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REVIEW OF METHODS FOR THE ECONOMIC VALUATION OF WATER IN ALTERNATIVE USES

WORKING PAPER

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ABSTRACT

Economic valuation of water resources is a basic component of rational management. While water is a renewable resource, it is not unlimited at any given time and place. Utilization is often constrained by available quantity and quality. With increasing demand, the supply of high quality water is diminishing and conflicts between users are emerging. This paper reviews the methodology for determining values and charges for various water uses.

Opportunity costs, or values foregone are implicit in all water use conflicts. These must be determined on an economic basis and in relation to non-economic factors. The economic value of water as measured in dollar terms is determined by the willingness of consumers to pay for it. For the most part economic values of water must be imputed, since direct market prices are either non-existent or fail to reflect the full opportunity costs of usage. Subjective evaluation of the positive and negative effects of non-quantifiable water use, such as environmental quality, should also be completed.

This paper introduces the issues of value, choice and opportunity costs as they relate to water resources. The concepts of a competitive market system and optimal resource allocation are introduced, followed by an explanation of how these fail in the area of water resources. Alternative measures for imputing the value of water are then examined. Application of these measures of value can be used to generate opportunity cost data necessary for rationally choosing among competing water uses.

Having developed the economic context within which opportunity costs can be viewed as a tool for the allocation of water resources, it is then argued that they should also be incorporated into the prices charged for the use of water. Pricing on this basis would encourage economic efficiency and maximize the social benefits accruing from water use. In addition to quantifiable economic costs, water use charges should also reflect the direction and magnitude of non-economic impacts.

Clearly, if not all water uses can be accommodated, then those uses which are more valuable should take precedence over less valuable ones. To achieve the desired result, rational and efficient allocative mechanisms and pricing structures are required. Unfortunately, in both past and present water use decision making, these have been sadly lacking. This paper provides the background necessary to develop a foundation upon which such structures can be built.

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I. INTRODUCTION

In recent years considerable attention has been focused on the "crises" in non-renewable resources. Most notable of these is the rapid depletion of liquid hydrocarbons - commonly known as the energy crisis. Energy clearly plays a dominant role in the structure and functioning of our modern industrialized society. However, no less critical to the survival of current civilization are other resources including land, water, forests, and fisheries. The importance of water, in particular, cannot be denied. Too much or too little of this vital resource can spell disaster.

A distinguishing feature of water is its potential capacity for re-use and consequently, its perpetual service to mankind. However, because of past mismanagement, increasing population pressures and industrial expansion, the existence of unlimited supplies can no longer be taken for granted. It is apparent therefore, that as with all resources, man must consciously endeavour to nurture and manage the natural water environment.

At any given time and place, water is not unlimited. Utilization is constrained by both quantity and quality. Whether such constraints constitute a problem is a matter of circumstance. In the past, high quality supplies were relatively abundant. Water, therefore, was treated as a free good and was used without concern for conservation. In the process, however, large quantities of water were polluted and made unfit for certain uses. The capacity of water to renew itself is an important characteristic, but it is by no means absolute. Continued misuse of the resource base can, in fact, have irreversible consequences and may render it non-renewable. As the demand for water continues to expand, it becomes increasingly important to see that water is allocated in a manner which minimizes conflict between uses and ensures a continued availability of high quality supplies. Only through proper management of water resources can long-term benefits to society be maximized.

Scarcity in both time and place is a matter of degree. Economic growth and development (increases in population, income, and leisure time) intensify demands on the natural resource base. Scarcity, in part, is due due to conflicting demands of resource use. Although alternative uses can co-exist without adversely affecting each other, in many instances demand for one use will result in the decline for another.

Where conflict does arise, procedures must exist by which resolution can occur. While there are other determinants of water resource allocation, social values associated with alternative uses are of fundamental importance. Knowledge of these values makes possible the efficient allocation of water resources in accordance with the desires of society.

Value, choice of use and water resource allocation have long been subjects of discussion among economists. While progress has been made in these areas, information gaps, inconsistencies and unsolved problems remain. The inability of economists and other social scientists to provide a workable framework within which rational decisions can be made continues to hinder efficient water resource allocation. It is the purpose of this paper to analyze some of these difficulties, and in so doing:

(1) provide a framework for incorporating economic principles into water management decisions; and,
(2) identify means for incorporating economic values into pricing water uses.

Although primary concern will be with the economic aspects of water use, a number of non-economic factors will also be discussed.

II. VALUE, CHOICE, AND OPPORTUNITY COSTS

Until recently, there has been little need for resource managers in Canada to evaluate and choose between different water uses in a specific location. Abundant, high quality supplies with few competing demands have generally allowed co-existence of all possible uses without adverse effects. However, population growth, industrialization and urbanization and continued dependence on resource industries, have led to increased water demands and inevitable conflict between users. Water resource management, therefore, now requires a sound theoretical approach based on economics that is also sensitive to social and environmental needs. Such an approach would allow a meaningful valuation of water resources in various uses and permit rational allocation of existing supplies.

A. Economics as a Science of Value and Choice

"Wherever there is a problem of choice, wherever one thing must be given up to have another thing, economics pertains. Economics has been called the 'pure logic of choice', and it has been defined as the science that studies human behaviour in terms of a relationship between ends and limited means which have alternative uses."[1]

Historically, study in economics has centered on the production of the maximum amount of goods from a given resource base at minimum cost. The reason for this focus is that man's overriding concern has been to provide goods and services - food, clothing, shelter, transportation, and similar material wants - to an expanding population. However, as the demand for natural resources increased so did the costs of obtaining resources and the costs associated

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1 David Seckler and L.M. Hartman, "On the Political Economy of Water Resources Evaluation", in California Water: A Study in Resource Management, ed. David Seckler (Berkeley and Los Angeles: University of California, 1971), p. 285.

with resulting environmental impacts. This growing awareness of environmental considerations brought into focus the broader scope of economics.

If quality natural resources are limitless and readily available to everyone, no competition exists and, therefore, no statement value is expressed for them. Scarcity of resources produces value and induces people to trade off one desirable item for another in search of an improved state of being. A role of economics is to establish the relative value of the goods and services that both the natural and human environments can provide so that decisions about the use of resources can be made. In this sense, economics is a science of value and choice.

B. The Concept of Opportunity Cost

If rational choices are to be made among competing water uses, knowledge of the value of alternative uses is needed. From an economics point of view, if all water uses cannot be accommodated then those uses which are more valuable in specific locations should take precedence over less valuable ones and, only if the values gained are greater than (or can compensate for) the values lost is a particular water use worthwhile.[2]

In economics, "opportunity cost" refers to the notion that any decision will involve foregoing other valuable alternatives: the value of the alternatives which are foregone must be considered as a cost of the activity undertaken. Opportunity costs are implicit in all water use conflicts. However, in cases where water uses are compatible (for example, the same water can often be used for both fisheries and domestic supply purposes), no loss in value is

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2 This is based on the criterion of a potential Pareto improvement which proposes that an activity is socially valuable if the gainers can afford to fully compensate all losers, or owners of the values foregone.

involved. An example of opportunity cost that is often encountered in water planning is the conflict between the construction of a dam and movement of anadromous fish. The detrimental effect of the construction of a dam on a fish population may be significant and any decrease in the value of the fishery must be considered as a cost attributable to the dam. If benefits accruing from the proposed dam are greater than the combined costs of all labour and capital inputs, as well as any foregone resource values, the project should go ahead. In other words, the project should be undertaken only if the gains can more than compensate for the incurred losses.

Privately owned inputs for dam construction (such as labour) are easily measured by the market prices charged by resource owners. However, because most water resources are publicly owned, or held in common, market input prices are not readily available and it is much more difficult to estimate the value of activities foregone, and even harder to be certain that these values are considered in project planning. Public ownership means that there is no single owner to legally defend his property and ensure that compensation is received if his resource is adversely affected by a development. If a privately owned home is flooded by a hydroelectric dam the owner will likely be compensated but if this same dam destroys a fishery, compensation is much less likely since ownership is held by the public at large.

It falls upon public water resource managers to ensure that opportunity costs, regardless of the difficulties in evaluating them, are considered when allocating water to alternative uses. Measures of opportunity costs are the essence of rational planning, and are central to many kinds of management decisions.

C. <u>Measures of Value of Opportunity Costs</u>

The value of water in alternative uses can be defined from a number of perspectives. Our principle concern here is with economic values

since measures of opportunity costs are to be used in comparison with other market determined values in order to make decisions concerning water allocation. In the process, of course, non-economic factors must also be given consideration.[3]

In a market economy prices are the basic indicator of relative value. However, due to the absence of market activity, prices for water resource uses are not readily available. For example, in most cases one cannot directly determine the dollar value of a watershed for sports fishing because anglers are not required to pay for fishing rights on a particular river. Competitive prices, therefore, must be estimated by an indirect and synthetic estimation procedure.

The basic premise underlying these estimates is that where ownership of the good (resource) is not held by the user, economic value is measured in dollar terms by what he would be willing to pay for it. It is argued that because willingness-to-pay reflects the consumer's willingness to forego all other goods that could be purchased with the same amount of money, it represents the minimum economic value of the good in question.[4] Attempts to measure economic values of non-marketed water use, if no property rights are held, should therefore be focused on willingness-to-pay.

Economic factors, however, are not the only objectives in water planning. Current resource planning acknowledges that social, cultural, and environmental concerns must also be considered. Since most of these values cannot be measured in dollar terms, opportunity

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3 The appendix to this report provides further discussion of these factors.

4 The consumer may value a particular good much more highly than is indicated by the market price. When the consumer is willing to pay more than the going price for some commodity, he obtains free benefits which are termed consumer's surplus. See E.J. Mishan, Cost-Benefit Analysis (London: Allen and Unwin, 1971), Chapter 7.

costs should be considered subjectively, taking into account both positive and negative effects of alternative water uses.

It is important to recognize that both economic and non-economic criteria must be given explicit consideration in evaluating water uses. Economics alone provides only a partial answer to the problem of allocation, as it ignores all factors which cannot be measured in dollar terms. For example, evaluation of fishery opportunity costs of a dam must consider the economic value of commercial fishery losses. But the commercial value of fish does not adequately measure important non-economic concerns, such as the role played by subsistence uses of the fishery in maintaining the traditional culture of native peoples.[5] Nor are environmental factors such as the potential effects upon an endangered aquatic species measured in an economic assessment. Many of these kinds of factors can be defined in economic terms but are impossible to measure in dollar terms with present techniques, and must therefore be considered subjectively.

To summarize, the value of water in alternative uses must be determined on an economic basis and in relation to non-economic factors. The economic value of a water use as measured in dollar terms is the willingness of consumers to pay for it. For the most part, economic values of water uses must be imputed, since direct market values are typically not at hand. A subjective evaluation of the positive or negative effects of a water use upon principle non-economic factors must also be completed.

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5 While subsistence fisheries do not represent an opportunity cost for all water resource developments, they are of considerable importance in many parts of Canada, particularly the northern regions. See Thomas R. Berger, Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry, vol. 1 (Ottawa: Minister of Supply and Services Canada, 1977) for an excellent discussion of the values associated with subsistence fishery and hunting activities.

D. The Role of Opportunity Costs in Water Management

Measures of the value of water in alternative uses, determined by both economic and non-economic criteria, provide the opportunity cost data necessary in water resource planning. Knowledge of opportunity costs is essential for rational decision-making in at least three areas of management:

a. choosing between alternative uses;
b. setting regulations; and,
c. pricing.

Choice between alternative water uses is the most obvious application of opportunity cost data. For example, since hydro development is usually owned by the public, a complete cost-benefit analysis should be undertaken to reveal all opportunity costs. A thorough analysis of benefits should show the size of power benefits required to compensate for fishery losses. As noted earlier however, because of public ownership of water resources some of these environmental costs are often neglected. It is important to ensure that this does not happen; assessment of opportunity costs are important because they indicate what is being given up. As such, they are necessary for judging the relative merit of alternatives and choosing among them. In our example, dam construction should only proceed if benefits are greater than all associated costs.

Efficient regulation of water usage also requires knowledge of opportunity costs. In this case they should indicate the extent of the values to be protected. If fishery values in a particular stream are significant but the value of the stream to industrial users is shown to be greater, from an economic point of view the industrial use is more desirable. It is possible that through regulation of industrial activity, water quality can be maintained at a standard to preserve the fishery. However, the opportunity costs of such regulation must always be considered.

Finally, the evaluation of opportunity costs is important in setting prices for water uses. In this case, opportunity costs represent the uncompensated losses borne by water resource owners (society) for allowing a particular water use. Water charges established on the basis of opportunity costs would help to meet water management objectives and make explicit the resource losses which result from specific water-based activities.

Subsequent pages of this report develop the notion of opportunity costs more fully. Measurement techniques, evaluation methods, and policy applications are all important topics that are discussed. Underlying these discussions is the need to provide for rational, efficient, water allocation and pricing structures, which are often lacking in past and present water management practices. A set of guidelines aimed in this direction is developed as fully as possible.

III. PARAMETERS FOR EVALUATION OF WATER USES

A good has an economic value when its supply is limited relative to its potential demand. Where resources are available in unlimited supply, there is no competition for use and in economic terms the resources are considered free. However, as soon as all demands in either quantity or quality cannot be met, scarcity arises; water therefore, acquires a positive economic value due to competition for its use. In a market system, these values (prices) serve as guides to allocating resources between alternative uses by directing them into their highest valued use.

Until quite recently water throughout most of Canada was considered a free good. Abundant supplies of high quality water with few competing demands were the rule except in specific localized instances. However, an increasing population, continued growth of natural resource industries, and development of major energy sources have led to increases in the demand for water for various uses and have intensified the problem of scarcity. As a result the allocation of water resources between alternative uses has become a major issue in Canadian resource management.

As noted earlier, in order for resource managers to make rational decisions about competing water uses, some notion of the social value of the possible alternatives is necessary. In this report the primary concern is with economic values associated with water resources and their ability to provide information for water resource management decisions.

The purpose of this section is to provide a conceptual framework for evaluating water resource uses in economic terms. First, the notion of a perfectly competitive market system and optimal resource allocation are presented. Next, reasons for the failure of this model in relation to water allocation are discussed. The principles of benefit-cost assessments, including methods for the measurement

of social benefits for resource activities are then introduced. Finally, the concept of opportunity cost and its application to resource evaluation is emphasized.

A. The Problem of Value

> "Value is not a property of objects in themselves; it is an attribute we assign to objects. It is not, then, the instrinsic value of water that is important; it is the value that people put on it (in that marginal area where the values of different commodities - or amenities - compete) that is important. People must make evaluations, and this, of course, makes economic values a function of the other values one has and thus makes it relative."[6]

Different water management policies can be evaluated only if they relate to the same standard of value. In other words the policies must have a common "numeraire" (any unit common to the entities being compared) in order for them to be compared. For example, the statement "three apples minus two oranges" is meaningless. It is meaningless because it poses a relation ("minus") in terms of two different properties. However, the statement "three fruit minus two fruit" is meaningful; it means there is one fruit. Denoting some common property, the "numbers" make sense; without a common property they do not. This, then, is the numeraire principle.

A fundamental assumption of economics is that goods are subjectively evaluated by individuals who develop consistent preferences for various combinations of these goods. It is further assumed that individuals can evaluate the marginal satisfaction (or utility) of an increment of a good and compare it to the marginal satisfaction of all other goods. In brief, it is assumed that all goods are

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6 David Seckler and L.M. Hartman, "On the Political Economy of Water Resources Evaluation", in California Water: A Study in Resource Management, ed. David Seckler (Berkeley and Los Angeles: University of California, 1971), p. 293.

related by the same standard of value often refered to as "utility", "satisfaction" or "welfare".

The advantages of this fundamental assumption become clearer if we consider how a person selects from the various consumption options open to him. Given a budgetary constraint each individual will rationally choose that set of activities yielding him the highest utility, choosing goods such that:

$$\frac{MU_a}{P_a} = \frac{MU_b}{P_b} \quad \ldots\ldots\ldots\ldots \quad = \frac{MU_n}{P_n} \qquad (1)$$

(where MU_a = marginal utility of a and P_a = price of a) will maximize his utility; that is, he will choose a combination in which the utility of the last dollar of expenditure on each individual good is equal.

An economist observing the behaviour of any individual could conclude only that he had picked a basket of valued objects or goods; for the economist has no knowledge of the numeraire which any single individual employs in discriminating the value of goods comparatively. The utility, the standard of value, is strictly subjective. However, if the individual's "means" had been in the form of money, we would have an objective, that is, an observable numeraire. Manipulation of equation (1) reveals that:

$$\frac{P_b}{P_a} = \frac{MU_b}{MU_a} \quad \ldots\ldots\ldots \quad \frac{P_n}{P_{n-1}} = \frac{MU_n}{MU_{n-1}} \qquad (1a)$$

Thus, the ratio of prices is equal to the ratio of values. We can never observe relative values, but we can observe relative prices and, as in (1a), we can deduce an isomorphism between the subjective value and the objective numeraire of relative prices. The fact that an individual is willing to pay more for good (a) than for good (b) tells us that he values (a) more than he values (b).

Unfortunately, the analysis of a single individual - a Robinson Crusoe economy - is a rather simplistic exercise. An individual considers only his own preferences and his own resources to make decisions. In a society of many individuals with different tastes and capabilities, some way must be found to organize and coordinate all components into a reasonable whole. Under certain conditions, the market system does just that. Prices are set by the equilibrium of demands and supplies. Their movement "signals" when more of one kind of good is needed and less of another. These signals, combined with the profit motive, cause resources to move in and out of the production of goods as demand for them changes.

B. Competitive Markets and Resource Allocation

The perfectly competitive model in modern economic theory is based on the supposition of an economic system comprised of completely effective and efficient markets. The basic assumptions of this model are that all scarce resources are privately held by numerous owners, that all resources are readily divided between the owners, and that no external or third party effects occur with respect to any resource use. Moreover, all purchasers of resources are assumed to be perfectly rational (i.e. economic maximizers of profit or utility) with no single purchaser or seller large enough to influence the price or quantity of goods transacted.

Under these restrictive assumptions, the model economy would function completely efficiently in allocating society's scarce resources. All resources would be used for their most socially desirable purpose (as determined by supply and demand) and utilized in a manner that would minimize costs and maximize value of output. Economic efficiency would be achieved, meaning that all unambiguous possibilities for increasing social well-being would be exhausted.

In more comprehensible terms this means that under competitive conditions, the market system and resultant prices would enable

consumers to indicate their relative preferences for various goods. It also means that prices would serve to reflect relative scarcities of all inputs (including natural resources). Thus, prices would indicate economic value and would be the basis for all production and consumption decisions. If all markets fit the competitive model then all resources would be directed to their highest value in use.

An example may help to clarify this point. Suppose that in a perfectly competitive economy a group of businessmen wanted to develop a stream for industrial production purposes. The businessmen would consider the expected returns from the production, in terms of both quantity and quality, and compare it to the costs of resources necessary for the project. Costs would be indicated by the market value of labour, the interest on capital and the prices of resources required, including the value of the resource uses which would be precluded or adversely affected. Thus if the water needed for this operation was owned by other resource consumers, the businessmen would be required to compensate them. This might require purchasing a downstream village's domestic water rights or compensating fishermen who use the stream for recreational purposes. Under these circumstances the businessmen would only undertake their development at that location if it was the best (most profitable) site for their plant, and if industrial production was the most socially valuable use of the resources involved. Since the businessmen would compensate all owners of the required resources, including the present users of the water supply, the plant would only be built if it provided a net gain to society. This type of gain is termed a "Pareto improvement". The economy would be at a "Pareto optimum" if no further net gains could be realized through reallocation of resources.

In theory, a purely competitive market system could resolve all resource allocation conflicts. Unfortunately such a market system, with all the restrictive conditions identified earlier, does not exist in our society. A perfectly competitive model is only a theoretical model which provides an indication of the most desirable

results (in monetary terms) of using scarce resources. Therefore, it is merely a yardstick adopted by economists to measure the efficiency and desirability of resource utilization options.

C. The Causes of Market Failures in Water Resources

Water resources do not usually fit into the competitive norms outlined above. There are a number of reasons why the market system does not work in water resource management. Some of these reasons include; lack of well defined rights, a user group composed of many unorganized individual consumers, existence of externalities, existence of activities which are not marketed, and the presence of other values referred to as existence and option values.

Probably the most important reason for market failure in water allocation is the lack of carefully defined property rights. "Common property resource" is a technical term applied to resources such as water, air and ocean fisheries. These resources have historically been viewed as "free", i.e. unlimited supply, and available to all users. The problem is that with no owner to charge a rent for the use of these resources, consumers tend to use them as if they are valueless with no incentive to conserve. Air and water pollution and the over-exploitation of the fisheries are examples of problems associated with common property resources.[7] Water is usually administered by government agencies, and water rights are generally allocated to users by way of a permit. However, lack of well-defined rights of ownership means that transactions between resource owners and prospective buyers are usually impossible, prohibiting market solutions to resource allocation.

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7 See H. Scott Gordon "Economic Theory of a Common Property Resource: The Fishery", Journal of Political Economy, April 1954 for a statement of the basic components of the problem.

A second reason for market failure in water use is that certain user groups such as recreationists, are composed of a large number of individual consumers who do not function as a cohesive market unit. These groups often compete with single large developers for the use of the same water environment. Transactions between a group of individual users and a large developer do not often result in optimum allocation of the resources in question since the parties are not equivalent in terms of market power.

A third departure from the competitive norm is associated with externalities resulting from interdependencies in water use. Externalities arise when one user creates unmarketed positive or negative side effects on other users. An example would be a factory which alters the quality of a river by using it for waste disposal, making the water less desirable for downstream uses such as recreation or municipal water supply. The externality, in this case, is equal to the uncompensated value of the reduction in the downstream use of the river.

A fourth reason for market failure in water use is that many water resource based activities do not enter into market transactions. Recreation water users, for example, are seldom required to purchase the rights to participate in their activities. Because recreation is generally viewed as a common property activity, there are no dollar values determined by supply and demand with which the competitive market can allocate resources to alternative uses.

Water resources are frequently associated with other values referred to as existence and option value. It has often been demonstrated that certain groups in society attach strong social values to particular natural resources even though they may not indicate these values through direct use. People obtain a sense of satisfaction in knowing that wilderness areas still exist in our increasingly urbanized world and would feel worse off if this was no longer the case. An example is the world-wide campaign to protect whales, even

though most participants do not actually expect to view a whale in the wild. This kind of behaviour indicates that unique aspects of the natural environment are the source of social values which, in many ways, are as important as conventional market values. These have been termed existence values.

Another type of non-user value[8] relevant to water resources has been identified in the literature of resource economics. Option values are the values that people place on having the option or choice to increase their participation in a certain activity at a future date. When irreversible developments are contemplated, it is imperative to consider the various resource use options that will be lost, even though the values of foregone options cannot be judged with any certainty due to a lack of knowledge regarding the public's future desire to exercise these options.[9] The possibility that either existence values or option values may be associated with particular water resources reiterates that market solutions to water resource questions are not by themselves efficient ways to solve conflicts.

D. Water Resource Management in the Absence of Competitive Markets

Because water is a common property resource and not amenable to the market framework, conflicts in water use must be resolved through management instead of competition. To a large extent water management depends on the same kinds of information and operates with the same objectives as would a market framework. The basic purpose is to manage water to maximize its social value in use. This generally means that water uses which are more valuable should take precedence over less valuable ones. To make rational water resource allocation decisions, therefore, some measure of the economic value of water in alternative uses is essential.

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8 See appendix A for a further discussion of non-user values.

9 See K.J. Arrow and A.C. Fisher, "Environmental Preservation, Uncertainty, and Irreversibility", Quarterly Journal of Economics, 88 (1974).

As outlined in previous sections, prices are the basic indicator of relative values in a market economy. However, for reasons just discussed, information on prices of alternative water uses is usually not available due to a lack of market activity. Therefore, in order to obtain prices as indicators of water values, some kind of synthetic estimation procedure must be followed. To estimate the economic worth of water uses, "the objective is to simulate prices that would result had the technical limitations been overcome and a competitive market could operate."[10] Because these synthetic prices are to be used in making comparisons of economic values, they should follow the same principles as a market system. The basic concept underlying the estimation of economic values is that where ownership of a good is not held by the user, the value is determined by what he would be willing to pay for it. The rationale is that willingness-to-pay reflects the consumer's willingness to forego all other goods that could be purchased with the same amount of money. This measure, therefore, represents the minimum social value of the good in question.

Historically, the value of water in use has not been explicitly considered due to lack of information regarding prices. This is especially true for water use activities such as outdoor recreation, which are not part of our market system. However, as indicated in the example of perfectly competitive market activity given earlier, a water resource development should only go ahead if it provides a potential Pareto improvement, i.e. if the gainers can fully afford to compensate the losers for all resources which are foregone. Therefore, measures of the resource values to be lost and gained are imperative to sound economic water management.

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10 R. Young and L. Gray, Economic Value of Water: Concepts and Empirical Estimates. Colorado State University, National Technical Information Service, March 1972, p. 11.

Given economic values for alternative water uses, the resource planner can begin to make choices and comparisons. He is then in a position to measure the values to be gained or lost of following certain management approaches. To return to our previous example, suppose that a conflict occurs between industrial development and fishery production. After obtaining measures of the economic value of both these activities, it is discovered that although fishery values are significant, the value of the stream to industrialists is greater and thus represents a more desirable use of the resource. However, it may be possible through regulating water use by the industry, to maintain water quality which will allow the fishery production to continue. By comparing the cost of curtailing industrial uses of water with the benefits from fishery production, it is possible to judge the relative merits of alternative management options.

In summary, economic values for water resource uses are a basic component of rational water management. Because competitive market information is generally not available, it is often necessary to simulate values by estimating the willingness of users to pay for various water activities. When estimating these values, it is necessary to account for all water uses, including those activities such as recreation which are normally outside the market framework. Non-user benefits, such as option values, should also be assessed even though they cannot be rigorously quantified.

Given this information, the decision maker can begin to weigh interdependencies and to assess the values to be gained or lost in alternative uses of the water resource. The objective of this process is to manage water activities to provide the maximum satisfaction of society's wants.

E. Cost-Benefit Analysis

The principles just outlined closely parallel the cost-benefit

assessment framework. Cost-benefit analysis is a tool utilized by economists to aid in planning the use of public resources. Although much of the literature in cost-benefit analysis has been devoted to water activities (probably because it is such a prevalent public issue), the principles are relevant in all public investment contexts.

Cost-benefit studies attempt to measure society's preferences for various resource allocations. This is accomplished by systematically comparing the net benefits of alternative uses of resources. Benefits are interpreted as the social value of a particular activity (or good), and costs are the opportunities foregone of using the same resources in their next best alternative. The objective is to provide resource managers with information about the relative values of, and tradeoffs implicit in, alternative uses for a given resource base.

Modern cost-benefit studies are based on the premise that society has multiple goals including income maximization, regional development, environmental quality as well as others. Some of these goals are quantifiable in dollar terms while others are not.[11] When analyzing a project from the viewpoint of economic efficiency, the approach is to measure preferences in monetary terms. In keeping with the precepts of economic value which have been previously outlined, society's willingness-to-pay for a particular good (or a water resource activity) is considered to be a measure of its gross social value.

In order to estimate the net benefit a specific "good" would provide, we must substract the costs associated with its production. Costs include the market value of all labour and capital (i.e. their opportunity costs), as well as the value of all

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11 Non-income goals are discussed in Appendix A.

resource use activities that would have occurred in the absence of the current use. In other words, when evaluating a potential development project it is necessary to consider the resource values foregone. Generally, gross benefits (or willingness-to-pay) less the social opportunity costs will equal the new social benefit of the particular good (or resource use activity).

The nature of social benefits can be more precisely defined in technical terms. Benefits for marketed goods are usually estimated on the basis of willingness-to-pay (WTP). Willingess-to-pay is comprised of two distinct parts: total revenue (TR), or the sum of all payments by consumers to purchase the good (price x quantity), and consumer's surplus (S). Consumer's surplus is defined as the free value obtained by all consumers who would be willing to pay more than the market price for the good in question. Total revenue is made up of benefits in the form of rent (R) and producer's surplus (P), along with the costs of production (C). Algebraically, this is:

$$\begin{aligned} WTP &= S + TR \\ TR &= R + P + C \\ WTP &= S + R + P + C \\ \text{Net Social Benefit} &= WTP - C = S + R + P \end{aligned}$$

For purposes of evaluation, the usual approach for a marketed good is to estimate gross benefits as the total revenue from new production (the expected price multiplied by the quantity produced) along with a measure of the change in consumer's surplus. In most situations, where the price of the good is changed only slightly, the consumer's surplus is ignored.

There are many steps to cost-benefit analysis and numerous pitfalls involved in its' application; these issues are too extensive to be

summarized here.[12] The purpose of this discussion is to point out that cost-benefit studies are a systematic way to compare economic values in water resource planning. As a general rule benefits for marketed goods are determined by willingness-to-pay, and projects (or water resource uses) are considered socially beneficial only if the opportunities to be gained can compensate for or are more valuable than the opportunities to be lost. Thus cost-benefit studies are a logical extension of the use of economic values in water management.

F. Property Rights and Evaluation

As might be expected, decisions regarding property rights can have a major effect on the valuation of alternative resource uses, especially for non-marketed activities. It is imperative therefore that their significance be clarified before proceeding further.

A simple example may be the best way to introduce the relevant issues. Suppose we have a wilderness river valley that could be allocated to either of two competing uses, mining or wilderness recreation.[13] What is the proper measure of resource opportunity costs arising from a choice between these two mutually exclusive activities? The mining company's value should be equivalent no matter how property rights are assigned.[14] That is the firm would

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12 See E.J. Mishan, Cost-Benefit Analysis (London: Allen and Unwin, 1971) for a thorough introduction to the issues and techniques of cost-benefit analysis.
Also useful is Verne Loose, ed., Guidelines for Benefit-Cost analysis, Environment and Land Use Committee Secretariat, Victoria, 1977.

13 This example is borrowed, as are the theoretical concepts from J.V. Krutilla and A.C. Fisher, The Economics of Natural Environments (Baltimore: John Hopkins Press, 1975), pp. 28-32.

14 This presumes that the mining company is only motivated by profit, and obtains no unquantified benefits in terms of quality of life, outdoor amenties, etc., from its industry. Independent placer mines probably do not fit into this mold, so the example is perhaps more appropriate to large mining corporations.

either buy the rights to mining, or sell them to recreationists, for an amount equal to the net value it could obtain from the ore deposit, i.e. total revenues less all costs. But for outdoor recreation (or amenity uses), the value is not uniquely determined and will vary with the assignment of property rights. If the mining company has the initial rights, the value to recreationists would be measured by their collective income-constrained willingness-to-pay for recreation, or the amount they would pay to buy out the company's property rights. However, if the recreationists hold the initial rights, the recreation value of the area is determined by the unconstrained minimum amount of compensation required to make them as well off if they lose their recreation activity. This value is determined by the price which would induce recreationists to sell the area to the mining company.

In formal economic terms, these alternative valuation concepts correspond to different measures of consumer's surplus. The query "What would you pay to purchase the rights to use?" is a measure of compensating variation consumer's surplus, while "What compensation would you require to forego present use?" measures equivalent variation consumer's surplus. For ease of discussion, the approaches can be termed "willingness-to-pay" and "required compensation", respectively. As Mishan indicates, these two measures correspond to alternative states of ownership for a particular good.[15]

In general, these two measures of value will not be the same for non-marketed uses of a resource. Budget constraints as well as high transactions costs between numerous users, reduce the ability of consumers of amenity resources to pay large sums. Economic theory indicates that the income or wealth effect normally results in

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15 E.J. Mishan, Cost-Benefit Analysis (London: Allen and Unwin, 1971), Chapter 48.

required compensation being higher than willingness-to-pay. Moreover, the limited empirical information collected in studies attempting to measure values for recreation have shown that required compensation is invariably larger than willingness-to-pay.

The assignment of property rights could prove to be a major determinant of values when analyzing alternative resource activities. As outlined in the Pareto optimality criteria, resource development projects should only proceed if the potential gainers could afford to compensate all losers, including those whose current resource activities would be impaired. If lost natural resource values are measured as the compensation required for users to relinquish their property rights, these values will be much greater than if measured by willingness-to-pay.

Since we are dealing with publicly-owned common property resources, private legal ownership does not exist and rights are determined (either implicitly or explicity) through management decisions by public agencies. Some writers, notably Mishan, Krutilla and Fisher, make a case for assigning priority in property rights to natural resource uses which are less destructive, particularly when irreversible developments are contemplated. In other cases, implicit property rights have been assigned to existing resource users,[16] a practice which normally confers higher values to existing recreation or amenity resource activities in a particular area.

The designation of property rights for water uses is, therefore, an important determinant in the allocation of the water resource. It

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16 See Canadian Resourcecon Ltd., McGregor Diversion Project Resource Evaluation, B.C. Hydro and Power Authority, Vancouver, 1978, for an example of applied attempts at incorporating required compensation measures into water resource planning.

is generally agreed that required compensation is the more appropriate measure for water resource activities now enjoyed by the users. This means that the change in well-being experienced by a water user, preempted by an alternative use, would be equal to the dollar amount required to make him as well-off as before. This approach is in keeping with water law, where priority of rights is based on the chronology of use.

Clear rules for the allocation of property rights in resource evaluation studies have not yet been formulated.[17] However, because differences between willingness-to-pay measures and required compensation measures may be very large, it is necessary to provide a rationale for their use. The approach followed here is to point out the conditions necessary to justify required compensation as the appropriate measure of benefits associated with a specific activity. Moreover, because of empirical problems associated with estimating the value of required compensation, most studies either skirt the issue or resort to willingness-to-pay measures. In any case, if existing resource users are assumed to hold implicit property rights to their activities, estimates of compensation required form the appropriate measure of benefits. For commercial activities such as industrial and municipal water uses, required compensation should produce about the same results as willingness-to-pay and have no real effect on relative values compiled by the two methods. However, for recreation users such as boaters, fishermen and wilderness enthusiasts, the value of required compensation compiled by the two methods could be substantially different. Similarly, and of particular importance in northern Canada, the valuation of native subsistence activities could be highly influenced by this approach to property rights for water activities.

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17 See John Dales, "Land, Water, and Ownership", Canadian Journal of Economics and Political Science, 1968 for a discussion of property rights allocation and their importance in water resource management.

The problems with measures for required compensation arise in attempting to obtain empirical estimates of value. In the next section these difficulties are discussed along with methods developed to estimate the net social values associated with resource activities.

G. Methods for Estimating Values of Water Uses.

Economic evaluation of water use is essentially an attempt to measure the net social gain provided by a particular activity. Net gains are defined as the gross economic benefits produced by the activity, minus all costs, where costs include the opportunities foregone of not using the resource in its next best use. Following the principles discussed earlier and when property rights are not allocated, society's willingness-to-pay for a good is considered a measure of its gross benefits.

Translating these concepts into dollar estimates is straightforward for a good which is conventially bought and sold and in the market system. The market price times the quantity sold represents gross benefits while costs are calculated as the market value of all required inputs. A few water uses (notably commercial fisheries) can be evaluated on this basis, but most other water related activities exist outside the market framework. Therefore, a number of techniques have been developed to synthesize economic values for non-marketed goods. Most relevant to current water issues are alternative cost valuation technique, techniques measuring willingness-to-pay for recreation, and techniques measuring required compensation. These are discussed below.

1. Alternative Cost Valuation

Alternative cost as a measure of benefits has been discussed extensively in economic literature.[18] In this context,

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18 See for example, Peter O. Steiner, "The Role of Alternative Cost in Project Design and Selection", Quarterly Journal of Economics, 79 (1965), pp. 417-430.

"alternative" refers to a different means of accomplishing the same end. The approach is useful where there exists more than one way to provide an equivalent quantity of the same good.

In general, it is much easier to measure the costs of anything than to measure the benefits accruing from them. Indeed this assumption results from the success as well as the failure in benefit measurement. Benefit measurement is difficult and time consuming, and should be undertaken only when required. Where direct estimation of value at the margin proves difficult, the cost of the next best alternative project provides a means of estimating consumer's willingness-to-pay.

In some cases alternative costs substitute for benefits, in others they provide upper limits of benefits and in still others they provide minimum target levels that benefits must reach for the choices that have to be made. The problem is complicated because a specific proposed public project may have various alternatives. For example, "a dual purpose public project may have a single purpose public alternative to each purpose, it may have a variant dual purpose public alternative or it may have private alternatives to either or both purposes. These alternatives may be equivalent in quantity, quality and distribution of services, or they may differ. Furthermore, the conditions under which a specified alternative activity will actually come into operation if the specific public project is not undertaken will vary."[19]

A private alternative to the services of a specific public project is determined presumably, by attention to revenues, costs, availability of capital, etc. Where there are no viable alternatives, explicit or implicit, alternative cost has no role

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19 Steiner, op. cit., p. 418.

to play and there is no substitute for showing benefits to be at least equal to costs in justifying government action.

If the only alternative to a government project is some other public project, a comparison of costs may eliminate all but one project. The benefits attributable to a specific government action will be limited by the costs of alternative government action, but that limitation neither limits the benefits nor does it avoid the necessity of showing absolute merit (benefits greater than costs).

Where a viable private alternative exists and will be activated in the absence of government action, its costs do substitute for benefits. If the output or product from the two alternatives is the same, then the gross benefits are equal, in which case the cost savings of the best production method over the next best possibility indicates its net social benefits. In this case, direct benefit measurement is unnecessary and comparative costs provides necessary and sufficient conditions for choice. While "this condition will not often be met, the range of circumstances in which a substantial part of the benefits will accrue in any case is larger and in these circumstances comparative cost plays a potentially significant role in three ways: firstly, in narrowing required benefit measurement to incremental benefits, which may be much easier to measure than total benefits; secondly in providing (though not necessary) conditions for choice without benefit measurement that may apply to a significant number of cases; thirdly in providing target levels of benefits that must be found to justify a project."[20]

2. Estimating Willingness-to-pay for Recreation

Growing demand for recreation and aesthetic enjoyments is

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20 Steiner, op. cit., p. 418.

increasing the value of those resources which can provide them. Changing values call for continuing adjustments in resource allocation to better satisfy the varying wants and preferences of consumers.

Recreation resources possess three distinct value components - exchange value, option value and existence or preservation value. Exchange value is that value which results from direct consumption by present users. It is commonly measured by the area beneath imputed demand curves which represent the consumer's willingness-to-pay for the service. Option value is the amount that risk averse individuals, who are uncertain about future demands for the service, are willing to pay to retain the option of consuming the service in the future. Existence value represents that amount that individuals who are certain not to use the resource are willing to pay for the knowledge that the resource will be preserved or bequeathed to future generations. In attempting to measure the value of a recreational resource it is desirable to use methods which fully capture all three associated values.

Techniques to impute the willingness of recreationists to pay for their activities have been developed by resource economists over the last two and a half decades. Despite this period of rather intensive research, no fully satisfactory method for determining values has evolved. This failure is at least partially due to the non-homogeneous nature of recreation experiences, where diverse "products" are "consumed" on a particular outing and also due to inconsistencies in the methods employed.

Predictively, measures of willingness-to-pay should proceed from a demand curve. Given a demand schedule for sports fishing, the benefits from such an activity can readily be calculated as the

total area under the demand curve. The area under the curve measures the amount consumers would be willing to pay to maintain the opportunity to acquire the given units of recreation product and is an appropriate guide for social choice. Although the assumptions of a constant marginal utility of income over the relevant range and utility maximization are necessary for this definition, they generally do not pose practical difficulties. Most expenditures for recreation, for example, represent only small amounts of the total income of any single individual.

An output value measured by a competitive price equals the total area under the demand curve when the demand curve over the relevant range is completely horizontal. This is the usual case in competitive markets and is the primary reason prices adequately measure the value of outputs of most commodities. The indivisibility of natural resource developments, however, may be sufficiently large in comparison to the relevant market and make a single price meaningless as a measure of value. This necessitates measuring the area under the demand curve. The two measures, the single price measure and the area under the curve, are not inconsistent but are really measures of the same thing under different market circumstances. Since recreationists are only required to pay a nominal amount for sport fishery licences, nearly all social benefits will be in the form of consumer's surplus, with little or no total revenue benefits.

There are difficulties in estimating a demand curve for an activity or set of activities which are not sold in the marketplace. Techniques which have been developed to impute these price-quantity relationships can be divided on the basis of methodology into two groups: approaches which use some measure of travel costs or transfer costs, and approaches which employ direct surveys.

The basic premise of the travel cost method is that an individual's willingness to incur costs in travel is related to his willingness-to-pay, and therefore a measure of his minimum value for recreation at a particular site. Data is collected on origin, expenditures, frequency of visits and distance of travellers from a recreation site. This information is then used to impute a demand curve for the activity. In general it has been found that recreationists visiting any particular site will decrease with increases in distance and associated travel costs.[21] The area under the derived demand curve approximates a willingness-to-pay and the value of the specific opportunities afforded. Any external benefits that accrue as a result of the provision or preservation of a site would have to be added, and the variable costs of providing the services of the site would have to be substracted to reach a net figure of the values afforded or the economic benefits of such an investment.

Introduced initially by Clawson, the travel cost method has been utilized in many recreation studies[22]. However, in spite of its wide use, there are still many problems in its application. Some of the more important ones are outlined below.

a. When recreationists travel to a particlular area they often participate in a number of activities during their stay. Therefore, it may be erroneous to assume that all travel costs were incurred for the sole purpose of participating in a recreational activity.

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21 It has been suggested that this is not an entirely reasonable assumption. For a summary of the argument see Nicolas Coomber and Asit K. Biswas, Evaluation of Environmental Intangibles (New York: Geneva Press, 1972), pp. 20-21 and p. 24.

22 Marion Clawson and Jack L. Knetsch, Economics of Outdoor Recreation, John Hopkins Press, 1966.

b. The composition of the base population will vary across the regions where recreationists originate. Of particular concern is the variation in regional income.
c. The availability of other recreational activites will vary across regions.
d. There are different kinds of costs encountered when travelling to a recreational area. It is difficult to put a monetary value on such factors as the cost of time and desirability of travel.

Despite these apparent difficulties, the travel cost method is potentially the best technique for accurate estimates of recreation benefits. Numerous case studies have developed and refined the technique to include time costs and substitute activities.[23] As yet, no single method has gained general acceptance but with continued work significant advances are foreseeable.

The direct survey method tackles the evaluation problem by asking recreationists how they would respond to particular situations. Typically, the referent group is queried as to the maximum amount they would be willing to pay rather than discontinue using the resource (or, as discussed later, the compensation required in order to forego rights to use the resource).

The survey method has the distinct advantage of directly addressing the particular resource question at hand through the use of specific questions. Separating recreation activities and sites is not a problem, when using this approach.

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23 For an excellent discussion of these see J. Gibson, "Recreational Land Use", in The Valuation of Social Cost, ed. David W. Pearce (London: Allen and Unwin, 1978), pp. 68-96.

> "If the researcher wishes to develop an economic value for skiing on a specific mountain during a certain period of the year, he need only identify the activity in the questionnaire. Another distinct advantage is that the direct survey method is the only (approach) which captures option values."[24]

Three basic criticisms of the direct survey method are:

a. questions are often so hypothetical that it is difficult or impossible to receive meaningful answers;

b. gamemanship on the part of the respondents may cause them to bias their answers; and

c. high survey costs.

The first two of these problems can be reduced or eliminated by a properly designed survey. Obviously, the reliability of the results depends on how seriously respondents take the game and how accurately they perceive the alternatives (it is helpful if these can be limited to situations with which they are familiar, or which have small deviations from them, and if back-up information such as films, recordings, models and photographs are used). As well, respondents can be encouraged to give their answers serious consideration, by explaining how their answers will be used.[25]

3. Estimating Required Compensation

The only method available to estimate compensation values is the direct survey technique. As outlined above, the referent group is queried on the amount of compensation required to make them as well off if they forego their rights to the current resource use. This approach has the distinct advantage of flexibility in

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24 W. Sinclair, The Economic and Social Impact of the Kemano II Hydroelectric Project on British Columbia's Fishery Resources, Fisheries and Marine Service, Department of the Environment, 1976, p. 8.

25 W. Sinclair, Op. cit.

scope and freedom to identify activities. Valuation problems can be defined as narrowly as, "the compensation required by Native Indians to offset the loss of subsistence fishery". Moreover, with proper technique, the survey approach can at least partially capture values, such as option value, which do not stem from direct use.

Problems inherent in this approach lie in formulating questions which can readily be grasped, and which foster serious well-considered responses by the sample group. In the past these problems have proved formidable; a number of studies which have attempted to estimate compensation values have had difficulties in drawing conclusions from the data collected. For example, Brown and Hammock's work dealing with migratory waterfowl remarked that their surveys for required compensation met with some resistence, and their results were questionable.[26] A study by Sinclair for the Fisheries and Marine Service attempted to collect data on required compensation for sport fishing in waterways affected by the Kemano II project in British Columbia. He apparently could not make use of the survey results in his report because the users surveyed typically object to inferences that they sell their recreation rights.[27]

Gordon and Knetsch[28] have looked at differences between the level of required compensation for particular activities, compared to willingness-to-pay measures for the same activities. Drawing on the works of Hammock and Brown, Sinclair

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26 J. Hammock and G. Brown, Jr., Waterfowl and Wetlands: Toward Bioeconomic Analysis (Baltimore: John Hopkins Press, 1974).

27 W. Sinclair, Op. cit.

28 I. Gordon and J. Knetsch, Consumers' Surplus Measures and the Evaluation of Resources, Discussion paper, 75-5-13, Department of Economics and Commerce, Simon Fraser University, 1977.

as well as research by Gordon, the authors conclude that required compensation was consistently many times greater than willingness-to-pay. Traditional economics attributes this occurrence to "income" or "wealth" effects, yet the results indicate much larger differences in value than would be expected from that source alone.

In summary, direct surveys to establish required compensation values have the distinct advantages of flexibility and ease of specification for diverse environmental issues. However, previous works have had limited results, due to the reactions of respondents to hypothetical questions. Empirical evidence suggests that compensation values could be many times greater than willingness-to-pay values for the same activity.

H. Other Methods to Estimate Water Values

A number of other techniques have been developed to estimate the value of benefits associated with the use of water resources. Although generally less useful than those discussed in the previous section, they are worth noting.

1. Residual Imputation

When a project affects a product input, thereby lowering production costs, benefits accrue to consumers in the form of lower final product prices and to owners of factors of production in the form of increased returns. To evaluate these effects generally requires a complex analysis of the supply and demand conditions facing the affected firms. However, in certain specialized circumstances, the analysis can be greatly simplified. If it can be assumed that output prices, costs of labour and materials are unaffected and that new firms cannot enter the industry, then an increase in the firm's income can be used as a measure of the project's benefits. Residual

imputation is the residual remaining after the costs of all other resources are deducted from the total value of production (income).

This technique is most often applied to agricultural irrigation projects. It is partially justified if the affected farm outputs are only a small fraction of the total supply of agricultural product. However, the assumption of limited entry of new firms may be less valid. Given sufficient time, new firms could enter the market, thereby increasing input prices and decreasing output prices. Therefore, this approach might serve only to estimate short-term benefits, since over time increases in income to any firm may be completely eroded. A further problem is the difficulty in assigning prices to other resources which lack market prices (unimproved land, management and risk-bearing services, and family labour).

2. Property Values

An alterntive method of evaluating intangibles associated with a public good is to examine property value differentials. In fact, Clawson[29] argues that the full assessment of the economic value of a recreational resource or facility include increments in land value as well as net user benefits. However, in using this method, care must be exercised to avoid double counting; benefits can be over estimated to the extent that landowners are counted as visitors and revenues from sales to park visitors are distributed to the value of the land.

"The thesis underlying this approach has been that the service flow from a piece of residential property depends not only on the quality and facilities of the property, but also on the quality and facilities of the surrounding neighbourhood

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29 Marion Clawson and Jack Knetsch, Economics of Outdoor Recreation (Baltimore: John Hopkins Press, 1966), p. 283.

environment."[30] Higher property values, then, can serve to reflect intangible benefits.

There are basically two methods for singling out the influence of environmental quality on property values. The first is the with and without approach. The problem with this method is that the data requirements are exceedingly high. A more commonly employed approach is econometric analysis. However, this method requires the unrealistic assumptions that land rents are always in equilibrium. There is also the problem of separating property values into its various components. If this separation is not done properly it can lead to erroneous results. Finally, the data requirements of the econometric approach may be as high or higher than those encountered in any with and without analysis.

Land value increments, therefore, do not provide a useful basis for estimating the intangible benefits associated with water-based recreational activities and water supply projects, nor can they be easily integrated into the planning process.

3. Standard Unit Values

An approach often used in studies of willingness-to-pay is to employ average values for activity days. Values derived in studies of similar activities at comparable sites are multiplied by the number of activity days pursued in the study area to approximate user benefits. This approach suffers serious conceptual weaknesses, in that it fails to recognize differences in values held by users, neglects the relationship between price

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30 Roy W. Bahl, Stephen P. Coelen; and Jeremy J. Warford, "Land Value Increments as a Measure of the Net Benefits of Urban Water Supply Projects in Developing Countries", in Government Spending and Land Values, ed. C. Lowell Harriss (Madison: University of Wisconsin Press, 1973), p. 20.

and demand for an activity, and is dependent upon the similarity between sites and activities. In spite of these shortcomings, this approach is often employed for determining willingness-to-pay values. Reasons for its use are usually a lack of time or funds, or because the quality of results are not likely to be significantly improved through a more rigorous approach.

4. Gross Expenditures Method

This method assumes that recreation has a value which is at least equal to the total expenditure made by consumers in persuit of their recreation experience. Most often it is adopted to impress potential investors on the size of gross consumer expenditures, but it is inadequate for investment decisions because:

a. it reflects only the total amount spent on recreation and not the net value of a particular recreation opportunity; and,
b. it includes secondary benefits in addition to primary benefits.

"If we use only the gross expenditure data for an evaluation of primary benefit, we can come to stupid conclusions like 'the further away the fish are, the harder and more expensive it is to get there, the more they are worth'."[31]

The technique can be refined by substracting supply costs from gross expenditures. While this is an improvement, it still only eliminates the first problem. Furthermore, these expenditures are a reflection of the various services associated with a

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31 Ingemar Norling, "Economic Evaluation of Inland Sport Fishery", Technical Report No. 7, European Inland Fisheries Advisory Commission Rome, 1968, p. 6.

recreation facility and not of the value of the recreational opportunity.

Finally, the expenditure method is applicable only to non-resident consumption, as residents are assumed to contribute no direct economic return for participation (in the absence of water-based recreation they would probably spend their money on other activities).

IV. PARAMETERS FOR EVALUATION SPECIFIC WATER USES

Previous sections have outlined some common methods for estimating resource values. Attention is now focused on the factors which determine the economic value of water in specific uses. No attempt is made to measure actual opportunity costs associated with specific water conflicts but factors which determine the value for the activities are pointed out.

The basic approach that should be used in evaluating specific water uses can be summarized as follows:

a. Choose the most appropriate evaluation technique on the basis of available information and the nature of the activity.
b. Utilize this technique to estimate economic value in the base year.
c. Estimate how this value will change in the future, on the basis of increased use or the expectation that the relative value of the activity will change.
d. Calculate the present discounted value to determine the total value of the activity.

In this paper no attempt is made to go beyond the initial step since the purpose is to identify approaches to determining economic benefits rather than definitive evaluations of alternative uses. However, issues which have bearing on Steps b-d will be discussed on occasion.

A. Hydroelectric Power Development

Hydroelectric development is likely to result in the creation of significant opportunity costs as development of a river's power potential is generally synonomous with abrupt and large scale changes in regional, economic, social, and environmental characteristics. This section will sketch the major issues involved in the evaluation of hydroelectric activities.

Economic assessments of hydroelectric projects traditionally evaluate benefits on the basis of the cost of achieving the same power output from the next best alternative source. It is assumed that demand for the incremental power at the anticipated selling price exists. Since consumer's desire is for increased power production, the gross benefits of two projects which supply identical amounts of power are equal, and the net benefits of any one project are the savings in costs.

To calculate the net value of a hydroelectric development it is further necessary to deduct resource opportunity costs from the cost savings over the next best alternative. The opportunity costs of a hydroelectric development will be specific to its particular location and design. As a result, a formal assessment of project benefits and costs, including an evaluation of all income and non-income values that might be lost, is required. Information for this analysis would come from detailed engineering and environmental assessments of project impacts, as well as analyses of the anticipated changes in resource uses and socio-economic factors.

Losses associated with hydroelectric developments, in some cases, includes reductions in recreation, fishery and wildlife resources. Development of hydroelectric plants is likely to alter the recreational wilderness experience associated with travel on free flowing rivers. However, the creation of reservoirs can provide new recreation opportunities although it results in a shift in user class eg. from wilderness canoe enthusiasts to motor boat owners and water skiers. Reservoirs may also lead to changes in the value of adjacent lands. Decisions regarding the assignment of property rights, and the legal status afforded prior uses, are likely to greatly affect final estimates of net project benefits. The issue of evaluation for recreation fisheries, and wildlife opportunity costs are discussed elsewhere in this chapter.

If there are large increases in the supply of power from the construction of a hydroelectric project, the use of the next best alternative costs for valuing power will tend to over-estimate benefits. In this case, it would be necessary to measure not only the price at which the increased quantity would be sold , but also the increased consumer's surplus of its purchasers.

B. Water Supply and Pollution Control

For municipal, industrial and waste disposal uses, the benefits of water use can be defined as the cost savings over the next best alternative which would meet water requirements. Thus, the benefits of municipal water supplies are essentially the transportation cost savings of obtaining water from the nearest source. Assuming that alternative sources are available, industrial use benefits are defined in the same manner[32]. Benefits of industrial uses must be adjusted to account for opportunity costs foregone of alternative uses, particularly fisheries.

In theory, benefits of using water for waste disposal could be defined in the same manner.[33] Municipalities and industries derive direct benefits from using rivers for waste disposal. These benefits are equal to the costs of the next least expensive method

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32 If not, then the benefits of water for industrial use would be the net benefits of the activity after all other costs and scarce resources are compensated.

33 The most direct means of determining water value in waste assimilation is to estimate the relative damages associated with various water quality levels. The benefits from water used for flow augmentation are taken to be the associated reduction in costs or damages. However, it is extremely difficult, if not impossible, to estimate all factors in the damage function.

See R. Young, G. Radosevich, S.L. Gray and K. Leathers, "Economic and Institutional Analysis of Colorado Water Quality Management", Colorado State University, Completion Report Series No. 61, March, 1975, Chapter 3 for discussion of the damage function.

of waste disposal or treatment. By imposing effluent treatment standards society has decreed that the benefits of meeting the standards exceed the treatment costs. Thus the benefits of meeting effluent standards are by definition socially desirable. When standards are not set, the benefits of water disposal are defined as the savings realized over alternative means, eg. recycling existing supplies, transporting of wastes to a further site. These benefits must be adjusted to account for opportunity costs imposed on other uses.

C. Irrigation

Given the lack of competitive price information, the most common technique for assessing the value of water for irrigation is using residual imputation. This approach measures the direct benefits of an irrigation project by the increase in net farm income. Accepting the somewhat unrealistic assumption of fixed supply, this is equivalent to the area under the producers demand curve for water and thus is a measure of willingness-to-pay. In order to calculate this value it is necessary to forecast the change in agricultural output (excluding those which are also inputs) resulting from irrigation. This is done using "with" and "without" analysis, comparing similar farms in terms of soil, climate, etc., but applying different amounts of irrigation water. The resulting prices of the farm products, provide estimates of the gross value. Summing these figures, and deducting the input costs and the opportunity costs of foregone water uses, yields the value of the net change in agricultural output due to irrigation.

Although this technique suffers from the conceptual problems mentioned previously, it nevertheless remains the most appropriate method for calculating the benefits from irrigation, i.e. the value of water in use. When projecting crop values, however, one must consider the availability of markets for the increased output. The expansion of agricultural production made possible by irrigation is

of no value if the additional quantity cannot be sold. As well, any subsidies made available to farmers should be deducted from the benefits attributable to irrigation.

Secondary benefits attributable to irrigation projects are less easily determined. Examination of increased sales to farmers and purchases from them, as well as the ratio of increased non-farm to increased farm earnings, can provide an indication of the impact of the project on the economy. Such estimates, however, are only rough indicators and are likely to be difficult to calculate prior to project development.

D. Transportation

Benefits associated with navigation use of waterways are equal to the cost savings realized over the next best alternative means of transporting goods. Any new sources of shipping revenue attributable to improvement in water transportation routes should also be included.

Water transport is inexpensive relative to most other modes of shipping goods. Furthermore, the opportunity costs associated with water transportation are small, since few alternative uses need to be foregone. With the possible exception of associated river improvement programs, navigational uses do not (in contrast to hydroelectric developments) result in major impacts on other resource uses.

E. Flood Control[34]

Flood control benefits arise whenever a water project serves to prevent physical property damage and losses of income due to forced

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34 See David Reid, Revelstoke Project Benefit-Cost Analysis, B.C. Hydro and Power Authority, May 1976, for an excellent example of actual flood control benefit estimation.

idleness. Development of a hydroelectric dam, for example, may regulate river flows and prevent floods which accompany high water levels during the spring and early summer. A benefit of the project, in addition to any power production, is the reduction in costs associated with annual flooding. Physical properties in the floodplain area would increase in value and the insurance costs of homeowners and businesses would decline. Flood control structures, such as dykes, would no longer be needed, so the labour and materials previously tied up in their construction and maintenance would be freed for use elsewhere in the enonomy. Productive activities on the floodplain would no longer be curtailed, and the increased production would serve to boost regional income and employment. Of course, calculation of the net benefits associated with flood control must take into account any additional costs of the design and construction of the flood control works.

F. Fisheries

Fishery resources provide a diverse economic benefit to Canadians. In various parts of the country fisheries resources support commerical fisheries, both resident and non-resident sport fisheries, and the subsistence needs of native peoples.

1. Commerical Fisheries

Because commercial fisheries are marketed, price information can be used as a measure of the value of this resource use. Total revenue (price x quantity) less costs (labour, capital, operating expenses) yields net economic benefits. The price of fish, the quantity harvested and sold, and the costs of harvesting, are the main parameters of commercial fisheries value. A change in any one of these factors could have a significant effect on fishery values.

2. Sport Fisheries

Sport fishing is a major recreation activity for both residents

and non-residents. This water resource activity provides unmarketed "income", or free economic benefits to resident users, in the form of access to a valuable resource.[35] Non-resident users contribute economic benefits by adding tourist dollars to the economy.

The assignment of property rights is extremely important in the evaluation of this water-based activity. If fishermen have implicit priority to their activities, then the appropriate measure of value is the "required compensation" approach; if they have no special rights, then the "willingness-to-pay" approach is the appropriate measure. In theory, management costs, i.e. the public costs of providing this recreation, should be deducted from measures of gross benefits to determine the net benefits. However, since these costs are usually minimal they rarely affect estimates.

The factors which determine the net benefits of resident sport fishing are demand for the activity (which is usually indicated by user rates) and the measure of value. Demand is a function of population, access, and leisure time, while value is dependent upon property rights of users. For current users, "required compensation" is the preferred approach, however, empirical estimates of these values are not usually available.

Non-resident fishermen and tourists, account for sizeable expenditures in the economy. The net value that these expenditures add to the economy are legitimate economic benefits attributable to the fishery (no free value or non-marketed benefits are counted for non-residents, only income that has been added to the economy). Published figures on visitor

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35 The definition of "residents" will depend on the viewpoint of the analysis. From a national perspective, residents are defined as all Canadians.

expenditures are usually available. The problem, however, is to determine the extra amount of expenditure that is made because of the fishery, and then to estimate the net value of this added expenditure by subtracting costs. Most studies[36] show net economic benefits from fishery expenditures to be considerably lower than total visitor expenditures, usually 10 to 15 percent of the gross figure. The factors important in determining net economic benefits from sport fishing by non-residents are the level of non-resident fishing activity, the extra expenditures made because of this fishing activity and the costs involved in providing the goods which are purchased by the tourists.

3. Subsistence Fisheries

In many areas of Canada native people have historically relied on fishery resources for subsistence purposes. While evidence suggests that the importance of subsistence fishing has declined, substantial numbers of Indians continue to fish for both economic and socio-cultural value.

Available data on subsistence fishing are believed to under-estimate both the economic and social significance of this activity. Participation figures recorded by government agencies[37] do not include native people who receive fish but do not fish themselves. Yet, sharing of the catch among needy band members is an important part of subsistence fishing. Also, figures do not include participation by non-status Indians. Furthermore, official harvest data are probably low since many Indians do not apply for permits or report their catch. Thus subsistence fisheries, while declining in importance, are likely

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36 For example, Pearse Bowden Economic Consultants Ltd., The Value of Non-Resident Water Sport Fishing in British Columbia, B.C. Fish and Wildlife Service, Victoria, 1971.

37 Personal communication with Department of Fisheries officials.

to be more significant than indicated by available data.

The issues involved in evaluating subsistence activities depend on the allocation of property rights. It has been argued that required compensation is the more appropriate method to evaluate these activities. However, at the present time subsistence fishing is not quantifiable using this approach. If willingness-to-pay values are used, replacement values (the dollar value of fish produced) are probably the best measures. However, it should be noted that this approach ignores the social and cultural significance of subsistence activites and is therefore likely to underestimate the true value.

G. Wildlife Habitat

Wildlife habitat is probably the least apparent use of water addressed in this paper. Wildlife does not require the diversion or relocation of water as in the case of hydro-electric power, does not create pollution as do municipal or industrial uses, and does not live in water as do fish. Yet at the same time, wildlife resources are completely dependent on the availability of water for existence. Moreover, they are often adversely affected by certain kinds of water resource developments, and therefore, often comprise a component of water opportunity costs for large projects.

The kinds of benefits provided by wildlife are in many respects similar to fisheries: sport hunting benefits for both residents and non-residents, commercial benefits (eg. trapping) and, subsistence uses (for both pelts and meat). In addition, wildlife provides non-consumptive benefits in the form of satisfaction enjoyed in passive activities such as viewing or photographing animals. The issues and approaches relevant in measuring these benefits are similar to those utilized for fishery resources and will not be discussed here. Non-consumptive values, which are unquantifiable, are discussed in Appendix A.

H. General Outdoor Recreation

Outdoor recreation associated with the water environment is a growing activity in Canada. In this analysis, water recreation refers to activities such as canoeing, power boating, camping and scenic or historic viewing. Fishing and wildlife activities have been addressed earlier. In practice it is impossible to separate boating and scenic viewing from activities such as fishing or wildlife observation since they are all part of the recreation experience. However, in order to avoid repetition, that distinction is made here.

Many lakes and rivers in Canada have not yet been significantly altered by human activities. In recent years appreciation of the value of the "wild" character of water bodies has been growing. Undeveloped rivers are often more productive for fishing, some have outstanding beauty, and others possess unique ecological systems. As a result large numbers of people have come to attach considerable value to wild areas, and increasing numbers use them for recreation purposes. There is need, therefore, to evaluate the benefits of rivers and lakes in their natural state, in order to compare these values against other conflicting uses of the resources.

To measure the economic value of wild rivers and lakes for recreation, three kinds of benefits must be considered. First, there are unmarketed or free values captured by resident users of a public resource without paying for the activity. Next there are economic benefits created by expenditures of non-residents for outfitters, transportation and accommodation in the local economy. Finally, there are non-user values associated with unique natural environments. Ways to assess the value of the first two of these benefit streams have been discussed previously and are summarized briefly here.

The question of property rights is also a key factor in the evaluation of resident water-oriented recreation. It has been argued that a good case can be made for assuming that recreationists hold implicit property rights or priority in the use of recreation areas. If this is the case, the most appropriate measure of social benefits is the compensation required by recreationists to forego their activities.[38] However, if recreationists do not have implicit property rights, then the willingness-to-pay approach is the better measure.

At present, data which could be used to quantify these measures are limited. Furthermore, studies concerned with outdoor recreation in one area of Canada, as a rule, cannot be generalized and used to measure recreation value in other areas. Although many unique and highly valued wild areas exist throughout Canada, at present, they remain unquantified (using either required compensation or willingness-to-pay) and represent a major gap in the information base of relative values for water uses.[39]

Similarly, data describing expenditures by non-resident participants in Canadian water recreation are also lacking. Again the value which should be obtained is the value of tourist expenditures, after all costs of providing the goods and services are substracted.

Other values associated with unique or wild natural environments, refered to as existence value and option value are discussed in Appendix A. In general these social values are associated with preservation of unique natural attributes, such as environments,

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38 Outdoor recreation in wilderness areas is the classic example of a benign use of amenity resources which should be considered to have priority (in terms of property rights) over destructive alternative uses. See Krutilla and Fisher, op. cit. pp. 28-36.

39 The exceptions are British Columbia and Ontario where a number of good studies on willingness-to-pay for recreation have been completed.

landscapes, or wildlife species. These values are not reflected in the direct use of a resource, but are associated with the knowledge that they will still be available for use in the future. These values are often held by people who will likely never see or participate in the use of the resource in question.

Option values arise where a unique natural resource used for amenity purposes is threatened with a potential development that has irreversible consequences.[40] Existence values are often associated with support for the preservation of natural areas.

To incorporate non-user social values into water planning, it is necessary to consider each water resource project individually. An analyst must determine whether:

a. the particular water environment is used as a recreational resource;
b. the natural attribute of the water resource is unique; or,
c. the natural resource is being considered for an irreversible development.

If these characteristics are present, option value exists. Unfortunately, at present there is no way to quantify or measure these values and they must be considered as a non-quantifiable factor in water planning (Appendix A). The only option open is to point out to decision-makers whether the non-user benefits for a particular project are significant.

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40 Krutilla and Fisher, op. cit., pp. 70-72.

V. PRICING OF WATER

Previous chapters of this study have developed the economic context within which opportunity costs can be viewed as a tool for the allocation of resources. In this chapter a case is made for incorporating opportunity costs into the prices charged for the use of water.

First the advantages of proper pricing and the recommended role of prices in water resource management are discussed. Next the rationale for establishment of a system of charges based on opportunity costs is examined and an approach for incorporating economic values in water pricing is developed. Finally, alternative pricing criteria and the interaction of pricing and regulatory initiatives are addressed within the context of current water management practices.

A. Recommended Approach to Water Pricing

Prices are the means by which preferences are revealed and values are determined in a market system. Prices, therefore, function as a messenger between consumption and production. An appropriate or competitive price will discourage excessive comsumption of goods and encourage the production of desired commodities.

Unfortunately because of the common property[41] nature of water resources, prices alone cannot be used to allocate water among competing users. With public ownership, water is considered to be a free good available to all at a low or zero price. As a result, no mechanism is available by which the public (as a resource owner) can receive information regarding the value of the service which is provided through the use of water. Since producers have no incentive to conserve a free supply, greater quantities of water are used relative to other (priced) inputs. Moreover, because of the

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41 For a readable explanation of the common-property situation, see Garrett Hardin, "The Tragedy of the Commons", Science, 162 (1968).

lack of prices, users are not made aware of the opportunity costs of their activities, and there is no incentive to select lower cost water supplies.

If water resources were allocated through a competitive market system, a number of key objectives of water management would be achieved.

a. Established prices would fully reflect the opportunity costs or foregone values resulting from the use of a resource. Individual water users would have a clear financial incentive to minimize the costs imposed on other water users, either by careful selection of supply or by the alteration of their water use operation.
b. Only water uses which realize a net gain after opportunity costs are taken into account would proceed. Therefore, redundant or wasteful uses would be eliminated, and the basic criteria of economic efficiency would be met.
c. Public resource owners would be compensated for losses resulting from reduced values of water.
d. Users of final products requiring water as an input would be charged with the full value of resources required to produce their goods. For example, the price of minerals would reflect any adverse affect of mining on fisheries resources.

The theory of pricing suggests that these goals would best be accomplished under a system of marginal cost pricing. "Marginal cost" is defined as the addition to cost that is associated with an incremental production of a good or service.[42] With this approach prices adjust with changes in marginal costs and are reflected in the price of the product or service output. Marginal costs also

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42 If all units of a good are priced at the marginal cost of the last unit which is produced, the additional satisfaction which consumers have already gained from the consumption of earlier supplies of the good is known as their "consumers" surplus.

remind us that products which are consumed at varying times or locations may be physically similar but economically distinct, and must therefore be priced as separate goods. For example, the water in a stream which serves as a salmon spawning ground should be priced differently i.e. is worth more to society, than the water in a stream which is devoid of fish life.

Marginal cost pricing is a form of pricing developed for use in a competitive economy, and not directly applicable to the circumstances surrounding most water uses. Not only is specific quantity-related information generally unavailable, but the more important management decisions involve non-marginal changes in water use eg. construction of a dam on a river or the diversion of a stream's flow for irrigation will impose changes in the water resource base. In addition, the only costs involved in providing water are the losses imposed on foregone water uses which cannot be measured in marginal terms.

The pricing rule which best meets the economic and water management objectives is a charge based on the opportunity cost of water. Pricing in this manner would meet the objective of economic efficiency by allowing maximization of social benefits from the use of scarce water resources. It would also ensure that only those water resource uses which provide net gains over all water costs would proceed.

This approach to pricing cannot be accommodated by the current practice of standard charges per acre foot of water allocated. There is no way to relate the opportunity costs of most activities to specific quantities of water; moreover, the differences in opportunity costs between activities and locations means that a uniform charge would be inappropriate.

Issues on how opportunity costs may be calculated have been covered

in previous sections. The question remaining is how to implement compensation for resource costs within the water pricing structure. Currently, firms contemplating the use of a stream, need only pay an application fee and meet the conditions which are attached to their authorization. However, under a management framework based on opportunity costs, the direct costs of labour, capital and materials required in their operation and the value of all resources impacted by the project (including all resource values which might be precluded) would have to be considered. In this case, firms may find it more economical to reduce costs imposed on others, by altering the design or operation of their project (for example, purchasing equipment which uses less water) to reduce losses, rather than pay the full compensation required for any damages.[43] Therefore strong financial incentive for mitigation of project-induced losses (lower resource opportunity costs and reduced levels of required compensation payments) would make both resource developers and society better off.

A number of special concerns arise in the implementation of water charges based on economic values. The first problem involves the evaluation of non-income opportunity costs. As previously stated, unquantifiable losses or resource uses and activities are likely to be of importance in the evaluation of alternative water uses. Although a schedule of fees or charges based on consumer

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43 The terms compensation and mitigation are frequently used interchangeably but possess clearly distinct meanings. Mitigation includes those measures taken during the planning, design, or operation of a project which are intended to lessen adverse impacts on affected resource values. An example would be limitations placed on construction in an area used by a valuable wildlife species. Compensation measures, on the other hand, are payments made for those reductions in social values which are not remedied by mitigation and remain as opportunity costs of a project. If, following the example above, wildlife losses were not entirely alleviated, then compensation could be paid to cover those values which are reduced by the project.

willingness-to-pay can effectively meet most of the income-valued resource opportunity costs associated with a project, the evaluation of non-income losses must remain largely subjective. It is not possible to estimate one price for a water use which accurately reflects both income and non-income costs.

Non-quantifiable factors should have a bearing (upward or downward) on prices charged for quantifiable water uses. For example, assume that evaluated income losses of a water project are estimated to be $20 million. In addition, significant non-quantifiable costs (for example, extinction of a marine species) are anticipated. The final price which should be charged for use of the water should be adjusted upward (above $20 million) in order to reflect the non-quantifiable losses. On the other hand, if significant non-income benefits are anticipated, charges should be set below $20 million. In either case, the size of the recommended adjustment will be based on the subjective evaluation of the analyst and cannot be calculated precisely.

Often, another consideration is that estimates of economic opportunity cannot be predicted except within a range of values. This lack of precision is due to many factors, including uncertainty regarding physical impacts, the prevalence of non-market values, uncertainty over property rights and so on. In such situations, the most viable procedure is to recognize this uncertainity in the price and charge an average of the maximum and minimum costs which can be expected. If better information becomes available, the price can then be adjusted.

Finally, there is no reason why all opportunity costs have to be recovered at once. Water charges may be set either on an annual basis or as a lump sum payment at the beginning of the project. Often the water user would find it prohibitive to pay for the total value of current and future losses at one time. Moreover,

the relative values of future water uses cannot always be predicted with certainty. Therefore, a more desirable solution may be to set the rate on an annual basis and adjust the charge if it becomes clear that a precluded water use is growing (falling) in value.

A final important point concerns those situations in which it is deemed desirable to charge less than the full cost imposed by a water-based activity, therefore granting an explicit or implicit subsidy through the free use of water supplies. For example, it may be judged prudent to provide electricity at a lower price by not charging the full opportunity costs of hydroelectric power development. The purpose of such a subsidy would be to provide an incentive for industrial development or allow a cost saving for consumers.

Water use charges which do not include all opportunity costs indicate that policy makers are concerned with different (non-economic) pricing criteria. Pricing, other than on the basis of economic efficiency, is discussed in the next section.

B. Issues in Pricing Water Use

1. Alternative Criteria

This paper proposes the adoption of charges for water activities which reflect the economic value of alternative resource uses. The goal of water use allocation therefore, is to set water prices for each activity equal to the opportunity costs which they impose. There are times, however, when goals other than economic efficiency should be reflected in the price charged for water. Some of these alternative pricing criteria are discussed below.

Subsidized prices may be used to encourage particular kinds of development within a region. Hydroelectric power projects, for example, have often been charged less than the full opportunity

costs of water in order to build up a region's stock of social overhead capital. Similar incentives could also be provided to other objectives such as increasing regional employment opportunities or expanding recreational facilities even if the value (price per unit of water times the quantity of water committed) derived from the water use is less than its opportunity cost.

An alternative objective of charges may be to improve equity by influencing the distribution of costs and benefits among producers. Water users, for example, would be required to make payments in proportion to the cost of services, except in those cases where an explicit subsidy was necessary for equity purposes. Hence lower income users may be required to pay less for an input such as water in order to facilitate a more equitable income distribution. Alternatively all users may receive a certain basic ("lifeline") quantity of a resource free or very low charge and face rising rates for additional incremental consumption. Such equity goals, however, may conflict with efficiency objectives and do not necessarily represent the most appropriate means of achieving the desired distributional objectives.

Pricing may also be advocated as a means of raising government revenues. Charges would be levied to cover all information transactions and administrative costs involved in the management of a water resource in addition to providing a specific lump sum or percentage revenue. In theory, all economic rents could be taxed away without affecting production decisions and final consumer prices. In practice, however, the application of revenue objectives may conflict with economic efficiency goals and is likely to be at variance with income redistribution goals as well.

Finally, pricing may be utilized as an extension of political objectives. Lower fees may be used as rewards for implementation of a desired action or high charges may be levied as punitive measures. "Water projects are in fact, infamous for serving as bargaining collateral in 'pork barrel' agreements".[44] Payments from beneficiaries of public agency projects are almost always difficult to extract and beneficiaries of water resource projects are no exception. Only rarely do those who gain volunteer to pay the costs involved in the provision of a service; the allocation of financial responsibility in water related projects then becomes a political rather than technical decision.

No guidance can be offered on when it may be desirable to follow a particular pricing criterian. Our analysis has demonstrated that pricing water on the basis of opportunity costs will meet economic objectives. The consideration of other objectives in water resource management can only be decided at the political level. However, one can identify the cost of meeting other objectives by measuring the losses (opportunity costs foregone) which occur by not following economic criteria. This, in itself, is valuable information for decision-makers.

2. Pricing and Regulation

At the present time a combination of federal and provincial regulations cover most aspects of water use in Canada. Our advocacy of a pricing system does not imply that regulations should not play an important role in water management. In many cases, such as in the setting of maximum standards for the discharge of toxic pollutants, the existence of regulations is necessary in order to develop and maintain effective water

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44 Neil Swainson, ed., Managing the Water Environment (Vancouver: UBC Press, 1976), p. 181.

management. At the same time, reference to licenses which have been awarded show that only infrequently do existing regulations consider the economic implications of their requirements. The conceptual framework of pricing is therefore necessary so that opportunity costs associated with a specific regulatory structure can be clearly established.

Consider, for example, two streams which are being contemplated for industrial development. Assume the streams are physically similar but differ in terms of their respective use. One stream is used for a native subsistence fishery while the other is not used because of its remote location. Since the two streams are physically similar under existing environmental regulations they would be treated the same. However, the social and economic costs associated with their use would be very different. The opportunity costs of the remote stream could be close to zero, while the opportunity costs of the food-fishery stream could be very high. A regulatory rather than pricing structure may remain as the appropriate means of management, but it is essential that the imposed regulations reflect the different resource losses which result from development.

VI. SUMMARY AND CONCLUSIONS

This chapter provides a summary of guidelines which can be used to establish water use charges and some recommendations for future work that could be initiated to expand the profession's capability for developing water use pricing.

A. Guidelines for Water Charges

This section presents a set of guidelines which can be used to incorporate opportunity costs in the administration of water use fees. These guidelines represent a synthesis of the major ideas in this paper and are presented to provide a framework for efficient water management.

a. Opportunity costs, or values foregone, are implicit in all water use conflicts. In order to make optimum water use management decisions, these values should be measured and explicitly compared. Values of opportunity costs have both economic and non-economic components.

b. Because price information is usually unavailable for water uses, the economic values of these activities must be synthesized. Principles to be followed when estimating unmarketed economic values parallel those of a competitive market context. The allocation of property rights is a major determinant of value for non-marketed water use.

c. Non-income opportunity costs associated with alternative water uses must be considered subjectively. The non-income factors deemed most important are environmental quality and preservation, regional employment and development, and the distribution of project benefits and costs. These factors should be included when determining opportunity costs of alternatives.

d. Prices charged for water uses should not be determined on the basis of physical parameters such as acre-feet of water used, but on the basis of opportunity costs of the water activity. Prices established in this manner, would give

society an indication of the costs of providing water for a given use. The price charged for a particular use should fully reflect opportunity costs. These charges would ensure that only projects which provide benefits greater than their opportunity costs would proceed. Their adoption would also provide an incentive for water users to seek locations and projects which minimize costs imposed on other uses. Finally these charges would ensure that users of the final outputs pay the full economic costs of providing their goods and services. In some circumstances it may be desirable to provide water at subsidized prices, but these decisions should not be made until the opportunity costs for such decisions has been determined.

e. In addition to quantified economic costs, water use charges should reflect the direction and magnitude of non-quantifiable impacts. Non-economic effects must be evaluated subjectively and should result in an adjustment in the quantifiable economic factors. For example, detrimental non-quantifiable impacts (costs) could increase and positive non-quantifiable impacts (benefits) could decrease the appropriate monetary charge. No guidance can be given on how much the charges should be adjusted since these factors can only be measured in qualitative terms; in certain circumstances, non-economic factors may be significant.

f. All opportunity costs need not be recovered immediately, nor can they be calculated with complete certainty. There is no reason why the values of all current and future losses, caused by a project, need to be paid for when the licence is granted. The opportunity costs could be built into an annual user fee which reflects the losses borne in that year. Moreover, it may be impossible to predict exactly how the value of water uses will change in the future. Therefore, if it becomes apparent that a foregone water use is increasing in relative value, the annual charge could be

adjusted. Finally, when assessing the value of opportunity costs, there is often so much uncertainty that it is impossible to predict these values except within a very wide range. Thus, prices implemented should reflect this uncertainty by charging, say, an average between the maximum and minimum losses which are anticipated.

g. Regulations may be used in addition to water use charges to meet water management objectives. When setting regulations, it is necessary to collect information regarding economic and non-economic opportunity costs in order to know the dimensions of values which are to be protected. If opportunity costs still exist after the terms of regulations are satisfied, they should be reflected in water use fees.

B. Recommendations for Future Work

To develop a complete set of pricing guidelines and aid the process of evaluation in future studies, further research and policy development are required. Some of the more important aspects which require clarification are:

a. The issue of property rights of recreationists and other water users. A clearer stand on these property rights would provide a better focus for future assessments of alternative water use values.

b. More programs should be inititiated to provide information on the extent and value of non-market water activities in Canada. These programs should focus on outdoor recreation uses, and should attempt to measure either willingness-to-pay or compensation values for these activities. Since very often there is little time to collect new data when assessing specific projects, it is recommended that the studies be done as soon as possible to minimize future major water use conflicts.

The entire process of evaluation for alternative resource

activities could be improved if administrative agencies were to collect information on a provincial or territorial basis.

c. Guidelines should be established to determine what kinds of water use projects require formal benefit-cost assessments and which can be assessed with the use of only limited economic analysis.

d. The concept of opportunity cost pricing should be tested to determine whether appropriate results can be obtained. Consultation with affected water use groups is recommended in order to clearly articulate the objectives and procedures which are involved in water pricing on this basis.

APPENDIX A

PARAMETERS FOR THE EVALUATION OF NON-ECONOMIC OBJECTIVES IN WATER RESOURCE PLANNING

This study has focused on the evaluation of economic costs and benefits which are affected by the allocation of water resources. It has been stressed that economic goals are only one objective of rational resource planning and that other, non-income goals must also be considered in project selection and development. Evaluation of the quantitative impacts of a project has thus been developed within the overall context of a multiples objective planning framework.

This appendix deals specificially with the non-income goals of water resource planning. Three non-quantifiable objectives - environmental quality and preservation, regional development and employment, and equity in benefit (and cost) distribution - have been singled out as being of particular importance and will be discussed in some detail.

It should be emphasized that although a careful delineation and presentation of each objective facilitates comparisons and trade-offs among non-income and income goals, it is not possible to fully integrate all concerns within a single "umbrella" measure. To the extent that elements of regional development, income distribution, or environmental objectives can be evaluated in commensurable monetary units, they should be handled as part of the income account itself. The commercial benefits of salmon fishing, for example (given sufficient information), can be quantified and displayed along with other economic costs and benefits of a project. Yet certain resource gains and losses, such as the destruction of an important native food fishery or the preservation of an endangered species, cannot be measured in monetary units no matter how detailed the available information is regarding the resource base and its use.

Thus, although the focus of this study has been on the evaluation of the

economic impacts of water-based activities, the analysis of income effects alone is not considered to be an adequate basis for project selection or design. An evaluation of opportunity costs remains necessary in that they demonstrate the foregone economic activities which result from the influence of other objectives or project plans. In other words, the costs, in terms of income foregone, of meeting other than economic goals can be accounted for through the use of a multiple objective evaluation framework. But the question of whether the non-income benefits of a particular water resource development plan are worth more or less than the income gains foregone must remain a matter of judgement by policy makers.

A point of particular significance concerns the anticipated rate of change in income and non-income parameters over time. A number of studies have shown that non-quantified values have increased significantly in recent years, and that their annual rate of increase is likely to exceed that of income benefits over the study period. In particular, the non-priced amenity services of environmental resources have been shown to be growing rapidly with demand increasing more than proportionally with income.[45] The rate of growth in demand for non-income values can be roughly calculated as a function of the increase in population, income, (which will increase consumer willingness-to-pay), and changing consumer tastes. A first estimation could show that non-priced benefits of water uses will increase at an annual growth rate of 10 percent and only 5 percent for income benefits. Comparison of alternative uses of a river, eg. using it as a wild river recreation area or as a source of hydroelectric power, would need to take into account this expected difference in the time stream of future benefits. Also

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45 For example, see G.H. Stankey, "A strategy for the Definition and Management of Wilderness Quality", in Natural Environments: Studies in Theoretical and Applied Analysis, ed. John V. Krutilla (Baltimore: John Hopkins Press, 1972). Stankey argues that wilderness recreation and recreation in undeveloped natural areas is the most rapidly growing outdoor recreational activity, increasing at roughly 10 percent per year.

of importance to the calculation are the implications of technical change for the development and preservation options, since future technological improvements are likely to decrease the relative value of commodity income benefits in comparison to non-priced environmental amenities.

A. Environmental Quality and Preservation

1. Background

In this section, the principle parameters which aid in the evaluation of non-quantified environmental impacts of a project are reviewed. The key characteristics of the non-quantifiable objective will be noted but development of an explicit accounting structure is not attempted.

Four theoretical problems confront the analyst when attempting to develop means for measuring potential project impacts on environmental quality and preservation. First, with externalities the prudent resource developer rarely captures the gain which his care bestows on society, while the irresponsible developer is seldom forced to assume the social costs of his poor management. Second, the environment is a public good, owned by everyone and hence accessible to all. Third, uncertainty regarding both future consumer demand and the quality of the product cannot be eliminated but is inherent in the nature of environmental amenities. Fourth, environmental preferences are not uniform among all individuals and in fact at times can become directly competitive; yet, the strength of alternative individual desires cannot be rigorously compared.

The development of "operational" indicators of environmental quality is extremely difficult due to the individual characteristics of specific natural environments. For example, while it is true that the components of an ecological system are interconnected, it is not true that all parts are equally important. Similarly, impacts do

not occur uniformly over space and time; the natural environment is characterized by the presence of variability and the interplay of multiple equilibria, with abrupt shifts in behaviour just as "natural" as are the more accustomed incremental changes. To state that many natural areas are extremely fragile and highly sensitive is therefore only the opposite side of the statement that other areas are remarkably resilient and capable of adsorbing large exogeneous pressures.

2. Option Value

The concept of option value provides a guiding philosophy for the environmental objective. The underlying premise is that, in the case of a decision involving intergenerational trade-offs characterized by uncertainty, utility will be increased through the maintenance of options. Another way to state this concept is that utility will have been decreased if future events prove that the better option has been foreclosed as a result of a prior decision.

Several aspects of option value may be differentiated. One aspect is concerned with the element of uncertainity in the future demand for a good. With continued increases in population, income, and leisure time, it is reasonable to expect that future generations will place a relatively higher (real) value on natural amenities. A second component of option demand emphasizes the importance of maintaining choices, a criterion of particular concern in the face of "irreversible" developments decisions.[46] Against a background of economic, biological, and social uncertainty there is value in the retention of options that would otherwise be foreclosed. The fewer the available substitutes for a foreclosed experience, the greater is the value attached to its loss.

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46 The term "irreversible" is used to signify an alteration of the environment for which no feasible means of restoration exists within an acceptable period of time.

Existence values form a subset of option demand. Preservation of natural wilderness areas and the survival of unique animal species, for example, are concepts from which a large segment of society clearly derives satisfaction. Yet very often the expression of value is strictly non-consumptive; witness the concern for whales on the part of individuals who will likely never observe these species in the wild. This sense of value involves something more than the merely personal preference and there is a perception that the community of "humanity" is in a very real way enriched by the presence of these phenomena and, correspondingly, would be diminished were they to disappear.

In summary, key determinants of option values include the following:

a) uniqueness, within the particular area considered, of the potentially affected environmental resources;
b) the current level of demand for the amenity services in question;
c) the anticipated relative increase in demand over the period under consideration for the type of amenity services provided; and,
d) the degree to which project consequences represent irreversible impact upon the natural environment.

3. Evaluation Parameters

Having developed the framework within which the non-income objectives of environmental quality and perservation are to be evaluated, it now remains to discuss the key environmental indicators which affect water resources and their associated uses. The broad range of potential project induced impacts makes it inappropriate to categorize specific impact types. Instead, the key determinants of environmental quality and preservation objectives are presented as a guide for resource managers, who can then apply them to particular water conflicts. A total of six indicators are specified.

a. Uniqueness

In general, the more unique an area or species the smaller are the number of available substitutes and the larger are the associated option and existence values. "Uniqueness" may refer to physical properties of an area, such as a waterfall of unusual beauty; it may refer to an unusual animal species or their behaviour, for example the presence of an endangered species or the existence of a caribou migration area; or it may refer to the unusual adaptive behaviour of a plant or animal species.

b. Terrestrial and Aquatic Ecology

Beneficial or adverse changes in the type, abundance, or diversity of a plant or animal species, that are not included as part of the income objective, should be counted here. The disruption of nesting or feeding habitats, for example, could represent a significant adverse impact on terrestrial ecosystems, while changes in water flow or volume would adversely affect the aquatic ecology of a region. Similarly, habitat improvement or the protection of a threatened species would represent beneficial impacts of a project. Increased access to an area could result in significant longterm impacts on the ecology of a natural region and must also receive careful attention.

c. Irreversible Impacts

Option and existence values both increase to the extent that a planned water use, such as a major hydroelectric development, result in irreversible environmental changes. In contrast, some water uses cause only temporary impacts on the environment. Placer mining, for example, may destroy a fishery for a number of years but after restabilization of streambeds and banks, fish will usually return.[48] The asymmetrical implications of

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48 Example borrowed from Krutilla and Fisher, op. cit.

irreversible impacts emphasizes the need for caution in project design and selection.

d. Naturalness

In general, the more pristine the environment, the more rare it is and hence the more highly valued. Municipal waste disposal into an already polluted river may, therefore, be preferable to waste disposal into a "wild" river.[49] "Naturalness" is of course a relative term; an area exhibiting a rich and diverse selection of wildlife for example, is more "natural" than a more limited environment which supports only a few plant and animal species.

e. Aesthetics

This criterion is obviously highly subjective. In recent years, however, a number of approaches to ranking landscapes have been developed.[50] The evaluation of aesthetics is made easier in that an absolute scale is not required; rather comparison is most often made between two or more specific environments.

f. Range of Recreational Opportunities

A diminishing resource base leads to a reduction in the variety of alternative recreational opportunities, resulting in losses in social welfare. Wilderness activities such as canoeing, for example, have become more valuable in some areas because the experience is no longer as readily available.

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49 On the other hand, a wild river may be able to process wastes more easily while the already degraded river may assimilate wastes less quickly and add to existing pollution problems.

50 See for example, John Dearinger, "Measuring the Intangible Values of Natural Streams, Part II", University of Kentucky, Water Resources Research Institute, Research Report No. 66, December, 1973.

The preceeding six indicators can be evaluated within a framework which includes the following criteria for each:

i. direction of project impact: beneficial (+) or adverse (-);

ii. magnitude of the impact: the scale which is utilized might rank impacts from -5 (highly adverse) to +5 (highly beneficial). Magnitude is used in the sense of degree, scale, or extensiveness of impact, and reflects the specific characteristics of the project under consideration;

iii. importance of the perceived impact: a very important impact would be awarded 1 point, while an impact of minor significance would be awarded a score between 0 and 1. Importance is defined in relation to the anticipated significance of each indicator for ecological values and the associated impact on human demands for the attendant change in amenity services and option values which are provided. This criterion should probably remain invariant for all projects under consideration;

iv. probability of impact occurrence: a probable impact would be awarded a score between 1/2 and 1, while an unlikely impact would be rated between 0 and 1/2; and,

v. mitigation/enhancement of project impacts: the possibility which exits for mitigating adverse impacts or enhancing beneficial impacts, rated as poor, limited, fair, or good.

Impact direction, magnitude, importance, and probability could be evaluated for each of the indicators selected. A total score for each key indicator is then derived by multiplying each impact magnitude ranking by its associated importance weighting and probability score. The sum of these values would represent the final scoring of the environmental quality and preservation objective. A high positive score would signify an overall beneficial impact on the environment, while a negative ranking would suggest that environmental degradation would be expected to accompany project development. The cardinal scores of individual projects could be compared and an ordinal ranking compiled. The

results of the environmental quality and preservation objective could then be compared to those of other accounts.

B. Benefit Distribution

1. Background

Traditional cost-benefit analysis starts with the premise that, in project selection, it does not matter who the beneficiaries of a program are and who bears the costs. A dollar of increased income to a poor man is valued equally as a dollar of added income for a rich man. Benefits that accrue in wealthy regions are valued in the same manner as those that accrue in poorer regions. The reason for this approach does not lie in a disregard for equity, but rather from assumptions in welfare economics.

Welfare economists have argued that allocation and distribution of project benefits are separate issues and projects should be chosen on the basis of efficiency criterion only. Distribution of project benefits on the other hand, should be carried out separately through established standards of justice or equity by means of taxes or monetary transfer payments.[51]

This separation of efficiency and equity in project selection has come under attack in recent years.[52] A number of economists have argued that the assumptions of welfare economics are not applicable in cost-benefit analysis. Furthermore, distribution by other means

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51 For a restatement of this position see Richard A. Musgrave, "Cost-Benefit Analysis and the Theory of Public Finance", Journal of Economic Literature 7 (1971), pp. 797-806.

52 See Arthur Moss, "Benefit-Cost Analysis: Its Relevance to Public Investment Decisions", Quarterly Journal of Economics 80 (1966), pp. 208-226, as an example of one of the earliest, and perhaps the most spirited, attacks on the separation of efficiency and equity.

such as transfer payments are not costless, often involving both administrative and political costs. Even more important, governments do not try to separate efficiency and equity; they typically want to pursue both objectives in project selection. In order to be useful, the analyst should be adaptive and respond to the needs and intentions of the decision-makers.

2. Distribution Effects of Projects

The distinction between "efficiency" and "equity" is often analytically useful, but it is nonetheless arbitrary. If efficiency were viewed broadly as a measure of the difference between all the advantages (benefits) and all the disadvantages (costs) of a program, the equity or distribution effects of a project or activity could be viewed as a subset of the "grand-efficiency" effects. To the extent that equity effects were favourable they could, in principle, be included in the benefits of the program, and to the extent they were unfavourable they could be included among the costs.

The problem, of course, is placing a value on such favourable or unfavourable effects so that they are commensurable with other costs and benefits. Although progress is being made in this area, the valuation of the distribution effects of public expenditure programs has so far eluded economists.

Because of their importance to policy makers the redistribution effects of projects should at least be spelled out and discussed. To improve analysis, project managers, for their part, must provide economists with guidelines concerning the distribution objectives (income, region, special group, etc.).

C. Regional Development and Employment

The major goals of regional development and employment objectives should be to improve the distribution of population, production, and industrial development within the country. Although the development

of strong growth centres should not be discouraged, the economic base of smaller communities needs to be protected and stabilized in a manner commensurate with their unique qualities.

The human and social costs associated with unemployment also need to be addressed to utilize society's scarce labour resources in a productive manner. Emphasis therefore, should be put on the creation of a viable economic base to stabilize long-term employment in all regions. Development of a river for hydroelectric power, for example, may provide a substantial short-term economic boost to a local community. However, in the longer run such a development may prove to be very disruptive to both the economic and cultural life in an area.[53] Enhancement of a renewable resource base and the development of industries which utilize traditional natural resources, on the other hand, is likely to provide significant long-term benefits to a region.

Development of regional accounts is important because it may show impacts of water uses which are significantly different from provincial, national, or even international accounts. For example, development of hydroelectric power in Northern British Columbia may result in substantial economic gains to the province and nation but at the same time may create significant non-income (project impact) losses for local communities. The regional development account requires the identification of regional non-income parameters and allows for inter-regional trade-offs to be made explicit. Similarly, benefits which accrue to one region because of increased industrial activity may camouflage any resulting changes in the water resource and the subsequent reduction in employment in

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53 A good example of this is the James Bay hydroelectric development project. The claimed benefits, in terms of income and employment, are large but it is now apparent that the costs of environmental degradation and social disruption of native peoples are also significant.

commercial fisheries, or in tourist activities associated with sport fishing, in downstream communities. A shift in the type of employment opportunities which are available may also occur. For example, employment based on the renewable resources of a region may shift to employment in service or tertiary industries.

Because of the subjective nature of the required evaluation of the non-quantifiable water use impacts, only a very simple accounting structure is required. Merely judging an anticipated project impact on its direction (positive or negative), magnitude (low, medium, high), and anticipated probability of occurrence (unlikely, probable) can provide a workable inventory of indicators. Further refinement of each criterion is suggested in the case of larger projects.

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