HANDBOOK FOR THE ECONOMIC EVALUATION OF APPLICATION FOR APPROPRIATION OF SURFACE AND GROUNDWATER IN THE STATE OF IDAHO

by

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FOR THE

SNAKE RIVER STUDIES ADVISORY COMMITTEE

Cecil D. Andrus, Governor

STATE OF IDAHO

WATER for IDAHO

IDAHO WATER RESOURCES RESEARCH INSTITUTE

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PREFACE

The "Swan Falls Agreement" signed on October 25, 1984 by Governor John Evans and Attorney General Jim Jones for the State of Idaho and James Bruce, Chief Executive Officer of the Idaho Power Company established a framework for resolving a controversy that has been simmering for sixty years. Citizens of the Upper Snake Valley in Idaho became concerned in the early nineteen-twenties that a downstream water right for hydroelectric power generation (a non-consumptive, in-stream use) could stand in the way of future upstream diversionary uses, (such as for irrigation and industry). In 1928, the Idaho Constitution was amended to permit the State to regulate and limit the use of water for power purposes. Since that time, several state water licenses granted for purposes of generating electricity have included "subordination language," which meant that the right to use water for power generation could not prevent upstream water diversions, even if the upstream project adversely affected power generation.

Increasing demands for electricity in their service area, much of which came from pumping for irrigation, caused the Idaho Power Company in recent years to seek additional power sources. A proposed coal-fired electricity plant was rejected on environmental grounds. Caught in a dilemma, the Company filed suit against the State to determine the status of its water rights at its Swan Falls hydroelectric plant above the Company's Hells Canyon power complex. The Swan Falls facility had a pre-1928 water right, and the Idaho Supreme Court held in 1982 that the Swan Falls water right was <u>not</u> subordinate to the upstream developments that had occurred over the intervening decades. The Snake River suddenly was over-appropriated.

Legislative attempts to resolve the issue were stalemated, leaving a legal cloud over thousands of Snake River water rights. Facing the possibility of lengthy court battles, the parties entered into negotiations to attempt a complete settlement of the water rights controversy. The agreement signed in October 1984 called for the Idaho Power Company to accept a right at Swan Falls Dam of 3900 cubic feet per second (cfs) in the summer and 5600 cfs in the winter. The Company's water right becomes subordinate to all uses in place at the time of the agreement. Development of potential new upstream consumptive uses may be permitted, subject to the new diversion meeting certain public interest criteria. A reserve of 600 cfs was left for future development. Of this, one fourth (150 cfs) is to be available for domestic, commercial, municipal and industrial (D.C.M.I.) purposes.

Any proposed new uses would be evaluated under new public interest criteria as a condition for receiving a state permit. The Director of the Department of Water Resources is called upon to consider:

1. the potential benefits, both direct and indirect, that the proposed use would provide to the state and local economy;

2. the economic impact the proposed use would have upon electric utility rates in the State of Idaho, and the availability, foreseeability and cost of alternative energy sources to ameliorate such impact;

3. the promotion of the family farming tradition;

4. the promotion of full economic and multiple-use development of the water resources of the State of Idaho;

5. in the Snake River Basin above the Murphy gauge whether or not the proposed development conforms to a staged development policy of up to twenty thousand (20,000) acres per year or eighty thousand (80,000) acres in any four (4) year period.

The Idaho Department of Water Resources (IDWR) has published rules and regulations to implement these criteria (Idaho Department of Water Resources, Rules and Regulations: Water Appropriation, October, 1986). The salient portions are reproduced as Appendix A of this report. These Rules and Regulations provide general guidance on how the State is to evaluate the benefits and costs of proposed water projects.

The State of Idaho has commissioned this study to provide guidance for its officials in implementing the economic component of the Public Interest Evaluation Criteria. The study authors were directed to draw upon the currently available economic literature to ensure that the methodologies proposed are well-grounded in "generally-accepted" economic principles.

The authors performed the study as independent contractors. The views and recommendations here are those of the authors, and publication of this report should not necessarily be construed as an endorsement by the Idaho Department of Water Resources or the Idaho Water Resources Board.

CHAPTER 1

INTRODUCTION

A. Background

Water, a renewable resource, is subject to special regulations in most jurisdictions. Because of its mobility -- it may flow, seep, evaporate, or transpire -- the exclusive property rights basic to a private enterprise economy are difficult to establish and enforce. Also, only rarely is water fully consumed by a particular user. The "return flows" from upstream users may be reduced in quantity and quality, creating problems for downstream interests. The "same" water can often be used for more than one purpose (e.g., irrigation, power generation, municipal and industrial use, wildlife habitat, and recreation). Private ownership may capture only a part of these complementarities and interrelationships. Further, many view water as contributing special community and cultural values, and prefer not to have the resource treated as a commodity.

The absence of market systems in allocating water requires public agencies to develop means of appraising projects and programs relating to water. Such is the case with the state of Idaho, as the growing importance of hydroelectric power emphasizes the need for methods to reconcile competing uses of Snake River waters. Idaho needs to assess, on behalf of the public, "the potential benefits, both direct and indirect, that proposed new uses would provide to the state and local economy."

Normal private sector profitability tests, where all resources trade in properly functioning markets, would usually serve to assure the most productive allocation of resources. However, where the foregone benefits to potential or existing other users are not priced, some public review is needed to assure that the public interest is being satisfied.

The need for Idaho to establish new water allocation procedures stems from the potential for the interests of private water developers to differ from and perhaps be in conflict with a broader public viewpoint. Upstream depletions by industry or for irrigation, for example, impose a cost on users of electricity generated downstream. The reduced hydro power supply requires acquisition of higher cost electricity from other (probably fossil fuel) power generation sources, and eventually raises the rates to electricity users within the state. This was the basis of the stipulation in the legislation cementing the Swan Falls agreement that the benefits of new depletionary developments above Swan Falls must exceed the costs imposed on electricity users.

B. The Role of Water in the Idaho Economy

Much of the southern part of Idaho is semi-arid. Water, both from surface and from underground supplies, is nevertheless relatively plentiful. Productive soils and adequate growing seasons have made irrigation of agricultural crops a profitable venture and has laid the foundations for many prosperous communities. Hydroelectric power is increasingly important. A generally prosperous society with growing leisure time commits more time and money to outdoor recreation activities. Many leisure pursuits need or are enhanced by water: fishing, white-water boating and various non-contact streamside activities.

Table 1 summarizes some characteristics of water use in Idaho as of 1980. Irrigation represents the largest user of water, accounting for withdrawals of 18 million acre feet in 1980. The state, in fact, ranks

Table 1
Characteristics of Water Use
in Idaho, 1980
(mgd except as noted)

Total withdrawals		18,313
ground water	6,300	
surface water	12,000	
reclaimed sewage	13	
Conveyance losses		3,600
Consumptive use		5,900
Per capita withdrawals (gpd)		19,000
Public supplies		160
Rural domestic and livestock		68
Irrigation		16,000
Self-supplied industrial		2,205
thermoelectric		5
other		2,200
Hydroelectric (instream)		76,000

Source: Solley, W.B., E.B. Chase and W.B. Mann, IV, Estimated Use of Water in the United States in 1980, Circular 1001, U.S. Geological Survey: Washington, D.C., 1983.

fourth in the nation (after California, Texas and Nebraska) in both acreage served and consumptive use of irrigation water, and leads the nation in per capita withdrawals of water. With a small urban and industrial sector, diversions for other than agriculture are about 14 percent, a relatively small proportion of water use.

C. Purpose and Scope

The purpose of this Handbook is to provide a procedural manual for use by agencies of the State of Idaho and potential water rights applicants in performing economic evaluations of proposed water development projects. The handbook sets forth guidelines for the State's economic evaluation of proposals made by private sector or local government entities, the evaluation being carried out from the point of view of the State of Idaho as a whole. The major concern of economic evaluation is to assure that aggregate benefits exceed aggregate costs from the State's point of view, i.e., that all scarce resources, labor, capital, enterprise, and know-how as well as water, be used to achieve their maximum advantage to the State.

This handbook represents, we believe, the first statement of a set of guidelines for economic evaluation of water development proposals strictly from the point of view of a state in a federal system. As will be seen in the text, the assumption of a state accounting stance changes the rules of the economic evaluation game: the viewpoint is that of the state's well-being. In contrast to a national (or even worldwide) accounting stance, the incidence of benefits and costs is crucial: who gets the benefits and who pays the costs of a project? The location of beneficiaries and cost-bearers is likewise important and financial arrangements such as cost sharing, cost repayment agreements, and project output pricing are also significant.

Does this mean that the authors are advocating departure from the norms of accepted economic analysis? Not at all, and we will take pains to identify situations in which the state's interests deviate from national interests. On the other hand, one cannot expect water managers below the federal level always to assume a national point of view. To do so would overlook many of the financial incentives that the Congress has embodied in law: subsidies to outputs, price supports, cost sharing on construction, special tax benefits and the like. While these incentives may lead to economically inefficient actions at the state level, such policies may be justified by noneconomic objectives at the national level. This may be an excessively optimistic interpretation of Congressional motivations, but it is unrealistic to ask state decision makers to overlook the advantages of special federal programs and laws. If one finds them objectionable, the critique should be aimed at the national level, not at state and local governments.

This handbook also represents one of the few instances wherein project evaluation guidelines have been developed especially for use by an agency other than the party that intends to carry out the project. Benefit-cost analysis has evolved largely for the use of agencies that are in the business of identifying, designing, constructing, and operating projects. The major users of the technique in the United States have been the U.S. Army Corps of Engineers, the Bureau of Reclamation and the Soil Conservation Service--just such construction and operating agencies. More recently, however, the U.S. Environmental Protection Agency has been making extensive use of benefit-cost analysis to assess various pollution control programs -- programs that are to be carried out mostly by private industries and municipalities. These analyses have been carried out from the traditional national viewpoint. Failure to apply benefit-cost analyses by regulatory agencies like the Occupational Safety and Health Administration (OSHA) have led to regulations that in many cases are so costly they are never implemented.

To have a public agency in a position of socially evaluating proposals made by others is, in many ways, an advantageous situation. It has frequently been advocated that project evaluation should be separated institutionally from construction and operation, to avoid the pro-structural and capital-intensive biases that historically have plagued water planning when carried out by agencies whose primary payoffs are from construction and operations (Howe, 1976, p. 39ff). However, taking such a viewpoint actually increases the complexity of the analysis since it encompasses the evaluation of impacts usually incompletely taken into account by the proposer: externalities, improperly priced inputs and outputs, socially inappropriate discount rates, and other social objectives at the state level. What values are to be used for these additional benefits and costs? Of equal importance, the state's analysis is intended to take a long-run viewpoint: What will this use of water mean to the state not only in the short term but in the future--a period within which social, demographic, and economic conditions can be seen only imperfectly and which probably reaches beyond the private and local planning horizon?

Whether or not it is important to have the state review these water allocation decisions depends on at least two things: (1) the likely differences between private or local and state viewpoints concerning what is important; and (2) the flexibility or inflexibility of water allocation following the initial permit or licensing. If we could be sure there would be no deviation between private profitability and overall state welfare, the state could simply license all private applications for which water is available. If water is freely tradable among users following initial licensing, then the initial permitting becomes less important because the water market will tend to correct mistakes, i.e. reallocate water to uses that turn out to be more productive.

Idaho water law and related Bureau of Reclamation practices inhibit (although do not prohibit) subsequent water rights transfers (Gardner, 1985), so initial allocations are important. Because of potential effects on parties outside the transactions, water rights transfers tend to be lengthy and expensive proceedings. There are also numerous reasons why private profit calculations or even local government evaluations will not reflect fully the broader state viewpoint. Much of the text of the handbook deals with these differences. The handbook thus deals with issues that are important and marks a departure from the usual national economic efficiency analysis, a departure that will, hopefully, be of greater relevance to the issues confronting Idaho.

CHAPTER 2

THE POLICY FRAMEWORK AND FACTUAL DATA BASE FOR STATE ECONOMIC EVALUATION OF WATER APPLICATIONS

This handbook deals primarily with procedures for determining "potential benefits, both direct and indirect, that the proposed use would provide to the state and local economy" (Preface, pp. vi, above). We interpret the phrase "potential benefits" in the preceding quotation to refer to potential <u>net</u> benefits (that is, benefits net of costs). No decision is without costs. The costs of any given choice are the benefits foregone elsewhere.

Economic evaluation, often termed "cost-benefit analysis" (CBA) attempts to quantify the advantages and disadvantages to society of alternative policies or actions in terms of a common monetary unit. Put another way, economic appraisal seeks to assure that scarce resources (such as labor, capital, natural resources and management) are all employed to their best advantage. Cost-benefit analysis can be applied to many public actions (or private actions which affect the public interest), including appraisal of investment projects, to evaluate policies and regulations, and in general to evaluate any proposed decision which may imply measurable economic consequences.

An important strength of economics is the practice of thinking within a "systems" framework. A system is a set of elements whose individual behavior is best understood in terms of interrelationships among those elements. The understanding of the behavior of certain elements of the system must take into account the nature of certain other elements.

Economics has been characterized by some authorities as the "study of the unintended consequences" of human action in the social system encompassing production, exchange and consumption of goods and services.

> ...economics begins where direct observation leaves off. ...The immediate impact of most economic decisions is apparent even to the untrained: a legal control holding price below the market-clearing price makes goods less expensive (in money terms); a minimum wage set above the market-clearing level raises the income of (employed) workers. Economics deals with the hidden impacts of these problems or phenomena not readily understood to be aspects of these problems (for example, shortages and unemployment). (O'Driscoll, 1977, pp. xviii)

Henry Hazlitt (1979) has written:

> The art of economics consists in looking not merely at the immediate but at the longer term effects of any act or policy; it consists in tracing the consequences of that policy not merely on one group but for all groups.

The above insights have particular meaning in the case of water resource planning. The immediate (direct) effects of investments in or changes in use of water resources are evident in increased production and satisfaction to water users. Many of the local indirect impacts are also readily anticipated: increased economic activity and employment in the local area follow from purchases by water users. Indirect negative effects, however, are likely to be felt also, but are not so readily apparent because they typically are registered on individuals in other localities or jurisdictions. These negative impacts may take any of several forms: changes in price, employment, income, or welfare. More difficult to quantify than direct positive effects, these negative impacts often can only be measured as the prospective value of foregone opportunities.

A. <u>The Multiple Objective Planning and Evaluation Framework (MOPE)</u>

Public sector decision-making is a complex process, whether viewed from social, political or technical points of view. This handbook deals with the technical economic issues involved in Idaho's water permitting process, but no discussion of applied economic analysis can ignore the larger social and political decision-making process because that framework determines the demand for the input of economic analysis, the weight to be placed on economics in comparison with other considerations, and sometimes the pressures that are present to distort the economic analysis.

The public sector today clearly operates within a framework of multiple objective planning and evaluation (henceforth MOPE) within which economic net benefits are presented to decision makers along with analyses of environmental, social, and regional impacts. This approach was embodied in the U. S. Water Resources Council's "Principles and Standards" (1973) and is partially retained today in the Council's "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (1983).

The evolution of the MOPE approach warrants some attention so that the economist can better appreciate the place of economics and the role it currently is called to play. Modern treatments of the appraisal of public works often begin with the Flood Control Act of 1936, which called for the justification of projects on the basis of an explicit analysis to determine if the benefits "to whomsoever they might accrue" would exceed the costs. It was, however, only in the post-World War II era that benefit-cost analysis became important in its U.S. applications, primarily in the public water resources sector. The nature of the principles and techniques practiced in the 1950s was manifested primarily in Proposed Practices for Economic Analysis of River Basin Projects (originally issued in 1950 and revised in 1958), commonly called the "Green Book," compiled by the federal Inter-Agency Committee on Water Resources, and in the incisive books by Krutilla and Eckstein, Multiple Purpose River Development (1958) and Eckstein, Water Resources Development (1961). The procedures embodied economic efficiency analysis from a national viewpoint. While they fully encompassed the evaluation of multiple purposes (power, flood control, navigation, irrigation), they did not encompass multiple objectives, i.e., they did not provide for the analysis of income distributional effects, environmental impacts, or regional benefits and costs. The procedures did not provide for any tradeoffs of other objectives against efficiency.

The national efficiency benefit-cost criterion became firmly embodied in federal procedures in the form of Bureau of the Budget Circular A-47 (1952), which was designed to emphasize private water development and required that benefits exceed costs for executive branch approval of federal projects. The resultant reduction in the federal water development program led to a congressional revolt, culminating in hearings before the House Committee on Interior and Insular Affairs in 1955. Congressional resistance to a strict benefit-cost criterion continued through 1961 when the Bureau of the Budget commissioned a consultant panel report on "Standards and Criteria for Formulating and Evaluating Federal Water Resources Developments" (U.S. Bureau of the Budget, 1961). In this report one finds for the first time explicit mention of "objectives other than national income," including the importance (and difficulty) of evaluating outdoor recreation benefits and preservation of valuable natural areas, as well as assessment of income distribution and other merit wants.

The consultants' report was not formally published or promulgated as a guideline document but was soon followed by another policy document drawn up by a task force under the Secretaries of Defense, Interior, Agriculture, and H.E.W. entitled "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources". Published by the U. S. Senate (87th Congress, 2nd Session) as Senate Document 97, this statement was approved by President Kennedy for application by each of the executive branch departments and by the Bureau of the Budget in its review of proposed programs and projects. It anticipated nearly all subsequent developments in the benefit-cost field and substantially expanded the scope of analysis to objectives other than national economic efficiency. It was further stated that national, regional, and local viewpoints should be fully considered, but that significant departures from the national viewpoint required to accomplish regional, state, or local objectives should be explicitly set forth in planning reports. Thus the explicit policy transition was made from single-objective national economic efficiency to an evaluation procedure with explicit consideration of such items as recreation, fish and wildlife opportunities, preservation of unique areas, and the "well-being of people," even when not quantifiable in economic terms.

Two observations help identify the strengths and weaknesses of traditional benefit-cost analysis. The strength was shown by the fact that benefit-cost analysis began to show that many specific projects which had long been touted by government agencies and special interest groups as highly profitable and as great generators of regional growth were in fact of questionable value from the national point of view. Uneconomical projects were being weeded out through benefit-cost analyses. The weakness of benefit-cost analysis was that there were legitimate objectives that could not easily be included in the national economic efficiency analysis. In the 1950s, some minor attention was being given to recreation as a consideration in project design and evaluation, but no recognition was given to issues now more in the forefront, such as water quality, wilderness preservation, or species survival.

One can philosophically accept the possibility of devising ways of inferring the public's values for such effects and still admit that such techniques are not sufficiently developed to permit efficiency analysis to be all inclusive, i.e., that responsible social planning requires a multiple-objective framework. Economists (including Daniel Bromley, William Lord and Allen Schmid) who were seriously concerned about this issue began the formal development of multiple-objective evaluation techniques. Unfortunately, in our view, they were joined by agencies and clientele groups who, worried at the lack of new project starts, saw multiple-objective planning as a way of fuzzing up the analysis and de-emphasizing economic efficiency in project evaluation. This became the hidden agenda of some of those espousing multiple-objective planning.

Many mainstream economists, without adequately weighing the practical advantages and theoretical consistency of multiple-objective planning, stoutly resisted these developments. One basis for resistance was a belief that all benefits and costs were, in fact, monetizable: "However, conceptually all real net project effects are part of economic efficiency.

Therefore, we think that the new multiple account framework offered by the ... [(Water Resources Council)] ... is redundant and conceptually unsound ...." (Cicchetti et al., p. 16). Also, "We should urge renewed efforts to develop and gain consensus on appropriate methodologies for the estimation of values for these nonmarketed outputs. In our judgment, this is the first order of business" (Knetsch et al., p. 12). These were legitimate professional concerns. On the other hand, part of economists' resistance to multiple-objective planning was strategic in nature, an attempt to avert the potential de-emphasis of economic efficiency analysis.

Today, however, there is broad acceptance of the MOPE framework. We visualize an idealized framework for public decision-making as one in which high quality, objective technical analyses of the economic, environmental, social, and regional impacts of proposed programs and projects are presented to decision-makers and the public alike, with weights being assigned to these various objectives in keeping with the decision-makers' preferences and their interpretation of the public's desires.

B. Administrative Criteria To Be Applied by the Department of Water Resources and Their Relationship to MOPE

The Rules and Regulations: Water Appropriation contain a detailed set of criteria (reproduced here in Appendix A) that must be met and/or evaluated for applications for both unappropriated water and the so-called "trust waters" that were freed for reappropriation under the Swan Falls resolution (see Costello and Kole, 1985). Some of these criteria (listed below) correspond directly to the main objectives in MOPE. Others are intended to facilitate the administrative processes (e.g. provision of needed information by the applicant); to assure compliance with existing water and environmental laws; and to express values of particular importance to Idaho that are consistent with the broad MOPE objectives but need to be spelled out in greater detail (e.g. desirability of staged development, impacts on employment, and impacts on the family farm). At least one criterion, the avoidance of speculation in water, represents a social concern that is probably at odds with the economic efficiency criterion, because "speculators" can help dampen wide price swings and can perform the role of identifying highest and best use of the resource (e.g. see MacDonnell and Howe, 1986).

The listing of the proposed IDWR criteria which follows will serve to spell out the particular impacts and conditions considered important in Idaho, and to help the staff economists understand the broader framework of evaluation of which economic analysis is a part. Short interpretations relating to economic issues have been added in brackets in Table 2.

These required criteria and measurements, representing the interests of the State of Idaho, make it clear that economic analysis (items 5a, 5b, 5c, 8 in Table 2) is just a part of a broader evaluation process. The economic analysis itself goes beyond the usual benefit-cost analysis in its measurement of employment impacts and the effects on the main sectors of the Idaho economy.

C. Data To Be Provided By The Applicant

The data needs of the evaluation process are extensive. The Department of Water Resources must, therefore, rely rather heavily on data provided by the applicant concerning the intended uses of water, project costs and employment, etc. The Rules and Regulations for Water Appropriation require that the data shown in Table 3 be provided by the applicant.

Table 2
Criteria and Measurements To Be Applied
by the Director of Water Resources

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1. Impacts of the use described in the application on the quantity and quality of water available to satisfy existing water rights. (Consideration of externalities from return flows).

2. Adequacy of available unappropriated or trust supplies to meet the needs specified in the application. (Protection of existing water rights; avoidance of costs to other parties.)

3. Evidence of a "good faith" application, that it is not for purposes of speculation or delay. (Speculation can play a beneficial economic efficiency role such as reserving water for anticipated future uses, but it can also be used to create an artificial scarcity of water. The potential for such monopoly powers is generally overemphasized.)

4. Adequacy of the applicants' financial resources (to assure completion and operation of the proposed water use).

5. Coincidence of the new use with the local public interest as measured by:

   a. employment impacts by sector;

   b. changes in revenues (gross sales) to all sectors of the state economy;

   c. stability of revenue (sales) and employment gains during construction and over the operating life;

   d. impacts on fish and wildlife;

   e. compatibility with air quality standards, water quality standards, and zoning regulations;

6. (for trust water) Impacts on hydropower generation in Idaho;

7. (for trust water) Likely impacts on electric utility rates;

8. (for trust water) Direct and indirect economic benefits and costs (from the state's point of view);

9. (for trust water) Impacts on family farming;

10. (for trust water) Conformance with a desirable pattern of "staged development" in the area above the Murphy gauge.

Table 3
Data To Be Provided by the Applicant

1. Water requirements of the project in terms of surface and/or ground water sources; rate, volume, and timing of withdrawals; consumptive uses; and quantity and quality return flow effects. These data must be certified by a registered engineer for projects appropriating more than 25 cfs or 10,000 acre-feet for storage.

2. Plans, specifications and costs of the project.

3. Any information on likely local impacts.

4. Comments on project impacts from each of the following agencies:

   a. the unit of local government encompassing the project;

   b. Department of Fish and Game;

   c. Department of Health and Welfare;

   d. Division of Health and Environment;

   e. Any irrigation districts or ditch companies that would be involved.

5. Cropping patterns, acreages, and intended rotations.

6. Jobs known to be created or eliminated by the project.

7. Changes in needed community services during construction and operation, including school services, housing, roads, public utilities, public health and safety services.

8. Project energy needs and intended sources.

Items 1, 2, 3, 5, 6, 7, and 8 in Table 3 all relate to the economic analysis of the proposed project. Items 2, 3, and 7 remind us that the economic analysis is to go beyond the direct benefit-cost assessment of the project, extending to community and statewide effects such as employment, demands for infrastructure, and demands for community services.

The overview of MOPE and its relations to the specific Idaho criteria and data requirements has now been completed. It should be clear that economic analysis can provide inputs that are vital to water application evaluation, from a direct project benefit-cost analysis to quantification of impacts both by sector and statewide. Chapter 3 now presents the basic concepts and principles that are used in carrying out the economic analysis.

CHAPTER 3

GENERAL PRINCIPLES AND CONCEPTS FOR THE ECONOMIC EVALUATION OF IDAHO WATER ALLOCATIONS

The general strategy of applied economic evaluation is defined by one basic underlying axiom, supplemented by certain concepts and definitions that must be consistently applied across proposed projects and programs and across time. Stokey and Zeckhauser (1978, p. 137) label the basic axiom as the fundamental principal of evaluation: "In any choice situation, select the (policy) alternative that produces the greatest net benefit." The net benefit principle can be shown to be based on Paretian welfare economics which in turn is rooted in utilitarian ethics. This handbook will not treat the underlying fundamentals; the interested reader is referred to any of a number of texts on benefit cost analysis, such as Gramlich (1981), Pearce and Nash (1983), Campen (1986), or to Randall's essays (1984a; 1984b; 1986).

A. General Definitions and Principles

The economic evaluation of projects or proposals is based on balancing the beneficial and the adverse effects generated by the proposal. Benefits are the "good" or "desired" impacts generated by each project, and the costs are the "bad" or "undesired" impacts. Peskin and Seskin (1975) point out that:

> Cost-benefit analysis is a formal procedure for comparing the costs and benefits of alternative policies. It differs from more informal comparisons of costs and benefits in two principal ways. First, the terms costs and benefits are defined more narrowly than in general English usage. Second, the formal procedure and basis of comparison rely on specialized techniques and principles, most of which are derived from economic theory.

All decisions entail costs, since at the very least, a choice of one course of action implies a decision not to do something else. The costs of any choice are the benefits lost or the gains that would otherwise be realized. For a given project, the difference between benefits and costs is called "net benefits". Thus, the economic desirability of proposed projects can be determined by measuring their net benefits. The appropriate measurement of project benefits and costs will be treated in detail below.

1. Classifying and Defining Economic Effects of Proposed Actions or Policies

As implied above, economic evaluation selects from all of the effects or consequences of an investment or policy a specific set of impacts to be measured quantitatively. In addition to the basic distinction dividing effects into benefits and costs, it will be useful to specifically identify and define the other types of effects appropriately considered in the economic evaluation.

A major classification concerning the nature of benefits and costs is the distinction between "real" and "pecuniary" effects. Real effects are changes in actual quantities of goods or services available to beneficiaries or changes in the amount of resources used. In the case of benefits, real effects are additions to welfare of final consumers, while in the case of costs, they represent the actual use of resources which are diverted from alternative uses. Pecuniary effects are transfers and result from price changes that increase revenues for some people by the same amount that outlays are increased by others. Positive and negative pecuniary effects are usually assumed to more or less offset each other at the national level, and hence, are ignored. However, distinguishing between real and pecuniary effects is not always straightforward.

Another important distinction is between "direct" (or "primary") and "indirect" (or "secondary"). Direct effects are those immediately resulting from the investment or program being evaluated.

Direct benefits are goods and services produced by an investment project which further the purposes of the investing entity. They are the monetary value of project-produced goods and services. Direct benefits are measured in terms of the willingness to pay of beneficiaries for project services. Benefits from irrigation are conventionally measured as the excess of the value of crop outputs over associated costs.

Direct costs reflect the value of resources or inputs sacrificed to make the investment. Costs are measured by the foregone benefit from using a scarce resource for particular purpose rather than in its next best alternative use. This "foregone benefit" concept is often referred to the "opportunity cost" principle. In appraising irrigation developments, direct costs are often subdividecd into "project costs" and "associated costs". The costs of on-farm inputs, including the costs of the irrigation system, are the associated costs. Among the associated costs would be certain labor, capital and energy costs necessitated by the farming operation and by development and operation of the irrigation system. "Project costs" represent the value of capital and operating inputs required to deliver the water to a farm.

Indirect effects are those arising in addition to the direct project impacts, and affecting third parties. They can be either positive or negative, and are usually called "external" or "spillover" benefits and/or costs in the economic literature.

Two types of indirect effects are usually distinguished. Technological indirect effects are the result of physical interaction among the activities of two or more affected parties. In the case of water resource systems, the indirect technological impacts of interest are often the addition to or subtraction from water supplies available to third parties. Return flows to downstream water users can usually be regarded as a positive or favorable indirect physical effect. A reduction in water supplies to instream users (hydropower; recreation) is an example of adverse indirect effects, and is, in effect, precisely the problem which motivated the Swan Falls settlement and led to this report. Technological indirect effects are not, by definition, valued in market exchanges, so some process of imputing values is necessary. As we shall see, the same general valuation principles as applied to analysis of direct impacts are generally employed.

Pecuniary indirect effects are uncompensated side effects (either benefits or costs) transmitted through the market system. "Induced" (also called "backward-linked") pecuniary impacts are those registered on suppliers of inputs to project beneficiaries (fertilizer, machinery, or fuel in the case of irrigation). "Stemming-from" (also termed "forward-linked") impacts accrue to those who process, store, and transport outputs of project beneficiaries.

A major issue regarding indirect pecuniary effects arises in water project appraisals, to which we will return in some detail: to what degree, if any, are apparently indirect pecuniary effects actually real, thereby requiring measurement. (This topic is also the subject of a separate study in this series commissioned by the State of Idaho.)

Idaho's Snake River regulations can be interpreted as requiring the identification and quantification of, among other impacts, real net economic benefits from any proposed water development for irrigation and/or from municipal and industrial water use. Instream uses foregone, including hydropower and recreation, would be important examples of indirect technological costs. Any net real induced and stemming-from (forward and backward linkages) impacts registered elsewhere in the state economy would also be included.

As with the assessment of private sector investments, public sector analysts can choose from a number of dollar-denominated measures to appraise investments. A corporate financial specialist might employ gross revenues, cash flow, net profits or a number of other concepts to aid in deciding on the desirability of an investment. Profitability, in the final analysis is the most useful and appropriate measure in the private enterprise economy. In the public sector, gross revenues, value added (payments to primary factor owners) or net benefits are among the possible measures of social desirability of investments. These are all measured in dollar (monetary) terms. <u>However, as with profits in the private sector, "net benefits" is the most useful measure</u>.

<u>Additional effects</u> -- In addition to the real economic welfare impacts of a project measured in benefit-cost analysis, other effects or "impacts" may be experienced by the physical environment, the sectors of the local economy, or society. The totality of labor <u>employment</u> generated by the operation of the irrigation project may be an important variable for

community planning, demographic analysis, or state financial purposes. This would be the "direct employment impact" of the project. Other impacts related to the economy might be the expansions of related supplying or processing sectors or changes in tax payments to local, and state, governments. Quantification of such impacts often is an important part of economic analysis, even though they do not constitute benefits or costs as normally defined.

Of course, projects can have environmental, regional, and social impacts (for example: water and air quality changes, changes in regional population, or changes in the distribution of income and wealth among population subgroups). All of these "impacts" are important and may require quantification, along with economic benefits and costs.

2. **The "With-Without" Principle**

The basic objective of any type of project evaluation, whether economic, environmental, or social, is to contrast the "state of the world" as it would be with the project constructed and operating to the "state of the world" as it would be without the project. "State of the world" is to be broadly interpreted here, and it includes all differential impacts on sub-geographical areas and population sub-groups. An important implication of the "with-without" principle is that project evaluation is not adequately accomplished by contrasting conditions before the project with conditions after the project. Many of the changes in the world from "before" to "after" would have occurred without the project, so such effects should not be used in project justification. The state of the world must be compared over time as it would have been both with and without the subject project.

Consider the following simple example. Suppose state income stands at $10 billion in 1985, having exhibited a steady 5% growth rate in the past, a rate which is expected to continue in the future. Supposing that the construction of irrigation Project A begins in early 1988 and continues through 1992, a five year period. At the end of 1993, the first year of operation of Project A, state income is noted to stand at $13.42 billion. How much of the change in state income can be attributed to Project A for 1993 and subsequent years?

It is clear that not all of the $3.42 billion change can be attributed to the project, since at a 5 percent growth rate, state income would have grown to $13.40 billion anyway. Only the difference between the observed (with project) 1993 level of income and the (without project) level that would have existed anyway (i.e., $0.02 billion) can be attributed to Project A. In subsequent years, it is likely that project-generated income might grow somewhat, although it still would not account for but a fraction of the increase in state income.

3. The "Accounting Stance" to be Used in Evaluating a Project

A project may have benefits, costs, or other impacts that are confined to the local area or they may be felt nationwide or even worldwide. The geographical area within which the decision maker decides to count benefits, costs, and other impacts defines the decision maker's "accounting stance".

For example, a new irrigation project in Idaho will generate benefits, most of which will accrue to persons in that state. Construction costs will be defrayed by the water users (and perhaps partly by taxpayers, depending on the project). Other costs in the forms of foregone water uses, damages from lower water quality, and foregone electric power generation will accrue to individuals, towns, and firms located in states further downstream in Oregon and Washington. In some river basins, a "national accounting stance" might be too narrow: in the Colorado River basin, such an accounting stance would not include any costs which might be imposed on citizens of Mexico.

An Idaho state accounting stance would count only the benefits and costs actually experienced in Idaho. If one subdivided the entire United States into a set of exhaustive and mutually exclusive regions or states and then evaluated benefits, costs, or other impacts from the several regional or state accounting stances, the sum of the regional benefits, costs, and other impacts, some positive, some negative, would be expected to equal the corresponding national measures. If a new project in Idaho provides 100 jobs, and if half the workers come from existing jobs that are not replaced by unemployed workers in Montana, the national increase is 50 jobs: plus 100 in Idaho and minus 50 in Montana. Of course, if persistent unemployment exists in either or both states, the national increase could approach 100 jobs.

Federal agencies are directed to use a national accounting stance for benefit-cost analyses of their projects (even though there are regulations requiring that international impacts be taken into account, e.g. NEPA, Sec. 102 (E) and Principles and Guidelines, Principle 4). In an ideal world, one might hope that all decision makers would utilize national or even global accounting stances. However, political boundaries create incentives to weigh local benefits and costs heavily and external benefits and costs lightly, if at all. While some of this result may be attributed to a "beggar thy neighbor" attitude, some of the sources of bias are intentionally created through national legislation. Examples would be the artificial stimulus to irrigated agriculture created by federal commodity price supports and generous federal cost sharing for water projects.

Thus, one cannot expect local or state decision makers to utilize a national accounting stance. In promoting the welfare of their citizens, state officials cannot be expected to ignore local or state advantages that may not be in the national interest. If the deviations between state and national interests become too great, consideration should be given to changing the national legislative framework.

While the assessing of benefits, costs, and other impacts is initially limited to those within the state, any responsible evaluation procedure must be alert to effects a project may create outside the state. Notifying the political decision makers about such effects can reduce the probability of conflicts with out-of-state parties, including other state governments.

4. Newly Created Values versus Transfers of Existing Values

Economic analysis is primarily concerned with the creation of new values through the appropriate (efficient) allocation of existing resources. New values can be created through acts of production (e.g. agriculture or manufacturing) or through the exchange of existing assets (e.g. auctioning goods to persons with a higher willingness to pay). Production creates value by converting some bundle of resources or inputs (land, labor, capital) into a more valuable form. Opportunities for creating value by exchange are limited, while the creation of new values through production are constrained only by tastes, technology, and available inputs.

Some asset transfers create no new values, as when payment of an inheritance tax shifts wealth from a family to the government. Another example somewhere in between would be the USDA Payment-in-Kind (PIK) program of 1983, in which grain stocks owned by the Federal Government were transferred to farmers in return for reductions in crop acreage. No new assets were created, but presumably those choosing to participate were made better off.

5. **The Unique Role of IDWR in Water Allocation**

The role of IDWR is that of guardian of state values and the long-run state public interest. The evaluation carried out by IDWR is not of projects to be funded and executed by the state, but it is an evaluation of other parties' projects (public and private) that propose to use waters either constitutionally belonging to the state or that have been given to the state in trust for reallocation from the Swan Falls agreement. (See Costello and Cole, 1985). It is important that a balanced and impartial analysis of impacts be conducted.

In Idaho at the present time, water once allocated to a particular use is transferable to other uses only with considerable difficulty (see Gardner, 1985). While annual water rentals do take place and while a new 1985 law purports to "encourage water marketing", only a few halting steps have been taken to increase the long-term flexibility of water allocations. Thus the state is allocating a finite water resource which, while currently still in plentiful supply, must meet the needs of future economic and population growth. The water in fact currently has real opportunity costs in terms of hydroelectric power and possibly recreational and fishing benefits foregone, both within the state and further downstream through the entire Columbia River system. This water will continue to have an even higher and higher scarcity value.

The state must, therefore, balance the present value of the projected net favorable impacts of proposed uses against the very uncertain present values of future activities that may be precluded by current allocations. This is a difficult task when no markets, let alone futures markets exist. History tells us that as water becomes more scarce and values increase in the future, institutional changes will occur to make reallocation possible. Nonetheless, the state today must act as the representative of public values from water use and the guardian of future uses. This will affect the choice of economic parameters, such as prices and interest rates.

B. Adapting the With-Without Criterion for Economic Evaluation.

To this point, we have made many references to "benefits and costs" without precisely defining either concept. While there exist traditional economic definitions, we will see that the definition really depends on the accounting stance.

1. **Monetary Measures of Benefits and Costs**

To be incorporated in economic analysis, benefits and costs must be expressed in monetary terms, i.e. in dollars. Since the physical inputs and outputs of projects are expressed in physical units such as tons, bushels, acre-feet, etc., these physical inputs and outputs are transformed into commensurate value terms by applying the appropriate prices to each input and product. In a planned economy, these prices might be generated by a large-scale computerized optimizing model used by the planners. In most countries, however, prices result from market activity, usually under some government regulation. In some cases it will be appropriate to use existing market prices, while in other cases it will be necessary to make adjustments to those prices. In many water resource planning situations, it will even be necessary to estimate prices that don't exist in the market, e.g. the "price" of a day's boating on a public reservoir or the value of an acre foot of water used for irrigation or power generation. When either estimated or adjusted "prices" are used in cost-benefit analysis, they are termed "shadow" prices.

In all cases, these prices are interpreted as expressions of a "willingness to pay" for a particular good or service by either consumers, producers, or units of government. The assertion that "value" should be measured by willingness to pay follows from the philosophy that it is primarily individual preferences that should be the basis for public policy. Of course, there are many instances where willingness to pay fails to capture all aspects of a benefit or cost and must be adjusted before being used as a benefit or cost in project evaluation.

Benefits are thus any positive effect, material or otherwise, for which individuals, groups, firms, or government are willing to pay. Costs are detrimental effects that some affected parties would be willing to pay to avoid, i.e. measures of the values of opportunities foregone because of the commitment of resources to a particular project. For this reason, the economist often uses the term "opportunity cost" to refer to foregone benefits.

Willingness to Pay (WTP) represents the total value of an increment of project output. WTP is the individual's best offer to purchase the increment. Willingness to pay can be related to the more familiar measures of economic value, market price and economic surplus. Benefits and costs are appropriately valued as <u>economic surplus</u>, that is, the value of a good or service over and above its factor costs (Randall 1984a, p. 59). Economic surplus can be divided into consumer surplus and producer's surplus. Producer's surplus is usually measured as returns or rents accruing to fixed resources (Marglin 1986, p. 40-42). In the case of Idaho water resource development, the fixed resource would be the water itself.

2. **Treatment of Federal, State, and Local Taxes and Subsidies**

Taxes -- The most important principle here is that taxes should be treated in the net benefit analysis in the same way that they are treated in the evaluation of hydropower benefits foregone. We assume that the latter analysis treats taxes as costs.

Taxes can be conceptualized two ways: (a) as payments for services rendered; or (b) as transfers from taxpayers to other individuals via the government. There is no question that the public safety and health provided by government at local, state, and federal levels, plus other helpful services are necessary to the smooth functioning of the economy. This suggests the payment for services approach: the closer the association between services rendered and payments made, the more taxes should be counted as costs.

On the other hand, taxation is often for income transfer purposes, in which case the associated expenditures are not for direct purchase of resources or services. Furthermore, many government services have the characteristics of "public goods". Once such "non-rival" goods are provided, any number of beneficiaries can use them without seriously diminishing the utility of the service to each other. In this case, the marginal cost of providing these services to additional parties is quite low, perhaps zero, implying that the efficient price for government to charge should also be low or zero. These two points would imply that a benefit-cost analyst taking a national accounting stance should not count taxes as a cost.

From a state accounting stance, federal taxes must be treated differently: they represent an outflow of state resources whether or not they correspond to services rendered.

Recommendation: Federal taxes should be treated as a cost, and the net benefit criterion must be calculated net of federal taxes. This stands in contrast to the usual approach under the national accounting stance.

State and local taxes (including both sales and property taxes) are much more closely related to services rendered, especially since most state and local governments are required to have balanced budgets.

Recommendation: State and local taxes should be counted as payment for services, i.e. as costs.

Subsidies -- Federal subsidies represent the mirror image of federal taxes.

Recommendation: Any federal subsidies which influence the willingness to pay of Idaho water users should be a credit to the net benefit calculations. We anticipate that this point will have limited application. A federal subsidy on interest rates is, in effect, available to municipal and some other public entities borrowing money in national financial markets, which will be reflected in our recommendation on interest rates. Some federal subsidies can be obtained by farmers for soil and water conservation activities, as well as for some farm commodity sales. Farm subsidies of these types should be credited, but caution is advised in projecting them over a long planning horizon due to the uncertainties of federal policy.

3. **The Choice of Price Level for Measuring Benefits and Costs.**

If benefits and costs are to be expressed in monetary units (dollars) and compared among projects or over time, the dollars used should be dollars of the same "real" value, i.e., where prices are corrected for inflation. For example, 1973 and 1985, the general price level in the United States as measured by the Consumer Price Index (CPI) (1967=100) rose from 130 to 320. The meaning of $1 of net benefits from a project in 1985 was clearly different from $1 of net benefits in 1973.

Projects have lifetimes ranging from a few years to over a hundred years. If we are to "add up" the benefits and costs over the project's lifetime, we would want one dollar to have the same meaning in terms of its buying power regardless of which year that dollar referred to. In the case of ex ante (pre-construction) evaluation of projects, the analysis is usually carried out on the assumption that the price level will remain constant: future benefit and cost items are calculated on the basis of today's price level. In the case of ex post analyses of existing projects, it becomes very clear that we cannot simply add dollars of benefits and costs regardless of the price level. Cost data for the Colorado-Big Thompson Project can be used to illustrate these difficulties.

The cost data reflected in Table 4 indicate that actual costs deviated from early projections. It also illustrates the importance of clarifying the basis used for cost comparisons. A major conceptual issue is whether the values are measured in dollars of comparable purchasing power. The original construction cost estimate of $44 million was a projection of

Table 4
Summary Cost Data for C-BT and NCWCD
(millions of dollars)

Original construction cost estimate, 1937[a]	$ 44.0
Revised United States Bureau of Reclamation estimate, 1946	128.1
Revised United States Bureau of Reclamation estimate, 1952[b]	162.6
Reported final project cost	163.0
1960 present value of total C-BT project costs from 1937 through 1953 (project completion) in 1960 dollars[c]	443.3

[a]U.S. Department of the Interior, Bureau of Reclamation, Colorado-Big Thompson Project, Synopsis of Report on C-BT, Plan of Development and Cost Estimate, S. Doc. No. 80, 75th Cong., 1st Sess. (1937).

[b]United States Bureau of Reclamation, Colorado-Big Thompson Project, Addendum to Definite Plan Report, 1952.

[c]Costs indexed to 1960 and discounted or compounded to 1960 at 5%.

anticipated costs in terms of prices prevailing in 1937. This is standard procedure in planning and benefit-cost studies. The 1946 reestimate of $128.1 million is conceptually confusing, because it contains both costs actually incurred up to that date and costs still to be incurred up to project completion. Prices generally began rising in 1939 and continued to rise slowly during World War II when most prices were controlled. The Engineering News Record (ENR) construction cost index (1960 = 1.00) increased from 0.35 in 1938 to 0.47 in 1946, later to rise to 1.52 in 1970 and 3.57 in 1980. Thus the 1946 cumulative costs consisted of dollars of differing purchasing power representing different amounts of real inputs per dollar, while the future costs were projected in 1946 prices. The same can be said of the reestimate of 1952 and the reported final project cost.

To make the Colorado-Big Thompson cost figures comparable, it is desirable to convert each year's dollar cost into dollars of a constant purchasing power before discounting and summing them. The ENR building cost index was chosen to adjust all dollar costs to the input purchasing power of a dollar in 1960. The choice of 1960 as a base year was made to avoid indexing the large construction expenditures over too long a period. Costs were thus expressed in dollars of 1960 input purchasing power and then discounted at 5% to arrive at the figure of $443.3 million.

In principle, one must also allow for changes in <u>relative</u> prices. For example, during the 1950's, the general price level was nearly constant. Yet wage rates rose at about 5% per year. Thus the price of labor relative to the general price level (and relative to other types of productive inputs) increased by nearly 65% in that decade. In the mid 1970's, the general price level was rising by more that 10% annually, but energy prices rose (in steps) even more quickly, so the <u>relative</u> price of energy rose. During the last several years, the general price level has been relatively stable, but prices of many electronic components are falling every year due to technological improvements. Their relative prices are falling, as historically, have mineral and agricultural commodity prices.

However, over the longer term, it is often difficult to distinguish between cyclical movements and more persistent long-term trends. The sharp rates of increase in energy costs and food prices observed in the 1970's were predicted by many analysts to continue indefinitely. The perspective of the 1980's suggest that those fluctuations were only the rising parts of a short term cycle. Analysts should be very cautious in attempting to forecast changing relative prices. Long-term averages in constant dollar terms will be much more likely to be accurate.

While the economic evaluation of projects is usually carried out in terms of a stable price level, financial planning requires making projections of revenues and costs in terms of the price levels expected to exist in future years. A rising general price level will push construction and operating costs up in nominal terms, and financial planning must guarantee the availability of funds to meet these higher (current) dollar costs, perhaps by a corresponding increase in predicted project output prices.

4. **Choice of Planning Period**

The planning period or period of analysis refers to the length of time over which project impacts are included in a particular evaluation. A number of factors influence the choice of planning period. The expected physical life of the facility is a natural choice. However, the economic life of a facility may be shorter than the physical life, due to technological or market obsolescence. Expected economic life is the usual choice of planning period in private sector analysis.

In Idaho's case, many proposals will be for groundwater development. The expected economic life of pumps and wells is often assumed to be 15-20 years. Surface water diversion structures might have much longer lives. Since the issuance of a development permit grants a long-term property right to the successful applicant, we believe the State should not base their planning on short periods.

No water project in the United States has yet been in operation for 100 years. Roosevelt Dam on the Salt River (the first federal reclamation project) is approaching 80 years and Hoover Dam is now more than 50 years old. There seems little question that such major structures, properly maintained and periodically rehabilitated, can be productive for a century. Canals and headworks, however, may suffer from soil instabilities and unavoidable cavitation and erosion.

Economic factors suggest a more limited horizon. Forecasting abilities are also limited. Demand levels, prices, hydrologic flows, and even population are increasingly uncertain the longer the horizon. The discounting of future values naturally limits their contribution to present values. Figure 1 exhibits the percentage of total present value of a 100 year stream of uniform values that is accounted for at various points in the project's life. At discount rates of 5% or more, at least 90% of total present value is accounted for by year 50. This would also suggest the sufficiency of a 50 year horizon in the case of major water supply structures. We therefore recommend a fifty year planning horizon to the State of Idaho.

The differences between this practice of using a uniform 50 year horizon and the more usual business practices related to fixed investment evaluation should be noted. When a farm or business manager contemplates buying a piece of equipment that is expected physically to last 10 years, the evaluation of benefits (or revenues) and costs is limited to the lifetime of the equipment. The State, however, is obligated to take a longer time horizon during which fixed investments associated with a

Percentage of Present Value Accounted for by Year t
(Various Discount Rates)

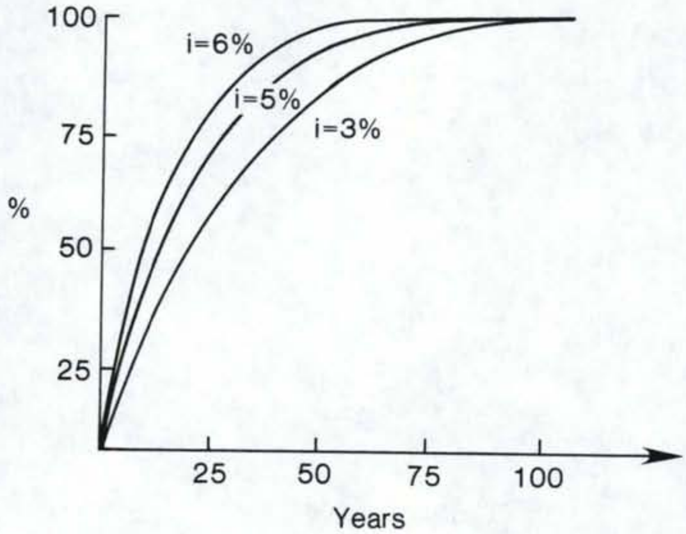

Figure 1

proposed water use may have to be replaced several times, e.g., five times in the example above, to fit within the State's 50 year horizon.

5. **Comparability and Commensurability**

The process of evaluation calls for predicting the consequences or impacts expected to follow from choosing a particular investment alternative, estimating the magnitudes of each impact and conversion of each magnitude into common units of measure. A number of conceptual problems arise in this process of achieving commensurability. We touch on the general issues here, and return to some special problems in the particular water use sector analyses at later points in the report.

Unit of measure - While it is possible to measure impacts in physical terms, it is quite inconvenient to do so. One of the advantages of the exchange economy is that it provides a system for measuring relative value in monetary terms. Tons of hay, hours of labor and bags of potatoes, as well as acre feet of water, can be most usefully made commensurate in money terms. This approach is readily understood, and avoids the cumbersome problems of trying to determine the value of physical units of potatoes relative to units of hay.

Monetary measures, however, are available for measuring many different concepts, including gross revenues, cash flows, profits, etc. Economic evaluation (cost-benefit analysis), in order to assure commensurability, adheres to the concept of "willingness to pay" which is developed more fully elsewhere in this report.

Comparability in time - An investment will yield returns, hopefully, for many years. The economic life of investments in competing sectors (e.g., irrigation versus hydropower) may vary substantially.

Recommendation: To avoid erroneous comparisons, the analysis must assure that the planning period for each alternative is equivalent. If the economic lives differ, or are not conveniently rounded out to our recommended 50 years, then the budgets for the cost analysis must reflect the reinvestment and replacement of depreciated assets and/or allow for salvage value of partially depreciated investments.

C. Measuring Project Net Benefits.

1. **Overview**

According to the with-without principle, the cost of Project A would be the net benefits given up elsewhere as a result of committing resources to Project A. The problem is to identify what is being given up elsewhere. In some narrow decision situations it may be clear that the construction of Project A will preclude construction of a particular Project B, perhaps because of a construction budget constraint. Then the cost of A would be the foregone net benefits of B. In general, however, things are not this clear, and we usually don't know what is being given up elsewhere.

However, in a competitive economy, certain prices will prevail for the inputs needed for A. These prices presumably are needed to attract inputs to A, so they must be at least as high as the prices that would be paid for the inputs in their next most profitable use. If there is competition for inputs elsewhere, each of them would be paid a price equal to the value of their net marginal product. As long as units of an input are interchangeable, all must receive the same price and, therefore, have the same value of net marginal product. Thus, the values of the net marginal products being foregone should be roughly the same, regardless of the source from which the input has been attracted. Under these conditions, input prices represent what is being foregone elsewhere. If the economic system is approximately competitive, market prices can then provide us with appropriate unit values for benefits and costs.

However, there will be some situations when market prices will not be appropriate measures of value and others when some project inputs or outputs have no market price. The following situations will be found (Howe, 1971):

a. market prices exist and are correct measures of value for project inputs and/or outputs;

b. market prices exist but are not appropriate measures of value for inputs or outputs and need to be adjusted to appropriate values;

c. no market price exists but there exist plausible, credible methods for estimating marginal values through "willingness to pay" studies;

d. no market price exists and there seems no plausible, credible way of estimating willingness to pay.

Examples of each case are readily identified. Prices for potatoes, which are influenced by price support programs only to a minor degree, would be an example of (a). Situation (b) might be represented by crops whose prices are influenced by federal supply management programs, such as wheat or corn. The appropriate shadow price would be less than the observed transaction prices. Situation (c) is well illustrated by many environmental amenities such as recreation on public lands or improvements in air or water quality. There is no price _per se_, but it is quite feasible to determine what people would be willing to pay. The various techniques will be described in detail later in the handbook.

It is often difficult to place a dividing line between situations (c) and (d). As indicated in Chapter I, some economists feel that all relevant values can be monetarily quantified and that the only thing lacking is improved methods for eliciting values. Many would disagree with this viewpoint, among them philosophers, environmentalists, and quite a few economists. One philosophical basis for the disagreement is that contemporary economics is anthropocentric, i.e., all values originate from and exist only because people have feelings towards things: the value of wildlife is only the sum of willingness of humans to pay for its existence. In contrast, a naturalistic ethic holds that values in nature are derived external to mankind, i.e. wildlife has an inherent right to exist. (Schulze and Howe, 1985).

The valuation of human life is a major point of contention. Even though it is easy to demonstrate that many everyday decisions are based on implicit values for human life (auto safety measures, airline flight procedures, surgical decisions, etc.), many people reject any explicit attempt to value lives saved or lives prolonged (Schulze, Brookshire, and Sandler, 1981; Thaler and Rosen, 1976). The value of species preservation is currently being assessed by some economists (e.g. Gardner Brown, 1985) but is a topic that many would place outside of economics.

2. Techniques for Measuring Direct Beneficial and Adverse Impacts: A Brief Review

Several different approaches to measuring benefits and costs are commonly employed. The appropriate methods differ according to the nature of the impact and the type of good or service produced. Goods and services derived from water may accrue to producers, such as farms, hydroelectric plants or industrial firms, in which case they are known as "intermediate" or "producer" goods. (Intermediate goods, in other words, are those used in production of other goods and services.) "Consumer's goods" are final consumption items benefitting consumers. Water for household use is a consumer's good. "Public goods" are those which are non-rival in consumption, for which one user's benefit does not reduce the utility derived by other beneficiaries. Water-based recreation is (at least under some circumstances) such a good, since the aesthetic enjoyment of one boater, picnicker or fisherman may not preclude benefits to other similar users. In this section, we present a brief overview of measurement procedures for direct and indirect technological effects. Indirect pecuniary effects are sufficiently important and controversial that we treat them separately in a later section of this chapter. Moreover, they are the subject of a separate study by the State of Idaho (Keith and Glover, in preparation).

The basic measurement principle remains that of willingness to pay.

In certain cases, willingness to pay can be directly observed. In that event, statistical techniques can be employed to generate the users' demand curve. Several other approaches are also relevant. Direct observation is most often employed in measuring demand for household water.

Intermediate or "Producers" Goods -- Producer's benefits are usually measured in terms of the profitability added by the intermediate good to the enterprise. The method known as "change in net income, (abbreviated hereafter CINI) equates willingness to pay of the producer with the increment in profit ("change in net income") attributable to an addition to the producers' water supply (Gray and Young, 1983; Young and Gray, 1985). Forecasted profit without the project is subtracted from profit with the project. This approach has been endorsed by the U.S. Water Resources Council (1973) and by the U.S. Bureau of Reclamation (1983) for determining irrigation benefits. This apparently simple definition conceals a number of complexities, including which future prices to employ, which technology will be adopted and what is the appropriate scale of operation to assume.

Another method appropriate to intermediate goods, as well as to consumer goods, is called the "Alternative Cost" approach. This term refers to the cost of the most likely feasible alternative means of achieving project purposes. Willingness to pay is limited to and measured as the cost of the most likely alternative to the planned project. The method must be subject to the requirement that the alternative itself is economically feasible. A number of alternatives are possible to any project, in both private and public sectors. This technique can be applied in certain cases where willingness to pay is difficult to obtain either directly or indirectly. The most common application in water resource planning is to hydroelectric power. The value of the water for electricity generation is determined by the cost of creating electric power by the best alternative method, e.g., a fossil-fuel steam electric plant. Alternative cost methods are also often applied to municipal and/or industrial water supply projects. Ground water as an alternative to surface storage for municipal supply is another relevant example.

Adhering to the constraint that the alternative is itself economically feasible is essential. Otherwise, any project could be justified. It is always possible to define an alternative project which is more expensive than the project under consideration, thereby generating net benefits. Herfindahl and Kneese (1974) explain the approach's strengths and limitations in more detail.

Public Goods Values: User Surveys -- The final approach mentioned here is appropriate to determining the value of water when either no exchange transactions or no diversions for production exist. These cases are usually associated with recreation and aesthetic enjoyment of water in natural surroundings where water is a collective or public good (McConnell, 1985; Anderson and Bishop, 1986). Two general lines of approach are possible, both based on surveys of actual or hypothetical behavior. The first collects data on actual user expenditures and infers net willingness to pay from the data. The well-known "Travel Cost" method is the most prominent example. Another approach is to directly ask users for willingness to pay for incremental environmental services. This method is called the "contingent valuation" approach, since it seeks users "bids" contingent on hypothetical environmental or water supply situations (Cummings, et al., 1986).

3. Dependence of Appropriate Benefit Measures on the Accounting Stance

Whether or not a given price is appropriate as a measure of benefits or costs or whether or not a given non-priced impact should be quantified and counted in the economic evaluation will always depend, in part, on the accounting stance being taken. Should the state of Idaho use the federally supported price levels for grains or the much lower shadow price representing the true marginal value to society? Since Idaho farmers will receive the support price, Idaho should use that price. At the same time, the federal Bureau of Reclamation should use the much lower shadow price since the federal government evaluation is (or should be) interested in gains to the nation, not just gains to a particular sector or state.

What of possible downstream water quality effects or losses of hydropower? The IDWR Rules make it clear that losses of power within Idaho will be counted as costs for any reallocation of trust water, but the Rules are silent regarding applications for the appropriation of non-trust waters. From the economic viewpoint, any hydropower losses that result in higher costs to Idaho power users should be charged to any withdrawal that increases consumptive use.

The out-of-state power losses on the Columbia River system that would result from expanded consumptive use in Idaho are estimated to be very large, probably greater that the net benefits of any near-term use in Idaho. (See Butcher, et al., 1986 and Hamilton and Whittlesey, 1986). Since some Bonneville Power Administration electricity is marketed in Idaho, some effect on Idaho rate-payers will be included. This represents a case in which a strict state accounting stance is likely to lead to conclusions that do not agree with regional and national evaluations.

4. The Concept of Opportunity Cost

The general concept of costs employed in economic analysis define costs of resources used for particular productive ends as the "economic benefit or value foregone in the best alternative use". For the most part, water project appraisal assumes that the relevant market prices reasonably reflect the cost of factor services required for project construction and operation. In cases where the market for a resource is either absent or biased due to government intervention, a shadow price will be appropriately substituted in the analysis. The concept of opportunity cost is the usual basis for determining the shadow price of a resource. In the case of irrigation investment evaluation, the value of water in alternative uses and the shadow wage rate are particularly significant issues. Measurement of the opportunity cost of water for hydropower is being dealt with outside this study and will be discussed in Chapter 6 only in a cursory fashion. Chapter 6 also deals with the value of instream flow for recreation.

<u>Opportunity Cost of Labor</u> -- A basic issue regarding wages, particularly in irrigation investment analysis, is whether the full prevailing wage rate for agricultural labor should be charged in the production cost analysis or if some deduction from that amount is appropriate. In a properly functioning economy with minimal long-term unemployment, the wage rate is a satisfactory measure of the cost of labor. Federal evaluation procedures permit shadow pricing of labor in cases where unemployment exists during the construction phase. However, use of shadow wage rates for the operating phase (i.e., as a part of "associated costs" discussed above) is discouraged. Special justification may be required to employ shadow wage rates in such cases.

In instances where high levels of unemployment or even underemployment are expected to persist over the project's life, the foregone productivity of workers will likely be less than the wage rate. Hence, some estimate of a shadow wage may be required. The issue then is: what precise level of shadow wage rates is most appropriate?

Numerous formulations of the shadow wage rate under unemployment have been proposed. Two broad approaches can be discerned. The traditional model asserts that since the foregone productivity of an unemployed worker is, at the margin, zero, the shadow wage should also be zero. The second position notes that if labor yields disutility relative to leisure, the shadow wage should measure loss of utility rather than foregone productivity, and hence, should be greater than zero. This second version emphasizes the fact that some jobs remain unfilled, implying that the going wage is often unable to attract workers into the work force, inferring that the shadow wage should approach or even exceed the market wage.

Gramlich (1981) points out that the two positions to some degree stem from alternative views of the role and effectiveness of government. Political liberals believe that unemployment is bad in a society where most people are working. The working skills and work habits of unemployed persons deteriorate, and more important, they lose self-respect. Unemployment has negative social value, and public programs which employ workers while producing other benefits are properly encouraged by the low or zero shadow wages.

The conservative position is skeptical of public spending projects and objects to assumptions which would significantly reduce the cost of projects. This "no free lunch" perspective points out that the public expenditures to create employment must come from borrowing or taxation, each of which is likely to have an eventual negative effect on employment in some other segment of the economy. Furthermore, the existence of unemployment in the presence of standardized wage rates indicates the worker values leisure, and will not enter the work force unless his/her reservation price is exceeded. This position concludes that the social cost of labor is equal to its budget cost.

We paraphrase Gramlich's (1981) suggested rules for valuing unemployed labor. <u>Shadow wages at less than market or budget cost are permissible if</u>:

1. The reduction in unemployment can be sustained. Forces will not be set up which require cutbacks in spending, generating offsetting unemployment somewhere else in the economy.
2. The project itself is responsible for reducing unemployment, and other public policies would not have accomplished the reduction.

3. It can be persuasively argued that some social externality makes the opportunity cost below market wages.

Gramlich believes that his conditions will only occasionally be met. Either the jobs are not net new jobs, they are not the only way to create jobs, or the jobs do not have that much social value.

D. Criteria (Decision Rules) for Project Selection.

1. **General**

All projects generate changing time patterns of benefits, costs, and other impacts. An irrigation project that involves building a diversion dam, main canal, distribution system, land leveling, etc. involves high initial construction costs, then lower annual operating and maintenance costs until some major component needs to be replaced. The benefit stream will be zero until some of the land is actually brought into production, perhaps rising gradually towards a stable level when all land is under production and all farmers have gained experience.

Other types of projects will exhibit changing patterns of benefits and costs for other reasons. A hydroelectric project's benefit pattern will depend on changes in the demand for baseload and peak power. Demand for municipal water supply will reflect changing population and per capita use rates.

Can benefits and costs occurring at different points in time simply be added to one another to arrive at some kind of total cost figure? We have already noted at least one reason why this may not make sense: price levels change over time. Private sector and government expenditure accounting practices have done little to allow for changing price levels. Only in the national income accounting area have regular practices been developed for calculating production and income figures that are expressed in comparable dollars (e.g. constant dollar GNP, personal income, investment, etc.).

However, in addition to expressing values in dollars of equivalent purchasing power, some adjustment must be made to allow for the differences in timing. Costs (or returns) expended (received) at different points in time have different values. Early returns are worth more than later returns, if for no other reason than because the sooner benefits are received the sooner they can be spent (consumed) or be reinvested. The difference in value between early returns (costs) and later receipts (expenses) is taken into account by the process known as discounting. Put another way, the interest rate reflects the fact that the market values a dollar now equally with $(1+i)^{-t}$ if received t years in the future.

The general formula for discounting (also known as "finding the present value") is:

$$PV = \sum_{t=0}^{T} \left(\frac{B_t}{(1+i)^t} \right) \tag{3-1}$$

where:

PV: Present Value (i.e., when t=0)

B_t: Dollar value of (say) a benefit received t years into the future

i: interest (or discount) rate

t: years (t=0, 1, 2, ..., T)

T: last year of planning period

The discount factor (for year t) is the name given to the expression $1/(1+i)^t$. To avoid having to calculate it each time it is needed, discount factors for representative values of t and i have been summarized into tables. Gittinger (1973) provides a relatively complete set of interest rate tables. Such tables are often found in appendices of textbooks in project analysis (e.g., Gittinger, 1982; James and Lee. 1971), or they may be incorporated into micro-computer software designed for project analysis.

2. The Discounting Process in Appraising Long-Lived Projects

The rationale for discounting is nearly always stated in terms of the interests of some decision-maker (person, private firm, government agency) who is contemplating some investment (call it Project A) that involves streams of benefits and costs over time. Assume the net benefits of any year $(B_t - C_t)$ could be financially invested at an interest rate i over the remaining project life. The decision-maker presumably has in hand a sum of money, C_0, equal to the initial cost of the project which, in the absence of the project, could also be financially invested at a guaranteed annual interest rate of i (e.g., 0.05, 0.1, etc.) over the project's life of T years. Application of the with-without principle would then lead to the following comparison of net benefits (in monetary values) in terms of a stable price level:

$$\frac{(B_1 - C_1)}{(1+i)} + \frac{(B_2 - C_2)}{(1+i)^2} + \ldots + \frac{(B_T - C_T)}{(1+i)^T} - C_0 > 0. \qquad (3\text{-}2)$$

This expression provides a test of the desirability of the investment. It is called the "present value of the investment when the investor's opportunity cost of capital is i."

Associated with each of the discounting procedures is a <u>selection criterion</u> or "decision rule", which states the conditions for economic feasibility (acceptance or rejection) of specific projects. The selection criterion for the Net Present Value formula is: "Accept projects having a positive net present value, and reject all others." This, the reader will recognize, is the precise statement of the "Net Benefit Principle" with which we began this chapter.[1]

One further note: the costs in the time stream in formula (3-2) include capital costs (in early years) and operating and maintenance costs further on. These calculations replace the depreciation and interest used in financial analysis.

3. **Alternatives to the Net Present Value Formula**

Several other more or less equivalent formulas to determining project feasibility can be utilized. Federal water development agencies have long employed a concept called the "benefit-cost ratio" (BCR), while other entities (e.g., the World Bank) often utilize the "internal rate of return" (IRR). These two rules are useful in cases where investment capital is limited. In the common situation of limited budgets, a rule calling for maximizing present value will not necessarily identify the best sub-group of projects from among those having positive net present value. Hence, when capital budgets constrain expenditures, the BCR or the IRR (or both) are used by many planning agencies. A third approach uses the "annual

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[1]For projects designed to serve a growing user demand, it is often possible to improve an already feasible project's net present value by postponing the starting time while demand grows further. Procedures exist to find the optimum starting date, but we do not develop that refinement here. See Gittinger (1982).

equivalent value" to convert net present values to equal annual amounts. Each of these is described briefly below.

<u>Benefit-Cost Ratio</u> - Formula (3-2) asserts that the Present Value of the stream of annual net benefits should be positive (PVNB > 0). That formula can also be rearranged to:

Present Value of Benefits (PVB) > Present Value of Costs (PVC),

$$\sum_{t=0}^{T} \frac{B_t}{(1+i)^t} > \sum_{t=0}^{T} \frac{C_t}{(1+i)^t} \qquad (3\text{-}3)$$

Formula 3-3 can be further rearranged, dividing through by $\sum_{t=0}^{T} \frac{C_t}{(1+i)^t}$ to yield

$$\frac{\sum_{t=0}^{T} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+i)^t}} > 1 \qquad (3\text{-}4)$$

Formula 3-4 is called the Benefit-Cost Ratio (BCR). The associated selection criterion is, of course, select projects whose BCR exceeds one. The most preferred projects are, generally speaking, those with the highest return per dollar expended, that is, those with the highest benefit-cost ratio.

<u>Internal Rate of Return</u> - The internal rate of return (IRR) is defined as the interest rate which is required to equate the present value of net benefits with zero. Put another way, it is the interest rate that would make discounted benefits just equal discounted costs. The IRR is a

percentage rate that is sometimes said to be more comprehensible to nonspecialists that the Net Present Value. In symbols the formula is:

$$\sum_{t=0}^{T} \frac{(B_t - C_t)}{(1+r)^t} = 0 \qquad (3\text{-}5)$$

where r is the unknown rate of interest which permits the present value of benefits to equal the present value of costs. A trial and error process is necessary to find the unknown rate r (Gittinger, 1982). The associated selection criterion is expressed in terms of interest rates: accept projects whose rate of return exceeds the pre-selected cut- off interest rate, and choose those with the highest IRR first.

Equivalent Uniform Annual Net Benefits - Many analysis find it preferable to express benefits and costs in "annual equivalents", rather than computing the present value, the benefit-cost ratio or the rate of return. It can be simpler to compute and is thought by many to be more readily understood by non-specialist audiences.

A predicted time stream of benefits (or costs) can mathematically be converted into a constant value stream. For any fluctuating stream of net benefits (NB_t), there exists an "equivalent uniform annual stream", denoted A, such that

$$\sum_{t=0}^{T} \frac{A}{(1+i)^t} = NPV = \sum_{n=0}^{T} \frac{NB_t}{(1+i)^t} \qquad (3\text{-}6)$$

If a constant amount equal to A were to be received each year for T years, the net present value of that stream is the same as the net present value of the fluctuating stream NB_t for the T years.

A special discounting factor, usually called the CRF (for "capital recovery factor") is employed to convert the Net Present Value into annual equivalent costs or benefits. The CRF represents the fraction of a dollar which allocated at interest rate i for T years will equal one dollar of net present value. Alternatively, it is the annual payment required to retire a loan of one dollar in T years with compound interest on the unpaid balance. The CRF permits the calculation of the equal installments (A) necessary to amortize a given investment over a stated period at a specified interest rate. The CRF is found in any set of compounding and discounting tables, (e.g., Gittinger, 1973; James and Lee, 1971).

The CRF is useful in converting capital plus interest costs of an investment into equal annual equivalent charges. It is important to understand that such a conversion replaces the depreciation plus interest charges deducted from a representative year's revenues often employed in business or farm management investment planning.

The CRF is often used to convert an initial capital cost into equal installments over the planning period. This facilitates the task of calculating the unit capital cost of supplying water. One merely takes the initial capital cost, multiplies it by the CRF appropriate to the planning period (T) and interest rate (i), and divides the result by the average annual water delivery expected for the project.

For the Equivalent Uniform Annual Net Benefit approach, the selection criterion is identical to the first case, the Net Present Value rule, i.e., accept only those projects with positive Equivalent Annual Net Benefit. (Note also that a Benefit-Cost ratio can be readily computed by taking the ratio of annual net benefits to annualized costs.)

4. **Recommendation**

We suggest that the Equivalent Uniform Annual Net Benefit (EUANB) approach be the usual criterion of choice for the appraisal of Idaho's water investment decisions. The BCR or IRR are not precisely relevant, since limited public budgets are not constraining for private investments. The EUANB formula can be the least burdensome to apply of the four criteria discussed. The annual benefits net of operating cost can be simply assumed to be the same for all years by estimating values for a representative year, and then compared with the equivalent uniform annual cost.

Indirect impact estimates are another important reason for suggesting this approach. Single-year values for representative indirect economic impacts are easily included. The process of estimating indirect impacts is usually so complex and time-consuming that only one representative year is typically estimated. This formula is also more readily understood by non-specialists, since the costs and benefits can be converted into values for familiar physical units, such as net benefit per acre foot.

Some cases, however, may call for another measure. In the event the state has feasible proposals which exceed the limit of 80,000 acres in any consecutive four years, a Benefit-Cost ratio would aid in selecting the highest return proposal(s) from the feasible group.

E. Choice of the Interest (Discount) Rate

1. **Alternative Interest Rate Concepts**

Several different viewpoints are discerned in the economic literature on the choice of interest rates for public investment planning. No other single issue in economic appraisal of projects generates more disagreements among specialists. Three broad conceptual approaches can be identified, supporters of each exhibiting some variations in viewpoint. The most common perspective of governmental agencies at the federal level accepts the cost of capital (government borrowing rate) as determined by the financial markets for public funds as the appropriate rate. The two major alternatives, the social time preference and social opportunity cost approaches, are based on differing theories of the failure of capital markets to yield appropriate rates. See Lind (1982), for an exhaustive review of the various points of view.

Government Borrowing Rate -- This approach is relatively straightforward, setting the government's cost of capital for long-term borrowing as the appropriate rate of discount. "Long-term" usually refers to bonds that have at least 15 years to maturity. The capital markets are recognized as functioning efficiently according to textbook principles in that the price of money (the interest rate) is determined by the balancing of lenders' offers of rates on loan funds and borrowers' willingness to pay to enjoy present consumption or make current investments rather than wait for future income.

The U.S. government has adopted a "government borrowing rate" approach for its water planning, based on legislation dating back to 1967. The rate is set at the long-term nominal or market cost of capital to the government, subject to a "ratchet" clause preventing rates from changing more than 0.25 percent between fiscal years. The rates for recent fiscal years have exceeded eight percent, due to the high inflation rates in the 1970s.

A basic objection is that the federal procedure ignores the effects of inflationary anticipations on interest rates. An inflation-adjusted interest rate is necessary to be commensurate with inflation-adjusted prices and costs recommended earlier. The borrowing rate approach was put in place following a period of relative price stability, but the inflationary price movements of the 1970's raised borrowing rates to levels several times those observed earlier, and the federal government's rate was held down only by the 1/4 percent ratchet requirement.

An adjustment for inflation is clearly necessary. What, however, should be the adjustment? Perhaps the best way to understand the relationship between the nominal market rate of interest (which presumably contains an upward allowance for inflation) and the "real" rate that should be used if a constant general price level is assumed (as is usually done in benefit-cost analysis) is to consider how we would calculate the present value of net benefits first, using nominal prices and interest rates reflecting inflation and second using a constant price level and discount rate appropriate for no inflation. Calculating the second case first, following the formulation of equation (3-1):

$$PVB_2 = \frac{B_1}{(1+i)} + \frac{B_2}{(1+i)^2} + \ldots + \frac{B_T}{(1+i)^T}$$

Logic dictates that, in calculating the formula for which inflation is included, the interest rate used should be such as to give us the same value of PVB. Letting $\hat{B}_t$ be the benefits in year t expressed in current (inflated) dollars, r be the market rate of interest (reflecting inflation), and g be the rate of inflation, PVB_1 can then be written

$$PVB_1 = \frac{\hat{B}_1}{(1+r)} + \frac{\hat{B}_2}{(1+r)^2} + \ldots + \frac{\hat{B}_T}{(1+r)^T}$$

$$= \frac{B_1(1+g)}{(1+r)} + \frac{B_2(1+g)^2}{(1+r)^2} + \ . \ . \ . \ + \frac{B_T(1+g)^T}{(1+r)^T} \qquad (3\text{-}7)$$

But it should be clear from (3-1) and (3-7) that PVB_1 can equal PVB_2 only if

$$(1+r) = (1+i)(1+g) \qquad (3\text{-}8)$$

(where i is, as before, the real rate of interest) for only then will terms cancel out to yield the equality. That is, if the capital market "fully" incorporates inflation into the current market (or nominal) rate of interest, (3-8) must hold, i.e.,

$$(1+r) = 1 + i + g + (i \cdot g) \qquad (3\text{-}9)$$

or

$$i = r - g - (i \cdot g) \qquad (3\text{-}10)$$

Equation (3-10) gives the technically correct formula for correcting the market rate into the "real" rate of discount. However, the term $i \cdot g$ will likely be very small, e.g., with a real rate of 5 percent (i.e., $i = 0.05$) and inflation at 10 percent (i.e., $g = 0.1$), $i \cdot g = 0.005$. (See Howe, 1971, p. 81). Thus it is generally considered acceptable simply to subtract the rate of inflation from the market rate to derive the real rate.

The "market failure" alternatives - The majority of academic authorities take the position that existing capital markets are inadequate to the task of accurately mirroring the correct public interest rates for investment planning. Two sharply different views can be identified. The "social time preference" school judges market interest rates to be too high, while the "social opportunity cost" approach feels they are too low.

The social time preference model spotlights the short planning horizons of individuals as compared to that assumed to be relevant for the society as a whole. Since life span is uncertain, and also because people by nature seem to be more interested in consumption now than in the future, their financial market decisions lead to a higher interest rate than would occur if the public as a whole were trading off present for future. This point rests on the fact that a high value on distant future consumption is reflected by a low interest rate, while emphasis on early returns is measured by high interest rate. A number of perspectives on what the social rate should be can be identified, but a prominent view, associated with Stephen Marglin (1963) is that the public interest rate is to be determined as a social value judgement which mirrors society's perspective on how to trade off current sacrifice for long-term benefits. A social discount rate of three or four percent is characteristic of this view.

The social opportunity cost school begins its argument with the principle that return on public capital investment at the margin should be equal to the private sector's marginal return (e.g., see Hanke and Anwyll, 1980). If this is not the case, the social value of output could be increased by reallocating capital to whichever is the more productive arena. In particular, they note, investments by the public sector selected according to low interest rate criteria are likely to foreclose more productive private sector alternatives. The social opportunity cost school then observes that government intervention in the form of taxation on investments distorts private market returns. The social return on private capital (measured by pre-tax rates of return) is higher than the after-tax private return, so financial market interest rates are too low to properly reflect the public interest.

We do not believe that either of the social interest rate arguments at the national level are relevant for a state-level accounting stance or specifically for Idaho water planning decisions. The social time preference argument, in our view, is less compelling than the opportunity cost approach for problems of investment planning.

However, as noted earlier, the federal tax on investment returns in Idaho is a drain to the state, so Idaho's returns on investment, (private or public) must be measured on an after-tax basis.

Therefore, we return to a market borrowing cost as the appropriate interest rate with which to evaluate Idaho investments. We suggest, in keeping with the discussion on price levels above, that the market rate be adjusted for inflation, i.e., converted to a real rate, to be consistent with real costs and benefits used in the analysis. Further, the rate should be averaged (normalized) to smooth out short-term fluctuations.

In both the federal and state cases, where public funds are directly used, one can calculate the opportunity cost of those funds being given up by identifying the sources of those funds and the rates of return being given up by the providers of those funds. A similar calculation could easily be made for the State of Idaho, but the rationale would have to be that the state was directly investing its own funds (raised by taxes and borrowing) in the projects being evaluated. For the allocation of unappropriated and trust waters, this is not the case: the state is evaluating from a broad state social viewpoint privately or locally proposed projects that will use waters belonging to or held in trust for the citizenry of Idaho.

Thus, we must return to the basic question, "What is the function of the state's evaluation of these projects?" From an economic point of view, it is to direct water to those uses (projects) that will provide the greatest net benefits to the citizenry, account being taken of two key factors (a) differences that exist between private (or local) benefits and costs and state benefits and costs that would be produced by the project; and (b) the opportunity cost of the capital that will be committed to the project. Differences between state and private (or local) benefits and costs are treated in other sections. The key issue here is that the opportunity cost of capital for a given project will differ from project to project, depending upon the sources of capital involved and the nature of the project. Sources of capital can include in-state and out-of-state sources, institutions specializing in small high risk loans (e.g., industrial banks and savings institutions), local venture capital brokers, and large institutional investors such as insurance companies.

Capital markets are quite imperfect, partly by provisions of public policy. For example, local and state government bonds are free of federal taxes (and of some state taxes, too) which increases the demand for them, driving their interest rates down when compared to rates on taxable debt instruments. Costs of capital will also vary with the perceived riskiness of the loan, i.e. with the credit rating of the borrower, and the lender's perception of the soundness of the project. Since capital is being raised from diverse sources to finance Idaho water-related projects, risks are not pooled in any way (i.e. in the sense of Arrow and Lind, 1970). Risk bearing is thus a real cost as argued by Bailey and Jansen (1972) and Hirshleifer and Shapiro (1983) and should be reflected in differences in interest rates. This line of reasoning implies that IDWR should use different discount rates depending on the nature of the sponsor of the project.

2. **Recommended Procedures for Idaho Interest Rates**

For the State of Idaho, the following elements are important in setting an interest rate: (1) the current and anticipated scarcity of capital in general, (2) the riskiness of the investment and (3) the life of the investment or term of an investment loan. We also assume that the interest rate employed in measuring the opportunity cost of water in hydropower generation will be determined by the same principles as employed here (i.e., anticipated borrowing costs adjusted for inflation).

Some public sources of loan funds, to farmers and to some public agencies, include an element of subsidy, and so may be priced even below actual scarcity cost of capital. Hence, the rate selected for Idaho would best reflect the current opportunity cost of capital if it were based on rates offered by private sector banking organizations or on rates in national financial markets, adjusted for the amount of the subsidy. The market's current evaluation for risk and time to maturity of the loan could be reflected by using rates from the private sector's loans to the same risk class, tax class and duration. The only adjustment necessary would be for inflationary expectations.

Since there are numerous classes of potential borrowers, we suggest the following approach: Two risk classes should be recognized, one for private investors and one for public districts or agencies. The private investors will doubtless be required to pay a somewhat higher rate than would public districts. The nominal rates available to each risk class on the national capital market would be adjusted for inflation by deducting from the borrowing rate the average change in price level measured by the GNP deflator.

One rate would be for public projects, in which the income from the borrowing (bond interest)is exempt from federal taxes. This rate would be based on the forecasts of long-term municipal bond interest rates. An authoritative source would be the rate on the "20-year Municipal Bond Buyer" index. We suggest these be averaged for the twenty year future period comprising the three past observed years and the forecasted future seventeen years. These are available to Idaho planners in the Wharton Econometrics Long Term Alternative Scenarios and 25-Year Extension published twice per year. Wharton Econometrics also aids the Division of Financial Management, Office of the Governor of Idaho, in maintaining and updating the Idaho Economic Model and in publishing the Idaho Economic Forecast.

The interest rate on private water development investments, including irrigation, should be drawn from the market for riskier private investments. An appropriate indicator for risky ventures would be the rate on Moody's BAA Seasoned long-term corporate bonds. Past experience and long term forecasts for this rate are also reported each quarter in the Wharton Long-Term Forecast.

These two selected rates should be both adjusted for expected inflation by subtracting from them the corresponding annual inflation estimates, as represented by the GNP Implicit Price Deflator. This deflator, both historically observed and forecasted for twenty years is also available in the Wharton Econometrics Long-Term Alternative Scenarios and 25-Year Extensions (August 1987).

The suggested formula for calculating the interest rates is as follows:

$$\hat{i} = \frac{\sum_{t=1}^{20} r_t}{20} - \frac{\sum_{t=1}^{20} \Delta d_t}{20}$$

where $\hat{i}$: calculated real interest rate.

r_t: observed or forecasted nominal interest rate for year t (t = 1, ..., 20).

Δd_t: observed or forecasted percent change in GNP implicit price deflator.

A sample calculation appropriate to 1988 planning is given below:[2]

	20-Year Municipal Bond - Buyer Rate %	BAA Corporate Bonds (Moody's) %
Observed and Predicted Annual Interest Rates, Average, 1985-2004	7.2	10.7
Observed and Predicted Annual Inflation Rates, Average, 1985-2004	4.2	4.2
Estimated Real Interest Rates	3.0	6.5

F. Indirect Pecuniary Benefits and Costs

A project requires inputs and produces outputs. The latter are frequently given further processing. Thus a new project typically stimulates additional output from regional supplying sectors ("backward

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[2]These estimates are for illustration only because of an error detected in the August, 1987, Wharton Econometrics Long-Term Forecast. The corrected forecasts are not available as of this writing.

linkages") and induces additional output in the regional processing sectors ("forward linkages"). Figure 2 pictures these linkages.

The major conceptual question associated with indirect pecuniary benefits and costs (which could more clearly be called the question of indirect pecuniary net benefits) is whether or not these project linkages will create additional real net benefits that should be attributed to the project from a state point of view.

While it is clear that Project A will need inputs, it is not clear to what extent those outputs will come from the project region or to what extent Project A's outputs will stimulate further processing in the project region. For example, if A represents irrigated feed grain and forage crops, their availability may stimulate or permit an expansion of the beef feeding sector. However, if demand conditions do not permit the profitable expansion of beef output in the State, the added feed and forage products may simply be exported from the state for other uses.

It is also possible that the expansion of the processing sector may not depend on Project A, that there exist alternative sources of supply which, in the absence of A, would provide all that the processing sector demands. In that case, too, the with-without comparison tells us that there is no forward linkage attributable to A.

How should we evaluate the net indirect impacts that might be generated in the supplying and processing sectors within the State? First, it is necessary to determine whether or not the processing and supply activities exist in the state. Then, existing commercial ties will show whether or not it is likely that they will process the outputs and supply inputs to the project area. If Project A is large, it is likely that the price of its

Forward and Backward Linkages for an Irrigation Investment

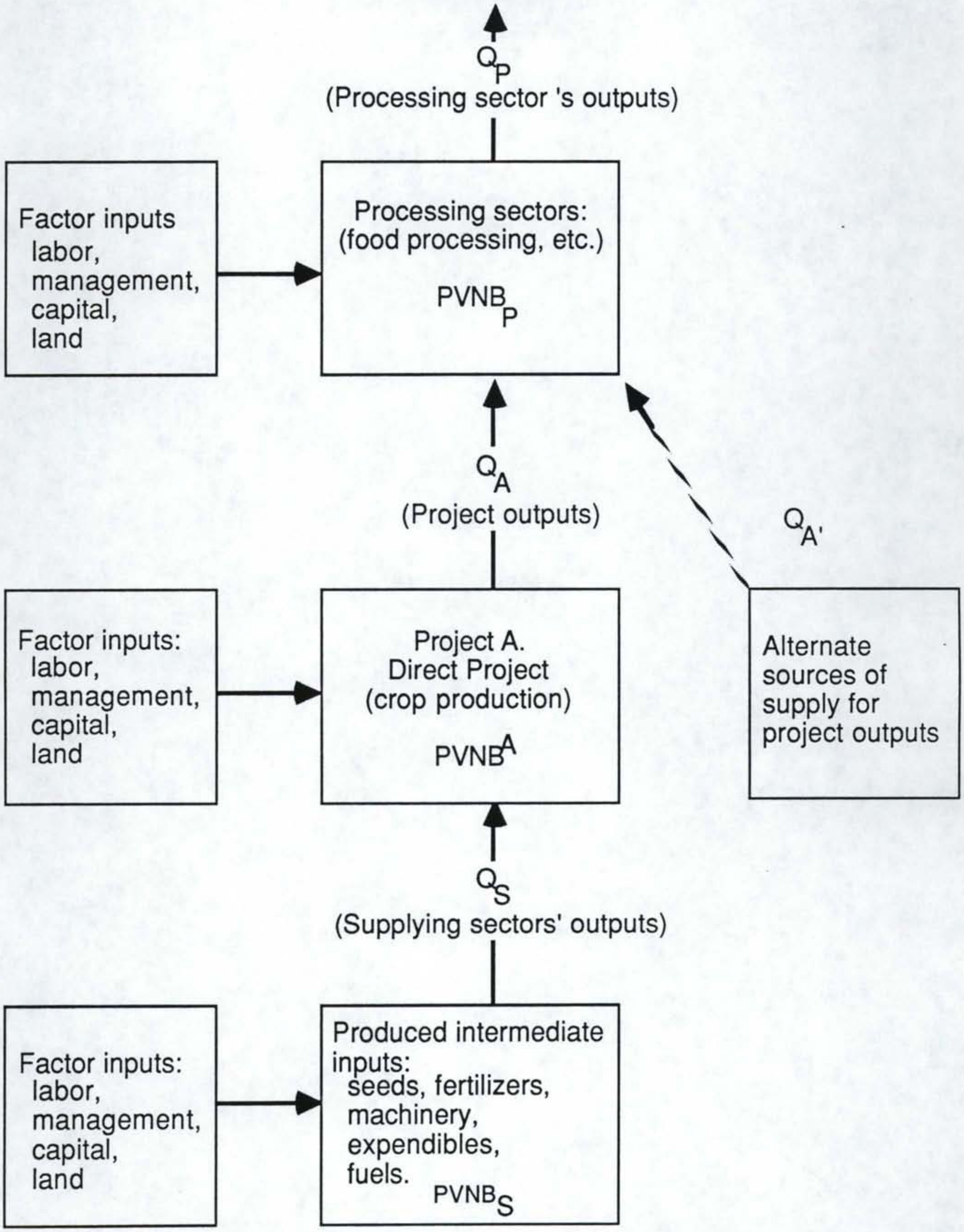

Figure 2

output and the prices of the outputs from the supplying and processing sectors will change in response to A's output. Then the appropriate benefit estimation would have to count changes in user (producer plus consumer) surpluses as well changes in revenues. It could also happen that scale economies or underutilized capacity in the processing and supplying sectors would lead to additional benefits. In principle, there is no reason why we could not calculate the total of these indirect net benefits using standard benefit-cost techniques: changes in user surpluses + changes in revenue - added factor costs - added purchases of intermediate goods, i.e., for forward linkages (P):

$\Delta PVNB_P$ = change in user surplus

+ change in revenue
- increase in purchases from A
- changes in factor payments

For backward linkages (S)

$\Delta PVNB_S$ = change in surplus for S

+ change in revenue
- changes in purchases from suppliers
- changes in factor payments.

If markets are competitive and the economy reasonably well employed, the costs used in calculating these changes in $PVNB_P$ and $PVNB_S$ should fully reflect the net benefits being given up elsewhere in the economy because of the use of inputs in A, in the processing sector, and in the supplying sector. There is no further need to worry about what other projects might be undertaken in the absence of A.

The difficulty in practice of carrying out such an analysis is having available ex ante all of the required information needed for such an incremental benefit-cost analysis of the processing and supplying industries: which plants will do the processing; who will supply needed inputs; what are the conditions of production in these sectors; are alternative supplies available for the processing sector? For such reasons, net indirect benefits are usually omitted from benefit-cost analyses that take the national accounting stance. From a state point of view, however, net indirect benefits are likely to be of some importance.

When the needed information is not available, existing economic models may be helpful in estimating secondary net benefits. A frequently used approach is to utilize a state input-output model to trace likely impacts of Project A on other sectors. The procedure is as follows:

a. check the structure of local industries to see whether or not forward linkages appear likely;

b. calculate the added processing output, Q_P, that is likely to follow from the availability of Q_A;

c. insert Q_P in the input-output (inverse) model to determine what output changes will be required from all sectors other than that containing Project A;

d. calculate the increased factor payments (i.e., to labor (households), rent, interest, profits) that the model predicts to follow from the increased output levels in all sectors other than A;

e. estimate the opportunity costs of these newly employed factors to the state and subtract them from the increased payments calculated in (d) to get secondary net benefits.

This procedure, if followed with judgment and care, can produce a rough approximation to indirect state benefits from Project A. It constitutes an accounting for the increased net benefits by counting net increases in factor incomes rather than calculating net benefits directly. The difficult (and frequently omitted) part is step (e): to estimate the income levels of the factors within the state before they are attracted to Project A and its linked sectors. If it seems likely that these inputs would otherwise have been unemployed within the state (long term structural unemployment), their opportunity cost would be very low. If the new occupations represent an upgrading of (say) in-state labor to higher paying, more productive jobs, then the increase in income is a legitimate benefit. Under most circumstances, one would expect the percentage increase in factor incomes to be fairly small, although such increases must be enough to induce factors to move from one use to another. Howe (1986) used the following assumptions in an ex post analysis of the Colorado-Big Thompson Project:

(a) Capital newly employed by project-related activities had a rate of return that averaged 25 percent greater than its opportunity cost. For example, capital that had been earning 20 percent per annum would earn 25 percent in the new project-related activities. That would mean that 20 percent of the payment of interest and dividends from project-related activities would represent a net gain to the state.

(b) Labor newly employed by project-related activities experienced a productivity increase over former or alternative employments of 20 percent if already resident in the project state or 40 percent if moving into the project state was necessary. Thus, 20 percent of the change in payment of wages and salaries to residents and all other payments for immigrant labor would be new income to the state.

Hamilton and Gardner (1986) and Young and Gray (1985) have clearly pointed out the many pitfalls that can occur in following these procedures and that the procedures have historically been abused to provide overstatements of secondary net benefits. First, value-added in a project is not the same as net benefits of that project since it does not allow for the opportunity cost of the factors used. Secondly, value-added in secondary activities is not equal to the net benefits generated by the expansion of those activities, for it also fails to allow for the opportunity costs of the added inputs. Thirdly, the input-output model, by its proportional or linear method of construction, is incapable of estimating indirect benefits caused by increased user (e.g. consumer) surpluses, scale economies, or the substitution of one input for another.

Accounting for indirect net benefits from a state or regional accounting stance involves other difficult considerations, namely whether the opportunity cost of the newly employed resources is incurred within the project state or region or not. If Project A and its linked activities in Idaho draw their added productive factors from other uses in Idaho, then Idaho value added must be reduced by the full opportunity cost of these factors. If these factors move into Idaho from outside as a result of the increased activities, then no opportunity cost would be deducted from a strict state accounting stance (e.g. see the assumptions used by Howe above). The general approach of Hamilton and Gardner (1986) for the Swan Falls evaluations is a suitable approach to measuring real indirect net benefits. (Keith and Glover, 1988, forthcoming, provide forecasts of indirect net benefits to the State of Idaho.)

G. Employment Impacts

The job-creating impacts of water resource development can be approached with the same categories as are economic impacts: direct and indirect (with the latter divided further into forward and backward-linked).

1. **Measuring Direct Employment**

Direct employment consists of those individuals working in the sector putting the water to its intended use, e.g., irrigation or industry.

Direct employment estimates can be made with at least three approaches, farm or industry budgets, input-output models or econometric (statistical) analyses.

Farm or industry budget approach - The data base for budget analysis ordinarily includes the labor requirements for a unit production process. (A unit process might refer to an acre devoted to producing a crop, a ton of product, etc.). The initial estimates of labor needs are usually based on detailed specification of hours required by each machine or process as related to output. "Time and motion" studies or interviews with firm managers yield estimates of labor per unit output,(e.g., man-hours per ton of product) or labor per unit input (e.g., man hours employment per 100 acre feet of water in irrigated crop production). Labor requirements, of course, vary by industry and by degree of mechanization (capital-intensity).

Recent studies show that as irrigated farms become larger and more mechanized, labor requirements have fallen sharply however measured (per unit product, per acre or per acre foot of water). Sprinkler irrigation, for example, has proven to be a labor-saving as well as a water-saving technology. Field and forage crop production with sprinklers annually utilize about four to seven man-hours per acre.

Some further empirical results on direct irrigation employment are given below. The High Plains-Ogallala study in Colorado reported 0.2 workers directly employed per 100 acres of irrigated crop land, (1 worker year = 2,000 worker hours) (Young, et al., 1983). Irrigation in that region is largely with center pivot sprinklers. Gollehon, et al. (1981) studied the potential effects of reduced irrigation due to diversion of agricultural water to the energy sector in parts of the Rocky Mountain West (including Montana, Wyoming, Colorado and New Mexico). The area studied is largely mountainous, producing mainly forages. A 600,000 acre foot transfer would reportedly cost only 450 direct jobs, or about 0.75 jobs per 1,000 acre feet. Transformed into acres, this is about 0.25 jobs per 100 acres.

Input-Output Models - Models of regional economies of the type usually termed "Leontief Input-Output Models" derive their employment coefficients from the same process as do budgets, or from the budgets themselves. Young (1984) showed a nearly identical figure for the hay and pasture sector of California irrigated agriculture as did Gollehon, et al., i.e., 0.70 direct workers per 1000 acre feet. More intensive crops such as cotton required 2.2 workers per 1,000 acre feet while fruits and vegetables demanded around 31 direct workers per 1,000 acre feet. Industrial sectors, by contrast ranged from 8,100 (aircraft) to 20,000 workers (communication equipment) per 1,000 acre feet. Young (1981) reported for Colorado irrigated agriculture 4.8 workers per 1,000 acre feet in the state (1970 data). Coal mining employed 2,500 workers per 1,000 acre feet, while for electronics the equivalent figure was 32,000.

Econometric models - Statistical analysis using the regression technique is another approach which has only limited application to date. The only study of this type we have identified which focused directly on irrigated farm labor is Mann, et al., (1987). They analyzed U.S. Census data (for 1979) from 104 counties with irrigated lands in Nebraska, Kansas and Colorado. The study reported 3.6 workers in irrigated agriculture and related on-farm activities (mainly cattle feeding activities) per 1000 irrigated acres. This is equivalent to about 2.4 workers per 1,000 acre feet. (The study region is a short-season, feed-grain livestock area which, except for the near-absence of potatoes, exhibits production opportunities similar to southeastern Idaho.) Mann, et al., further noted (from research in progress) that direct workers per 100 acres had fallen 72 percent since 1950.

The general inference from these cited studies is that direct labor impacted from irrigated agriculture is not likely to be large in modern, capital intensive agriculture. An exception to that generalization might be found in fresh fruit and vegetable production.

2. **Indirect Employment Effects**

The input-output studies and the econometric analysis all provide a basis for estimating indirect employment impacts. Gollehon, et al., Young (1981) and Young, et al., (1983) reported labor multipliers ranging from 2 to 2.5. That is, each direct agricultural worker induced 1 to 1.5 additional jobs in the region. The California data analyzed by Young, (1984) included both forward and backward links. Irrigated agriculture multipliers were from 1.8 to 5, the higher coefficients found in sectors such as forages which have large downstream (forward-linked) effects from livestock production. It is important to note that due to the small direct labor requirements, the absolute number of induced workers in the state for those sectors was not large.

The econometric approach of Mann, et al., (1987) measured total labor force changes (forward and backward links plus consumption effects) per 1,000 irrigated acres in the counties studied. They reported 13 workers in the county labor force per 1,000 acres irrigated. At a depletion rate of 1.75 acre feet/acre, this amounts to 7.4 workers per 1,000 acre feet depleted.

3. Recommendation

The several different approaches to estimating employment impacts of water resource development have shown that under present day conditions, irrigation has surprisingly small direct and indirect employment effects. (Industrial employment per acre foot of water consumed tends to be substantially larger. Young, 1984) Farm budgets and input-output models for Idaho should be assessed to determine relevant direct and indirect employment figures for the state. This should require relatively little effort, since the basic information is now available.

H. Treatment of Uncertainty

Uncertainties are the unpredictabilities in the factors that affect the success of a proposed investment plan. No aspect of investment appraisal is more difficult to handle or more pervasive than our imperfect ability to precisely forecast the events of the distant future.

Several approaches can be taken to better comprehend the uncertainties associated with any investment plan. The most important point is that imperfect knowledge of the future should not be ignored. To base a plan on a simple set of best-guess projections may invite an unwanted sense of security regarding the results. All projects should be subject to some sort of analysis for uncertainties.

Advanced treatises on operations research advocate various modeling approaches to uncertainty. Among these techniques are attempts to define an explicit probability distribution for each key variable and to derive a corresponding probability distribution for net benefits. However, estimating long-term probabilities of phenomena arising from economic, political and social change is beyond the capability of the social sciences. It is doubtful that this approach is feasible with the anticipated available resources.

A less demanding and complex technique is appropriate for the present case. We briefly describe two related techniques, and recommend both be applied to the appraisal of Snake River water appropriations. One is called "Sensitivity Analysis" and the other is termed the "Switching Value" test.

1. Sensitivity Analysis

Sensitivity analysis is a systematic technique for determining the effect on project net benefits of changes in assumptions about the future. A sensitivity analysis usually proceeds by varying one element at a time and ascertaining the effect on the measure of project worth (i.e., the present value of net benefits).

Sensitivity analysis should be performed on the most significant factors. The interest rate is a prime candidate. In agricultural projects, tests should also be performed on product prices and on crop yield assumptions. Other variables which should be tested are cost overruns and energy prices (Gittinger, 1982).

2. Switching Value

This is a variation of the sensitivity analysis approach. The switching value test asks how much an important element would have to change in an unfavorable direction before the project would no longer meet the chosen feasibility criterion. For example, what level of crop prices or interest rates would reverse a recommendation to proceed?

3. Remarks

Once some recognition of uncertainty is incorporated into the analysis, the choice of whether to permit an investment is no longer clear-cut. This introduces a subjectivity into the decision process that all will not welcome. Nevertheless, it represents a more realistic approach to public decision-making.

CHAPTER 4

EVALUATING DIRECT BENEFITS OF IRRIGATION DEVELOPMENTS

A. Statement on Perspective

For purposes of this report, irrigation is particularly significant. Up to 450 cfs out of 600 cfs of the trust waters set aside in the Swan Falls agreement could be available for agricultural uses. We interpret the primary purpose of the IDWR "Rules and Regulations" is to protect the interests of the Idaho electricity consumer. Therefore to set out a strict but fair accounting for the net benefits of irrigation is the purpose of this chapter.

B. General Economic Setting for Idaho Agriculture

Some four million acres of crops are irrigated in Idaho. Agriculture accounts for 18 million acre feet per year withdrawals, and an annual net consumption of 6.3 million acre feet. Most of the state's major crops could not be profitably grown without a supplement to the limited rainfall. The major portion of crop production values in the state originate with irrigation.

As is well known, Idaho continues to lead the nation in the production of potatoes, accounting for nearly one-fourth of those produced in the country in 1985. Several other crops including barley, sugar beets, wheat and dry edible beans are ranked high in the national production picture.

A number of well-publicized factors are affecting Idaho's and the nation's agricultural sector in recent years. Crop prices have been unfavorable when compared to those of the last decade. Nevertheless, costs of purchased productive inputs have continued, in general, to rise.

Some Idaho crop prices are directly affected by national agricultural price and income policy, and the future outlook for major irrigated crops will be greatly influenced by decisions reached in Washington, D.C. Income possibilities are directly or indirectly dependent on future federal price support programs.

The outlook for Idaho commodity prices must be understood in both shorter term and long term perspective. The current financial stress in agriculture can be traced to economic and political events of the 1970's. Due to national and international macroeconomic events and policies, export demands for agricultural commodities were rapidly growing, real interest rates were low (even negative at times) and inflation was accelerating. The capacity for agricultural production expanded greatly as farmers planted "fence row to fence row", and rapidly adopted the more advanced technologies. Land value increases provided the basis for the more venturesome to further draw on credit to invest in additional productive capacity (McCalla and Learn, 1985).

Meanwhile, in other countries throughout the world, the same forces also served to increase food production per capita. An event of particular importance has been the shift toward free enterprise incentives in the agricultural sectors in both the centrally planned economies (e.g., China) and those nations who had followed a policy of controlling agricultural prices to favor urban consumer interests without considering the disincentive effects on agricultural producers (e.g., India).

By 1980, however, interest rate and tax policies in the U.S. were reversed in order to eliminate inflation. The U.S. dollar strengthened, which severely impacted our markets for farm products abroad. Former food importers, such as Mexico, put the brakes on borrowing and "tightened belts" so as to reverse their increasing burden of debt. As a consequence, production surpluses and accumulating stocks of grain have caused lower commodity prices. Worldwide excess productive capacity and limited growth in demand backed by real spending power suggest that pressure will continue on food prices.

A longer term perspective yields, in the writers' view, an only slightly more favorable outlook for crop prices. Since early in this century, technology has, in the U.S. and in most of the world, outpaced demand growth. More productive inputs, higher rates of input use, and improved varieties of crops have combined with the size economies of larger farms to reduce real production costs. Technological advance, particularly from application of biotechnology to crop and livestock production, is likely to continue in the future. Relatively small increases in food consumption follow from lower crop prices in a high income nation. While government supply control programs (in the U.S. and elsewhere) and cyclical weather patterns may temporarily reduce food supplies, the forces of technological advance, we believe, will continue to affect the prospects for agriculture.

Federal farm programs have been augmented to help the agricultural sector. The Food Security Act of 1985 commits the federal government to nearly $25 billion per year in support of commodity programs. Given the deficit situation and the fact that the programs don't seem to be fully resolving the difficulties in farm communities, it is not clear how long the Congress and the general public will continue the present policy.

Idaho irrigated crops are, for the most part, not directly supported by public programs. Potatoes, malting barley, dry beans and hay, as well as specialty crops, are among the commodities generally produced without direct public support programs. However, to the degree that production controls and low returns on basic commodities send farmers throughout the nation on a search for alternative source of income, Idaho products will most likely share the future price experience of U.S. crop producers in general.

For these reasons, we find it difficult to paint an optimistic picture on the long-term (50+ year) outlook for crop prices in the U.S. and Idaho. Potential investments in irrigation should be based on a realistic examination of the future of agriculture in view of the state's interest in maximizing beneficial use of water.

C. General Recommended Approach to Irrigation Benefit Estimation

The "Change in Net Income" (CINI) method which was briefly described in Chapter 3, above, is recommended as the most suitable procedure for estimating direct irrigation benefits. The CINI method calculates the net returns or rents to the fixed water and land resource inventory. To review, the direct benefit in this method is simply expressed as:

$$\text{Change in Net Income} = \text{Net Income } \underline{\text{With}} \text{ Added Water} - \text{Net Income } \underline{\text{Without}} \text{ Added Water}$$

The Change in Net Income approach applied to irrigation requires the assembly of farm budgets for the with and without cases. In the next portion of this section, we describe the general process of developing appropriate farm budgets. We then take up a number of specific conceptual and practical problems in performing this analysis.

Several particular choices arise in calculating net income over a long planning horizon. These include a) estimating the change in output per unit land due to irrigation, b) selection of the list crops to analyze and the mix or proportion of each on the farm (specifying a typical crop rotation), c) predicting the appropriate technology and productivity levels for future production, d) predicting future prices for crops and inputs, e) identifying what role livestock should play in the analysis, and f) handling supplemental water supplies to existing operations as compared to new irrigation development.

Each of these issues are discussed below, and recommended solutions listed.

1. **Assembling the Farm Budgets**

Budgets for farm investment planning are prepared so as to identify and value the inflows of resources and the outflow of products with a specified accounting period, usually one year. Budgets provide the basis for assessing and comparing the impact of a plan or an investment, in which some clearly specified package of inputs is committed, and from which are yielded a flow of costs over the project life (Brown, 1979). Farm budget analysis draws on the agricultural sciences, economics and accounting to infer the returns under alternative situations.

Budgets to reflect the financial or economic impacts of alternative farm plans can be developed for a number of purposes. Most commonly, they are assembled by farm operators or technical advisors to analyze such problems as machinery investment decisions, choice of production technology, alternative crop rotations, land purchase decisions and many others, including the subject of interest here, irrigation planning. One version, known as "partial budgets" deals with changes whose impacts minimally affect the total organization of farm resources. Partial budgets represent an incremental analysis, and forecast change in farm income from a proposed operating adjustment.

When the proposal potentially will have major, long-term impacts on resource organization and productivity, a "complete" budget becomes appropriate. This involves a full calculation of income and cost for the business. The complete budget approach is almost always necessary for irrigation benefit analysis, and is recommended for Idaho evaluations.

Farm Models -- When budgeting a planned investment in irrigation is planned, a simplified representation of the farm situation, called a "farm model" is a helpful analytic device. This model will typify the situation or situations being analyzed. It serves to facilitate the analysis, and will consist, first of all, of a list of the assumed characteristics of the farm(s) subject to evaluation. The characteristics of interest are an inventory of principal resources, including land, labor, water, climatic factors, financial backing, and perhaps machinery, equipment and buildings. Realistic assumptions should be made about the productivity of resources, technologies adopted and managerial ability.

"Representative" farm situations should be analyzed, rather than a separate analysis for each landowner. These assumptions are necessary, but each simplification drains the exercise of some degree of realism. Which simplifications are adopted, and how each affects the final net benefit estimate will determine the credibility of the final result.

2. Budgets for Each Year or for a Representative Year?

An early decision must be to choose among (a) a full analysis for each year of the planning period, (b) one representative year or (c) some compromise. (The compromise could involve budgeting for each five or ten years of the planning period).

We do not anticipate that the resources and the knowledge to budget for each year or even for five year interval budgets will be available to IDWR. "Representative year" budgets are recommended for the usual budgeting exercise. (We return later to how prices and technology should be treated for that year.) (For larger projects, a series of simplifying assumptions regarding sizes (acres), type of crops produced and technology of production should be made in order to reduce the task of estimating benefits for an irrigation investment to a manageable level.)

3. Unit Table of Operations and Inputs

The general procedure recommended is to begin with the "Unit Table of Operations and Inputs" which represent the technical and economic opportunities for producing a unit (one acre) of a single crop. These tables combine all the necessary assumptions regarding the technology of production of each potential crop into a common format. An example of a Unit Operations Table is presented as Table 5.

The Unit Operations and Input table specifies resource requirements and yields from the production process for each given crop. It implicitly or explicitly represents the assumptions regarding the typical farmers' production technology adopted for the analysis. The technology assumptions necessarily relate to a specific inventory of machinery and equipment (owned or rented) which can perform necessary tasks in the production process. The

Table 5
Representative Format for Unit Table of Operations and Inputs (One Acre for One Crop)

Crop ________________ Projected Yield Per Acre ____________

	Machinery		Per Acre Inputs		
Operation	Power Source (size & type)	Equipment (size & type)	Machine Hours	Labor Hours	Materials (Itemized)
Seedbed Preparation					
Step 1	______	______	______	______	______
Step 2	______	______	______	______	______
"	______	______	______	______	______
"	______	______	______	______	______
Plant	______	______	______	______	(seed)
Fertilize	______	______	______	______	(fertilizer)
Pesticide	______	______	______	______	(chemicals)
Cultivate	______	______	______	______	______
Irrigate	______	______	______	______	(water)
Harvest	______	______	______	______	(bags, ties)
Haul	______	______	______	______	(miles)
Store	______	______	______	______	(months)

size in acres of the farm is also specified. The machinery and equipment inventory must be appropriate for the size of farm assumed.

The data for a Table of Operations and Inputs is usually developed in consultation with experts from agronomy, soils, horticulture, agricultural engineering and often with local Extension Service agents. These specialists can help assure that the balance of input factors is accurate from their disciplinary perspective and the projected crop yield is appropriate to input levels.

The budget may be put together "from scratch" or from previous publications. A number of universities, including the University of Idaho and also the U.S. Department of Agriculture have developed computerized "budget generator" systems. The analyst can select for each crop from a range of production techniques and equipment sizes, and the computer program generates a cost and return budget tailored for that case.

4. **Total Farm Budgets**

Figures 3 and 4 depict graphically the steps in assembling a total farm budget and indentify the principal components required for each step.

Table 6 illustrates the recommended format for performing the Change in Net Income calculations for the total farm. For simplification, the format shows only two crops for each of the cases "with" and "without" but the specific situation should dictate the appropriate crops for each case. The crops in the "with" situation may be the same as for the "without" case, but will usually be a different set.

Part A of Table 6 summarizes Revenues, while Part B itemizes variable costs for each crop for each situation.

UNIT CROP BUDGET: RETURN NET OF VARIABLE COSTS (PER ACRE)

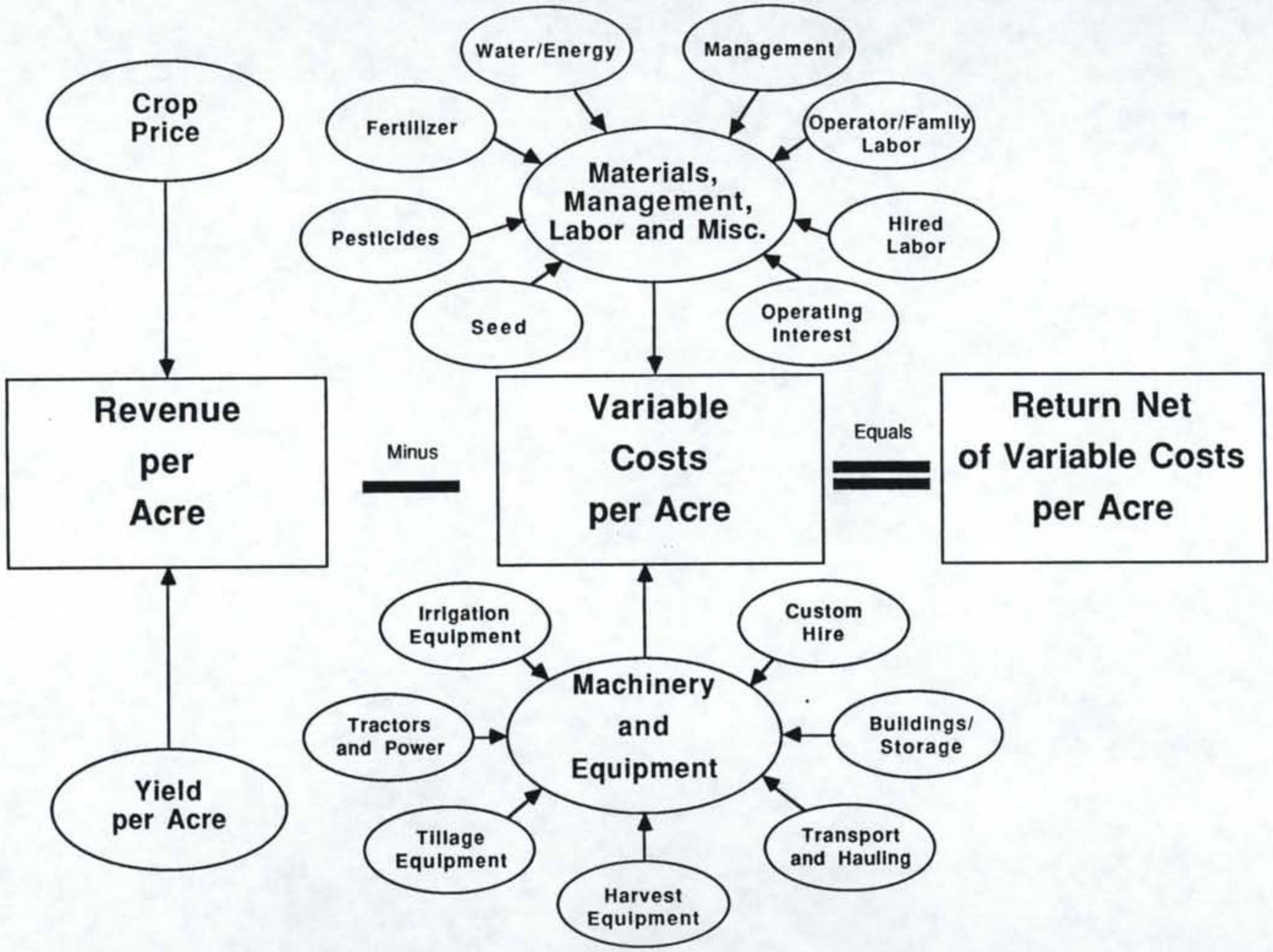

Figure 3

TOTAL FARM BUDGET:
RETURNS NET OF TOTAL COSTS

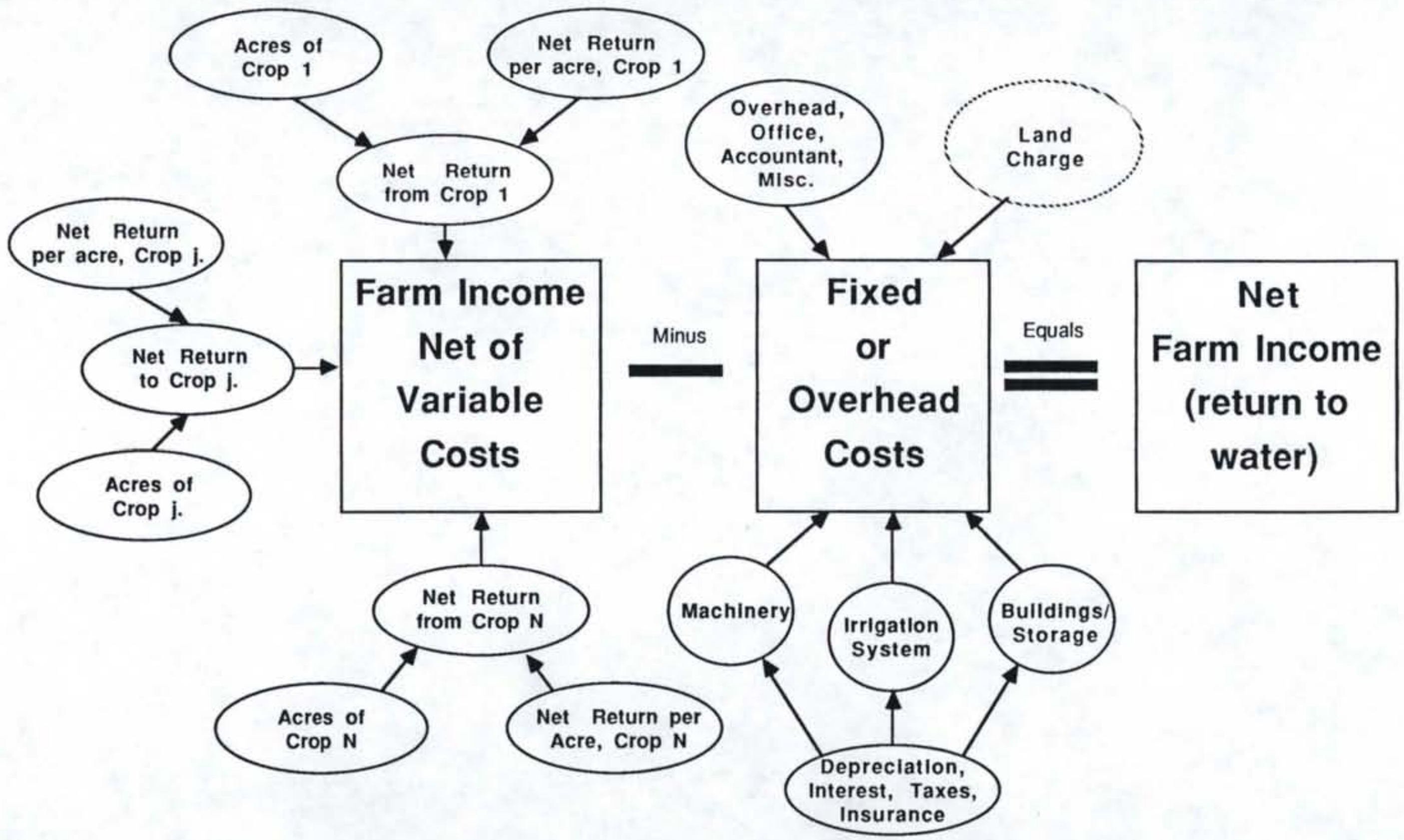

Figure 4

Table 6
Representative Budget Format for With and Without Analysis of Irrigation Developments

Item	Part I - Return Over Variable Cost by Crop: "Without" Development Situation		"With" Development Situation	
	Crop A	Crop B	Crop C	Crop D
	$	$	$	$
A. Revenues Per Acre				
1. Projected Yield/Acre	________	________	________	________
2. Projected Price/Unit	________	________	________	________
3. Projected Revenue/Acre	________	________	________	________
B. Variable Costs Per Acre				
1. Land Preparation	________	________	________	________
2. Plant	________	________	________	________
3. Fertilizer and Pesticide	________	________	________	________
4. Other Pre-Harvest Operations	________	________	________	________
5. Irrigation	________	________	________	________
6. Harvest	________	________	________	________
7. Hauling and Storage	________	________	________	________
8. Management	________	________	________	________
9. Operating Int.	________	________	________	________
10. Total Variable Costs	________	________	________	________
C. Total Return Over Variable Cost: "Without" and "With" Development				
1. Return Over Variable Cost/Acre	________	________	________	________
2. Acres	________	________	________	________
3. Total Crop Return Over Variable Cost	________	________	________	________
4. Total Farm Return Over Variable Cost	________		________	

Table 6 (continued)

Item	"Without" Development Situation	"With" Development Situation
	Part II - Net Return to Farm Operations	
D. Annual Overhead and Annualized Capital Costs (Total Farm)		
	$	$
1. Land Development	________	________
2. Machinery and Equipment	________	________
3. Buildings	________	________
4. Trucks and Other Transport	________	________
5. Irrigation Water Supply	________	________
6. Irrigation Water Distribution	________	________
7. General Overhead (Taxes, Insurance, Office)	________	________
8. Federal Income Tax	________	________
9. Total Farm Capital and Overhead Costs (sum of 1-8)	________	________
E. Net Farm Income (C3 minus D9)	________	________
	Part III - Change in Net Income Calculation	
		$
F. Change in Net Income ("With" minus "Without")		________
G. Acre feet of water depleted		________
H. Net Benefit per unit water ($/Acre foot depleted)		________

The unit "return over variable cost" budgets for the individual crops are collected or summed into total farm budget of net returns over variable costs for both the "without" and "with" cases in Part C. The analyst must choose how many acres are to be allocated to each crop.

The fixed or overhead costs are subtracted at the next stage (Section D of Part II). Overhead charges include capital charges (i.e., interest and depreciation) on machinery, equipment, buildings, and other durables, insurance and general business overhead (accountant, telephone, etc.).

Part III illustrates the format for the total farm Change in Net Income calculations. If desired, benefit per unit water depleted is calculated (Part H).

Note that if the proposed development utilizes land previously in simple farming systems (idle, or in range land, or in a one-crop dry land system), it probably will suffice to calculate only the "with" water supply budgets. The opportunity cost, the net return to land in the "without" case, can be simply represented as a fixed land charge in the "with" project budget. This fixed land charge can be reflected as an annual rental rate for the existing use or an annual interest charge on the investment if the land is to be purchased.

D. Conceptual Economic Issues in Determining Irrigation Benefits

This section takes up several major conceptual issues which arise in determining if an irrigation project is economically feasible. Among the major issues discussed are: the opportunity cost of productive inputs; labor; the future trends in crop prices as related to the future trend in technology and resource productivity in crop production; and the choice of crops for the cropping pattern.

1. **The Opportunity Cost of Production Inputs**

The general concept of costs employed in economic analysis define costs of resources used for particular productive ends as the "economic benefit or value foregone in the best alternative use". In an idealized competitive economy with exchangeable property rights, the opportunity cost of a resource is fully reflected in the market price for the resource. In general, Idaho irrigation water project appraisal can assume safely that the relevant market prices reasonably reflect the cost of factor services required for project construction and operation. Labor and electricity may pose special problems, which are discussed below.

Labor. Wage rates are often viewed as a particular problem for public planning, but this should be the case only if serious long-term unemployment or underemployment is present or anticipated. As discussed earlier in more detail in Chapter 3, Part C, we would adjust for unemployment only in the most unusual situations. Prevailing wage rates for relevant classes of labor are appropriate for the irrigation planning budget in Idaho. Unpriced family labor should be priced at the cost of replacing those labor services with hired workers of similar capability.

Electricity. Energy prices, particularly energy for pumping, must be treated with particular care in the present case. Hydroelectric power generated from dams built decades ago is quite inexpensive to the user.

Electricity is traditionally priced in Idaho and elsewhere on the basis of a "historical accounting cost" procedure. The cost of electricity can be divided into generation and transmission costs. The historical accounting cost approach prices electricity at the actual costs of developing the power, supply, averaged over the various sources of supply, but not adjusted for changes in price level.

Recent writings on electricity pricing reject the above approach in favor of a "marginal cost" concept. Actual rates and shadow prices for electricity should be based on the same concept, the cost of supplying the incremental unit of power (Cicchetti, et al., 1977; Munasinghe and Warford, 1982). Electricity for pumping occurs in the summer season so the extra cost of an additional unit of electricity should represent the actual technology and energy source providing the incremental power supply.

The general evaluation of the allocation of Snake River trust waters involves a comparison of the benefits water diversion with the consequent foregone benefits of hydroelectric power generation. This estimate of the marginal cost of electricity is to be conducted outside the framework of the present analysis, but will be available for evaluation of irrigation development as outlined in this chapter. <u>For simplicity and convenience, we recommend that the cost of generating new power to replace that which would have otherwise been available from hydroelectric units be made the basis of irrigation pumping charges in the State's appraisal. The basic generation costs should be further adjusted for transmission costs and losses to derive the incremental costs of electricity appropriate to the farm level</u>.

2. **Management Charges**

A resource cost should be charged for efforts not included in fieldwork labor requirements. These efforts include time spent for planning, purchasing inputs, hiring and supervising labor and marketing (Burrell and Hall, 1980). A basis for estimating management charges can be found in the fees charged to absentee owners by commercial farm management firms. The fee will reflect the complexity and riskiness of the farming operation, and is usually based on a fixed percentage of either variable production costs or total revenues. The U.S. Bureau of Reclamation (1983) suggests "at least 6 percent of variable production costs". The writers are of the opinion a higher percentage will be warranted for perishable specialty crops. We recommend a management charge of 5 percent of gross income for nonperishable field crops and 10 percent of gross income for specialty crops such as potatoes.

3. The Interrelation Between Technological Advance and Real Commodity Prices

Historically, crop yield improvements and technological advances have provided food for a growing population while permitting a reduction in labor force. The prediction of input use, yields and production technology into the distant future is a key aspect of the economic feasibility forecast, one which must be treated in a coordinated and consistent fashion.

Improvements in crop yield per acre can be classed as due to either increased inputs or to improved technology. Often it is difficult to separate the two determinants. Several potential technological sources for improved yields can be identified. Variety improvement is the most important source of yield increase. Sprinkler and drip application and laser leveling of land are examples of technological advances which have improved the productivity of irrigation water. Fertility management involves control of quantity, timing and content of fertilizer. Improved cultural practices such as tillage and weed control operations can provide some increase in productivity with little effect on costs. Improved pesticides for disease and insect control are another source of productivity gains.

Irrigation project planning has often been based on forecasts of continued productivity improvements throughout the life of the investment.

Yield improvements and the added associated costs are incorporated into the unit budgets. Analysts should be careful that evaluations do not understate or ignore the added resource costs associated with new technologies and increased productivity.

If improved yields per acre are forecasted, the adverse price impacts which will be a consequence should also be considered. Crop price forecasts are among the most important factors influencing economic feasibility of irrigation. However, the methods traditionally used by federal agencies (based usually on a moving average of historically observed prices), have serious limitations.

The main concern is to recognize that the historical tendency throughout the world in the past century has been for food commodity prices to fall in real (constant dollar) terms due to productivity outstripping demand increases. This point warrants some further discussion.

Since the advent of the systematic application of science to crop production, which can be placed roughly as beginning with the public funding of research stations just over a century ago, the march of technology has outgrown the growth in the demand for food, particularly in the United States. As agricultural productivity has improved, commodity prices have fallen in real terms. In addition to the decline in the real cost of food and fiber products, there have been important impacts on export markets. As productivity in the U.S. improved, the nation has moved since the last century to become a major food exporter, with one in every four or five acres devoted to producing for the export market. However, adoption of market-like incentive systems in the Third World (e.g., India, China) and the increasingly rapid transfer of improved technology to these countries, combined with weak demands for food imports have stopped and even reversed the growth in demand for U.S. farm exports.

A major weakness of federal appraisals of irrigation development has been the tendency to ignore the long-term effect of technological advance on real commodity prices. The problem for the Idaho analysis is to project the long-term trends in prices, as influenced by probable directions in domestic and export demand versus production increases. In an important sense, irrigation feasibility assessment turns on the analyst's long-term judgement and assumptions on this interrelated set of issues.

One obviously enters a highly uncertain realm in projecting several decades into the future, but the writers' instincts are to expect continued improvement in technology. We anticipate per capita food production in the world to continue to increase. This will place in the future, as it has in the past, a downward pressure on real commodity prices.

We emphasize here the mutual interdependence of prices and technological advances elsewhere in the nation and the world. Harberger (1974, p. 19) wrote:

> Almost any investment made today would become profitable if no competing investments were made in the future . . . the "profitability" of today's investments should be estimated on the assumption that all "profitable" future investments will also be made . . . Here, of necessity, the project analyst himself has to estimate an expected time path of the prices--not on the assumption that his project stands alone, nor on the assumption that future projects will be held up in order to "protect" his current project, but on the much more rigorous assumption that future investments will be made on their own merits.

<u>Alternative Approaches to Crop Price and Yield Forecasts</u>. Federal planning procedures have been to forecast continued improvement in crop production and yields, but to use real historical prices. As the argument

above concluded, this approach is misleading and likely to overstate the future realized prices. If technological improvements are expected, commodity prices used in Idaho's analysis should reflect the net negative effects of these productivity advances.

One way to forecast long-term price changes would be to employ the trend in commodity prices relative to farm production costs. This relationship, termed the parity ratio, has fallen by nearly 1/2 percent per year for the past 75 years. Extending this historical trend into the future would yield predictions of reduced crop prices relative to costs by a similar degree into the future.

<u>A simpler approach, which we recommend to the State of Idaho, is to assume that the positive effects on net farm returns of technological improvement and increasing farm size are exactly offset by falling real crop prices, such that real net income per acre is projected to remain constant over the planning period. To normalize for short-term and cyclical price effects, an inflation-adjusted average of several (five to seven) years of annual farm-gate prices should be calculated</u>. This approach is reasonably reflects historical experience and avoids the difficulties of projecting prices, yields and production technologies decades into the future. The University of Idaho crop production budgets can be readily adapted to this approach, which is an important advantage.

4. **Choice of Crops and Crop Acreage Limits for Feasibility Analysis**

Numerous alternative crops can be grown on the lands of any irrigation development. The analyst must predict with some degree of accuracy what products will be typically selected by farmers, and what proportion of acreage will be devoted to each.

Crops vary widely in their gross and net returns per acre. Net returns over variable costs are associated with the degree of complexity of the production process and the riskiness of production process. High risk crops characterized by complicated technologies for production tend to have high gross margins (gross return net of operating costs). High gross margin crops are more likely to justify proposed irrigation investments than are low margin crops, other factors being equal. Hence, there is a natural tendency of project proponents to select high-margin crops for the farm plans, and to allocate a large portion of lands to such crops. We believe the high return to fixed assets (water and land) are more apparent than real, being due to an inadequate accounting for management in the budget exercise. A part of the high net return should be charged to management, as we have recommended in our earlier discussion.

The actual practices of farmers in existing irrigated areas is to limit the amount of land and other resources allocated to high margin, but risky crops. This is probably because most farmers have limited capital and even though the high margin crops are initially attractive, the high operating costs and the risk of catastrophic loss and even bankruptcy due to short-term yield or price fluctuations inhibits the majority from committing more than a fraction of their lands to risky and complex enterprises. Specialty crops also often require that processing, packing, and/or marketing facilities be readily at hand to preserve and speed them to consumers. Perishable crops typically demand a high level of management skills and production expertise.

One procedure for constraining projected cropping patterns to realistic proportions was adopted by the U.S. Water Resources Council in their 1983 Principles and Guidelines. High margin specialty crops cannot be included in federal irrigation project evaluations on the grounds that irrigated lands are not constraining on acreage of these enterprises. Benefits can be calculated only on production of ten basic crops. The ten basic crops include rice, cotton, corn, soybeans, wheat, milo, barley, oats, hay, and pasture (U.S. Water Resources Council, 1983, III-2.3.2).

Hamilton and Gardner (1986) take a similar position, asserting that there are some specialty crops with limited, local, or controlled markets for which total regional acreage would change only slightly, even though substantial acreages would be grown on the new lands. Specialty crop production on new lands would simply displace production on old lands, with little or no net change for the region as a whole. It is suggested that the economic process by which this occurs is via the price system. Increased production of a specialty crop will force a new lower equilibrium price, driving higher cost old areas out of production.

<u>We recommend a relatively strict position on specialty crop acreage be adopted, following the federal approach and that advocated by Hamilton and Gardner. Specialty crop acreage in a proposal should be limited to the proportion of acreage of such crops already grown in the region. Only if a crop has shown a growth trend in its proportion to total acreage, as has potatoes in Idaho, some growth allowance might be permitted</u>.

5. The Potential Adverse Effects of Large Scale Irrigation Development on Crop Prices

The discussion of the previous section makes the (conventional) assumption that the proposed development is small relative to total market supplies and the increased output would have no impact on prices received for crops. Keith and Glover (1988) point out that the magnitude of total new lands developed with 450 cubic feet per second of right is quite large. Given the highly price-inelastic demand for agricultural crops, noticeable price decreases might in fact follow.

The writers are of the opinion that if the procedures outlined in sections 3 and 4 (just above) are followed, such that the forecasted acreage of specialty crops is constrained to historical levels and crop prices and yields are treated jointly and realistically, the assumption of negligible price effect is appropriate for Idaho's purposes. Potatoes, dry beans and grains are produced largely within the parameters of a national market, and whatever adverse effect on prices of those crops would likely be too small to distinguish from statistical "noise". An exception to this reasoning might be found with alfalfa hay and other forages. The net effect of new water supply will likely be to increase acreage of forages. Due to their bulky nature and the associated high cost of transportation, local supply increases will have much effect on hay prices.

We suggest that this issue be given some additional attention by Idaho authorities in implementing the Rules and Regulations. The appropriate estimates of long run demand elasticity must be developed to assess the issue properly.

6. **Size of Farm**

The size of the typical farm in the feasibility analysis affects the estimated average costs of production. The larger the unit, up to a point, the more efficiently are the machinery, equipment and other durables combined with labor, land, and variable inputs. Hence, the prospects for feasibility of irrigation are favored by larger units.

Traditional farm management budgeting procedures, in the writers' view, tend to overemphasize the above relationship. The basic reason for this overstatement is the use of budgeting procedures which typically assume that depreciation of durables is dependent on age rather than amount of hours operated. If the life of a durable were to be expressed in hours of use rather than age in years, the perceived cost savings from more hours of use of durable equipment would soon vanish and the long run cost curve would remain flat after initial economies are captured. Independent evidence for this hypothesis is found in empirical studies of unit production costs as related to the size of the farm business (Tweeten, 1979; Seckler and Young, 1979). We therefore anticipate that no significant unit cost savings are likely to accrue to projects which expand on an existing farm.

The evidence on where the average costs of production cease to fall significantly with size is mixed, but the writers are of the opinion that most gains are obtained for irrigated crop production by six hundred acres for feed-forage farms, and at lower acreages for more intensive situations (fruits and vegetables). There is some evidence to suggest that unit costs actually rise again at sizes above which the family labor cannot do a significant proportion of the work and the labor force is mostly hired.

We further note that small developments will be self-constrained, to a degree, by relatively high costs of production. We therefore recommend no special treatment be given to the farm size issue, and average or typical production costs can be utilized for evaluating irrigation proposals.

7. Production Technology

Will the typical farm be labor intensive and small or capital intensive and large? Will "advanced" technologies of production, employing high level of pesticides, fertilizers be expected, or will organic farming be the rule? Will irrigation be carried out by flooding, ditch and furrow, sprinklers or drip/trickle systems?

Choices made on these points are related to other input cost decisions discussed above. If the opportunity cost of water and labor are set relatively high while interest rates are low, then the capital-intensive techniques are more economically appropriate. If the contrary outlook is accepted, more labor- and water-intensive production practices would be appropriate.

A general solution to this problem would be to construct a detailed model in which a wide range of alternative production and irrigation technologies would be incorporated, and the technology is chosen on profitability criteria, depending on assumptions selected regarding interest rates, shadow wages and the foregone value of water. This step is beyond the needed detail for all but the largest investments and is not probably necessary for Idaho water managers to consider. We recommend the budgets adopt technology currently in common use by "good" managers as the appropriate future level of technology and capital intensity.

8. Livestock's Role in Budgets for Valuing Irrigation Water

Beef, sheep and dairy activities are often found on irrigated crop farms. Due to the fact that livestock feeding is practiced by specialty producers, who buy most or all of their feed, the theory of competitive markets implies that the price differential between feeder stock and fattened animals will, on the average, reflect exactly the costs of production, (including the stockers and feeder animals going into the feeding process, the feed, labor, medications plus the opportunity costs to management and risk-taking required to draw effort into these activities). Hence, there will be, under competitive conditions, no surplus from the livestock fattening activity which should be credited as direct benefits to water and/or land, from the public's perspective. The same reasoning applies to dairy production.

This conclusion also is consistent with the analysis put forth elsewhere in this report for the idea of limitation of the proportion of risky specialty crops in cropping plans. The general point is that livestock feeding is also a risky, managerially demanding process. The economics profession is not yet able to accurately separate out the return to water from the return to managerial and risk-taking activities. The result is that returns to risk and management for risky activities are often incorrectly assigned to other fixed resources, such as to water. This provides a bias or an overstatement of the actual returns to the water resource. Livestock enterprises backward-linked to irrigated crop production will generate returns over factor costs only in the event of unemployment or immobility of resources.

We recommend livestock enterprises not be included in evaluation of direct irrigation benefits. Livestock activities should be treated as a "downstream" (forward-linked) activity just as are other steps in processing raw products into food. This recommendation is consistent with recent federal planning procedures (U.S. Bureau of Reclamation, 1983).

9. With-Without Analysis for Supplemental Water

The Change in Net Income method has an advantage of providing satisfactory benefit estimates for not only new irrigation developments, but it can as easily reflect net benefits of adding some supplemental water to an existing farm operation. The "without" situation represents the operation as it exists, and the "with" situation calculates the income with the added capacity.

Fixed costs might, at first glance, be thought to not change for small additions in irrigated acreage, so that incremental costs would be relatively less. However, added usage will wear out machinery faster, so these added costs should be taken into account. An appropriate way to estimate the added fixed costs would be to rely on a "hours of use" concept of machinery life, rather than a "years life" with implicitly assumed annual hours. (See discussion regarding size of farm, above.) No special treatment is otherwise advocated for supplemental irrigation.

10. **Federal Income Tax**

As noted in Chapter 3, the state accounting stance requires that taxes be treated as a cost of production. Also, in order to be consistent with the treatment of taxes in the hydroelectric power evaluation, federal taxes should be incorporated in the irrigation benefit calculation.

Estimating taxes on a case by case basis would be overly burdensome. We suggest the State of Idaho seek to determine from the U.S. Internal Revenue Service an estimate of the representative marginal tax rate appropriate to irrigated crop farming in Idaho. If that information is not available, the tax rate could be calculated on the basis of a "representative farm" budget analysis, applying the current tax tables to the predicted net pre-tax income. We would hazard a guess that this figure would be in the neighborhood of 15 to 20 percent of pre-tax net income under the 1986 federal tax legislation.

E. University of Idaho Farm Budgets: Potential Role

The University of Idaho Department of Agricultural Economics maintains and updates a series of crop cost and returns budgets. These budgets represent the current technology and current cost situation recommended above. They would need to be modified only minimally to meet the conceptual framework outlined in this chapter. We recommend, first, the use of a normalized price series, (i.e., a five to seven year average expressed in current price levels) for crop prices. Second, we suggest that the land rental charge as presently conceptualized be modified, because this now partially measures the residual net return to the fixed water resource endowment that analysis seeks to identify. Rather, for the "without" case, the return to land should be the residual that is estimated when the existing use is not for irrigation. Third, where pump irrigation is planned, the appropriate shadow energy rate should be employed. Finally, charges to reflect the opportunity cost of management should be deducted, rather than leaving risk and management as a part of the residual benefit of irrigation.

CHAPTER 5

CALCULATING NET BENEFITS FROM PROJECTED INCREASES IN MUNICIPAL AND INDUSTRIAL USES

A. General Considerations

Evaluation of municipal applications to appropriate water must be based on the reasonableness of the municipality's demand projections and the relationship of those projections to the town's total supply picture. A complete analysis by IDWR of a given supply and demand situation would be too costly and time consuming, especially in light of the small percentage of total withdrawals and consumption now accounted for by municipalities. Thus IDWR must establish certain standards of analysis and demand-supply comparisons that are to be required of municipalities.

Municipal demand is to be interpreted as including (1) public sector withdrawals and consumption; (2) residential withdrawals and consumption; (3) commercial (service sector) withdrawals and consumption; (4) industries (usually small) served by the public supply system, and (5) system losses of produced water. Large industry users are usually self-supplied and this group is treated separately below.

Municipal water managers tend to be extremely risk averse in relation to system shortages. Even in situations where shortages can be met by modest, low cost conservation measures on the parts of both the utility and water users (e.g. supply system loss controls and alternate day lawn watering), water utility managers associate a very high public relations cost with shortages. This is not without some basis in experience, for public reaction to imposed conservation measures is sometimes quite heated.

For these reasons, municipalities often "hoard" raw water supplies, i.e. they often accumulate water rights greatly in excess of average annual demands and even greatly in excess of "shortage scenarios" based on persistent serious droughts and high demand growth. Thus, an evaluation of requests for new appropriation <u>should be based on a comparison of current and projected demands with the municipality's whole portfolio of water holdings</u>.

Urban withdrawals constitute a very small part of total withdrawals in Idaho and an even smaller part of total consumption. (Refer to Table 1, which characterizes water use patterns in Idaho as of 1980.) Public supplies constitute less than 1 percent of total withdrawals for offstream uses. Thus minor transfers from agriculture and instream uses can provide many times the current publicly-supplied municipal uses.

Urban water demands show uneven patterns over time: higher summer demands; very high peak day demands during high temperature events; and marked peaks within each day. Providing the supply to meet these various peaks is largely a matter of providing raw water and treated water storage and managing peak demands through appropriate metering, pricing, and other controls.

In the past 15 years, all types of urban use have been influenced by the state and federal water quality management programs which have set strict effluent and ambient standards for towns and industries. These programs have exerted direct control over effluents and indirect controls through consequent increases in sewage charges. Industrial and commercial users have responded to these constraints and increased charges by greatly reducing the intake of water per unit of product or service. <u>The effect of</u>

conservation must be taken into account in making withdrawal projections. These effects have been dramatic but have largely been worked through the system and are not likely to be repeated.

All new urban uses should be metered to permit volumetric pricing and equitable sharing of system costs. (However, it may not be cost efficient to retrofit meters on small, especially residential, users.) Modern rate structures should include the following components:

a. a tap fee on new services to cover the present value of raw water acquisitions and system expansion costs caused by the new service;

b. a fixed fee per billing period to cover fixed administrative costs;

c. a level or increasing block rate structure that reflects all variable system costs plus any scarcity value of the water itself not reflected in water acquisition or development costs in (a) above.

The rate structure should be adequate to provide for adequate maintenance, replacement, and emergency reserves. All urban water supply, sanitation, and flood control agencies should have rate structures that allow the agencies to be self supporting, although borrowing will be useful at times of system expansion. (Gardner, 1987, presents guidelines tailored for the Idaho situation.)

IDWR should also insist on reasonably "tight" urban systems. Many towns lose from 30 to 50 percent of the water they produce, mostly through leaky mains and from abandoned services. Techniques are available for locating and reducing these loses (see Howe, 1971). Ten percent is considered an irreducible minimum level of losses, and in areas of geological activity and/or unstable soils, the minimum loss rate may range up to 25%. Cities above this level should be required to tighten their systems.

B. General Strategies for Estimating and/or Evaluating Municipal Water Demands

Two strategies are available to IDWR in assessing municipal water demands: (1) simply to assess the "reasonableness" of the request in light of the expected population increase and industrial structure, or (2) actually to estimate benefits associated with the proposed additional water use. In light of the small quantity of water withdrawn by public systems (Table 1), the first strategy makes the most sense.

Strategy (1) simply requires the gathering of some comparative data on per capita water use from a sample of Idaho municipalities that are acknowledged to have well-managed water utilities. Since it is appropriate to require all new municipal uses to be metered, comparative data should be gathered only from towns that are largely metered (i.e. some older homes and some public uses might remain unmetered). For each town in the sample, per capita withdrawals should be determined for the following categories:

1. public uses, including municipal government, hospitals, schools, parks and parkways, golf courses, etc.;
2. residential withdrawals, broken down into:
    a. single family dwellings;
    b. duplex/triplex/townhouse category;
    c. apartments;
3. commercial (service) sector withdrawals;

4. industrial withdrawals supplied by the water utility;

5. supply system losses.

It is important to separate industrial uses from others because of the variability of industrial structure and water use from town to town. One or two heavy water-using industries can dominate the town's water use pattern.

Strategy 1 rests on the assumption that the consumption component of raw M & I water is more valuable than the foregone Idaho hydroelectric power benefits. This appears to be generally the case in the arid West as reported by Gibbons (1986).

Once data are gathered on these categories of water use, acceptable ranges of values would be selected. If a town's proposed rates of water use (say, residential) fall within those ranges, and if the projections of population seem reasonable, the application would be approved.

The second strategy would be to estimate demand functions for typical users in each category of users, and then to use those demand functions both for projecting reasonable rates of use and for estimating benefits associated with the growth of urban water uses.

From the viewpoint of developing a refined urban water policy, this second approach has several advantages. The first is that it permits an actual benefit-cost comparison for urban applications, rather than the simpler "reasonableness" test against other towns. The second advantage is that it would permit IDWR to estimate the effects of changes in metering, housing mix, water pricing, and income changes on urban water demands. For example, if towns are frequently unmetered or if urban water is underpriced, the effects of moving to metering and more appropriate pricing could be estimated and incorporated in the quantities for which IDWR would grant permits.

The disadvantages of this strategy are that it requires extensive data gathering and related statistical analysis to estimate the demand functions. Secondly, data usually allow estimating demand functions only for residential users, with benefits for the other sectors having to be roughly estimated by techniques like "alternative cost".

C. Estimating Municipally-Supplied Industrial Water Uses and Benefits

Large industrial users are often self-supplied and usually need to be reviewed as special cases because of site-specific technological differences. In the U.S. as a whole, water intake by manufacturing industries has fallen by about 25 percent since 1978 (U.S. Department of Commerce, 1986). The largest users are typically chemical and allied products, primary metals, and paper and allied products that nationally accounted for 74 percent of total manufacturing withdrawals. About 60 percent of water withdrawn by manufacturing enterprises is used for cooling. Each large industrial user should be required to demonstrate that their processes are in keeping with water quality regulations and that the extent of recycling is in keeping with current industrial practices.

The only practical approach to estimating industrial water benefits is to estimate the so-called "alternative cost" of getting water from the next best source other than the municipal source. Naturally, in a few cases, there will be no practical alternative. In some cases, it might be practicable for the industry to provide its own supply from wells or surface diversions. The alternative to an increased supply from the municipal utility might be increased recirculation of currently used water. See Gibbons (1986) for a more detailed discussion.

The rationale of using alternative cost is the following: it is assumed that the value of added water supply to the user would be great enough to justify the costs of the alternative, i.e. in the absence of municipal supply the industry would proceed with the alternative. When this is true, the greatest benefits that could be attributed to the municipal supply would be the costs of the alternative supply.

This approach must be used with good judgment about the reality of these conditions. If the cost of the alternative supply is high, many industries might find it unprofitable to operate. Only when it is clear that the alternative supply would actually be developed in the absence of a municipal supply can this approach to benefit estimation be used.

D. Estimating Public and Commercial Water Demands

It usually is not possible to estimate full demand functions for public sector uses and the various classes of commercial uses because of absence of data - especially the absence of sufficient price variation. Without observations on the price variable, we can't estimate willingness to pay and, consequently, the benefits to be attributed to these uses.

Few studies of public and commercial uses have been carried out. There is in any case a real question of the usefulness of detailed demand studies for sectors that withdraw only a small part of total water supplied. It usually suffices simply to relate public sector use and commercial sector use in the aggregate to projected population. That is, a regression can be fitted to historical data, in the forms

$$Q_{D,pub} = f(\text{population, time})$$

$$Q_{D,com} = g(\text{population, time})$$

These relations will permit sufficiently accurate projections of these classes of use. As noted earlier, increasingly stringent water quality regulations since 1970 have significantly tightened up public sector and commercial water use patterns. Thus one should use only data recorded since, say, 1975.

E. Recommended Approach

Strategy 1 which consists of a simple assessment of the "reasonableness" of the proposal in view of expected change in population and industrial structure, is recommended for Idaho at the present time. It would be desirable to work towards strategy 2, perhaps with help from the universities in estimating demand functions. Techniques for implementing Strategy 2 are more complex. A detailed procedure is described in Appendix B of this volume.

CHAPTER 6

VALUING FOREGONE INSTREAM USE BENEFITS

The Swan Falls agreement gave recognition to the growing importance of hydroelectric power to the Idaho economy. The economic analysis recommended in this Handbook is designed to determine if the benefits of new offstream diversions can outweigh the foregone hydropower benefits. Estimated hydropower benefits foregone estimates are to be provided from another source, but in order to make this document more nearly self-contained, a brief discussion of this issue is provided. Due to the expected increasing role of recreational uses, the second part of the chapter summarizes the current status of techniques for valuing benefits of those instream uses.

A. Benefits of Hydroelectric Power Production

Several attributes of hydropower stand out. As a renewable resource, water supplies are replenished annually. Hydropower facilities are flexible and can be quickly brought up or shut down in response to changing local requirements. An important characteristic of most hydro systems, including Idaho's Snake River complex, is that a unit of water generates electricity several times as it descends from dam to dam. The pollution problems associated with fossil fuel plants are absent, and a hydropower plant is very long-lived and requires relatively little maintenance. On the other hand, they tend to be capital intensive, and in an era of sensitivity to environmental values, they can inundate large areas of land, fish and wildlife habitat and whitewater recreational possibilities.

The amount of electricity produced per unit of water depends primarily on two factors: the net "head" (the vertical feet the water falls in making electricity) and the efficiency with which the falling water's energy is transformed into electricity. Efficiency depends on the technology of the plant but 85 percent is frequently assumed (Young and Gray, 1972).

For given efficiency, each unit of water produces the same amount of electricity per foot of head, implying constant and equal marginal and average products. Gibbons cites a standard relationship of 0.87 kilowatt hour per acre foot per foot of head.

Considerable experience has been obtained on the methods and results for evaluating hydropower developments. Typically, such studies have evaluated the total plant investment, rather than focussing on the water resource. Furthermore, a zero opportunity cost of water is typically assumed in such efforts.

The general approach to estimating the foregone hydropower value relies on a combination of the alternative cost principle and the residual imputation approach (Young and Gray, 1972, Chapter 13). The calculated alternative cost of the equivalent output of electricity from a privately owned steam-powered plant is derived as a first step. (The economic value of hydroelectric output is not properly measured by the actual rates charged. Such rates typically reflect a historic accounting approach, in which the rate is derived by finding the weighted average of the historical costs of the various sources of power. The appropriate social opportunity cost is reflected by the cost of supplying the marginal unit of output.) Generally, marginal cost of electricity is determined by calculating all costs, including a return on capital, over a specified plant life. Thus, an equivalent value of power is calculated, using hydroelectric to thermal conversion factors representing capacity, transmission facilities, and proration of fixed costs. The alternative (steam) production methods is costed for a base load capacity equivalent to that for a specific hydroelectric installation.

Next, the value of the output change resulting from a marginal reduction in water supply is calculated. The part of the value attributable to water can be calculated by subtracting all known costs of the hydroelectric plant. When the hydroelectric plant and operating costs are prorated by output and subtracted from the alternative cost, the residual represents the value of the volume of decreased water.

Because hydro systems are often used for peak as opposed to baseload power, the alternative cost calculation should reflect the expenses associated with generating peak power by alternative means.

Gibbons (1986) summarizes and updates a number of estimates of the value of water in hydroelectric power, and provides references to more detailed exposition of the techniques for their estimation.

B. Water-Based Recreational and Amenity Benefits

1. General

Outdoor recreation activities may utilize water in several ways. Swimming, fishing, boating and water skiing are "contact" uses of water by recreationists. While water is not essential to "non-contact" activities such as picnicking, hiking and sightseeing, water adjacent to the activity often greatly enhances the enjoyment of such experiences. Water-based recreation is becoming increasingly important in Idaho. Donnelly, et al. (1985) and Sorg, et al. (1985) are among recent efforts at estimating net benefits of fishing in the state.

Recreational use of water resources is rarely priced in ways which properly reflect benefit (willingness to pay) values, if at all, so sources other than observed market prices must be employed. Water-based recreation poses a particularly difficult problem of valuation. Because water-based outdoor recreation on public lands is itself seldom priced, a non-market evaluation technique must be applied to assign monetary value to the recreation activity. Then, because recreation benefits are typically a product of a number of other resource inputs in addition to water, a net benefit to water must be derived.

A convention has been established among economists in that the recreation experience is valued in units of "visitor-days". We discuss first the problem of establishing a visitor day value, then turn to valuing water itself.

Following the U.S. Water Resources Council (1983), we identify three possible approaches to the problem of valuing outdoor recreation. These, all assumed to measure net consumer surplus, are a) methods based on markets in related goods (the "expenditure function" approach), b) direct questioning techniques (which confront potential users with hypothetical markets in which individual users can reveal their valuations), and c) one relying on expert judgments to approximate willingness to pay (the "Unit Day" method).

2. Direct Questioning Approaches

Direct questioning approaches, as the name suggests, rely on survey questionnaires in which hypothetical future situations are valued in monetary terms by each respondent. Theoretically speaking, this method seeks to measure the money compensation necessary to restore the initial level of utility to a person experiencing an increment (or decrement) in the level of environmental services. This amount of compensation reflects willingness-to-pay (WTP) or willingness to accept payment (WTA) for the change (Brookshire, Randall and Stoll, 1981; Randall, 1984b, 1987).

The most common version of this approach is called the contingent value (CV) method. Contingent valuation techniques attempt to utilize a representative cross-section sample of the relevant population. Personal interviews or mail questionnaires ask willingness to pay for recreation activities contingent on hypothetical changes in their availability. Photographs, maps, tables or diagrams are often employed to clarify the hypothesized changes. Cummings, et al. (1986), provide an exhaustive assessment of the method in their recent volume. Briefer reviews are presented by Anderson and Bishop (1986), Freeman (1985, 1979), McConnell (1985) and Walsh (1986).

The reliability of results depends upon a number of factors involved in the design of the questionnaire. First and foremost, the quantity, quality, time and location of the hypothetical change in recreational activity must be carefully described to the respondent. Precision and realism in the description of the alternatives are necessary to provide the basis for an evaluation. The rules of the hypothetical market game must be clearly spelled out for this method to be reliable.

Critics have questioned the reliability of responses regarding hypothetical experiences unavailable to the interviewee. However, when carefully applied, the method appears to yield plausible and consistent results. The authors believe the contingent value method to be the most accurate for valuing instream flows in Idaho and in the longer term future, the State should devote research resources to permit its application.

3. Expenditure-Based Approaches

If the supply of recreational services influences the demand for any marketed commodity, observations on purchasing behavior relating to the marketed commodity can be employed to generate information on the value of the environmental amenity. For certain types of goods and services, derived demand curves can be estimated for recreational activities. The "Travel Cost" approach and the "Land Value" methods are the main examples. The land value method relies on land sale price data related to differing water supplies. Since streamflow variations cannot be easily reflected in land prices, it is not well-suited to valuing stream flows, and is not treated further.

The travel cost method involves two steps: the first is to estimate the individual recreationist's demand curve for the resources, and second, deriving the relevant resource demand curve. The underlying assumption of the travel cost method is that observable recreationist behavior as related to increasing costs of travel reflects the changes in demand for the activity which would occur if prices were actually charged.

The Travel Cost approach is appropriate in cases where costs are found to vary significantly among users, when non-destination benefits are not important and when single destination trips are the rule.

The travel cost method is difficult to apply to estimating marginal values of water. Data collection tasks are formidable. It must be assumed that recreationists can accurately predict flow level changes, and that no other un-measured factor influences frequency of trips.

As will be seen in our subsequent empirical survey, travel cost methods nevertheless have recently been successfully combined with contingent value methods to estimate flow values (Loomis, 1986; Ward, 1987). Basic visitor day values are established and augmented with questions regarding the effect of flows on future visits.

4. **The "Unit-Day" Method**

Where time and/or resource constraints prevent the application of one of the direct consumer surplus methods listed above, guidelines issued by the U.S. Water Resource Council permit an alternative approach. The unit day value approach rests on expert judgement to provide an approximation for willingness to pay for water-based recreation activities. Walsh (1986) indicates the federal guidelines were initially derived from a survey of entrance fees at private recreation areas in 1962, adjusted for inflation since that time. The numerical estimates are assumed to measure consumer surplus - willingness to pay net of cost of enjoying the recreation experience.

The Unit Day Method is implemented by referring to a pair of tables provided in the Water Resources Council Guidelines (1983) and also in earlier editions of the Principles and Standards. (They are also reproduced in Walsh, 1986.) The guidelines provide specific unit day values for each of four types of recreation activity for each of a range of "Quality of Experience" scores.

The four classes of recreation activity include:

General recreation - requires the development and maintenance of convenient access and developed facilities. Representative examples include picnicking, swimming and tent and trailer camping.

General Hunting and Fishing - This is similar to general recreation, and is exemplified by warm-water boating and fishing and small game hunting.

Specialized recreation - This class is identified by more limited opportunities, low intensity of use and specialized skills. Examples include wilderness backpack camping, canoeing and white water rafting, and skilled nature photography.

Specialized Hunting and Fishing - Examples include trout, salmon, and steelhead fishing, big-game hunting and upland bird and waterfowl hunting.

The unit day values recommended in the Guidelines (updated by the present authors to 1987 price levels) vary from $7 to $21 for specialized recreation and from about $2 to over $5 for general recreation (see Table 8).

The "quality of the recreation experience" is the factor that governs the range of unit day values. Five factors or criteria are employed to rate sites. These are 1) congestion, 2) availability of substitutes (measured in travel time), 3) carrying capacity (in terms of facilities), 4) accessibility, and 5) environmental quality. Table 7 reproduces the guidelines for rating quality. Each of the five criteria is assigned a maximum weight. The sum of the weights totals to 100. In application of the approach, the field analyst must rate the site by judgmentally assigning points to each criterion. These points are summed to yield an index of quality of the experience, which is then applied to Table 8 to yield the

Table 7

Guidelines for Rating Quality of the Recreation Experience on a 100-Point Scale

Criteria	Quality of the Experience, 100-Point Scale				
Recreation Experience	Heavy use or crowding or other interference with use	Moderate use, other users evident and likely to interfere with use	Moderate use, some evidence of other users and occasional interference with use due to crowding	Usually little evidence of other users, rarely if ever crowded	Very low evidence of other users, never crowded
Total Points: 30 Point Value:	0-4	5-10	11-16	17-23	24-30
Availability of Substitutes	Several within 1 hr. travel time; a few within 30 min. travel time	Several within 1 hr. travel time; none within 30 min. travel time	One or two within 1 hr. travel time; none within 45 min. travel time	None within 1 hr. travel time	None within 2 hr. travel time
Total Points: 18 Point Value:	0-3	4-6	7-10	11-14	15-18
Carrying Capacity	Minimum facility development for public health and safety	Basic facilities to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Total Points: 14 Point Value:	0-2	3-5	6-8	9-11	12-14
Accessibility	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site, fair access, good roads within site	Good access, good roads to site; fair access, roads within site	Good access high standroad to site; good access within site
Total Points: 18 Point Value:	0-3	4-6	7-10	11-14	15-18
Environmental Quality	Low aesthetic factors[a] exist that significantly lower quality[b]	Average aesthetic quality; factors exist that lower quality to minor degree	Above average aesthetic quality; any limiting factors can be reasonably rectified	High aesthetic quality; factors exist that lower quality	Outstanding aesthetic quality; no factors exist that lower quality
Total Points: 20 Point Value:	0-2	3-6	7-10	11-15	16-20

[a]Major aesthetic qualities to be considered include geology and topography, water, and vegetation.
[b]Factors to be considered in lowering quality include air and water pollution, pests, poor climate, and unsightly adjacent areas.

Source: U.S. Water Resources Council.

Table 8. Relation between Quality of the Experience and Unit Day Values Recommended by the Water Resources Council, 1987.

Recreation activities	Quality of the experience, 100-point scale										
	0	10	20	30	40	50	60	70	80	90	100
	$	$	$	$	$	$	$	$	$	$	$
General Recreation	1.80	2.16	2.40	2.76	3.36	3.84	4.20	4.44	4.80	5.16	5.40
General Fishing & Hunting	2.64	2.88	3.12	3.48	3.84	4.20	4.68	4.80	5.16	5.28	5.40
Specialized Recreation	7.32	7.80	8.40	9.00	9.60	10.80	12.00	14.40	16.80	19.20	21.50
Specialized Fishing & Hunting	12.60	12.95	13.20	12.55	13.90	15.25	16.55	17.65	18.95	20.30	21.50

Source: Walsh, 1986, p. 271. Updated to October 1987 using Personal Consumption Expenditures (PCE) Implicit Price Deflator (Survey of Current Business).

desired unit day value. For example, a specialized fishing site which is given 24 points on congestion, 10 points on availability of substitutes, 8 points on carrying capacity, 14 points on accessibility and 16 points on environmental quality would have an index of 72 (i.e., 72 percent of maximum). From Table 8, the unit day value would be 72 percent of $21 (the maximum for specialized fishing) or about $15.10.

The Unit-Day method might potentially be adapted for in-stream flow use (although we are unaware of any specific application). This could be done by calculation of "with and without" Unit Day Values for a given change in flow. The reduction in flows from an upstream activity could be translated into change in the value points for the appropriate criterion in Table 8 and a change in unit day value derived.

The particular Unit-Day weighting system used for federal studies has, it must be noted, severe drawbacks in application to assessing the value of alternative flow rates in Idaho. The weighting scheme places heavy emphasis on such elements as congestion, facilities, availability of substitutes, and accessibility, while quality of experience constitutes only a fraction of the weights. Therefore, even drastic changes in quality of fishing or boating experiences would have relatively little effect on the point score and hence on the change in unit day values. This drawback is more pertinent to the specific application to instream flows in Idaho (which exhibits little congestion and many substitutes) than to the principles underlying the method.

Serious objections can also be leveled at the casual empiricism of the approach. The relative weights for alternative criteria would be expected to have changed in a quarter century due to shifts in income, recreational tastes, and availability of leisure. Recent research techniques might also be expected to improve the precision of the estimates of the initial weightings. The apparent fact that the weighting scheme has not been updated for other than inflation in more than two decades (Walsh, 1986) suggests some caution is in order. Further, the subjective judgments required to implement the procedure are a source of concern to many. The preponderance of opinion among non-governmental recreational specialists, we believe, would be to reject the approach in favor of field studies of specific problem areas employing one or the other of the previously discussed techniques. Only in circumstances where time or budget constraints precludes use of the more precise approaches should the Unit-Day method be adopted.

The U.S. Forest Service also has developed its own unit day value system. These values, developed from a summary of empirical studies using other means, are provided for eleven regions of the U.S. for each of a number of activity types. The day values for anadromous fishing in the Pacific Northwest is $33, for example. No scaling for other factors is provided, so in its present form, this system also can be of little value for changes in flows. We therefore do not discuss it further, but the interested reader is referred to Walsh, (1986, Chapter 8) for more details.

5. Empirical Studies of In-Stream Water Value

A growing literature is available on valuing environmental amenities. Most such studies have yielded estimates of the value of a recreational site or activity in terms of dollars per user day. After the total value of a site or activity is determined, this total in many instances must be allocated among the various attributes of the recreation site including both natural scenic characteristics and, if present, capital investments in recreation facilities.

Few efforts have been yet made to derive marginal or incremental unit values of water in recreational pursuits. (See Gibbons, 1986, for a recent survey.) The main approach has been to use direct consumer questioning (contingent valuation surveys). Photographs of alternative levels of flow in a stream have been presented to recreationists, and willingness to pay for increasing or decreasing amounts at the margin are revealed. The estimated values, as hypothesized, have the general shape of the textbook demand curve. Marginal willingness to pay for water is revealed as initially high but falling to zero or even negative values with increased supplies. Marginal values vary, depending on the type of activity (e.g., fishing, white water boating or streamside picnicking) the season of the year, and the proximity of the site to large populations.

Another approach begins by obtaining a user day value at a site, and then establishes the effects of changing flow rates on users valuations. Observation of the way visitation changes with flows or more commonly, direct questioning to elicit estimated visitation rates due to hypothetical flow changes are both possible.

Daubert and Young (1979, 1981) made the first attempt to relate flow rates to the marginal value of water. Employing the contingent valuation (CV) approach based on hypothetical entrance fees on the Cache la Poudre River in Colorado, in 1978 they interviewed a sample of recreationists involved in fishing, white-water and shoreline activities. Color photographs of alternative flow rates at several sites were used to elicit willingness to pay for increased flows. Fishing recreationists reported willingness to pay of $16 per acre foot at flows below 50 cubic feet per second (cfs), with the marginal value dropping to zero at about 500 cfs. White water enthusiasts exhibited a constant $6 per acre foot, while shoreline recreationists indicated $11 at less than 50 cfs. The first 100 cfs, adding together the values in each class, had a value of nearly $33 per acre foot.

Walsh, et al., (1980) studied several Colorado rivers, also in 1978. They found a marginal value of $23 per acre foot at 35 percent of maximum flow, $7 at 65% of maximum.

Amirfathi, et al., (1984) examined a case in the Cache Valley of northern Utah. This team employed a travel cost approach to determine existing fishing benefits, supplemented with a contingent value questionnaire to obtain the effects of flow change. Marginal values of $75 per acre foot were reported at low flow rates, falling to zero at higher levels. Loomis (1986) performed a similar modification of the travel cost approach to the upper reaches of the Snake River in Idaho.

Ward (1987) reported a modified travel cost study of the Rio Chama in northern New Mexico. Anglers and white-water boaters visitation rates were evaluated to generate flow values. The estimated values averaged $24 per acre foot for low runoff years and $14 for high runoff years.

Gibbons (1986) summarized a few other studies. An average value of $19 per acre foot is noted for the Bumping Lake project in Yakima River system (Washington), while $23 per acre foot was the reported value for water to preserve fish reproduction on California's Trinity River. We have not seen the original sources of these latter estimates, and are not in a position to assess their reliability.

Gibbons concludes her survey of the value of water in recreation with the assertion: "Obviously there is compelling empirical evidence of the economic rationale for considering in-stream values in water use decisions." (p. 71).

6. **Recommendation**

We are not aware of any estimates of the effect of water flow rates on recreational values in the middle and lower Snake River basin. Because the magnitude of flows is generally higher in the Snake River than in other rivers previously studied, and because recreational pressures are also rather less, the value per acre foot at the margin would likely be less than reported in these earlier studies. Nevertheless, a total reduction of 600 cfs could have a noticeable effect on total recreation benefits.

To establish appropriate benefit estimates for Snake River conditions, we suggest that the Idaho Department of Water Resources or the Department of Parks and Recreation commission a study of this subject in order that the recreational component of the public value of water be reflected in future policy decisions. The most suitable approach for the long term would be to conduct a contingent value (CV) survey for each of the major reaches of the Snake which would be affected by upstream development.

As an interim, less expensive expedient, we recommend the State develop a special unit-day system for the effected portions of the Snake River. This could be based on, as is the U.S. Forest Service approach mentioned earlier, on the best available evidence of recreational benefits of varying instream flows from throughout the western U.S. Rather than adopting the proportional weights shown in Table 8, a set of weights suitable to Idaho conditions would be developed. Concerns of fishermen, boaters, and non-contact users should each be reflected. A panel of experts might be convened from among university research specialists and from the U.S. Fish and Wildlife Service's Instream Flow Group and similar organizations to develop a system suitable for Snake River conditions.

APPENDICES

APPENDIX A

PUBLIC INTEREST EVALUATION CRITERIA[1]

5,3. CRITERIA FOR EVALUATING PUBLIC INTEREST.
If the director determines that a proposed use of trust water held by the state pursuant to Section 42-203B(5), Idaho Code, will cause a significant reduction, the director will consider the criteria of Section 42203C(2), Idaho Code, before acting on the application or permit being reprocessed. The director shall consider and balance the relative benefits and detriments for each factor required to be weighed under Section 42-203C(2), Idaho Code, to determine whether a proposed reduction of the amount of water available for power production serves the greater public interest. The director shall evaluate whether the proposed use sought in the permit being reprocessed or the application will provide the greater benefit to the people of the state of Idaho when balanced against other uses for the same water resource. In evaluating the public interest criteria, the director will use the following guidelines:

5,3,1. THE DIRECTOR WILL CONSIDER THE POTENTIAL BENEFITS FROM BOTH DIRECT AND INDIRECT, THAT THE PROPOSED USE WOULD PROVIDE TO THE STATE AND LOCAL ECONOMY. The economic appraisal shall be based upon generally accepted economic analysis procedures which uniformly evaluate the following factors within the State of Idaho and the county or counties directly affected by the project:

5,3,1,1. Direct project benefits.

5,3,1,2. Indirect benefits including net revenues to the processing, transportation, supply, service and government sectors of the economy.

5,3,1,3. Direct project costs, to include the opportunity cost of previous land use.

5,3,1,4. Indirect project costs, including verifiable costs to government in net lost revenue and increased regulation costs, verifiable reductions in net revenue resulting from losses to other existing instream uses, and the increased cost of replacing reduced hydropower generation from unsubordinated hydropower generating facilities.

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[1] Idaho Department of Water Resources, Rules and Regulations: Water Appropriation, Boise, October, 1986, pp. 26-30.

5,3,2. THE DIRECTOR WILL CONSIDER THE IMPACT THE PROPOSED USE WOULD HAVE UPON THE ELECTRIC UTILITY RATES IN THE STATE OF IDAHO, AND THE AVAILABILITY, FORESEEABILITY AND COST OF ALTERNATIVE ENERGY SOURCES TO AMELIORATE SUCH IMPACT. These evaluations will include the following considerations:

5,3,2,1. Projections of electrical supply and demand for Idaho and the Pacific Northwest made by the Bonneville Power Administration and the Northwest Power Planning Council and information available from the Idaho Public Utilities Commission or from the electric utility from whose water right trust water is being reallocated.

5,3,2,2. The long term reliability of the substitute source and the cost of alternatives including the resulting impact on electrical rates.

5,3,3. THE DIRECTOR WILL CONSIDER WHETHER THE PROPOSED USE WILL PROMOTE THE FAMILY FARMING TRADITION IN THE STATE OF IDAHO. For purposes of this evaluation, the director will use the following factors:

5,3,3,1. If the total land to be irrigated by the applicant, including currently owned and leased irrigated land and land proposed to be irrigated in the application and other applications and permits of the applicant, do not exceed 960 acres, the application will be presumed to promote the family farming tradition.

5,3,3,2. If the requirement of Rule 5,3,3,1. is not met, the director will consider the extent the applicant conforms to the following characteristics.

5,3,3,2,1. The farming operation developed or expanded as a result of the application is operated by the applicant or a member of his family (spouse, parents or grandparents, lineal descendants, including those that are adopted, lineal descendants of parents; and spouse of lineal descendants);

5,3,3,2,2. In the event the application is filed in the name of a partnership, one or more of the partners shall operate the farming operation; and

5,3,3,2,3. If the application is in the name of a corporation, the number of stockholders does not exceed fifteen (15) persons, and one or more of the stockholders operates the farming operation unless the application is submitted by an irrigation district, drainage district, canal company or other water entity authorized to appropriate water for landowners within the district or for stockholders of the company all of whom shall meet the family farming criteria.

5,3,4. THE DIRECTOR WILL CONSIDER THE PROMOTION OF FULL ECONOMIC AND MULTIPLE USE DEVELOPMENT OF THE WATER RESOURCES OF THE STATE OF IDAHO. In this regard, the extent to which the project proposed complies with the following factors will be considered:

5,3,4,1. Promotes and conforms with the adopted State Water Plan;

5,3,4,2. Provides for coordination of proposed and existing uses of water to maximize the beneficial use of available water supplies;

5,3,4,3. Utilizes technology economically available to enhance water and energy use efficiently;

5,3,4,4. Provides multiple use of water, including multipurpose storage;

5,3,4,5. Allows opportunity for reuse of return flows;

5,3,4,6. Preserves or enhances water quality, fish, wildlife, recreation and aesthetic values;

5,3,4,7. Provides supplemental water supplies for existing uses with inadequate water supplies;

5,3,5. THE DIRECTOR WILL CONSIDER WHETHER A PROPOSED USE, WHICH INCLUDES IRRIGATION, WILL CONFORM TO A STAGED DEVELOPMENT POLICY OF UP TO TWENTY THOUSAND (20,000) ACRES PER YEAR OR EIGHTY THOUSAND (80,000) ACRES IN ANY FOUR (4) YEAR PERIOD IN THE SNAKE RIVER DRAINAGE ABOVE MURPHY GAUGE. In applying this criteria, the director will consider the following:

5,3,5,1. "Above Murphy gauge" means the Snake River and any of its surface or groundwater tributaries upstream from Murphy gauge which gauge is located on the Snake River approximately four miles downstream from Swan Falls Dam from which trust water is to be reallocated;

5,3,5,2. Twenty thousand (20,000) acres per year or eighty thousand (80,000) acres per four (4) year period is a four (4) year moving average of 20,000 acres/year of permits issues during a calendar year for irrigation development. If permits for a development of less than 20,000 acres are issued in a year, additional development in excess of 20,000 acres can be permitted in succeeding years. Likewise, if more than 20,000 acres is permitted in one year (recognizing that a single large project could exceed 20,000 acres) the permitted development in succeeding years must be correspondingly less to maintain no greater than a 20,000 acres/year average for any four year period;

5,3,5,3. The criteria of Rule 5,3,5. applies to multiple-use projects with irrigation as a principal purpose. Projects which use irrigation as only an incidental purpose, such as the land treatment of waste, shall not be included within this policy; and

5,3,5,4. An application determined by the director to be otherwise approvable but found to exceed the acreage limitations, when considered with other applications approved for development, may be approved with conditions providing for the construction of project works and beneficial use of water to be commenced in a future year.

5,3,6. No single public interest criterion will be entitled to greater weight than any other public interest criterion.

5,3,7. Until such time as the studies prescribed in Policy 32 I of the State Water Plan are completed and accepted by the Idaho Water Resource Board, applications and permits reprocessed which propose to divert water to surface storage from the Snake River and surface tributaries upstream from Murphy Gauging Station shall be presumed to satisfy the public interest criteria of Section 42-203C(2), Idaho Code. Applications or reprocessed permits which are approved prior to completion of the studies, will not be subject to additional reprocessing.

5,3,8. Applications for permit for trust water sources filed prior to July 1, 1985, for projects for which diversion and beneficial use was complete prior to October 1, 1984, are presumed to satisfy the public interest criteria of Section 42-203C(2), Idaho Code.

5,3,9. Applications or permits to be reprocessed proposing a direct diversion of water for irrigation purposes from the Snake River between Milner Dam and Swan Falls Dam or from tributary springs in this reach are presumed not to be in the public interest as defined by Section 42-203C, Idaho Code. Such proposals, are presumed to prevent the full economic and multiple use of water in the Snake River Basin and to adversely affect hydropower availability and electrical energy rates in the state of Idaho.

5,3,10. Proposed DCMI uses which individually do not have a maximum consumptive use of more than two acre-feet/day are presumed to meet the public interest criteria of Section 42-203C(2), Idaho Code, unless protested.

APPENDIX B

DETAILED PROCEDURES FOR ESTIMATING DEMAND FUNCTIONS FOR THE DIFFERENT MUNICIPAL SECTORS

These materials are presented to guide the longer term efforts of DWR in helping to shape rational municipal water policies in the face of increasing water scarcity. The procedures outlined here are more detailed and demanding than the practical approaches recommended in Chapter 4.

Residential Demand

We begin by defining what is meant by a "demand function". Such a function expresses the quantity of water withdrawn from the supply system by some user unit (household, firm, farm, etc.) per unit of time as a function of a set of explanatory variables that determine water use behavior. Equation (B-1) gives the general symbolic representation of such a relationship:

$$\text{(B-1)} \qquad Q_D = f(x_1, x_2, \ldots, x_n)$$

where the x's represent the explanatory variables, Q_D is the rate of withdrawal per unit of time (month, billing period), and f gives us the mathematical form of the relationship. The literature on residential demand functions is becoming extensive. (See Al-Qunaibet, 1987; Young, 1973; Morgan and Smolen, 1976; Morgan, 1973; Foster and Beattie, 1978; Agthe and Billings, 1980; Billings and Agthe, 1980; Young, Kinsley and Sharpe, 1983; and Martin and Thomas, 1986.)

Three questions immediately arise: (1) What unit or collection of units is represented? (2) Over what time period is the function valid?

(3) What are the appropriate explanatory variables? Since we are studying municipal behavior, we want to study the behavior of the municipal sectors listed earlier, namely residential, public, commercial, industrial served by the utility, and system losses. For each of these sectors, we must answer the preceding questions.

Regarding the residential sector, user units are usually classified as: (a) single family detached dwellings; (b) duplex, triplex, and townhouses; (c) apartments. The distinctions among these classes are made because of the different methods of metering the users and because of the differences in outdoor use patterns among the classes. Single family detached units typically have more yard and garden area than the other types of units and are usually individually metered. Duplex, triplex, and townhouses generally have less outdoor space per unit than single family detached units, but are also usually individually metered. Apartments exhibited much less outdoor area per unit and are usually only master metered, i.e. the whole apartment complex has one meter.

Metering is quite important in determining demand. When the residential unit is individually metered, with the water bill being based (at least in part) on the volume of water used, users are much more conservative in water use than they are under unmetered or master metered conditions. Without meters, water is treated as a free good, even when periodic fixed fees are charged. Under master metering as in an apartment building, water is seen as a "common property resource", with the costs of additional use being shared by others.

Residential demand functions are typically estimated for "typical units" within each residential class, i.e. for the individual household.

The alternative would be to estimate a demand function for the entire subsector, i.e. for all single family units together, all duplex-triplex-townhouse units together, and all apartments together. One reason for choosing the individual "typical unit" is the possibility of gathering both cross section and time series data which will provide greater variation in the explanatory variables. Another reason is that the availability of such detailed demand functions permits more refined analysis on sub-classes within each class if forecasts of the explanatory variables are available, e.g. high income housing units versus low income, large families versus small, etc.

The time period used in demand function analysis is the billing period over which use is metered and the total bill computed. The length of the billing period may have an effect on demand because more frequent billing causes a greater awareness of water costs.

The explanatory variables that are relevant to residential water demands typically include the following:

a. the price of water and/or other measures of the price structure. Marginal price should be used.

b. income of the residential unit, since income is highly correlated with water using appliances and outdoor uses;

c. number of residents;

d. climate conditions, usually measured as degree days or as potential evapotranspiration less effective rainfall.

When seasonal conditions vary greatly, it is desirable to estimate seasonal demand functions, at least "summer and winter" functions. Howe (1982) has estimated the following winter and summer demand functions in linear form for single family dwellings in the western United States:

(B-2) $$Q_{D,W} = 234 - 128P_w + 4V - 7D_w$$

(B-3) $$Q_{D,S} = 385 - 796P_S + 8V - 12D_S + 158MD$$

In these equations, Q_D is the number of gallons per household per day, P is the marginal price on the rate structure facing the household (in $ per gallon), V is the appraised market value of the house in thousands of dollars (as a surrogate for household income), D_w is a "difference" variable to account for the effects of an increasing or decreasing block rate structure (see Howe, 1982), and MD is an estimate of moisture deficit.

Other functional forms for residential demand functions that have frequently been used are the following:

(B-4) log - log:

$$\ln Q_D = a_0 + a_1 \ln P + a_2 \ln V + a_3 D + a_4 \ln MD$$

(B-5) log - linear:

$$\ln Q_D = a_0 + a_1 P + a_2 V + a_3 D + a_4 MD$$

D can take on both positive and negative value (usually positive for declining block rate structures and negative for increasing block) so must be entered linearly in (B-4). The function in (B-4) implies constant elasticities with respect to each of the explanatory variables, while (B-5) implies a decreasing elasticity as price rises. The latter seems more reasonable.

Two approaches can be used in adapting functions like those in (B-2) to (B-5) to conditions in Idaho. The more desirable of the two is to gather data from various Idaho towns and to estimate residential demand functions from those data. This guarantees the applicability of the functions to Idaho conditions.

A second approach is to take functions that have been estimated for other areas and to calibrate them to current Idaho use rates, prices, etc. by changing the constant term until the functional value equals current use rates. Naturally, there is some risk that conditions in the other areas differ from those in Idaho, although this risk can be reduced by finding studies from areas climatically and economically similar to Idaho.

There are two remaining questions regarding residential demands: (1) If the demand functions represent typical households of the single dwelling, multiple dwelling, and apartment types, how are projections of aggregate use to be made?; (2) How are benefits to be measured from the demand functions?

The answer to the first question lies in linking the number of dwellings of each type to total population. A regression of number of units of type j on total population and time has frequently been used:

$$\text{(B-6)} \qquad N_j(t) = a_0 + a_1 \text{ Pop}(t) + a_2 \, t.$$

This relation captures trends in housing types as well as the effects of population growth. The aggregate projected water use by housing class j is then given by

$$\text{(B-7)} \qquad Q_j(t) = N_j(t) \, Q_{D,j}(t)$$

where projected future population, prices, incomes, etc. are inserted in equations (B-1) and (B-6) to arrive at (B-7).

Benefit estimation is based on calculating the "total willingness-to-pay" of the typical user in each residential class. This requires calculation of the inverse demand function which expresses price (marginal willingness-to-pay) as a function of the quantity demanded, plus the other explanatory variables in the original demand function. To illustrate the derivation of the inverse demand function, we give the inverses of (B-2), (B-4), and (B-5) below:

(B-2a) $$P_w = 1.83 - 0.0078\, Q_{D,W} + 0.0313\, V - 0.0547\, D_W$$

(B-4a) $$\ln P = - a_0/a_1 + 1/a_1\, Q_D - a_2/a_1 \ln V - a_3/a_1\, D - a_4/a_1 \ln MD$$

or

(B-4b) $$P = e^h$$

where h is the right hand side of (B-4a).

(B-5a) $$P = - a_0/a_1 + 1/a_1 \ln Q_D - a_2/a_1\, V - a_3/a_1\, D - a_4/a_1\, MD$$

Since the price at any given quantity represents the marginal willingness to pay for one more unit, the sum of these marginal values up to some quantity Q gives the residential unit's total willingness to pay for that quantity, i.e. the most they would be willing (and able) to pay rather than do without water. This is represented by the area under the inverse demand function out to quantity Q (or mathematically by the integral of the inverse function between Q = 0 and Q).

As an example, let us calculate the total willingness to pay (per day) that is implied by (2a) for a household using 300 gallons per day during the winter season, under the following conditions:

V = 50 (thousand dollars)

D = - $2.50

The area under the daily demand function out to 300 gallons per day (0.3 thousand gallons per day) can be graphically calculated to be about $0.41 per day or $12.24 per month. However, this is expressed in terms of mid-1960's prices, so that inflating that figure by 3.2 to allow for increases in the consumer price index would give us a figure of $39.17 per month.

A difficulty in using the area under an inverse demand function is that, while the estimated function may fit the observed (historical) data quite well, there are rarely any observations at very high prices and correspondingly low quantities. Little information is available on the shape of the function close to zero quantities. A few studies of losses incurred by urban households during severe drought (e.g., Russell, 1970) indicate that losses can be quite high and one would infer that an informed willingness to pay would be correspondingly high. Martin and Thomas (1986) have ingeniously combined observations from the U.S. with points derived from other very high-priced situations in Kuwait and in Western Australia. Interestingly, they report that a constant elasticity demand curve can be traced out from this set of observations from disparate sources.

In summary, demand functions can be estimated for typical residential users, and these demand functions have proven quite useful in making forecasts of use under varying price, income, and climate conditions. The use of the demand function to estimate net benefits per household, however, involves greater possibility of error, because of our limited knowledge of the shape of the demand function close to the price axis.

For some applications, this may not be a problem. If we want to estimate the added benefits per existing household following from a price decrease or the loss of benefits caused by a price increase, the demand function is likely to be sufficiently accurate in that price range. Gibbon (1986), following Young and Gray (1972), has taken this approach. However, if we want to quantify total benefits per household for new households coming into an area, we face the problems noted above.

BIBLIOGRAPHY

Agthe, D.E. and R.B. Billings, 1980, "Dynamic Models of Residential Water Demand," Water Resources Research, Vol. 16, No. 3: 476-480, June.

Al-Qunaibet, Mohammed H., 1988, "The Municipal Demand for Water: An Overview," Land Economics, forthcoming.

Amirfathi, P., R. Narayanan, B. Bishop, and D. Larsen, 1984, "A Methodology for Estimating Instream Flow Vlaues for Recreation", Utah Water Research Laboratory, Utah State University.

Anderson, Glen and R. C. Bishop, 1986, "The Valuation Problem," in D. W. Bromley, ed., Natural Resource Economics, Boston, Kluwer-Nijhoff Publishing.

Anderson, Terry L. and Ronald N. Johnson, 1986, "The Problem of Instream Flows," Economic Inquiry, 24(4:535-554).

Arrow, Kenneth J. and R.C. Lind, 1970, "Uncertainty and the Evaluation of Public Investment Decisions", American Economic Review, Vol. 60, pp. 364-378.

Bailey, M.J. and M.C. Jensen, 1972, "Risk and the Discount Rate for Public Investment," in M.C. Jensen, ed., Studies in the Theory of Capital Markets, New York, Praeger.

Bentkover, Judith E. and others, 1986, Benefits Assessment: State of the Art, Dortrecht, Reidel Publishers.

Bergmann, Helmuth and J.M. Boussard, 1976, Guide to Economic Evaluation of Irrigation Projects, (revised ed.) Paris, Org. for Econ. Coop. and Development (OECD).

Billings, R.B. and D.E. Agthe, 1980, "Price Elasticities for Water: A Case of Increasing Block Rates", Land Economics, Vol. 56, No. 1, 78-84, February.

Bowen, R.L. and R.A. Young, 1985, "Irrigation Net Benefit Functions for Egypt's Northern Delta", Water Resources Research 21(9:1329-1335).

Bromley, Daniel W., ed., 1986, Natural Resource Economics, Boston, Kluwer-Nijhoff Publishing Co.

Brookshire, David S., A. Randall, and J. R. Stoll, "Valuing Increments and Decrements in Natural Resource Service Flows," American Journal of Agricultural Economics, 63:478-488.

Brookshire, David S., James L. Merrill, and Gary L. Watts, 1983, "Economics and the Determination of Indian Reserved Water Rights", Natural Resources Journal, 23(4:749-765).

Brookshire, David S., Gary L. Watts, and James L. Merrill, 1985, "Current Issues in the Quantification of Federal Reserved Water Rights", Water Resources Research, 21(11:1777-1786).

Brown, Maxwell L., 1979, Farm Budgets: From Farm Income Analysis to Agricultural Project Analysis, Baltimore, Johns Hopkins Press (for the World Bank).

Brown, Gardner M., Jr., 1985, "Preserving Endangered Species and Other Biological Sources", presented at the International Conference, Man's Role in Changing the Global Environment, Venice, Italy, Oct. 1985.

Burness, H.S., R.G. Cummings, W.D. Gorman and R.R. Lansford, 1983, "Practically Irrigable Acreage and Economic Feasibility: The Role of Time, Ethics, and Discounting", Natural Resources Journal, Vol. 23, April, pp. 289-303.

Burrell, A. and B. Hill, 1980, "The Problem of Imputing a Charge for Farmers' Management," Journal of Agricultural Economics, May.

Butcher, Walter R. and Philip R. Wandschneider, with Norman K. Whittlesey, 1986, "Competition Between Irrigation and Hydropower in the Pacific Northwest" in (ed.) Kenneth D. Frederick, Scarce Water and Institutional Change, Washington, D.C.; Resources for the Future, Inc.

Campen, James T., 1986, Benefit, Cost and Beyond: The Political Economy of Benefit-Cost Analysis, Cambridge, MA, Ballinger Publishing.

Carruthers, Ian and Colin Clark, 1981, The Economics of Irrigation, Liverpool University Press.

Cicchetti, Charles J., Robert K. Davis, Steve H. Hanke, Robert H. Haveman, and Jack L. Knetsch, 1972, "Benefits or Costs? An Assessment of the Water Resources Council's Proposed Principle and Standards". Dep. Geography and Environ. Eng., Johns Hopkins University, Baltimore, March.

Cicchetti, Charles J., W.J. Gillen, and P. Smolensky, 1977, The Marginal Cost and Pricing of Electricity, Cambridge, MA, Ballinger Publishing.

Costello, Patrick D. and Patrick J. Kole, 1985, "Commentary on the Swan Falls Resolution", Western Natural Resource Litigation Digest, Summer, (pp. 11-15).

Cummings, Ronald G., D. S. Brookshire, and W. D. Schulze, 1986, Valuing Environmental Goods: An Assessment of the Contingent Valuation Method, Totowa, NJ, Rowman and Allanheld Publishers, 270 pp.

Daubert, J.T., R.A. Young with S.L. Gray, 1979, "Economic Benefits from Instream Flows on a Colorado Mountain Stream", Colorado Water Resources Research Institute Completion Report No. 91, Fort Collins, Colorado.

Daubert, J.T. and R.A. Young, 1981, "Recreational Demands for Maintaining Instream Flows", Am. Journal Agric. Econ. 63(4:667-676).

Donnelly, Dennis M., et al., 1985, Net Economic Value of Recreational Steelhead Fishing in Idaho, Resource Bulletin RM-9, Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service, Fort Collins, Colorado.

Eckstein, Otto, 1961, Water Resource Development: The Economics of Project Evaluation. Cambridge MA: Harvard University Press.

Foster, H.S. and B.R. Beattie, 1978, "A Cross-Sectional Investigation of the Determinants of Urban Residential Water Demand in the United States, 1960 and 1970", Technical Report 86, Texas Water Resources Institute, Texas A & M University, May.

Foster, H.S. and B.R. Beattie, 1979, "Urban Residential Demand for Water in the United States", Land Economics, 55(1:43-58), February.

Frederick, Kenneth D., 1986, Scarce Water and Institutional Change, Washington, D.C., Resources for the Future, Inc.

Freeman, A.M. III, 1979, The Benefits of Environmental Improvement, Baltimore, Johns Hopkins Press.

Freeman, A.M., III, 1985, "Methods of Assessing Benefits of Environmental Programs," in A.V. Kneese, ed., Handbook of Natural Resource and Energy Economics, Vol. 1, Chap. 6, Amsterdam, Elsevier.

Gardner, Richard L. and R.A. Young, 1984, "Effects of Electricity Rates and Rate Structures on Pump Irrigation: An Eastern Colorado Case Study", Land Economics, 60(4:352-357).

Gardner, Richard L., 1985, "Water Marketing - Idaho Style", paper presented at the annual meeting of the American Water Resources Association, Tucson, Arizona, August 13th.

Gardner, Richard L., 1987, Guidelines for Setting Water and Sewer Rates in Idaho, Association of Idaho Cities, Boise.

Gibbons, D.C., 1986, The Economic Value of Water, Washington, D.C., Resources for the Future.

Gittinger, J.P., 1973, Compounding and Discounting Tables for Project Evaluation, Baltimore, Johns Hopkins Press.

Gittinger, J.P., 1982, Evaluation of Agricultural Projects, Revised, Ed., Baltimore, Johns Hopkins Press.

Gramlich, E.M., 1981, Benefit-Cost Analysis of Government Programs, Englewood Cliffs, NJ, Prentice-Hall.

Gray, S.L. and R.A. Young, 1984, "Valuation of Water on Wildlands" in G.L. Peterson and A. Randall, eds., Valuation of Wildland Resource Benefits, Boulder, Colorado, Westview Press.

Hamilton, Joel R. and Richard L. Gardner, 1986, "Value Added and Secondary Benefits in Regional Project Evaluation: Irrigation Development in the Snake River Basin", Annals of Regional Science, Vol. XX, No. 1, March, pp.1-11.

Hamilton, Joel R. and Norman K. Whittlesey, 1986, "Energy and the Limited Water Resource: Competition and Conservation", Chapter 12 in N.K. Whittlesey (ed.) Energy and Water Management in Western Irrigated Agriculture, Boulder, CO; Westview Press.

Hanke, Steve H. and James Bradford Anwyll, 1980, "On the Discount Rate Controversy," Public Policy, Vol. 28, No. 2 (Spring), 171-183.

Harberger, Arnold C., 1974, Project Evaluation: Collected Papers, Chicago, IL, Markham.

Hazlitt, Henry, 1979, Economics in One Lesson, New Rochelle, Arlington House Publishers.

Herfindahl, O. and A.V. Kneese, 1974, Economic Theory of Natural Resources, Columbus, Ohio, Merrill.

Hirshleifer, J. and D. Shapiro, 1983, "The Treatment of Risk and Uncertainty," in Robert H. Haveman and J. Margolis, eds., Public Expenditure and Policy Analysis, 3rd ed., Boston, Houghton Mifflin Co.

Houston, J.E. and N.K. Whittlesey, 1986, "Modeling Agricultural Water Markets for Hydropower Production in the Pacific Northwest," Western Journal of Agricultural Economics, 11(2:221-230).

Howe, Charles W., 1971, Benefit-Cost Analysis for Water System Planning, Water Resources Monograph No. 2, Am. Geophysical Union, Washington, D.C.

Howe, Charles W., 1971, "Savings Recommendations with Regard to Water System Losses", Journal American Water Works Association, Vol. 63, No. 5, May, pp. 284-286.

Howe, Charles W., 1976, "The Design and Evaluation of Institutional Arrangements for Water Planning and Management", paper prepared for the United Nations Water Conference, Mar du Plata, Argentina, 14-25 March, 1977, paper E/Conf. 70/A.4 dated/18 Nov. 1976.

Howe, Charles W., 1982, "The Impact of Price on Residential Water Demand: Some New Insights", Water Resources Research, Vol. 18, No. 4: 713-716, August.

Howe, Charles W., 1986, "Project Benefits and Costs from National and Regional Viewpoints: Methodological Issues and Case Study of the

Colorado-Big Thompson Project", Natural Resources Journal, Vol. 26, Winter, pp. 77-93.

Howe, Charles W. and K.W. Easter, 1971, Interbasin Transfer of Water, Baltimore, Johns Hopkins.

Howe, Charles W. and F.P. Linaweaver, Jr., 1967, "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure", Water Resources Research, Vol. 3, No. 1: 13-32.

Idaho Agricultural Statistics Service, 1986, Idaho Agricultural Statistics 1986, Boise, Department of Agriculture.

Idaho Department of Water Resources, 1986, Water Appropriation: Rules and Regulations, Boise, Idaho.

Irvin, George, 1978, Modern Cost-Benefit Methods, London, McMillan.
James, L.D. and R.R. Lee, 1971, Economics of Water Resource Planning, New York, New York, McGraw Hill.

Keith, John and Terry Glover, 1988, Secondary Impacts and Benefits of Water Reallocation in the Snake River Basin of Idaho, University of Idaho, Idaho Water Resource Research Center Technical Report, (forthcoming).

Knetsch, Jack L., Robert H. Haveman, Charles W. Howe, John V. Krutilla, and Michael F. Brewer, 1969, Federal Natural Resources Development: Basic Issues in Benefit and Cost Measurement, Natural Resources Policy Center, George Washington University, Washington, DC, May.

Krutilla, John, and Otto Eckstein, 1958, Multiple-Purpose River Development. Baltimore MD: Johns Hopkins University Press for Resources for the Future.

Lind, Robert C., ed., 1983, Discounting for Time and Risk in Energy Policy, Baltimore, Johns Hopkins.

Loomis, John B., 1986, "Economic Losses to Recreational Fisheries due to Small-Head Hydro-Power Development: A Case Study of Henry's Fork, Idaho," Journal of Environmental Management, 22(1): 85-94.

Loomis, John, 1987, "The Economic Value of Instream Flow: Methodology and Benefit Estimates for Optimum Flows," Journal of Environmental Management, 24:169-179.

McCalla, A.F. and E.W. Learn, 1985, "Public Policies for Food, Agriculture and Resources: Retrospect and Prospect," in Kent A. Price, ed., The Dilemmas of Choice (National Center for Food and Agricultural Policy Annual Policy Review), Washington, D.C., Resources for the Future.

McConnell, K.E., 1985, "The Economics of Outdoor Recreation," in A.V. Kneese, ed., Handbook of Natural Resource and Energy Economics, Vol. II, Amsterdam, Elsevier (pp. 677-723).

McKean, Roland N., 1958, Efficiency in Government Through Systems Analysis, New York, Wiley.

MacDonnell, Lawrence J. and Charles W. Howe, 1986, "Area of Origin Protection in Transbasin Water Diversions: An Evaluation of Alternative Approaches", University of Colorado Law Review, 57 (3:527-548).

Mann, Roger, R.A. Young, and E.W. Sparling, 1987, "Regional Growth Impacts from Irrigated Agriculture: Econometric Evidence from the Northern Ogallala-High Plains Groundwater Resource," Water Resources Research, 23 (9:1711-1718).

Marglin, S.A., 1963, "The Social Rate of Discount and the Optimal Rate of Investment," Quarterly Journal of Economics, Vol. 77.

Marglin, S.A., 1967, Public Investment Criteria, Cambridge, MIT Press.

Martin, W.E., et al., 1985, Saving Water in a Desert City, Washington, D.C., Resources for the Future, Inc.

Martin, W.E. and J.F. Thomas, 1986, "Policy Relevance in Studies of Urban Residential Water Demand," Water Resources Research, 22:1735-1741.

Mikesell, R.F., 1977, The Rate of Discount for Evaluating Public Projects, Washington, D.C. American Enterprise Institute, (64 pp.).

Morgan, W.D., 1973, "Residential Water Demand: The Case from Micro Data", Water Resources Research, Vol. 9, No. 4:1065-1067, Aug.

Morgan, W.D. and J.C. Smolen, 1976, "Climate Indicators in the Estimation of Municipal Water Demand", Water Resources Bulletin, Vol. 12, No. 3:511-518, June.

Munasinghe, Mohan and J.J. Warford, 1982, Electricity Pricing: Theory and Case Studies, Baltimore, Johns Hopkins Press.

O'Driscoll, G.P. Jr., 1977, Economics as a Coordination Problem, Kansas City, Kansas, Sheed, Andrews, and McMeel, Inc., (172 pp.)

Organization for Economic Cooperation and Development (OECD), 1984, Guide for the Multi-Objective Evaluation of Multi-Purpose Hydraulic Projects, Paris and Washington.

Pearce, D.W. and C.A. Nash, 1981, The Social Appraisal of Projects, New York, Wiley.

Penn, J.B., 1985, "The Agricultural and Rural Economies: Profile, Current Issues, and Policy Implications," in Kent A. Price, ed., The Dilemmas of Choice, (National Center for Food and Agricultural Policy, Annual Policy Review), Washington, D.C., Resources for the Future.

Peskin, H.M. and E. Seskin, 1975, "Introduction and Overview," in H.M. Peskin and E. Seskin, eds., Cost Benefit Analysis and Water Pollution Policy, Washington, D.C., Urban Institute.

Prest, A.R. and R. Turvey, 1965, "Cost Benefit Analysis: A Survey", Economic Journal.

Randall, Alan, 1984a, "Benefit-Cost Analysis as an Information System," Chapter 3 in G.L. Peterson and Alan Randall, eds., Valuation of Wildland Resource Benefits, Boulder, Colorado, Westview Press.

Randall, Alan, 1984b, "Theoretical Bases for Non-Market Benefit Estimation" Chapter 4 in G.L. Peterson and A. Randall, eds., Valuation of Wildland Resource Benefits, Boulder, Colorado, Westview Press.

Randall, Alan, 1986, "Valuation in a Policy Context," in D. Bromley, ed., Natural Resource Economics, Boston, Kluwer-Nijhoff Publishing, (163-199).

Randall, Alan, 1987, Resource Economics, 2nd ed., New York, Wiley.

Sassone, Peter G. and W.A. Schaffer, 1978, Cost-Benefit Analysis: A Handbook, New York, Academic Press.

Schulze, William D., David S. Brookshire, and Todd Sandler, 1981, "The Social Rate of Discount for Nuclear Waste Storage: Economics or Ethics?", Natural Resources Journal, 21 (4:811-832).

Schulze, William D. and Charles W. Howe, 1985, "Observations on the Frontiers and Fringes of the Neoclassical Paradigm", American Journal of Agricultural Economics, 67 (5:1035-1038).

Seckler, D.W. and R.A. Young, 1978, "Economic and Policy Implications of the 160-Acre Limitation in Federal Reclamation Law," American Journal of Agricultural Economics, 60 (2:575-588).

Sorg, C.F., et al., 1985, The Net Economic Value of Cold Water and Warm Water Fishing in Idaho, Ft. Collins, Colorado, Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service.

Stokey, Edith and Richard Zeckhauser, 1978, A Primer for Policy Analysis, New York, Norton.

Tarlock, D., 1979, "The Recognition of Instream Flow Rights: 'New' Public Western Water Rights," Proceedings, Rocky Mountain Mineral Law Institute, (25).

Thaler, R. and S. Rosen, "The Value of Saving A Life: Evidence From the Labor Market", in N.J. Terlecky (ed.), Household Production and Consumption, New York, Columbia University Press.

Tweeten, Luther, 1979, Foundations of Farm Policy, 2nd ed., Lincoln, University of Nebraska Press.

U.S. Bureau of the Budget, 1961, "Report of a Panel of Consultants to the Bureau of the Budget on Standards and Criteria for Formulating and Evaluating Federal Water Resources Development", Maynard M. Hufschmidt, Chairman, John V. Krutilla, and Julius Margolis, with assistance of Stephen A. Marglin. Mimeographed. Washington DC, 30 June.

U.S. Bureau of the Census, 1986, "1982 Census of Manufacturers: Water Use in Manufacturing", USGPO, March.

U.S. Bureau of Reclamation, 1983, Planning Instructions No. 83-16, (7116), Washington, D.C., July 1.

U.S. Congressional Budget Office, 1983, "Current Cost-Sharing and Financing Policies for Federal and States Water Resources Development", Special Study, Washington, D.C. (July).

U.S. Department of Commerce, Bureau of the Census, 1986, Water Use in Manufacturing, MC82-S-6 (GPO Stock No. 003-024-05629-17), U.S. Government Printing Office, Washington, D.C., March.

U.S. Geological Survey, 1983, Estimated Use of Water in the United States in 1980; Geological Survey Circular 1001, Distribution Branch, USGS, 604 S. Pickett St., Alexandria, VA, 22304.

U.S. Inter-Agency Committee on Water Resources, 1958, "Proposed Practices for Economic Analysis of River Basin Projects," (Revised) Washington, D.C., ("The Green Book").

U.S. Senate, 1962, "Policies, Standards, and Procedures in the Formulation, Evaluation, Review of Plans for Use and Development of Water and Related Land Resources". Senate Document No. 97, 87th Cong. 2nd Sess. Washington DC, 29 May.

U.S. Water Resources Council, 1973, "Principles and Standards for Planning Water and Related Land Resources", Federal Register 38(174): Part III, Sep. 10, 167 p.

U.S. Water Resources Council, 1983, "Economic and Environment Principles and Guidelines for Water and Related Land Resources Implementation Studies", U.S. Government Printing Office, March 10.

Walsh, R.G., et al., 1980, An Empirical Application of a Model for Estimating the Recreation Value of Instream Flow, Completion Report 101, Colorado Water Research Institute, Colorado State University, Fort Collins, Colorado.

Walsh, R.G., 1986, Recreation Economic Decisions, State College, Pennsylvania, Venture Publishing (637 pp.).

Ward, Frank, 1987, "Economics of Water Allocation to Instream Uses in a Fully Appropriated River Basin: Evidence from a New Mexico Wild River," Water Resources Research, 23 (3:381-392).

Ward, F.A. and J. Loomis, 1986, "The Travel Cost Demand Model as an Environmental Assessment Tool: A Review of Literature," Western Journal of Agricultural Economics, 11 (2:164-178).

Water Purification Associates, 1974, "Western Water Needs for Energy Conversion and Processing with Environmental Constraints", progress report, supported by NSF-RANN, Grant No. GI-43788.

Weatherford, Gary D., 1982, ed., Water and Agriculture in the Western U.S.: Conservation, Reallocation, and Markets, Boulder, CO, Westview Press.

Weatherford, Gary D. and F. Lee Brown, eds., 1986, New Courses for the Colorado River, Albuquerque, NM, University of New Mexico Press.

Whittlesey, N.R., J. Hamilton, and P. Halverson, 1986, An Economic Study of the Potential for Water Markets in Idaho, Moscow, Idaho, Idaho Water Resources Research Institute, University of Idaho.

Young, C.E., R. Kinsley, and W. Sharpe, 1983, "Impact on Residential Water Consumption of an Increasing Rate Structure," Water Resources Bulletin, 19:81-88.

Young, R.A., 1973, "Price Elasticity of Demand for Municipal Water: A Case Study of Tucson, Arizona", Water Resources Research, 9 (4:1068-1072).

Young, R.A., 1979, "Economic Analysis and Federal Irrigation Policy: A Reappraisal", Western J. Agr. Econ., 3 (2:257-268).

Young, R.A., 1981, "The Need for Irrigation: An Economist's View", in Heerman, D.F. and D.D. Fangmeier, eds., Irrigation: Challenges of the 80's. St. Joseph, Mich., Am. Society of Agric. Engineers, 29-34.

Young, R.A., 1984, "Direct and Regional Economic Impacts of Competition for Irrigation Water", in E.A. Englebert, ed., Water Scarcity: Impacts on Western Agriculture, Berkeley, University of California Press.

Young, R.A., 1986, "Why Are There So Few Transactions Among Water Users?" American Journal of Agricultural Economics, 68 (5:1143-1151).

Young, R.A. and S.L. Gray, with R.B. Held and R. Mack, 1972, Economic Value of Water: Concepts and Empirical Estimates, U.S. National Water Commission Technical Report (Springfield, Virginia, Nat. Tech. Info. Service, No. PB210356).

Young, Robert A. and S. Lee Gray, 1985, "Input-Output Models, Economic Surplus and the Evaluation of State or Regional Water Plans", Water Resources Research, 21(12:1819-1823).

Young, R.A., L.R. Conklin, et al., 1982, "Water and Energy Scarcity and the Future of the Regional Economy on the Colorado Ogallala-High Plains," Southwestern Review of Management and Economics, 2:2(29-48).

Young, R.A. and R. Haveman, 1985, "Economics of Water Resources: A Survey", in Allen V. Kneese and J.L. Sweeney, eds., Handbook of Natural Resource and Energy Economics, Volume II, Amsterdam, Elsevier.