THEORY AND PRACTICE OF
BENEFIT-COST ANALYSIS

by

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CHAPTER I

THE PROBLEM

A. Introduction

Public policy for water is a national problem of major proportions and significance. Industrial and domestic water supplies have become increasingly inadequate to meet needs throughout the country. The problem of developing power sources from replaceable water resources becomes more pressing as the reserves of irreplaceable mineral power resources decline. In every major river basin of the United States, the annual losses from the ravages of flood are substantial. In the arid regions of the nation, an expansion of developed water resources appears to precede economic expansion; and available water supplies appear to offer an effective constraint upon economic expansion in even the more humid areas. The Mid-Century Conference on Resources for the Future concluded:

> The Nation's base of water resources could be so diminished during the next 25 years as to precipitate a series of critical situations. Some ground water reservoirs could be exhaused, pollution could creep farther along the streams, the land cover of watershed areas could deteriorate further. Major needs for electric power, for cultivable lands, for municipal supplies could go unmet.[1]

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[1]Mid-Century Conference on Resources for the Future, "Water Resource Problems," Section III, A Mid-Century Look at Resources: Background Papers, (Washington, D. C.: Brookings Institution, 1953), p. 3.

Historically, private enterprise and public agencies have collaborated in the development of water resources in the United States. Roy Huffman[2] has suggested that the major goal of public resource development in a capitalistic economy is to increase the capacity of the resource base to support private enterprise.[3] Thus the federal government has sponsored programs and policies designed to improve the usability of water resources of the nation for private enterprise. As Huffman has put it:

> Public programs to develop hydroelectric power and construct irrigation and drainage projects are not too far removed from our historical experience wherein the federal government subsidized canals and wagon roads, made land grants to the railroads, and provided free public land to private enterprises of all kinds.[4]

Public water resource development should be carried out in the most economic manner possible. This involves consideration of all possible uses for water resources, as well as of all possible methods of supplying those uses. That use, supplied by means of the appropriate method, which provides the highest net benefits will be the most economic.

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[2]Head, Department of Agricultural Economics and Rural Sociology, Montana State College, Boseman, Montana.

[3]Roy Huffman, "The Water Resource Problem," Farm Foundation, National Conference on Increasing Understanding of Public Problems and Policies, 1955.

[4]Roy Huffman, "Role of Private Enterprise in Water Resource Development," Law and Contemporary Problems: Water Resources, (School of Law, Duke University, Vol. XXII, No. 3, 1957), pp. 434-35.

The choice of the projects which fulfill this criterion from among all of the possible projects is made by the public agencies on the basis of the benefit-cost analysis. The benefit-cost analysis is an economic study of water-use project effects. It involves the collection of data pertinent to water resource development in terms of the benefits which can reasonably be expected to accrue as a result of project formation, and of the estimated cost of providing these benefits. Central to the benefit-cost analysis is the determination of the need for project goods and services, the value of these goods and services, and the alternative costs of the resources used in developing the project.[5] After the data relating to benefits and costs have been collected and the two effects have been measured, their magnitudes are compared. If the benefits expected from a given project exceed its estimated cost, the project can be said to be economically justified. Those projects which provide highest net benefits can be said to be most economical,[6] but this would illustrate an application of the results of the benefit-cost analysis rather than a part of the analysis itself.

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[5]Subcommittee on Benefits and Costs, Proposed Practices for Economic Analysis of River Basin Projects: Report to the Federal Inter-Agency River Basin Committee, (Washington, D. C., United States Government Printing Office, May, 1950), pp. 3-12.

[6]*Ibid*., p. 5.

B. Statement of the Problem

In planning resource development projects, such as those which provide reservoirs of water for irrigation, facilitate navigation, solve problems of water pollution, generate power, enlarge domestic and industrial water supplies, improve drainage, and offer protection against the ravages of floods, public agencies use the benefit-cost analysis as a tool for determining the economic justification of the various projects.[7] This study is concerned with the United States Corps of Engineers, the Bureau of Reclamation, the Department of Agriculture, and the Federal Power Commission. By the terms of the Flood Control Act of 1936, these agencies are required to carry out an analysis of the benefits and costs of their respective projects, and to recommend for development only those projects which promise to return a surplus of benefits over costs.

These legislative requirements point up the two aspects of the benefit-cost analysis with which we will be concerned.

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[7] Subcommittee, "Proposed Practices," op. cit., pp. 5-6. The phrase "economic justification" is used here in its widest sense, encompassing the more limited "economic" and "financial" feasibilities. Economic feasibility is achieved whenever project benefits exceed costs. Financial feasibility is attained when benefits can be associated with costs in such a manner that repayment can be expected to occur in proportion to benefits received. We will be principally concerned with the problem of economic feasibility, although the problem of financial feasibility will be discussed briefly in Chapter IV.

The first aspect includes both the practices adopted by the public agencies in conducting the benefit-cost analysis and the characteristics of water resources which seem to require public rather than private development. The second is the use to which the findings of the analysis can be put in selecting and ranking projects for development.

1. The Public Agency Benefit-Cost Analysis

The major purpose of the benefit-cost analysis is to determine how effectively proposed projects may be able to use economic resources. The economic feasibility of any given project is ascertained through the ratio of its expected benefits to its estimated costs.[8] By a well established rule in the use of the benefit-cost analysis, only those projects which would result in a surplus of benefits over costs should be considered for development, and, in multiple-purpose projects, no individual purpose should be included for which benefits are not at least equal to the cost of its inclusion.[9] It is also recognized that investment in the individual purposes of water-use projects should be carried out to the point at which the marginal benefits from investment in any given purpose will be equal to the cost of the last segment of investment.[10]

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[8] _Ibid._

[9] _Ibid._

[10] _Ibid._

Thus the benefit-cost analysis is essentially a marginal analysis, and is entirely in accordance with the general requirement of the economy that, if resources are to be utilized most efficiently, goods and services are to be produced only if their returns exceed their costs. Through the use of the benefit-cost analysis, the public agencies are enabled to consider the merits of each project, and of each segment of that project, and to make recommendations for or against development on economic grounds.[11]

There is, however, a problem involved in defining benefits and costs. In the private sector of the free enterprise economy, the costs upon which entrepreneurs base production decisions are those which the firm must pay; the benefits considered are the revenues which the firm can obtain from its customers. A private firm may well produce benefits for which it may receive no money return or incur costs for which no money payment is paid. Such benefits and costs do not, however, usually enter into the firm's production decisions. The firm's

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[11]Subcommittee, "Proposed Practices," op. cit., p. 3. The subcommittee pointed out that development decisions might well be made upon other grounds than the results of the benefit-cost analysis. This does not imply conflict between economic and political decisions, but rather that the economic analysis as conducted by the public agencies is necessarily limited to the scope of the agency, and cannot take into account all of the ramifications of high level political decisions. Even so, the results of the analysis may prove to be invaluable in aiding such high level decisions to be made in the direction of greatest efficiency.

motive is to maximize net revenues (profits) over time. Although the objective for public investment is similar (the maximization of net value returns over time), the calculation of benefits and costs is more difficult because it is necessary for public agencies to take a much wider account of the effects of public investment. Indirect benefits and costs which arise as a result of investment, although measurable in monetary terms, cannot usually be exploited by private firms. Intangible benefits and costs which do not yield to measurement in monetary terms, and are ignored by private firms, must be given a place in public investment decisions. Public agencies will usually have to take such effects into account if the benefit-cost analysis is to be complete.

A second problem is created by the fact that a substantial part of public investment in water-use projects is made in projects which are of tremendous scope, requiring exceptionally large capital outlays, and often necessitating long lapses of time before returns begin to accrue.

For both of these reasons, it is not surprising that a major portion of the controversy surrounding the use of the benefit-cost analysis as a yardstick in public investment decisions should concern the methods used in computing the secondary benefits and costs and in taking account of the time factor.

The major purpose of the study will be, then, the examination of the public agency benefit-cost analysis, and the methods of its use, with these difficulties in mind. Particular attention will be directed to such matters as the choice of the time period over which the project may be expected to yield net benefits, the choice of the price level by means of which benefits and costs are to be valued, the interest and discount rates selected to reduce benefits and costs to an equivalent annual average,[12] evaluation of those intangible effects which cannot be measured in monetary terms, and of those indirect benefits and costs which arise as result of investment in the project but are not expressed through changes in the prices of project goods and services.[13]

Attention is also directed to the conditions of supply and demand in the water resources field which give rise to divergence between market and social values. This requires discussion of direct interdependencies which do not operate through the market mechanism, and of the effect of investment

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[12] Project life, the price level, and the choice of the interest and discount rates are clearly related to the difficulty posed by time in public investment decisions. The length of life assumed for the project determines the relavent time period for investment. The price level must reflect the magnitude of benefits and costs at the time when they occur. If benefits are to be compared to costs on any sound basis when they occur at different points in time, they must be made comparable by the use of interest and discount rates.

[13] Intangible and indirect benefits and costs together comprise the secondary effects which must be considered in public investment decisions. These effects are usually ignored in the making of private decisions.

in water-use projects upon private profits.[14] Direct interdependencies will occur whenever individuals and firms can obtain the goods and services produced by the project without paying for them; or when the output of the project will depend, not only upon its own use of resources and the scale of its development, but upon the activities of other projects as well.[15] Interdependencies also arise out of investment indivisibilities and the dynamic process of investment.[16] This type of interdependence operates through the market mechanism, and will be of interest in that many of the indirect benefits and costs of project development appear to result from this source.[17]

2. Project Ranking

After the benefit-cost analysis has been completed, and the benefit-cost ratios of the projects have been computed,

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[14]Tibor Scitovsky, Two Concepts of External Economies," Journal of Political Economy, Vol. LXII, April, 1954, pp. 143-51.

[15]John V. Krutilla and Otto Eckstein, Multiple Purpose Water Development: Studies in Applied Economic Analysis, (Baltimore: The Johns Hopkins Press, 1958), pp. 52-58.

[16]Tibor Scitovsky, op. cit., pp. 148-49.

[17]This appears to be particularly true of stemming benefits which arise in connection with the processing of the immediate products of a water-use project.

the problem of deciding which of the economically justifiable projects should be developed, and in what order, becomes of crucial importance. Disagreement exists, both among the responsible public agencies and among writers in the field, whether projects should be ranked on the basis of their benefit-cost ratios, upon the size of the surplus of benefits which each project exhibits, or on the basis of the benefit-cost ratios of the individual purposes of the projects. The importance of this aspect of benefit-cost analysis can hardly be stressed enough, since all of the efficiency gains obtained through the use of the benefit-cost analysis could be nullified by an inefficient ranking system.

A secondary purpose of this study will be an evaluation of this aspect of benefit-cost analysis. This requires examination of the effect of the interest rate upon the scale of development, and the conditions under which capital is made available for investment in water-use projects.

We have set forth two objectives. The first consists of an examination of the practices of the public agencies with respect to benefit-cost calculations, and the supply and demand characteristics of water-use projects. The second concerns the use which will be made of the results of the analysis in allocating public funds among the variety of projects which have been indicated to be justified in an economic sense. The first will constitute the major problem;

the second will be of considerable importance, but will be largely incidental to the first.

3. Economic and Financial Feasibility

There must be, however, one qualification made to the objectives as outlined above. The benefit-cost analysis, in its widest meaning, involves determination of both economic and financial feasibility. The first relates to computation and comparison of benefits and costs expected to accrue to any given project. If the benefits expected from the project exceed its estimated cost, the project is held to be economically feasible. Financial feasibility involves association of benefits with costs in such a manner that those individuals who receive the benefits will bear the costs.[18] Although it is not questioned that problems relating to financial feasibility are of great importance, and must ultimately be faced, it will be primarily with the problem of economic feasibility that we will be concerned here. This appears to be the area within the benefit-cost analysis where the economist can be

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[18] Association of benefits and costs has been achieved perfectly when the individual who receives benefits pays exactly full cost of providing those benefits. If benefits and costs are not so associated, there will occur a redistribution of income which may or may not be desirable.

of most assistance, and the area in which he can make some definitive suggestions.[19]

C. Basic Concepts and Definitions

A few of the basic concepts and definitions which are generally accepted in the field of benefit-cost analysis follow. Others are added throughout the study as the need for them arises.

It is assumed that, over the long run, the expanding economy will require ever increasing amounts of resources and goods and services to satisfy increased needs resulting from both population growth and higher living standards. The controlling principle of evaluating a project on the basis of the difference in the effect on the economy with and without the project is consistent with this basic assumption. The measure of benefits from any given project will be the difference between the level of income which will be attained with the project and that which would prevail if the project were not undertaken.

Project services will have value only to the extent that there is expected to be a need or demand for those

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[19] This is not meant to imply that the economist can say nothing definitive about the desirability of income redistribution, but simply points out the greater area of usefulness which the economist will have in evaluating the physical effects of water-use projects upon the general welfare.

services. The ultimate aim of water resource development is to satisfy human needs and desires, and the phrase "goods and services" is generally accepted in the literature of benefit-cost analysis as including all objects and activities which have the power of satisfying these wants, and which may be increased or decreased as a result of a given project.

Fundamental to the evaluation of costs is the fact that, when goods and services are utilized for a specific purpose, these same goods and services cannot be used for any other purpose. From this it can be concluded that the economic cost of using goods and services for any specific purpose can be calculated in terms of the value of benefits foregone in the most likely alternative use to be expected. If there were no alternative use, the economic cost of the goods and services would be zero. This would be far from the usual case, however. It is usually assumed that the value of goods and services produced would be about equal to the market cost of the goods and services used.[20] This means that market prices may be used to measure the benefits foregone and, hence, to measure project costs.

The term "project" may be taken to include any program of water resource development undertaken by the agencies of the federal government either by themselves or concurrently

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[20] Subcommittee, "Proposed Practices," *op. cit.*, p. 9.

with non-federal elements. Usually the non-federal elements which are considered to be a part of the project relate to those measures which the federal government requires non-federal agencies to undertake as a condition of federal participation.

Project costs are considered to be the value of goods and services which are used in the establishment, operation, and maintenance of the project, including an allowance for induced adverse effects, whether such effects are compensated for or not. Thus it is necessary to calculate not only the costs involved in project construction to provide, for example, for an increased supply of domestic and industrial water, but to include such costs as might be involved in reduction of the supply of water for other purposes.

Associated costs are the value of the goods and services needed, other than those included in direct project costs above, to place the immediate products and services of the project into the hands of the consumer. In the above example, this would involve those costs which would occur in the process of distributing the water to consumers.

Secondary costs are the value of the goods and services, other than those above, which are used as a result of the project. Costs of this type would include the cost of additional processing of the immediate goods and services, and any other costs over and beyond project and associated costs, stemming from or induced by the project.[21]

Primary benefits are the values placed upon the immediate products or services which result from development of the project. In an irrigation project, for example, the primary benefits would be measured by the increased value of the crop produced by the irrigating farmer. This will, in effect, be the same as the value of the water used. In a hydroelectric project, the primary benefits can be measured by the value of the power produced by the project.

Secondary benefits are considered to be those values added over and beyond the values which accrue from the immediate products and services of the project. They are divided into two groups, those indirect benefits which are either induced by or stem from the project, and the intangible benefits which occur as a result of project formation. Indirect benefits will be reflected in income changes, and can be typified by values added in successive stages of processing of raw materials from a given project. Intangible benefits are not susceptible to monetary measurement in any acceptable manner. An example of this type of benefit would be provision of recreational facilities. A good deal of the

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[21]This definition is used since it states agency practice, but a good deal of controversy has centered around this very problem.

controversy in the literature of the field can be traced to confusion of these two types of effects.

D. The Government Agencies

We will be concerned with the benefit-cost practices of four government agencies: the United States Corps of Engineers, the Bureau of Reclamation of the Department of the Interior, the Department of Agriculture, and the Federal Power Commission. These agencies will usually be referred to hereafter as the Corps, the Bureau, the Department, and the F.P.C. respectively. These agencies are required (under the terms of the Flood Control Act of 1936) to compare the benefits expected to be derived from a water-use project with its costs to determine economic feasibility.

Although all of the above agencies are interested, to a greater or lesser extent, in projects of a multiple-purpose nature, each of them has a specific range of specialization which undoubtedly influences the pattern followed by each in evaluating benefits and costs, both for purposes falling within the range of specialization and for those which lie outside of it. The Department of Agriculture is legally responsible for construction of watershed treatment programs, for example, and, although it is often forced by technical conditions to include other purposes in its projects, those other purposes are apt to be measured by the same set of criteria by which watershed treatment programs are measured. In the same way, the fact that the Bureau is specifically charged with problems of land reclamation may tend to lend some influence in the Bureau's evaluation of other purposes which may be related to reclamation only by reason of the fact that they are technically feasible within the reclamation project structure. The same logic applies to the Corps and to F.P.C.[22] This fact will tend to complicate the analysis of the agency practices which follows; but failure to recognize the existence of both the problem and its source would tend to invalidate a good deal of the value in such an analysis.

E. Statement of Organization

The problem of water resource development is a complex one, and its complexity is compounded by the political values which surround it.[23] For this reason it seems best to conduct discussion of benefit-cost analysis, as it relates to this problem, in three distinct and separate parts.

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[22]But note the F.P.C. practice of securing benefit-cost computations for purposes other than power from one of the other agencies. Infra, p. 31.

[23]John F. Timmons, "An Economic Framework for Evaluating Watershed Development Programs," Journal of Farm Economics, Vol. 36, (1954).

1. Part I

The first part is introductory in nature. It consists of description of the practices adopted by the four public agencies relative to the benefit-cost analysis in their attempts to develop the water resources of the nation. For purposes of clarity, the agency practices are presented without comment in this part, with evaluation and discussion reserved for Part II.

To facilitate comparison of the practices of the individual agency, the methods of treatment of each facet of the benefit-cost analysis are dealt with individually. This involves some duplication, but it has the advantage of pointing up differences in the practices of the agencies.

This part also includes a brief discussion of the legal and administrative requirements for the use of benefit-cost analysis, and the area of responsibility of each of the four public agencies. It is felt that the differences in function of these agencies may account, at least in part, for the difference in methods of conducting the benefit-cost analysis. Understanding of major functions of the agencies should lead to a better understanding of the benefit-cost analysis.

2. Part II

Part II consists of discussion and evaluation of the practices of the public agencies with respect to the benefit-cost analysis. This part begins with a brief discussion of indivisibilities, complementarities, and production constraints as they apply to benefits and costs of water-use projects. From this we move to evaluation of agency practices in calculating benefits and costs.

This part will also contain discussion of the problems surrounding the choice of the period of analysis, selection of the price level, and determination of appropriate interest and discount rates. The analyses of these and related problems which have appeared in the literature of the field will be considered, with particular reference to the Report of the Panel of Consultants to the Commissioner of the Bureau of Reclamation,[24] and to the series of papers presented at the Conferences on Water Resources and Economic Development of the West.[25]

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[24]Report of the Panel of Consultants, Secondary or Indirect Benefits of Water Use Projects, to Michael W. Strauss, Commissioner, Bureau of Reclamation, (Washington, D. C.: United States Government Printing Office, 1952).

[25]Papers presented at the meetings of the American Association for the Advancement of Science, Water Resources and Economic Development of the West, Reports No's. 1, 2, 3, 4, and 5, (Reproduced by the Committee on the Economics of Water Resource Development of the Western Agricultural Research Council, 1953-54-55).

Finally this section will include a detailed analysis of the uses to which the benefit-cost analysis findings may be put in ranking the various projects for development purposes. This analysis will lead into discussion of the availability of funds for public development of water resources. The central importance of the latter for an efficient ranking system will be discussed.

Throughout Part II such questions will be examined as the following: What is the controlling principle of the benefit-cost analysis? Does it mean, in effect, that net benefits can never be larger than the difference in benefits and costs with the project and without it? Should it be assumed that needs met by a project would be met if the project were not constructed? By what procedure should the benefit-cost analysis account for stimulating expansion of the nation's productive capacity? Can the procedures for evaluating primary benefits logically be expanded to provide adequate evaluation of secondary benefits? Should project costs, associated costs, and secondary costs, in terms of market values, be considered an adequate measure of benefits foregone from alternative uses? Should the effects of alternative uses be compared with or deducted from the benefits of project uses? How can measurements of benefits from a local viewpoint be converted to represent the public viewpoint? Do secondary benefits and costs vary in any substantial way for different types of commodities and for different projects? Can an identical procedure be used to evaluate secondary benefits from irrigation, power, municipal and industrial water supply, and other purposes? Should savings to power consumers from lower rates be considered as a primary or secondary benefit?

3. Part III

Part III presents concluding remarks concerning the benefit-cost analysis and a broader evaluation of the benefit-cost analysis as a criterion of water resources development policy.

F. Concluding Remarks

Only since World War II has any considerable amount of work been done in the field of economics relative to the benefit-cost analysis. Prior to that time, although economists engaged by the several public agencies were concerned with the problems inherent in its use, its application was made generally subject to engineering requirements and by individuals more interested in the engineering elements than in the economic implications of the project. The legal requirement for its use as a yardstick for development came into being as late as 1936, with the passage of the Flood Control Act. This act gave legal recognition to the importance of allocating resources used in public development projects in such a manner as to maximize the benefits to be derived from such projects.

In 1946 the Federal Inter-Agency River Basin Committee appointed a Subcommittee on Benefits and Costs to formulate principles and procedures for determining benefits and costs for water resources projects. The membership of this subcommittee was drawn from the public agencies responsible for development of such projects. Inspired largely by the 1950 report of the subcommittee, a substantial number of articles and studies have been published during the past few years. Most of these articles and studies have been directed at specific areas of benefit-cost analysis;[26] the Report of the Panel of Consultants, the papers presented at the meetings of the American Association for the Advancement of Science, a series of articles by such men as Roy Huffman, M. M. Kelso, Ciriacy-Wantrup, Otto Eckstein, and John Krutilla, to mention only a few, fall into this category. The work of the last two men, however, holds special interest since it represents the effort in the field of benefit-cost analysis of

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[26]There are, however, two books which have been published within the past few months which delve deeply into the economic background of the analysis. The first, by Otto Eckstein, _Water Resources Development: The Economics of Project Evaluation_, (Cambridge: Harvard University Press, 1958), has not been examined. The second, John Krutilla and Otto Eckstein, _Multiple Purpose River Development: Studies in Applied Economic Analysis_, (Baltimore: Johns Hopkins Press, 1958), became available only as this study was nearing completion.

general economists rather than of agricultural economists, who have previously dominated the field. The work of such agricultural economists as Roy Huffman, M. M. Kelso, and Ciriacy-Wantrup has been of an inquisitive and critical nature and of generally high caliber. In many cases, however, one has the feeling that their emphasis has been placed more upon uses of water resources as they apply to the agricultural sector of the economy than upon the economic interest of the nation as a whole in these water resources.

In 1950 The President's Water Resources Policy Commission completed a three volume study of water resources in the United States.[27] Volume 1 is of special interest, in that it represents one of the most complete expositions of water resources problems published to date. In spite of the tremendous volume of factual information which the study presents, the study provides the surest proof that benefit-cost analysis is in its infancy. The collection of the socio-economic data necessary to conduct a benefit-cost analysis has only just begun, in a comparative sense.

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[27] The President's Water Resources Policy Commission, A Water Policy for the American People, Vol. 1, Ten Rivers in America's Future, Vol. 2, and Water Resources Law, Vol. 3, (Washington, D. C.: United States Government Printing Office, 1950).

Regional data are almost completely lacking for many of the important river systems. In many cases the lack of effective channels of communication between the government agencies which collect the data and the agencies involved in water resources development hamper the efforts of the latter in conducting benefit-cost analysis. The importance of the collection and dissemination of the appropriate socio-economic data for benefit-cost analysis cannot be overstated.

CHAPTER II

PUBLIC AGENCY BENEFIT-COST PRACTICES

A. Introduction

Over the past one-hundred years, largely due to the inability of state and local groups to deal with the problems inherent in the field,[1] Congress has assigned increasingly broad responsibilities with regard to water resources development to federal agencies.[2] We are concerned with the methods adopted to discharge these responsibilities by four agencies; the United States Corps of Engineers, the Bureau of Reclamation, the Department of Agriculture, and the Federal Power Commission. Each of these agencies is primarily concerned with a specific area, or group of areas, of water resource development. Projects which have as major

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[1] The President's Materials Policy Commission, Resources for Freedom: Selected Reports to the Commission, Vol. V, (Washington, D. C.: United States Government Printing Office, June, 1952), p. 91.

[2] The inability of state and local groups to deal effectively with water resource problems stems from the fact that most of the major streams flow across state and/or international boundaries. The Supreme Court has held (Kansas v Colorado, 304 U. S. at 110, 1907) that the question of apportionment of inter-state streams is one of federal common law which lies beyond the statutes and decisions of the states.

purpose flood control or navigation are assigned to the Corps.[3] Those projects which have reclamation of lands through irrigation as a primary objective are developed by the Bureau.[4] The Department accepts responsibility for programming watershed development to aid in flood control,[5] and for small water facilities which supply domestic, stock, and irrigation water.[6] The Commission has the function of facilitating private development of water-power resources under "terms and conditions designed to safeguard public interest and protect other water uses......Although the scope of the Commission's investigative power is broad, its surveys have been primarily concerned with power."[7] Since many, if not most, of the water resource projects are multiple purpose in nature, each of these agencies will frequently undertake development of purposes which lie outside of their special range of interest.

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[3]President's Water Resources Policy Commission, _Water Resources Law_, Vol. 3, (Washington, D. C.: United States Government Printing Office, 1950), pp. 505-506.

[4]_Ibid._, p. 506.

[5]H. R. 8455, Pub. No. 738, Flood Control Act of 1936, June 22, 1936.

[6]Water Facilities Act, Act of August 28, 1937, 1, 50 Stat. 869, 16 U. S. C. 590r-590x.

[7]President's Water Resources Policy Commission, Vol. 3, _op. cit._, p. 507. The F.P.C. has authority to determine whether power from federal projects can be used advantageously by the United States for its public purposes. The Corps and the Bureau are responsible for federal power development.

By the terms of the Flood Control Act of 1936, the Corps of Engineers and the Department of Agriculture are required to analyze the benefits and costs of water resource development as they accrue to flood control and watershed development, and to recommend for development only those projects for which benefits exceed costs.

> It is hereby recognized......that investigations and improvements of rivers and other waterways, including watersheds thereof, for flood control purposes are in the interest of the general welfare; that the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds thereof, for flood control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs......in their reports upon examinations and surveys, the Secretary of War and the Secretary of Agriculture shall be guided as to flood-control measures by the principles set forth in section 1 (above) in the determination of Federal interests involved.[8]

There has been no specific legislation to extend this requirement to other agencies and other purposes, but administrative acceptance has caused it to be used by all of the agencies.

> While the requirement for a benefit-cost ratio has never been incorporated into Reclamation Law, it was found to be a useful administrative tool and has been adopted as a part of official reclamation procedure. Congressional committees apparently attach considerable significance to the ratio.[9]

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[8]Flood Control Act of 1936.

[9]J. Karl Lee, Bureau of Reclamation, Boise, Idaho, "Economic Implications of Recent Developments in the Bureau of Reclamation," _Water Resources and Economic Development of the West: Institutions and Policies_, Report No. 2, Conference Proceedings, Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Bozeman, Montana, June 28, 29, and 30, 1954, pp. 79-80.

> Moreover, all of the federal agencies concerned do evaluate such relative benefits and costs in considering projects.[10]

All of the agencies submit benefit-cost estimates for proposed projects, and submit recommendations for development of only those projects which exhibit a favorable benefit-cost ratio.

This chapter deals with the methods by which these four agencies compute benefits and costs in conducting the benefit-cost analysis. It is primarily expository in nature, with comment and evaluation reserved for Part II.

There are substantial differences in the methods used by the several agencies in calculating benefits and costs, and in applying the benefit-cost analysis, which to a considerable extent can be accounted for by differences in the basic functions of the agencies. Increased emphasis upon multiple purpose development has, however, caused considerable over-lapping of these functions. The Corps of Engineers, for example, may find it advisable, in undertaking improvement of navigation facilities, to include pollution abatement, irrigation, and hydroelectric power as additional purposes of its projects. The effects of this over-lapping and of the differences in methods of calculation are discussed in Part II.[11]

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[10] President's Water Resources Policy Commission, Vol. 3, _op. cit._, pp. 518-519.

[11] These differences in methods of calculation and application, and over-lapping, are of considerable importance. There might be compelling reasons for computing effects of different purposes on different bases; there would not appear to be equal reason for computing the same purpose effects on different bases.

In the discussion which follows, each specific purpose and the practices of the four agencies relating to it are treated separately. This involves some duplication, but it has the advantage of pointing up differences between agencies.

B. Measurement of Tangible Benefits and Costs

The tangible effects of a project are normally defined as those which are measurable in monetary terms.[12] Most of the effects of water resource development can be evaluated on the basis of market prices, or can be derived or estimated indirectly from prices established in the market for similar or analogous effects, or from the cost of obtaining the same result by the most economical alternative means.

1. Benefits

All of the agencies give consideration to tangible benefits which enter into the benefit-cost ratio separately from intangibles. The general basis for measuring tangible benefits is presented first. The agency practices relating to the measurement of such benefits from specific purposes will

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[12]Except where otherwise noted, the source for the benefit-cost practices of the four agencies is Subcommittee on Benefits and Costs, _Proposed Practices for Economic Analysis of River Basin Projects: Report to the Federal Inter-Agency River Basin Committee_, (Washington, D. C.: United States Government Printing Office, May, 1950), pp. 58-85.

follow. In Table I the types of purposes for which each agency calculates benefits are stated.

The Corps of Engineers measures tangible benefits as savings in costs, as reductions in losses, and as increases in incomes, directly resulting from project formation. Navigation benefits can usually be measured by the savings in costs to shippers on improved waterways, while flood control benefits will be reflected largely by reductions in losses. Benefits accruing to both purposes, not measured by the above method, show up as increases in incomes due to increased use of the resources involved. All tangible benefits are reduced by the amount of all costs associated with development other than those directly connected with construction of the project. These associated costs are the costs involved in establishing, maintaining, and operating the project.

The Bureau of Reclamation measures tangible benefits by the value of services rendered, except in the case of irrigation, where benefits are measured by the contribution of the project to national income. Estimates of benefits from flood control are either obtained from the Corps or are arrived at by similar measures. The Bureau compares these benefits with the total of construction and associated costs, instead of reducing tangible benefits by the amount of the associated costs and comparing the remainder with construction costs as the Corps does.

TABLE I

COMPARISON OF AGENCY BENEFIT PRACTICES

Practice	Corps	Bureau	Department	F.P.C.
Period of analysis	50	100	perpetuity	50
Prevention of flood damage				
To agricultural crops . . .	yes	yes[a]	yes	yes
To business, industry, and commerce	yes	yes[a]	no	yes
Increase in the value of agricultural production				
Direct effects	yes	yes	yes	(b)
Indirect effects	no	yes	no	(b)
Increased utilization of non-agricultural property .	yes	yes	yes	(b)
Hydroelectric power production				
Direct effects	yes	yes	no	yes
Indirect effects	no	yes	no	no
Navigation	yes	yes	no	yes
Sedimentation control	yes	yes	yes	(b)
Salinity control	yes	yes	no	(b)
Recreational facilities . . .	yes	yes	no	no
Pollution abatement	yes	yes	no	(b)
Increased employment	no	yes	no	no
Fish and wildlife	yes	yes	no	no
Increased use of capital . .	no	yes	no	no
Domestic and industrial water supply	yes	yes	yes	(b)

[a]Secured from Corps and adjusted by historically based price level.

[b]Secured from agency responsible for project.

The Department of Agriculture measures tangible benefits by increases in gross incomes on lands upon which project measures are installed, as increases in gross income less increased cost of production on other lands, plus reductions in costs and losses on all lands. These benefits are then compared with project costs which include both public and private expenditures for the installation and operation of the project.

In all cases where benefits are expected to occur, other than those resulting from increasing hydroelectric power production, the Federal Power Commission relies upon the agency which will be responsible for the project to make the calculation of benefit values. The method used by the Commission in computing hydroelectric benefits is discussed below.[13]

a. Prevention of flood damage

The Corps of Engineers measures benefits from the prevention of flood damage as the amounts of reduction of flood damage, computed on the basis of damage frequency relations.

> The amount of flood damage to be expected in a given area varies with the magnitudes expected. Although the date of occurrence of a flood of any given magnitude cannot be predicted, the probability of occurrence of a flood of any given magnitude in a specified period of time such as 50 or 100 years or in a particular season of the year can be estimated when adequate stream flow data

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[13] *Infra*, p. 36.

> are available. Accordingly, the average annual damage to be expected from all floods that may occur in the period of analysis of a project can best be computed on the basis of the expectancy in any one year of the various amounts of flood damage that would result from floods of all magnitudes up to those approaching the maximum possible flood. The difference in expected damages with and without flood control is the benefit attributable to the project.[14]

Damage to land and other property is measured by the cost of restoration or, where restoration is impossible, by reduction in land values caused by recurrence of floods. Damage to agricultural crops is measured by the market value of the crops lost, adjusted for any production costs not incurred and for any replanting possibilities. Damage caused by interruption of business, industry, commerce, etc., is measured by the net loss in income or by the added costs of operation, whichever is less, to the extent that these losses and costs cannot be avoided.

All of the other agencies calculate benefits from flood control on essentially the same basis as the Corps or obtain their estimates as to the extent of such benefits directly from the Corps. (See Table I). There are two minor variations adopted, one by the Department of Agriculture, the other by the Bureau of Reclamation. The Department does not calculate damages resulting from interruption to business, commerce, and industry. The Bureau adjusts the estimates of benefits

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[14] Subcommittee, "Proposed Practices," op. cit., p. 42.

from flood damage, as they are received from the Corps, by a price level based upon the average of 1939-44 prices.[15]

b. Increase in the value of agricultural production

The Corps of Engineers measures benefits resulting from an increase in the value of agricultural production by the increase in net farm income. This is generally accepted as the increase in gross farm income minus the increase in the cost of production. Extended effects, that is, the effects of increased farm production upon other than farm incomes, are not usually measured.

The Bureau measures the benefits from an increase in the value of agricultural production by the contribution which such an increase will have upon national income. These benefits are, however, computed on two levels. The first consists of effects at the farm. Benefits at this level are determined by the increase in the difference between gross farm income and all farm expenses, plus the increase in wages paid hired farm workers, plus the increase in interest payments on farmers' borrowed capital. The second considers indirect effects beyond the farm. These benefits are measured by the added income resulting from an additional volume of agricultural products flowing through industry and trade,

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[15]See below (Chapter VIII) for a discussion of price levels.

plus the added income from increased purchases of goods and services in the project area.[16]

The Department of Agriculture calculates benefits from the increase in the value of agricultural production for lands on which project measures are installed by the increase in gross farm incomes, with any increase in production costs accounted for as a part of project costs. For lands other than those on which the project features are located, the benefits are measured by the increase in net farm income. The Department does not usually measure the effects of increased agricultural production on non-farm incomes.[17]

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[16]These first are of the "stemming from" variety, while the latter are of the " induced by" type. Stemming from benefits are those indirect benefits which arise from processing the products of the project, from the initial product through its various stages to the finished product which the consumer purchases. Induced by benefits are those indirect benefits which arise as a result of expansion of economic activity induced by the project. The practice of computing these two effects has led to violent controversy in the field, since it attempts to measure both supply and demand effects, and to add them together. A large portion of Chapter V is devoted to an analysis of this problem.

[17]The essential difference between the treatment given this form of benefit by the agencies lies in their attitudes toward indirect benefits. In cases where this type of benefit is taken into consideration by the Corps and the Department, it is valued as a percentage (10%) of the direct benefits. Only the Bureau attempts actual calculation.

c. Increased utilization of non-agricultural property

The benefits from increased or higher utilization of non-agricultural property are measured by the Corps in terms of increases in earnings expected under average future conditions due to changes in use made practicable by the development program. The annual increase in earnings is determined by applying the current average rate of return associated with the activity concerned to the increase in capital value, except where the increase in earning power can be directly determined. In the latter case, the values of such benefits are measured by the difference in net income expected from the use of the property, and resources used in conjunction with it, with and without the project.

The Bureau measures such benefits by converting the estimated future increases in the market value of land to an equivalent annual average amount, using a standard interest rate of 2½ per cent.[18]

Benefits resulting from increased utilization of non-agricultural property are computed by the Department of Agriculture in terms of increases in property values above the capitalized value of all damage reductions. Estimates of these increases are obtained either from studies of values in comparable areas or by capitalizing the expected increase

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[18] Reduction to equivalent annual average amounts has the effect of placing a present value upon these future increases.

in annual land income. In either case the benefits are converted to an equivalent annual average basis by use of an interest rate ranging from $4\frac{1}{2}$ to $6\frac{1}{4}$ per cent, depending upon the size of the risk allowances set up to provide against foreseeable risks.

d. Hydroelectric power production

The Federal Power Commission considers benefits from increasing power production as the value at the bus bar of the project for dependable and usable capacity during the critical stream flow period, and for usable energy from the average stream flow, based on the cost of capacity and energy from the most economical alternative source of providing power.[19] Additional benefits are measured by the improvement in downstream power values attributable to the project, reduced by the costs incurred by the downstream recipients in order to realize the improved power values.

The Bureau of Reclamation computes the value of benefits from hydroelectric power production in terms of the estimated gross revenue to the project from the sale of power. The total so obtained is then adjusted for any gains or losses to downstream recipients. In addition to these "direct" benefits, the Bureau measures the indirect benefits from hydroelectric power production by the increase in the returns

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[19]The alternative used is usually modern, low cost private steam generation.

to the power distributor, plus the savings to consumers from lower power rates and benefits attributable to power from the project in the final production of goods and services. This technique differs from that used by the F.P.C. only in the calculation of the benefits attributable to power from the project in the final production of goods and services.

The Corps of Engineers computes the value of hydroelectric power production on the same basis as the Commission, while the Department of Agriculture does not usually calculate the effect of such benefits in monetary terms.

e. Navigation

The Corps of Engineers measures benefits from improved navigation facilities by the savings to shippers, as determined by the difference between costs of shipment via water routes and the cheapest alternative method, or by savings in water-carrier time and operating costs on an improved waterway which supercedes an existing waterway. This last is used only when no suitable alternative is available for comparison. The Corps also adds the estimated recreational value of harbors and waterways to small boat traffic. This type of benefit is usually measured in terms of hours of use or in terms of estimates of expenditures made to take advantage of the facilities. If measured in terms of hours of use, a value of one dollar an hour is usually assigned.

Navigation benefits are measured for the Bureau of Reclamation by the Corps. The Bureau then adjusts the results of Corps computations by the 1939-44 price level. The Federal Power Commission also uses Corps computations, but makes no adjustment. The Department of Agriculture does not measure navigation benefits in monetary terms.

f. Miscellaneous

Benefits from sedimentation and salinity control are measured by the Corps of Engineers by the value of the damage prevented or by reductions in costs and increases in the value of services provided and maintenance costs avoided, computed in terms of damage frequency relations. Benefits from recreation facilities are measured by expected expenditures by persons visiting the area plus general benefits to surrounding areas. Benefits from pollution abatement are measured by the cost of providing the most economical alternative method of waste treatment or disposal, or, where no alternative method exists, by reductions in maintenance and operating costs of purification plants. The Corps places no monetary value on fish and wildlife benefits or upon benefits resulting from increased use of capital.

The Bureau of Reclamation is the only agency which attempts the measurement of benefits from improved fish and wildlife and from increased employment. The first is based upon the estimates by the Fish and Wildlife Service of the expenditures of sportsmen on fishing and hunting and of the gross market value of fish and fur taken for commercial purposes. The benefits from increased employment is measured by labor's share of added incomes, taken as part of the benefits from agricultural production and from power.

Benefits from salinity control are computed by the Bureau on the basis of the value of damages prevented, by the increased use made possible, or by maintenance costs avoided, calculated in terms of damage frequency relations. Benefits from sedimentation control are measured in much the same manner except that, in some cases, they must be measured by increases in the value of services provided. Domestic and industrial water supply benefits are computed by comparison with the most economical alternative supply or, in the absence of an alternative supply, by determining the value of the additional water to the consumer. Benefits from pollution abatement are calculated in essentially the same manner. The Bureau measures benefits from increased use of capital by assigning to capital a share in the increase in income from agricultural production and provision of power.

The Department of Agriculture measures benefits from sedimentation control by the value of the damage prevented, by reductions in costs or increases in the value of the services provided, or by the value of the extended life of the project facilities. Benefits from salinity control, recreation, fish and wildlife, increased employment, pollution abatement, and from increased use of capital are not measured by the Department.[20]

2. Costs

There is less variation in the cost practices of the agencies than in their benefit practices. The project costs which the agencies measure include all expenditures by the Federal Government and by all other agencies which take part in the establishment, operation, and maintenance of the project. These costs are reduced to an equivalent annual average in order to facilitate comparison with benefits expressed in the same terms. It is in this latter respect that the major differences exist among the agencies.

a. Initial investment costs

The Corps of Engineers includes, as initial investment costs, all costs incidental to the construction of the project subsequent to Congressional approval, such as labor, materials, and equipment necessary to design and construct the project. Included in this category also are the costs of lands, rights-

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[20]Both the Department of Agriculture and the Corps of Engineers assume that other equally profitable methods of using capital could be employed, with the result that no increased use can result from project formation.

of-way for construction and operation, damage compensations, structural and utility relocations, remedial measures, legal expenses, overhead costs, and all other costs incurred in establishing the project, including interest during construction and allowances for contingencies, plus an allowance for the salvage value of the land but not for project structures. The allowance for interest during construction is set at three per cent for Federal investments and at 3½ per cent on non-Federal investments.[21] The allowance for contingencies is on a sliding scale, depending upon the degree of refinement and the accuracy of the data used in cost determination. Typically, the net annual charges on initial investment will be approximately 4.15 per cent on Corps' projects.

The Bureau of Reclamation includes as initial investment costs the same items as does the Corps. The major differences between Bureau and Corps practices are the inclusion by the Bureau of a salvage allowance based on the use value remaining in major project structures, and application of an interest rate of 2½ per cent on all costs, Federal and non-Federal. These two factors, in conjunction

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[21]Non-Federal costs are largely those costs which the Federal Government requires state and local agencies to undertake as a condition of Federal participation. An example would be the cost of setting up required agencies to determine repayment assessments.

with somewhat lower amortization and replacement charges can result in net annual charges on initial investment costs of only 3.13 per cent as contrasted with the 4.15 per cent of the Corps.

Initial investment costs as computed by the Department of Agriculture are somewhat more inclusive than is the case for the other agencies, partly because it includes in total investment costs a charge for consequential damages, which are not calculated by the other agencies. Total investment costs are defined as all Federal and non-Federal costs subsequent to Congressional approval of the project. These include such costs of establishing projects as labor, materials, equipment, lands, rights-of-way, engineering plans and designs, technical assistance and supervision, and allowances for contingencies and for guidance and assistance in relocating displaced persons. The allowance for contingencies varies with the degree of refinement of the cost data available. The major differences between the Department of Agriculture and the other agencies lie in the Department's treatment of consequential damages, its failure to calculate salvage values for either the land or major structures or to set up an amortization fund, and in the fact that it uses an interest rate of two per cent on its initial investment costs to reduce them to average annual amounts. No salvage values or amortization charges are assigned by the Department because it assumes that its projects will have perpetual life. The lower interest charge plus no amortization charge cause the Department's typical net annual charges to be approximately 3.01 per cent.

The Federal Power Commission includes in initial investment costs all costs for labor, materials, lands, rights-of-way, damage compensations, structural and utility relocations, and remedial measures needed to establish the project. To these it adds twenty-five to thirty-five per cent to cover such additional costs as engineering, inspection, legal expense, interest during construction, administrative and miscellaneous general expense, and an allowance for contingencies. An interest rate of 2½ per cent for all costs, Federal and non-Federal, is used to convert non-uniform costs to an equivalent annual average. The typical net annual charges for the F.P.C. are approximately 5.65 per cent. Extremely high amortization and miscellaneous charges, plus the fact that no salvage value is assigned to either project structures or land, cause the net annual charges for Commission projects to lie substantially above those of the other agencies.

b. Computation of annual costs

The results of annual cost computation have been pointed out in connection with treatment of initial investment costs and in Table I. It is necessary now to examine the methods of computation upon which those results are based.

The Corps of Engineers calculates interest charges on the total of the original investment cost without any deduction for salvage values of the land. If Table II is read as dollars with relation to an original Federal investment of 100, using an interest rate of three per cent, interest charges would be three dollars.[22] Amortization charges, however, are based upon the initial investment cost reduced by the salvage value of the land. Again in terms of Table II, using a period of analysis of fifty years and an interest rate of three per cent, deduction of the salvage value of the land from total initial investment costs brings amortization charges to .80 in relation to an initial Federal investment of 100.[23]

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[22] The interest charges are based upon the entire initial investment under the assumption that expectations will be fulfilled and subsequent investment made at the same rate. Under this assumption, amortization and initial investment will exactly match at the end of the time period.

[23] Total sinking fund charges will be higher by the amount of replacement charges, in this case .48.

TABLE II

ANNUAL CHARGES FOR A GIVEN HYPOTHETICAL PROJECT CONDITION[a]

Item	Corps	Department	Bureau	F.P.C.
Investment in land	30	30	30	30
Investment in project works. .	70	70	70	70
Total investment	100	100	100	100
Period of analysis (maximum for each agency is used) . .	50	(b)	100	50
Annual charges other than operation and maintenance:[c]				
Interest	3.00	2.00	2.50	2.50
Amortization fund charges[d]	.89	none	.23	1.03
Major replacements[d] . . .	.48	1.01	.52	.60
Taxes	small	none	none	1.40
Insurance.	none	none	none	.12
Gross annual charges (excluding operation and maintenance.	4.37	3.01	3.25	5.65
Deductions to allow for remaining use value:				
(a) land	.22	none	.07	none
(b) project works.	none	none	.05[e]	none
Net annual charges	4.15	3.01	3.13	5.65

These amounts may be read either as percentages or as dollars with relation to an initial federal investment of 100.

[a]Subcommittee on Benefits and Costs, Proposed Practices for Economic Analysis of River Basin Projects: Report to the Federal Inter-Agency River Basin Committee, May, 1950, Table 3, p. 85.

[b]The Department assumes perpetual life for its projects.

[c]Operation and maintenance charges vary widely for the various types of projects under the jurisdiction of the several agencies and have, therefore, not been included.

[d]The division of the sinking fund into amortization and replacement is made for bookkeeping expedience. Total sinking fund charges will be the sum of amortization and replacement charges.

[e]Maximum allowance of fifty years beyond the original period of analysis is assumed.

All costs, other than initial investment costs, over the entire period of analysis, which are incurred as a consequence of maintaining and operating the project are taken into account by the Corps through allowances for operation and maintenance. Major replacement costs are converted to present values, and interest and amortization charges are made upon such values over the full period of analysis.

Interest costs are computed by the Bureau of Reclamation on the basis of total initial investment minus an allowance for the present value of the land as salvage, and an allowance for the remaining use value of major structures. An interest rate of 2½ per cent is applied to the remainder. Amortization charges are calculated in the same manner. In both cases the period of analysis could run as high as one-hundred years.

The Bureau of Reclamation is unique in its method of determining its replacement costs, by virtue of its use of a "net" measurement. Total replacement costs are reduced by the present use value of replaceable items on a straight-line depreciation basis whenever the life of replacement items extends beyond the life of the project as a whole. In no case, however, is such depreciation extended for more than fifty years beyond the end of the original period of analysis. All other types of costs which are incurred in operating and maintaining the project are included as operational and maintenance costs. The Bureau makes no allowance for insurance costs, since the reserve for contingencies is adjusted according to the degree of known risk, or for loss of taxes. It is the position of the Bureau that increases and decreases in taxes will offset one another.

Since the Department of Agriculture assumes perpetual life for its projects, it makes no allowance for salvage values or for amortization. This means that interest charges on initial investment costs are made on the total of such costs and are included in annual cost in perpetuity. An interest rate of two per cent is applied for this purpose. The Department includes the allowance for replacement cost as a part of maintenance cost, and computes the allowance by dividing the initial cost by the estimated life of the item.[24] All costs, whether Federal or non-Federal, including increases in costs of production on lands containing project features, which are necessary for operation and maintenance of project investments in perpetual life, are considered to be part of operation and maintenance costs.

Like the Department, the Federal Power Commission makes no allowance for either the salvage value of the land or for major structures. Therefore the allowance for interest on the initial investment is made on the basis of total

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[24]The Department of Agriculture assumes that the project will have perpetual life, subject to replacement of project features as they depreciate.

initial investment at the rate of $2\frac{1}{2}$ per cent. 1.03 per cent of initial investment costs is set aside for amortization purposes. The fund so established is intended to amortize the investment cost in full over the period of analysis. In addition to this rate for amortization, the F.P.C. allocates .60 per cent of the total investment cost to an allowance for annual average replacement cost, .12 per cent to an allowance for insurance cost, and 1.40 per cent as an annual fixed charge in lieu of taxes that would be paid to state and local governments if the projects were privately owned. (See Table II).

The Commission computes operating and maintenance costs as all costs, other than the above, as they are incurred in the operation and maintenance of the project. In no case are any costs computed for any project elements which are not connected with hydroelectric power and the general administration thereof.

It is extremely difficult to compare agency estimations of operational and maintenance charges. As stated by the subcommittee:

> In general, they appear to be on consistent bases but in amount they vary over a wide range due to the great variation in project conditions encountered. The only major point of difference in current practice is that the Department of the Interior uses a selected historical base level of prices in estimating its operation and

maintenance costs whereas all other agencies use prices prevailing at the time of the analysis.[25]

As Table II illustrates, however, there is substantial difference in agency treatment of other types of annual charges. A part of this difference lies in the interest rate selected by each agency, both to calculate interest charges and to reduce amortization and replacement charges to equivalent annual averages. Another difference lies in the period of analysis which each agency assumes for its projects. If the hypothetical project considered in Table II were analyzed over a single time period for each agency, the variation in annual charges would not be quite so wide. To do so would, however, be unrealistic since the agencies will seldom, if ever, apply the same period of analysis to any given project. The Corps of Engineers and the Federal Power Commission apply a fifty-year limit to their projects as a means of allowing for the uncertainty of predicting future conditions and events, rather than because of certainty that the project will fail to be economical beyond that time period.[26] The Bureau attempts to estimate the economically useful life of their projects to the limit, relying upon risk allowances and the interest and discount rates to compensate for

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[25] Subcommittee, "Proposed Practices," op. cit., p. 84.

[26] Ibid., p. 83.

uncertainty. The Department of Agriculture always assumes perpetual life for their projects under the assumption that future requirements for watershed treatments will increase and that each project will have to be maintained in perpetuity.[27]

C. Choice of the Price Level

The soundness of project formulation and justification analyses depends upon the accuracy of benefit and cost estimates, and upon the ability to make the two fully comparable. This makes the choice of the price level, in terms of which the values of the benefits and costs will be expressed, a matter of crucial importance.

The Subcommittee on Benefits and Costs states:

> Ideally, measurement standards in project evaluation should reflect the interests of society as a whole. As such, these standards should be concerned with real costs and benefits.[28]

If this were the case, the cost to society of resources used for project construction could be measured by the amount of other goods and services for which those resources could be exchanged at the time when they are to be used. It is, unfortunately, not possible to establish and apply such a real

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[27] *Ibid.*, p. 84.

[28] *Ibid.*, p. 16.

standard of value. The legislators and planners who are responsible for water resource development are, other considerations aside, products of our market oriented society, and are accustomed to thinking in market terms. Yet future benefits must be expressed in terms comparable with more immediate costs if the benefit-cost analysis is to have meaning. The extent of the problem becomes apparent when one considers the fact that the periods of analysis vary from the fifty year period used by the Corps and the Commission, to the one-hundred year period used by the Bureau, and perpetual life assumed for its projects by the Department. Over such extended periods, it is possible for the price level to fluctuate widely.

The Corps of Engineers, the Department of Agriculture, and the Federal Power Commission all use the price level prevailing at the time of the analysis for calculation of benefits and costs. The Bureau of Reclamation, however, uses several price levels, its choice at any particular time depending upon the types of benefits to be measured. For calculating benefits from irrigation, the Bureau estimates the average prices expected to prevail during the life of the project. It is currently basing its estimates upon the 1939-1944 price level. The future costs expected to accrue to irrigation features are calculated on the same basis. Power benefits are measured on the basis of the annual average power rates expected to prevail over the life of the project. Fish and wildlife benefits and costs are measured by prices occurring locally within a ten year period immediately prior to the time of analysis. Recreation benefits and costs are computed on the same basis as for irrigation effects.

The major part of the Bureau's benefits, then, are measured on the basis of a price level which is currently in the neighborhood of one-half the prevailing price level. This means that Bureau benefit figures will be far understated as compared with those of the other agencies.

D. Intangible Benefits and Costs

There is usually no attempt made by any of the agencies to measure such intangibles as loss of historic or scenic sites. Although these effects may be included in computations, this is not normally done until after initial justification has been determined. The values placed upon such effects are based upon Fish and Wildlife Service estimates of the use value of such sites as recreation facilities. Other types of intangible effects, such as resettlement and consequential costs, are measured only by the Department of Agriculture. These effects are included by the Department as an offset to benefits, and their value is established by estimates based upon experience in comparable areas.

E. Comparison of Benefits and Costs

In comparing benefits and costs (see Table III), all of the agencies place upon the cost side of the ledger only those costs which they consider to be project costs. These would be the cost of initial investment plus those costs associated with operating and maintaining the project. All other costs are usually deducted from benefits. The benefits figure with which project costs are compared is thus benefits net of all costs other than project costs. This aids in achieving the goal set forth by the Subcommittee on Benefits and Costs of conservatism in valuing project effects.

> In general, it is preferable that estimates be on the conservative side, and have a reasonably high degree of certainty of occurrence.[29]

The costs which are compared with benefits in Table III are, then, only those costs which are considered to be "project" costs. It will be noticed, however, that the Department of Agriculture includes in this category the cost to farmers of installation and increased operating expense, while the Corps of Engineers includes the cost to non-Federal agencies for terminals which are necessary for utilization of navigational facilities. The Bureau does not include the costs to users in an irrigation program, but does include this on

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[29] Ibid., p. 18.

TABLE III

METHODS OF COMPARING PRIMARY PURPOSE BENEFITS AND COSTS[a]

Benefit side of the ledger	Cost side of the ledger
The Department of Agriculture	
Off-site benefits (such as flood and sediment damage prevention and increased property utilization) which consist of increases in net incomes (equivalent to increases in gross income less costs other than project costs), plus on-site benefits which consist of increases in gross incomes resulting from higher production on lands on which the measures are installed and reductions in normal operating expenses on such land.	Project costs include the cost of project measures to governmental agencies and to owners and operators of lands on which the measures are installed, decreases in gross incomes on any such lands, and increases in normal operating expenses on such lands.
The Bureau of Reclamation	
Increase in gross crop incomes. The Bureau has made the assumption that this item is equivalent to the sum of net direct benefits to agricultural interests (increase in water users net crop incomes), and the net indirect benefits, to both agricultural and non-agricultural interests, resulting therefrom.	Project costs include the cost of project measures, but do not include farmers' or water users' costs since they are assumed to be accounted for on the benefit side.
The Corps of Engineers--Flood Control	
Amount of direct and indirect flood damages prevented. (No costs other than project costs are involved) plus increase in net income resulting from higher utilization of property (equivalent to increase in gross income less costs other than project costs).	Project costs include the cost of project measures, but do not include property users' costs where necessary to realize increased utilization benefits, since such costs are deducted on the benefit side.
The Corps of Engineers--Navigation	
Savings due to use of water transportation as compared with alternative methods (equivalent to the total cost of the alternative less all costs by the waterway method, other than project costs; e.g., water carrier costs).	Project costs include cost of project measures, and costs of public terminals, and navigation aids, but do not include water carrier and private terminal costs, which are deducted from benefits.
The Federal Power Commission	
Value of hydroelectric capacity and energy from the project (based upon the cost of equivalent power from an alternative source, usually steam electric, with certain adjustments, which allow for any differences in transmission costs and losses).	Project costs include the cost of the hydroelectric development, but does not include transmission costs, which are accounted for on the benefit side.

[a]Taken from Table 2, Subcommittee on Benefits and Costs, _Proposed Practices for Economic Analysis of River Basin Projects_, _op. cit._, p. 68.

the benefit side as a part of the gross increase in crop income.

In Tables IV and V, the benefit-cost ratios of the agencies are compared as they will be affected by the divergences in the treatment of indirect effects. Since the Bureau is the only agency which calculates such effects, the comparison is made between the Bureau results and those of the other agencies as a group. Indirect effects are taken, for this latter group,as being a ratio of 1.415 to 1 to net primary benefits.[30] The value of indirect effects will be taken for these agencies as being established by this ratio, i.e., 1.415 times the value of primary benefits.[31] In both cases, a five per cent credit for use of unemployed resources will be applied. The benefits which are considered to stem from the project from processing of project products are reduced by the costs incurred in the course of processing. In the same way a net figure is arrived at for those benefits which are induced by an expansion of economic activity

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[30] Report of the Panel of Consultants, op. cit., p. 26.

[31] Report of the Panel of Consultants, op. cit., pp. 26-28. The other agencies assume that the $3,000,000 of secondary benefits are derived from the $2,120,000 of primary benefits. This provides the ratio of 1.415 to 1. They then apply the same ratio to the net primary benefits. The ratio would vary from project to project, depending upon the magnitudes of primary and secondary benefits.

TABLE IV

CALCULATION OF THE BENEFIT-COST RATIO BY THE BUREAU OF RECLAMATION[a]

Item	Benefits and Costs	Nets
Gross primary product	$10,000,000	
Less associated costs	7,880,000	
Equals primary benefits		$2,120,000
Stemming benefits	$12,500,000	
Less stemming costs	11,500,000	
Equals net stemming benefits		$1,000,000
Induced benefits	$24,000,000	
Less induced costs	22,000,000	
Equals net induced benefits		$2,000,000
Total benefits net of associated and indirect costs		$5,120,000
Project costs	$2,000,000	
Less 5% credit for using unemployed resources	100,000	
Net project costs		$1,900,000

Benefit-cost ratio = $\frac{\$5,120,000}{1,900,000}$ = 2.69 to 1

Net primary benefits = primary benefits - net project costs = $220,000

Total net benefits = net primary benefits + net stemming benefits + net induced benefits = $3,220,000

[a]This table is derived from information found in the Report of the Panel of Consultants, Secondary or Indirect Benefits of Water-Use Projects, to Michael W. Strauss, Commissioner, Bureau of Reclamation, Oct. 1952, pp. 23-28. It is probable that the Bureau's B/C ratio is somewhat understated since no allowance has been made for salvage values.

TABLE V

CALCULATION OF THE BENEFIT-COST RATIO BY THE OTHER AGENCIES[a]

Item	Benefits and Costs	Nets
Gross primary product	$10,000,000	
Less associated costs	7,880,000	
Equals primary benefits		$2,120,000
Indirect benefits calculated on the basis of the ratio of secondary to primary benefits, estimated at 1.415 to 1		311,000
Total benefits net of associated and indirect costs		$2,431,000
Project costs	$2,000,000	
Less 5% credit for using unemployed resources	100,000	
Net project costs		$1,900,000

Benefit-cost ratio $= \frac{\$2,431,000}{\$1,900,000} = 1.28$ to 1

Net primary benefits = primary benefits - net project costs = $220,000

Total net benefits = net primary benefits + indirect benefits = $531,000

[a]This table is derived from information found in the Report of the Panel of Consultants, Secondary or Indirect Benefits of Water-Use Projects, to Michael W. Strauss, Commissioner, Bureau of Reclamation, Oct. 1952, pp. 23-28. The Corps of Engineers would probably have a slightly higher B/C ratio since this example makes no allowance for salvage, which the Corps computes.

induced by the project. It will be observed that this course is followed only by the Bureau.

The Bureau and the other agencies subtract associated, or non-project, costs from gross benefits before project costs are deducted. The net direct benefit figure is taken to be the same for all agencies, including the Bureau. The net indirect benefits are, however, quite different. Application of the 1.415 to 1 ratio to net direct benefits yields a value of $311,000 for the other agencies. Direct calculation of indirect benefits yields a net indirect benefit figure of $3,220,000 for the Bureau. By dividing the total of primary benefits and net indirect benefits by net costs, the benefit-cost ratios of the agencies can be determined. In the case of the Bureau, this means that we divide $5,120,000 by $1,900,000 and obtain a benefit-cost ratio of 2.69 to 1. For the other agencies, a benefit-cost ratio of 1.28 to 1 is obtained by dividing $2,431,000 by $1,900,000. It is probable that the Bureau benefit-cost is somewhat understated since no allowance has been made for salvage values, but for the same reason, the other ratio would probably be somewhat low for the Corps of Engineers.

PART II

DISCUSSION AND EVALUATION OF

BENEFIT-COST ANALYSIS

PART II

INTRODUCTION

In Part I, the practices of the public agencies with respect to the benefit-cost analysis have been outlined. Part II consists of discussion of the various aspects of this analysis and of some of the problems inherent in its use.

It is assumed throughout that the basic purpose of the benefit-cost analysis is to determine whether and to what extent resources are used more effectively in the project under consideration than in alternative uses. It is further assumed that the appropriate measure of resource effectiveness will be the ability of those resources to produce net benefits. Resources will be used most effectively, then, when benefits most exceed costs. This requires a careful examination of the methods of measuring both benefits and costs. Economic analysis conducted by public agencies must give full expression to social benefits and costs. This objective can be attained only by taking all relevant costs and benefits into account, private and social alike.

> If efficiency in the development of water resources is to be achieved, devices for extra-market allocation must be used to supplement the market. This requires efficiency criteria which will take account of the relevant social gains and costs to be used as an aid in budgeting public revenues for development of water resources.[1]

Public agency practices will also be evaluated on the basis of clarity of the results produced. There is considerable value to be derived from an economic analysis of water-use project effects beyond the immediate decision as to whether given water-use projects are to be developed. Much can be learned from comparison of benefit-cost estimates made prior to construction of a project, and the actual results from that construction. The lessons learned in such a comparison might result in improvements in the techniques of measurement and calculation. It is desirable, then, that values placed upon project effects, and offsets to these values, be clearly defined.

In the following chapters attention will be directed to problems created by the existence of indivisibilities and complementarities in water-use projects, to problems of time in measurement of project effects, to problems of divergences between private and social benefits and costs,

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[1]John V. Krutilla and Otto Eckstein, Multiple Purpose River Development: Studies in Applied Economic Analysis, (Baltimore: The Johns Hopkins Press, 1958), p. 53.

and to problems of ranking in project development. These and related problems provide the framework for our evaluation of public agency benefit-cost practices.

CHAPTER III

MARKET AND SOCIAL VALUES

A. Introduction

The point of view from which water-use project benefits and costs are considered is of major importance in evaluating the extent to which the benefit-cost analysis is successful as an economic analysis. Since public agencies and public funds are concerned, all of the effects of development, private and social, must enter into the analysis.

> The adequacy of results obtained in project formulation and in evaluation of the justification and relative desirability of projects depends upon how completely a comprehensive public viewpoint can be realized; that is, how completely all effects on individuals and society as a whole can be traced and evaluated in comparable terms . . .[1]

In this chapter attention will be directed to situations in which divergences may occur between private and social benefits and costs. This requires discussion of diffused benefits and costs, communal services, external

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[1]Subcommittee on Benefits and Costs, Report to the Federal Inter-Agency River Basin Committee: Proposed Practices for Economic Analysis of River Basin Projects, (Washington, D. C.: United States Government Printing Office, May, 1950), p. 6.

economies and diseconomies, complementarity and substitutability between projects and project purposes, and adjustment to market prices to compensate for tax effects, the presence of unemployed resources in the system, and additions to social overhead caused by the project.

B. Diffused Effects and External Economies and Diseconomies

It is usually assumed that, under perfectly competitive conditions, the total output of a firm, when valued at market prices, will reflect the total returns from the uses of productive resources in that firm. Under equilibrium conditions, the marginal costs of the resources used in production would equal marginal returns from their use. This sets the limits for productive investment in the firm.

There are, however, two situations in which investment to the point of marginal equality of costs and returns will give rise to divergence between market and social values, making it possible to reallocate resources in such a manner as to increase welfare.[2] The first of these

[2] Tibor Scitovsky, "Two Concepts of External Economies," Journal of Political Economy, Vol. LXII, April, 1954, pp. 143-151.

situations will arise whenever there is direct interdependence among members of the economy which does not operate through the market mechanism, the second when investment in one firm gives rise to increased profits in another firm.[3] Both of these situations are relatively common in water resource development. The objective of net benefit maximization through development of water-use projects requires that all relevant costs and benefits, private and social alike, be taken into account.

1. Direct Interdependence

Direct interdependencies will affect the magnitudes of both direct and indirect benefits and costs, but their effects will not be reflected through the market mechanism. Direct interdependencies will occur whenever individuals and firms can obtain the goods and services produced by the project without paying for them; or when the output of the project will depend, not only upon its own use of resources and the scale of its development, but upon the activities of other projects as well. This involves, then, problems of joint benefits derived from project formation,

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[3] *Ibid.*, p. 144 and p. 148.

and joint supply by different projects and by different purposes within the same project. It is probable that direct interdependencies exist between project purposes as well as between projects. A problem arises, therefore, regarding the degree to which complementarity between purposes ends and substitutability begins.

a. Joint benefits and joint supply

The clearest example of joint benefits in demand and joint supply is to be found in flood control purposes of water-use projects. A storage reservoir designed and constructed by community A to protect it from flood damage will also protect community B in the same reaches of the river. The inhabitants of B receive the protection of the flood control devices of A, but cannot be assessed a fee for that protection. Protection for A alone might be too costly in terms of the value which that community receives, but the project might become economically justified in terms of the aggregate value to A and B considered together.[4]

Even if the large original outlay would be small if divided equally among all beneficiaries, each individual

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[4]Cf. W. G. Hoyt and Walter B. Langbein, Floods, (Princeton: Princeton University Press, 1955), pp. 229-230.

> might decide that it would be in his interest to avoid a commitment to pay on the chance that the contribution of others would make it unnecessary. Simultaneously, each might also be reluctant to commit himself for repayment for fear others might fail to contribute, making the cost to him greater. . . Pricing mechanics are not equal to the collection of payment so long as protection cannot be denied one who is delinquent without simultaneously denying protection to those who willingly meet their obligations. In the absence of extra-market incentives, no private enterprise has an incentive to provide the requisite services.[5]

The existence of wide-spread joint benefits in flood control purposes of water resource projects renders it unlikely that private individuals will provide such services. Communal action will usually be required.

Before flood protection can be offered to even a limited number of individuals in a flood plain, there is a certain irreducible level of investment required.[6] The initial investment required may be quite large, and once made, will offer protection to all individuals in the flood plain. In addition to the indivisibility in investment in individual projects, there is a certain amount of functional interdependence between flood control projects in a river basin. This contributes to investment indivisibility to

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[5]John V. Krutilla and Otto Eckstein, Multiple Purpose River Development: Studies in Applied Economic Analysis, (Baltimore: The Johns Hopkins Press, 1958), pp. 55-56.

[6]Ibid., p. 55.

the extent that the success of a flood control project in delivering the benefits which it was designed to produce depends upon investment in other projects above it.

> Regulation of floods by the TVA system can be considered as a four pronged effort: First, the acceleration of flood threatening flows through the system; second, the impounding of the contributary flow from tributary streams; third, a flattening of flood crests by impoundage at projects close to the point of flood hazard; and last, the gradual release of stored water following the flood crest to regain storage capacity. The first of these functions is accomplished largely by the chain of main stream projects. The second is accomplished by tributary projects having substantial reservoir capacity, while the third makes use of both tributary and main-river storage.[7]

Elimination of a storage reservoir in the system will have the effect of reducing the benefits to be derived from those remaining. This may create an investment indivisibility necessitating a specific level of investment in all of the projects if the flood control purposes of the individual projects are to be economic and effective. It is this combination of collective demand and sizable initial investment which leads the public agencies into the field of water resource development.

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[7]Reed A. Elliott, "TVA Experience in Multiple Purpose River Development," Paper presented at the National Convention of the American Society of Civil Engineers, Knoxville, Tennessee, June, 1956, p. 12.

Important as are the divergencies between market and social values for flood control purposes of water-use projects, the other purposes of such a project may exhibit interdependencies which are equally impressive. There is, for example, considerable interdependence between storage in the headwaters of a stream for production of hydroelectric power and the downstream generation of that power. Thus a hydroelectric project may add substantially more to a power system than the energy which it generates on the site. To the extent that a hydroelectric project confers downstream benefits upon other projects, there will be a divergence between project and social benefits if these projects are fiscally independent. The divergence will be indicated by the difference between at site power generation and the total generation effects attributable to the project.

> Storage provided at upstream reservoir sites will often do double, and in some cases greater, duty as it contributes to the prime power generation of hydroelectric power plants downstream. For example, storage provided at the Hungry Horse site on the Flathead River of the Columbia River tributary system can be used to generate 212,000 kilowatts of prime power at the Hungry Horse powerhouse. Its contribution of prime power under coordinated system operation, at downstream plants currently built or under construction, is nearly three times as great. (628,000 kilowatts)[8]

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[8] John V. Krutilla and Otto Eckstein, *op. cit.*, pp. 63-64.

The difference between the returns which a private enterprise could obtain from the sale of 212,000 kilowatts of prime power and the returns accruing to the total prime power output resulting from the interdependence of the Hungry Horse site and the downstream sites yields an approximation of the difference between the project and social values resulting from development of the Hungry Horse site,[9] that is, the value of the 628,000 kilowatts of prime power produced at downstream plants as a direct consequence of Hungry Horse development.

To a considerable extent, power production at the project site will depend also upon the facilities of projects upstream, when upstream projects rely upon water storage. Release of water from upstream storage sites during critical flow periods provides additional water supplies for the downstream project, and, hence, a larger output of primary power from that project.

Efficient investment in water resource projects must take these interdependencies into account, in addition to

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[9]It is possible that a private developer of Hungry Horse might make a deal with downstream operators which would enable him to share in this gain. This would, however, only reduce the divergence, not eliminate it.

the returns to the individual project.[10] This requires coordination of management to maximize system output rather than outputs at individual projects in the system. In any event, calculation of benefits and costs expected to follow from development of a specific project site must be sufficiently broad to encompass downstream effects, in terms of both gains and losses to downstream locations.

All of the agencies except the Department of Agriculture, which does not usually evaluate benefits and costs from power production, calculate downstream effects as a part of the direct benefits from increased power production. It is not clear to what extent these downstream effects are considered for such purposes as sedimentation control and domestic and industrial water supplies. It would be difficult for benefits and costs from navigation facilities, pollution abatement, salinity control, and flood control to be calculated without taking downstream effects into account, since the impact of these purposes generally occurs downstream from the project area. It can therefore be assumed

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[10] Note that agency practices with respect to calculation of hydroelectric effects take downstream benefits and costs into account to the extent that those benefits and costs can be directly attributable to development of the specific project.

that project effects on downstream projects will enter into agency calculations.

b. Interdependence between purposes

There will be direct interdependence between the purposes of water-use projects, as well as between the projects. Most of the purposes of a project will call for storage of stream waters. If storage is provided to meet the requirements of one purpose, flood control for example, this same storage can frequently be used to serve other purposes, such as recreation, power production, navigation, and industrial and commerical water supply.[11] There is usually, however, a definite range of complementarity within which this joint use is possible. Outside of this range it is possible to provide more storage for any given purpose only by reducing the scale of other purposes. Thus a specified degree of flood control at any given point may necessitate curtailment of power output which relies on storage reduction (by placing minimal flood storage requirements upon the reservoir). In the same way, minimum channel depths for navigation will place a constraint upon the amount of storage that may be accumulated for other purposes.

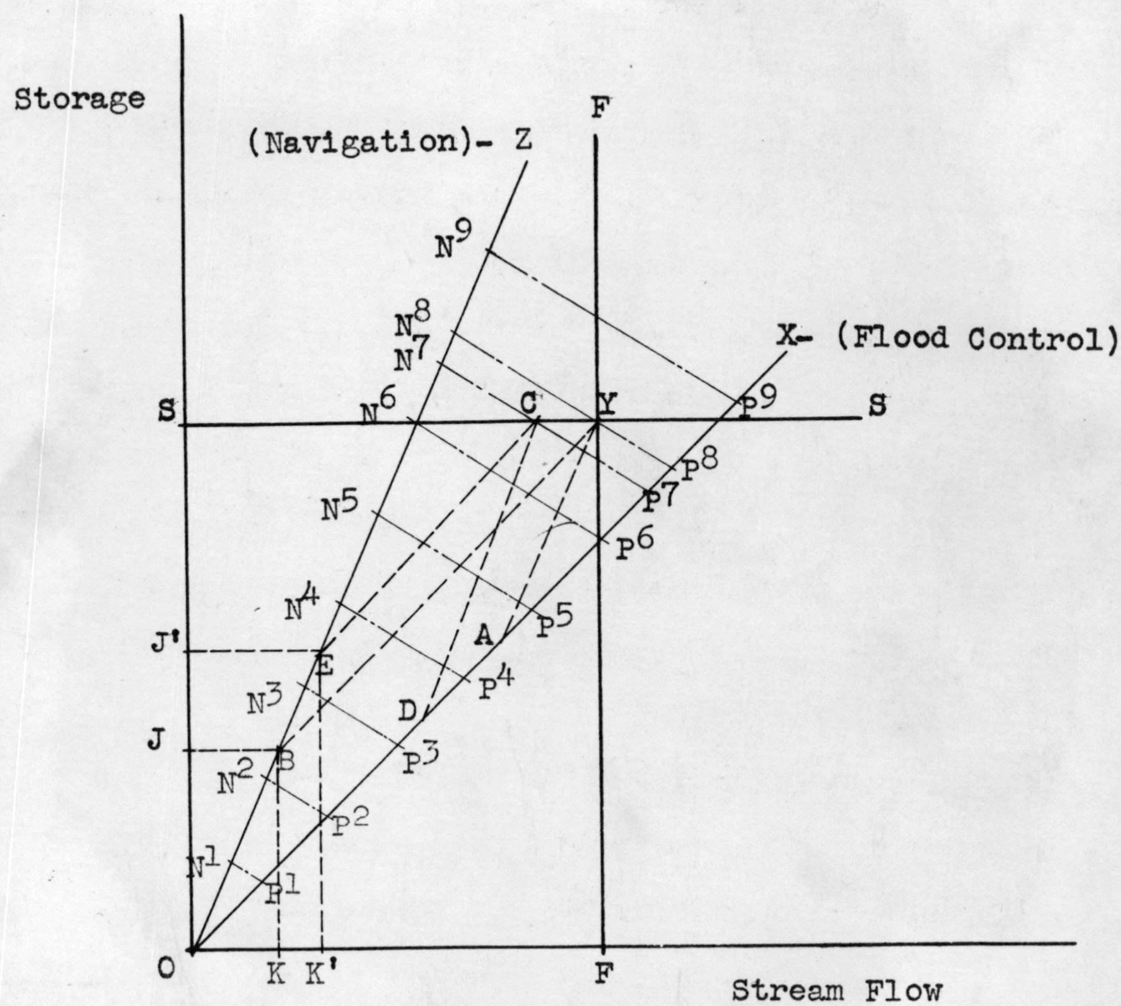
[11] *Ibid.*, p. 69.

This can be explained by the linear programming techniques illustrated in Figure 1. Here the discussion of substitution between purposes of a project is conducted in a manner analogous to that of factor substitution in the usual analysis of the firm. The distinction here is the assumption that there exists a minimal requirement for one of the two purposes considered. For simplicity it is further assumed that the value of each unit or output of the two purposes is independent of the number of units produced, and that the same linearity holds for unit costs.[12] Thus each point on a purpose line (Z and X) will designate (1) a certain physical output, (2) a certain value of output, (3) a certain cost of factors, and (4) a certain net value of output. Each iso-value line will designate combinations of the two purposes yielding the same net benefits. Along any purpose line the net value of output will equal the physical output times the net value per unit and will be proportional to the physical output. It must be stressed that the scales by which net value returns (net benefits) are measured on the purpose lines are not necessarily the same, since the scale of each line reflects the

[12]This means that returns and costs will be constant over the relevant production range.

FIGURE 1

PURPOSE SUBSTITUTABILITY WITH A MINIMAL REQUIREMENT FOR NAVIGATION



productivity of the factors used in that particular purpose and has no connection with the net benefit scale on any other purpose line.[13]

The two purposes under consideration will be flood control and navigation. It will be assumed that these two purposes will be constrained by the storage available (as represented by the dam and reservoir), and by the natural flow of the stream. These constraints are indicated by the lines SS and FF respectively. Since these are supposed to be effective constraints, all scales of the two purposes which lie above line SS and to the right of line FF are impossible of attainment. A solution must be sought within the area OSYF. Any point within the area OSYF represents a particular amount of storage and stream flow which can be used simultaneously. Since the project has the choice of operating at any feasible point, and the objective sought is maximization of net benefits, a point will be selected which lies on the highest iso-value line possible of attainment (N^1P^1, N^2P^2 etc.). The highest iso-value line possible of attainment in Figure 1 is N^8P^8, and the relevant point on that value line will be its point

[13]Cf. Robert Dorfman, "Mathematical or Linear Programming: A Non-Mathematical Exposition," American Economic Review, Vol. XLIII, No. 5, December, 1953, p. 801.

of intersection with the constraint lines SS and FF, or point Y. By dropping two lines from this point, one parallel to line OZ (navigation), and the other parallel to OX (flood control), combinations of purposes Z and X which will result in a maximum of net benefits are found. Thus OB of purpose Z and BY of purpose X (i.e., AY of purpose Z and OA of purpose X) will maximize net benefits.[14] OJ of storage and OK of stream flow will be used for navigation, and JS of storage and KF of stream flow will be used for flood control.

Let us now introduce a further constraint and assume that a minimum of storage and stream flow represented by OE is required for purpose Z because of indivisibility. A new obtainable position must be sought. By drawing in line EC parallel to the purpose line OX, it is found that the best obtainable solution will be that in which OE of purpose Z and OD of purpose X are developed. This will entail an increase in the amount of navigation (Z) and a decrease in the amount of flood control (X). Navigation will be increased in the amount of OE, with storage and stream flow for this purpose being increased by JJ' and

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[14] It will be remembered that constant returns have been assumed.

KK' respectively. Flood control will be reduced in the amount of DA, with storage and stream flow for this purpose reduced by JJ' and KK' respectively. This bears out the original suggestion that beyond the range of complementarity, a relationship of substitutability exists which will entail sacrifice of amounts of one purpose to obtain additional amounts of any other purpose. Calculation of project benefits and costs will require determination of the range of complementarity and substitutability between the purposes of the project, as well as of the interdependence between projects.

The agencies concerned with water resource development appear to recognize this need.

> The desired scale of development is that at which the net benefits are at a maximum. That condition is met if the scale of development is extended to the point where the benefits added by the last increment of extension of scope are equal to the costs of adding that increment. The increments of scope to be considered in this way are the smallest increments on which there is a practical choice as to inclusion or omission from the project.[15]

Where there exists a practical choice as to inclusion or exclusion from the project, the scope of investment in any particular purpose may be either increased or decreased

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[15] Subcommittee, "Proposed Practices," op. cit., pp. 36-37.

according to net benefits received. Ability to determine the practicality of inclusion or omission of any particular segment of a purpose requires knowledge of the range within which one purpose can be substituted for another.

2. Investment, Profits, and Market Interdependence

Direct interdependencies result from the existence of joint demands and joint supply which operate outside of the market mechanism. The type of interdependencies discussed in this section occurs within the market mechanism because of the existence of investment indivisibilities and because investment is a dynamic process in which the economy may be moved away from, rather than toward, equilibrium.[16]

Investment in an industry or firm will lead to an expansion of its productive capacity, with the result that the price of its product may fall and the costs of its factors may rise.[17] If that product is used as a factor of production in another industry, the latter's profits will rise. This rise in profits gives rise to external economies which will benefit firms. If a water-use project

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[16] Tibor Scitovsky, _op. cit._, pp. 148-149.

[17] _Ibid._

adds to the supply of hydroelectric power to such an extent that the price of power falls for firms using that power as a factor of production, the profits of those firms will rise. The addition to profits constitute benefits to firms attributable to the project. If the increase in profits causes the firms to increase their output, and, hence, their demand for electricity, the price of electricity will rise again. This could call forth additional investment in the hydroelectric facilities, causing the process to be repeated until equilibrium is reached.

> The profits of industry B, created by the lower price of factor A, call for investment and expansion in industry B, one result of which will be an increase in industry B's demand for industry A's product. This in its turn will give rise to profits and call for further investment and expansion in industry A; and equilibrium is reached only when successive doses of investment and expansion in the two industries have lead to the simultaneous elimination of profits in both.[18]

This is the basis for the Bureau of Reclamation's practice of calculating the indirect benefits from irrigation on the basis of the increased volume of agricultural products used in industry.[19] With respect to the purpose for which the

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[18] Ibid.

[19] It is, in fact, the basis for the measurement of all benefits which result from reduction in costs.

dynamic process is almost certain to occur, namely industrial cooling and processing water supply,[20] none of the agencies calculate the benefits from increased profits.

As productive capacity is expanded, the costs of factors used in production may rise. As Krutilla and Eckstein have pointed out, the profits of railroads in particular have generally risen because of the development of irrigation projects.

> Since freight rates are generally set for wide areas and are unlikely to be altered by the regulatory bodies as a result of an increased volume of freight from one relatively small area, the "pecuniary external economies" to railroads serving farmers become significant.[21]

The increased cost of factors are not measured specifically by any of the agencies, although benefits from increases in the cost of labor and capital will show up in the Bureau of Reclamation calculations through its measurement of benefits from increased employment and increased use of capital.

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[20]It is extremely probable that increases in the demand for water sufficient to cause the price of water to rise will call forth additional investment in water facilities. This is largely due to the relationship between water for industrial uses and water for domestic consumption, and the concern of authorities for adequate supplies of water for both uses.

[21]John V. Krutilla and Otto Eckstein, op. cit., p. 59.

It is likely that the effects of direct interdependencies will be reflected in the benefit-cost calculations to a much greater extent than will those interdependencies which operate without the market mechanism. A good many of the direct interdependency effects will, however, appear in those calculations as intangible effects and, hence, will be used when deciding which projects should be developed first, but not used to determine whether the project is economically feasible. The effects of interdependencies which occur through increased investment and rising profits will usually be reflected only in the benefit calculations of the Bureau of Reclamation. Both types of interdependencies will, however, give rise to important divergences between market and social values. The market orientation of the benefit-cost analysis, as applied by the public agencies, causes many of these divergences to be ignored.

C. Adjustment to Prices to Reflect Social Values

So long as it can be assumed that market prices adequately reflect the opportunity costs involved in the use of resources in water-use projects rather than for some other purpose, these prices will reflect the social cost involved in the use of those resources. But this approach yields an accurate reflection of social values only under conditions of perfect competition. As soon as there is any variation from those conditions, the conclusions reached under the terms of those conditions fail to apply.[22] For this reason, it is probable that the figures derived on the basis of market prices will have to be corrected if an accurate picture of the social value of benefits and costs from water resource development is to be obtained.

H. B. Chenery suggests three adjustments which must be made before full social value can be derived.[23] First, correction must be made for tax, subsidy, and tariff policies; secondly, a correction must be made for administered prices; and, finally, a correction is necessary for the presence of idle resources in the economy.

From the point of view of the public interest, some taxes are not a real social cost of the type that is involved in the use of goods and services in development of

[22] J. E. Meade, The Theory of International Economic Policy; Trade and Welfare, Volume II, (London: Oxford University Press, 1955), Chapter VII.

[23] H. B. Chenery, "The Application of Investment Criteria," Quarterly Journal of Economics, LXVII, February, 1953, pp. 76-96.

water-use projects.

> The only real cost engendered by the project is the increased cost of the governmental services that are required. Allowances for taxes would be adequate if project and associated costs included all increases in the costs of government services considered essential for realization of project benefits.[24]

Market prices should be corrected for any excess of taxes above this amount.[25] In the same way, and to the same extent, a correction should be made for the effect of subsidies upon market prices. The real cost to society of the project goods and services will be the marginal costs of producing those goods and services. There are, however, no adjustments made by the agencies for these effects. The only allowance made for taxes is the allowance for tax revenues lost to state and local governments due to project formation. This allowance is discussed in Chapter IV and is quite distinct from the type of adjustment referred to above.

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[24]Mark M. Regan and John Timmons, "Current Concepts and Practices in Benefit-Cost Analysis of Natural Resource Developments," Water Resources and Economic Development of the West: Benefit-Cost Analysis, Report No. 3, Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Berkeley, California, March, 1954, p. 12.

[25]To the extent that tax effects are uniform throughout the economy, adjustment to market prices for project goods and services could lead to an increased divergence. This may be particularly true for such taxes as those upon profits. Considerable care in applying and adjustment for tax effects will be required in such a case, to insure that adjustment is made only for relative differences in the project effects and those in other spheres.

A correction should also be made for additions to social overhead which are made necessary by project development. Galenson and Liebenstein have pointed out that, if new schools, hospitals, etc., are required due to formation of the project, the extra capital and operating expenses must be added to project costs if total costs are to reflect the entire social cost of the project.[26] Unless the workers themselves pay the taxes which finance this addition to social overhead, the opportunity cost of labor in money wage terms will normally not reflect this social cost. There are no adjustments made to compensate for increased social overhead. Market prices are used to value project effects under the assumption that they reflect only the opportunity costs of the resources used and nothing more. This leads to mis-statement of those effects.

The use of price and income measurements in benefit-cost calculations lends a national bias to analysis results. For this reason it will probably be necessary to make an adjustment in the project calculations to compensate for the effect which the project might have upon regional price

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[26] W. Galenson and H. Liebenstein, "Investment Criteria, Productivity, and Economic Development," Quarterly Journal of Economics, LXIX, August, 1955, p. 360.

levels. Most of the project benefits will occur within the region and may significantly affect regional prices. If the regional price averages are above the national averages, benefits from the project will probably be somewhat overstated in real terms. Thus, in cases in which the effect of the project upon the average price levels of the region is different than that of the nation as a whole, adjustment must be made in the results of the analysis. As the Subcommittee states:

> Special treatment will be required whenever the project production is sufficient to affect materially the relationship between area and national averages.[27]

This adjustment will be required to reflect the values to society from avoiding higher prices in the case of price reduction and the cost to society involved in a general price rise under price increase. If the regional average of prices after the project is undertaken lies below the national average, benefits from the project will be higher by the amount of the difference. If the regional price level lies above that of the nation as a whole, a downward adjustment of project benefits in the amount of the difference should be made. This adjustment is made by the public agencies according to the method indicated above.

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[27] Subcommittee, "Proposed Practices," op. cit., p. 20.

Care should be taken, however, to avoid over-correction. If before the project were undertaken a discrepancy had existed between the regional and national price levels, this might provide an offset to the adjustment. This would depend, however, upon the side upon which the discrepancy lay. If regional prices prior to the project were lower than the national average, and lower still after the project, the relevant adjustment would be only the amount of the reduction.

Up to this point such traditionally accepted areas of adjustment as those which must be made for the existence of decreasing costs have been largely ignored. Social returns can usually be increased by expanding production to the lowest point on the average social cost curve, so long as the economies gained are of the irreversible variety.[28] There is, however, some question whether such an adjustment should be made in the price level or should be treated separately as an addition to benefits. In general, the effects of such economies will show up as both an increase in production and as a reduction in cost and could be calculated on either basis.

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[28]H. S. Ellis and W. Fellner, "External Economies and Diseconomies," Reprinted in American Economic Association, Readings in Price Theory, edited by George J. Stigler and Kenneth E. Boulding, (Chicago: Richard D. Irwin, Inc., 1952), pp. 256-259.

As Otto Eckstein has pointed out, industries such as transportation and communication may very well be operating under decreasing cost conditions in sparsely populated areas.[29] This would mean that any project or project facility which would utilize the services of such industries would measure the social cost of those services by marginal costs rather than by the higher average cost. The benefits of the project should reflect this saving. The agencies' practice of measuring benefits and costs by market prices does not, however, give expression to this type of benefit.

In somewhat the same context, Krutilla suggests that interdependence of investment may lead to an additional project benefit which is given only passing attention in current benefit-cost calculations. He refers to the role which project formation may play in increasing the rate of capital formation in under-developed regions.

> . . . resource programs of the kind undertaken by the federal government should focus attention (within the limitation of their statutory authority) on influencing the supply functions of factors for which demand is highly responsive to secularly rising income nationally. These factors may be referred to as "strategic" factors. They will consist of productive factors for which demand will be relatively elastic both with respect to

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[29] Otto Eckstein, "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics," Quarterly Journal of Economics, LXXI, February, 1957, p. 62.

> price and income, and favorably influenced by changing technology and tastes.[30]

Development of projects which offer supplies of these strategic resources will do much to attract external capital to the region. This will be particularly true if these resources are required by industries which have a product demand of high price and income elasticity, since such industries can be expected to respond readily to changes in regional supply schedules, that is, can be expected to enter into production quickly as regional supplies of resources become more abundant.

Krutilla also stresses the possibility that stimulation to capital formation might be derived from triggered development in addition to development stimulated by shifts in factor supply.[31] He cites as evidence the increases in capital formation in the Tennessee Valley which resulted from agglomeration economies, as industries moved into the area to take advantage of the presence of basic industries which had been attracted by the shift in factor supply caused by water development.

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[30]John V. Krutilla, "Criteria for Evaluating Regional Development Programs," American Economic Review: Papers and Proceedings, Vol. XLV, No. 2, May, 1955, p. 127.

[31]Ibid., p. 128.

> The initial development at Calvert City took place in 1948 when Pennsylvania Salt Manufacturing Company erected a hydrofluoric acid plant. In addition to fluorspar, the basic requirements of the firm were relatively low-cost electric energy, large quantities of processing and cooling water, and water transportation for shipment of sulphur and salt. Concurrently the Pittsburgh Metallurgical Company built facilities for producing ferroalloys to realize savings through joint development of docking and rail facilities. Pennsalt added a chlorine plant which, along with B. F. Goodrich's plans to locate vinyl chloride facilities in the area, prompted construction of a calcium carbide and acetylene plant by Air Reduction.[32]

There were many other additions, each building on the other, until only ten years after completion of the Kentucky Dam project, the total investment in new production facilities approximated seventy million dollars, just slightly less than the total investment in the project.[33]

D. Summary

Calculation of project benefits and costs should be sufficiently broad to include social benefits and costs. In cases in which market values do not reflect the full amount of social benefits and costs, an adjustment should be made in the results of the benefit-cost analysis to compensate for the divergence. Because of the assumption

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[32] *Ibid.*

[33] *Ibid.*, pp. 128-129.

of the agencies that market prices will reflect the full opportunity costs of factors used in development of water-use projects, many of these adjustments are not made, with consequent mis-statement of project benefits and costs.

Most of the divergence between market and social values which result from direct interdependence operating outside of the market mechanism is compensated for, however, at least to the extent that the agencies can estimate the values which individuals place upon such things as flood protection, recreation, and improved navigation facilities. Downstream effects of hydroelectric projects are calculated and included as a benefit for the project under evaluation. The agencies do not, however, consider the benefits accruing from system operation in the other direction, that is, upstream. This is an inadequacy in current agency practices. Failure to measure upstream effects points up the aspect of benefit-cost analysis, as applied by the public agencies, which is most susceptible to criticism, namely, the emphasis placed through the analysis upon project rather than system justification.

The divergence between market and social values which results from interdependence operating within the market mechanism enters directly into the calculations of only the Bureau of Reclamation. These are calculated as indirect effects of project construction. The other agencies assume that this type of benefit will amount to ten per cent of the direct benefits from project construction, and apply this correction as a type of super-numeraire of project construction.

The agencies' practice of evaluating project benefits and costs in terms of market prices (or in terms of a projected price level) leads to mis statement of project effects; since tax, subsidy, and tariff effects will cause a divergence between market and social values, at least to the extent that these effects differ for the project than for the private sphere. The agencies do not normally make any adjustment for this type of divergence. Neither do they make adjustment for increases in social overhead.

The effect of project development upon decreasing cost industries and upon capital formation on the regional level should be calculated as additional benefits to the project. Both of these enter into agency calculations only imperfectly, being reflected only in price and income changes. It may be, however, that these may be among the more important of project effects and should be calculated directly.

The effect of development upon regional price levels calls for adjustment in agency calculations to the extent that the regional effect differs from the national, or from the previous regional-national price relationship. The agencies do make this adjustment, reducing project benefits when the regional price effects move above the national average, increasing project benefits when the regional price effects lie below the national average.

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CHAPTER IV

PROJECT EFFECTS: DIRECT, INDIRECT, AND INTANGIBLE

A. Introduction

There are two steps in the calculation of project benefits and costs. The first takes the form of an analysis of existing and potential demands for the goods and services expected to be produced by the project, including estimates of the uses which can be expected to be made of project goods and services and of the prices which these goods and services can be expected to command. The second step involves calculation of the values of increases and decreases of goods and services under expected future conditions both with and without the project, the difference between the two representing the effects of the project.

The first step consists of measurement of demand for the goods and services of the project; the second constitutes a study of the supply conditions of these goods and services with project construction and without it. Both steps are essential to an economic analysis of benefits and costs, and both steps are followed by the agencies involved in water resources development.[1]

In this chapter attention is directed to problems involved in calculation of direct, indirect, and intangible effects. Some of the major problems will concern measurement of benefits resulting from reduced prices and cost reductions, comparison with alternatives, measurement of _stemming from_ and _induced by_ benefits and costs, and the general problem of computing the values of intangible benefits and costs. In the final part of the chapter, the problems of salinity control, benefit or cost of production, taxes as a project cost, project influence on the level of economic activity, and cost allocation will be discussed.

Following are definition of some of the terms which will be used throughout the chapter.

Direct benefits are the value of the immediate products and services resulting from the facilities of the project. They are generally measured as the savings in costs, reductions in losses, or increases in incomes, although the

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[1]Cf., Subcommittee on Benefits and Costs, _Report to the Federal Inter-Agency River Basin Committee: Proposed Practices for Economic Analysis of River Basin Projects_, (Washington, D. C.: United States Government Printing Office, May, 1950).

Bureau of Reclamation measures the benefits from irrigation by the effect of the project on national income.

Direct costs are the value of goods and services used for establishing, maintaining, and operating the project, and in making the immediate goods and services of the project available for use or sale. These costs are usually evaluated in terms of market prices under the assumption that these prices will reflect the opportunity costs of the resources employed.

Indirect benefits are the values added over and above the value of the immediate goods and services of the project. They are of two types, induced by benefits and stemming from benefits. These types of benefits are measured directly only by the Bureau of Reclamation, which computes their value in terms of income changes. The other agencies assume that indirect benefits will be a percentage of direct benefits and calculate them on that basis.

Induced by benefits are indirect benefits which arise as the result of added purchases made by individuals and firms in the project area as a result of project investment. The total value of induced by benefits is the total of the added profits and increased employment from this increase in purchasing.

Stemming from benefits are indirect benefits arising from the increased flow of goods into the general economy resulting in increased supplies of goods as factors of production for processing industries and in increased amounts of goods available to ultimate consumers. The process used by the Bureau of Reclamation calls for evaluation of net values added to project goods and services through all stages of production up to the consumer. These net values added are considered to constitute the value of stemming from benefits.

Indirect costs are the costs which are necessary for further processing of project products and any other costs over and above direct costs which stem from or are induced by the project.

Intangible effects are those benefits and costs which have no market value, and which do not enter into money income changes. These effects are usually calculated by the agencies in descriptive terms but do not enter into the analysis for purposes of economic justification.

Separable costs represent the difference between the cost of a multiple purpose project with and without individual purposes. The separable cost of a purpose thus represents the cost of adding that purpose to the project.

Joint costs represent the difference between the cost of the multiple purpose project as a whole and the total of the separable costs for all project purposes.

B. Measurement of Direct Benefits and Costs

Direct benefits and costs are estimated on the basis of expected demand for the products of the project under conditions with and without the project. The direct benefits attributable to the project are considered by the agencies to be the value of any reductions in costs to firms which use the products and services of the project as factors of production and of any increase in the volume of production. Where the goods and services have a market value, actual or estimated, calculation is comparatively simple.[2] In other cases, however, it is usually necessary to measure these effects in terms of the cost of production of the most economical alternative.

There are some problem areas in the measurement of direct benefits. In the measurement of benefits deriving from irrigation, for example, it would be extremely misleading if the effect which increased production from

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[2]Calculation is relatively simple, but the results of the calculation might have to be adjusted for divergence between market and social values as outlined in Chapter III.

irrigated lands might have upon government payments under a farm price support program were not taken into account. Even though it may be confidently expected that increases in the level of population will ultimately lead to pressures upon the supply of food and fiber,[3] present increases in agricultural production might lead to increased expenditures by government to support the prices of the goods produced. Benefits expected to accrue to water-use projects should be adjusted downward sufficiently to account for any net increase in farm price support payments occasioned by project formation.[4] Such an adjustment is not usually made by any of the agencies, and their benefit-cost calculations are incorrect to the extent that increased payments result from project formation.

Where project development increases the supply of a good sufficiently to cause a reduction in the price at which that good can be sold, two problems arise. First,

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[3]Cf., L. L. Boger, "Discussion of the Demand Side," Journal of Farm Economics, Vol. 36, 1954, p. 801. Ervin L. Peterson, Agriculture Bulletin: Columbia Basin Issue, (Salem, Oregon: Oregon State Department of Agriculture, 1951) p. 2.

[4]This adjustment will be necessary only on a net basis so long as the government is not forced to store and hold the products. If the product is removed permanently from the market, the benefits from the increase in production will be zero.

there is a problem as to the appropriate price at which to value the output; second, there is a problem as to the time period over which the price reduction will remain in force.

The problem concerning the appropriate price for valuation arises out of the fact that the price of the new output may vary from unit to unit. For this reason, neither the price which would hold in the absence of the project nor the price at which the last unit of output will sell will adequately reflect the value of the output. Krutilla and Eckstein have suggested that:

> If the development of a multiple purpose project increases the supply of a marketable product sufficiently to influence the price at which the total can be marketed, the drop in price calls for special treatment in estimating the value of the project output. The aggregate increment in supply is represented by the amount which could be collected if each unit of the block of new output could be offered separately for sale at the price it could command.[5]

To the extent that the demand function is linear, the value of the increase in output will be approximately that of the physical units multiplied by the average price for which they would sell. This problem is not resolved by the agency practice of valuing output at market prices or,

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[5]John V. Krutilla and Otto Eckstein, Multiple Purpose River Development: Studies in Applied Economic Development, (Baltimore: the Johns Hopkins Press, 1958), p. 74.

as the Bureau does, in terms of a projected price level. The former method applies the price which would hold in the absence of the project; the project price level applies the price at which the last unit of output will sell. Current market prices will over-value benefits from increased production where this increased production results in lower prices. The projected price level will tend to under-value benefits from this source.

The problem concerning the time period over which the price reduction remains in force is caused by the fact that demand sufficient to clear the market of the increased production may develop without lower prices, but lower prices may bring it into being sooner.[6] If this is true, the price of the product will rise again as soon as demand has increased enough. Hydroelectric power production offers a case in point. The per capita demand for power in the Pacific Northwest is probably relatively low when compared with other areas of the country. As markets develop in the Pacific Northwest for increased quantities of goods and services, industries will have an incentive to

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[6] J. M. Clark, M. M. Kelso, and E. Grant, Report of the Panel of Consultants: Secondary Benefits and Costs, to Michael W. Strauss, Commissioner, Bureau of Reclamation, (Washington, D. C.: United States Government Printing Office, 1952), p. 15.

enter into production of those goods and services in the region in which they are demanded. Power is a factor of production, and as such, its cost enters into production decisions. Lower power rates make it possible for industries to begin production in the region sooner than would otherwise be the case, but it seems likely that such production is likely to occur ultimately with or without the lower power rates. Thus the period of time over which the benefits derived from the increase in production will be of finite duration.

There are two measures of direct benefits used by the agencies, the value of increased production and reduction in costs. The problem of the appropriate price for valuation and that of the time period over which the price reduction will be in force will affect both measures. A close approximation of the correct price by which to evaluate project benefits from increased production under these conditions would appear to be the average price over the life of the project. Benefits from reductions in costs will accrue only as long as the price reduction prevails. Since the agencies calculate the values of increases and decreases of goods and services under expected future conditions with and without the project, it can be assumed that both of these problems are recognized, although the prices used to value these benefits will probably not give an adequate measure of either the benefits from increased production or those from reduction of costs.

Benefits from water-use projects are limited by the cost of alternatives. It is necessary, therefore, that the benefits and costs of alternatives must be computed. Alternatives to water-use projects are of two types. There is first the possibility of obtaining from other sources benefits similar to those which would be yielded by the project. For example, the alternative frequently used as a measure of hydroelectric power benefits is modern privately owned steam generation of electric energy.[7] The second type of alternative is that in which benefits are secured by using resources differently, in constructing schools, highways, and hospitals, for example. If net benefits are to be maximized, a project should be compared with both types of alternatives, and the net benefits from the project should be computed as the difference between project benefits and those of its closest alternative after all costs have been deducted.

The public agencies compute the benefits and costs for the first type of alternative, so far as it is possible.

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[7]Subcommittee, "Proposed Practices," _op_. _cit_., p. 76.

> In theory, the broadest possible range of alternatives for any given objective should be considered but it is recognized that in practice, the range of alternatives that can be considered at regional levels may be limited by the information available at such levels. Also, there may be alternative possibilities that are not known to an agency responsible for project analysis. Nevertheless, consideration of alternatives on the broadest possible basis should be given at all levels of responsibility and necessary information for that purpose should be exchanged among the Federal agencies involved and utilized at appropriate levels of project analysis and review.[8]

This can be interpreted to mean that both types of alternatives should be considered. It is safe to assume, however, that present levels of information make it likely that alternatives other than those which provide similar benefits are considered, if at all, only at the highest levels. Attention should be directed to collection of data and improvement in channels of communication which will enable full consideration of both types of alternatives.

There is usually very little difficulty involved in the calculation of direct project costs. They are generally measured in terms of market prices prevailing at the time the costs are incurred. As indicated above,[9] there may be adjustments required in these prices to compensate for

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[8] Ibid., p. 37.

[9] Supra, pp. 82-84.

taxes, subsidies, and tariffs, and direct project costs should include increases in social overhead caused by the project.

C. Indirect Benefits and Costs

Indirect benefits and costs are generally defined as benefits and costs in activities stemming from or induced by increased production made possible by the project. Indirect benefits in irrigation, for example, are held to be the "values added by transporting, processing, and distributing the added farm products from the project, plus any values added by other activities stemming from or induced by the project."[10] These benefits are usually measured by the difference in net income in secondary activities under expected conditions with and without the project. Use of the "with and without" measure gives expression to the indirect costs of handling the increased output of the project.

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[10] Subcommittee, "Proposed Practices," *op. cit.*, p. 40.

1. Changes in National Income

As indicated above, indirect benefits and costs are usually assumed to be reflected in changes in national income, and, if market prices can be assumed to reflect opportunity costs, these changes will be in real terms. An increase in real national income may take two possible forms: first, employed resources may be shifted from less to more productive uses; and, second, resources that would otherwise be unemployed might be put into use.

The productivity of resources can be increased by giving them a more plentiful supply of complementary resources with which to work. This aspect of the water-use project is of considerable significance to regional development. As Krutilla has pointed out, the multiple purpose development of the Tennessee River produced a considerable shift in the region's resources supply schedule by increasing the output of power in the area; while development of an inland waterway and a water control program increased both the supply of low-cost water transport and of high quality processing and cooling water.[11] All of these are

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[11] John V. Krutilla, "Criteria for Evaluating Regional Development Programs," American Economic Review: Papers and Proceedings, Vol. XLV, No. 2, May, 1955, pp. 126-131.

basic inputs in the chemical industry, and investment in facilities for production of chemicals in the Tennessee River area has expanded at a rate above that of the national average.[12] This increase in complementary resources has led in this instance, and should generally lead, to more effective use of other resources, and to shifts in production to improve the quality and type of goods and services produced. This should result in important indirect benefits to the area. These will usually be largely of the stemming from variety of indirect benefits.

In many cases project development might make it possible for resources to be placed in employment which might not otherwise be available for use. Irrigation facilities, for example, which are used to increase production of green beans might cause bean growers to draw upon school-age children as a source of labor supply. Since this work is of a highly seasonal nature and of relatively short duration, these laborers, not otherwise interested in entering the labor market, might be attracted to bean picking.

Employment of resources that are presently unemployed, but would otherwise be in the labor market, will lead, also, to an increase in real national income. Both of these

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[12] *Ibid*., pp. 128-129.

employment effects will take the form of induced by benefits. It is worth noting at this time that stemming from benefits and costs are a form of supply effect of the project, while induced by benefits and costs are a form of demand effect.

a. Stemming from benefits

The indirect benefits which are generally presumed to stem from a project are those which accrue in connection with processing of immediate products. Stemming from benefits arise from the increased flow of goods into the general economy resulting in increased supplies of goods as factors of production and as consumer goods. This type of indirect benefit is related to the "pecuniary external economies" discussed by Tibor Scitovsky,[13] and to the financial interdependencies discussed in Chapter III above.

S. V. Ciriacy-Wantrup contends that "such benefits above all secondary costs quickly find expression in the demand for processors for the immediate products of a project"

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[13] Tibor Scitovsky, "Two Concepts of External Economies," Journal of Political Economy, Vol. LXII, April, 1954, p. 148.

in competitive markets.[14] This leads him to believe that calculation of this type of indirect benefit will lead to double counting because an estimate of the demand function for immediate project products in one of the first steps in benefit-cost analysis. It is probable, however, that the demand analysis which he refers to is less comprehensive than he imagines. The calculation of direct effects in this analysis goes no further than calculation of the values and costs associated with the immediate products. It does not concern itself with the side effects involved in processing those products.

It has been argued that some types of agricultural processing industries are faced with indivisibility in production, which, where the market for output, or the supply area, is not sufficiently large to support a number of such industries, will cause a decline in competition.[15] Wantrup argues that, even under these conditions, the monopoly profits that might occur to the processors would

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[14] S. V. Ciriacy-Wantrup, "The Role of Benefit-Cost Analysis in Public Resource Development," Water Resources and Economic Development of the West: Benefit Cost Analysis, Report No. 3, Reproduced by the Committee on the Economics of Water Resources Development of the Western Agricultural Economic Research Council, December, 1954.

[15] John V. Krutilla and Otto Eckstein, op. cit., p. 57.

be of only short duration, due to the effect which increased quantities of the commodities in question would have upon their prices.[16] He is probably correct in this conclusion, but this seems to indicate merely that stemming from benefits should be calculated along the lines of the "once over" type of analysis discussed by Harrod,[17] not that they should be ignored.

b. Induced by benefits

Induced by benefits are those indirect benefits which result from increased purchases made by firms and individuals in the project area as a consequence of project investment. The major problem in calculating this type of indirect benefit lies in the fact that alternatives will generate induced benefits also. It is necessary, then, that care be taken to distinguish between induced benefits with and without the project. If it can be assumed that unused capacity exists, the net induced by benefits (net above those produced by alternatives) may be substantial. If no unused capacity exists, the magnitude of these net

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[16] S. V. Ciracy-Wantrup, op. cit., p. 24.

[17] R. F. Harrod, Towards a Dynamic Economics, (London: MacMillan and Company Ltd., 1954) p. 10.

induced by benefits will largely depend upon the ability of the project to stimulate purchasing in the area to a greater extent than would follow from alternatives. Some projects will be much more effective in this respect than others.

2. Critique

The Bureau of Reclamation is the only agency concerned with water resource development which calculates the value of indirect benefits through direct calculation. The other agencies calculate indirect benefits as a percentage of direct benefits. The percentage used for this purpose is usually ten per cent.[18]

The Bureau of Reclamation calculates indirect effects as:

> . . . the costs of further processing of the immediate products or services of the project, over and above project and associated costs, stemming from or induced by the project.[19]

In other words, they calculate both stemming from and induced effects. As pointed out above,[20] stemming from benefits are

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[18] Cf. Panel of Consultants, *op. cit.*, pp. 23-28.

[19] Subcommittee, "Proposed Practices," *op. cit.*, pp. 8-9.

[20] *Supra*, p. 107.

a type of supply effect, while induced by benefits are a type of demand effect. To the extent that supply and demand is a circular process, a policy of evaluating both effects results in double counting. It would seem, therefore, that it would be proper to evaluate one or the other, but not both. It might be added that this does not preclude the use of both types (there are undoubtedly situations where the use of one might be preferred over the other), but both types should not be calculated for the same process. In cases where both are calculated, the proper benefit figure to apply would appear to be that of the smaller, where they differ,[21] since only the smaller of the two will present a realistic picture of indirect benefits.

> It follows that the composite effect of benefits "stemming from" the project and the benefits "induced by" the project are not additive; a 10% increase in demand plus a 10% increase in supply creates a 10% increase in national real income, not a 20% as would be the result if the two were added together. There is a real possibility that either supply or demand may be the effective limiting factor in the increase in national real income. For example, suppose a 10% increase in supply with a 7% increase in

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[21] M. M. Kelso, "Evaluation of Secondary Benefits of Water-Use Projects," Water Resources and Economic Development of the West: Research Needs and Problems, Report No. 1, Proceedings of the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Berkeley, California, 1953, p. 53.

> demand, or a 10% increase in monetary demand with a 7% increase in physical supply; in either case the resultant will be a 7% increase in aggregate real income.[22]

The choice as to the appropriate side from which to approach measurement of these indirect benefits will be largely determined by the stage of development. Induced benefits will probably be larger than <u>stemming from</u> benefits during the earlier stages of production. During the operational stage of the project, however, it seems likely that stemming benefits will exceed induced.

The method used by the Bureau of Reclamation for calculating <u>stemming from</u> benefits involves assignment of a factor representing the total value of margins produced by the processing and marketing services, from the project to the consumer level, to each important project product. This has a tendency to place an upward bias on the benefits accruing to project products involving considerable processing, and a downward bias to benefits from those which do not involve so much processing.

> For cotton the "value added" with present procedures mounts up to six times the farm value of the raw cotton, chiefly because it includes the values added by making it into fabrics and such finished products as dresses, and marketing them. The crop in present procedures is allocated between domestic use and export

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[22] <u>Ibid</u>.

> on the basis of average national proportions, so that most of the crop is in effect assumed to be made into finished products such as dresses; whereas the marginal use, which appears pertinent for this purpose, is presumable export, which adds 50% to the value of raw cotton instead of 60% as is the case for its being made up into dresses. Or the marginal use might be idle storage. On a "with and without" basis, it seems clear that these cotton dresses would be made in any case. It appears that "stemming from" calculations should at least stop short of the fabricating process in which the values added considerably exceeds that of the project grown materials. . . The method followed distorts the relative gains from different crops in favor of those requiring much processing or handling before reaching the consumer, as against such things as dairy products or fruits and vegetables sold unprocessed.[23]

It is probable that this type of calculation leads to overstatement of benefits from irrigation projects and to some distortion as between relative benefits from products of such projects. This could be corrected either by stopping the calculation short of the final stages of production as suggested above or by calculating the stemming from benefits only for the major products of the project, stating them as an average.

In all cases, however, these effects should be calculated both with and without the project. It is probable that alternatives by which agricultural purposes can be evaluated may be lacking, although Rudolph Ulrich has

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[23] *Ibid.*, p. 55.

suggested that alternatives may be found in other areas, as distinguished from the project area.[24] He suggests that the proper alternative by which to compare irrigation effects in the Northwest might well be application of fertilizer, etc., in some other part of the country. This is, however, an overly-simplified approach, since each project and each method of increasing output will normally demonstrate unique characteristics which may lessen comparability.

The *with* and *without* measure of indirect benefits is, however, somewhat more clear-cut as regards some of the other purposes with which development is concerned. For flood control, navigation, water supply, and electric power, for example, it is rather certain that alternative solutions are available against which concrete comparisons can be made. In the area of electric power generation, considering the over-all power shortage (particularly in the West), if hydroelectric resources are not utilized it is probable that steam power will be developed. In other words, electric power will probably be forthcoming from

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[24] Rudolph Ulrich, "Relative Costs and Benefits of Land Reclamation in the Humid Southeast and the Semi-Arid West," *Journal of Farm Economics*, Vol. XXXV, February, 1953, pp. 62-73.

one source or another. This provides an immediate yardstick against which to compare the indirect benefits with and without the project. The same corollary seems to apply to the other purposes mentioned above. The difficulties relative to bias among products are of primary concern for problems of repayment. The aspect of most importance to the economic analysis will be the degree of accuracy with which the with and without measure will value indirect effects.

In 1952 the Chairman of the Subcommittee on Benefits and Costs, in a letter to the Chairman of the Federal Inter-Agency River Basin Committee, suggested that indirect effects might be used for economic justification of projects in cases where the primary effects with the project would be greater than the primary effects to be expected with alternatives.

> The subcommittee recognizes that secondary benefits may be properly creditable to a project for the purposes of an economic analysis when the primary production of a project is greater than the primary production to be expected from alternative use in marginal enterprises of that part of the project-required resources which can be reasonably expected to be used in the absence of the project. As an expedient procedure to meet the immediate needs of AWRBIAC for evaluating the net returns in secondary activities that would stem from the primary production under such conditions, the subcommittee suggests that an arbitrary factor of 10 per cent be applied to the value of the increase in agricultural products sold by the farmer,

> the value in the increase in power at the load center, and the value of the increase in other project products and services at comparable points as an approximation of the secondary benefits creditable to a project.[25]

This appears to be implicit recognition of the two facts regarding indirect effects. First, indirect effects should constitute an additional justification for project development where it can be shown that these indirect effects would not have occurred in the absence of the project. Second, the techniques for measuring these effects are not sufficiently advanced that a reliable statement of their value can be made at present.

There is, however, a danger in applying an arbitrary figure on a percentage basis. Indirect effects may vary widely from project to project and from purpose to purpose. There is at least the probability that an estimate of their value made upon the basis of a percentage of direct effects would lead to error as surely as would current attempts to calculate their actual value. If such an arbitrary standard should come into general usage, the incentive to develop improved techniques of measurement would be absent. On this basis alone it would seem preferable that

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[25]George L. Beard, Chairman of Subcommittee on Benefits and Costs, Letter to Chairman of Federal Inter-Agency River Basin Committee, Washington, D. C., October 17, 1952.

indirect effects should be computed, and that they should be considered as contributing to economic justification in all cases where estimates as to their worth appear to be justified.

D. Intangibles

Intangible benefits and costs include all of those benefits and costs to which no monetary values can be assigned. All of the agencies involved in water resources development use a descriptive method for expression of these effects and do not include them in benefit-cost calculations for purposes of determining economic justification. Intangibles may, however, be included for ranking purposes. The Subcommittee on Benefits and Costs concurs in this method, as does the President's Water Resources Policy Commission.

> Intangibles, that is to say, effects which it is considered impossible or undesirable to express in monetary terms, such as scenic values, should be described in such a way that their importance and influence on project formulation and selection can be clearly indicated.[26]

As Warren Gramm has pointed out, however, this type of

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[26] President's Water Resources Policy Commission, _A Water Policy for the American People_, Vol. 1, (Washington, D. C.: United States Government Printing Office, 1950), p. 56.

presentation makes it likely that intangible effects will be ignored, since they cannot be treated with the rigor demanded by the technical mind.[27]

Some types of intangibles can be measured indirectly, in terms of physical units of use (man hours spent at recreation, using project facilities) or by means of license payments and fees assessed. In other cases, where neither of these is applicable, intangible effects are sometimes assumed to be equal "to the cost of installing, operating, and maintaining specific recreational facilities, plus an equal amount considered to be the value of the benefits attributable to recreational use of project facilities provided for purposes other than recreation."[28] These are plainly measures which yield, at best, roughly approximate figures. This would appear to be a case in which an educated guess is to be preferred to no guess at all. Preservation of natural or historic sites, development of recreational facilities, and fish and wildlife conservation can, by these means, be placed on the record and can

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[27] Warren S. Gramm, "Limitations of the Theory of the Firm for Water Resource Analysis," Land Economics, Vol. XXXIV, No. 2, May, 1958, p. 119.

[28] Subcommittee, "Proposed Practices," op. cit., p. 51.

be given at least a proportionate role in development plans. As Wantrup has stated:

> Whether the economist likes it or not, evaluation of these items (and also dismissal of such evaluation) is already a part of the political process. It is difficult, for example, to pick up a report of fish and game departments without finding some attempt to evaluate. One may have professional doubts about some of the procedures being used. Still, these attempts should be encouraged.[29]

The social values represented in intangibles are, from one point of view, the justification for public resource development. A public agency should be required to take these values into account and to make them a part of the economic analysis. In this case, as with indirect effects, tools for measurement can be developed only through application. Inclusion of intangible effects in the results of benefit-cost analysis is unlikely to result in greater error than exclusion, and, with practice in calculation, greater accuracy might be attained.

E. Taxes

In Chapter III the problem of adjustment to prices to offset the effect of taxes was discussed. It was suggested that such an adjustment would be required if benefits and

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[29] S. V. Ciriacy-Wantrup, *op. cit.*, p. 21.

costs were to reflect social values. Taxes are discussed here as a cost to the project. If a project is developed, the area of land upon which project facilities are constructed is stricken off of the tax rolls of the region in which the project is located.

Only two of the four agencies involved in water resource development make any allowance for this tax loss to the community. The Corps of Engineers assesses an annual charge against the project, over the entire period of analysis, to cover the loss of taxes to local taxing agencies. If the local agencies derive any revenue from reservoir rentals, the amount of this revenue is applied as an offset against the tax loss.[30] The Federal Power Commission makes an annual charge of 1.40 per cent of total investment as an allowance for local tax loss.[31] The Department of Agriculture and the Bureau of Reclamation make no allowance for tax losses under the assumption that increases and decreases in tax revenues will offset one another, that is, they assume that the project will cause property values to rise to such

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[30]Subcommittee, "Proposed Practices," _op. cit._, p. 81.

[31]_Ibid._

an extent that taxes on the increased base will offset the original loss.[32]

The taxes with which the agencies are concerned are almost exclusively property taxes,[33] so there is probably some justification in the approach of the Department and the Bureau. As Regan and Timmons have pointed out, adjustments in tax payments should normally have the effect of lowering rates to power users.[34] This, combined with increased tax yields due to increase in property values, plus the stimulating effect on production and income from increased utilization of project facilities and output, would tend to offset losses in government tax revenues.[35]

The extent to which property tax allowances are used in the analysis, however, will affect the type and size

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[32] Ibid.

[33] Ibid., p. 30.

[34] Mark M. Regan and John Timmons, "Current Concepts and Practices in Benefit-Cost Analysis of Natural Resource Development," Water Resources and Economic Development of the West: Benefit-Cost Analysis, Proceedings of the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Berkeley, California, 1953, p. 13.

[35] Ibid.

of development. If tax allowances are relatively high, those projects with low initial investment (smaller projects) will be favored. Lower tax allowances will favor those projects with relatively high initial costs, and the scale of development will be correspondingly higher.

F. Salinity Control

Salinity control is calculated as a benefit by the Corps of Engineers, the Bureau of Reclamation, and the Federal Power Commission on the basis of the value of damage prevented, increased use made possible, or maintenance costs avoided.[36] This is a questionable practice since it results in double-counting of benefits. Benefits from irrigation, from domestic water supplies, and for cooling and processing water, accrue as a result of application of water to specific purposes. If the water has a saline content, the benefits from that application will be reduced. If benefits from project purposes are calculated on the basis that reasonably salt-free water will be applied, salinity control becomes a cost of production, not a benefit. Since the agencies usually measure benefits from water-use projects on the

[36] Subcommittee, "Proposed Practices," *op. cit.*, p. 77.

assumption that these benefits will continue over time,[37] the implication is that relatively salt-free water will be provided. The effect of calculating salinity control benefits is, therefore, to count the same benefits twice, once from the use of salt-free water, again from the provision of salt-free water.

G. Adjustment for the Level of Economic Activity

All of the agencies apply a correction to the results of the benefit-cost analysis for benefits from increased employment caused by construction of a project during periods of depression. This adjustment takes the form of a percentage reduction in costs, the percentage by which costs are reduced depending upon the percentage of unemployment at the time the project is constructed.[38]

The Subcommittee on Benefits and Costs recommended to the Federal Inter-Agency Committee that an adjustment in the results of the benefit-cost analysis be made during low levels of economic activity.

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[37] Ibid., p. 25.

[38] J. M. Clark, M. M. Kelso, and E. Grant, Report of the Panel of Consultants to the Bureau of Reclamation: Secondary or Indirect Benefits, to Michael W. Strauss, Commissioner, (Washington, D. C.: United States Government Printing Office, 1952), pp. 30-33.

> Except in unusual circumstances projects should be formulated and analyzed under the assumption of a relatively high level of resource employment. Adjustments for under-employment of labor and other economic resources should be considered only if construction is expected to be undertaken during a period of relatively low economic activity.[39]

So far as this recommendation goes, it is sound. There is little doubt that aid provided by a project in reducing relief costs and unemployment compensation would constitute a direct project benefit. The stimulating effect which a project would have upon incomes and employment in general would also be likely to result in additional indirect benefits, which are computed, however, only by the Bureau of Reclamation, which calculates labor and capital's share of added incomes measured as part of the benefits from agricultural production and from power.[40]

The basic assumption of benefit-cost analysis is that the cost of resources used in water resource development can be measured in terms of the most favorable alternative uses to which these resources can be put. During periods when resources are relatively fully employed, market prices can be assumed to measure these alternative costs with some

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[39] Subcommittee, "Proposed Practices," op. cit., p. 28.

[40] Ibid., p. 78.

precision. The Subcommittee recommendation and the practices of the agencies are based upon the additional assumption that, during periods of relatively low economic activity, the reduction in or lack of alternative uses will warrant some adjustment in the market price evaluation.

It is questionable whether an adjustment which is concerned only with the effect of direct labor used in the project[41] will accurately reflect the changes in alternatives. There is likewise no hint as to whether the criteria for application of an adjustment factor is to be that of regional or general unemployment; nor is there any indication as to what the appropriate level of unemployment would be for application of the adjustment.

The Panel of Consultants suggested the use of a sliding scale of offsets, ranging from plus to minus according to the state of employment at the time the project is scheduled for construction.[42] Instead of being based upon the percentage of unemployment (the measure now used), this scale would be based upon the percentage of resources used in the project which would be drawn from unemployment rather than from other uses. When unemployment is heavy, this would

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[41] Ibid., p. 28.

[42] Panel of Consultants, op. cit., p. 32.

probably be more than the average percentage of unemployment. When unemployment is light, the percentage upon which the scale of offsets is based would be smaller than the average of unemployment, approaching zero when unemployed reserves approach three or four per cent.[43]

A scale of this type would have the advantage on an area or regional basis, depending upon the location from which resources would be drawn. Given appropriate data on a regional basis, a much higher degree of precision would obtain for the adjustment factor than is obtained through present methods. Much more difficult to assess would be the diffused effects of the project beyond the borders of the area or region in which the project is located. It is likely that their values can only be approximated through income changes.

It must be emphasized that the adjustment for the level of economic activity applies only to the construction stage of a project, not to the effects of its continued operation.

H. Cost Allocation

There are two reasons for allocation of costs among the purposes of water-use projects. The first relates to

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[43] _Ibid._, p. 33.

economic feasibility of project purposes. A project purpose can be said to be economically feasible when the cost of including the project is exceeded by benefits derived from its inclusion. The second reason for cost allocation lies in the necessity for determining financial feasibility, which requires that those individuals who benefit from project formation bear the cost of providing those benefits.

Costs are allocated among the various purposes of a project on the basis of the "separable costs-benefits remaining" method.[44] By this method the separable cost of including each purpose in the total project is determined by finding the cost of the project with and without the purpose.

> Separable costs include more than the direct or specific costs of physically identifiable facilities serving only one purpose, such as an irrigation distribution system. They also include all added costs of increased size of structures and changes in design for a particular purpose over that required for all other purposes, such as the cost of increasing reservoir storage capacity. In effect, separable costs are computed from a series of project estimates, each representing the multiple purpose project with one purpose omitted.[45]

The separable costs of each purpose are then subtracted from the total benefits of that purpose, following which,

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[44] Subcommittee, "Proposed Practices," *op. cit.*, p. 54.

[45] *Ibid.*

the joint costs are allocated among the purposes in the ratio which the total joint costs bear to total remaining benefits. Thus, if total joint costs are ninety per cent of total remaining benefits, each purpose will have allocated to it joint costs in the amount of ninety per cent of its separable costs.

1. Cost Allocation and Economic Feasibility

The agencies recognize the fact that allocation of joint costs is not required for determination of economic feasibility.

> Allocation of project costs may be desired for various administrative purposes. However it is usually necessary in the economic analysis only when public policy requires that charges for all or certain products or services of the project shall be based upon costs incurred therefore.[46]

The only costs which are relevant for purposes of economic feasibility are those costs which accrue to a purpose specifically, namely, the separable costs of that purpose. Not only is allocation of joint costs unnecessary for economic feasibility, it may result in impairment of economic efficiency. The following example illustrates this point.

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[46] Ibid.

Let us assume that joint costs are proportional to separable costs and will be so allocated.[47] In this case, a purpose with relatively low remaining benefits could be eliminated from the project if a joint cost allocation proportional to its separable costs were made to it, and net benefits would be reduced. Suppose, for example, that the project has two purposes, power and flood control, with joint costs of $300,000, separable costs for power and flood control respectively of $375,000 and $325,000, and remaining benefits of $500,000 for power and $100,000 for flood control. If joint costs were allocated on the basis of the purposes' separable costs, flood control would be allocated about forty-six per cent of total joint costs, or $138,000. This purpose would no longer be feasible, in spite of the fact that net benefits with the purpose would be $300,000 and only $200,000 without it (power only costs are $675,000, and power benefits are $875,000).

In projects containing structures which are used by some purposes but not by others, the costs of those structures become separable costs for those purposes which require

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[47] There is at least as much basis for the assumption that joint costs are proportional to separable costs as for the agencies' assumption that joint costs are proportional to remaining benefits.

them rather than joint costs for all purposes. So long as the benefits from those purposes which use those structures exceed their separable cost plus joint costs, that group of purposes will be economically feasible.

There are, then, three criteria for economic justification. First, benefits for the project as a whole must exceed costs; second, benefits for individual purposes must exceed costs; and, third, benefits for groups of purposes must exceed costs. The project as a whole must return benefits in excess of total costs, as must groups of purposes. The individual purposes need return benefits only in excess of their separable costs.

2. Cost Allocation and Financial Feasibility

For purposes of financial feasibility, a system of cost allocation must be found which will insure that beneficiaries from public resource development pay for the benefits received. The Subcommittee assumes that beneficiaries should pay the cost of providing those benefits. Ciriacy-Wantrup suggests that the proper payment is for the assessable benefits and not their costs.[48] If individual

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[48] S. V. Ciriacy-Wantrup, "Economic Analysis of Water Resources Policies," Water Resources and Economic Development of the West: Research Needs and Problems, Proceedings of the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Berkeley, California, 1953, p. 29.

beneficiaries are to pay the cost of providing the benefits which they receive, some method must be found of allocating joint costs among the purposes in a manner which reflects the part which they add to those costs. The method presently used probably does not accomplish this. If beneficiaries are to pay for assessable benefits, more may well be paid for a project than its costs, in one case, and less than its cost in another. Neither of these results is desirable.

It is probable that the most acceptable solution to the problem of allocation of joint costs may be the apportionment of joint costs to each purpose in the ratio of estimated cost of facilities required for each use in relation to the sum of estimated costs for all such facilities. This is admittedly an arbitrary measure of the joint costs attributable to each purpose, but it does have the advantage of relating cost allocation to the scale of development of each purpose. It seems probable that costs, both separable and joint, will bear a closer relationship to the scale of development than to benefits.

CHAPTER V

PROBLEMS OF TIME: PERIOD OF ANALYSIS AND THE PRICE LEVEL

A. Introduction

The usefulness of the benefit-cost analysis depends upon the ability of the public agencies to express benefits and costs in comparable terms. Benefits which accrue at the same point in which the costs involved in obtaining those benefits are to occur are readily comparable. All that is required for comparability of immediate benefits and costs is knowledge of current prices, which would be readily obtainable in a market situation.

Benefits which are expected to follow only after a considerable time has elapsed will complicate the problem of comparability. In such a situation, attention must be directed towards the problem of expressing the value of those future benefits in present terms. This involves two basic problems; determination of the price level which might be expected to prevail at the time the benefits occur, and selection of interest and discount rates and risk allowances which will give monetary expression to differences in time and certainty of occurrence of benefits and costs. The price level will establish the value of benefits and costs at the time they occur; the interest and discount rates and risk allowances establish their values in the present. Discussion of the interest and discount rates and risk allowances is reserved for Chapter VI.

In this chapter attention is directed at the following aspects of the benefit-cost analysis: (1) the period of analysis, as determined by the time period over which net benefits are expected to accrue to the project. This will determine the time period upon which the price level, interest and discount rates, and risk allowances will be based; and (2) the choice of the price level by which benefits and costs will be measured for purposes of comparison.

B. The Period of Analysis

All of the public agencies have established maximum limits to the duration of the period of analysis except the Department of Agriculture. The Corps of Engineers and the Federal Power Commission assume that none of their projects will have an economic life of longer than fifty years. The Bureau of Reclamation has set one-hundred years as the maximum economic life of its projects. Only the Department of Agriculture considers its projects to have perpetual life. These are, however, maximums. In cases in which projects are expected to have shorter lives, the shorter time period is taken as the period of analysis.

It sometimes seems incongrous, when one looks at the physical plant of a large-scale water-use project, to learn that it is expected to have an economically useful life of only fifty to one-hundred years. It would seem, on the face of it, that such a structure would continue to provide net benefits far in excess of these time periods, perhaps even into perpetuity as is assumed by the Department of Agriculture. Actually, however, there are both physical and economic forces which will operate to limit its economic life.

Following are some terms which will prove useful in discussing the problem of the period of analysis.[1]

Usable storage is the total capacity of the reservoir. Due to technical and physical limitations, all of the water stored in a reservoir cannot be drawn off when needed.

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[1] These, and other terms, are to be found in the glossary at the conclusion of the chapter.

Useful storage is that part of the capacity of a water-use reservoir in which water can be stored and drawn off as needed for consumptive use. This will be a smaller part of total capacity, and hence, will be less than usable storage, except for flood control purposes.

Primary power is that amount of power which can be produced during all time periods. A hydroelectric plant which relies upon run-through water can produce continuously only that amount of power which can be generated by the minimum stream flow. Construction of a reservoir will increase the amount of primary power by increasing the supply of water available for use during periods of minimum stream flow.

Secondary power is power in excess of primary power and is available only during certain peak production periods (any time stream flow is above the minimum and in excess of reservoir capacity).

1. Siltation and Its Effect Upon the Economic Life of a Project

It has been estimated that many of the reservoirs of large scale water-use projects are losing from one to five per cent of their capacity each year due to siltation, the result mainly of soil erosion on agricultural and range lands.[2] As Hugh H. Bennett has pointed out, "In our present economy, it is not generally practicable to clear a major reservoir of sediment once it has filled up."[3] This means that, once a reservoir is silt clogged, the economic usefulness of the reservoir can be considered as ended. The rate at which a reservoir accumulates silt, therefore, plays an important role in determining the economic life of a project. The expected economic life of a project in turn determines the length of the period of analysis, for

> All agencies consider that the period of analysis to be used for calculating the annual costs of a project should be not greater than the estimated economic life of the project.[4]

Reservoirs, however, which are of equal size but are designed to serve different purposes are not susceptible to siltation damage in the same degree, even when receiving

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[2] Carl B. Brown, The Control of Reservoir Silting, Foreword by Hugh H. Bennett, Chief, Soil Conservation Service, Miscellaneous Publication No. 521, (Washington, D. C.: United States Government Printing Office, 1943), p. ii.

[3] Ibid., p. ii.

[4] Subcommittee on Benefits and Costs, Report to the Federal Inter-Agency River Basin Committee; Proposed Practices for Economic Analysis of River Basin Projects, (Washington, D. C.: United States Government Printing Office, 1950), p. 83.

the same incoming load of sediment. A power project, for example, is damaged by siltation only to the extent that its full usefulness depends upon storage, and then only when siltation occurs above the lowest level of drawdown.[5] Positioning of the intake valves and flumes will determine this level. If silting occurs above this level, the capacity of the reservoir for storage of high water flows is diminished and the minimum constant flow of water is decreased.

> This loss progresses until a point is reached at which the storage space behind the dam is no greater than the space occupied by the original stream channel within the original reservoir area. With all storage capacity gone, the power plant then has no greater resources to draw on, so far as the reservoir is concerned, than the available natural stream flow.[6]

Except for some of the larger multiple purpose projects, a reservoir of sufficient size to impound the full natural

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[5]There are other types of sediment damages, for example, abrasion of turbines. This type of damage is generally lower when water passes through a sizable impounding reservoir than for power plants relying upon run-through water. If the reservoir is silt-logged to the extent that the dead water storage level is substantially reduced, the incidence of this type of damage rises at a fairly sharp rate. Silting below the dead water level will, however, cause no damage in this respect. It is likely, therefore, that the economic usefulness of a reservoir will be practically over before this type of damage becomes a serious problem. Silt damage due to clogging of intake valves and pumps seems to be in the same class. Carl Brown, _op. cit._, pp. 12-20.

[6]_Ibid._, p. 15.

flow of a stream would be uneconomic.[7] For this reason, power plants are seldom designed to utilize the stream flow in its entirety.[8] This means that all natural flows in excess of the capacity of the reservoir will be lost over the spillway or used in the production of secondary power. If the reservoir is silted to any degree, the loss of water from the reservoir will be equal to the natural stream flow plus an amount of water equal in volume to the silt in the reservoir minus the unused storage capacity of the reservoir.[9]

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[7] Ibid., p. 15.

[8] Let us suppose that the full natural flow of a stream is 43,560 cubic feet per second. Water from this stream would enter a storage reservoir at the rate of one acre foot per second. This is the equivalent of one acre of water one foot deep. This means that 86,400 acre feet of water will enter the reservoir in a twenty-four hour period at full natural flow. A reservoir designed to impound that natural flow for a four month period would have to have a capacity of 10,368,000 acre feet. The total storage of all of the reservoirs under construction in the Ohio River Basin in 1950 was only 8,123,980 acre feet.

[9] The amount of water lost can be computed in the following manner. If it is assumed that a reservoir has an annual siltation rate of two acre feet, and a capacity of 80,000 acre feet initially, at the end of one year the capacity of the reservoir will be 79,998 acre feet. If the stream has a natural flow of 21,780 c.f.s. and the unused capacity of the reservoir is 22,000 acre feet, the loss of water in a twenty-four hour period will be 21,202 acre feet.

If this spillway loss is followed by a low runoff period during which the stored water is drawn off to the lowest possible level, the loss from silting can be measured in terms of the kilowatt hours of electrical energy which water equal in volume to the sediment in the useful storage area could have produced.[10]

There will be a loss due to siltation, then, during those periods when the reservoir must be drawn down to its lowest feasible level to supplement a stream flow deficiency. There will, however, be a loss additional to this since continuity of production provides the distinction between primary and secondary power, and since primary power has a higher sale value than does secondary power.[11] The actual loss from sedimentation would best be measured by the difference between the sale value of a higher rate of production of primary power and a lower rate of production of primary power, less the sale value of secondary

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[10] Ibid., pp. 15-16.

[11] John Krutilla and Otto Eckstein, op. cit., p. 67. They suggest, in fact, that the value of secondary power may approach zero at times, if it is produced during periods of slack demand.

power produced during periods of greater flow.[12] The rate of production of primary power declines in direct proportion to reduction in storage.[13]

Those project purposes which are related to the provision of a supply of water will be damaged by siltation to the extent that it reduces storage capacity below the minimum level required to safeguard the continuity of the supply necessary to achieve the benefits expected from those purposes. This minimum capacity would necessarily include an amount of water sufficient to meet reasonable expected increases in needs plus a reserve for unexpected emergencies, as well as an amount adequate for the needs originally intended to be met. Projects constructed with capacities in excess of this combined amount could, with justice, write off the cost of the excess capacity as prepaid insurance against siltation losses.

Flood control purposes of a water-use project are designed to provide sufficient capacity to impound a flood

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[12]Since sedimentation would reduce the storage capacity of the reservoir, the amount of primary power to be derived from water impounded in the reservoir would be reduced. It would also mean that the amount of secondary power would be increased due to the inability to store water in the former quantity during periods of accelerated run-off.

[13]Carl Brown, *op. cit.*, p. 15.

of a magnitude which, calculated on an actuarial basis, occurs on an average of once in a computed number of years.[14] If sedimentation takes place within the flood storage basin, this simply means that the dam could contain with equal facility only a flood of lesser magnitude. Such a flood will occur with greater frequency than that for which the project was originally designed.

Many projects are basically multiple purpose in nature.[15] The flood control storage may comprise the upper five or more feet of storage above the pool level which is maintained for purposes such as power generation, irrigation, or water supply. It is probably that, as the reservoir of such a project loses capacity due to siltation, the revenue producing purposes may be maintained by reducing the storage allotment for flood control, even though the flood control capacity will normally be reduced more

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[14]"A single flood record may represent a period of high flood activity or low activity. Taken alone it provides little if any knowledge of its normality in this respect. But we can compute the chance that an observed flood is likely to recur in various recurrence intervals. Thus we compute that there is a 50 per cent chance that the highest flood in a 25-year record might be the highest in a 12-year period, or a 52-year period. We can do the same for the second highest, and so on." William G. Hoyt and Walter B. Langbein, Floods, (Princeton, New Jersey, Princeton University Press, 1955), p. 65.

[15]Cf. President's Water Resources Policy Commission, Ten Rivers in America's Future, Vol. 2, (Washington, D. C.: United States Government Printing Office, 1950), pp. 637-640.

slowly than other types, since, for flood control purposes, the useful capacity of a reservoir will be equal to the total capacity.

> . . . it is estimated that as a result of siltation alone 21 per cent of the Nation's water supply reservoirs will have a useful life of less than 50 years, another 25 per cent will last 50 to 100 years, whereas only 54 per cent will provide enough storage to suffice for present requirements (not the estimated future needs) 100 years hence. It is probable that irrigation and recreation reservoirs will be depleted at similar, if not somewhat faster, rates. Flood-control reservoirs, except for certain types, as those in Los Angeles County, Calif., will be depleted at much less rapid rates, but will furnish progressively less and less flood protection from the date of their completion. Because of the dual purpose of power dams for head and storage, evaluation of the effect of silting on power reservoirs is complicated to such an extent that no adequate analysis of the national aspects of silting on this class of reservoir has yet been possible. The damages are known to be large, however, and may exceed those of any other class.[16]

It is important to note that the loss in capacity relates to useful rather than to usable or active storage. The operation of a reservoir will probably become uneconomical before the entire usable storage capacity is depleted. Net benefits will be a function of useful rather than of usable capacity, and will be likely to fall at a rate

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[16] Carl Brown, op. cit., pp. 20-21.

somewhat higher than the rate of decline in useful capacity.[17] As soon as net benefits become negative, the economic life of the project will be at an end.[18] This means that the economic life of any given project will probably be somewhat shorter than the period of time in which useful capacity will be totally depleted, and will certainly be shorter than the time period within which usable capacity is exhausted.

This does not mean, however, that elimination of net benefits for any single purpose in a multiple purpose project will necessarily signal the end of the economically useful life of the project. As has been noted above,[19] the different purposes are susceptible to siltation damage in different degrees. Consequently it is likely that depletion rates for purpose benefits will vary to the same extent. One or more project purposes might experience

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[17]Net benefits will probably fall at a higher rate than the rate of decline in useful capacity because some of the purposes require minimal quantities of water to produce any given level of benefits. If useful storage declines, benefits will decline for all of such purposes.

[18]As soon as the costs involved in providing the benefits from the projects are higher than the benefits, the net benefits will be negative. The project would be economic until this point is reached since the benefits derived from the project will equal or exceed the cost of providing them until then.

[19]<u>Supra</u>, p.

depletion of benefits to the point at which negative net benefits threaten, while the project as a whole is returning positive net benefits. This would depend, of course, upon the relative importance of the various purposes in the benefit total, but it does seem to suggest that the economic life of multiple purpose projects may be limited to the expected economic life of its major purpose or purposes.[20] If the major purpose of a project, in terms of net benefits, is flood control, it might be expected, all other things being equal, that the project as a whole would enjoy a longer economic life than if its major purpose were to be provision of hydroelectric power.

Figure 2, showing siltation rates in typical water supply reservoirs in seventeen states, indicates that siltation damage is no more uniform from project to project than from purpose to purpose.[21] For example, water supply

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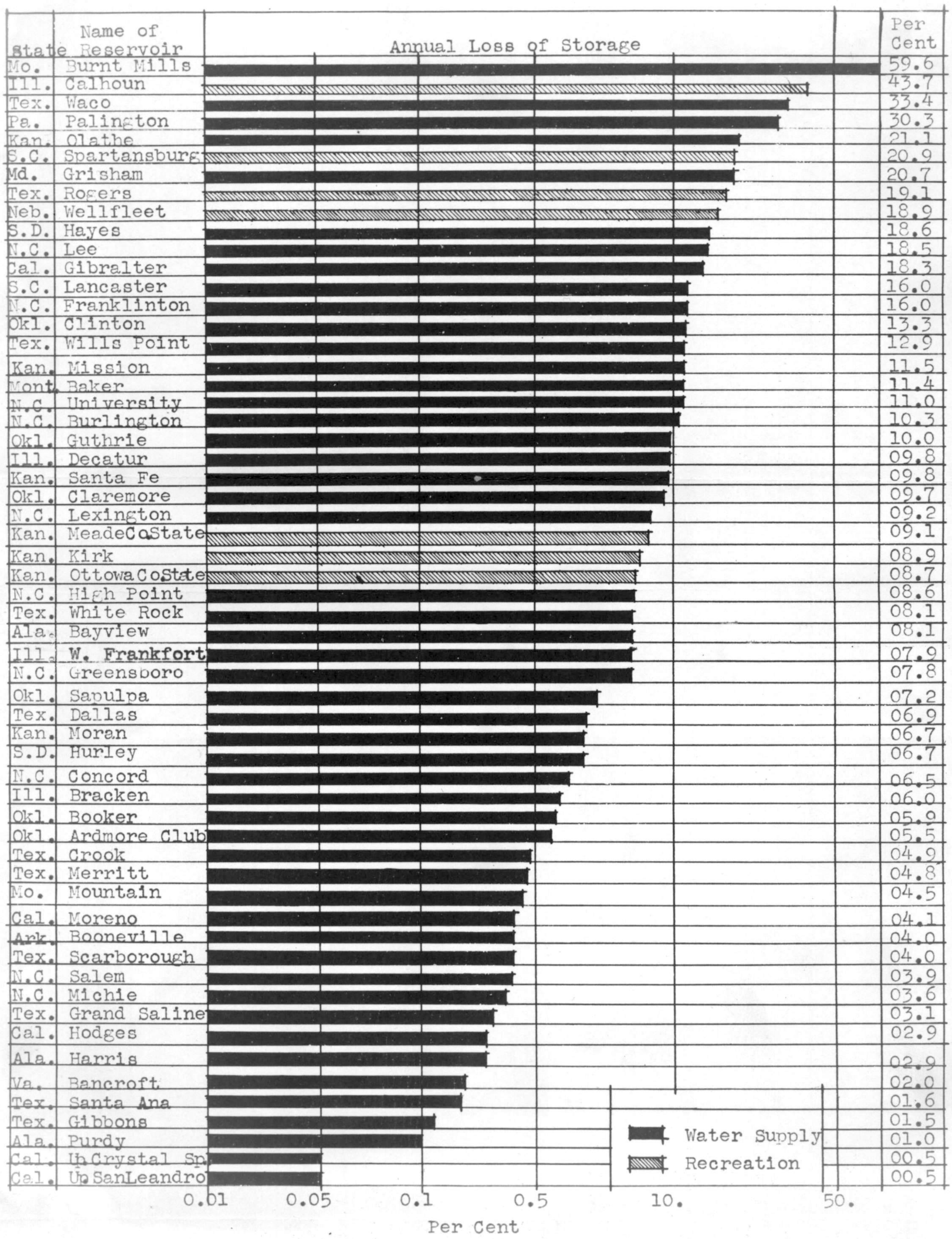
[20]This will depend, to a certain extent, upon the original benefit-cost ratio of the project. A project with a low, although favorable benefit-cost ratio might depend more heavily upon minor purposes for economic justification than would a project with a higher benefit-cost ratio. This would mean that depletion of benefits from minor purposes due to sedimentation might cause net benefits from the project as a whole to become negative at the time the benefits from minor purposes become negative. This would apply, however, only to those projects which are very close to being marginal projects at the time of formulation and development.

[21]All information relative to siltation rates has been derived from Carl Brown, op. cit., Figure 8, p. 20.

FIGURE 2

RATES OF SILTING IN TYPICAL WATER SUPPLY RESERVOIRS[a]



[a]Adapted from Figure 8, Carl B. Brown, The Control of Reservoir Silting, Miscellaneous Publication No. 521, United States Department of Agriculture, United States Government Printing Office, 1943, p. 20.

projects in the Piedmont Section of North Carolina have an annual average water supply capacity loss from siltation of about six per cent.[22] For the state as a whole, however, the annual average capacity loss from siltation rises to 9.54 per cent. Projects of the same type in the California area, but excluding those projects in Los Angeles County, have an annual average capacity loss from siltation of about one per cent. If Los Angeles County projects are included, the annual average capacity loss rises to about five per cent.[23] This means that project life, as it is affected by siltation, will vary from an average maximum of twenty years in North Carolina to about one-hundred years in California. It also means, however, that there are projects in North Carolina which will last for approximately thirty years, and some which will have become completely silted after only six years. The absolute length of time would depend upon the rate at which the depletion

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[22]The Piedmont section projects are Lexington, High Point, Greensboro, Concord, Salem, and Michie.

[23]Information on the rate of siltation in reservoirs in the Pacific Northwest is unavailable. The President's Water Resources Policy Commission, op. cit., Vol. 2, p. 55, cites the collection of sedimentation data as a major need for the Columbia Basin. It is likely, due to the nature of the topography of the region, that siltation will not constitute a major problem in this region, and that the rate of siltation is less than one per cent.

of capacity will reduce net benefits to zero. This will depend largely upon the size of net benefits accruing to the individual project, purpose by purpose, and upon the relative importance of each purpose in the total.

Finally, projects with large reservoirs are apparently less susceptible to damage from siltation than are small reservoir projects of similar types similarly located. This is largely due to the fact that, as soil is loosened by erosion, its heavier particles are dropped to the bottom of the stream as soon as water flow slows down even slightly.[24] The smaller particles flow on in suspension until completely dead water is reached. Dams on small streams with their higher velocity of water flows will receive silt deposits at a higher rate per square mile of watershed area than will dams on watershed areas.

> Measurements made by the Soil Conservation Service in 1934 and 1935 in reservoirs in the Southeastern States show an annual silt accumulation of 2 acre-feet per square mile of drainage area in a reservoir having a drainage area of 5 square miles, a rate of 1 acre-foot per square mile in a reservoir having a drainage area of 10 square miles, and rates as low as one quarter acre-foot in reservoirs with drainage areas of 100 square miles and upwards. The variation in rate of annual silt accumulation between

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[24] Sherman M. Woodward, "The Comprehensive Engineering Point of View," Headwaters Control and Use, Upstream Engineering Conference, 1936, p. 218.

> reservoirs on large and small streams in the Southwestern States is greater. A reservoir with a drainage area of 1 square mile had an annual silt accumulation of 5.5 acre-feet a year. Reservoirs with drainage areas of 10 square miles had a rate of about 2.5 acre-feet; those of 100 square miles about 1.5 acre-feet.[25]

If it can be assumed that the size of the reservoir is, at least in part, a function of the size of the river, then it follows that the large reservoirs will be less susceptible to siltation damage than small reservoirs. The larger the drainage area is, the larger will be the stream which feeds it.

2. Obsolescence

The economic life of any water-use project will be affected by obsolescence of project features. This is largely an unknown quantity and can be taken into account in only the roughest manner. It can be dealt with, however, along the following lines.

Let us suppose that the obsolescence problem is that connected with hydroelectric energy. There is a possibility that developments in the field of atomic science may render the hydroelectric facilities obsolete. At present, the best alternative to hydroelectric power (on

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[25] *Ibid.*, p. 218.

a cost basis) is steam generation. In a coal-burning power plant it is customary to attribute the cost of power generation to amortization of capital investment, operating cost, and fuel cost. Walter H. Zim has pointed out that, for a steam plant having a cost of generation of nine mills per killowatt hour, amortization costs would be approximately 4.5 mills per kwh, fuel costs about 3.5 mills per kwh, and operating costs about one mill per kwh.[26]

A similar breakdown must be made for the nuclear power plant if the two are to be compared. Mr. Stuart McLain has stated that as of June, 1957, atomic power plants showed an annual amortization rate of 22 mills per kwh, with operation and fuel costs of 8 and 5 mills respectively.[27] This would indicate that the cost of generation of electricity by nuclear energy will approximate 35 mills per kwh. Latest developments in nuclear research promise to reduce fuel costs to about one mill

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[26]Walter H. Zim, "An Appraisal of the United States Nuclear Power Program," Atoms for Power: United States Policy in Atomic Energy Development, the American Assembly, (New York: Columbia University, December, 1957), p. 86.

[27]Stuart McLain, "Boiling Water Power Reactors," The American Public Power Association 14th Annual Convention Proceedings, (New York: June 25, 26, 27, 1957), p. 45.

per kwh, and amortization charges to approximately nine mills per kwh.[28] Assuming that operating costs are not reduced significantly, an analysis of capital charges, operating costs, and fuel costs indicates a foreseeable power cost for nuclear produced electricity of approximately eighteen mills per kwh.

The cost of production of hydroelectric power can be broken down in the same way. The figures used will be those prevailing in the Pacific Northwest. Hydro power costs in other areas of the country will probably be significantly higher. It has been estimated that the capital charges for a hydroelectric plant will approximate 1.5 mills per kwh, with operating costs of about 1.79 mills.[29] Fuel costs are zero. The production cost of hydroelectric power in the Pacific Northwest will approximate 3.29 mills per kwh.

Steam generated electric energy is presently considered to be the most economic alternative to hydroelectric energy. Nuclear power plants must overcome the cost

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[28]Walter Zim, op. cit., p. 87.

[29]Leland Olds, "The Challenge to Local Publicly Owned Utilities in Providing More Power at Lower Cost," The American Public Power Association 14th Annual Convention Proceedings, (New York: June 25, 26, 27, 1957) p. 45.

advantage of steam plants before they can be considered to be an economic threat to hydroelectric facilities. If the calculations of Mr. Zim are used, the production costs of nuclear plants are still approximately one and a half to three times those associated with steam generation, in spite of the fact that fuel costs of nuclear plants are considerably lower than those of steam plants. If Mr. McLain's estimate is correct, the cost relationships are even more unfavorable to nuclear generation.

The greatest part of this cost differential is to be found in capital charges. Before atomic energy will become economic, some method must be found to reduce these charges at least to the point that nuclear capital costs plus fuel costs will be equal to steam capital costs plus fuel costs. In view of the specific conditions required for nuclear power generation, there is little reason to believe that this will occur in the immediate future. The materials from which nuclear plants are constructed must meet extremely high specifications. First, these materials must be capable of withstanding tremendously high temperatures. Second, they must withstand radiation from nuclear fuels. Third, they will have to be able to resist corrosion by the cooling liquids used in the process.[30] Another problem involved in overcoming the cost lead held by steam lies in the difficulties of control. "In coping with control, the engineers find their plants becoming more complex--and more expensive."[31] Yet a third problem relates to disposal of waste materials. These waste materials must be disposed of in a manner which is conducive to public safety. At present, this is a relatively expensive process.[32] All of these problems must be overcome, to a greater or lesser extent, before the production costs of power produced by nuclear energy can be reduced to a point where nuclear plants will be economic by comparison with steam. It will probably be somewhat longer before nuclear production costs will have fallen to the level of production costs of hydroelectric energy in the Pacific Northwest.

Low-cost power sites are not, however, inexhaustable. As time passes, those hydroelectric sites remaining will involve higher and higher costs of development. It can

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[30]Henry M. Jackson, "Atomic Power: The Technological Challenge," The American Public Power Association: 14th Annual Convention Proceedings, (New York, New York, 1957), p. 9.

[31]Ibid.

[32]Ibid.

be expected then, that nuclear plants will have to overcome the cost advantage of these future sites, rather than that enjoyed by currently planned developments.

Figure 3 presents the Pacific Northwest's long range outlook for energy load and average energy resources as estimated by the Bonneville Power Administration. It constitutes a forecast of the expected load and source of supply of electric energy through the year 2,000.[33] It will be noticed that the expected power load for this area for the year 2,000 is approximately 40,000,000 kilowatts, as compared to about 6,000,000 kilowatts as of 1956. Until 1972, increments of power are expected to be derived from new hydroelectric construction. From that time until 1975, additions to the power load are expected to be derived from conventional steam power sources as the low cost hydro sites come into short supply, although small additions to the construction of hydro plants are expected at least through year 2,000. From 1975 to 1980, major additions to the power load will be made through steam

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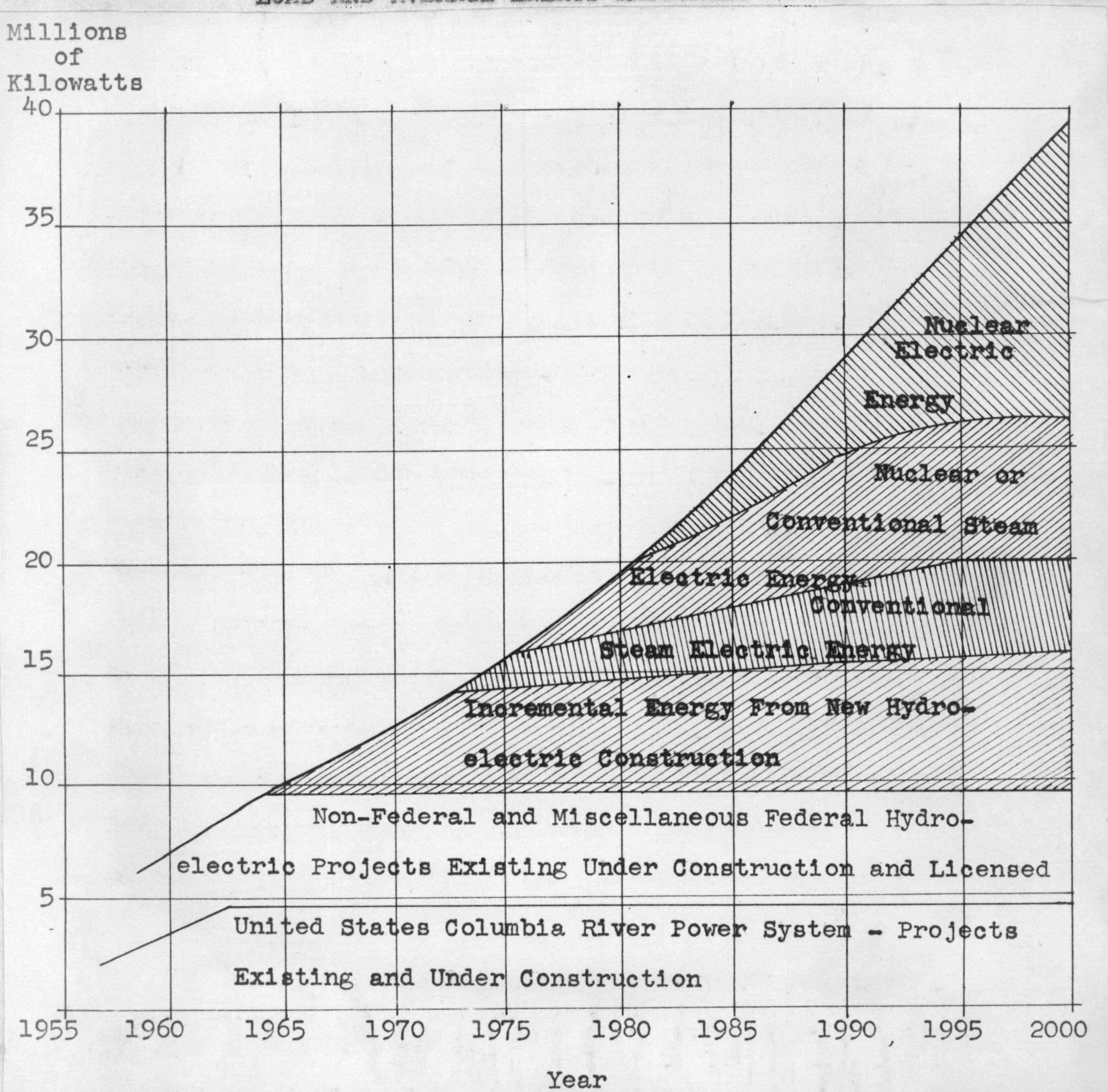
[33]United States Senate, 84th Congress, 2nd Session, Upper Columbia River Development, Joint Hearings before Interior and Insulars Affairs and a Special Subcommittee of the Committee on Foreign Relations, March 22, 26, 28, and May 23, 1956, p. 150.

FIGURE 3

PACIFIC NORTHWEST LONG RANGE OUTLOOK FOR ENERGY LOAD AND AVERAGE ENERGY RESOURCES[a]



[a]United States Senate, 84th Congress, 2nd Session, Upper Columbia River Development, Joint Hearings, March 22, 26, 28, and May 23, 1956, p. 160.

generation and/or nuclear energy. After 1980 it is expected that substantial additions will be made through construction of nuclear plants. In other words, it is anticipated that the combination of rising cost of producing power through hydro and conventional steam and reductions in the cost of producing nuclear power, will have caused power produced in nuclear plants to become increasingly economic. By 1995, it is expected that major additions to the power load will be obtained through construction of nuclear power plants,with only minor increases expected in the construction of hydro and conventional steam plants. This does not mean that existing hydroelectric facilities will not be economic; in fact, projects which have been constructed prior to 1995 will probably still have a substantial cost advantage. The shift is expected to occur because low cost hydro sites will have been previously developed, with only higher cost sites remaining.

3. Changes in Demand

The Corps of Engineers and the Federal Power Commission have adopted a fifty year maximum for the period of analysis for their projects as a hedge against changes in demand and other unforeseen effects.[34]

Changes in demand so far as water-use projects are concerned are largely a function of changes in the level of population. Department of Commerce forecasts through the year 1975 indicate that by that time the population of the United States will be in excess of 230 million.[35]

> While agriculture has increased its productive capacity over the past decade by approximately one-third, it appears necessary, in the light of expected population growth and the disposition of people to eat better so long as their incomes permit it, that a further increase of between 25 per cent and 35 per cent will be needed over the next 25-year period.[36]

This would seem to indicate that it can be expected that changes in the level of population will provide an offset against decline in the level of benefits expected from such water-use project purposes as irrigation and processing water, which might be caused by changes in demand for the output of those purposes. It seems reasonable to assume that these increases in population will provide some protection against decline in the benefits from other purposes as well.[37] Increases in population will increase

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[34]Subcommittee, "Proposed Practices," op. cit., pp. 83-84.

[35]Economic Report of the President, (Washington, D. C.: United States Government Printing Office, January, 1957), Appendix C.

[36]Ervin L. Peterson, Agriculture Bulletin: Columbia Basin Issue, No. 170, (Salem, Oregon: State Printing Office, June, 1951), p. 2.

[37]Subcommittee, "Proposed Practices," op. cit., p. 2.

the need for domestic water supplies, as well as for power, navigation facilities, recreation facilities, and flood control.

Since federal agencies take cognizance of future population trends in computation of future benefits, only population increases in excess of their expectations will lead to benefits in excess of their calculations. Errors in forecasting could lead to over-statement of project benefits. For this reason the public agencies purposely err on the conservative side in their estimates of benefits expected from this source.[38] They usually select the more conservative of the population forecasts of the Bureau of the Census as the basis for their calculations. It is probable that the mean estimate of the Bureau of the Census provides a more realistic appraisal of future population trends.

4. Summary

The public agencies consider the period of analysis to be the economic life of the project as determined by the time period over which the project returns benefits

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[38] *Ibid.*, p. 25.

at least equal to costs. The Corps of Engineers and the Federal Power Commission consider that none of their projects will have an economic life in excess of fifty years, while the Bureau of Reclamation limits its period of analysis to one-hundred years.

Any arbitrary period of analysis applying equally to all projects would be unrealistic, at least so far as siltation damage is concerned. There may be instances in which siltation damage may prove to be the effective constraint upon the duration of economic life for a particular project, but this must be determined through examination of the characteristics of the individual project and of its component purposes. This last is probably of central importance, since the economic life of any project will necessarily be dependent upon the economic life of its major purpose or purposes. As was noted, siltation will affect different purposes in varying degree and under varying circumstances.

The risk of obsolescence is foreseeable to some extent, although not nearly so much so as siltation damage. Obsolescence of projects and project purposes is a matter of relative cost relationships between water-use projects and alternative means of providing the same type of benefits. The combination of the necessity for developing higher and higher cost hydro sites due to prior development of the lower cost sites, together with reductions over time in the costs of providing the same or similar services through alternative methods, atomic energy in particular, makes it relatively certain that hydroelectric purposes will eventually become obsolete. This is, however, a time process that can be calculated in advance with some degree of accuracy as indicated by the B. P. A. forecasts. Obsolescence may be an effective constraint upon project development where the project relies heavily upon purposes which are threatened by obsolescence in the foreseeable future. This constraint will vary from project to project, depending upon the cost relationships of the important purposes with alternatives, and thus are taken into account by the relevant federal agencies.

Changes in the level of demand will change with respect to population changes and changes in the level of incomes. To this extent they may provide an effective constraint upon development. Changes in demand, however, should not be compensated for by shortening the period of analysis. In the interests of clarity, these changes should be taken into account by the interest and discount rates. The practice of the Corps of Engineers and the Federal Power Commission of using the period of analysis as a hedge against uncertainties of the future renders comparison of projects extremely difficult.

C. The Choice of the Price Level

As indicated in Chapter II, all agencies except the Bureau of Reclamation use the price level prevailing at the time of the analysis for calculating the monetary value of both benefits and costs. The Bureau bases its benefit calculations upon the price level which is expected to prevail during the life of the project. Future costs involved in irrigation and power are computed on the same basis, while immediate costs are calculated at prevailing prices at the time of analysis. Under the assumption that the price level over the life of the project can be approximated by an average price for the period, the Bureau bases its expectations upon the average of 1939-44 prices. There is the possibility that this method will be abandoned in favor of a price level based upon a series of projections of future levels of economic activity, patterned after the method used by the Department of Agriculture in its watershed treatment program.[39]

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[39] Subcommittee, "Proposed Practices," *op. cit.*, p. 9.

Because of the difference in the price level used as a base, the benefit estimates of the Bureau at the present time, for such purposes as flood damage, watershed improvement, and irrigation,[40] are approximately one-half those of other agencies.[41] In terms of today's prices, the Bureau is understating benefits relative to costs, probably to such an extent that, were it not for the inclusion of indirect effects which are largely ignored by other agencies, projects considered highly feasible by the Corps, the Department, and the Commission would be submarginal by Bureau standards.

Given the fact that benefits will normally occur much later than costs, the methods of the other agencies are not accurate to any greater degree. If benefits and costs are calculated on the basis of the price level prevailing at the time of analysis, the extent to which the two effects are comparable is entirely dependent upon the length of time that the current price level persists.

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[40] Ibid., p. 83.

[41] Using the average of wholesale prices of 1910-1914 as a base, the average prices for the period 1939-1944 stand at about 120. Using the same base period, the current wholesale price level is in the neighborhood of 280. Source: Department of Commerce.

The Subcommittee on Benefits and Costs recommended that prices be estimated as they are expected to hold at the time when benefits are received and costs incurred.[42] This means that project effects must be considered as falling into three categories: investment costs, which are immediate; operation, maintenance, and replacement costs, which are incurred over a variety of time periods throughout the life of the project and will vary as to rate during each of these time periods; and finally, benefits, which occur throughout the life of the project.

Initial investment costs can normally be evaluated on the basis of the price level prevailing at the time of project analysis so long as it may be assumed that the project is to be undertaken within a reasonable time thereafter. Even if this assumption cannot be made, once the analysis is completed and investment costs have been computed on the basis of the then current price level, it will be a relatively simple matter to adjust the cost figures so obtained for any later change in the price level if the project is postponed for any length of time.

The Bureau of Reclamation estimates operation costs, maintenance costs, replacement costs, and benefits on the

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[42] Ibid., p. 15.

basis of the price level expected to prevail at the time the benefits and/or costs are to occur by estimating the average price level expected to prevail over the life of the project.

The relevant problem is, however, that of accounting for relative price changes, not changes in the price level as such. Relative price changes will express the real value of benefits at the time they occur. A change in the price level will express their monetary value. It is generally recognized that under ideal conditions, measurement standards should reflect the public interest and should give expression to real costs and benefits.

> . . . the real cost to society of the resources used for project construction is measured by the amount of other goods and services for which such resources could be exchanged at the time when they are to be used. Similarly the real value of benefits is determined by the amount of goods for which they can be exchanged. If it were possible to postulate projections of real values, applicable to benefits when realized and to costs when incurred, and to supplement those values by consideration of society's long-range welfare, an adequate gauge of the public interest would be secured. Unfortunately it is not practicable to establish and apply such a system of real value.[43]

There is a further problem involved where the agencies are concerned. It is conceded that acceptance of the price

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[43]*Ibid*., p. 16.

level at the time of analysis, as modified by allowance for anticipated change in relative prices, has the advantage of stating benefits and costs in terms of relative values which are independent of changes in the price level.[44] It will not, however, lend itself to statement of the dollar benefits which the individuals can expect to receive from the project. This fact will complicate the problem of securing participation of individuals in project activities and of making repayment assessments.

This price level, further, will not give expression to the role played by water-use projects in counter-cyclical policy.

> In the past, low price levels have been associated with low levels of employment. Resource project costs incurred in such times are relatively low, and the benefits which accrue later are apt to have higher value in relation to costs than they would have if the projects were initiated during periods of high level employment. Under these circumstances of low employment, project justification and initiation are favored by the procedure recommended. Conversely, this procedure is less favorable to project justification and initiation when employment levels and the associated phenomena of prices are high.[45]

It is agreed that there is some value in expressing benefits and costs in the terms of which individuals are accustomed

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[44] *Ibid.*, p. 17.

[45] *Ibid.*, p. 17.

to thinking; but, to the extent that there is a divergence between real and monetary values, it will be difficult to compare costs which, being measured by current prices, will be in real terms, with benefits which are measured in monetary terms. It would appear to be preferable to state the value of benefits and costs in terms as near to real terms as possible. If it is assumed, and the Subcommittee makes this assumption, that current market prices reflect real values, it would seem to follow that the price level prevailing at the time of analysis should be used.

With respect to the stabilization value of the projects, it would probably be better, at least in terms of the economic value of the analysis, to apply an adjustment outright to the results of the analysis to compensate for changes in the level of economic activity, rather than to attempt to compensate for these changes through the price level.

APPENDIX TO CHAPTER V

GLOSSARY

An acre foot of water is an amount of water sufficient to cover an acre of land to a uniform depth of one foot.

Cubic feet per second of water flow is the number of cubic feet of water which will flow past a given point of a stream in one second. 43,560 cfs is equal to one acre foot.

Primary power is that amount of power which can be produced during all time periods. A hydroelectric plant which relies upon run-through water can produce continuously only that amount of power which can be generated by the minimum stream flow. If a reservoir is constructed, the amount of primary power can be increased by increasing the supply of water available for use during periods of minimum stream flow.

Secondary power is power in excess of primary power, and is available only during certain peak production periods (any time stream flow is above the minimum and in excess of reservoir capacity).

Usable storage is the total capacity of the reservoir. Due to technical and physical limitations, all of the water stored in a reservoir cannot be drawn off when needed.

<u>Useful capacity</u> is that part of the capacity of a water-use reservoir in which water can be stored and drawn off as needed for consumptive use. This will usually be a smaller part of total capacity, and, hence will be less than usable storage for purposes other than flood control.

CHAPTER VI

THE RATE OF INTEREST AND PROJECT RANKING

We are here concerned with two closely related aspects of the benefit-cost analysis: the selection of interest and discount rates and risk allowances to make benefits and costs comparable with respect to time and certainty of occurrence, and the use of benefit-cost analysis in ranking projects for development. Since both the role of the interest rate and the projects selected for development will be influenced by the characteristics of the supply of capital for financing water resources development, a discussion of these characteristics will be included in the discussion of the interest rate.

A. Interest and Discount Rates and Risk Allowances

1. Introduction

In the discussion of the choice of the price level by means of which future benefits and costs are given monetary expression, we were concerned with the problem of expressing the magnitudes of those effects in terms which would reflect the opportunity costs of resources at the time of their use and the value of benefits at the time they are received. This was a first step towards making benefits and costs comparable. There is, however, another problem to be overcome before this goal can be achieved. Benefits and costs will be comparable, in the real sense of the word, only when they have been converted to a uniform time and certainty basis, that is, when future benefits and costs have been adjusted to reflect preferences for present as compared with future goods and the risks and uncertainties attending future production. Interest and discount rates are used to convert benefits and costs to a uniform time and certainty basis.

The interest rate has three functions: first, it gives expression to the time preferences of individuals; second, it gives expression to the risk element in future production; and, third, it is a price, the price of capital, and acts as a rationing device to channel capital funds into their most productive use.

It is probable that society, as well as individuals, has a tendency to place a somewhat higher value upon present as compared with future income and consumption. The interest rate is of importance as it reflects this preference as to time. There is some discount rate which, when it is applied to future benefits and costs, will cause the resultant value of those effects to be equal to comparable effects in the present.

Public investment, as well as private investment, is carried out in a rapidly changing world. Technological developments, changes in consumer tastes, and other unknown risks lend an aura of risk and uncertainty to investment decisions. Calculation of vague social benefits and costs could add to the risks for public investment.[1] Relatively, present uses are sure and certain. Consequently, if present and future benefits and costs are to be comparable, future effects must be discounted for these hazards of the future.

2. Time Preference

The public agencies involved in water resources development consider the interest rate to be "an expression of the exchange relationship between present and future goods."[2] This means, in effect, that they conceive the

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[1]It is doubtful, however, that present practices relating to measurement of social benefits and costs involve much risk because of agency conservatism in calculating intangibles.

[2]Subcommittee on Benefits and Costs, Report to the Federal Inter-Agency River Basin Committee: Proposed Practices for Economic Analysis of River Basin Projects, (Washington, D. C.: United States Government Printing Office, 1950), p. 22.

purpose of the interest rate to be at least partly that of reducing the amounts of future benefits and costs in such a manner as to express society's higher preference for resources in the present as compared to a future date.

Although the agencies generally assume that the interest rate on long term government bonds affords a satisfactory measure of the cost of capital used in water resources development,[3] the Corps of Engineers and the Department of Agriculture use a somewhat higher rate in converting benefits and private costs over time to an equivalent annual average. Both agencies use rates from four to five per cent for this purpose.[4] The Subcommittee on Benefits and Costs recommended that a rate of not less than four per cent be used in converting deferred benefits and private costs, with the objective in mind of reflecting more adequately the values attached to deferred benefits by individuals participating in the project and, also, to

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[3]They assume that the interest rate applying to long term government bonds is the applicable rate because it is relatively risk free. Most risks are presumed to be eliminated from capital costs by the use of risk allowances, by conservative methods of calculating project benefits, or by inclusion of a risk factor in the discount rate.

[4]Subcommittee, "Proposed Practices," op. cit., p. 76.

encourage private investment and participation.[5] The rate which would be applied to federal and public non-federal[6] costs and benefits would, however, be that of long term government (from 2½ to 3½ per cent). The use of different rates to convert private and public effects is apparently based upon the assumption that private evaluations and preferences as to time lie somewhat above those of society as a whole. Use of the lower rates for all effects would probably decrease the willingness of individuals to participate in the project by under-stating the time preferences of those individuals.

Krutilla and Eckstein have suggested that the rate of interest which will reflect society's relative valuation of incomes in different periods will lie between 5.44 and 5.81 per cent.[7] They determined this range by an analysis of the asset and credit position of each income class in the United States to determine the rates at which these

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[5]*Ibid.*, p. 23.

[6]These are usually costs which are required to be incurred as a prerequisite for federal participation. They might take the form of costs incurred in setting up an irrigation district which will undertake the task of assessing participants for benefits received.

[7]John V. Krutilla and Otto Eckstein, "The Cost of Federal Money, Hells Canyon, and Economic Efficiency," *National Tax Journal*, March, 1958.

classes borrow or save. The interest rates on which consumers make their borrowing-saving decisions were estimated on the amount of debt held in all forms, from government and high grade private securities to sales finance companies. The final figure was obtained by weighing the average rates applicable to the income classes by their share of tax savings as represented by deductions from income taxes for interest paid.

The primary objection to this calculation, as its results apply to water resource development, lies in its inclusion of a very high risk factor (relevant rates for low income groups were averaged at twelve per cent, and at nine per cent for the rest). The relevant interest rate for public investment, since risk has been eliminated by use of a discount rate and risk allowances, would probably lie below 5.44 per cent. However, a discount rate for deferred benefits of four per cent at a minimum, plus downward revision of benefits by conservative estimation, might lead to an implicit rate of very near that figure.

3. Risk and Uncertainty

Risks fall into two categories, known and unknown. Risks which can be predicted on the basis of probability, such as losses from fire, storm, pests, and diseases, can be accounted for either through insurance or by setting up appropriate allowances. Most of the public agencies take the known risk factor into account by means of the latter. The Federal Power Commission, the only agency to utilize insurance as protection against loss from unforeseen risk, includes it in annual charges as 0.12 per cent of total investment costs.

Unknown risks, such as fluctuations in the level of economic activity, changes in consumer tastes, and obsolescence of project features, can be provided for in several ways. A limited economic life can be assumed for the project, as is done by the Corps of Engineers and the Federal Power Commission. A minimum salvage allowance can be made, as is the policy of the Corps of Engineers and the Federal Power Commission.[8] Contingency reserves can be set up, or benefits can be computed on a conservative basis. Finally, a risk factor can be included in the discount rate. In most cases, several of these techniques are used by the agencies. Thus all predictable risks will usually have been deducted from net benefits, and at least a part of the

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[8]The Department of Agriculture makes no allowance for salvage, but this is because of its assumption of perpetual life for its projects rather than out of any desire to protect against unknown risk.

unpredictable risks will have been deducted through one or more of the indirect methods outlined above.

It would seem to be preferable to take unknown risks into account by means of a risk factor added to the discount rate. Even though it might be argued that the result would be the same, a part of the value of the benefit-cost analysis lies in the fact that it brings the relative effectiveness of water resource development vis-a-vis other investment opportunities into the open. It seems desirable that the magnitudes of project effects be expressed in uncomplicated terms in order that a clear choice may be made.

4. The Supply of Capital

Capital theory often assumes that the supply of investment funds is determined by the willingness of savers to lend an amount equal to what they would save at any given rate of interest, plus bank lending, and that investors will have, and take advantage of unlimited access to investment funds as long as their expected returns lie above the market rate of interest.

Investment funds for water resources development come chiefly from the federal government, and do not appear to be significantly related to the prevailing market rate of interest, as represented by the cost of borrowing.

Unless we assume that all water-use projects are financed through sale of government bonds, the supply of public investment funds cannot be held to be dependent upon the willingness of savers to lend. In view of the fact that most water-use projects are financed wholly, or in part, out of tax revenues, it must be concluded that the supply of investment funds for water-use projects is relatively independent of the rate of interest.

Federal funds for water-use projects are appropriated by Congress. While Congress has evinced considerable interest in economic justification of such projects,[9] that is, in the productivity of water resources investment, it is not likely that all economically justified projects are allocated investment funds.[10] In fact, comparison of federal expenditures for water resources development with total federal expenditures, gross national product, gross private domestic investment, and total federal investment

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[9]Cf. Flood Control Act of 1936.

[10]In 1954 a benefit-cost analysis was made of a proposed development of the Tualitin River Basin in Oregon. The results of the analysis indicated that the benefit-cost ratio of the proposed project was in excess of two to one. The project was not recommended by the Corps of Engineers on the grounds that the project was not politically feasible. (Source: Discussion with an official of the Planning and Development Division, Civil Works; Office of the Chief of Engineers, Department of the Army, in Forest Grove, Oregon, 1955.)

seems to indicate that the productivity of water resources development may play only a minor role in determining the level of investment in water-use projects. Such a comparison is made in Table VI. Expressed as a percentage of total federal expenditures and of gross private domestic investment, federal expenditures in water resources development were higher in the middle and late thirties than in later years. This might indicate that investment in water resources development is more responsive to fluctuations in the level of economic activity than to the rate of return expected from development. Taken as a percentage of gross national product, water resources expenditures remained relatively steady over the years 1936 to 1951.

During the post-war years there has been some increase in water resources expenditures, although it is difficult to say whether the rise is a continuing one on a percentage basis.

> After the beginning of the war the general appropriation bill for 1951, as enacted, reduced the amount for water development, and further cuts will be made. Water programs have generally suffered during periods of war and defense activity.[11]

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[11] The President's Water Resources Policy Commission, A Water Policy for the American People, Vol. 1, (Washington, D. C.: United States Government Printing Office, 1950), pp. 82-83.

TABLE VI

FEDERAL EXPENDITURES FOR WATER RESOURCES DEVELOPMENT[a]

Item	1936	1937	1938	1939	Fiscal Year 1940	1947	1948	1949	1950	1951
Total federal expenditures in billions	8.5	7.8	7.0	9.2	39.3	33.8	40.1	43.3	43.3	42.4
Water resources expenditures as percentage of total federal expenditures	3.4	3.6	4.1	3.2	3.5	1.1	1.7	2.1	2.6	3.1
Gross national product in billions	77.4	86.4	87.4	88.0	96.4	222.2	246.2	257.4	259.7	276.0
Water resources expenditures as percentage of GNP	.39	.33	.32	.32	.35	.19	.24	.32	.43	.48
Gross private domestic investment in billions	6.2	8.2	8.2	8.4	10.6	26.8	34.3	37.2	38.6	37.8
Water resources expenditures as percentage of private investment	4.8	3.7	3.7	3.6	2.8	1.5	1.8	2.2	2.8	3.4
Total federal investment in billions								7.7	9.9	11.2
Water resources expenditures as percentage of total federal investment								10.4	11.1	11.6
Total water resources expenditures in millions	289.6	283.3	282.2	284.4	323.2	421.3	585.8	825.5	1116.2	1329.5

[a]Adapted from President's Water Resources Policy Commission, A Water Policy for the American People, (Washington, D. C.: United States Government Printing Office, 1950), Table 3, p. 92.

Although the percentages cited in the table are inconclusive, in that they cover only a limited time period, they support the belief that the supply of investment funds for water resources development is not significantly a function of either the rate of interest or the rate of return to be expected from water-use projects. Congressional appropriations for water resources development seems to be to some extent determined by the mood of Congress at any given point in time.

Institutional factors relating to the manner in which development funds are made available make it necessary to assume that the supply of those funds is determined exogenously and is independent of the rate of interest. Increases in the supply of funds may be called forth by growing unemployment in the economy or by the pressures of local interest groups upon Congressional representatives.[12] Decreases in the supply of funds may be brought about by the threat of inflation or by political ideology. In all cases the supply of funds will be limited by the willingness

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[12] Earnest A. Engelbert, "Political Aspects of Future Water Resources Development in the West," *Water Resources and Economic Development of the West: Research Needs and Problems*, Proceedings of the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Berkeley, California, 1953, p. 93.

of Congress to allocate money for water-use projects. To the extent that Congressional willingness to appropriate funds for water resources development arises from other reasons than the results of benefit-cost analysis, the supply of those funds is determined exogenously.

5. The Internal Effect of the Interest Rate

Although much of the controversy in the field centers about the effect of the interest rate in allocating funds between public and private investment, relatively little has been written concerning the internal effect the interest rate might have upon benefit-cost analysis conclusions. If, for example, the rate of interest used is low, those projects having a comparatively high demand for capital will be in an advantageous position with respect to the benefit-cost ratio. If, on the other hand, the rate of interest used is high, then those projects which are relatively less capital intensive would be more likely to exhibit a superior benefit-cost ratio. The low rate will benefit long-term projects; the higher rate will aid short-term projects.

This fact suggests that the government might well set the rate of interest for water resource development at that level at which it would be equal to the rate of return from the marginal project. The rate of interest so set could then be applied to all projects, with projects selected for development according to the traditional method of comparing the rate of return and the interest rate. All projects which promise a rate of return in excess of the rate of interest would be developed; those projects offering a lower rate of return would not. This is illustrated in Figure 4. Line BR indicates the rates of return expected from the various projects, as determined by the benefit-cost ratio minus one.[13]

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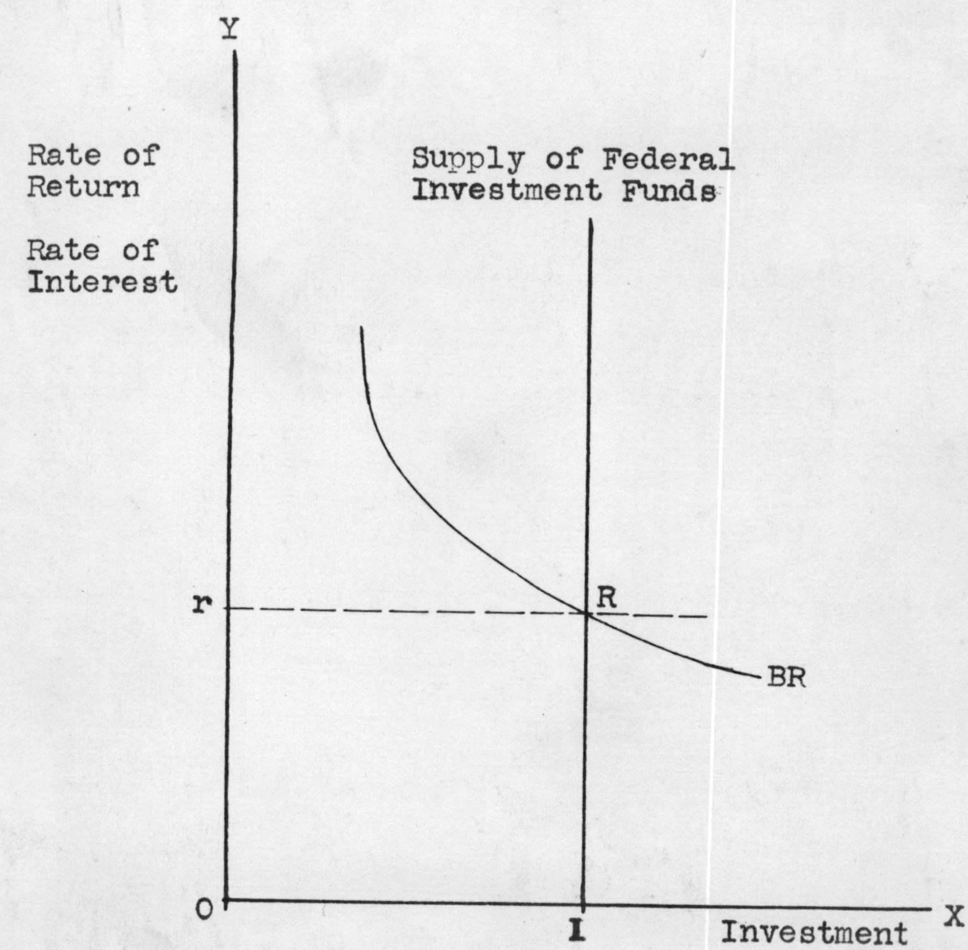
[13]The inclusion of operating costs in project benefit-cost ratios for comparison with other alternatives is necessary in order to reflect the full opportunity cost of using factors in water-use projects. It is doubtful, however, that operating costs are paid out of the supply of investment funds. Therefore, for purposes of ranking projects, the benefit-cost ratio should be one in which operating costs have been deducted from benefits. This means that the benefit-cost ratio relevant for ranking purposes is one in which only investment costs are included in the denominator. This will have some effect on the order in which projects are ranked, that is, those projects with large operating costs will have correspondingly higher benefit-cost ratios. The elimination of operating costs, however, will cause the benefit-cost ratios to reflect more accurately the productivity of water-use projects. An example will make this apparent. Let us suppose that the benefits derived from a specific project amount to \$1,000,000, and that the initial investment costs are \$600,000and operating costs are \$200,000. The benefit-cost ratio of this project for comparison with alternatives will be 1.25 to 1. For purposes of ranking, the operating costs are deducted from benefits, leaving benefits in the amount of \$800,000 and costs of investment of \$600,000. The new benefit-cost ratio is 1.33 to 1. The rate of return for this project is .33.

FIGURE 4

THE INTEREST RATE AND THE
MARGINAL RATE OF RETURN



The rate of return on the marginal project would then be indicated by point R, and the interest rate, r, would be set equal to R. All projects would then be ranked in the order of BR on a descending scale, with those projects lying to the left of point R eligible for development, while those projects lying to the right of that point would be considered ineligible.[14] As Otto Eckstein has pointed out:

> The relative valuation of incomes in different periods which is implicit in the use of the internal rate of return of the marginal project will generally not be the optimum rate. The planning authorities must pick both the rate of interest and the amount of investment simultaneously . . ." [15]

In other words, the rate of interest so set would reflect the productivity of investment in water-use projects, but would reject the market judgement as to the share of national income which is to be devoted to investment as well as the market's relative valuation as to time. To all intents and

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[14]The supply of capital for the government can be considered perfectly elastic up to point R and perfectly inelastic beyond that point. By contrast, the supply of capital in the private market will probably be upward sloping throughout.

[15]Otto Eckstein, "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics," Quarterly Journal of Economics, LXXI, February, 1957, p. 64.

purposes, the first of the latter two factors has already been rejected by the manner in which decisions as to quantity of funds to be made available for water resources development are reached. The second has been largely rejected by the manner in which investment funds have been obtained, that is, through taxes rather than the capital market.

B. Project Ranking

The purpose of benefit-cost analysis is to enable the agencies to determine the economic effectiveness of resources used in water resource development. They assume that resources will be used most economically when net benefits from development are at a maximum.[16] Projects are considered to be economically justified whenever benefits exceed costs. While a comparison of the net benefits of one project with those of other projects would show which projects would produce the most net benefits, no basis would exist for comparing the relative costs of obtaining these benefits. Project A. might have benefits in the amount of $2 million and costs in the amount of $1.5 million, while Project B has benefits of $10 million and and costs of $9,500,000, but the ratio of project benefits to

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[16] Subcommittee, *op. cit.*, p. 13.

costs will be 1.33 to 1 for project A and only 1.05 to 1 for project B. Project A will use resources more economically than will project B. For this reason, the Subcommittee recommended that projects be ranked for development on the basis of their benefit-cost ratios.[17] This method gives expression to both benefits and costs and would insure that those projects which produce the most benefits in relation to their costs will be developed first, if there were unlimited funds available for water-use project development.

In Figure 5 we are concerned with two potential projects, A and B. Both are economically justified, that is, they both have benefit-cost ratios in excess of 1. If there is six million dollars available for development, there is no difficulty posed by the ranking system. Suppose, however, that only four million dollars can be used for development. The Subcommittee recommendation would lead to use of the entire four million on project A. Though it is true that project A's average benefit-cost curve (a) is higher than that of B, the same is not true for all ranges of the marginal benefit-cost curves.

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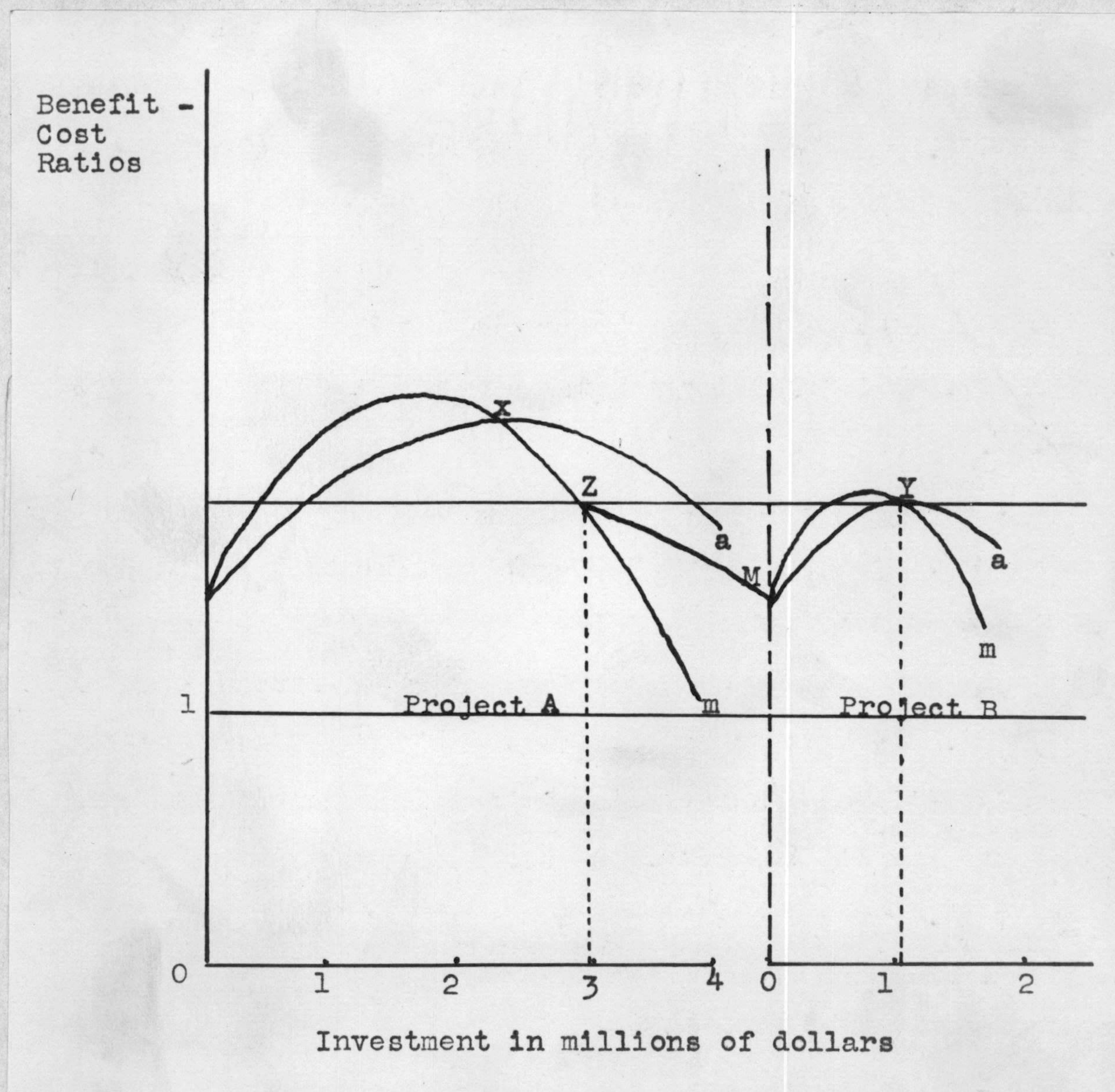
[17] *Ibid.*, p. 14.

FIGURE 5

PROJECT RANKING WITH
CAPITAL LIMITATION



Up to point X, additional investment in project A will cause its marginal benefit-cost ratio to exceed its average benefit-cost ratio. Beyond point X, however, additional investment will be relatively less productive. The average benefit-cost ratio curve will begin to decline at that point, but at a slower rate than the marginal benefit-cost curve. Up to point Y, the marginal benefit-cost ratio of project B is rising at a higher rate than its average benefit-cost ratio; and, in this range, project B will add more benefits relative to its costs than will additional investment in project A past point Z. Thus net benefits would be higher if $2.9 million were invested in project A and $1.1 million in project B, than if the entire $4 million were invested in project A. A ranking system which orders projects for investment by their benefit-cost ratios may, therefore, result in inefficient use of public investment funds.

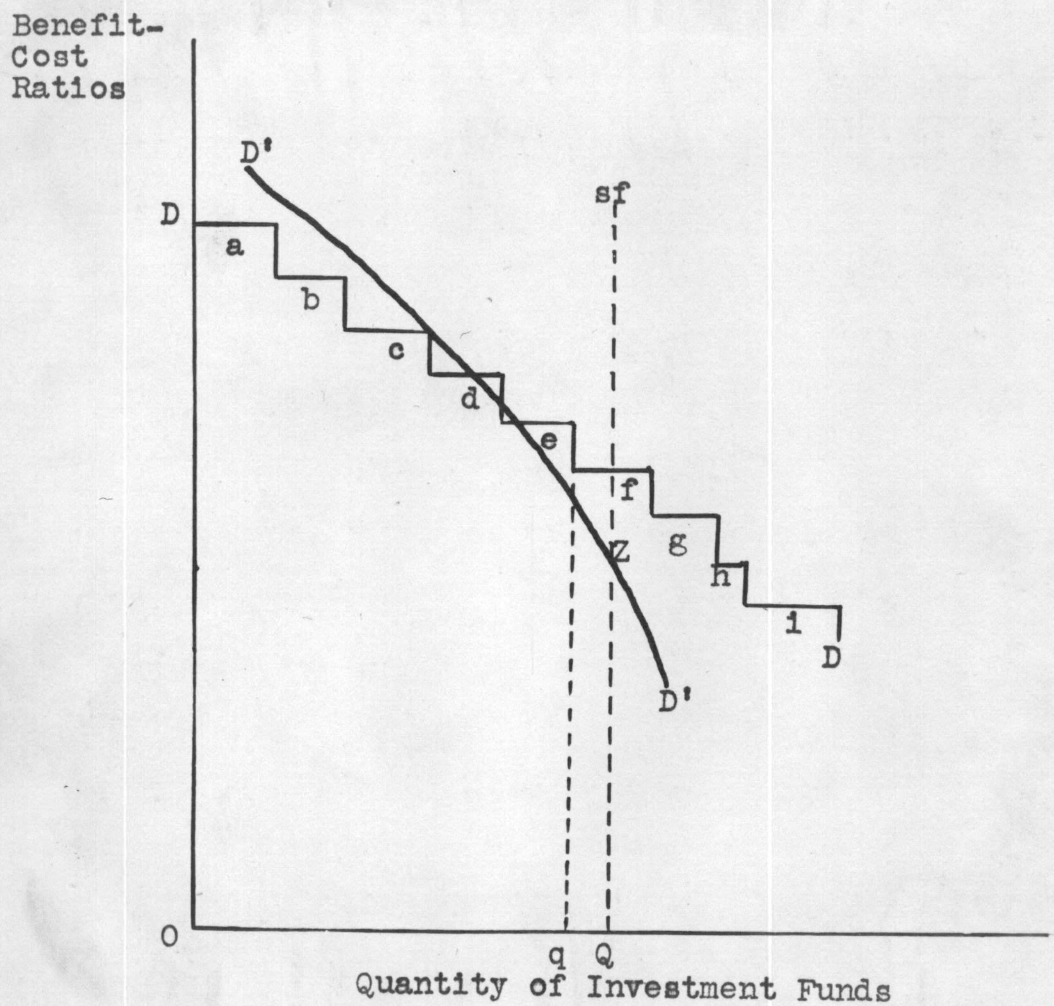
The above case indicates that investment in projects should be carried out to the point at which their marginal benefit-cost ratios are equal. If this can be done, net benefits will be maximized. This will require, however, that water-use projects be infinitely divisible. This does not appear to be the case.[18]

An alternative system of ranking is that which computes the benefit-cost ratios of separable purposes, rather than of total projects, and selects for development those purposes which possess the highest ratios. In Figure 6 such a case in presented. Taking first the discontinuous demand curve D as the demand for investment funds for various projects under conditions of indivisibility, that is, either an entire project or nothing, it can be noted that the curve constitutes a ranking of possible projects by their benefit-cost ratios. Under the assumption that the supply of investment funds is limited to the amount OQ, projects A through E could be completed, with the quantity of investment funds utilized indicated by Oq, and the quantity of investment funds available but unused shown as by qQ. It might be that another project, H for example, could utilize those surplus funds and be completed ahead of F and G. This would involve developing an inferior project ahead of superior projects, and a consequent reduction in net benefits relative to the amount possible if the superior projects could be developed first, or if

[18] Supra, Chapter IV.

FIGURE 6

RANKING BY PROJECT AND
BY PURPOSE



the purposes which caused those projects to have superiority were developed first.

Just as the benefit-cost ratios of projects vary in amount, so do those of the separable purposes. Line D' in Figure 6 illustrates ranking by separable purposes. A project with a very high benefit-cost ratio may have one or more separable purposes with even higher benefit-cost ratios, and one or more purposes with lower benefit-cost ratios. A project with a lower average benefit-cost ratio may very well have one or more separable purposes with higher ratios than those of the lower order in the former project. Since by taking high-ranking purposes out of otherwise low ranking projects the maximum of benefit-cost ratios is raised, the upper range of D' will lie above the upper range of D and the lower range of D' will lie below the corresponding range of D. All project purposes to the left of point Z should then be developed. Such a system of ordering should maximize net benefits.

The use of this method is, however, subject to the technical requirements involved in construction of multiple purpose projects. It is clearly possible that inclusion of a project during the initial stages of construction may result in somewhat lower costs than would accrue to the same purpose if it were to be added to the project at a later date. In addition, the companion purposes of the project may be found to bear a higher cost if one of the purposes is omitted than if the purpose were included. The existence of joint costs in project construction would cause the benefit-cost ratios of those purposes remaining to be lower than would otherwise be the case.[19] For this reason it is unlikely that this method would be any more efficient than ranking of projects by their benefit-cost ratios.

Of the types of ranking schemes discussed, it is probable that the most efficient, in terms of maximization of benefits in relation to costs, will be one in which projects are developed to the point at which their marginal benefit-cost ratios are equal, subject to the degree of indivisibility which exists.

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[19] *Supra*, Chapter IV.

PART III

CONCLUSIONS

CHAPTER VII

CONCLUSION

A. Introduction

The end towards which the benefit-cost analysis is directed is economic justification. If a project and its component parts are selected from among the most economical alternatives open, if the scale of the project is established at the point at which net benefits are at a maximum, given the surrounding circumstances, and if benefits exceed costs by enough to cover opportunity cost of capital, it can be said that the project is economically justified. The extent to which benefits exceed costs will be indicated by the benefit-cost ratio. This ratio will be of value principally as a device by which the relative desirability of all justified projects may be compared.

Project evaluation is aimed at ensuring fulfillment of the main purpose of benefit-cost analysis, namely, determination of the economic justification of specific projects. In the course of this evaluation, the need for each purpose of the project will be established, and the details of project development will be set according to the most economical available method of accomplishing the project purposes.

B. The Need for the Project

The value of a project lies in the need which exists for the goods and services which may be expected to be produced by the project. In other words, the demand for a project is derived from its output. In many cases the nature of that demand may place a limitation upon the type and scope of project development. The demand which may be expected for hydroelectric power will be determined largely by future economic developments in the market area of the project and by the price which must be charged for that power. For flood control, the limitation will be placed upon the scope of development by the maximum flood against which protection is demanded. The soil types to be found in the project area, or future expectations relative to transportation may determine the demand for water for irrigation. One of the first tasks of project evaluation will be that of evaluating the possible limitations to demand for all of the purposes of the project under study. The types of data which will be required for an analysis of project demand are illustrated in Table VII.

TABLE VII

BASIC SOCIO-ECONOMIC DATA REQUIREMENTS
BY TYPES, FUNCTIONS, AND STAGES OF DEVELOPMENT[a]

	I	II	III	IV	V	VI	VII	VIII	IX
Population:									
Number, location, density	PO	P	P	P	PO	PO	PO	PO	PCO
Income and expenditures	PO			P	P	P		PCO	PCO
Age, sex, race, size of families	PO			P	P	P	P	PCO	PCO
Resources:									
Land		PCO	PCO	P	P			PCO	PCO
Water	PCO	PO	PCO	PCO	PCO	PCO	PO	PO	PC
Mineral	P	PCO		P	P	PO			P
Industry:									
Mining	PO			PO		PO	PCO		P
Manufacturing	PO			PO		PO	PCO		PC
Agriculture		PO	PCO		PCO				PCO

Utilities									
Markets:									
Agricultural	PO								PC
Industrial	PO			PO	PCO				
Other	PO			PO		PO			
Production:									
Agricultural		PO	PO		PCO				PCO
Mineral	PO	P		PO		P			
Other industrial	PO	P	P	PO		P	P		P
Damages		PCO	PCO				PO		PCO
Prices	PCO	PCO	PCO	PCO	PCO	PCO	PCO	PCO	PC

Column I - Navigation, Column II - Flood Control, Column III - Drainage, Column IV - Hydro Power, Column V - Irrigation, Column VI - Water Supply, Column VII - Pollution Abatement, Column VIII - Recreation, Column IX - Watershed Management.

P - Planning (preliminary examinations, surveys, and definite project reports).

C - Construction (including plans and specifications).

O - Operation and maintenance

[a] President's Water Resources Policy Commission, op. cit., p. 333.

It will be noted that the types of data required for analysis of demand vary according to the purpose under consideration, and according to the stage of construction. For evaluation of the demand for irrigation, for example, it is important that complete information relative to population data be available. This will necessarily include the number of individuals, their location, and the density of population, information as to income and expenditures, and the ages, sex, race, and size of families. For flood control, on the other hand, it is necessary only to determine the population, size, location, and density. The collection of data on the level required for even approximately accurate estimation of demand has only just begun. For a summary of the major deficiencies in the basic economic data needed for water resource planning, see Appendix I. As shown in Table VII, only five of the nine water-use purposes listed require information relative to markets. Three of those not needing market data are valued in terms of damage reductions. Only watershed treatment requires both market and damage data. Only recreation requires neither market nor damage information. Yet, all of the purposes are seen to need price data for valuation purposes. In other words, in only five of the nine cases can market values be directly applied. In the other four purposes market values must be either imputed, or the value of such purposes must be described in non-price terms.

C. Three Dimensional Aspect of Water-Use Projects

Water-use projects are three dimensional in nature. These three dimensions, the physical, the economic, and the institutional, carry special weight in considerations of water-use projects, adding complications to the problems involved in making an economic analysis of such projects.[1]

Physical studies of project resources enable determination of the range and limits of physical possibilities. These will be established by the types of soil, by available water supplies, by the topography of the area, etc. Technological advances may offer possibility of enlargement of the range of physical possibilities, but this range cannot, and will not, be influenced by either economic or institutional considerations. It is essential that the physical problems be considered closely in making an analysis of a water-use project, but the basic elements of water

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[1]John F. Timmons, "Some Policy Aspects of Water Resource Development," Water Resources and Economic Development of the West; Institutions and Policies, Report No. 2, Conference Proceedings Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Bozeman, Montana, 1954, p. 55.

resource development policy cannot be established on this basis alone. This may have been a weakness of water resource development in the past; that is, physical and engineering problems seem to have provided the over-riding considerations for past water resource development in some instances.[2]

Economic studies enable determination of economic feasibility and of the appropriate level of development for maximization of want satisfaction.[3] Technological advances will increase the range of economic feasibility. Changes in the level of demand, changes in prices and costs, and changes in the level of business activity, will all affect the range of economic feasibility. The range within which economic feasibility will affect development policy, however, depends both upon that which is physically possible and that which is institutionally permissible.[4]

The institutional aspect of water-use development will determine the extent to which it is institutionally permissable to undertake forms of development which pass both

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[2] Ibid.

[3] Ibid., p. 56.

[4] Ibid.

the physical and the economic tests. This aspect is controlled by laws, customs, organizations, etc., and may act to either limit or expand development. As Timmons says:

> In analyzing policy aspects of water resource development, we must, however, recognize clearly the interrelationships of physical and institutional as well as the economic dimension.
>
> Probably a brief example with respect to irrigation of agricultural land from natural bodies of surface water would help clarify this point. Let us assume that the engineers, hydrologists, geologists, agronomists and other physical scientists conclude that it is physically possible for "X" river to provide 12 acre inches of water per year on "Y" acres of cropland at six intervals of two inches per application. The range of physical possibilities thus runs from zero to 12 inches of water for the cropland under study. Under given cost and price conditions, it is economical to use only six acre inches of the water that is physically available. However, since this particular river is covered by the riparian doctrine of water rights, it is not institutionally possible to use any of the water for cropland irrigation even though it is physically possible to provide 12 acre inches and economically feasible to use six acre inches.[5]

In the case outlined, the physical supply is twelve acre inches per year, the economic supply is six inches per year, and the institutional supply is zero. The institutional factor provides the effective constraint, in this case, setting the limit to development.

It is entirely possible that problems of permissibility may force enlargement of projects. The pressure of special

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[5]*Ibid*.

interest groups such as conservationists might make necessary inclusion of project purposes and facilities which would be ruled out by economic considerations. Those groups in the Pacific Northwest which are pressing for fishlife preservation provide a good case in point. On strictly economic grounds, provision of fish ladders and related facilities in projects under consideration seems to be open to criticism in many cases, and yet, if those facilities are not included, otherwise justified projects might no be politically possible.

The important point in this respect is that studies of potential development should encompass all three dimensions, and that the physical and social scientists must integrate their work. The economist will contribute effectively to the planning of water resource development only to the extent that he is able and willing to take the physical and institutional limitations into account in his calculations of economic feasibility.

D. Critique of the Public Agency Benefit-Cost Analysis

The public agency benefit-cost analysis is of relatively recent origin and, as yet, many of the data necessary for a thorough-going economic analysis of the effects of water resources are lacking. Partly as a consequence of this, partly as a consequence of what Warren Gramm has called "preoccupation with conventional price theory and avoidance of a broader valuation concept,"[6] the benefit-cost analysis, as it is currently conducted, has some important weaknesses.

1. Reliance upon Market Values

In spite of the fact that public agency entry into the field of water resources development is predicated upon a divergence between market and social values, the agencies rely on market values as the measure of project benefits and costs, to the extent that project values which cannot be stated in those terms are not included in the analysis for economic justification. If used at all, these latter values are applied as a super-numeraire when choosing between otherwise justified projects for ranking purposes.

The Subcommittee on Benefits and Costs recognized the desirability of stating project benefits and costs in real terms, but reasoned that individuals who are expected to participate in the project, and Congressmen who have to make appropriations for water-use projects, are accustomed to thinking in monetary terms and might reject any other

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[6] Warren S. Gramm, "Limitations of the Theory of the Firm for Water Resource Analysis," Land Economics, Vol. XXXIV, No. 2, May, 1958, p. 117.

valuation.

> Unfortunately it is not practicable to establish and apply such a system of real value. There would be the technical difficulty of devising such a pattern upon acceptable assumptions and furthermore, the administrators who recommend projects and the legislators who consider them would likely be averse to receiving project estimates couched in theoretical terms rather than in terms of expected dollar costs.[7]

The Subcommittee therefore concurred in the general agency practice of giving descriptive treatment to those values which cannot be expressed in monetary terms and holding them apart until the project has been otherwise justified. As Gramm has observed that this method, by placing intangibles outside the formal analytical framework, may encourage the agencies to understate or ignore intangibles in the process of evaluation.[8]

A benefit-cost analysis conducted by public agencies should be one in which social benefits and costs are given fullest possible expression. The excessive preoccupation of the public agencies with market values in present benefit-cost practices makes it unlikely that social values are given the attention they deserve.

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[7]Subcommittee on Benefits and Costs, Report to the Federal Inter-Agency River Basin Committee, Proposed Practices for Economic Analysis of River Basin Projects, (Washington, D. C.: United States Government Printing Office, 1950), p. 16.

[8]Warren S. Gramm, op. cit., p. 119.

2. Indirect Benefits and Costs

Indirect benefits and costs occur largely as a result of interdependencies which operate through the market mechanism. These benefits and costs are of two types, those which stem from, and those which are induced by the project. Indirect benefits and costs are susceptible of measurement through income changes, although the lack of precision inherent in this technique has been the source of a great deal of controversy over inclusion of these types of benefits and costs in the analysis for purposes of economic justification.

The method used by the Corps of Engineers, the Department of Agriculture, and the Federal Power Commission in calculating net indirect benefits as a percentage of direct benefits probably leads to understatement of their values in most cases, since these agencies assume the percentage to be only 10 per cent.[9] The magnitudes of indirect effects will probably vary substantially from project to project, depending upon the purposes involved and upon the type of project constructed. It is probable that net indirect benefits will lie fairly consistently above ten per

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[9] _Supra_, p. 110.

cent of direct benefits and almost certain that the actual percentage will vary from project to project.

The method used by the Bureau of Reclamation, on the other hand, will probably lead to equally consistent overstatement of the values of benefits and costs. Stemming from benefits and costs are a type of demand effect, while induced by benefits and costs are a supply effect. Calculation of both demand and supply effects results in double counting. As M. M. Kelso has pointed out, only one of the two types should be calculated, and that the smaller of the two.[10]

Calculation of indirect benefits and costs is essential if public agency benefit-cost calculations are to reflect full social values. Extreme care must be taken in their measurement, however, if misstatement is to be avoided, and the probability exists that substantial refinement of national income accounting data and techniques will be required before any real degree of precision is attained in statements of their values.

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[10] M. M. Kelso, "Evaluation of Secondary Benefits of Water-Use Projects," Water Resources and Economic Development of the West: Research Needs and Problems, Report No. 1, Proceedings of the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Berkeley, California, 1953, pp. 49-61.

3. Adjustment for the Level of Economic Activity

The present agency practice of adjusting the results of benefit-cost analysis for unemployment in the economy on the basis of the percentage of unemployment leaves much to be desired. It is not made clear whether regional or national employment data are to be used as the determinant of the amount of the adjustment. Neither is it stated at which level of unemployment the adjustment is to be applied. Finally, the adjustment relates only to the direct labor used in the project, with unemployment of other resources omitted from consideration.

The suggestion of the Panel of Consultants, that the adjustment be made upon a sliding scale based on the percentage of resources used in the project which is drawn from unemployment rather than other uses, appears to offer a superior solution. First, such a scale could easily be applied on a regional basis, and thus would work more smoothly into coordination with government employment policy. Second, the adjustment would be applied at any time resources are drawn from unemployment into project use. This lends predictability to the analysis and gives expression to the intangible benefits accruing from a reduction in unemployment. Finally, the percentage adjustment would take into account all reductions in unemployment, rather than reductions in labor unemployment alone.

4. Allowances for Replacement and Amortization

It appears that three of the four agencies set up, as a part of annual charges, allowances for both replacement and amortization. The Subcommittee on Benefits and Costs, in its summary of agency practices,[11] indicates that this is standard practice for all agencies other than the Department of Agriculture.[12] It is, however, extremely difficult to be certain that this practice is actually followed. In calculation of the separable costs and annual charges of the McNary Project, the Federal Power Commission included both allowances as a charge against the project.[13] Since replacement costs were included with operation and maintenance costs, in this case, there is the possibility that the replacement costs referred to were for minor replacements, with major replacements covered under amortization.

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[11] Subcommittee, "Proposed Practices," op. cit., pp. 80-84.

[12] The Department of Agriculture, since it assumes perpetual life for its projects, makes no charge for amortization.

[13] Federal Power Commission, Interim Allocation of Costs: In the Matter of the McNary Project, (Washington, D. C.: United States Government Printing Office, November, 1953), p. 28.

In the hypothetical case discussed by the Subcommittee on Benefits and Costs,[14] however, both amortization and major replacements charges were explicitly made, with minor replacements omitted along with operating and maintenance charges.

To the extent that this practice is followed by the agencies, double counting of annual charges will result. Provision should be made for either amortization or for replacement of major structures, but not both for the same project. To the extent that this double counting does not occur, the agency statement of practices is confusing. For the sake of clarity, the type of charges made should be stated explicitly.

5. Indirect Offsets for Risk and Uncertainty

The Corps of Engineers and the Federal Power Commission have set a maximum economic life for their projects of fifty years in spite of the fact that many of those projects can be assumed to return benefits in excess of costs far beyond this time period. The fact that benefits will probably exceed costs beyond the fifty year maximum is recognized by both agencies, but the shorter than actual

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[14] Subcommittee, "Proposed Practices," _op_. _cit_., p. 85.

economic life period is used as an offset to risk and uncertainty in the calculation of future benefits and costs.[15]

In addition to this method of accounting for risk and uncertainty, all of the public agencies at times use conservative estimates of project benefits as such an offset; at other times they inflate the allowances for known risks for this purpose.[16]

Even though the end result may be the same, it seems preferable to compensate for unforeseen risk and uncertainty by means of a risk factor added to the discount rate, rather than by use of these indirect methods. A part of the value of benefit-cost analysis lies in the lessons to be learned from comparisons of expected results of project development with experienced results. It is largely through continuing evaluation of past results that future improvements in the use of the analysis will be made. This requires that benefit-cost estimates be stated in clear and uncomplicated terms in order that expected and experienced benefit-cost relationships can be readily analyzed.

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[15]Subcommittee, "Proposed Practices," *op. cit.*, pp. 83-84.

[16]*Ibid.*, p. 23.

6. Project Ranking

It can be stated as a general rule that the economic desirability of any specific project will be reflected by its benefit-cost ratio. If there were no other considerations involved, it would be possible, therefore, to follow the agency practice of developing those projects first which demonstrate the highest benefit-cost ratios.

If, however, funds for water resources development are so limited that all economically justified projects cannot be developed, it may be necessary to seek another solution. An alternative might be ranking of project purposes, rather than projects, by their benefit-cost ratios, using the available funds to develop those purposes which possess the most favorable benefit-cost ratios. Project purposes are not, however, completely indivisible. Even where purposes can be developed separately, their benefit-cost ratios will probably be altered by the existence of joint costs and joint benefits. It will be necessary to take these joint benefits and costs into account, and also to consider the possibility of an increase in the cost of companion purposes if they are to be added to the project at a later date. It will also be necessary to make provision for purposes to be added later, at the time the original project facilities are to be installed. This will necessitate absorption of higher construction costs by those purposes to be developed first than would be the case if those purposes were to remain independent over time. For this reason it is not likely that ranking by purpose will result in any substantial increase in efficiency relative to the method now in use.

The agency practice appears to be based upon the assumption that water-use projects are completely indivisible; that is, that each project must be developed in its entirety or not at all. To a certain extent, indivisibility does exist in water-use project development, but certainly not to this degree. It appears likely that considerably more flexibility is possible than is assumed by the agencies. Within the range of flexibility, it would be possible to enhance the effectiveness of water resources investment by developing water-use projects to the point at which the marginal benefit-cost ratios of all projects are approximately equal. This would involve changes in the scope of water-use projects, but it should also result in higher net benefits from water resources development.

7. The Orientation of Benefit-Cost Analysis

The benefit-cost analysis, as it is applied by the public agencies, is oriented, to a very great extent, towards project justification in a field in which the existence of interdependencies between projects and between systems of projects would seem to indicate the application of the analysis on a broader basis.

The downstream effects of project construction are taken into account to some extent by the agencies, but the relationship between a given project and those which are developed higher in the river system is largely ignored. Comprehensive and effective development of water resources will require that the benefit-cost analysis be applied on a level which will reflect the benefits and costs which will accrue to other projects in the system from additional development. This will probably involve calculation of benefits and costs for entire river systems on much the same type of "with and without" basis now employed in calculating the separable benefits and costs for project purposes.[17]

E. Concluding Remarks

The benefit-cost analysis as it is applied to water resources development represents an attempt to place such development under economic scrutiny in a way that is quite different from other forms of public investment. As the benefit-cost analysis is refined and the data for measurement and the techniques of measurement are developed, this type of economic evaluation can be made of other forms of public investment activity. This will have important consequences for water resources development, since it will then be possible for water resource development to "take

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[17] The Oregon State Water Resources Board recently completed a study of the development potential of the Snake River which included just such an analysis.

A broader analysis of this type would probably include some calculations relative to the effect which system development might have upon regional growth along the lines indicated by John Krutilla. A part of the preliminary work of benefit-cost analysis would then be an evaluation of the types of resources to be developed, with an eye towards development of those resources which would attract "growth" industries to the region. John V. Krutilla, "Criteria for Evaluating Regional Development Programs," _American Economic Review: Papers and Proceedings_, Vol. XLV, No. 2, May, 1955, pp. 120-132.

its proper place in the allocation of public funds to the gamut of government functions."[18]

In addition, the development of improved techniques for evaluating the effects of water resources developments could well serve as a step towards better techniques for treatment of the general problem of development.[19] The necessity, in benefit-cost analysis, for working out solutions to the problem of expressing social values and costs could lead to some workable answers to a problem extending far beyond water resources development.

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[18] Warren S. Gramm, op. cit., p. 120.

[19] Ibid.

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APPENDIX I

SUMMARY OF MAJOR DEFICIENCIES IN BASIC ECONOMIC DATA NEEDED IN WATER RESOURCE PLANNING[a]

Item of Deficiency	Description of Deficiency	Need for the Data	Comment and Recommendation
A. Over-all economic base study:			
1. Population	Age, sex, race, size of family data need to be provided on an annual basis for as small as the county unit. These are provided by the decennial census, but estimates for intervening years are necessary.	For analyzing present and future demands of the river basin economy for water and other services that can be provided by river development. Also for evaluating impact of programs.	State and local units should be encouraged to make these estimates for interim census years on the basis of uniform estimating techniques developed on the national level. Federal agencies in cooperation should develop a method for adjusting state and local data now being collected to accord with the United States census data.
2. Labor force and employment	Uniform annual data for as small as the county unit and by principal industry groups.	(See above).	
3. Income	Income estimates are now made annually on a national and state basis and the need is for county estimates not only in aggregate terms but by principal sources of income.	(See above).	Periodic bench-mark income estimates by counties should be prepared by the national government and extended and supplemented by state and local agencies. In the absence of official estimates, the latter agencies should be encouraged to prepare county estimates by breaking down the available state estimates, using local-area data and a uniform technique of estimation.
4. Production	Discussed below in connection with specific activities.		
B. Functional studies:			
1. Agriculture: Inventory of land use and ownership	Important deficiencies are the major uses and ownership classes of rural land outside farms by different types of cover correlated with other characteristics of the land, such as, its productive value.	Information on major uses of land outside farms is needed periodically similar to the census of land in farms. In preliminary examinations and surveys of river basins and in watershed management, specific data by counties on the use, cover and ownership of all land are essential for intelligent action.	The necessary data possibly can be obtained in one of two ways: (a) Incorporation of appropriate questions and procedure in the Census of Agriculture which will permit assembly of information by counties on major uses and ownership classes of all rural land, and (b) a survey conducted possibly in cooperation with state and county officials utilizing available airphotos, maps, land and assessment records.

[a]President's Water Resources Policy Commission, Water Policies for the American People, Vol. 2, (Washington, D. C.: United States Government Printing Office, 1950), pp. 366-370.

APPENDIX I (continued)

Item of Deficiency	Description of Deficiency	Need for the Data	Comment and Recommendation
Estimates of conservation needs	More precise and complete estimates are needed of the extent and character of the total land and water conservation job and the time in which it should be completed in order to maintain the suitable agricultural area in use. Data on the conservation works installed, areas covered, and effectiveness of installations also are needed.	As additional river basin and related land and water programs are developed, the problem of maintaining an up-to-date inventory of needs and accomplishments will become increasingly important in the interest of wise investment and economical administration of installation and watershed management programs.	The needed data can be obtained by establishing more uniform procedures for use of interested public agencies for classification and annual reporting on estimates of needs, plans, and areas covered by necessary land treatments and water control measures. This procedure could be made a part of the present system of published annual reports, and would make it possible to obtain total national balance sheet of conservation needs, estimates and installations, excluding duplications.
Costs of land development	Information is insufficient for the on-the-farm costs of land improvement measures, such as, clearing, drainage, preparing land for irrigation, the cost of irrigation water to users and beneficial effects, reclaiming gullied land, seeding pastures, ranges, and other measures and practices used in the land phase of river basin development and watershed management.	For analyzing costs and probable returns in planning needed land measures and in judgment by farmers as to whether they can afford the improvements.	The needed data could be obtained by a few sample surveys to represent the different major situations of the country. Urban and industrial construction costs generally are not applicable to farm costs.
Prices of farm products	Data on prices of farm products are essential in river basin planning in order to convert production estimates into income estimates.	Cost and income estimates are needed in the economic analysis of proposed projects and component measures. Studies of prices and costs also are necessary to make a determination of the relationship between withdrawals from the land and additions necessary for production and maintenance.	The price data collected by the state agricultural statisticians generally can be supplemented to reflect local conditions in current river basin planning. Periodic studies to estimate the expected future general price level for various commodities also are desirable.
Economic relationships of weather and floods	Weather and flood data and information on important economic relationships of weather and floods are inadequate in some regions. A larger number of weather recording stations is needed in several agricultural and forest areas with the observations correlated with data for planting and harvest dates, crop and pasture yields and quality,	More complete coverage of the country by weather and flood information is needed to guide further agricultural developments and watershed management programs.	The necessary data could be obtained by increasing the present program of weather data collection and analysis and by relating agricultural data on crop and pasture yields, condition and quality to the seasonal weather records.

APPENDIX I (continued)

Item of Deficiency	Description of Deficiency	Need for the Data	Comment and Recommendation
	as well as for crop damages and extra costs resulting from weather and floods.		
Economic aspects of land classification	An inventory of areas and production of land suitable for development, and the new land currently being developed by clearing, drainage, and irrigation is vitally needed to help in projection of agricultural production trends, probable needs, land requirements, and potential lands available.	Investigation of land areas believed to have potentialities should precede actual construction planning so as to aid in selection of good land for development.	The necessary data can be obtained by continuation and expansion of soil survey, and land classification work, in river basins believed to have good potentialities for further land development.
2. Forestry	Initial surveys to obtain information on the location, area, stocking, volume, kind of trees, condition, growth and drain are needed on some 200,000,000 acres of forest land. In addition, resurveys of areas covered about 10 years ago should be made as rapidly as possible. Data are also needed on stand improvement and reforestation needs, and on cost and returns on various forest projects.	Satisfactory development of water resources requires adequate information on the condition of the forest land, because of its economic importance in terms of income employment and other benefits.	The United States should be covered by a forest inventory every 10 years. This means surveying 62,000,000 acres per year. Such surveys should be intensified and adjusted to meet the needs of water resources development.
3. Commercial fishery and trapping	In connection with broad river basin planning, there is a major deficiency in the amount of production, employment and income data presently available by states. Such data are needed for the harvesting, processing, and distributing levels of these industries. More information regarding the fresh-water fishing industry is needed by states and by major bodies of water within each state. More information regarding fur trapping is needed by states and by counties within each state.	These data are all required to evaluate properly the role of this activity in the economy of the region, and to make proper program provisions in connection with water resource planning.	Needed data might be collected jointly by the Bureau of the Census, the Fish and Wildlife Service, and the individual states. Much of the information could be obtained by increasing the coverage of the Census of Manufactures and through the collection of more detailed income data by county and by principal occupational sources of income. Additional information regarding fish and fur production could be obtained through more intensive surveys by the Fish and Wildlife Service and the states.

APPENDIX I (continued)

Item of Deficiency	Description of Deficiency	Need for the Data	Comment and Recommendation
4. Manufacturing and mining	A major deficiency is the use of water (quantity and quality) by different types of industry and mining correlated with other characteristics of the industry such as employment. Information on present usage and circumstances of use by different sources of water (direct river, municipal water and ground water) also are needed. Deficiencies in production and other data are not cited here inasmuch as needs for these data are more directly related to other than river basin planning needs.	As rivers are more fully developed, the problem of competition among the several uses will become real. Intelligent planning should take into account the use of water for industry. Adequate data on industrial and mining use of water do not exist to forecast such use even if the future level of manufacturing in the area were known. Mineral resource data are needed to provide advance indication of where mining and dependent manufacturing industries are likely to decrease because of exhaustion of reserves and conversely where new mining and manufacturing industries may start because of the development of new deposits.	The necessary data can be secured for manufacturing in 1 or 2 ways: (1) Incorporation of appropriate questions in the Census of Manufactures which will permit correlation with other data, and (2) a sample survey of different types of industries which will permit a fuller set of questions. For mining, the collection of data on water consumption perhaps could be made part of the Bureau of Mines program.
5. Tourism and recreation	Most data requirements can be satisfied by special surveys in connection with contemplated projecte for basin developments.	Special surveys are required to fit recreational potentialities of proposed water resource developments into proper balance with regional and local needs.	Tourism and recreational aspects of water developments should be investigated concurrently with surveys for other purposes which should be coordinated closely with data the Geological Survey will collect.
6. Transportation and navigation	Readily available basic data on costs (not rates) of transportation by competing means, such as railroads, truck, and alternative waterway routes; costs of airlines and airports; economic costs of operation of bus lines, private passenger cars. Lack of complete coverage of costs and economics of completed water-ways in operation. Data on basic origin and final destination of commodities.	For determination of most economical alternative means of transportation in evaluating waterway improvements; determination of flood losses and benefits to transportation in flood control studies; estimating costs of operation on relocated routes in project cost estimates. Sufficient data has generally been available or obtainable by special effort; data are needed for evaluation of transportation savings by new improvements.	Data affecting railroads and commercial trucking costs could be collected by Interstate Commerce Commission in regular reports by the carrier; for airlines and airports by the C.A.A. More widespread study of economics and costs of transportation on completed waterways.

APPENDIX I (continued)

Item of Deficiency	Description of Deficiency	Need for the Data	Comment and Recommendation
7. Power and Energy	A major deficiency exists in data on electric energy purchases, generation, sales, and maximum demands for industrial (mining and manufacturing) establishments of the country in each year on an individual plant basis. Improvement is needed in data on sales of electric energy by electric utilities for classified use, namely, for the farm, residential, commercial and industrial classifications. As presently reported to the Federal Power Commission, these data are lacking in uniformity and accuracy of definition. A deficiency exists in data on the use of electric appliances in homes and on the amount and types of electrically operated equipment used on farms. A limited amount of information on electric appliance use is collected by a few trade groups and Government agencies, but the data obtained are not uniform or adequate as to coverage, subject matter or geographic unit.	For analyzing industrial power requirements and supply and their relation to river basin hydroelectric developments. These data are needed to analyze utility load growth and to prepare estimates of future loads for use as a measure of the need for additional generating capacity that may be required in connection with planned river basin developments. These data are needed to analyze the growth of residential and farm loads and to estimate future load requirements as a measure of the additional electric generating capacity that may be required in connection with planned river basin developments.	It is recommended that the Federal Power Commission conduct an annual canvass of manufacturing and mining establishments to obtain these data in years for which the census data would not be available. It is recommended that data on energy deliveries by electric utilities to ultimate consumers be sought on the basis of classified use rather than on the present loose sales classifications. In order to meet minimum requirements, it is recommended that these data be obtained by appropriate agencies of the Government, possibly on a sampling basis. It is further recommended that this information be made available on a river basin and county basis.
8. Trade, services, and construction	Water requirements for these activities are included in overall domestic water supply requirements and generally require no speical treatment.	Existing data generally adequate for determining place of these activities in present and future regional economy.	Analysis should be made occasionally of these activities to determine significant departures or trends in water use.
9. Government installations	Water requirements of special installations such as in connection with atomic energy needed in areas of limited water supplies. Impact studies on governmental revenues and costs of the total river program would be helpful.	Need to appraise full effects of river basin programs on governmental costs and revenues--beneficial as well as adverse--on a case study basis. Should be a continuing study to get full effects of programs.	Location of defense and other governmental installations requiring large amounts of water should be coordinated with river basin planning. Case studies of full effects of river basin programs on government should be initiated, especially in areas where programs have been in operation for some time.

APPENDIX I (continued)

Item of Deficiency	Description of Deficiency	Need for the Data	Comment and Recommendation
10. Flood control (flood damages)	Flood damages differ from flood characteristics and usually require special surveys in each flood area for evaluation. Where flood conditions may be considered similar, standardized or sampling techniques may be applied. Further study of effects of floods; determination of standard relations and their limits of applicability desirable. More information would be desirable on the physical effects of floods on structures and their contents, particularly when complete destruction does not take place, but merely requires clean-up and effects more rapid depreciation. Specific data for flood areas are generally lacking, and must generally be secured by special surveys or approximation by prorating larger unit data.	For evaluation of flood damages and benefits, standard data, if determined to be applicable to a given situation, would expedite and lower costs of studies, and evaluation of effects of floods and improvement projects. County-wide or larger units do not give specific enough data for evaluating trends of development in flood areas.	Further study of measurement procedures, basic data and the applicability of "standard relations" by Corps of Engineers or FIARBC. Effects of floods on more rapid depreciation would be best secured from property owners if they could be encouraged to keep more accurate records; follow-up surveys after completion of improvements. Specific or sample surveys by investigating office will probably continue to be the most economical means of securing the necessary data on a less-than-county-wide basis, unless local governmental agencies can aid in periodic surveys or censuses. Much of this information is already being gathered by the Corps of Engineers, but additional data is needed.
11. Watershed management (discussed under B 1)			
12. Domestic and industrial water supply:			
Population	See item A 1.	See item A 1.	See item A 1.
Employment	See item A 2.	See item A 2.	See item A 2.
Income	See item A 3.	See item A 3.	See item A 3.
Industrial activity	By type of industry, i.e., manufacturing, trade, etc., and by specific industry within each type, i.e., rayon manufacturing, coal mining, etc.	To permit: (1) estimate of future of industries; (2) estimate of future water requirements.	Census of manufacturing and business made as frequently as possibe with information on specific industries by counties, major urban centers and river basins.
Building and other construction	Official data by types of buildings and other construction for counties, major urban centers and river basins for intercensus years.	To predict future construction activity and resulting water usage.	Data might be gathered at time of each Census of Manufactures and for Census of Business.

Item of Deficiency	Description of Deficiency	Need for the Data	Comment and Recommendation
Water usage	A major deficiency is the use of water (quantity and quality) by different types industry, commercial building and residences. See also item B 4 above.	Adequate data on use of water under varying climatic and industrial situations do not exist to forecast either future use of water or future ability of area to expand its industrial activities or even the population which it can support. See also B 4 above.	Data should be collected both from municipal water systems and from individual manufacturing and processing concerns. To a considerable extent, this is already being done by the Public Health Service for quantity and quality of domestic water supplies, and this agency has facilities for extending their program. Supplementary information might be collected either in connection with existing census procedure or through special studies covering only this purpose. See also B 4 above.
13. Pollution abatement:			
General data	The same as items 12 above.	See 12 above.	See 12 above.
Specific data on pollution	Data on sources of pollution, effects of pollution on economic values, costs, and estimated effects of pollution abatement have not been systematically gathered for the country as a whole.	Adequate planning of pollution control in the interests of industrial development is impossible without comparable data for each river basin.	Collection of information should be put on a continuing basis under the Water Pollution Control Division of the Public Health Service. This activity has recently commenced.
Fish and wildlife	Data similar to those discussed under B 3 above are needed on commercial fishing and trapping and on the commercial aspects of recreational hunting and fishing which require protection from adverse effects of river-basin development.	See B 3 above.	Data could be collected as suggested under B 3 above.

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