz 1979; Mitchell and Carson 1981; Randall, Hoehn and Tolley 1981).

If option values are not expressed through ordinary market settings, then how are the individual holders of option values to be identified? First, it has recently been pointed out that "substantial donations to conservation groups seeking to preserve species or wildlands geographically distant from donors' homes indicate the importance aesthetic existence values can have" (Lovett 1983, p. 513). Second, political preferences, expressed either through voting behavior or through other social actions, are frequently a direct expression of citizens' intrinsic value structures.

Inferring Intrinsic Values From Use Values

Due to the importance of including intrinsic values within benefit-cost analyses and the difficulty of measuring these values, there has been considerable interest in the use of proportional relationships by which intrinsic benefits (costs) may be calculated as a fixed positive fraction of certain recreation values.[27]

Fisher and Raucher (1983) reviewed previous research which had estimated user and nonuser values independently, and found that "intrinsic benefits are large in relation to recreation use benefits" (p. 2). Also, in tracing the previous empirical studies, they concluded that the "studies indicate a remarkable similarity in the magnitudes of per capita intrinsic benefits . . . even though different methodologies and data bases were employed" (p. 2).

The previous analyses examined by Fisher and Raucher are listed in Appendix 7 to this study. The nine listed empirical studies exhibit ratios of nonuse value to use value ranging from 0.47 to 1.39, with a weighted average of 0.60. Thus, on average, nonuser recreational value/household was found to be approximately 60% of _user_ recreational value/household. This study's

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[26] See previous section, "Alternative Methods of Estimating the Value of Recreation."

[27] Abel, Tihansky and Walsh (1975) were the first to use a proportional relationship for inferring intrinsic benefits from user values. Unger (1976) also inferred nonuse benefits from recreational benefits, and Freeman (1979b) also derived nonuse benefits (of air and water pollution control) from certain user benefits. A comprehsive review of these and other such studies is found in Fisher and Raucher 1983.

Social Benefit-Cost (SBC) model of hydroelectric development excludes consideration of existence value but internalizes option value through the assumption that option value (per interested[28] non-user) of recreation benefits foregone is equal to 60% of the consumer's surplus (per user).

Internalizing Environmental Costs Through Mitigation

Instead of estimating the value of environmental amenities lost, as is done in the SBC model for user and option values associated with (whitewater) recreation benefits foregone, another approach to internalizing environmental externalities is through modification of the hydroelectric project operation on the benefit side of the model. This is the approach which is utilized in Chapter V for internalizing recreational fishing impacts of the proposed Clavey-Wards Ferry Project.

With this approach, explained in detail in Chapter V, the project is presumed to be operated in a manner which would minimize, if not eliminate, serious damage to the recreational resource. The result, in the case of the Tuolumne, is increased releases for fisheries and hence decreased flows available, on a month-by-month basis, for electricity generation.[29]

Social Benefits of Hydroelectric Development

The private (internal) benefits of hydroelectric development considered in the SBC model are: (1) provision of electrical capacity and energy; and (2) provision of an incremental, firm water supply. External benefits which

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[28]How is the relevant population of "interested non-users" identified? As previously indicated, individuals express their intrinsic value structures through voting behavior and through support of public and private interest groups. The specific "proxy population" used in the Tuolumne analysis and other aspects of option value estimation are discussed in Appendix 19.

[29]An alternative route would be to view the fisheries impacts as costs of the hydroelectric project and to enter these costs in the denominator of the B/C ratio. This would necessitate placing a monetary value on the fishing-days of recreation. For a recent discussion of alternative methods for doing this, including the TCM approach, see Vaughan and Russell 1982, particularly pp. 129-154.

are internalized are (reservoir/flatwater) recreational fishing and boating.[30]

Four alternative benefit estimation methods are cited by the U.S. Water Resources Council (1983):

(1) willingness-to-pay based upon actual or simulated market prices;

(2) changes in net income;

(3) cost of the least costly, practical alternative; and

(4) administratively established values.

In the case of the electricity generation benefits of a hydro project, the first alternative, actual market prices, is often inappropriate because electrical utilities are natural monopolies and are frequently regulated. Hence, the prices they charge in the market may be different from those which would prevail under competitive conditions, and thus may be meaningless in terms of indications of relative resource scarcity and economic efficiency (Eckstein 1958).

The SBC model consequently uses the generally accepted method of valuing the electrical capacity and electrical energy from a hydroelectric facility, namely, the avoided cost of the least expensive alternative means of meeting an identical load (alternative 3, above). This approach is endorsed by the U.S. Federal Energy Regulatory Commission (FERC):

> The procedures employed by FERC staff in determining economic justification of non-federally financed hydroelectric projects . . . (are such that the) . . . . economic justification study usually requires that the total annual cost of operating the proposed project be compared with the total annual cost of obtaining equivalent capacity and energy, with equal reliability, from a practical alternative source (U.S. Department of Energy 1979, p. 3-3).

The Water Resources Council states that both structural and non-structural

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[30]See Eckstein 1958 for discussions of estimating flood control benefits (pp. 111-159), navigation benefits (pp. 160-191) and irrigation benefits (pp. 192-236).

alternatives should be considered.31

The SBC model provides for the inclusion of a mix of various sources of electrical capacity (kilowatts) and energy (kilowatt-hours) in order to establish a least-cost alternative plan, the avoided-cost of which is the measure of the electricity-related benefits of the hydroelectric project being evaluated. The options included are coal generation, combustion turbines using petroleum or natural gas, geothermal sources and conservation voltage regulation. Additional structural and non-structural alternatives can be added to the model, as appropriate.32

Based upon an "optimal" (least-cost) mix of practical alternative sources which will provide the same capacity and energy as the hydroelectric project, the SBC model calculates the total cost of capacity and energy combined and enters this as the electricity-related economic benefit of the hydroelectric project.

The SBC model also utilizes an avoided-cost measure to determine the value of incremental firm yield of water associated with the project (see Chapter V). For the internalization of projected flatwater recreation benefits, unit-day values are used to determine the economic value of reservoir-related fishing and boating. The Water Resources Council specifies conditions under which it is appropriate to use unit-day values rather than the usually preferred travel cost method or contingent valuation surveys. As is explained in the next chapter, these WRC criteria are utilized in this study to identify unit-day values as an appropriate benefit estimation method in the case of projected flatwater recreation at the proposed Wards Ferry Reservoir.

31Time did not permit a thorough examination of non-structural alternatives to the Clavey-Wards Ferry Project (see Chapter V). For an indication of how such an analysis might be structured, see Willey 1981.

32Note that the "true" least-cost alternative is cheaper than that identified in this study. Further analysis can identify less expensive technological and institutional alternatives. Hence, in this sense, the B/C ratios reported here tend to overstate the true picture of the Clavey-Wards Ferry Project.

The Social Benefit-Cost Ratio

and the Annual Net Economic Value of the Project

The final segment of the SBC model provides for the calculation of two decision criteria for project evaluation. The first, the benefit/cost ratio is simply the annual (levelized) social benefit of the project divided by the annual social cost of the project, where all calculations consider a specified planning period (50 or 100 years).

The model also calculates the annual net economic value of the project, which is the annual social benefits minus the annual social costs, all levelized over the entire specified planning period.[33] This result is greater than zero if the B/C ratio is greater than one; equal to zero if the B/C ratio is equal to one; and less than zero if the B/C ratio is less than one. The net annual economic value of the project is a measure of the project's expected annual contribution to the nation's economic welfare.[34]

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[33]The SBC model also provides for sensitivity analyses to be conducted on the major structural parameters of the model, including the discount rate, discount period, inflation rate and the (functional form) specification of the TCM participation function. As the assumed value of a particular parameter is varied, the B/C ratio and the net economic value (B - C) are recalculated. Further discussion is found in Chapter V of the study.

[34]In the text of Chapter V and in several appendices thereto, the execution of the SBC model is described in a step-by-step fashion (for the application to the Clavey-Wards Ferry Project on the Tuolumne River).

V

ASSESSING THE SOCIAL BENEFITS AND COSTS

OF FURTHER DEVELOPMENT ON THE TUOLUMNE RIVER:

AN APPLICATION OF THE SBC MODEL

    The essential incompatibility between the development of the remaining free-flowing reach of the Tuolumne River for electrical power and its preservation in a relatively undisturbed state requires a critical examination of the benefits and costs of these competing uses. Previous economic assessments of the Clavey-Wards Ferry (CWF) Project, however, have failed to take into account the environmental impacts which would be consequences of further hydroelectric development;[1] yet it is only by internalizing the expected environmental impacts of the CWF Project that an economic assessment can provide socially valid guidance to an investment decision.

    This chapter of the study documents an application of the SBC model to an analysis of the Clavey-Wards Ferry Project.[2] In the immediately following section, the principal parameter values of the model are established,

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[1]Clair A. Hill & Associates and R. W. Beck and Associates 1968; R. W. Beck and Associates 1976, 1979, 1980; Sverdrup & Parcel and Associates, Inc. 1981. An additional study by Norgaard (1982) sought to improve upon the Beck and Sverdrup & Parcel analyses by utilizing more recent and more realistic assumptions regarding fossil fuel costs (for benefit estimation), interest rates and delays during construction. For the most part, however, Norgaard did not attempt to internalize social and environmental costs, although he recognized that such costs may be substantial.

[2]See chapter I; for a more detailed description of the Clavey-Wards Ferry Project than is provided in this study, see R. W. Beck and Associates 1976, pp. V-1 through V-11.

including the discount rate and the discount period. The manner in which the private (internal) and external costs of the Project are calculated by the SBC model is carefully traced through a series of tables and appendices, and the same procedure is then followed for the internal and external benefits of the Project. The B/C ratio and the annual net economic value of the Project are determined, and their significance is explained. Finally, a sensitivity analysis is presented of the major parameters of the SBC model.

Identifying the Major Parameter Values of the SBC Model

The B/C assessments carried out by R. W. Beck and Sverdrup & Parcel were "first-year" analyses which simply examined the likely benefits and costs of the Clavey-Wards Ferry Project during its first year of operation. Such an approach does not adequately account for the uneven streams of benefits and costs which are spread out over 50 to 100 years in such a project. What is required instead is a full "planning-period" analysis, which examines the benefit and cost streams over the entire relevant time period. The SBC model, as was explained in detail in Chapter IV, provides for such an analysis. In general, because of the high capital costs of hydroelectric facilities relative to their operating costs, this approach results in more favorable B/C ratios than those calculated in first-year analyses. Hence, the SBC model is highly conservative from an environmental perspective in that it is likely to result in higher B/C ratios than would be calculated with a first-year approach.

Choice of Discount Period

R. W. Beck and Associates (1976) has estimated that the total time required for initial studies, preparation and processing of a license application, project design and preparation of contract bid documents for the Clavey-Wards Ferry Project would be approximately four years. As the preliminary permit for the Project was granted on April 6, 1983, this study assumes a bid date for the Project of January, 1987 (Table 1).

Whereas the four-year construction period assumed in the Beck analyses is theoretically possible, it is highly unlikely to occur (James Noda, personal communication, July 15, 1983). The U.S. Army Corps of Engineers (1981) estimates that at least six years should be allocated for hydroelectric projects including dams higher than 250 feet. Wards Ferry Dam would be 450 feet high. Furthermore, "every major dam constructed in California during the past decade and a half has been delayed, often for many years, for a variety of engineering, economic, environmental health and safety reasons" (Norgaard

TABLE 1: BASIC ASSUMPTIONS OF INTERNAL COST ANALYSIS OF CLAVEY-WARDS FERRY PROJECT

Bid Date	January 1987
Length of Construction Period	7 years
On-Line Date	January 1994
Bond Term	40 years
Bond (nominal) Interest Rate	10.72%
Reinvestment (nominal) Interest Rate	10.72%
Planning Period	50 years
Discount Rate (nominal)	10.72%
General Price Inflation (post-1983)	6.00%
Total Direct Cost (1994)	$495,790,000
Contingencies	15% of Total Direct Cost
Total Construction Cost (1994)	$570,158,000
Engineering and Administrative Costs	12.5% of Total Construction Cost
Total Project Cost (1994)	$641,428,000
Construction Expenditure Distribution over Seven-Year Period	12%-12%-13.5%-14.5%-15%-16%-17%
Interest During Construction (IDC) Factor	0.4239070
Interest During Construction	$271,906,000
Total Investment Cost (1994)	$913,340,000
Reserve Fund	One Year's Debt Service
Financing Expenses	1% of total financing
Working Capital	0.2% of total financing
Bond Issue	$1,039,133,000
Operation and Maintenance Costs (1977)	$5.19/KW
Interim Replacement Costs	1.4% of power plant costs
Administrative and General Costs	39% of Operation and Maintenance Costs
Insurance	0.1% of Total Construction Costs
Property Taxes	6.0% of Net Income

1982, p. 14).[3] Therefore, this analysis conservatively assumes a construction period of seven years duration, establishing an on-line date for the Project of January, 1994 (Table 1).[4]

In keeping with Federal Energy Regulatory Commission (FERC) policy, a forty-year bond repayment period and a fifty-year planning period are utilized in the analysis (Table 1).[5] Thus, the social benefit-cost analysis is carried out for the 50-year period beginning in 1994. In order to examine the suitability of the parameter choice, the impact on the calculated B/C ratio of lengthening the 50-year discount period to a 100-year period is examined in the sensitivity analysis later in this chapter.

Choice of Discount Rate

The official position of FERC for non-Federal projects is that the overall cost of money to the project developers should be used as the discount rate (U.S. Department of Energy 1979). In the case of public utilities, as in this study, the relevant cost is that of long-term debt (tax-exempt bonds). The question then becomes, what is the likely rate at which the project developers would be able to float tax-exempt revenue bonds in the year 1987.

Predicting how future bond rates four years from now will change from current rates is virtually impossible. The most appropriate indication of what rate future bonds may be sold at is the current rate at which similar issues are selling. As it happens, the Modesto Irrigation District, one of the CWF Project developers, was a participant in a June 16, 1983 issue of approximately $450 million of (San Juan) energy project tax-exempt revenue bonds (M-S-R Public Power Agency 1983). Based upon sales of those bonds as of

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[3] Because of strong opposition to the Clavey-Wards Ferry Project, there is likely to be extensive litigation which could substantially delay construction. For example, even if a FERC license were granted, environmental organizations and other interested parties could challenge the license under the Federal Power Act (16 U.S.C. Section 791(a) et. seq.) and the National Environmental Policy Act of 1969 (NEPA, 42 U.S.C.A. Sect. 4321 et seq). State considerations, including the public trust doctrine, might also be invoked.

[4] The "construction period" is defined as the time which elapses between the bid date and the on-line date; see Table 1 for specifics.

[5] The FERC recommendation of a 50-year discount period for large non-Federally financed projects is discussed in Chapter IV in a section titled, "Conceptual Issues Associated with Identifying an Appropriate Discount Period."

July 12, 1983, a discount rate of 10.72% is utilized in the analysis.[6] As with the discount period, a sensitivity analysis provides calculations of B/C ratios for the CWF Project using alternative discount rates.[7]

Dealing with Risk in the CWF Project Evaluation

Four major categories of risk[8] have been identified as being associated with a decision to undertake investment in the proposed Clavey-Wards Ferry Project (Norgaard 1982):

(1)   fossil fuel price risk: if the recent worldwide declines in fossil fuel prices are not a temporary aberration of the longer-term trend, then the benefits of the CWF Project will be significantly less than estimated in this study.

(2)   inflation/bond rate risk: the high interest rates which still exist in today's bond market are partly due to inflationary expectations; if inflation is successfully brought under control, the real rate of interest being paid on these bonds will be exceptionally high.

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[6] Based upon actual sales of the San Juan issue, as of July 12, 1983, a simple econometric estimation procedure provided the basis for an extrapolation to the likely rate at which M-S-R would be able to float 40-year bonds.

[7] The sensitivity analysis, reported later in this chapter, indicates that the B/C results are not appreciably affected by employing a reasonable range of alternative discount rates. Furthermore, it may be noted that the 10.72% rate is a nominal rate, and since the model provides for a 6% general price inflation rate, the implied real rate is about 4.5%, quite conservative compared with real rates of 6%, experienced in January of 1984. Indeed, it has been estimated that the real annual cost of capital may now be as high as 20% (Economist, April 30, 1983). For further discussion of this, see Hatsopoulos 1983.

[8] A generic discussion of methods of incorporating risk into B/C analyses is found in Chapter IV, section titled "Alternative Methods of Accounting for Risk."

(3) delay risk:[9] only moderate construction delays are incorporated into the SBC analysis; additional delays represent an added risk.

(4) energy demand growth risk:[10] as is examined later in this chapter, increasing energy prices could moderate future demand; the developers of the CWF Project could then find themselves with a new facility to pay for and a surplus of electrical generation capacity in a "buyers' market."

It might be argued that these risks are already internalized within the empirically derived discount rate used in this study. There are reasons to suspect, however, that this is not the case. Not only are many costs not internalized in project decision-making, but a variety of risk-factors are frequently excluded as well. For example, if the demand for electricity decreases or one of the project dams should fail, the developers are responsible only for their investment costs, even though the Canyon would be irreparably harmed. This risk is not internalized.

When financing is by bonds, the public loss can be even greater, because the developer is not risking his own funds. Furthermore, if tax-exempt bonds are utilized, as would be the case with this project, the developer is able to obtain capital at a lower rate of interest than that which is available for an equally risky, but non-tax-exempt project.

The bond purchasers' (implicit or explicit) analysis of a project's risks will indeed be reflected in the bonds' effective interest rate (yield). "Like the developer, however, they face a loss of no more than their investment, so the interest rate which they demand will not entail full internalization of a project's social risks" (Lovett 1983, p. 516). This last distortion is even

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[9] The M-S-R prospectus for the purchase of a share of the already-completed San Juan project buy-in states that one advantage of that arrangement over conventional alternatives is that it "avoids the common risks associated with the construction of a power plant, such as permits and licensing approvals, cost overruns, construction delays, and financial uncertainties . . ." (M-S-R Public Power Agency 1983). Empirical evidence of electrical utilities' encountering such risks is examined by Corey (1982).

[10] The major risk of the CWF Project is probably associated with the future demand for energy, which is highly correlated with GNP (over the short run). Since the risk of a project is a function of the covariance of the project returns with the (returns of the) economy in general, this indicates a positive and significant risk element in the CWF Project.

greater in the case of tax-exempt bonds.

In the case of the B/C analysis of the Clavey-Wards Ferry Project, there is thus substantial justification for providing for the internalization of risk, through a risk premium in the discount rate or through one of the other alternative methods considered in Chapter IV. Nevertheless, the social benefit-cost analysis in this study is executed under the conservative assumption that the market discount rate of 10.72% adequately captures the effects of all relevant Project risk. The sensitivity analysis, however, gives some notion of what the impact would be on the results if a risk premium were to be incorporated into the Project discount rate.

The Social Cost of the Clavey-Wards Ferry Project

The following sections describe the calculations of the denominator of the B/C ratio, beginning with the private or internal costs of the Project.

Internal Costs of the CWF Project

The internal costs of the Project are calculated by the SBC model[11] according to standard industry practice and in a manner which is parallel to the Beck and Sverdrup & Parcel analyses. The basic assumptions of the internal cost analysis (Table 1) have also been drawn, for the most part, from those earlier assessments.

The actual project construction costs are based upon information presented in the 1980 Beck analysis, which indicates a direct construction cost (for bid-level January 1979) of slightly less than $275 million (Table 2). Based upon this figure and the operation and maintenance costs, it is possible to determine the total annual levelized internal cost of the Project. The 25 steps through which this calculation is executed are documented and fully described in Appendix 10. Again, standard industry practice is utilized throughout. The result is an annual levelized (amortized) internal cost of $134 million (Appendix 10, item 25).

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[11] A copy of the computer output of the SBC model for the Clavey-Wards Ferry Project analysis is provided as Appendix 9.

TABLE 2:   CLAVEY-WARDS FERRY PROJECT
CONSTRUCTION COST ESTIMATE SUMMARY, BID-LEVEL 1979

Item	Estimated Cost
A. CLAVEY UNIT	
1. Preparatory Work	$ 7,880,000
2. Jawbone Diversion Dam and Reservoir...	27,547,000
3. Jawbone Ridge Tunnel	39,253,000
4. Hunter Point Dam and Clavey Reservoir.	7,210,000
5. Pressure Tunnel and Penstock	30,394,000
6. Underground Powerhouse	8,624,000
7. Tailrace Tunnel	2,540,000
8. Powerhouse Access Tunnel	2,695,000
9. Powerhouse Mechanical Equipment	11,267,000
10. Powerhouse Electrical Equipment	15,600,000
11. 230-kV Substation	4,574,000
B. WARDS FERRY UNIT	
1. Preparatory Work	7,457,000
2. Dam and Reservoir	47,125,000
3. Penstock	4,147,000
4. Underground Powerhouse	11,088,000
5. Draft Tube	325,000
6. Powerhouse Access Tunnel	3,697,000
7. Powerhouse Mechanical Equipment	9,259,000
8. Powerhouse Electrical Equipment	9,344,000
9. 230-kV Substation	3,855,000
C. POWER TRANSMISSION	
1. Right-of-Way Acquisition and Clearing.	1,039,000
2. Clavey to Moccasin 230-kV Line	2,950,000
3. Wards Ferry to Moccasin 230-kV Line ..	1,180,000
4. Moccasin Switchyard Expansion	1,805,000
5. Moccasin to Warnerville 230-kV Line ..	7,552,000
6. Warnerville Switchyard Expansion	683,000
Subtotal, Bid-Level January 1979	$269,090,000
Sales Tax	5,382,000
DIRECT CONSTRUCTION COST, Bid-Level 1/1979	$274,472,000

SOURCE: R. W. Beck and Associates, February 1980, Table III-1.

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External Costs of the CWF Project

The first of the external costs of the CWF Project which is evaluated
with the SBC model is the value of whitewater recreational boating (rafting)
benefits foregone. Project construction would lead directly to the
elimination of these recreation benefits because of diversions of water out of
the Tuolumne at Jawbone Diversion and Hunter Point Dam (Figure 2) and because
of inundation of the section of the Tuolumne below its confluence with the
Clavey (due to the creation of the Wards Ferry Reservoir behind the new Wards
Ferry Dam).

a.   Whitewater User Values

A regional travel-cost-method (TCM) model of recreation demand[12] is used
to measure the (consumers' surplus) value of the whitewater boating
opportunities lost. The application of this TCM model to the Tuolumne is
described in detail in Appendix 6.

In brief, the first step is to utilize empirical data on current use of
the River to determine the per capita visitation rates and costs from various
geographic origins (Appendices 11 and 12). Next, the participation functions
are econometrically estimated (Appendix 13), using three alternative
functional forms, linear, double logarithmic and semilogarithmic. As is
explained in Appendix 6, the semilog equation is identified as the appropriate
functional form (although the linear form results in substantially higher
estimates of recreational value lost).

Based upon these estimated equations, net consumer surplus is then
calculated (Appendices 14, 15 and 16). In this way, the 1994 (first-year)
annual whitewater recreational user value is found by the TCM model to be
slightly more than $3 million (Table 3, item 2). User fees and producers'
surplus are added to this amount (Table 3, items 3 and 4).[13]

b.   Whitewater Intrinsic Value

Based upon the empirically derived consumer surplus, above, and upon a
proportional relationship established from previous empirical research

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[12]A detailed description of the TCM model is provided in Chapter IV and in
Appendix 5.

[13]See Chapter IV, section titled, "User Fees and Producers' Surplus" and Figure
4.

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TABLE 3:
SOCIAL COSTS, CLAVEY-WARDS FERRY PROJECT

(1) Levelized Annual Internal Costs $134,224,000
      (Appendix 10, item 25)

(2) 1994 Consumers' Surplus of Users $ 3,099,000

(3) 1994 User Fees (1983 Fee, $3, at
      6%/year for 11 years) $ 128,000

(4) 1994 Producers' Surplus (.125 profit
      x $350 at 6% for 11 years x 6,400) $ 532,000

(5) 1994 Option Value (Consumer Surplus/
    User x option-value x proxy population) $ 33,503,000

    CA: $184.14 x 0.60 x 130,836
            =$14,455,000

    Other: $392.91 x 0.45 x 215,459/2
              = $19,048,000

(6) 1994 Total Recreational Value [(2) +
      (3) + (4) + (5)] $ 37,261,000

(7) Levelized Annual Cost of Recreational
      Value (Present value of 50 years,
      inflated at 6%, discounted at 10.72%,
      then levelized at 10.71% over 50 years) $ 80,039,000

(8) TOTAL OF PRIVATE AND RECREATIONAL
      ANNUAL COST [(1) + (7)] $214,263,000

(Appendix 7), whitewater recreational option value[14] is next estimated by the SBC model and found to equal approximately $34 million for the year 1994 (Table 3, item 5).[15]

c. Recreational Fishing[16]

The proposed Project would devastate the fisheries of the Tuolumne and Clavey Rivers (California Department of Water Resources 1982b; U.S. Department of Agriculture and U.S. Department of the Interior 1979). This is particularly serious considering the fact that the Clavey is managed by the California Department of Fish and Game as a "Wild Trout Stream," and the Tuolumne is considered to be one of the finest cold-water trout fisheries in California (U.S. Department of Agriculture and U.S. Department of the Interior 1979).

The method utilized in the SBC model for internalizing fisheries impacts of the Project is one of mitigation, where the operation of the Project is modified so as to leave "adequate" flows within the Tuolumne to prevent total

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[14]The concept of option value is examined in Chapter IV. For a detailed description of the estimation of these option values, see Appendix 19.

[15]Note that the estimated consumer surplus and option value per individual, both for California and elsewhere, is very low compared with previous studies of similar recreational opportunities. Comparable figures from Fisher and Raucher (1983), inflated to the same year (1994), would be a user value of $1,194/household and an option value of $712/household. These may be contrasted with this study's findings of $300/person for user value and about $140/person for option value.

[16]For detailed comments on the likely impact of the Clavey-Wards Ferry Project on the recreational fisheries of the Tuolumne and Clavey Rivers, see Chapter II, section titled "Fisheries Impacts."

destruction of the fishery.[17] Accordingly, when the benefits of the Project are calculated below, the Project is assumed to be operated in a fashion which at least partially mitigates fisheries damages.

It should be pointed out, however, that the procedure utilized by no means is intended to represent a complete internalization of fishery damages. On the contrary, the flow adjustments which are carried out do not mitigate the inundation of 12 miles of the Tuolumne by the Wards Ferry Reservoir nor do the adjustments prevent serious degradation of the Tuolumne between Jawbone Diversion and the headwaters of the Wards Ferry Reservoir. Rather, the flow modifications merely prevent the virtual elimination of the fishery, which would otherwise occur.

In the first step of this internalization method, the flows required for "maintenance" of the recreational fishery were identified on the basis of the expert opinion of the U.S. Fish and Wildlife Service and the California Department of Fish and Game (Appendix 2). Next, the flows available for energy generation (at the new Clavey Powerhouse) were precisely calculated on a month-by-month basis (Appendix 17 and Figure 5). Given the linear relationship between flow and energy generation, the impact of this mitigation on the Project's total annual generation was estimated (Appendix 17). As with the entire analysis, the estimates are both rigorous and conservative: the impact of flow modification on Project electrical capacity was not included in the final calculations.

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[17] Both Federal and State law independently call for flow modification to mitigate damage to the fishery resource. The applicant for a FERC license must consult with appropriate local, State, and Federal agencies prior to the issuance of a license, and FERC must consider these agencies' recommendations in the licensing process. The U.S. Fish and Wildlife Service would have to be consulted by the developers of the Clavey-Wards Ferry Project (Fish and Wildlife Coordination Act of 1958, 16 U.S.C. Section 662(a)). The result of such consultations would likely be a recommendation to maintain a specified flow rate to prevent damage to the fishery. Furthermore, the California Department of Fish and Game must be similarly consulted as part of a State water right process (Water Code Section 1243). As previously noted, the Department of Fish and Game has formally opposed the Project in the FERC preliminary permit proceedings.

FIGURE 5: TUOUMNE RIVER WATERSHED FLOW PATTERN
SUBSEQUENT TO DEVELOPMENT OF CLAVEY-WARDS FERRY PROJECT

Lake Lloyd
(117 SQ MI D.A.; 268,000 AF CAP)

Lake Eleanor
(79 SQ MI D.A.; 27,100 AF CAP)

Hetch Hetchy Reservoir
(455 SQ MI D.A.; 360,360 AF CAP)

Eleanor-Cherry Diversion Tunnel

352 cfs

238 cfs

1008 cfs

O'Shaughnessy Dam

Eleanor Dam

Tuolumne River

Cherry Valley Dam

Eleanor Creek

Runoff Below O'Shaughnessy Dam (29 SQ MI D.A.)

Cherry Power Tunnel

Canyon Power Tunnel

46 cfs

Cherry River

Robert C. Kirkwood Powerhouse

Early Intake Reservoir (115 AF CAP)

Dion R. Holm Powerhouse

Lower Cherry Diversion Dam

590 cfs

Early Intake Bypass Tunnel and Pipe

Runoff Between Eleanor and Cherry Valley Dams and Jawbone Diversion Dam (44 SQ MI D.A.)

40 cfs

Early Intake Diversion Dam

464 cfs

659 cfs (300 MGD)

Mountain Tunnel

Jawbone Ridge Tunnel

(395 cfs) 590 cfs

Jawbone Diversion Dam and Reservoir (724 SQ MI D.A., 4500 AF CAP)

Clavey River

(452 cfs)

874 cfs

Middle Tuolumne River (74 SQ MI D.A.)

Priest Regulating Reservoir

Priest Dam

Moccasin Powerhouse

Hunter Point Dam and Clavey Reservoir (143 SQ MI D.A.; 2340 AF CAP)

273 cfs

(83 cfs)

199 cfs

75 cfs

346 cfs

91 cfs

South Fork Tuolumne River (87 SQ MI D.A.)

Moccasin Reregulating Reservoir

Clavey Power Tunnel

1128 cfs

(642 cfs)

(573 cfs)

Moccasin Creek

Moccasin Creek

Clavey Powerhouse (300 MW CAP)

Moccasin Upper Dam

Tuolumne River

Runoff From Ungaged Area Above Wards Ferry Dam (165 SQ MI D.A.)

Moccasin Dam

North Fork Tuolumne River (69 SQ MI D.A.)

264 cfs

Foothill Tunnel

Wards Ferry Dam and Reservoir (1262 SQ MI D.A.; 158,800 AF CAP)

04 cfs

0 cfs

(195 cfs)

Oakdale Portal

Wards Ferry Powerhouse (100 MW CAP)

San Joaquin Pipelines

Woods Creek (97 SQ MI D.A.)

60 cfs

1402 cfs
1569 cfs (Gen)
258 cfs (Spill)
(230 cfs)

0 cfs

Red Mountain Bar Wasteway

Runoff Between Wards Ferry and LaGrange, excluding Woods Creek (181 SQ MI D.A.)

86 cfs

464 cfs (300 MGD)

City and County of San Francisco (Domestic Supply)

New Don Pedro Dam, Powerhouse and Reservoir (1533 SQ MI D.A.; 2,030,000 AF CAP)

1973 cfs

LEGEND
(Dam
Tunnel or Pipeline
Stream or Reservoir
Powerhouse

LaGrange
(1540 SQ MI D.A.)

NOTES
1. Proposed facilities are shown with dashed lines.
2. All flows noted are average annual flows used in determination of project power yield.
3. EDF flows are shown in parenthesis.

SOURCE: R. W. Beck and Associates 1976, plus adjustments (as indicated) by EDF.

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The Combined Social Cost of the CWF Project[18]

The (first-year) 1994 whitewater-user recreation values (including consumers' surplus, user fees and producers' surplus) are now combined with the 1994 intrinsic recreational value to yield a total 1994 recreational value of $37 million (Table 3, item 6). Because the SBC model provides for a full-planning period analysis (rather than a simple first-year assessment), the levelized annual cost of recreational value is next calculated (Table 3, item 7), and this is added to the levelized annual internal costs of the Project (Table 3, item 1) to yield the total social (private and recreational) annual cost of the Clavey-Wards Ferry Project, approximately $214 million (Table 3, item 8).

The Social Benefit of the Clavey-Wards Ferry Project

The following sections describe the SBC model's calculations of the numerator of the B/C ratio, beginning with the private or internal benefits of the project, electricity generation and provision of incremental firm water yield.

Electricity Benefit of the CWF Project

The SBC model uses the generally accepted method of valuing the electrical capacity and electrical energy which would be forthcoming from the CWF hydroelectric facilities, namely, the avoided cost of the least expensive alternative means of meeting an identical load,[19] an approach which is utilized by FERC staff in their own economic assessments of proposed projects. Consistent with the recommendations of the U.S. Water Resources Council (1983a), both structural and non-structural alternatives are considered.

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[18]Note that the fishery internalization procedure, described in the previous section, results in a modification of the total annual energy generation of the Project. Hence, that effect is introduced in the benefit side of the model (in a later section).

[19]See Chapter IV for a discussion of alternative electricity benefit estimation methods.

A "least-cost"[20] mix of practical alternative sources is identified, which provides, with equal reliability, the same capacity and energy as the CWF Project (after taking into account Project mitigation for fisheries damages). Alternatives included in the final mix are coal generation, combustion turbines using natural gas, conservation voltage regulation and load management.

a. A Least-Cost Mix of Alternative Sources

The SBC analysis of electricity Project benefits diverges from that of R. W. Beck and Associates (1976, 1979 and 1980) in two ways. First, Beck's analysis considered only the first year of the useful life of the Project facilities. This analysis, however, in keeping with the practice used for all cost calculations, estimates Project benefits over the entire 50-year planning period. Second, Beck's analysis of benefits was based on a mix of coal capacity and associated energy and of combustion turbine capacity and associated energy. Current information clearly indicates that such a mix is not a least-cost alternative, which is what is called for in the analysis.

The least-cost mix developed in this study includes the purchase of coal energy off-peak, without associated capacity.[21] Coal energy will be available on an off-peak basis from Southwest and Northwest sources over the indefinite future, due to the physical characteristics of the energy systems in those regions. In the Southwest, coal-fired capacity from base-load plants is being built for both capacity and energy purposes. Southwest electrical loads have a relatively low load factor, significantly lower than the capacity factor of base-load coal plants. In addition, capacity is installed to meet peak requirements plus reserve margin requirements, so the discrepancy between load factors and plant capacity factors is even greater. The result is a continuing surplus of off-peak coal energy relative to Southwest needs.

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[20]Note that a true least-cost mix of alternative energy sources would include wider use of non-structural alternatives and would result in a lower estimate of Project energy benefits. Time did not permit a thorough examination of non-structural alternatives to the Clavey-Ward Ferry Project.

[21]Because of the physical characteristics of both the Southwest and the Northwest electric systems, such off-peak energy will be available over the indefinite future, as the R. W. Beck and Associates (1980) analysis of the potential Humbug pumped-storage project recognizes. It should also be noted that another option would be geothermal capacity and associated energy; specific sites and projects have been identified by the Central California Power Authority, of which Modesto Irrigation District is an ownership participant.

A similar situation exists in the Pacific Northwest, although for somewhat different reasons. The Pacific Northwest electrical system has a large base of hydroelectric energy. The combined hydroelectric and thermal system, however, is built to have sufficient thermal-based energy to provide adequate supplies in drought years. Thus, in average and wet years, there is a surplus of thermal energy and (during spring runoff) hydroelectric energy available for export. Transmission lines are currently planned, in addition to existing transmission lines, which will allow for continued export of such surplus energy from the Pacific Northwest.

Although both the Southwest and Northwest will be able to provide off-peak thermal energy, this analysis is based on a Southwest source.[22] The basis of the cost estimates consists of data from Modesto Irrigation District's (MID) current contracts to obtain Southwest energy and capacity through the year 2019. The cost estimates for this Southwest energy, including relevant transmission costs, are developed in Appendix 18, Section D.

In the least-cost mix utilized in this study, peak energy and capacity are provided by combustion turbines. A portion of the electric capacity of CWF can be more economically provided by load management (such as the cycling of air conditioners and provisions for interruptible service), as is currently being implemented by the Sacramento Municipal Utility District (SMUD). Therefore, a portion of the capacity needs are met through load management.

Load management is included in the least-cost alternative analysis. SMUD is currently implementing load management programs which will save capacity equal to 6.2% of SMUD's 1994 peak demand. A similar load management program for MID and TID would produce savings in capacity (Appendix 18, Section G).

Combustion turbine capacity costs are based on the installed costs of MID's McClure Units 1 and 2, and on data from SMUD and R. W. Beck and Associates (1980). Section B of Appendix 18 documents the development of these costs. Annual costs over the 50-year planning period are based upon the costs of combustion turbines replaced one-and-a-half times during this time frame (Appendix 18, Section A). Using a capacity factor of 4%, based upon a range of 3% to 5%, combustion turbine variable costs are also developed (Appendix 18, Section C).

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[22] Note that such "inter-regional power transfers" are endorsed by the U.S. Water Resources Council (1983a) as an appropriate nonstructural measure to be included in an alternative plan being developed to estimate hydro project energy benefits. For a detailed discussion of nonstructural alternatives to hydroelectric facilities, see Willey 1981.

A least-cost mix of sources would also include energy that can be developed through conservation measures, such as weatherization retrofits (particularly important in the case of air conditioning loads) and more efficient electricity use (particularly important in the commercial sector).[23] In the present analysis, however, only two conservation practices are considered, Conservation Voltage Regulation (CVR) and load management.

CVR is the practice of lowering distribution voltages, within the acceptable range of voltages, during off-peak times for the purposes of energy conservation. It is estimated that CVR can save 2% of the energy requirements of the Modesto and Turlock Irrigation Districts (TID). Over the life of the Clavey-Wards Ferry Project, both the quantity and the value of this energy will increase. MID forecasts a growth rate of 2.6% per year over the period 1990 to 1996. The present analysis utilizes a long-term growth rate equal to half of this value. CVR energy savings are calculated in Appendix 18, Sections E and F.

b. Calculating the Electricity Benefits of the CWF Project

The alternative mix of sources so developed provides identical electrical capacity and energy as would be provided by the Clavey-Wards Ferry Project (Appendix 18, Section H). The last stage, then, in this phase of the analysis is to calculate the total annual cost of the least-cost mix of alternative sources (Table 4 and Appendix 18, Section I). Combining the net costs of coal energy and combustion turbine capacity and energy with the costs and impacts of Conservation Voltage Regulation and load management, the total electricity benefit of the Clavey-Wards Ferry Project is found to be approximately $184 million per year (Table 4).

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[23] The new "Principles and Guidelines" of the U.S. Water Resources Council (1983a) specifically calls for the inclusion of nonstructural measures, strategies or programs as alternative energy plans in the estimation of hydroelectric project benefits. The Council emphasizes measures which reduce demand by improving efficiency: "In determining the most likely alternative, the planner should give adequate consideration to nonstructural and demand management measures as well as structural measures" (p. 9). Furthermore, it is stated that "nonstructural measures include but are not limited to reducing the level and/or time pattern of demand by time-of-day pricing; utility-sponsored loans for insulation; appliance efficiency standards; education programs; inter-regional power transfers; and increased transmission efficiency" (p. 42).

TABLE 4:   ELECTRICITY BENEFITS, CLAVEY-WARDS FERRY PROJECT[a]

(1) Combustion Turbine Capacity	
340.3 MW x $104.96/kW-yr	$ 35,720,000
(2) Combustion Turbine Energy	
119.2 GWh x $.6042/kWh	72,020,000
(3) Coal Energy	
606.3 GWh x $.1453/kWh	88,100,000
(4) Less - value of CVR Energy	
73 GWh x $.1837/kWh	-13,420,000
(5) Cost of CVR Energy	
$16,609	20,000
(6) Cost of Load Management	
56.3 MW x $31.7/kW yr (at end use)	1,780,000
TOTAL	$184,000,000

[a]For detailed calculations, see Appendix 18 of this study.

Incremental Firm Water Yield Benefit of the CWF Project

The other internal benefit of the Clavey-Wards Ferry Project would be the provision of a small amount of additional firm water yield, approximately 11,900 acre-feet (AF) per year. Based upon R. W. Beck and Associates (1980) analysis, this water would be worth about $105/AF (in terms of avoided-cost) in the year 1990. Assuming 6% annual inflation, this translates into a little less than $133/AF in 1994, or a total for that year of almost $1.6 million (Table 5, item 3). Converting this to a levelized figure for the entire 50-year planning period, the annual benefit is found to be about $3.4 million (Table 5, item 4).

Thus, the total _internal_ levelized benefits of the Project are equal to about $187.6 million per year. The remaining step in the benefit calculations is to internalize the external benefits of the CWF Project, namely the provision of recreation opportunities at the newly created Wards Ferry Reservoir.

External Benefits: Flatwater Recreation

The Wards Ferry Reservoir would provide new opportunities for flatwater recreational fishing and boating. Because primitive or wilderness-type recreation in natural environments (such as whitewater rafting on the Tuolumne) requires significantly more land or surface area per recreation unit, it has been suggested that the more intensive recreation patterns associated with reservoir recreation will support many more recreationists and hence provide more recreation benefits than the same area could if preserved for relatively low-density recreational activities.

The values per unit of wilderness and developed recreation may differ substantially, however, and the demand for (and hence usage of) the developed-type of recreation may be relatively low, if it is already available in a region. Indeed, the nearby New Don Pedro Reservoir already exhibits characteristics of excess capacity (Krutilla and Fisher 1975).

Although Wards Ferry Reservoir would create the potential for additional flatwater recreation, such added opportunities would be extremely limited. According to the CWF Project's own evaluation, the reservoir would be a long, narrow and deep lake with difficult access down steep canyon walls and would be sunless most of the time (R. W. Beck and Associates 1976). Furthermore, according to the California Department of Water Resources,

> Operation of Wards Ferry Reservoir would result in approximately 100 feet of surface water elevation fluctuation. Combined with other characteristics of this reservoir, this would limit development of a flat water fishery and attendant recreation (1982b).

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TABLE 5:
SOCIAL BENEFITS, CLAVEY-WARDS FERRY PROJECT

(1) Levelized Annual Energy Benefit (Table 4: [(2) + (3) + (5) - (4)])	$146,720,000
(2) Levelized Annual Capacity Benefit (Table 4: [(1) + (6)])	$ 37,500,000
(3) Annual Benefit of Increased Firm Yield of Water for MID/TID (11,900 AF x $105/AF in 1990, 4 years at 6% to 1994)	$ 1,577,000
(4) Levelized Annual Benefit of Increased Firm Yield [(3) x 2.148]	$ 3,388,000
(5) Total Internal Levelized Annual Benefits [(1) + (2) + (4)]	$187,608,000
(6) Annual Flatwater Boating Benefit on Wards Ferry Reservoir (1600 user-days x $20/day, 1994)	$ 32,000
(7) Annual Reservoir Fishing Benefit (4,000 user-days x $30/day, 1994)	$ 120,000
(8) Total External Levelized Annual Benefits [(6) + (7) x 2.148]	$ 327,000
(9) Total Levelized Annual Project Benefits [(5) + (8)]	$187,935,000

In addition, "considerably better opportunity for flatwater recreation exists at currently undeveloped sites on larger reservoirs nearby" (U.S. Department of Agriculture and U.S. Department of the Interior 1979, p. 63).

A consequence of the CWF Project would be that large sections of the stream fisheries of the Tuolumne and Clavey Rivers would be replaced by reservoir fisheries, but "reservoir fisheries are in abundance in the Sierra foothills, whereas river trout fisheries of the quality of the Tuolumne are a rarity in the state" (U.S. Department of Agriculture and U.S. Department of the Interior 1979, p. 65). A former California Department of Fish and Game biologist has estimated that the Tuolumne River holds more than 1,000 pounds of fish per acre, whereas Wards Ferry Reservoir would probably maintain less than 10 pounds per acre (Gray 1976). Again, according to the Project proponents' analysis, "in view of the expressed preferences of fishermen for flowing water, this replacement (reservoir instead of stream), without offsetting compensation, would have to be considered a recreation loss" (R. W. Beck and Associates 1976, p. BV-1).

Although the recreational unit-value of the Wards Ferry Reservoir would thus be relatively small, it is, of course, still important to estimate it, for purposes of consistency. Whereas the travel cost method was used for the estimation of whitewater recreation benefits (lost), the unit-day value method, introduced in Chapter 4, is used for flatwater (reservoir) recreation benefit estimates.

Why is a different method of benefit estimation used in this phase of the study? In particular, given that the travel cost method was identified previously as the preferred approach for evaluating whitewater benefits, why is the unit-day value method used for flatwater recreation? The answer is provided by the U.S. Water Resources Council's "Guidelines," which lay out specific criteria to be used in the selection of benefit evaluation procedures.[24]

The criteria are related to three measures of the absolute and relative size of the recreation benefit created, destroyed, displaced or transferred by the proposed project and to the nature of the affected recreation activities. In the present context, the crucial questions are as follows:

(i) Do the affected uses of the site involve specialized recreation activities, "those for which opportunities in general are limited, intensity of use is low, and users' skill, knowledge, and appreciation is great?" (U.S. Water Resources Council 1983a, p. 68.)

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[24] See the text on page 68 and the diagram on page 69 of U.S. Water Resources Council 1983a.

(ii) Does the number of visits per year which is likely to be affected by the proposed project exceed 750,000?

(iii) Do the expected recreation costs exceed 25 percent of total project costs?

The first criterion is stated by the WRC as being a sufficient condition for the use of a travel-cost-method or contingent valuation model, and the WRC indicates that a negative response to all three of the above questions represents a jointly-sufficient (though not a necessary) condition for the use of the unit-day value method. Hence, the TCM model is clearly appropriate in the case of whitewater rafting on the Tuolumne, while the unit-day value method is the reasonable choice for the evaluation of flatwater recreation at the proposed Wards Ferry Reservoir.

In the unit-day value method, expert or informed estimates of activity-day values (dollar values for each person-day of participation in a particular type of recreation) are multiplied by estimates of annual user-days. According to the U.S. Departments of Agriculture and the Interior (1979), the probable usage of the Wards Ferry Reservoir would be 1,600 flatwater boating use-days and 4,000 flatwater fishing days per year. Extrapolating from the most recent, comprehensive research (Vaughan and Russell 1982), user-day values for flatwater boating and fishing are estimated to be $20/user-day and $30/user-day, respectively, in the year 1994. This yields a total 1994 recreational value of $152,000 per year. Converting this to a levelized 50-year figure yields an estimated total external annual benefit of $327,000 per year (Table 5, item 8).[25]

The Combined Social Benefit of the CWF Project

Table 5 combines the annual benefits of the Project associated with electrical energy (item 1), electrical capacity (item 2), incremental firm water yield (item 4), and flatwater recreation (item 8). The result is total levelized annual Project benefits of slightly less than $188 million (item 9).

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[25]Note that if this figure is inflated by 60% to account for possible option value associated with flatwater recreation, the benefit/cost ratio increases from 0.877 to 0.878.

The Social Benefit/Cost Ratio and the Annual Economic Value

of the Clavey-Wards Ferry Project

It is now possible to combine the results of the cost and benefit analyses which have been described in this chapter. Based upon an application of the SBC model, it is determined that the annual social benefits of the Clavey-Wards Ferry Project would be approximately $188 million, while the annual social costs would exceed $214 million. Thus, the net annual economic value of the Project is found to equal -$26.3 million (Table 6). This indicates a net annual loss to society of more than $26 million. Examining the investment over the entire 50-year planning period, the Project has a Net Present Value of approximately -$244 million. Lastly, the Clavey-Wards Ferry Project exhibits a social benefit-cost ratio of 0.877.[26]

These results are based upon a rigorous economic assessment of the Project, utilizing conservative assumptions and broadly accepted methodologies throughout. It is important to keep in mind that the analytical approach utilized in this study by no means internalizes all environmental impacts of the CWF Project. Because of this and because of the conservative assumptions used in all phases of the analysis, the results presented here probably overestimate the net social benefit (i.e. underestimate the magnitude of the net social cost) of the Project proposal.

If additional environmental impacts were internalized in the calculations, or if less conservative assumptions were used in the analysis, the Clavey-Wards Ferry Project benefit-cost ratio would likely be even less than the current value of 0.877, as is demonstrated in the following sensitivity analyses.

Sensitivity Analysis of the SBC Model

With any economic analysis, it is always important to examine the results' sensitivity to the assumptions under which the analysis was conducted. In particular, it is necessary to ask how the results might differ if alternative values were used for the major parameters of the Social Benefit-Cost (SBC) model. If different values were assumed for the discount rate or the discount period, for example, would the Clavey-Wards Ferry Project still exhibit a benefit-cost ratio substantially less than one?

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[26] A copy of the computer-generated results of using the SBC model to assess the Clavey-Wards Ferry Project is provided in Appendix 9.

TABLE 6: SOCIAL BENEFIT-COST CALCULATION, CLAVEY-WARDS FERRY PROJECT

BENEFITS:

(1)	Levelized Annual Energy & Capacity Benefit [Table 5, items (1) + (2)]	$184,220,000
(2)	Levelized Annual Water Benefit [Table 5, item (3)]	3,388,000
(3)	Levelized Annual Recreation Benefit [Table 5, item (8)]	327,000
(4)	Total Benefits [(1) + (2) + (3)]	$187,935,000

COSTS:

(5)	Levelized Project Capital Cost (Appendix 10, item 16)	99,860,000
(6)	Levelized Project Variable Cost (Appendix 10, item 24)	34,364,000
(7)	Levelized Annual Cost of Lost Recreation (Table 3, item 7)	80,039,000
(8)	Total Cost [(5) + (6) + (7)]	$214,263,000

B/C:

(9)	Benefit/Cost Ratio [(8)/(4)]	0.87712

B-C:

(10)	Net Annual Economic Value[a] [(8)-(4)]	-$ 26,328,000

NPV:

(11)	Net Present Value[b]	-$244,064,000

[a]Negative number indicates a net social cost.

[b]Net Present Value is explained in Appendix 3.

How Sensitive are the Results
to the Specified 50-Year Discount Period?

Based upon FERC guidelines,[27] this study's benefit-cost analysis utilized a 50-year planning period, although the assumed life of the CWF Project would be 100 years or more. In order to examine the impact of the 50-year discount period, the SBC model was re-run using a 100-year discount period. In the 100-year scenario, the cost side is adjusted in terms of annual amortization figures and the benefit side is likewise adjusted and is also modified to account for additional, alternative energy replacement facilities. As a result, the previous B/C ratio of 0.8771 increased only marginally, to 0.9124.

The Discount Rate and Questions of Risk[28]

Four distinct sources of risk were previously identified as being associated with a decision to undertake investment in the proposed Clavey-Wards Ferry Project: fossil fuel price risk; inflation/bond rate risk; delay risk; and energy demand growth risk. Furthermore, it was argued that at least a portion of this risk was not internalized in the market interest rate adopted for use as a discount rate in the B/C analysis. Hence, substantial justification exists for internalizing some of this risk through a risk premium in the discount rate (or through an alternative method).

The analysis, however, did not add a risk premium to the discount rate, assuming conservatively that the market rate had adequately captured the implications of all Project risk. The sensitivity analysis can now give some notion of what the impact would be on the results if a risk premium were to be incorporated into the Project discount rate. Moreover, in order to examine

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[27]FERC has stated that "Financial analysis is generally limited ... to a period of 50 years, recognizing the practical impact of the 50 year licensing period for non-Federal projects and the realities of funding non-Federal projects beyond the licensing period..." (U.S. Department of Energy 1979, p. 4-3). For the full quotation, see Chapter IV of this study, section titled "Conceptual Issues Associated with Identifying an Appropriate Discount Period."

[28]It might also be asked what the sensitivity of the model is to the assumed rate of general price inflation, 6%. The answer is essentially that the results would be unchanged. If, for example, no general price inflation had been assumed and, to be consistent, real discount rates and real escalation rates had been used in all parts of the analysis, the results would have been expressed instead in real dollars, rather than nominal ones, but the B/C ratios would be identical.

the results in the context of a range of possible discount rates, the original value of 10.72% is now bracketed by values of 12.0%, representing the inclusion of a risk premium, and 9.5%. The original B/C ratio of .877 falls to .799 for the risk-adjusted rate, and increases to .956 for a relatively low rate of 9.5%.

Alternative Travel Cost Method (TCM) Model Specifications

As was explained in detail in Appendices 5 and 6, three alternative TCM model specifications were utilized, and one was identified (a semilogarithmic form) as being preferred both on theoretical and empirical grounds. A large number of previous recreational studies, however, have utilized the linear form. Use of the linear specification, clearly inappropriate although frequently used, would reduce the Project B/C ratio from 0.877 to only 0.324. Alternatively, use of the double logarithmic functional form, also inappropriate (on theoretical grounds), would increase the B/C ratio to 0.956.

The sensitivity analyses for alternative discount rates and for alternative specifications of the TCM model may be combined into a matrix of results, both for the consequent B/C ratios and for the various results in terms of the Project's Annual Net Economic Value (Table 8).

What is the Impact of Delay During the Construction Period?

It is possible to estimate the impact of changing the Project construction period by making proportionate changes in the interest-during-construction (IDC) factor[29] and by shifting all project benefits and costs forward or backward in time as the construction period is shortened or lengthened, respectively. If no delays whatsoever were to occur (a highly unlikely scenario) and the Clavey-Wards Ferry Project were completed in 4 years, the B/C ratio would increase only slightly to 0.881. Alternatively, if delays were to increase the construction period from the assumed 7 years to 10 years, the B/C ratio would fall from 0.877 to 0.840.

Conclusions of the Sensitivity Analysis

In brief, the sensitivity analysis indicates, first, that the SBC model is relatively robust and capable of handling a reasonably wide range of parameter values. Second, the analysis indicates that the Project B/C ratio would still be significantly less than one even if assumptions regarding the discount period and delays during construction were made substantially more

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[29]See Appendix 10.

TABLE 8:
SENSITIVITY ANALYSIS

Benefit/Cost Ratio (B/C)

	i = 12.0%	i = 10.72%	i = 9.5%
Linear TCM	.317	.324	.330
Semilog TCM	.799	>> .877 <<	.956
Double Log TCM	.865	.959	1.056

Annual Net Economic Value (B-C)

($ Millions)

	i = 12.0%	i = 10.72%	i = 9.5%
Linear TCM	-383.7	-392.0	-406.8
Semilog TCM	-44.6	>> -26.3 <<	-9.2
Double Log TCM	-27.7	-8.1	10.6

favorable to the Project. Third, if a risk premium were incorporated into the discount rate, the Project B/C ratio would decrease slightly. Alternatively, a moderate decrease in the discount rate would result in a marginally greater B/C ratio, but one which would still be less than unity. Fourth, if the linear model of recreation demand has been used instead of the more appropriate semilogarithmic model, a substantially smaller B/C ratio would have resulted.

VI

SUMMARY AND CONCLUSIONS

The leading proposal for development of the main stem of the Tuolumne River in California is the Clavey-Wards Ferry (CWF) Project. In order to assess its economic merits, the Environmental Defense Fund (EDF) undertook this comprehensive study of its benefits and costs. Unlike traditional benefit-cost (B/C) analyses, which have not attempted to quantify environmental costs, the study monetizes and internalizes at least some of the environmental costs which would be occasioned by the CWF Project. Such an approach provides a more comprehensive assessment of the project's benefits and costs to society than does a traditional B/C analysis.

This final chapter begins with a brief summary of the study, highlighting those aspects of the economic analysis which differentiate it from previous benefit-cost assessments of the Clavey-Wards Ferry Project. Following this, the major conclusions of the economic and legal analyses are presented. Lastly, the study's major implications are developed, both with regard to the future status of the Tuolumne River and with regard to the role which the internalization of environmental values and social benefit-cost analysis may play in such questions.

Summary of the Study

Based upon a rigorous economic assessment, utilizing conservative assumptions and widely accepted methodologies, the analysis indicates that the proposed Clavey-Wards Ferry Project would result in a net social loss of more than $26 million per year. Even with only two of its environmental costs internalized, the Project exhibits a social benefit-cost ratio of 0.877, indicating that for each dollar which society were to invest in the CWF Project, it would receive in return less than 88 cents --- from a social perspective, a losing proposition.

Based upon recent advances in theoretical and applied economics, the model incorporates quantitative methodologies, endorsed by the U.S. Water Resources Council, for the evaluation of recreation effects of hydroelectric projects. The analysis internalizes two important environmental impacts of the proposed Clavey-Wards Ferry Project: (1) the virtual elimination of whitewater boating from an 18-mile stretch of the Tuolumne which is considered

to be one of the premier rafting runs in the United States; and (2) the near-total degradation of one of California's finest trout fisheries.

An empirical analysis of present and probable future use of the River, based upon a travel cost method (TCM) model of recreation demand, provided reliable estimates of both user and intrinsic (option) values of the resource. If additional environmental impacts were internalized in the calculations, or if less conservative assumptions were used in the analysis, the Clavey-Wards Ferry Project benefit-cost ratio would be even less than the current value of 0.877, as was demonstrated by a sensitivity analysis of the entire benefit-cost model.

Environmental impacts of proposed hydroelectric projects have historically been evaluated qualitatively and kept separate and distinct from any quantitative, economic analysis. But this approach has led to the undervaluation of environmental concerns in licensing decisions by the Federal Energy Regulatory Commission (FERC). As this study has demonstrated, advances in theoretical and applied economics have made it possible to quantify and internalize at least some environmental values. If (some) environmental impacts can be accurately evaluated in monetary terms and internalized within a project assessment, those environmental concerns are more likely to receive appropriate consideration in the decision-making process.

The central question of the study was whether or not developing the remaining canyon reach of the River is justified in relation to the recreational and environmental amenities which would be destroyed. In short, does the greater public interest lie in the proposed Clavey-Wards Ferry development or in the preservation of this stretch of the River in its natural state.

A Comprehensive Economic Assessment

of Additional Hydroelectric Development of the Tuolumne River

Traditional benefit-cost (B/C) analyses have typically failed to include consideration of environmental impacts. By omitting environmental amenities from the calculation of project benefits and costs, these important amenities are implicitly assigned a value of zero. In the language of the economist, environmental considerations thus remain "external" to the analysis. Yet such "externalities" are of profound importance, and any evaluation of how the public's interest will be served by a proposed development project certainly ought to include their full consideration.

This study has provided for such consideration of environmental impacts within the context of a comprehensive economic assessment of further hydroelectric development on the Tuolumne River. The analysis included consideration of a broad range of social (internal and external) benefits and

costs. Utilizing quantitative methods endorsed by the U.S. Water Resources
Council (March 1983a), the social benefit-cost model featured monetary
evaluations of whitewater boating and recreational fishing impacts of the
proposed Clavey-Wards Ferry Project. Furthermore, the quantitative model
provided for the partial evaluation of the intrinsic values of a river.

A Policy Perspective:

Quantifying the Previously Unquantified

The principle that Federal and State decision-makers must consider the
social benefits and costs of a proposed hydroelectric project (rather than
simply the internal benefits and costs to the project developers) is embodied
in a variety of Federal and State statutes, regulations and court decisions.
The usual practice, however, has been to assess environmental costs on a
descriptive or qualitative basis, rather than to attempt to quantify
environmental costs in a numerical benefit-cost analysis. In fact, the use of
a numerical benefit-cost analysis is sometimes discouraged when there are
important qualitative concerns (e.g., CEQ Guidelines, 40 C.F.R. Section
1502.23).

This reluctance to rely on a numerical benefit-cost approach is perhaps
explained by two factors: first, methodological limitations for internalizing
environmental impacts and other externalities in a B/C analysis; and second,
concern that the use of a numerical B/C approach will not account for
unquantified environmental impacts. FERC's record in hydropower licensing
indicates, however, that the qualitative assessment of environmental impacts
usually results in the undervaluation of those impacts. With the exception of
the Namekagon decision, decided thirty years ago, FERC and its predecessor,
the FPC, have not found the unquantified environmental costs of a project
sufficient to reject a license. Not quantifying environmental costs has had
the effect of assigning them a very low value.

In order to adequately assess the benefits and costs of a project to
society as a whole, it is essential to internalize (to the extent possible)
significant environmental externalities. The analytical approach developed in
Chapter IV by no means provides for the internalization of all environmental
effects. Nevertheless, it represents a significant improvement over
traditional benefit-cost models, which consistently have failed to provide for
the calculation of social benefits and costs and which have consequently
offered little guidance in evaluating the public merit of proposed
hydroelectric projects.

The internalization of environmental costs, where possible, is consistent
with Federal policies applicable to Federally financed water projects. The
U.S. Water Resources Council, under the authority of the Water Resources
Planning Act (42 U.S.C. 1962-2) recently issued new "Principles and
Guidelines" directly applicable to the U.S. Army Corps of Engineers, the U.S.

Bureau of Reclamation, the Tennessee Valley Authority and the Soil Conservation Service (U.S. Water Resources Council 1983a and 1983b).

These "Principles and Guidelines" require water project planners to monetize all project impacts which can be measured and to internalize all known direct project impacts, whether beneficial or adverse. While not binding on FERC, the "Principles and Guidelines" establish a clear Federal policy in favor of quantification, monetization and internalization of environmental impacts of proposed hydroelectric and other water projects.

In summary, the legal mandates to consider the broad social benefits and costs of proposed hydropower projects imply that environmental impacts should be internalized when possible. Given their duty to weigh project benefits and costs in the public interest, FERC, the California State Water Resources Control Board and other decision-makers should, at the very least, seriously question the social value of any proposed hydropower project for which it can be shown, as with the Clavey-Wards Ferry Project, that the project's completion will result in a net economic loss to society.

A Social Benefit-Cost Model

of the Proposed Clavey-Wards Ferry Project:

Major Conclusions of the Economic Assessment[1]

This study's economic analysis of the Clavey-Wards Ferry Project led to the calculation of two statistics for project evaluation. The first, the benefit-cost ratio is simply the annual (levelized) social benefit of the project divided by its annual social cost. The model also provided the annual net economic value of the Project, which is the annual social benefits minus the annual social costs, all levelized over the specified planning period. This net annual economic value is, in effect, a measure of the Project's expected annual contribution to the nation's economic welfare.

The annual social benefit of the proposed Clavey-Wards Ferry Project includes benefits associated with electrical energy and capacity, adjusted to mitigate at least partially the Project's negative impact on the fisheries of the Tuolumne and Clavey Rivers. Social benefits also include additional firm water yield and flatwater (reservoir) recreation. The annual social cost of

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[1]A detailed description of the SBC model is found in Part IV of the study and in Appendix 5.

the Project includes Project capital and variable costs and the value of whitewater recreation opportunities foregone.

Based upon an application of the SBC model,[2] it was determined that the annual social benefit of the Clavey-Wards Ferry (CWF) Project would be approximately $188 million, while the annual social cost would exceed $214 million (Table 7). Thus, the Project exhibits at best a social benefit-cost ratio of 0.877. This indicates that for every dollar which society invests in the CWF Project, it receives in return less than 88 cents; from a social perspective, a losing proposition.

The net annual economic value of the Clavey-Wards Ferry Project is found to equal -$26.3 million (Table 7). This indicates a net annual loss to society of more than $26 million. Lastly, the Project investment may be examined over the entire 50-year planning period; doing so results in the conclusion that the Net Present Value of the proposed investment is -$244 million (again, a net social loss).

These results are based upon a thorough and rigorous economic assessment of the Project, using conservative assumptions and broadly accepted methodologies. It is essential to keep in mind that the analytical approach utilized in this study by no means internalizes all environmental impacts of the CWF Project. Because of this and because of the conservative assumptions used in all phases of the analysis, the results presented here may overestimate the net social benefit (i.e. underestimate the magnitude of the net social cost) of the Project proposal.

If additional environmental impacts were internalized in the calculations, or if less conservative assumptions were used in the analysis, the Clavey-Wards Ferry Project benefit-cost ratio would be even less than the current value of 0.877, as was demonstrated in the sensitivity analysis in Chapter V.

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[2]A detailed description of the assessment of the Clavey-Wards Ferry Project, based upon an application of the SBC model, is provided in Chapter V of the study and in Appendix 6. Documentation of the computer-assisted analysis is provided as Appendix 9.

TABLE 7: SUMMARY OF SOCIAL BENEFIT-COST ANALYSIS,
CLAVEY-WARDS FERRY PROJECT,
FIFTY-YEAR PLANNING PERIOD, 1994-2044a

ANNUAL BENEFITS:

(1)	Electrical Energy and Capacity		$184,220,000
(2)	Additional Firm Water Yield		3,388,000
(3)	Flatwater Recreation		327,000
(4)	Total Benefits		$187,935,000

ANNUAL COSTS:

(5)	Project Capital Cost		$ 99,860,000
(6)	Project Variable Cost		34,364,000
(7)	Value of Lost Whitewater Recreation		80,039,000
(8)	Total Cost		$214,263,000

B/C:

(9)	Benefit/Cost Ratio	0.8771

B-C:

(10)	Net Annual Economic Valueb	- $26,328,000

NPV:

(11)	Net Present Valueb	- $244,064,000

aFor an explanation of all entries and their sources, see
Table 6 in Chapter V of the study.

bNegative numbers indicate a net social cost.

The Clavey-Wards Ferry Project

and Prospects to Protect the Tuolumne River

from Further Development

        Whereas a conventional, internal benefit-cost analysis can provide useful
information to the developers of the Clavey-Wards Ferry Project regarding
whether or not this additional hydroelectric development in Tuolumne River
Canyon will be financially profitable for them, such an analysis says nothing
about the economic merits of the Project from a broader, social perspective.
A public policy decision on whether to protect the Tuolumne River through
Federal designation as a Wild and Scenic River or as a Wilderness Area calls
for such a broad social perspective. Indeed, Congressional action should not
be based upon the private interests of two or three electrical utilities, but
upon broader social interests, reflecting regional and national perspectives.
Hence, it is necessary to ask whether the greater public interest lies in
construction of the proposed Project or in preservation of the River in its
natural state.

        The social benefit-cost analysis documented in this study provides
precisely such a comprehensive assessment. Based upon applications of widely
accepted economic evaluation techniques, the analysis leads to the inescapable
conclusion that construction of the Clavey-Wards Ferry Project would result in
a net annual loss to society of more than $26 million.

        Thus, the central question which was asked at the beginning of the study
may be answered. Developing the remaining reach of the Tuolumne River is not
economically justified in relation to the measurable recreational and
environmental benefits which would be lost.

        The quantitative analysis indicates that the greater public interest lies
not in the construction of the proposed Clavey-Wards Ferry Project, but in the
preservation of the Canyon and this important stretch of the River in their
natural state. Therefore, this study concludes that Congress should act to
protect the Tuolumne through designation as part of National Wild and Scenic

River System or National Wilderness Preservation System.3

Over the long run it is likely that the economic feasibility of the Clavey-Wards Ferry Project will decrease even further. This is because, in general, the value of natural recreation amenities is likely to increase at a rate greater than that of electricity, as the demand for wilderness resources becomes ever greater in an increasingly urbanized society (Mishan 1982):

> the value of man-made assets might well decline over
> time relative to resources of natural beauty that
> are preserved by national parks, since the former
> are becoming increasingly abundant and the latter
> are becoming increasingly scarce (p. 307).

Demand for wilderness recreational opportunities will increase along with population growth, increases in real per capita income, reduction in the work week and improvements in travel conditions (Clawson and Knetsch 1966). Also, demand for (and value of) wilderness recreation sites will increase due to continuing growth of urban areas (Mishan 1982).4

There is another important implication of this study with respect to the decision of whether or not to provide protection to the Tuolumne through a Wild and Scenic or Wilderness Area designation, and thereby to disallow, at least for the time being, further hydroelectric development of the River. As recent advances in economics have pointed out, when the future net benefits of a development project are at best uncertain and when a current decision to proceed with that project would lead to irreversible damage to the natural environment, current development policies ought to be more "conservative" than

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3Legislation has been introduced in both the U.S. Senate and House of Representatives to protect the Tuolumne River under the Wild and Scenic Rivers Act (16 U.S.C. Sections 1271-87). S. 142 (Cranston) and H.R. 2474 (Dellums) (98th Congress, 1st Session) would provide for the designation of the Tuolumne River as a Wild and Scenic River from its sources on Mount Dana and Mount Lyell in Yosemite National Park to the headwaters of the New Don Pedro Reservoir. Under Section 7(a) of the Wild and Scenic Rivers Act, the enactment of either of these bills would prohibit construction of the proposed Clavey-Wards Ferry Project (16 U.S.C. Section 1278(a)). In addition, S. 1515 (Wilson) could designate the Tuolumne River Canyon for inclusion in the National Wilderness Preservation System (16 U.S.C. Sections 1131-36).

4In the case of Tuolumne River whitewater boating, there is in fact already a clear trend of increasing demand over time (U.S. Department of Agriculture and U.S. Department of the Interior 1979).

they might otherwise be in the absence of such irrevocable decisions. This is because a more "conservative" resource-exploitation policy allows for the maintenance of greater flexibility in the long run:

> Uncertainty and irreversibility dictate caution and conservatism in natural resource decisions (Fisher and Krutilla 1974, p. 105).

> In the field of resource exploitation there is very good reason for not doing today something that can be postponed until tomorrow: for tomorrow we shall know more (Dasgupta 1982, p. 200).

The Limitations of Benefit-Cost Analysis

and its Proper Role in Decision-Making

Earlier in this chapter, it was argued that those environmental externalities of a hydroelectric project which can be accurately quantified, should be so quantified and internalized where possible within a benefit-cost framework for appropriate agency review. The reasoning behind this is straightforward.

Environmental impacts of proposed hydroelectric projects have historically been evaluated qualitatively and kept separate and distinct from any quantitative, economic analysis. But this approach has led to the virtual disregard of environmental concerns in licensing decisions by the Federal Energy Regulatory Commission (FERC). On the other hand, quantification, monetization and internalization of environmental externalities within benefit-cost assessments of hydroelectric projects is fully consistent with Federal policy, as articulated by the new "Principles and Guidelines" (U.S. Water Resources Council 1982a).

As this study has demonstrated, advances in theoretical and applied economics have made it possible to quantify and internalize at least some environmental values. If (some) environmental impacts can be accurately evaluated in monetary terms and internalized within a project assessment, those environmental concerns are likely to receive greater weight than otherwise in the FERC licensing process. Hence, what _can_ be quantified, _should_ be quantified. In the case of FERC, "not placing a value on recreation is . . . equivalent to placing a zero value on it" (Clawson 1959, p. 2).

Certainly, there are numerous limitations to benefit-cost analysis as an aid in decision-making. Those limitations lead to the conclusion that the B/C criterion, whether expressed as a ratio or as a difference, ought not be employed in hydroelectric assessments as either a _necessary_ or a _sufficient_

condition for project investment:

(1) If externalities have been excluded, the calculated B/C ratio may exceed 1.0, while total (social) benefits are actually less than total (social) costs.

(2) Given a particularly long discount period and a positive discount rate, the B/C ratio may exceed 1.0 only because future consequences have been ignored.

(3) In general, B/C analysis only examines efficiency questions. A project may be socially efficient, but inequitable in terms of its distributional impacts.

(4) The avoided-cost measure of project benefits, regularly utilized by FERC, may lead to a B/C ratio which is greater than 1.0 simply because both the hydro project and its alternative are economically undesirable, although the hydro project is less so.5

A benefit-cost analysis should therefore be only the first step in hydroelectric project assessment. If the project is found to have a B/C ratio less than 1.0, serious questions obviously exist regarding the economic feasibility of the proposed project. And if the ratio is found to be greater than 1.0, other questions remain, such as whether there are distributional effects, what they are and whether or not they are desirable.

When particular categories, of benefits or costs, such as those associated with environmental impacts, are systematically excluded from an economic assessment, benefit-cost analysis loses its potential value as an aid in decision-making. But if these so-called externalities are included in the analysis, a properly conducted benefit-cost study may provide a useful, coherent framework for assimilating diverse information regarding the relative merits of contemplated, alternative projects:

5This limitation of the avoided-cost measure of project benefits presents particularly fruitful areas for further study of Tuolumne River hydroelectric development proposals. Also, this limitation of the avoided-cost measure is particularly important in the present context. The consequence of using this type of benefit measure is that the only conclusions one may draw from the results are conditional ones of the form, "If the electricity which would be produced by the Project is truly needed, the B/C ratio of the Project is 0.877." If it turns out, under current investigation or future reality, that the Project is not "needed" for electricity production, the true B/C ratio will be substantially less than that estimated here.

In sum, a well-conducted cost-benefit study can be only a part, though an important part, of the data necessary for informed collective decisions (Mishan 1982, p. 199).

Benefit-cost analysis need not and cannot provide precise answers to policy questions. Rather it is a procedure that can provide a crude but highly useful picture of the relative merits of alternative policies (Lind 1982b, p. 24).

Public-policy decisions regarding the use of the nation's scarce natural resources are ultimately political decisions, and should remain so.

APPENDICES

APPENDIX 1: HETCH HETCHY WATER AND POWER SYSTEM
EXISTING PROJECT FACILITIES

WATER STORAGE AND REGULATION

Reservoir	Storage Capacity	Contributing Drainage Area
	(acre-feet)	(square miles)
Hetch Hetchy	360,360	455
Lake Eleanor	27,100	79
Lake Lloyd	268,000	117
New Don Pedro	2,030,000	1,533
TOTAL	2,685,460	2,184

POWER GENERATION

Powerhouse	Total Installed Capacity
	(kilowatts)
Robert C. Kirkwood	67,500
New Moccasin	90,000
Dion R. Holm	135,000
New Don Pedro	150,000
TOTAL	442,500

SOURCE: R. W. Beck and Associates. Hetch Hetchy Water and
Power System, Stage I Additions, Appraisal Report.
Prepared for the City and County of San Francisco,
Modesto Irrigation District and Turlock Irrigation
District. Seattle, Washington, January 1976.

APPENDIX 2:   FLOWS REQUIRED FOR MAINTENANCE
OF RECREATIONAL FISHERIES

        Several methods are commonly used for the determination of instream flow
requirements for fishery maintenance. Only one of these does not require
extensive field investigations (U.S. Department of the Interior 1979).   Given
the absence of such field investigations of the relevant sections of the
Tuolumne watershed, the present analysis is based upon the so-called "Montana
Method." Through an examination of natural, average annual flows, seasonal
minimum flow levels (which will provide protection for aquatic resources) may
be estimated (Tennant 1975). This approach usually provides satisfactory
preservation flows and is valid for streams with fluctuating flow regimes,
such as the Tuolumne and Clavey Rivers (Stalnaker and Arnette 1976).

        Tennant (1975) recommends a minimum instantaneous flow of 30 percent of
the average annual flow as "satisfactory" for fishery maintenance and 60
percent as "optimum." Others have indicated that releases of 30 percent or
less of average annual flow will severely damage or indeed destroy the
principal fisheries on a site (Hazel 1976).

        The present analysis utilizes the relatively conservative measure of 30
percent of the historic, annual average flow as being the absolute minimum
level which can in any sense be assumed to maintain the Tuolumne and Clavey
fisheries. Average annual flows are shown in Figure 5. This preliminary
estimate is supported by State and Federal fishery biologists (Bob Ehlers,
personal communication, June 1983; Jody Hoffman, personal communication, June
1983).

        Minimum flow releases for the Tuolumne River below Jawbone Diversion dam
would range from 330 cfs to 880 cfs with a yearly average of 495 cfs. For the
Clavey River, minimum flow releases would vary from 20 cfs to 100 cfs,
averaging 83 cfs.

        The assumed monthly distribution of fishery flow releases for the
Tuolumne River is nearly identical to the flow schedule recommended by the
U.S. Fish and Wildlife Service for the upper section of the river (U.S.
Department of the Interior 1976). The assumed flow distribution for the
Clavey River is approximately equal to the Clavey's actual, average seasonal
flow distribution (Appendix 17).

APPENDIX 3: PRESENT VALUE ANALYSIS

The present value of a stream of current and future beneits of a hydroelectric project may be defined as:

$$PV_b = \sum_{t=0}^{T} B_t(1 + i)^{-t} \, ,$$ (1)

where B_t = benefits in dollars realized in year t;

   i = discount rate; and

   T = length of project lifetime in years.

The present value of a stream of current and future costs of a hydroelectric project may similarly be defined as:

$$PV_c = \sum_{t=0}^{T} C_t(1 + i)^{-t} \, ,$$ (2)

where C_t = costs in dollars incurred in year t.

In order to examine the present value of all benefits and costs in terms of average annual values (annuities) over the life of the project, the present values may be "annualized" as follows:

$$AV_b = PV_b \, (i) \, [1 - (1 + i)^{-t}]^{-1}$$ (3)

$$AV_c = PV_c \, (i) \, [1 - (1 + i)^{-t}]^{-1}$$ (4)

A frequently used investment criterion, the benefit-cost ratio, B/C, can be calculated using either present values or annualized values:

$$B/C = PV_b/PV_c = AV_b/AV_c$$ (5)

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An alternative investment criterion, which does not necessarily result in identical ranking of a set of possible investment projects, is the net present value, NPV, defined as follows:

$$NPV = PV_b - PV_c \tag{6}$$

The so-called "annuity factor", AF, is used to levelize present values, as in equations (3) and (4) above:

$$AF = (i) \, [1 - (1 + i)^{-t}]^{-1} \tag{7}$$

Lastly, a present value factor for an escalating stream is used in the benefit-cost calculations of this study. The factor, F, for a stream escalating at i and discounted at r for n years is:

$$F = \{1 + i\} \, \{1 - [(1 + i)(1 + r)^{-1}]^{-n}\} \, (r - i)^{-1} \tag{8}$$

APPENDIX 4: CONCEPTUAL ISSUES ASSOCIATED
WITH ALTERNATIVE DISCOUNT RATES

There is a long and continuing debate within the economics profession regarding the appropriate discount rate for public investment projects. Four alternative rates are usually considered: (1) the social rate of time preference; (2) the consumption rate of interest; (3) the marginal rate of return on investment in the private sector; and (4) the opportunity cost of capital.

These alternative discount rates are examined in this appendix. Although much of the debate over appropriate discount rates has been on an academic plane, one recent study looked at the ways in which public and private electrical utilities actually identify discount rates for their own investment analysis (Corey 1982). This survey, which covered nearly half of the electrical generation capacity in the United States, indicated that utilities tend to use a discount rate which is significantly higher than the marginal cost of capital they experience.

The official position of the Federal Energy Regulatory Commission, expressed in its guidelines for hydroelectric power evaluation, is that for non-federal projects (such as Clavey-Wards Ferry), the overall cost of money to the project proponents should be used as the discount rate (U.S. Department of Energy 1979). This overall cost of money includes whatever sources are actually used. In the case of a private utility, this includes long-term debt (bonds), preferred stock and common equity; in the case of a public utility (as in this study), only the cost of long-term debt (bonds) is relevant.

The social rate of time preference is the rate at which society is willing to exhange present consumption for future consumption. Ideally, this is the appropriate rate with which to analyze a large-scale hydroelectric project. The problem, however, is that this rate is unobservable and hence must be estimated from other interest rates.

The consumption rate of interest is that rate at which individuals are willing to exchange consumption now for consumption in the future. The marginal rate of return on private investment is the incremental return on the last unit of investment by a private firm. Lastly, the opportunity cost of a public investment is the value of the private consumption and investment foregone as a result of that investment.

An alternative approach is to set the social rate of discount equal to the social rate of time preference and to account for the effects of the project investment on private capital formation through the use of the concept of the "shadow price" of capital. For a thorough discussion of this approach, see: Lind 1982b, pp. 39-55; Eckstein 1958; and Feldstein 1970.

In a theoretically ideal market economy, selecting a discount rate would be simple. The social rate of time preference and the opportunity cost of capital would both be appropriate and would be identical, both equal to the market rate of interest. But in a less than ideal world, the two rates diverge.

A body of literature exists which maintains that the social rate of discount should reflect both the consumption rate of interest and the marginal rate of return on private investment, respectively, insofar as private consumption and private investment are displaced. Hence, the social rate of discount should be a weighted average of the two rates, the weights being established in relation to the proportion of the public investment which is drawn from consumption and from private investment (Krutilla and Eckstein 1958; Haveman 1969; Howe 1971; Sandmo and Dreze 1971).

APPENDIX 5: REGIONAL TRAVEL COST METHOD (TCM) MODEL
FOR THE EVALUATION OF RECREATION DEMAND
AND NET CONSUMERS' SURPLUS

This appendix provides a detailed explanation of the regional travel cost method (TCM) model which is utilized in this study. Included are discussions of the major technical issues associated with TCM models and specifications of the variables and equations which constitute the TCM model used to evaluate recreation benefits foregone. The application of the TCM model for the Tuolumne River analysis is described in detail in Appendix 6.

The original suggestion for the travel cost method was made by Hotelling (1947), and early applications to outdoor recreation were made by Trice and Wood (1958), Clawson (1959) and Knetsch (1963). Advances in the methodology are exemplified by extensions of the original model by Burt and Brewer (1971) and by Cesario and Knetsch (1976).

Implicit assumptions and hypotheses of the TCM model proposed here include:

(1) specification: it is assumed that all relevant and statistically significant variables which affect recreation trip decisions are properly specified; the result is an unbiased slope estimate.

(2) capacity constraints: it is assumed that observed data points are the true demand points, i.e. there is no unobserved demand that is unsatisfied due to capacity restrictions.

(3) entry fees: it is assumed that an individual would react to an increase in entry fees in the same manner as to an increase in travel costs.

(4) single-destination trips: it is assumed that trips to the recreation site are not part of multiple-destination trips.

(5) homogeneity of on-site time: it is assumed that there is homogeneity across all trips with regard to time spent at the recreation site.

The suitability of these assumptions with regard to this study's application to the Tuolumne River is discussed in Chapter V and in Appendix 6.

The TCM model is based upon a simple model of participation in recreation at a given site by users who come from various areas of origin. First, the

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regional per capita visitation rate of recreators is posited as a function of the costs involved in traveling to and from the recreation site:

$$Q_i = f(TC_i) \qquad (1)$$

$$Q_i = V_i/n_i \qquad (2)$$

where Q_i = per capita visitation rate from origin i;

TC_i = average travel cost for a representative user from region i;

V_i = number of visitors from region i in year of analysis; and

n_i = population of region i in relevant year.

First, with regard to the left-hand side of equation (1), the per capita visitation rate can be interpreted as an expected participation rate for a representative user from each area of origin. An improvement in the measurement of such visitation rates would be (if data permits) to separate data into weekday and weekend trips (Cicchetti, Fisher and Smith 1976). Origin zones would ideally be defined as concentric rings around the recreation site, but for practical reasons associated with the availability of data on the independent variable(s), this is virtually never done (Johnston and Pankey 1968).

In most applications, as the distance from the site increases, the per capita visit rate from various zones decreases with no visits being observed from various intermediate and/or distant zones. A decision regarding the identication of zones must be made and could easily be arbitrary, yet the literature has not adequately addressed this problem. The approach used here is to establish the limits of the continental United States as the total area of consideration and to ensure that this total area is divided into zones which are mutually exclusive and exhaustive. While a degree of arbitrariness remains with regard to the total spatial limit (U.S.), this approach is consistent with the theoretical structure of the travel cost method (Clifford Russell, personal communication, June 1983).

Now, looking at the right-hand side of equation (1), it may be asked whether other independent variables, in addition to travel cost, ought to be included in the specification. In particular, should some measure of per capita income be included? Although there are certainly theoretical justifications for such a specification of the demand function, those empirical studies which have included an income variable have consistently reported statistically insignificant parameter estimates (for example,

Desvousges, Smith and McGivney 1983). Hence, income is not included as a separate independent variable in the TCM model.

Average travel cost for a representative user from a given region, i, consists of three principal components: actual transportation cost, opportunity cost of time spent traveling to and from the site, and opportunity cost of time spent on the site:

$$TC_i = TPC_i + OCT_i + OCS_i \qquad (3)$$

where TPC_i = transportation cost to and from the recreation site from region i;

OCT_i = opportunity cost of time spent traveling to and from the recreation site; and

OCS_i = opportunity cost of on-site time.

It is important to include provision for the opportunity cost of time. Ignoring this opportunity cost would produce potentially biased estimates of demand and of consumers' surplus (Cesario 1976), unless the marginal utility of travel time is zero and the time spent on site is independent of distance (Wilman 1980).

In the above specification (equation 1), transportation costs and time costs are combined within a single independent variable (travel costs) for purposes of econometric estimation. It has been suggested that these variables should be kept separate, but Allen, Stevens and Barrett (1981) attempted to utilize separate variables in a multiple regression framework, and concluded that it was difficult to distinguish separate effects, because of multicollinearity (Johnston 1972).

If individual visit data rather than aggregated zone averages were used for estimation, this problem might be reduced (Brown and Nawas 1973; Gum and Martin 1975). Further discussion of ways of dealing with the multicollinearity problem is provided by Maddala (1977, pp. 190-194). At any rate, most studies have estimated the cost of time and then added this to other transportation costs to derive a figure for total travel cost (Bishop and Heberlein 1979; Brown, Charbonneau and Hay 1978; Nicols, Bowes and Dwyer 1978; Cesario and Knetsch 1970).

Returning to the TCM model, for relatively nearby sites, transportation costs, TPC_i, are equal to the round-trip distance of each region (i) from the recreation site, $2 \times D_i$, multiplied by the average cost per mile of operating an automobile, CPM, divided by two persons per automobile:

$$TPC_i \;=\; (D_i)(CPM) \hspace{3cm} (4)$$

For more distant areas of origin, travel is assumed to be by air. In this case, transportation costs are equal to round-trip air fare plus automobile travel costs to the site from the nearest major airport:

$$TPC_i \;=\; RTA_i + (D_i)(CPM) \hspace{2cm} (5)$$

The next step is to estimate the opportunity cost of travel time. Bishop and Heberlein (1979) have demonstrated that the specific measure utilized can have a significant impact on estimates of total recreational value (consumers' surplus). The simplest approach to measuring time costs is to adopt the average hourly wage rate in the origin zone (or a weighted average reflecting the demographic makeup of the visitors).

A more flexible yet arbitrary approach is to use some fixed proportion of the relevant wage rate as the opportunity cost of time (Cesario and Knetsch 1970 and 1976; Nicols, Bowes and Dwyer 1978). In this frequently applied approach, the exact proportion is usually adopted from independent studies. Cesario (1976) used 0.33 as an approximation of this proportion (k in equation 6, below), but McConnell and Strand (1981) empirically found the proportion to be 0.6 in an analysis of Chesapeake Bay recreational fishing.

It should be noted that Johnson (1983) has pointed out that the ratio, k, is equal to 1.0 under a three-part sufficient condition: (1) the tax rate is zero; (2) marginal earnings are constant; and (3) nonwork income equals zero. Johnson notes that because the McConnell and Strand (1981) specification ignored the possibility of utility being derived from travel and the demand-shifting nature of family income, their results underestimate the opportunity cost of time and hence underestimate consumers' surplus.

Smith, Desvousges and McGivney (1983) evaluated all current proposals for valuing travel time in the specification of recreation demand models, and concluded that the wage rate itself (i.e., k=1) provides a plausible approximation of the opportunity cost of travel time. In particular, they state that on an empirical basis "there is greater support for the use of the wage rate as a measure of the opportunity cost of travel time than the Cesario that "it is even possible that k is greater than one and that equating the opportunity cost of travel to average wages underestimates the value of time" (p. 170).

This issue continues to be a troublesome one. It has been suggested that Schultz's (1972) work on the economic value of human time together with conceptual work of Linder (1970) and Baumol (1973) and comments by Phelps (1973) may provide the basis for synthesizing a broader conceptual basis for empirical work. In the meanwhile, the TCM model developed here provides for

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the identification of a value for k, and in the application to the Tuolumne (Appendix 6), k is conservatively assumed to be equal to 0.6.

Thus, opportunity costs of time are a function of the average wage rate in each region, the time spent traveling to and from the site, the time spent on-site, and the constant factor, k, $(0 < k < 1)$ which indicates what fraction of the wage rate is assumed to equal the opportunity cost of leisure time. For areas which are reached by automobile, the opportunity cost of travel time is

$$OCT_i = (D_i/50 \text{ mph})(w_i)(k),\tag{6}$$

and for regions from which air transport is utilized,

$$OCT_i = (2 \text{ days})(8 \text{ hrs/day})(w_i)(k)\tag{7}$$

where w_i = average wage rate of users from region i; and

          k_i = a constant assumed to be equal to the opportunity cost of leisure time divided by the hourly wage rate.

With regard to the opportunity cost of time spent at the recreation site, Wilman (1980) derives different implicit valuations for travel and on-site times, but Desvousges, Smith and McGivney (1983) maintain that "the existing literature does not provide an unambiguous theoretical justification for distinguishing the valuation assigned to the travel and on-site time components of a recreation experience" (p. 7-7). Therefore, the opportunity cost of time spent on the recreation site is defined as follows:

$$OCS_i = OST(w_i)(k)\tag{8}$$

where   OST = on-site time (measured in 8-hour days).

Equation (1) is statistically estimated from empirical data on the usage of the recreation site and the costs of travel and time for users from all origins. Various functional forms have been utilized in previous empirical work, and the choice of functional form can have a significant impact on estimates of consumers' surplus (Ziemer, Musser and Hill 1980).

Linear specifications have been the most widely used in empirical

applications of the travel cost method, presumably because of computational and analytical ease (Burt and Brewer 1971; Brown, Singh and Castle 1964; Cicchetti, Fisher and Smith 1976; Clawson and Knetsch 1966). Also, the U.S. Water Resources Council's (1983a) "Principles and Guidelines" implicitly endorse a linear functional form. But ". . . the linear demand curve is rarely in accord with either a sensible theory of the individuals' decisions or with typically observed data" (Bowes and Loomis 1982, p. 408). Vaughan, Russell and Hazilla (1982) conclude that "a priori linear specification is particularly dangerous, . . . especially . . . if an estimate of total site value is desired . . ." (p. 406).

Other researchers have utilized a log-log (double logarithmic) form (Kalter and Gosse 1969; Smith 1975; Wetzstein and Green 1978; Menz and Wilton 1983; Grubb and Goodwin 1975; Smith and Kopp 1980), a quadratic form (Gum and Martin 1975), or a semilog form (Batie, Jensen and Hogue 1976; Sawyer and Shulstad 1976; Smith and Kopp 1980; Smith 1975b; Ziemer, Musser and Hill 1980).

Although the double log form has been known to give a superior result in terms of goodness-of-fit, the semilog functional form has a logical shape (a positive intercept on the quantity axis) and typically has goodness-of-fit measures only slightly less than those of the double log form. Lastly, a number of studies have contrasted functional forms and have found the semilog form to be preferable (Smith 1975b; Ziemer, Musser and Hill 1980; Smith and Kopp 1980; Desvousges, Smith and McGivney 1983).

Once a functional form is identified, other problems associated with econometric estimation may remain. When the zones of origin have unequal populations, ordinary least squares (OLS) will "not lead to desirable estimates of per capita demand curves" (Bowes and Loomis 1980). Heteroskedasticity is introduced due to the grouping of samples of unequal size (Maddala 1977, pp. 268-274; Johnston 1972, pp. 214-221).

The usual approach to dealing with this problem is through the employment of generalized least squares (GLS) estimation or weighted least squares, which is a special case of GLS (Prais and Atkinson 1954; Christensen and Price 1982; Vaughan, Russell and Hazilla 1982; Bowes and Loomis 1980; Haspel and Johnson 1982).

It should be noted, however, that although the heteroskedasticity will result in inefficient OLS estimates (non-minimum variances of the estimated parameters) and biased estimates of the variances of the estimated parameters, the parameter estimates themselves will be unbiased and consistent. Hence, OLS estimation will lead to unbiased estimates of per capita demand and thus of consumer surplus.

Once the per capita participation function has been estimated for each region, the next step is to derive the implied demand for and economic value of the resource from the participation equation. Several methods have been used. One approach is to calculate the site's economic value as the area

under an aggregate demand curve for the site (Cesario and Knetsch 1976; Grubb and Goodwin 1968); another approach is to use the participation equation to derive a demand curve and economic value for the site from each origin, and then to aggregate across all origins to estimate the site's total economic value (McConnell and Strand 1981).

The method utilized in the TCM model of this study is to determine the site's value for each origin and aggregate across all origins. This "single-step" approach eliminates the derivation of the demand function, and depends exclusively on the participation function (Menz and Wilton 1983). Thus, each origin's demand for the site is estimated using the participation equation, and the net economic value for the site from each origin is calculated by taking the definite integral of the participation equation between the limits of the actual travel costs for the specific origin and the maximum willingness-to-pay. The total economic value (consumers' surplus) is found by adding together the net economic values for all of the origins.

This direct approach to estimating total economic value of the recreation site from the single participation equation is based upon the fact that aggregate demand is equal to the horizontal summation of individual demands. Thus, net economic value is equal to the summation of the areas above actual expenditures.

APPENDIX 6: APPLICATION OF THE REGIONAL TRAVEL COST METHOD (TCM) MODEL TO THE EVALUATION OF WHITEWATER RECREATION ON THE TUOLUMNE RIVER, CALIFORNIA

This appendix provides, in the immediately following section, a brief summary of the variable definitions and equations which constitute the travel cost method (TCM) model used in this study to evaluate recreation benefits foregone (a more thorough description of the TCM model is provided in Appendix 5). In the second section of this appendix, the application of the model to an analysis of whitewater boating (rafting) on the Tuolumne river is described in detail.

A. EQUATIONS AND DEFINITIONS

The regional TCM model is based upon a simple model of participation in recreation at a given site by users who come from various areas of origins. First, the regional per-capita visitation rate of recreators is posited as a function of the costs involved in traveling to and from the site (in this case, the town of Groveland, Califonia, near the Tuolumne River):

$$Q_i = f(TC_i) \tag{1}$$

$$Q_i = V_i/n_i \tag{2}$$

The total number of visitors (rafters) from each region using the site in the year for which the calculations are carried out, 1994, is estimated separately for two groups: persons going on commercially operated rafting trips and persons rafting the river independently:

$$V_{i\text{-total}} = V_{i\text{-commercial}} + V_{i\text{-private}} \tag{3}$$

$$V_{i\text{-com}} = (\% \text{ from region } i)(6400 \text{ users/season}) \tag{4}$$

$$V_{i\text{-pri}} = (\% \text{ from region } i)(9114 \text{ users/season}) \tag{5}$$

$$n_i = (\text{Population of region } i_{1980})(1 + \text{growth rate})^{14} \tag{6}$$

Average travel cost for a representative user from a given region, i, consists of three principal components: actual transportation cost, opportunity cost of time spent traveling to and from the site, and opportunity cost of time spent on the site:

$$TC_i = TPC_i + OCT_i + OCS_i \qquad (7)$$

In the case of visitors coming from within California and from other states west of the Rocky Mountains, actual transportation costs are calculated as the cost of operating an automobile, while for visitors from other parts of the United States, round-trip air fares are utilized:

$$\{\text{West of Rockies}\} \quad TPC_i = D_i(CPM) \qquad (8)$$

$$\{\text{East of Rockies}\} \quad TPC_i = RTA_i + D_{Sac}(CPM) \qquad (9)$$

Opportunity costs of time are a function of the average wage rate in each region, the time spent traveling to and from the site, the time spent on-site, and a constant factor $(0 < k < 1)$ which indicates what fraction of the wage rate is used as a proxy for the opportunity cost of leisure time:

$$\{\text{West of Rockies}\} \quad OCT_i = (D_i/50)(w_i)(k) \qquad (10)$$

$$\{\text{East of Rockies}\} \quad OCT_i = (2 \text{ days})(8 \text{ hrs/day})(w)(k) \qquad (11)$$

$$OCS_i = OST(w_i)(k) \qquad (12)$$

The variables used in the model are defined as follows:

Q_i = per capita visitation rate from region i;

$V_{i-total}$ = number of visitors from region i in year 1994;

V_{i-com} = number of visitors from region i going on commercial rafting trips in year 1994;

V_{i-pri} = number of visitors from region i going on private rafting trips in year 1994;

n_i = predicted population of region i in year 1994;

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TC_i = average travel cost for a representative user from region i;

TPC_i = transportation cost to the site from region i;

OCT_i = opportunity cost of time spent traveling to and from the site;

D_i = distance from region i to site;

CPM = average cost per mile of operating an automobile;

RTA_i = round trip air fare to Sacramento, California from region i;

W_i = average wage rate of region i;

OCS_i = opportunity cost of on-site time; and

OST = on-site time.

B. APPLICATION OF THE TCM MODEL TO TUOLUMNE RIVER WHITEWATER RECREATION

Before proceeding with the application of the TCM model, it is essential to examine briefly the various implicit assumptions of the general model, in the context of the proposed Tuolumne application.

Suitability and Implications of Assumptions

First of all, it should be noted that the TCM model, at best, produces a measure of consumers' willingness-to-pay for a recreational opportunity, but such a measure necessarily underestimates the true cost associated with the loss of that opportunity. Mishan (1982) points out that although willingness-to-pay is an appropriate measure in a B/C analysis for the benefits associated with the introduction of a good or service,

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> . . . if the public good, say a park or wilderness
> area, is already there, and the issue to be decided
> is whether to transform it into an industrial
> estate, the benefits that would have to be foregone
> in destroying the area --- which benefits have to be
> compared with the benefits of the industrial estate
> --- have to be calculated in terms of minimum
> compensatory payments to existing park or
> wilderness-area beneficiaries, including those
> beneficiaries whose welfare arises from option
> demand and non-participant demand. Granted that
> welfare effects are normal (or positive), the
> measure of _the benefits forgone from losing the area
> exceeds_ the measure of _the benefits gained by
> introducing the area, and this difference in
> measurement may be crucial in the decision_ (pp. 313-314).

In technical terms, Mishan is simply pointing out that if recreation is a "normal commodity" (positive income elasticity of demand), which it certainly is, then because the Hicksion (compensated) demand function is of greater slope (less responsive to price changes) than the Marshallion (Walrasian) demand function, compensating variation (the correct welfare-change measure) will exceed Marshallion consumer surplus, which will in turn exceed the equivalent variation. Thus, the TCM model produces a lower-bound estimate of the economic loss associated with the elimination of rafting on the Tuolumne.

Use of the TCM model implicitly assumes that all visits to the River (for the purpose of rafting) are essentially single-destination trips. Haspel and Johnson (1982) have demonstrated in an examination of users of Bryce Canyon National Park that an incorrect assumption of single-purpose trips leads to substantial differences in the estimated travel-cost demand functions; and Smith and Kopp (1980) have provided a method for detecting when violations of this and other assumptions of the TCM model are severe.

In the case of persons rafting the Tuolumne, whether on commercial trips or as individuals, single-destination trips are the rule, rather than the exception (Scott Armstrong and Steve Cutwright, personal communications, May 1983). Nevertheless, it should be noted that in the Tuolumne application, the distant regions are eliminated from the consumers' surplus in the linear model and have relatively little effect on the results in the semilog and double log models.

On another issue, if substitute recreation sites exist they will of course influence demand. Several methods have been developed for dealing with such situations:

(1) use of an index with the relevant site's demand function of the relative attractiveness and availability of alternative sites (Ravenscraft and Dwyer 1978; Talhelm 1978);

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(2) specification of the model to include travel costs of substitute recreation sites (Burt and Brewer 1971; Cicchetti, Fisher and Smith 1976); and

(3) respecification of the utility function in terms of attributes of recreation sites (Morey 1981).

In the case of whitewater rafting on the Tuolumne, however, true substitute sites do not exist within a relevant geographic range. The U.S. Army Corps of Engineers has described the affected reach of the River from Lumsden to Wards Ferry as "one of the finest whitewater boating rivers in the Nation" (State of California 1982). Calhoun (1981) describes the quality of the recreation experience this way: "Long considered the prime test of technical rafting in the western United States, the main Tuolumne boasts more than 60 rapids, including a dozen class IV's and one class V, Clavey Falls" (p. 102). In fact, according to the American River Touring Association, comparable experiences are found only on the Colorado River in the Grand Canyon and on the Salmon River in Idaho (Steve Cutwright, personal communication, July 1983).

It is also important to note that because the Tuolumne TCM model applies to the possible elimination of an existing site, the problem of competition with other sites does not arise in the context of estimating the participation function. Preferences for alternatives are already reflected in the use data (Clifford Russell, personal communication, September 1983). The significance, then, of alternative sites is that their existence places an upper bound on the magnitude of consumer surplus lost through elimination of the site in question.

Lastly, it should be noted that the impact of not including substitute sites in the model is indeterminate in direction because of uncertainty over the positive or negative nature of the correlation between the availability of substitute sites and their distance from the Tuolumne site (Dwyer, Kelly and Bowes 1977).

Use of the travel cost method often assumes that the same method of travel is used for visitors from all regions of origin, a questionable assumption if visitors come from a broad range of distances. The TCM model, however, does not assume this, but instead provides for surface vehicle transportation for users coming from within California and other western states and air transportation for all others.

With regard to the assumption of homogeneity of on-site time (see Appendix 5), the employment of this assumption in the Tuolumne analysis tends to bias the estimated participation function in such a way that the estimated elasticity of demand is an overestimate of the true elasticity. The impact of this upon the estimates of consumers' surplus (the area under the demand function) is indeterminate, and, at any rate, insignificant considering the role which on-site time plays in the calculation of total travel cost.

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One last assumption of the TCM model regards the non-existence of capacity constraints (Appendix 5); that is, it is assumed that there is no unobserved demand which is unsatisfied due to capacity restrictions. In fact, permit limitations are already constraining commercial rafting trips (Robert Volpert, personal communication, May 1983; Joseph Daly, personal communication, June 1983), and it is probable that by the year 1994 (the time of the TCM analysis), an overall capacity constraint will indeed have been reached for rafting on the Tuolumne.

What is the implication of this for the TCM analysis? Wetzel (1977) has indicated that if the recreation site being investigated with the travel cost method (TCM) is already congested or likely to become so within the time period of the analysis, then the TCM model will underestimate recreation benefits foregone. Beyond the scope of this study, but of related interest, is an extensive literature on the effects of congestion on the willingness to pay for recreational experiences: Fisher and Krutilla 1972; Cicchetti and Smith 1973; Anderson and Bonsor 1974; McConnell 1977; Deyak and Smith 1978; Stevens and Allen 1980; Anderson 1980; Menz and Mullen 1981; Smith 1981; and Walsh, Miller and Gilliam 1983.

Specification of the Tuolumne TCM Model

The application of the regional TCM model to whitewater recreation on the Tuolumne River is based upon an analysis of the origins from which visitors travel in order to raft the River. The per-capita visitation rate of rafters from various geographic origins is examined as a function of the costs involved in traveling to and from the town of Groveland, Califonia, near the Tuolumne River (Appendix 11):

$$Q_i = f(TC_i) \qquad (1)$$

Regions of origin were identified in a manner consistent with the theoretical foundations of the TCM. Given the limitation that most aggregate socio-economic data are available according to political jurisdictions, such as counties, regions were established which exhibited relatively small variance in the distance from various points within each region to the recreation site. In other words, a compromise was struck between the theoretically ideal usage of narrow, concentric rings around the recreation site and the practical availability of empirical data on the components of the independent variable.

The dependent variable, annual per capita visitation rate, is equal to the number of rafters from each region projected to raft the Tuolumne in 1994, the year of the analysis:

$$Q_i = V_i/n_i \qquad (2)$$

The total number of visitors (rafters) from each region using the site in the year for which the calculations are carried out, 1994, is estimated separately for two groups: persons going on commercially operated raft trips and persons rafting the river independently:

$$V_{i\text{-total}} = V_{i\text{-commercial}} + V_{i\text{-private}} \qquad (3)$$

To estimate V_i, the percentage of users currently rafting the Tuolumne from the various regions was calculated from survey data collected from rafting companies operating on the River, from a 1979 U.S. Forest Service sample of non-commercial rafters and from current-year permits issued by the Forest Service (Bill Lane, personal communication, June 20, 1983). This regional frequency distribution was utilized together with a relatively conservative estimate of future total use in each category:

$$V_{i\text{-com}} = (\% \text{ from region i})(6400 \text{ users/season}), \qquad (4)$$

$$V_{i\text{-pri}} = (\% \text{ from region i})(9114 \text{ users/season}) \qquad (5)$$

Future total commercial users were estimated as the maximum number of launch permits issued per season by the U.S. Forest Service multiplied by the average number of passengers per trip (Bill Lane, personal communication, June 20, 1983):

(400 launches/season) x (16 passengers/launch) =

6,400 commercial passengers per season in 1994.

Future total non-commercial users were estimated as the maximum number of permits issued per day by the U.S. Forest Service to private parties multiplied by 245 average rafting days per year. This yielded the predicted number of trips per year, which was then multiplied by an average of 9.3 passengers per trip (Bill Lane, personal communication, June 20, 1983):

(4 permits/day) x (245 rafting days/season) x (9.3 users/permit)

= 9,114 private users per season in 1994.

Thus, the total number of predicted rafters in the year 1994 is 6,400 + 9,114 = 15,514. Note that in estimating the future number of rafters on the River, the current maximum number of permits issued per season was utilized in the calculations. The result is a tendency to underestimate total 1994 usage levels, since it is probable that the continually increasing demand for

whitewater recreation sites will result in higher permit limits in the future than currently exist.

In order to express usage levels for each region as per capita rates, it was necessary to estimate each region's 1994 population:

$$n_i = (\text{Population of region } i_{1980})(1 + \text{growth rate})^{14} \qquad (6)$$

For regions of origin within the State of California, the annual rates of growth of the zonal populations were calculated from the 1980 Census of Population (U.S. Department of Commerce, Bureau of the Census 1981) and county projections for the year 1995 (County Supervisors Association of California 1981). Individual growth rates were calculated for the five most populous California regions, while a statewide rate was used for other parts of the State.

For all non-California regions, the annual rate of growth of the U.S. population was used, based upon an interpolation of the 1980 Census of Population (U.S. Department of Commerce, Bureau of the Census 1981) and the Bureau of the Census' predictions for 1995 (U.S. Department of Commerce, Bureau of the Census 1982). Considering the fact that the regions near the River may be growing faster than those farther away, the "smoothing" implied by the simple average may introduce a systematic error.

Average travel cost for a representative user from each region consists of three principal components: actual transportation cost, opportunity cost of time spent traveling to and from the site, and opportunity cost of time spent on the site:

$$TC_i = TPC_i + OCT_i + OCS_i \qquad (7)$$

In the case of visitors coming from within California and from other states west of the Rocky Mountains, actual transportation costs were calculated as the cost of operating an automobile, while for visitors from other parts of the United States, round-trip air fares were utilized.

Thus, for regions west of the Rocky Mountains (Region C and westward), it was assumed that rafters drive to the Tuolumne River. The one-way distance, D_i, from the population node of region i to Groveland (Rand McNally and Company 1983) was utilized because it was assumed that two rafters would share a vehicle and all driving expenses. This mileage was multiplied by the average cost per mile (CPM) of operating a motor vehicle.

To calculate CPM, the costs of operating various classes of motor vehicles (U.S. Department of Transportation 1982) were inflated to 1994 levels by a general price inflation rate of 6%/year (Data Resources, Inc. 1982) for

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the non-fuel cost components, and by an inflation rate of 10.14%/year for the fuel components (Data Resources, Inc. 1982). An overall average cost per mile was then calculated as the weighted average of each vehicle class (Kulp and Holcomb 1982). This average cost per mile is the CPM found in equation (8):

$$\{\text{West of Rockies}\} \quad TPC_i = D_i(CPM) \quad\quad (8)$$

For regions east of the Rocky Mountains (region D eastward), it was assumed that users would travel by air to Sacramento, California, and from there to Groveland by automobile. Transportation costs consisted of the standard round-trip coach airfare from the regional population node to Sacramento (Bernadette Adrego and Kim Krocker, personal communications, July 13, 1983), inflated by the general price inflation rate of 6%/year to the year 1994. This yields the term RTA_i in equation (9). Road travel from Sacramento to Groveland was calculated as in equation (8).

$$\{\text{East of Rockies}\} \quad TPC_i = RTA_i + D_{Sac}(CPM) \quad\quad (9)$$

Opportunity costs of time are a function of the average wage rate in each region, w_i, the time spent traveling to and from Groveland, the time spent on-site, and a constant factor ($0 < k < 1$) which indicates what fraction of the wage rate is used as a proxy for the opportunity cost of leisure time.

For areas west of the Rockies, the opportunity cost of time spent traveling to and from the site is as follows:

$$\{\text{West of Rockies}\} \quad OCT_i = (D_i/50)(w_i)(k) \quad\quad (10)$$

OCT_i is found by dividing D_i by 50 miles per hour to determine travel time, multiplying this by the 1994 wage rate of each region, and then multiplying the result by $k = 0.6$, the estimated ratio of the opportunity cost of leisure time to that of time spent in employment (Cesario 1976). Using the average regional wage rate underestimates the true opportunity cost of time for Tuolumne whitewater recreationists, because the distribution of income of these users falls in the upper end of the income distribution of the general population (Steve Cutwright, personal communication, June 1983).

Using 0.60 as the assumed value for k is in keeping with much of the applied economics literature on the travel cost method, in which the opportunity cost of leisure time has been repeatedly assumed to be approximately 60% of the hourly wage rate (McConnell and Strand 1981). Note, however, that Johnson (1983) indicates that under a wide variety of conditions, k may actually be greater than unity, which would significantly

increase estimated opportunity costs of time and hence travel costs (and estimated consumers' surplus) in the present model.

For areas east of the Rocky Mountains, the opportunity cost of travel time was estimated as follows:

$$\{\text{East of Rockies}\} \quad OCT_i = (2 \text{ days})(8 \text{ hrs/day})(w)(k) \quad (11)$$

In this case, OCT_i was calculated by assuming 2 days of round-trip travel per user including both air and road time. This was multiplied by an assumed 8-hour work day and the product multiplied by 60% of the wage rate, as above.

The wage rate for each California region was determined by inflating current regional wage rates (U.S. Department of Labor, Bureau of Labor Statistics 1983) by 6%/year to the year 1994. Wage rates for non-California regions were determined by calculating a population-weighted average of the component state average wage rates (U.S. Department of Labor, Bureau of Labor Statistics 1983) and inflating to the year 1994 as above.

Lastly, the opportunity cost of time spent at the recreation site is found by multiplying on-site time, OST (in terms of 8- hour days) by the appropriate wage rate and by $k = 0.60$:

$$OCS_i = OST(w_i)(k) \quad (12)$$

OST was assumed to be 3.5 days per person per trip, the current average duration of Tuolumne rafting experiences, including 2.5 days on the river and a half day before and after the actual rafting trip (Steve Cutwright, personal communication, June 15, 1983).

Econometric Estimation of Participation Functions

The next step in applying the TCM model to the Tuolumne River analysis is to statistically estimate the whitewater recreation participation function (Appendix 13), using linear, semilogarithmic and double logarithmic functional forms. Because the semilog form has a logical shape and gives a reasonably good fit (in terms of R^2 and t-statistics), it is utilized in the major calculations of the SBC model. The alternative functional forms are used in the sensitivity analyses of Part VI of the study. A thorough examination of all three functional forms is provided in Appendix 5.

Calculation of Consumers' Surplus

The final step is to utilize the estimated participation function to determine the whitewater recreational user value of the Tuolumne for each origin and to aggregate these values across all origins (see Appendix 5 for detail). This is done by evaluating the definite integral of the participation equation between maximum travel cost and the actual, average travel cost for each origin, multiplying each of the consequent per capita regional consumers' surplus figures by the regional population, and summing the results (Appendices 14, 15 and 16).

APPENDIX 7: USE AND INTRINSIC VALUES OF ENVIRONMENTAL RESOURCES FROM PREVIOUS EMPIRICAL STUDIES, 1974-1983

Study	Site	Estimates ($1994/household/yr)[a]		Ratio of Nonuse to Use
		Use	Nonuse	
Meyer 1974	Fraser River, British Columbia	1943	1051	0.54
Horvath 1974	Southeastern U.S.	5914	3296	0.56
Dornbusch and Falcke 1974	Communities along seven U.S. bodies of water	--	--	1.39
Meyer 1978	Fraser River, British Columbia	601	754	1.25
Walsh, Greenley Young, McKean and Prato 1978	South Platte River, Colorado	264	138	0.52
Mitchell and Carson 1981	U.S. national	540	253	0.47
Cronin 1982	Potomac River	88	63	0.72
Desvousges, Smith and McGivney 1983	Monongahela River	109	71	0.65
Cronin (forthcoming)	Potomac River	92	73	0.79
	AVERAGE VALUES	1194	712	0.60[b]

[a]Inflated at CPI to 1982 and at 6%/year to 1994.

[b]Does not include results from Dornbusch and Falcke 1974.

SOURCE: Fisher, Ann and Robert Raucher. "Intrinsic Benefits of Improved Water Quality: Conceptual and Empirical Perspectives." _Advances in Applied Microeconomics_, ed. V. Kerry Smith. JAI Press, Inc., forthcoming.

APPENDIX 8:   CLAVEY–WARDS FERRY PROJECT PROFILE

PROFILE
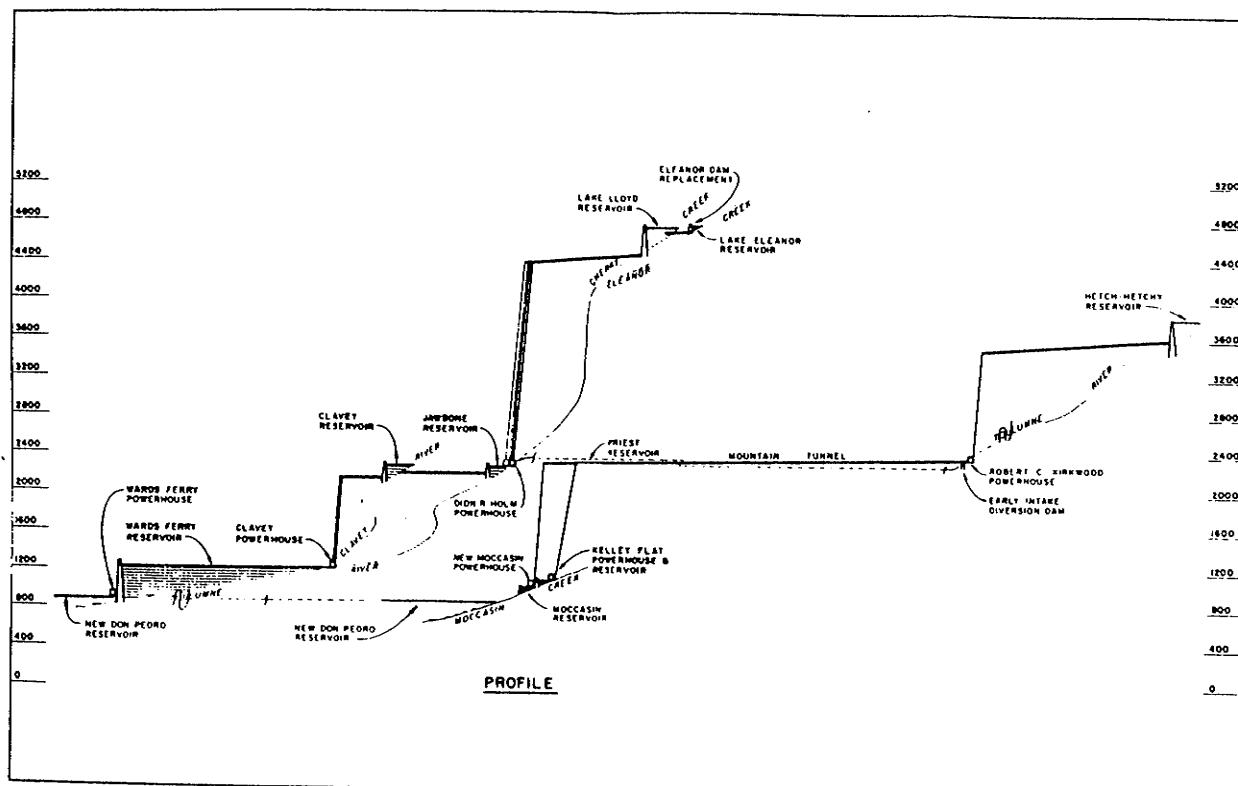
SOURCE: Clair A. Hill & Associates and R. W. Beck and Associates.   Report on
Potential Additions to the Hetch Hetchy Power Supply System.   Prepared
for the Public Utilities Commission, City and County of San Francisco,
January 1968.

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 1| ********* CLAVEY-WARDS FERRY BENEFIT COST ANALYSIS ********
 2|                      EDF/SBC MODEL
 3|              INTEREST RATE= .1072
 4|                      GPI= .06
 5|                       N= 50
 6|          ANNUITY FACTOR= .1078630846588162
 7|      CONSUMER SURPLUS-CA= 2642541
 8|                  NON-CA= 456956
 9|
10|      COST BID-83,SERVICE-87= 370047072
11|       ANN.ESC.TO SERVICE-91= 467175902.5797198
12| ACCOUNTING FOR 7YR.CONSTR.= 242931469.3414543
13|               LAST 3YRS. 74280968.51017541
14|                          83987015.06794789
15|                          94590375.7235289
16|                        = 495789828.6431065
17|             CONTINGENCIES= 74368474.29646598
18|    TOTAL CONSTRUCTION COST= 570158302.9395725
19|    ENGR. AND ADMIN. COSTS= 71269787.86744656
20|        TOTAL PROJECT COST= 641428090.8070191
21|
22|      1      BOY        CN    .5 x r    r x      EOY
23|      7      CWIP             x CN  BOY CWIP    CWIP
24|    .12 0              .12   .006432 0         .126432
25|    .12 .126432        .12   .006432 .013554  .266417510
26|   .135 .2664175104    .135  .007236 .028560  .437213468
27|   .145 .43721346751488 .145 .007772 .046869  .636854751
28|    .15 .6368547512324751 .15 .00804 .068271  .863165581
29|    .16 .8631655805645964 .16 .008576 .092531 1.12427293
30|    .17 1.124272930801121 .17 .009112 .120522 1.42390699
31|                                .0536   .370307
32|          7 YRS. IDC FACTOR= .4239069889830014
33| INTEREST DURING CONSTRUCTION= 271905850.6231187
34|       TOTAL INVESTMENT COST= 913333941.4301378
35|
36|       BOND ANNUITY FACTOR= .1090561239444779
37|               BOND ISSUE= 1039126577.14728
38|              RESERVE FUND= 113323116.7913748
39|        FINANCING EXPENSES= 10391265.7714728
40|           WORKING CAPITAL= 2078253.15429456
41|BND ISSUE LESS RSV FND CREDIT= 925803460.3559052
42| AMORT. AND INTEREST PAYMENTS= 99860017.02179399
43|
```

```
44|        OPERATION AND MAINTENANCE= 5885241.160597558
45|
46|        INTERIM REPLACEMENT COSTS= 2221832.538081217
47|
48|              ADMIN. AND GENERAL= 2295244.052633048
49|
50|                       INSURANCE= 570158.3029395725
51|
52|                  PROPERTY TAXES= 5025121
53|                                  _____
54|   TOTAL ANNUAL COSTS FOR 1994= 15997597.05425139
55|                     LEVELIZED= 34363618.26952973
56|                                  _____
57|TOTAL ANN.LEVELIZED INT.COSTS= 134223635.2913237
58|
59|   1994 CONSUMER SURPLUS(CA)= 2642541
60|                    (NON-CA)= 456956
61|                       TOTAL= 3099497
62|
63|     1994 USER FEES($3-1983)= 127565.6631683925
64|
65|     1994 PRODUCERS SURPLUS= 531523.5965349688
66|
67|                        (CA)= 14454999.41227789
68|                    (NON-CA)= 19047668.6422184
69|     1994 TOTAL OPTION VALUE= 33502668.05449629
70|
71|1994 TOTAL RECREATIONAL VALUE= 37261254.31419965
72|LEVELIZED ANN.CST.OF LOST.REC= 80038990.55306853
73|_____
74|   TOTAL OF PRIVATE AND RECR.= 214262625.8443922
75|LEVELIZED SOCIAL ANNUAL COSTS.
76|
77|----------------BENEFITS-----------------------
78|
79|   COMBUSTION TURBINE CAPACITY COSTS /KW
80|            (ON-LINE 1994)
81|TOTAL CONSTRUCTION COST W/IDC= 240
82|             ANN.ESC.TO 1994= 562.8931634567785
83|
84|           BOND ANNUITY FACTOR= .1232836213683153
85|                  BOND ISSUE= 650.9569812329598
86|                 RESERVE FUND= 80.25233400138573
87|          FINANCING EXPENSES= 6.509569812329598
88|             WORKING CAPITAL= 1.30191396246592
89|BND ISSUE LESS RSV FND CREDIT= 570.7046472315741
90|        FACTOR TO ACCOUNT FOR .7346497217985628
91| 50YRS.OF SERVICE W/20YR.LIFE= 1.547013080041724
92| AMORT. AND INTEREST PAYMENTS= 95.23097499294942
93|
94|      OPERATION AND MAINTENANCE= 2.311558155359398
95|
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```
 96 |              ADMIN. AND GENERAL= .80904535743757893
 97 |
 98 |                    INSURANCE= 1.407232908641946
 99 |                               _____
100 |   TOTAL ANNUAL COSTS FOR 1994= 4.527836418377133
101 |                    LEVELIZED= 9.726013334398703
102 |                               _____
103 |   TOTAL ANNUAL LEVELIZED COST= 104.9569883273481
104 |      COMBUSTION TURBINE $/KW.
105 |
106 |COMB.TURBINE VAR. COSTS($/KWH)
107 |     1994 COST OF FUEL $/MBTU= 17.33
108 |           HEAT RATE BTU/KWH= 15500
109 |               COST PER KWH= .268615
110 |  OPER.& MAINT.VARIABLE COSTS= .01265532372702306
111 |TOTAL LEVELIZED VARIABLE COST= .6041823657843576
112 |
113 |        COAL ENERGY COST ($/KWH)
114 |  SOUTHWEST COAL 1994 (W/O&M)= .04925
115 |   SW.COAL ENERGY TRANS. COST= .0184
116 |    TOTAL LEVELIZED COAL COST= .1453154975744244
117 |
118 |LOAD MANAGEMENT COST(1994$/KW) 189.829855905346
119 |   ANNUALIZED (W/ADJ,20/50YR)= 31.67607333903804
120 |
121 |CVR ENERGY (ANNUALIZED $/KWH)= .1838075650316991
122 |                               _____
123 |
124 |COMBUSTION TURBINE (340.3 MW)= 35716863.12779655
125 |               (119.2 GWH)= 72018538.00149542
126 |
127 |    COAL ENERGY (606.3 GWH)= 88104786.17937351
128 |   LESS CVR ENERGY (73 GWH)= 13417952.24731403
129 |                  CVR COST= 33558.63547206399
130 |  LOAD MANAGEMENT (56.3 MW)= 1783362.928987841
131 |                               _____
132 |      TOTAL ENERGY BENEFITS= 184239156.6258114
133 |
134 |    1994 FLATWATER BOATING= 32000
135 |  VALUE RESERVOIR FISHING= 120000
136 |           LEVELIZED TOTAL= 326503.4091842203
137 |
138 |1994 WATER BENEFIT (11900 AF)= 1577464.961736976
139 |                    LEVELIZED= 3388471.630761698
140 |                               _____
141 |TOTAL PROJECT SOCIAL BENEFITS= 187954131.6657573
142 |
143 |***************************************************
144 |    NET ANNUAL ECONOMIC VALUE= -26308494.1786349
145 |
146 |          BENEFIT-COST RATIO= .8772137974368829
```

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APPENDIX 10: INTERNAL COSTS, CLAVEY-WARDS FERRY PROJECT

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(1) Total Direct Construction Cost, Bid 1/79
      --Service 1/83 (from Table 2)[a] $274,472,000

(2) Annual Escalation to Bid 1/83 -
      Service 1/87 (Composite water and power
      construction cost index for 1/79 to
      1/83, 1.12 - 1.51)[b] $370,047,000

(3) Annual Escalation to Bid 1/87 -
      Service 1/91 (4 years at 6%/year
      GPI) $467,176,000

(4) Accounting for Escalation during last
      3 years of a 7-year construction
      period, Bid 1/87 - Service 1/94 $495,790,000

(5) Contingencies (15%) [.15 x (4)] $ 74,368,000

(6) Total Construction Cost [(4) + (5)] $570,158,000

(7) Engineering and Administration (12.5%) $ 71,270,000

(8) Total Project Cost [(6) + (7)] $641,428,000

(9) Interest During Construction[c]
      (Based on i = 10.72 and 7-year
      construction period) $271,906,000

(10) Total Investment Cost [(8) + (9)] $913,334,000

(11) Reserve Fund (One-year's debt service,
      10.72%, 40 years) $113,323,000

(12) Financing Expenses (1% of total
      financing) $ 10,391,000

(13) Working Captial (0.2% of total
      financing) $ 2,078,000

(14) Bond Issue [(10) + (11) + (12)
      + (13)] (Bond Annuity Factor =
      0.109056) $1,039,127,000

(15) Total Bond Issue Minus Credit for
Interest on Reserve Fund [(14) -
(11)] $925,803,000

(16) Amortization and Interest Payments
(10.72%, 50 years) $ 99,860,000

(17) Operation and Maintenance Cost[d]
($5.19/kW in 1977-$2,076,000;
inflated at Implicit GNP Price
Deflator from 1977 to 1982 (+ 47.84%),[e]
at 4% for 1983 and at 6% to Jan. 1994
(10 1/2 years) $ 5,885,000

(18) Interim Replacement Cost (1.4% of power
plant costs, which are $158,711,882
for Jan. 1994) $ 2,222,000

(19) Administrative and General [39% of
(17)] $ 2,295,000

(20) Insurance [0.1% of (6)] $ 570,000

(21) Property Taxes (6% of net income) $ 5,025,000

(22) Total Annual Cost for 1994 (1st
year) [(17) + (18) + (19) + (20)
+ (21)] $ 15,998,000

(23) Present Value of 50 years of annual
costs, inflated at 6% and discounted
at 10.72% $318,588,000

(24) Levelized Annual Cost over 50 years
at i = 10.72% [Direct Factor =
2.148048744] $ 34,364,000

(25) Total Annual Levelized Internal Cost
(for 50-year period) [(16) + (24)] $134,224,000

---

[a]R. W. Beck and Associates 1980

[b]Engineering News Record, March 24, 1983

[c]Based upon 7-year construction expenditure distribution:
.12/.12/.135/.145/.15/.16/.17.

[d]Sverdrup & Parcel and Associates, Inc. 1981
[e]U.S. Council of Economic Advisors 1983

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APPENDIX 11: DATA USED IN TRAVEL COST MODEL (TCM) OF TUOLUMNE RIVER WHITEWATER RECREATION

Region	Average Travel Costs[a] from Region to Site ($)	Per Capita Use from Region $(\times 10^{-6})$
1) Humboldt	643.31	70.080
2) Butte	566.76	11.316
3) Santa Rosa	441.13	491.137
4) Yolo	456.09	2059.277
5) Tahoe-Reno	538.84	752.949
6) Sacramento	430.22	868.768
7) El Dorado	401.27	991.147
8) West Bay	485.56	1510.583
9) East Bay	470.34	1360.516
10) South Bay	468.03	716.121
11) Stockton	384.20	1200.421
12) Tuolumne	347.48	5315.727
13) Fresno	474.19	176.380
14) Los Angeles	629.28	271.885
15) San Diego	730.78	191.908
A) Pacific Northwest	1207.16	15.361
B) Nevada (less Washoe County)	660.27	65.049
C) West	894.24	33.340
D) Mountain	1443.66	38.310
E) Plains	1728.90	1.764
F) Great Lakes	1991.95	4.690
G) Atlantic	2065.78	4.492
H) New England	2102.11	2.752
I) Southeast	1920.41	0.992

[a]See equation 7 in Appendix 6; these "average travel costs" are $TC_i = TPC_i + OCT_i + OCS_i$.

Note: Numbers and letters preceding region names correspond to maps provided on following page.
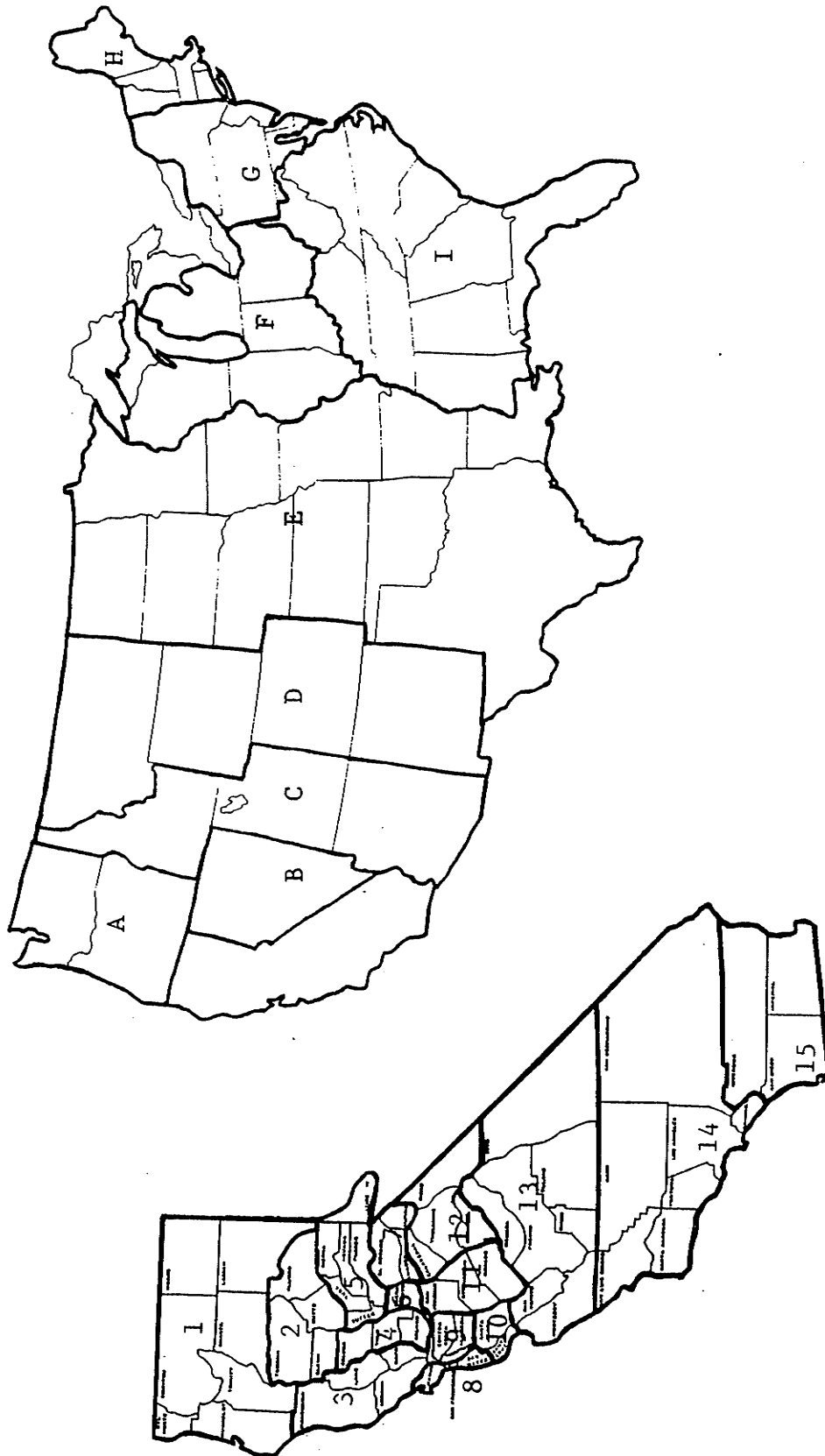
APPENDIX 12:
COMMERCIAL WHITEWATER RECREATION
TUOLUMNE RIVER, 1982

Outfitter	Passenger Use Days
A.A. Wet and Wild	440
American River Touring Association	1162
Echo: The Wilderness Company	1077
OARS	576
Outdoor Adventures	783
Outdoors Unlimited	804
Sierra Mac River Trips	377
Wilderness Waterways	585
All Outdoors	83
Sobek Expeditions	327
Zephyr River Expeditions	122
TOTAL	6336

SOURCE: Steve Cutwright, personal communication, July 1983.

$$Q_i = 1.43876 \times 10^{-3} - (8.55382 \times 10^{-7})\ TC_i$$

$$(3.77)^{**} \qquad (-2.42)^{*}$$

(a) $\qquad R^2 = .211 \qquad F_{1,22} = 5.87 \qquad n = 24$

$$\ln Q_i = \ln 15.72846 - 3.767194 \ln TC_i$$

$$(6.62)^{**} \qquad (-10.51)^{**}$$

(b) $\qquad R^2 = .834 \qquad F_{1,22} = 110.49 \qquad n = 24$

$$\ln Q_i = -5.90043 - 0.00362\ TC_i$$

$$(-13.19)^{**} \qquad (-8.73)^{**}$$

(c) $\qquad R^2 = .776 \qquad F_{1,22} = 76.152 \qquad n = 24$

---

[a]t-values are given in parentheses.

Asterisks indicate: [*] significant at the a = 0.05 level; and
[**] significant at the a = 0.01 level,
two-tailed tests, degrees of
freedom = 22.

TC$_i$

a) $Q_i=(1.43876\times10^{-3})-(8.55382\times10^{-7})TC_i$

b) $\ln Q_i=\ln 15.72846-3.767194\ln TC_i$

c) $\ln Q_i=-5.900433-0.0036159TC_i$
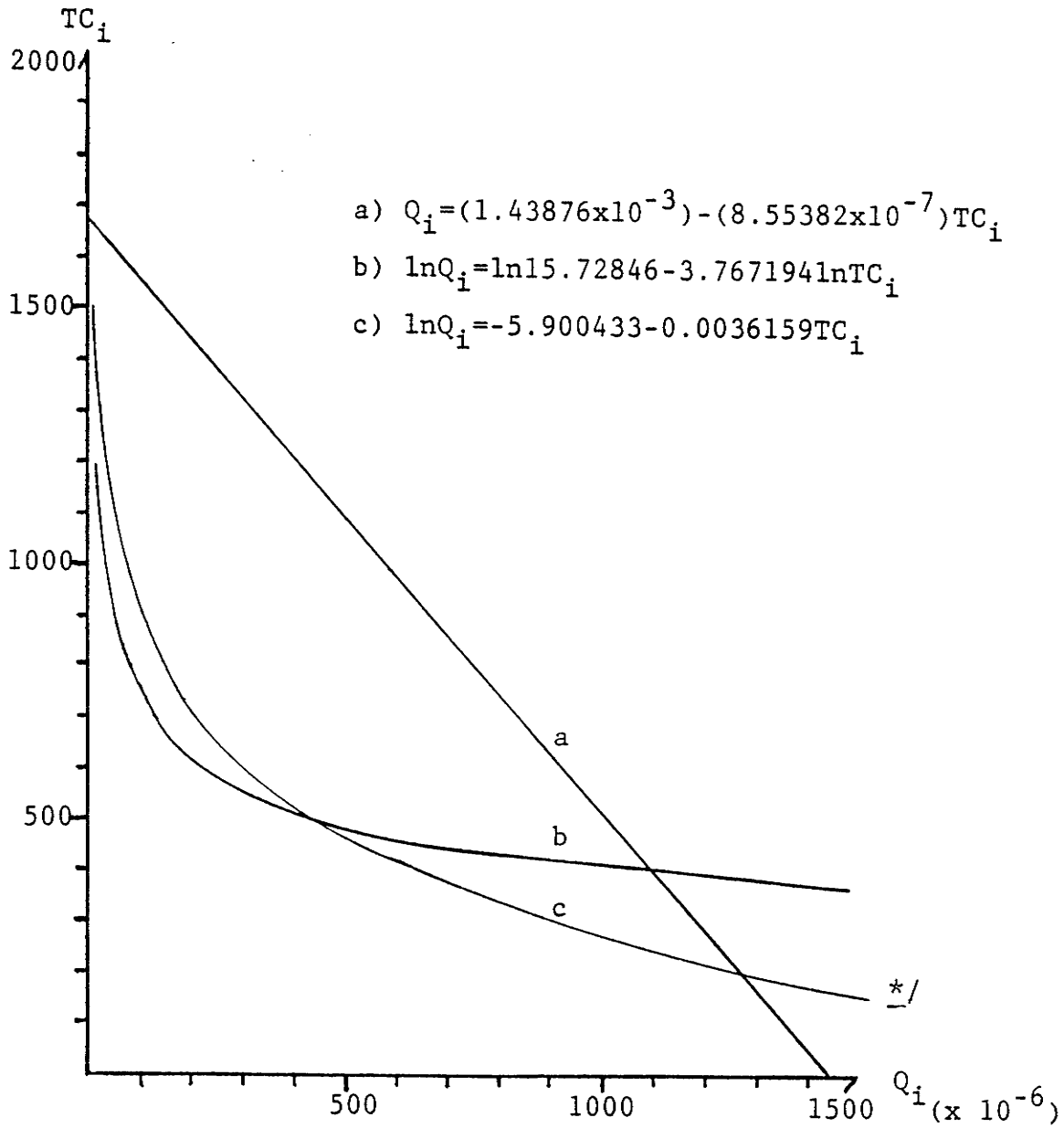
$\underline{*}/$ Q_i intercept for equation c is 2738.259×10^{-6}

APPENDIX 14: CALCULATION OF CONSUMER SURPLUS, LINEAR SPECIFICATION

Based upon the econometric estimation of the regional TCM participation functions (Appendix 13), regional consumer surplus may be calculated for the linear function as follows:

$$Q_i = (1.43 \times 10^{-3}) - (8.55 \times 10^{-7})\, TC_i \quad (1)$$

$$CS_i/n_i = (1.43 \times 10^{-3}) - (8.55 \times 10^{-7})TC_i\, dTC_i \quad (2)$$

$$CS_i/n_i = (1.43 \times 10^{-3})TC_i - (4.27 \times 10^{-7})(TC_i)^2 \Big]_{TC_i}^{TC_{max}} \quad (3)$$

$$CS_i = (CS_i/n_i)(n_i) \quad (4)$$

where Q_i = per capita visitation rate from origin i,

TC_i = average travel cost from origin i (including actual costs of travel plus opportunity cost of time spent traveling to and from the site),

CS_i/n_i = per capita consumer surplus for visitors from origin i,

n_i = population of origin i, and

CS_i = total consumer surplus for visitors from origin i.

Results of calculations of consumer surplus for each origin and of total consumer surplus, based upon a linear participation function, are found on the following page.

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	Region	Consumer Surplus per Capita	Population	Total Consumer Surplus
1)	Humboldt	0.461436201	399,545	$ 184,365
2)	Butte	0.531949057	265,115	141,028
3)	Santa Rosa	0.658549305	586,394	386,169
4)	Yolo	0.642768919	425,392	273,429
5)	Tahoe-Reno	0.558924559	332,028	185,579
6)	Sacramento	0.670183097	938,110	628,705
7)	El Dorado	0.701541337	134,188	94,138
8)	West Bay	0.612232144	1,541,127	943,527
9)	East Bay	0.627914855	1,897,075	1,191,202
10)	South Bay	0.630302847	1,779,028	1,121,326
11)	Stockton	0.720359618	858,032	618,092
12)	Tuolumne	0.761703266	94,813	72,219
13)	Fresno	0.623928740	1,434,401	894,964
14)	Los Angeles	0.473986755	12,269,904	5,815,772
15)	San Diego	0.386986293	3,397,467	1,314,773
A)	Pacific Northwest	0.096436334	7,681,750	740,800
B)	Nevada (less Washoe Cty)	0.446488043	691,784	308,873
C)	West	0.265416306	5,818,922	1,544,437
D)	Mountain	0.024297178	6,186,345	150,311
TOTAL CONSUMER SURPLUS				$ 16,609,709

APPENDIX 15: CALCULATION OF CONSUMER SURPLUS, DOUBLE LOGARITHMIC SPECIFICATION

Based upon the econometric estimation of the regional TCM participation functions (Appendix 13), regional consumer surplus is calculated as follows:

$$\ln Q_i = \ln 15.72846 - 3.767194 \ln TC_i \qquad (1)$$

$$Q_i = 6{,}773{,}036.045 \; (TC_i)^{-3.767194} \qquad (2)$$

$$CS_i/n_i = 6{,}73{,}036.045 \; (TC_i)^{-3.767194} dTC_i \qquad (3)$$

$$CS_i/n_i = -2{,}447{,}618.795 \; TC_i^{-2.767194} \Big]_{TC_i}^{TC_{max}} \qquad (4)$$

$$CS_i = (CS_i/n_i)(n_i) \qquad (5)$$

where Q_i = per capita visitation rate from origin i,

TC_i = average travel cost from origin i (including actual costs of travel plus opportunity cost of time spent traveling to and from the site),

CS_i/n_i = per capita consumer surplus for visitors from origin i,

n_i = population of origin i, and

CS_i = total consumer surplus for visitors from origin i.

Results of calculations of consumer surplus for each origin and of total consumer surplus are found on the following page.

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Region	Consumer Surplus per Capita	Population	Total Consumer Surplus
1) Humboldt	0.040470736	399,545	$ 16,170
2) Butte	0.057864288	265,115	15,341
3) Santa Rosa	0.116724469	586,394	68,447
4) Yolo	0.106351670	425,392	45,241
5) Tahoe-Reno	0.066692254	332,028	22,144
6) Sacramento	0.125171000	938,110	117,424
7) El Dorado	0.151987794	134,188	20,395
8) West Bay	0.089277930	1,541,127	137,589
9) East Bay	0.097595081	1,897,075	185,145
10) South Bay	0.098942164	1,779,028	176,021
11) Stockton	0.171530961	858,032	147,179
12) Tuolumne	0.226812030	94,813	4,878
13) Fresno	0.095395531	1,434,401	136,835
14) Los Angeles	0.043077568	12,269,904	528,558
15) San Diego	0.028154367	3,397,467	95,654
A) Pacific Northwest	0.006301097	7,681,750	48,403
B) Nevada (less Washoe Cty)	0.037591914	691,784	26,005
C) West	0.015694866	5,818,922	91,327
D) Mountain	0.003466442	6,186,345	21,445

E)	Plains	0.001728286	46,488,333	$ 80,345
F)	Great Lakes	0.000857182	47,331,766	40,572
G)	Atlantic	0.000683249	38,954,801	26,616
H)	New England	0.000605935	13,808,490	8,367
I)	Southeast	0.001050553	52,428,410	55,079

TOTAL CONSUMER SURPLUS $ 2,115,178

APPENDIX 16: CALCULATION OF CONSUMER SURPLUS, SEMILOGARITHMIC SPECIFICATION

Based upon the econometric estimation of the regional TCM participation functions (Appendix 13), regional consumer surplus is calculated as follows:

$$\ln Q_i \; = \; -5.900433 - 0.0036159 \; TC_i \tag{1}$$

$$Q_i \; = \; e^{(-5.900433 - 0.0036159 \; TC_i)} \tag{2}$$

$$CS_i/n_i \; = \; e^{(-5.900433 - 0.0036159 \; TC_i)} dTC_i \tag{3}$$

$$CS_i/n_i \; = \; -(0.0036159)^{-1} e^{(-5.900433 - 0.0036159 \; TC_i)} \Big]_{TC_i}^{TC_{max}} \tag{4}$$

$$CS_i \; = \; (CS_i/n_i)(n_i) \tag{5}$$

where Q_i = per capita visitation rate from origin i,

TC_i = average travel cost from origin i (including actual costs of travel plus opportunity cost of time spent traveling to and from the site),

CS_i/n_i = per capita consumer surplus for visitors from origin i,

n_i = population of origin i, and

CS_i = total consumer surplus for visitors from origin i.

Results of calculations of consumer surplus for each origin and of total consumer surplus are found on the following page.

Region	Consumer Surplus per Capita	Population	Total Consumer Surplus
1) Humboldt	0.073878918	399,545	$ 29,518
2) Butte	0.097463914	265,115	25,839
3) Santa Rosa	0.153559304	586,394	90,046
4) Yolo	0.145470198	425,392	61,882
5) Tahoe-Reno	0.107829536	332,028	35,802
6) Sacramento	0.159743187	938,110	149,857
7) El Dorado	0.177382092	134,188	23,803
8) West Bay	0.130755032	1,541,127	201,510
9) East Bay	0.138161091	1,897,075	262,102
10) South Bay	0.139316562	1,779,028	247,848
11) Stockton	0.188676944	858,032	161,891
12) Tuolumne	0.215482574	94,813	20,431
13) Fresno	0.136248821	1,434,401	195,435
14) Los Angeles	0.077728373	12,269,904	953,720
15) San Diego	0.053821851	3,397,467	182,858
A) Pacific Northwest	0.009542039	7,681,750	73,300
B) Nevada (less Washoe Cty)	0.069478501	691,784	48,064
C) West	0.029765234	5,818,922	173,202
D) Mountain	0.004007503	6,186,345	24,792

APPENDIX 16 (continued)

E)	Plains	0.001372824	46,488,333	$ 63,820
F)	Great Lakes	0.000477016	47,331,766	22,578
G)	Atlantic	0.000344905	38,954,801	13,436
H)	New England	0.000291756	13,808,490	4,029
I)	Southeast	0.000643478	52,428,410	33,737

TOTAL CONSUMER SURPLUS $ 3,099,498

APPENDIX 17:
FLOWS AVAILABLE FOR ENERGY GENERATION

Flows at Jawbone Diversion Dam, Hunters Point Dam (Clavey) and Wards Ferry Dam were determined using U.S. Geological Survey historical stream gaging data and flow data from R. W. Beck and Associates (1976 and 1979). Annual averages are shown in Figure 5. Fisheries maintenance releases, described in Appendix 2, were subtracted from the total flows to determine flows available for energy generation on a monthly basis (see next page). This methodology was verified with energy generation flow data from R. W. Beck and Associates (1976) and is presented on the following page.

For the verification calculation, an adjustment of 195 cfs was made to match flows used in the 1976 R. W. Beck analysis. That analysis assumed flows of 464 cfs through San Francisco's Mountain Tunnel; actual average flows and those used in Beck's later (1979 and 1980) analysis were 659 cfs. Note that it is assumed that San Francisco will continue its current operation of Mountain Tunnel (659 cfs) due to the fact that the previously assumed 72-foot head advantage of Clavey-Wards Ferry (R.W. Beck and Associates 1979) will be eliminated by the proposed, relatively small hydroelectric project below the Mocassin Powerhouse (Leo Bauer, personal communication, June 1983).

Energy generation was calculated using flows available for generation and data from R. W. Beck and Associates (1976). This calculation is shown below.

Wards Ferry:

    Average flow 1827 cfs - Adjustment 195 cfs = 1632 cfs
      (Beck 1976)   (Beck 1979)

$$\frac{1632 \text{ cfs}}{1827 \text{ cfs}} \times \begin{array}{c} 315,140 \text{ MWh} \\ \text{(Beck 1976)} \end{array} \text{generation} = 281,420 \text{ MWh}$$

Clavey: $\dfrac{\text{Average flow 642 cfs}}{\begin{array}{c}1128 \text{ cfs} \\ \text{(Beck 76)}\end{array}} \times \begin{array}{c}708,324 \text{ MWh} \\ \text{(Beck 76)}\end{array} = 403,142 \text{ MWh}$

Total Project Generation: = 684,562 MWh
                              = 685 GWh

CALCULATION OF FLOWS AVAILABLE FOR ENERGY GENERATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE[c] (CFS)
Verification—Beck[a]													
Jawbone	763	751	833	974	1845	2926	1528	633	568	465	494	519	1025
Clavey	322	365	410	665	774	345	83	26	19	22	80	165	273
SF Adjustment	195	195	195	195	195	195	195	195	195	195	195	195	195
Tuol. Release	-35	-35	-35	-35	-75	-75	-75	-55	-55	-35	-35	-35	-50
Clavey Release	-5	-5	-5	-5	-5	-5	-15	-15	-15	-5	-5	-5	-8
Available	1240	1271	1398	1794	2734	3386	1716	764	712	642	729	839	1435
Total-Gen	1240	1271	1398	1485	1485	1485	1485	764	712	642	729	839	1128
Spill	0	0	0	309	1249	1901	231	0	0	0	0	0	308
Flows with Fisheries Maintenance Releases (see Appendix 2)													
Jawbone	763	751	833	974	1845	2926	1528	633	568	465	494	519	1025
Clavey	322	365	410	665	774	345	83	26	19	22	80	165	273
Tuol. Release	-330	-330	-330	-880	-880	-880	-660	-639[b]	-567[b]	-330	-330	-330	-495
Clavey Release	-110	-110	-110	-110	-110	-110	-80	-20	-20	-20	-80	-110	-83
Available	645	676	803	1199	1629	2281	871	0	0	137	164	244	721
Total-Gen	645	676	803	1199	1485	1485	871	0	0	137	164	244	642
Spill	0	0	0	0	144	796	0	0	0	0	0	0	78

[a]Annual flows are from Beck (1976). Monthly distributions are from U.S. Geological Survey. (John Beck personal communication, June 1983.)

[b]Instream flow requirement of 660 cfs is not available these months.

[c]Annual average flows for the Tuolumne River Watershed are shown in Figure 5.

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APPENDIX 18: ELECTRICITY BENEFITS
OF THE CLAVEY-WARDS FERRY PROJECT

This appendix documents the calculation of the electricity benefits of
the CWF Project, based upon a least-cost mix of:

        (1)   combustion turbine capacity;

        (2)   combustion turbine energy;

        (3)   coal energy;

        (4)   conservation voltage regulation; and

        (5)   load management.

The appendix is divided into nine sections, A through I. Section A
describes the method through which the levelized annual capital costs of
facilities with lives of less than 50 years are calculated over the 50-year
discount period of the SBC analysis. Next, the calculation of the capacity
costs of a combustion turbine (including the estimation of the combustion
turbine capacity factor) is documented in Section B. Combustion turbine
variable costs are calculated in Section C.

Section D provides the methodology behind an estimate of coal energy
cost, and Section E documents the determination of the annualized Conservation
Voltage Regulation (CVR) energy value. The quantity of the CVR energy savings
is estimated in Section F. Load management capacity and cost are examined in
Section G.

The quantities of off-peak coal energy, combustion turbine capacity and
load management are calculated in Section H. The results of the analysis are
summarized, and the final electricity benefit calculations are presented in
Section I.

A.   LEVELIZED CAPITAL COSTS OF FACILITIES WITH LIVES OF LESS THAN 50
     YEARS, CALCULATED FOR THE 50-YEAR DISCOUNT PERIOD

A combustion turbine plant with a 20-year life, for example, must be
replaced (twice) before the end of the 50-year discount period of the
analysis. Only a portion of the second replacement cost--that portion
corresponding to the first 10 years of the second replacement facility's
life--needs to be considered. The calculations, for a facility with a life of
20 years, a general price inflation (GPI) rate of 6% and a 10.72% discount
rate are as follows:

Factors for Present Value of Cost of Replacement Facilities

$$\frac{(1.06)^{20}}{(1.1072)^{20}} = .4184; \qquad \frac{(1.06)^{40}}{(1.1072)^{40}} = .1751$$

Factor for Portion of Replacement Facility

Present value of 10 years of annual costs:

$$\frac{1 - \dfrac{1}{(1.1072)^{10}}}{.1072} = 5.959$$

Present value of 20 years of annual costs:

$$\frac{1 - \dfrac{1}{(1.1072)^{20}}}{.1072} = 8.111$$

Fraction:

$$\frac{5.959}{8.111} = .7347$$

Present Value

1 (initial facility) + .4184 (1st replacement) + .1751 x

.7347 (2nd replacement) = 1.5470

Levelized Over 50 years

1.5470 x .10786 = .1669

Similar calculations for a facility with a life of 30 years produces the following factor: 30 years --- 0.1345

B. COMBUSTION TURBINE CAPACITY COSTS (ON-LINE 1994)

(1) Total Construction Costs, including Interest During
            Construction (1980-81) $240.0/kW
      (Installed cost of MID's McClure units
      1 and 2, per M. Hawkins, MID) [$14.2M
      & $9,779,025, 99.8 MW]

(2) 1994 Cost (escalated per ENR index for turbines
    and generators 80-81 ave. to 83 and 6%/yr thereafter)

                               $562.9/kW

(3) Reserve Fund (One-year's debt service,
             10.72%, 20 years)   80.3

(4) Financing Expenses (1% of total financing)   6.5

(5) Working Capital (0.2% of total financing)   1.3

(6) Bond Issue [(2)+(3)+(4)+(5)]   651.0

(7) Bonds less Reserve Fund [(6)-(3)] $570.7/kW

(8) Amortization (10.72%, 50 years   95.2/kW-yr
      with factor for 20-year life)

(9) Operation and Maintenance & Interim
           Replacements, $1/kW-yr, (1980)   2.31/kW-yr

(10) Admin. & General [35% of (9) per Beck] $.81/kW-yr

(11) Insurance [.25% of (2)] $1.41/kW-yr

(12) Property taxes [none per Beck]   --

(13) Total annual costs 1994 (1st year) $4.53/kW-yr
     [(9) + (10) + (11) + (12)]

(14) Level over 50 years (x 2.148) $9.73/kW-yr

(15) Total [(8) + (14)] $104.96/kW-yr

C. COMBUSTION TURBINE VARIABLE COST (1994 LEVELIZED -- 50 YEARS)

(1) Cost of Fuel 1994 $17.33/MBtu
     (marginal cost of gas, PG&E Appl.
     No. 82-12-48, cite 3)

(2) Heat rate (Beck)   15,500 Btu/kWh

(3) Cost per kWh 1994 (1)x(2) $.269/kWh

(4) Level over 50 years ((3) x 2.148) $.577/kWh

(5) O & M, variable ($.005/kWh 1980) $.0127/kWh

(6) Level over 50 years ((5) x 2.148) $.0272/kWh

(7) Total variable costs 1994 $.6042/kWh
          [(4) + (7)]

                Combustion Turbine Capacity Factor

(8) Beck   5%

(9) M-S-R (p. B-6)   2.9%

(10) M-S-R (p. B-9)   5.3%

(11) Mid-range   4%

D. COAL ENERGY COST (1994 - LEVELIZED OVER 50 YEARS)

(1) San Juan variable costs 1994 $.0431/kWh
          (M-S-R p. 17)

(2) Tucson Electric Power
          (M-S-R p. 17) $.0554/kWh

(3) Average $.04925/kWh

(4) Transmission charge $.0184/kWh
          (M-S-R p. 17)

(5) Total (3) + (4) $.0676/kWh

(6) Level over 50 years [(5) x 2.148] $.1453/kWh

E. ANNUALIZED CVR ENERGY VALUE

The amount of CVR energy increases at 1.3% per year, a growth rate less than one-half of MID's forecasted growth rate 1990-1996 (M-S-R prospectus). The value of this energy increases 6% per year (general inflation). Thus the combined growth rate is 7.4% per year. The present value factor is

$$\frac{1.07378 \left[1 - \left(\dfrac{(1.07378)^{50}}{(1.1072)} \right) \right]}{1.1072 - .07378} = 25.19$$

The level annual value factor is

$$25.19 \times .10786 = 2.717$$

1994 value of coal fuel, $.0676/kWh

$$\text{annualized: } .0676 \times 2.717 = \$.1838/kWh$$

Cost of CVR

PG&E expenditures 1977 - 1982		$228,000/yr

MID 82 loads	1360 GWh	
TID 82	1049	
	2409	
PG&E 82	79760	

$$\frac{2409}{79760} \times 228,400 \qquad\qquad \$6,886/yr$$

Inflated to 1994 x $(1.06)^{14}$ 15,569

Levelized   x 2.148 $33,441/yr

F. QUANTITY OF CVR ENERGY SAVINGS

    1994 MID energy requirements   1741 GWh
          (M-S-R, p. B-9)

    1994 TID energy requirements*   1909 GWh
          (TID Appl. to Western Area
          Power Admin., Sept. 1981, p. 17)

        Total   3650 GWh

        CVR at 2%   73 GWh

_____

*If the growth in TID energy is assumed to be equal to the
growth in MID energy then 1994 TID energy requirements are
approximately 1257 GWh. CVR energy savings at 2% are then 60
GWh. This change leads to an overall benefit-cost ratio of
0.890 compared to 0.877.

G. LOAD MANAGEMENT AND COST

        <u>Capacity</u>

   (1) 1994 MID peak demand   483 MW
            (M-S-R p. B-9)

   (2) 1994 TID peak demand   584 MW

   (3) Total   1067 MW

   (4) load management savings 6.21%
          (SMUD 1994 - per CFM-IV,   66.3 MW
          Form R-1, Nov. 1982)

   (5) less - 10 MW MID load management   56.3 MW
          already planned (M-S-R p. B-7)

   (6) At point of generation ((5) x 1.06)   59.7 MW
          (6% losses per SMUD CFM-IV),
          Form R-2)

        <u>Cost</u>

   (7) 1994 [$100/kW 1983$ (range 40-200)] $189.8/kW

   (8) Annualized ((7) x .1669) $31.7/kW-yr

H. OFF-PEAK COAL ENERGY, COMBUSTION TURBINE CAPACITY AND LOAD MANAGEMENT

Combustion Turbine Capacity
    400 MW - 59.7 MW (load management) =   340.3 MW

Combustion Turbine Energy
    340.3 MW x .04 x 8.76 =   119.2 GWh

Coal Energy
    684 GWh - 119.2 GWh =   564.8 GWh
    (Note: 684 GWh is generated
    by the Project due to inter-
    nalization of fisheries
    damages; See Appendix 17)

    plus transmission losses:
          564.8 x 1.0735 =   606.3 GWh
          (M-S-R Bond Prospectus, p. 17)

I. FINAL BENEFITS: COAL, COMBUSTION TURBINE, CVR AND LOAD MANAGEMENT

(1) Combustion Turbine Capacity

    340.3 MW x $104.96/kW-yr $ 35,720,000

(2) Combustion Turbine Energy

    119.2 GWh x $.6042/kWh   72,020,000

(3) Coal Energy

    606.3 GWh x $.1453/kWh   88,100,000

(4) Less - value of CVR Energy

    73 GWh x $.1837/kWh   13,420,000

(5) Cost of CVR Energy

    $33,444   30,000

(6) Cost of Load Management

    56.3 MW x $31.7/kW yr   1,780,000
    (at end use)   ————————

TOTAL $184,000,000

APPENDIX 19:
ESTIMATING THE OPTION VALUE
ASSOCIATED WITH WHITEWATER BOATING
ON THE TUOLUMNE RIVER

This appendix provides a brief explanation of the economic concept of option value, outlines the empirical methods through which option value estimates may be made and describes the particular technique through which option value was estimated in this study.

The conventional welfare economics definition of a benefit follows from the neo-classical model of consumer behavior, in which an individual's utility is increased through the consumption of goods or services (Varian 1978). Well within the conceptual framework of the so-called neo-classical paradigm, however, a body of economic theory has come to recognize that under certain conditions persons may also gain utility from various goods and services without actually participating in the direct consumption of those goods and services

In addition to the value of a resource to its users, many resources have intrinsic value to nonusers as well. In the case of environmental resources, the so-called nonuser or intrinsic benefits may represent a substantial portion of the resources' total value (Krutilla 1967).

Unique natural areas, by definition, have few if any substitutes. Hence, the demand for the use of such areas tends to exhibit two critical features: highly inelastic demand and significant option demand (Howe 1979), where the latter is defined as the willingness to pay for the preservation of any area by a nonuser (who is also an "uncertain user"). This last phrase, "uncertain user," refers to someone who does not presently use the resource and is uncertain if he or she ever will use it and/or is uncertain that the resource will be available for use in the future when and if it should be demanded. The relevant willingness-to-pay concept, the option value, thus describes a willingness to pay which is in excess of the expected value of the consumer's surplus which would result from actual future use of the resource in question.[1]

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[1]Howe (1979) presents a simplified, geometric argument for the existence of significant option demand for unique natural areas. The crucial assumption behind his argument is that individuals are risk averse (i.e. the representative utility function is strictly concave), an assumption which is both reasonable and typical of consumer theory analyses.

Questions of risk and uncertainty are thus at the center of the option value concept. If uncertainty exists with regard to either the demand for or the availability of an environmental resource, such as whitewater for recreational boating, and if a contemplated investment decision will have irreversible consequences, as in the construction of a hydroelectric dam and reservoir, then the uncertainty itself may be something which consumers are willing to pay to reduce or eliminate. This payment, an amount in excess of expected consumers' surplus, is the option value of the resource.[2]

It should be noted in passing that there exists a third category of resource value, beyond the typical consumer's surplus (user) value and beyond option value. This is the "existence value," which reflects the fact that some individuals can realize utility without directly consuming a good or service and without any potential existing for future use. This category of resource value, described in Chapter IV, was not estimated in the present study, and thus represents an uninternalized cost of the proposed Clavey-Wards Ferry hydroelectric project.

Returning to option value, it may be noted that this concept has a rather straightforward, common-sense basis. In the case of the Grand Canyon, for example, there are many persons who value this environmental resource because of current or expected future use (consumer surplus or expected consumer surplus, i.e. user value or expected user value). Others are uncertain of whether they will ever visit the Canyon, but if a development project were being considered which threatened the Canyon in an irreversible manner, many of these persons would place a positive and finite value on the retention of the option to someday visit and "use" the Canyon for themselves. This is option value.

More than a theoretical abstract, option value is quite real and is frequently experienced by many individuals in regard to various goods and services, as the above example illustrates. This claim naturally leads to the question of whether or not option value can actually be measured. The answer is that it _can_ be measured; indeed it has been measured in a number of empirical investigations of various environmental resources (Bishop 1982; Fisher and Raucher 1983; Desvousges, Smith and McGivney 1983). How was this accomplished?

Because intrinsic values of "environmental goods and services" are ordinarily not traded in a conventional market setting, it is not possible to appeal to price-signals as indicators of relative scarcity and economic value. various direct methods, however, do exist for estimating intrinsic values,

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[2] The conceptual basis of option value and its development in the economics literature are described in greater detail by Bishop (1982), Fisher and Raucher (1983), and Desvousges, Smith and McGivney (1983).

notably the contingent valuation approach.[3]   A number of researchers have made empirical estimates of option value through contingent valuation surveys (Rae 1981a; Rae 1981b; Randall, Hoehn and Tolley 1981; Mitcehll and Carson 1981; Desvousges, Smith and McGivney 1983).

In the present study, financial and time constraints did not allow for a contingent valuation survey of option value of the Tuolumne River to be conducted.   An important alternative exists, however, for situations in which consumer's surplus (user value) of a resource has been directly estimated from empirical data (as in this study) but it is not possible to make direct estimates of option (nonuser) value.   This alternative is to infer intrinsic values from the measured user values.

Due to the importance of including intrinsic values within the benefit-cost assessment and the frequent difficulty of directly measuring these values, precedent now exists for the practice of utilizing proportional relationships through which intrinsic benefits (or costs) may be calculated as a fixed positive fraction of empirically estimated user benefits (or costs). In this approach, the likely ratio of nonuser to user values of the resource being studied is identified on the basis of previous research which examined similar resources and which directly estimated both user and nonuser values. Then, after the user value of the resource in question has been directly estimated (as though a travel-cost-metod sale), multiplication by the nonuser/user value ratio provides an estimate of per-capita nonuser value of the resource.

This approach was first used by Abel, Tihansky and Walsh (1975).   Later, Unger (1976) and Freeman (1979b) also derived nonuser benefits from user benefits through such proportional relationships.   A comprehensive review of these and other such studies is provided by Fisher and Raucher(1983).

The present study utilizes an estimated nonuser/user value ration which is based upon the review of previous research by Fisher and Raucher (1983). Appendix 7 lists nine empirical investigations which exhibit ratios of nonuse value to use value in the range of 0.47 to 1.39, with a weighted average of 0.60.   In other words, in the reported research, nonuser recreational value/household was found, on average, to be approximately 60 percent of user recreational value per household.

The first step, then, in the estimation of option value associated with the loss of whitewater rafting on the Tuolumne River is the multiplication of the empirically derived (consumer's surplus) recreational user values of the Tuolumne by the figure, 0.60.   Under the conservative

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[3]For a brief description of the contingent valuation method of estimating recreation benefits, see Chapter IV of this study.   For more extensive discussions, see Desvousges, Smith and McGivney (1983); and U.S. Water Resources Council 1983a.

assumption that remoteness from the recreation site may result in even lower nonuser/user ratios, the 0.60 figure is used only for calculations regarding visitors from within California; a ratio of 0.45 is used for all others.

In order to estimate the total nonuser value of the resource, it is necessary next to multiply the per-capita nonuser values by an estimate of the number of people in various regions of the country who are likely to maintain such option values. How is this relevant population of "interested nonusers" to be identified?

It has frequently been noted that in many cases persons express their intrinsic value structures through voting behavior and trough their support of public and private interest groups (Lovett 1983). The implication is that in the context of environmental resources, the membership of an environmental interest group should serve as a reasonable proxy of the relevant population of "interested nonusers." Hence, in this study the membership of the Sierra Club forms the basis of the proxy population calculations.

In order to be somewhat conservative in the option value estimation process, only one-half of the non-California Sierra Club membership and the full California membership were used as the actual proxy populations. The calculations, summarized in Table 3 of Chapter V, are presented in somewhat greater detail in Table 19-1, at the end of this appendix. As can be seen in the table, total 1994 option value associated with lost opportunities for whitewater recreation on the Tuolumne River are found to be approximately $33.5 million annually.

These figures and the direct estimates of annual consumer's surplus (user value) are found to be quite conservative when compared on a per-capita basis with results of previous studies of similar recreational resources. Comparable figures from Fisher and Raucher (1983), inflated to the same 1994 dollars which are used in the present study, are $1,194/household for user value and $712/household for option value. These may be contrasted with this study's findings of about $300/person for user value and $140/person for option value.

In order to gain an additional perspective on the willingness-to-pay for environmental values by non-users, it is useful to review several recent opinion polls. These polls give a general idea of the total population of non-users who would likely be willing-to-pay some amount of money to preserve the Tuolumne if directly asked. This total population can be contrasted with the very conservative "proxy population", Sierra Club membership assumed in the above option value estimates.

A national survey reported by Bloomgarden (1983) found that with regard to land use, 65% of the population favors leaving parts of the U.S. in their natural state, while 28% favor using whatever land is required to obtain needed resources. The same survey found that 56% of the general public favor maintaining environmental protection regulations even if the production of more energy is slowed, and that 40% of the general public want to preserve

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wilderness areas at all costs.

The President's Council on Environmental Quality (1980) reported the findings of polls conducted during 1979 and 1980 by Resources for the Future (RFF), Roper, and CBS News - New York Times. The RFF survey asked whether marsh and swamp areas should be developed or preserved in their natural state -- 65% favored preservation. Roper's question "are you more on the side of adequate energy or more on the side of protecting the environment?" was answered in favor of protecting the environment by 38% of the respondents. The CBS News - New York Times poll asked "which do you think is more important - producing energy or protecting the environment?"; 43% favored protecting the environment.

A final example is the Opinion Research Corporation Poll (1981) which asked "How do you feel about changing the use of wilderness areas so that roads could be built and the natural resources, such as timber, gas, oil, and other minerals could be developed as long as developers covered up all signs of use afterward? Would you favor or oppose such use if developers restored the environment, as neraly as possible, to its original state?" Even with the complete restoration possibility, 39% opposed such changes in widlerness areas.

These opinion polls are subject to many caveats; they did not ask specific questions about values associated with the Tuolumne River. They do make the general point, however, that a significant percentage of Americans strongly support preservation of wilderness environments (such as that of the Tuolumne River). While no attempt was made to quantify willingness-to-pay for preservation, these polls do indicate the existence of substantial non-user values among many Americans.

If the proxy non-user population used in the calculation of option values for the Tuolumne River were that portion of the U.S. general public which generally favors preservation instead of only those portions of teh Sierra Club membership described above, what would the per capita non-user willingness-to-pay have to be in order to support the total U.S. otion value estimated in Table 19-1? The opinion polls cited above tend to indicate roughly 40% of the U.S. population favors preservation. This implies an overall U.S. non-user population of approximately 101.9 million in 1994 (U.S. Department of Commerce 1980). This potential total non-user population would support the 1994 option value of $33.5 million for the Tuolumne (Table 19-1) with an implied annual willingness-to-pay of about 33 cents per concerned individual.

This $0.33 per person per year (implicit) willingness-to-pay among the U.S. population is intended only to illustrate the sensitivity of the per capita implicit payment to the assumed size of the proxy population Without direct contingent valuation surveys among the Sierra Club membership, there is no _direct_ way of ascertaining the reasonableness of this study's non-user willingness-to-pay values. The 33 cents per capita implicit payment requirement merely results from distributing the option value over a larger, and probably more accurate non-user proxy population.

It is certainly true that a preferable method of estimating option value would involve direct estimation using primary data, such as through a contingent valuation survey. Future researchers are encouraged to carry out such surveys to refine the option value estimates provided here. In the meanwhile, however, these estimates represent, at the very least, a reasonable first approximation.

This study has attempted to provide a relatively comprehensive valuation of whitewater recreation on the Tuolumne River within the broader context of a benefit-cost assessment of the Clavey-Wards Ferry Project. As such, it was important to include an estimate of option value even though it was necessary that the estimation procedure be an indirect one. As the theoretical literature amply demonstrates, option value may be of considerable magnitude in the case of environmental amenities. Hence, it is too important to be ignored.

TABLE 19-1:
ESTIMATING THE OPTION VALUE ASSOCIATED WITH WHITEWATER BOATING
ON THE TUOLUMNE RIVER

California

Consumer surplus per user from TCM model, based upon actual Tuolumne River rafting data	$184.14
Nonuser/user value ratio, based upon previous empirical research summarized by Fisher and Raucher (1983)	x 0.60
Estimated per-capita California option value	$110.48
California membership of Sierra Club	x 130,836
Estimated 1994 total California option value	$14,455,000

Other Regions of the U.S.

Consumer surplus per user from TCM model, based upon actual Tuolumne River rafting data	$392.91
Nonuser/user value ratio, based upon previous empirical research summarized by Fisher and Raucher (1983) and reduced to account for effect of remoteness from site	x 0.45
Estimated per-capita non-California option value	$176.81
Non-California membership of Sierra Club, reduced by one-half to account for effect of remoteness from site	x 107,730
Estimated 1994 total non-California option value	$19,048,000
ESTIMATED TOTAL U.S. OPTION VALUE (1994)	$33,503,000

APPENDIX 20

A SURVEY OF FEDERAL AND STATE LAW

SUPPORTING THE USE OF A SOCIAL BENEFIT-COST ANALYSIS

Introduction

        Federal and state laws applicable to the licensing and permitting of
hydroelectric development projects require that decision-makers weigh the
social costs of a proposed project, including the environmental impacts,
against the project's social benefits. The Federal Energy Regulatory
Commission (FERC) is required under the Federal Power Act and the National
Environmental Policy Act (NEPA) to consider not only those project costs and
benefits which are directly experienced by the project's developer, but also
those benefits received and costs borne by other individuals and entities
(e.g., loss of recreational, fish and wildlife, and other environmental values
which would result from project development). FERC practice traditionally has
been to determine first whether a project is "economically feasible" to the
project developer, by comparing the project's total construction, operation
and maintenance costs to the costs of alternative energy sources. This
strictly internal benefit-cost analysis accounts for environmental costs only
to the limited extent the developer is required to pay for mitigation of
environmental impacts and the mitigation costs are included in the benefit-
cost analysis. If a project is shown in this narrow sense to be economically
feasible, FERC then evaluates separately the environmental, recreational, and
fish and wildlife costs of development on a qualitative basis.

        The California State Water Resources Control Board (Board) must also
weigh the social costs and benefits of a proposed hydroelectric power project
in acting on an application for a water rights permit. Under the State's
water rights law, the Board must consider the effect that a proposed diversion
for hydroelectric purposes will have on competing beneficial uses of a river,
such as recreation and fish and wildlife uses. The Board's balancing of these
competing uses is subject to the state constitutional requirement of
reasonable use, whose overriding purpose is to maximize the beneficial uses of
water in the state. In addition, the Board (as well as the State courts and
other state agencies) has the continuing obligation to protect a river's
"public trust" values from degradation by a proposed project. As with FERC,
however, the Board traditionally has weighed the value of the competing
beneficial uses of a river on a qualitative basis.

        This appendix reviews the law applicable to FERC and to the Board which
requires the weighing of the social costs and benefits of a proposed

hydroelectric project. It is concluded that agency use of a social benefit-cost model which quantifies, monetizes, and internalizes environmental costs--such as that proposed in this study--would further the purpose of these legal requirements by providing for a more objective and thorough evaluation of a proposed project's environmental impacts. In certain cases, use of a social benefit-cost model may in fact be required.

Federal Law

The Federal Power Act

FERC has statutory authority under Part I of the Federal Power Act, 16 U.S.C. Sections 791(a) et seq., to license construction of hydroelectric facilities. However, in exercising this authority, FERC is required to weigh the project's benefits against the value of competing uses of the river which may be lost or degraded by development. Section 4(e) of the Act requires that a project be "desirable and justified in the public interest." 16 U.S.C. Section 797(e). In addition, Section 10(a) provides that:

> the project adopted . . . shall be such as in the judgment of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water-power development, and for other beneficial public uses, including recreational purposes 16 U.S.C. Section 803(a). (Emphasis added.)

As construed by the United States Supreme Court, these provisions of the Act require FERC to consider the benefits and costs of a proposed hydroelectric project to society as a whole, rather than just to the project proponents, and to reject a project which is not in the "public interest."

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See <u>Udall</u> v. <u>Federal Power Commission</u>, 387 U.S. 428 (1967).[1] In <u>Udall</u>, the Court addressed the question of whether FERC's predecessor, the Federal Power Commission (FPC), had adequately considered the potential degradation of a salmon fishery in its decision to license a proposed hydropower project on the Snake River. The Court said:

> The grant of authority to the Commission to alienate federal water resources does not, of course, turn simply on whether the project will be beneficial to the licensee. Nor is the test solely whether the region will be able to use the additional power. The test is whether the project will be in the public interest. And that determination can be made only after an exploration of all issues relevant to the "public interest," including future power demand and supply, alternate sources of power, <u>the public interest in preserving reaches of wild rivers and wilderness areas, the preservation of anadromous fish for commercial and recreational purposes, and the protection of wildlife</u>. 387 U.S. at 450. (Emphasis added.)

The Court also noted that the Fish and Wildlife Coordination Act (16 U.S.C. Sections 661 <u>et seq</u>.) requires that "wildlife conservation shall receive equal consideration and be coordinated with other features of water

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[1]Prior to the Court's decision in <u>Udall</u>, several Federal Circuit Courts of Appeals had interpreted the Federal Power Act to require the FPC to consider the broad social benefits and costs of a proposed hydroelectric project rather than only the limited costs and benefits to the project developers. <u>E.g</u>, <u>Scenic Hudson Preservation Conference</u> v. <u>FPC</u>, 354 F.2d 608 (2nd Cir. 1965) (<u>Scenic Hudson I</u>); <u>State of California</u> v. <u>FPC</u>, 345 F.2d 917 (9th Cir. 1965). The Seventh Circuit had specifically affirmed FERC's authority to deny a license because of the loss of recreational and scenic values. <u>Namekagon Hydro Company</u> v. <u>FPC</u>, 216 F.2d 509, 511-512 (7th Cir. 1954).

resource development programs." 387 U.S. at 443.2   Based on its conclusion that the FPC had not weighed the harm to the salmon and steelhead fisheries which could result from the proposed project, the Court remanded the case. Id., at 451.3

Neither the Federal Power Act, nor court decisions interpreting the Act, have defined any specific methodology FERC should use in weighing the various considerations making up the "public interest." In particular, neither the Act nor the courts require that FERC perform a formal benefit-cost analysis which internalizes environmental or other externalities. As discussed in more detail later, FERC practice is to consider the value of environmental losses caused by a project on a qualitative basis, and to balance these losses against the quantified internal benefits to the project developer. This practice can result in biased decision-making which undervalues a project's environmental costs.

National Environmental Policy Act of 1969

The requirement that FERC weigh the environmental costs of a proposed hydroelectric project against its benefits is strengthened by the mandate of the National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. Sections 4321 et seq. See Greene County Planning Board v. Federal Power Commission, 455 F.2d 412 (2nd Cir. 1972). For projects that may significantly affect the quality of the natural environment, such as Clavey-Wards Ferry, this is done through the preparation of an Environmental Impact Statement (EIS) under Section 102(2)(C) of NEPA, 42 U.S.C. Section 4332(2)(C).

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2 The Court emphasized that the need to consider the impact on fisheries was especially important due to the fact that there were already eight dams on the Columbia River system (of which the Snake was part), 387 U.S. 437, and pointed out that Section 10(a) requires that a project must be "adapted to a comprehensive plan" for a waterway. 16 U.S.C. Section 803(a). As previously noted, the Tuolumne River already has extensive hydroelectric development, and the Clavey-Wards Ferry Project would destroy one of the few remaining free-flowing stretches of the River.

3 The segment of the Snake at issue was included by Congress in 1975 in the Hells Canyon Recreation Area, 16 U.S.C. Section 460 gg et seq. The Act establishing the Recreation Area prohibited licensing of hydroelectric or other water projects on this segment. The FPC accordingly dismissed the license application in 1976. Pacific Northwest Power Co., 55 F.P.C. 2742(1976).

The leading case to establish that NEPA requires a careful weighing of the benefits and costs of a proposed project is _Calvert Cliffs' Coordinating Committee v. Atomic Energy Commission_, 449 F.2d 1109 (D.C. Cir. 1971). In _Calvert Cliffs_, the Court of Appeals for the District of Columbia Circuit held that

> NEPA mandates a case-by-case balancing judgment on the part of federal agencies. In each individual case, the particular economic and technical benefits of planned action must be assessed and then weighed against the environmental costs; alternatives must be considered which would affect the balance of values. 449 F.2d at 1123.

Courts since have repeatedly stressed the obligation of Federal agencies to give sufficient weight to environmental values as mandated by NEPA. In reviewing agency actions under NEPA, courts require that the agency's analysis of the environmental consequences of a project be objective and detailed enough to enable the agency to take a "hard look" at those consequences. _See, e.g., Kleppe_ v. _Sierra Club_, 427 U.S. 390, 410 n. 21(1976).[4] The courts have disagreed, however, on whether a formal benefit-cost analysis is required as part of the EIS process.

Several early NEPA cases addressing the adequacy of benefit-cost analyses used to justify Federal water projects not only require a benefit-cost analysis as part of the EIS, but also support the principle that environmental costs should be quantified and monetized whenever possible. _E.g., State of Alabama ex rel. Baxley v. Corps of Engineers_, 411 F.Supp. 1261, 1267-1268 (N.D. Ala. 1976); _Duck River Preservation Association v. Tennessee Valley Authority_, 410 F.Supp. 758 (E.D. Tenn 1974). Perhaps most notable among these is _Sierra Club v. Froehlke_, 359 F.Supp. 1289 (S.D. Tex. 1973), _rev'd on other grounds sub nom, Sierra Club v. Callaway_, 499 F.2d 982 (5th Cir. 1974). In _Froehlke_, the court questioned the objectivity of the Army Corps of Engineers consideration of the environmental impacts of the Wallisville-Trinity Project in Texas because the benefit-cost analysis of the project quantified purported

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[4]For more discussion on the use of benefit-cost analysis and the scope of judicial review under NEPA see Rodgers, _Benefits, Costs, and Risks: Oversight of Health and Environmental Decisionmaking_, 4 Harv. Env. L.R. 191, 210-214 (1980); Williams, _Benefit-Cost Analysis in Natural Resource Decisionmaking: An Economic and Legal Overview_ 11 Nat. Resources Law 761(1979); Note, _Cost-Benefit Analysis in the Courts: Judicial Review under NEPA_, 9 Ga. LR 417(1975); and Rosen, _Cost - Benefit Analysis, Judicial Review and the National Environmental Policy Act_, 7 Env. Law 363(1977).

environmental benefits, notably recreation, while not attempting to quantify the project's costs associated with the loss of environmental amenities. The court noted the bias in decision-making that can result if environmental costs are compared on a qualitative basis to more fully quantified project benefits:

> Conclusions arrived at based upon a procedure weighted in favor of developmental type recreation facilities does [sic] not take into account the desires of those who may prefer natural recreation. Unless measurement procedures accurately calculate both types of usages, the former can be emphasized at the expense of the latter.
>   359 F.Supp. at 1378-9.

NEPA and its legislative history support the court's reasoning in Froehlke and indicate that Congress envisioned development of methodologies to quantify and monetize environmental costs so that these costs would receive adequate consideration in the decisionmaking process. For example, NEPA requires that agencies "identify and develop methods and procedures . . . which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations." 42 U.S.C. Section 4332(2)(B). Similarly, NEPA's legislative history supports the use of formal monetized benefit-cost analyses in discussing steps the Council on Environmental Quality (CEQ) could take to ensure that environmental amenities are given suitable consideration:

> One way in which this might be done would be to develop a sophisticated method of cost and benefit analysis -- in which the total (and often not strictly economic) consequences of Federal activities may be assessed. H. Rep. No. 91-378, 91st Cong., 1st Sess., U.S. Cong. & Adm. News 2751, 2760 (1969).

The prevailing view among the courts, however, is that NEPA, while requiring a balancing of the social benefits and costs of a project, does not, at least in every case, require a formal benefit-cost analysis as part of the EIS. E.g., Suffolk County v. Secretary of Interior, 562 F.2d 1368 (2nd Cir. 1977); Trout Unlimited v. Morton, 509 F.2d 1276 (9th Cir. 1974); Sierra Club v. Morton, 510 F.2d 813 (5th Cir. 1975). This position results in large part from uncertainty as to the validity of methodologies for quantifying and valuing environmental amenities. See, e.g., Environmental Defense Fund v. Army Corps of Engineers, 492 F.2d 1123, 1133 (5th Cir. 1974); Environmental Defense Fund v. Froehlke, 368 F.Supp. 231 (W.D. Mo. 1973) aff'd sub nom. Environmental Defense Fund v. Callaway, 497 F.2d 1340 (8th Cir. 1974). It may also stem from a fear--articulated by the court in Froehlke-- that use of a formal benefit-cost analysis will emphasize the more traditional economic benefits of a project and will ignore or undervalue environmental costs. See,

e.g., 40 CFR Section 1502.23 (CEQ regulations implementing NEPA).5 Courts
thus have been reluctant to impose methodological requirements on agencies and
instead require only that the EIS contain sufficient detail and objectivity to
enable the agency and others to take the requisite "hard look" at a project's
environmental costs. See, e.g., Trout Unlimited v. Morton, supra; Robinson v.
Knebel, 550 F.2d 422 (8th Cir. 1977).

A recent Ninth Circuit case, however, confirmed that a formal benefit-
cost analysis, while not always mandated, may be required when necessary to
provide the decision-making agencies and public with the necessary information
to weigh fully the costs and benefits of a project. Columbia Basin Land
Protection Ass'n v. Schlesinger, 643 F.2d 585 (9th Cir. 1981). After noting
the prevailing view that a formal benefit-cost analysis is not an absolute
requisite to the sufficiency of an EIS, the court said:

> This is not to say that a mathematical cost-
> benefit analysis is never required. If an
> alternative mode of EIS evaluation is

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5 40 CFR Section 1502.23 provides in full:

> If a cost-benefit analysis relevant to the
> choice among environmentally different
> alternatives is being considered for the
> proposed action, it shall be incorporated by
> reference or appended to the statement as an
> aid in evaluating the environmental
> consequences. To assess the adequacy of
> compliance with sec. 102(2)(B) of the Act the
> statement shall, when a cost-benefit analysis
> is prepared, discuss the relationship between
> that analysis and any analyses of
> unquantified environmental impacts, values,
> and amenities. For purposes of complying
> with the Act, the weighing of the merits and
> drawbacks of the various alternatives need
> not be displayed in a monetary cost-benefit
> analysis and should not be when there are
> important qualitative considerations. In any
> event, an environmental impact statement
> should at least indicate those
> considerations, including factors not related
> to environmental quality, which are likely to
> be relevant and important to a decision. 40
> C.F.R. Section 1502.23.

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> insufficiently detailed to aid the decision-
> makers in deciding whether to proceed, or to
> provide the information the public needs to
> evaluate the project effectively, then the
> absence of a numerically expressed cost-
> benefit analysis may be fatal.
>
> 643 F.2d at 594

The court held that in the case before it, a formal monetized benefit-cost analysis was not required, in part because the methodology for performing such an analysis was still of uncertain value. Id. at 594. However, the case clearly supports the position that the use of methodologies for monetizing and internalizing environmental amenities may be required in appropriate cases in order to ensure objective evaluation of the environmental costs of a proposed project.

In summary, the mandate of NEPA is to consider the environmental costs of a project "to the fullest extent possible." 42 U.S.C. Section 4332. While NEPA does not impose an absolute requirement for a numerical benefit-cost analysis, it does require that agencies objectively evaluate a project's environmental costs and give these costs sufficient weight in the decision-making process. Put another way, NEPA requires that agencies employ methodologies in their EIS process which maximize the articulation of environmental values. The practice of most Federal agencies, including FERC, however, is to weigh environmental costs on a descriptive, qualitative basis.[6] As discussed in the next section, this practice often results in inadequate consideration of environmental losses in the FERC licensing process.

FERC Practice

While FERC acknowledges its duty to weigh the environmental impacts of a project against the project's benefits, it has in only one case denied a license application for an "economically feasible" project because environmental costs (assessed qualitatively) exceeded the project's benefits. Namekagon Hydro Company, 12 F.P.C. 203 (1953). The Namekagon decision was upheld by the Seventh Circuit, which affirmed the FPC's authority to deny a license because of the loss of fishing, canoeing, and scenic values. Namekagon Hydro Company v. Federal Power Commission, 216 F.2d 509, 511-512 (7th Cir.

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[6]According to one commentator, of the thirty-three agencies with major NEPA responsibilities, approximately one-third regularly include a systematic comparison of benefits and costs in their EIS. Williams, supra note 4 at 765.

1954). In subsequent licensing decisions, the FPC and FERC have recited the agency's environmental responsibilities, often citing _Namekagon_, but invariably have decided in favor of proceeding with the project, often despite recognized environmental degradation. _See_, _e.g.,_ _Monongahela_ _Power_ _Company_ _et_ _al._, 58 FPC 451 (April 21, 1977); _Public_ _Utility_ _District_ _No. 1_ _of_ _Snohomish_ _Co._ _and_ _City_ _of_ _Everett,_ _Wa._, 41 FPC 108, 116 (January 30, 1969).

In analyzing the public merit of a proposed project, FERC does not quantify (in monetary terms) or internalize environmental costs in the project's benefit-cost analysis.[7] Rather, that analysis accounts only for the internal costs and benefits to the project developers in order to determine whether the project is "economically feasible." U.S. Department of Energy 1979; _e.g.,_ _Solano_ _Irrigation_ _District_, 14 FERC 61,089 (1981). This internal benefit-cost analysis compares the average annual costs of a project to the project benefits, where the latter are calculated as the cost to the license applicant of obtaining power from the least expensive alternative source. This procedure accounts for environmental costs only to the limited extent that the costs of environmental mitigation are borne by the developer and included in the benefit-cost analysis.

Once a project is shown to be economically feasible, in this narrow sense, environmental considerations are examined. FERC's regulations for implementing NEPA require that applicants, in assessing various alternatives to the project, "must show how environmental costs, even if not quantifiable, are weighed against economic benefits/costs and technological and procedural constraints." 18 C.F.R. Chapt. I, Part 2, App. A, Section 8.5; _see_ _also_ 18 C.F.R. Section 2.80, 2.81. The regulations thus require full consideration of all environmental costs and even implicitly recognize that the value of some environmental amenities may be quantified. However, a review of FERC decisions indicates that the agency usually assesses a proposed project's environmental costs on a descriptive qualitative basis. _E.g._ _Monongahela_ _Power_ _Company,_ _supra_; _Public_ _Utility_ _No. 1_ _of_ _Snohopiah_ _Co.,_ _supra._

The fact that FERC has only once rejected an application on environmental grounds (_Namekagon_ _Hydro_ _Company,_ _supra_) is evidence that the qualitative evaluation of environmental costs often tends to undervalue those costs, especially when compared to quantified monetary benefits to the license applicant. Moreover, FERC and FPC licensing decisions suggest that the agency perceives its primary role as developing hydroelectric power and that it is "constrained" to license projects despite the environmental losses which

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[7]FERC may quantify the extent of environmental damage in the sense that it specifies the number of acres inundated or the number of a certain animal species lost. It does not, however, attempt to value the environmental costs in monetary terms.

result. E.g. Public Utility District No. 1 of Snohomish Co., 41 FPC at 116; Monongahela Power Co., 58 FPC at 471. This perception can introduce a pro-development bias weighted against environmental concerns into the agency's subjective balancing process.

In order to assure that FERC gives due weight to environmental costs, the agency should instead assess projects on a social benefit-cost basis, which would include quantification, monetization and internalization of all externalities, including environmental amenities, to the extent possible. Such an approach would make the assessment of environmental costs more objective and would require FERC to articulate clearly the assumptions underlying its evaluation of these costs. The use of a formal social benefit-cost methodology may in fact be required in appropriate cases to ensure that FERC adequately considers environmental costs, as mandated by NEPA and the Federal Power Act. See Columbia Basin Land Protection Association v. Schlesinger, supra. While some environmental costs likely cannot be quantified, and must still be considered on a qualitative basis, internalization of those environmental costs which can be quantified would help ensure that those costs are weighed on an equal basis with a project's more traditional quantified economic benefits.

The internalization of environmental costs, where possible, is consistent with Federal law and policies applicable to Federally financed water projects. Federal water resource planning agencies, such as the U.S. Bureau of Reclamation ("Bureau") and the U.S. Army Corps of Engineers ("Corps"), have historically been required to perform benefit-cost analyses to assess the merit of investment of public funds in proposed water projects. See, e.g. Flood Control Act of 1936, Sections 1 and 2, 33 U.S.C. Sections 701(a) and (b). These agencies have in the past frequently distorted the benefit-cost analysis process in favor of project construction, in part because of their failure to include environmental costs in the analysis. See, e.g., Sierra Club v. Froehlke, supra.

However, the U.S. Water Resources Council, under the authority of the Water Resources Planning Act, 42 U.S.C. 1962a-2, recently issued new "Principles and Guidelines" directly applicable to the Corps and the Bureau, as well as the Tennessee Valley Authority and the U.S. Soil Conservation Service, which require water project planners to monetize all project impacts including environmental effects which can be measured and to internalize all known direct project impacts, whether beneficial or adverse. U.S. Water Resources Council 1983a and 1983b. While not directly binding on FERC, the "Principles and Guidelines" establish a clear Federal policy in favor of quantification, monetization and internalization of environmental impacts of proposed hydroelectric and other water projects.

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Water Rights Permits

In order to appropriate water through diversion or storage for hydropower purposes in California, a project developer must have sufficient water rights under State law.[8] Unless the developer can establish sufficient existing rights (see discussion below), the developer must obtain a water rights permit from the State Water Resources Control Board (Board) under procedures codified at California Water Code Sections 1252-1257. Although not stipulated as a quantitative benefit-cost analysis, the Board must weigh the benefits of the proposed appropriation for hydropower against the loss of other beneficial uses, including specifically fish and wildlife and recreational uses. Moreover, even after obtained, water rights remain subject to the state constitutional requirement of reasonable use and to the public trust, both of which require a continuing balancing of hydroelectric use against the competing uses of a waterway.

The appropriation and subsequent use of water in California is subject to the state constitutional mandate of reasonable and beneficial use. See Cal.

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[8]See FERC Order Issuing Preliminary Permit and Denying Competing Application, Project Nos. 2774-000 and 5642-000 [Clavey-Ward's Ferry] (April 6, 1983) at 4. While FERC takes the position that a state may not condition or veto a proposed hydroelectric project subject to FERC jurisidction, a recent U.S. Supreme Court decision raises a serious question as to the validity of that position. In California v. United States, 438 U.S. 645 (1978), the United States Supreme Court held that states could impose conditions on Federal water projects authorized under the Reclamation Act of 1902, to the extent that those conditions were not inconsistent with Congressional authorization. The court rejected the U.S. Bureau of Reclamation's long-standing position that the Reclamation Act pre-empted State law, relying on its interpretation of Section 8 of the Reclamation Act which "saves" State water rights laws from supercedure, 43 U.S.C. Sections 372, 383. Section 27 of the Federal Power Act (16 U.S.C. Section 821) is very similar to Section 8 of the Reclamation Act and, in light of California v. United States, could be construed to allow states to impose conditions on FERC licensed hydropower projects. The scope of Section 27 has never been directly addressed in the numerous federal court decisions often cited in support of FERC's position. See, e.g., First Iowa Hydro-Electric Cooperative v. Federal Power Commission, 328 U.S. 152 (1946).

Const. Art X, Section 2, (adopted in 1928 as Art. XIV, Section 3).9 The overriding public interest mandate of the reasonable use requirement is to maximize the beneficial use of water in the state. E.g., Peabody v. City of Vallejo, 2 Cal. 2d 351, 360-361 (1935); In re Waters of Long Valley Creek System, 25 Cal. 3d 339 (1979).

A reasonableness standard by its nature requires the balancing of competing water uses. For example, the California Supreme in Joslin v. Marin Municipal Water District, 67 Cal. 2d 132 (1967), balanced the extent to which the public interest was served by diversions for municipal water supply against the use of a continued stream flow to deposit sand and gravel for a quarry operation. The court held that the benefits to the public of providing water for municipal purposes outweighed the largely private benefits to the quarry operator. See also Tulare Irrigation Dist. v. Lindsay-Strathmore Irrigation Dist., 3 Cal. 2d 489 (1935); Cowell v. Armstrong , 210 Cal. 218 (1930); People ex . rel. SWRCB v. Forni, 54 Cal. App. 3d 743 (1976).

This balancing requirement has been specifically incorporated into the statutory procedures the Board must follow in considering a water rights

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9 Article X, Section 2 provides in relevant part:

> "It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water.

The reasonable and beneficial use requirement is also codified at California Water Code Section 100.

permit application. California Water Code Section 1257 requires the Board to "consider the relative benefit to be derived from all beneficial uses of water concerned including, but not limited to, use for domestic, irrigation, municipal, industrial, preservation and enhancement of fish and wildlife, recreational, mining and power purposes, and any uses specified to be protected in any relevant water quality control plan...." The Board may allow an appropriation subject to such terms or conditions "as in its judgment will best develop, conserve, and utilize in the public interest the water sought to be appropriated." California Water Code Section 1253. Alternatively, it may reject an application if it determines, after weighing the value of the competing beneficial uses, that the appropriation "would not best conserve the public interest." California Water Code Section 1255.

The Board generally relies on the recommendation of the Department of Fish and Game (Department) to determine the flows needed to protect fish and wildlife. See California Water Code Section 1243. The usual procedure is for the Department to protest an application which will adversely affect fish and wildlife values. If the Department is able to negotiate permit conditions with the applicant which in its opinion are adequate to protect these values, the Department withdraws its protest. See Bank of America v. State Water Resources Control Board, 42 Cal. App. 3d 198, 211 (1974). However, these permit conditions rarely fully protect the fish or wildlife resources and do not account at all for the loss or degradation of other environmental amenities. Neither the Board nor the Department utilizes a numerical benefit-cost analysis in balancing the public interest among competing uses of a river.

The Board also must evaluate the proposed appropriation in light of the California Environmental Quality Act (CEQA), Pub. Res. Code Sections 21000 et seq. For major appropriations, CEQA requires an environmental impact report, the purpose of which is to "identify the significant effects of a project on the environment, to identify alternatives to the project, and to indicate the manner in which such significant effects can be mitigated or avoided." 14 Cal. Admin. Code Section 15011.6(a). As with NEPA, CEQA requires that all environmental costs, whether quantified or not, be considered. The CEQA guidelines require government agencies "to consider qualitative factors as well as economic and technical factors and long term benefits and costs, in addition to short term benefits and costs." 14 Cal. Admin. Code Sec. 15010(g). An agency may approve a project with significant environmental effects only if there exists no feasible way to avoid or mitigate the effects and the agency identifies the benefits which outweigh the environmental losses. 14 Cal. Adm. Code Section 15043.

Thus, in administering the State's water rights permit system, the Board must look beyond the internal benefits and costs to the project developers and must consider the broader social benefits and costs of a proposed appropriation. While the Board is not required to assess a project on a numerical benefit-cost basis, a social benefit-cost methodology, such as that proposed in this study, would help ensure that the recreational and fish and wildlife costs of a project are more fully addressed. For similar reasons as

those discussed in the previous section on FERC practice, such an approach would greatly assist the Board in determining the value of the competing uses of a river to the people of the state.

Pre-1914 Rights

In the case of the Clavey-Wards Ferry Project, the project developers may attempt to rely on "pre-1914" rights and thereby avoid the need for obtaining a water rights permit under the procedures discussed above. These permit requirements apply only to appropriations initiated after December 19, 1914.

Both the Tuolumne Irrigation District (TID) and the Modesto Irrigation District (MID) have asserted pre-1914 rights on the Tuolumne, based on prior irrigation use, in protests to a water rights permit application filed by Tuolumne County for the County's Clavey River project (Application Nos. 27333 and 27108). The Board has requested information from both Districts on the extent of pre-1914 rights they might claim for the Clavey-Wards Ferry Project (letters from Raymond Walsh, Chief, Division of Water Rights, to Ernest Geddes, TID, and Oral Moore, MID, August 2, 1983 and September 15, 1983), but the Districts have not yet attempted to quantify the rights they might claim. (Letter from Oral Moore to Sam Fuller, Division of Water Rights, November 23, 1983.)

The Board's jurisdiction over pre-1914 appropriations is unsettled, although it likely encompasses claims under the constitutional requirement of reasonable use and the public trust doctrine (discussed below). The courts also would have concurrent jurisdiction with the Board over reasonable use and public trust claims. EDF v. EBMUD, 26 Cal. 3d 183 (1980); National Audubon Society v. Superior Court, 33 Cal. 3d 419 (1983). The requirements of CEQA would apply to the project regardless of any pre-1914 claims (although the irrigation districts proposing the project would be the agencies responsible for CEQA compliance).

The validity of a pre-1914 rights claim asserted by the project developers thus is likely to be disputed either by the Board or by interested intervenors. Once acquired, an appropriative water right can be maintained only by continuous beneficial use of the water. Therefore, regardless of the amount claimed in the original notice of appropriation, or at the time of diversion, the amount that can now be rightfully claimed under an appropriative right initiated prior to December 19, 1914 has, in general, become fixed by actual beneficial use, as to both amount and season of

diversion.[10]

    In addition, while a pre-1914 appropriator may change the point of diversion, place of use, and purpose of use, this may be done only if such a change will not harm others. California Water Code Section 1706. Thus, it is highly likely that if the proponents attempt to rely on pre-1914 rights, their claims will be challenged, and either the Board or the courts (or both) will eventually be called upon to balance the competing uses of the Tuolumne.

Public Trust Doctrine

    The public trust doctrine is integrated with the water rights system in California. The doctrine is a judicial development which recognizes the State as sovereign, holding title to all navigable waterways as trustee for the benefit of the people. The California Supreme Court in National Audubon Society v. Superior Court, 33 Cal.3d 419 (1983), made it abundantly clear that recreational, scenic, and fish and wildlife values are among the most important uses of the trust. Thus, any considerations of development of the Tuolumne River will require assessment of public trust values.[11]

    The court in National Audubon Society emphasized that the "public trust" doctrine requires that any decisions concerning the use of the State's water resources must be based on consideration of the value of the resources to the people of the State, rather than to limited private interests. The Audubon decision requires that great weight be given to protecting public trust values in water resource decisions:

> The state has an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible. [Footnote omitted.] Just as the history of this state shows that appropriation may be necessary for efficient use of water despite unavoidable harm to public trust values, it

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[10]California Water Code Section 1202(b) states that all water appropriated before 1914 which has not been put to use with due diligence is to be considered unappropriated water. Water Code Section 1240 states that when the beneficial useful purpose ceases, the right ceases.

[11]The Tuolumne River is encompassed by the public trust. Navigable waterways include waterways usable only for pleasure boating. National Audubon Society v. Superior Court, 33 Cal. 3d 419, 435, fn. 17 (1983).

> demonstrates that an appropriative water
> rights system administered without
> consideration of the public trust may cause
> unnecessary and unjustified harm to trust
> interests. [Citation omitted.] As a matter
> of practical necessity the state may have to
> approve appropriations despite foreseeable
> harm to public trust uses. In so doing,
> however, the state must bear in mind its duty
> as trustee to consider the effect of the
> taking on the public trust [citation omitted]
> and to preserve, so far as consistent with
> the public interest, the uses protected by
> the trust. 33 Cal.3d at 446.

The _Audubon_ decision also establishes that the State courts have concurrent jurisdiction to enforce the public trust. 33 Cal. 3d at 449. The public trust doctrine thus requires the Board, as well as other State agencies and the State's courts, if called upon, to weigh the benefits of a proposed hydroelectric project, like the Clavey-Wards Ferry Project, against its effect on public trust values. The Board (or court) must take into consideration the important fish and wildlife, scenic, and recreational values of the Tuolumne which would be lost if the Project were to proceed and "preserve, so far as consistent with the public interest," those uses.

For reasons previously discussed , a social benefit-cost model which quantifies environmental and other public trust values to the extent possible, and internalizes those values in the benefit-cost analysis, would help ensure that those values are more thoroughly and objectively considered in the decision-making process.

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