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Water Development, Wildlife and Recreation: Panel

Charles W. Howe

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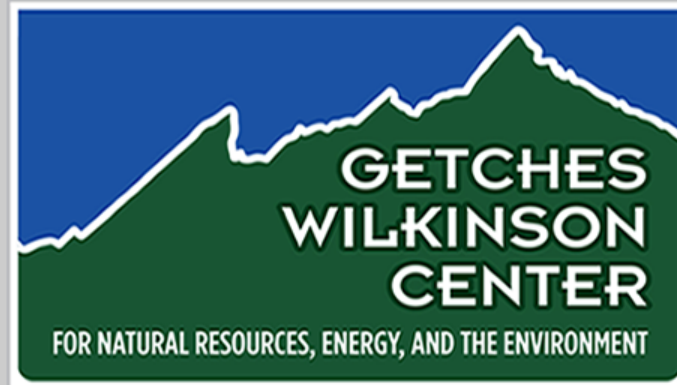
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WATER DEVELOPMENT, WILDLIFE AND RECREATION: PANEL

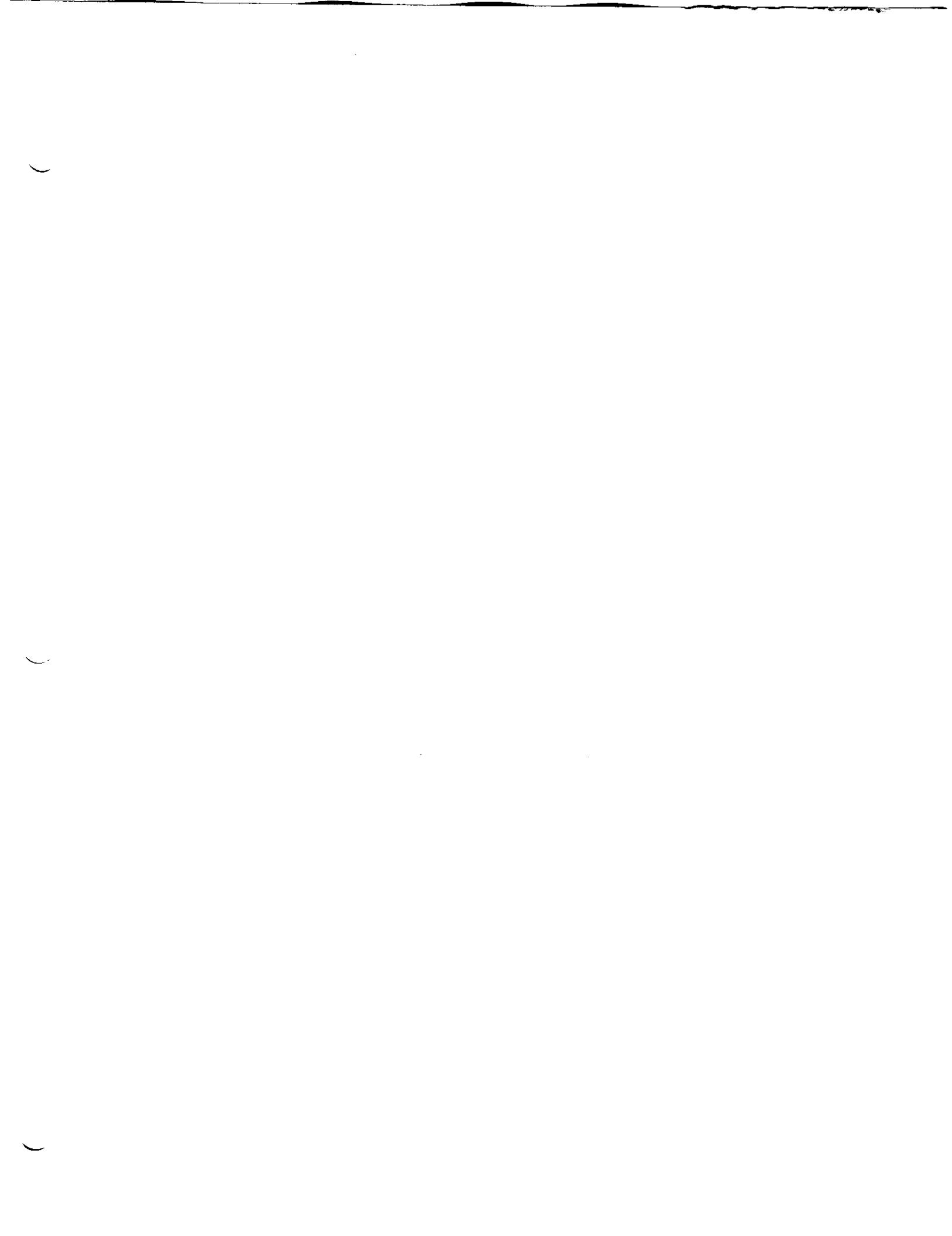
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WATER AS A PUBLIC RESOURCE: EMERGING RIGHTS AND OBLIGATIONS

A Short Course Sponsored by the
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REMARKS OF
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UNIVERSITY OF COLORADO, BOULDER

1. Principles for efficient and equitable mitigation of the negative effects of a water project.
 - a. Mitigation means steps for the reduction of negative project impacts and compensation for those experiencing negative residual effects.
 - b. Mitigation of what?
 - i) negative environmental effects;
 - ii) negative economic effects;
 - iii) negative social effects;
 - c. Absolutist approach: no residual negative effects whatsoever! Usually impossible or very costly.
 - d. Economic approach (transparency):
 - i) carry out mitigation to a level at which the marginal benefits (losses avoided) just equal the marginal costs of mitigation;
 - ii) optimal mitigation costs are a legitimate project cost that should be imposed on the project;
 - iii) residual costs should be compensated by the project and are a legitimate project cost.
 - e. Relationship to Colorado statutes and practices.
2. Illustrations of values lost in reducing streamflows and water quality:
 - a. Non-recreational instream values for the sub-basins of the Upper Colorado (source: Howe and Ahrens);
 - b. Recreational values related to seasonal streamflows: case of the Poudre River (source: Daubert, Young, and Gray, June 1979);
 - c. Values of higher water quality in the South Platte River (source: Greenley, Walsh, and Young 1980).

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OPTION VALUE: EMPIRICAL EVIDENCE
FROM A CASE STUDY OF RECREATION AND WATER QUALITY*

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ABSTRACT

A procedure for measuring option value and other preservation values of water quality is developed and applied to a case study area in the South Platte River Basin, Colorado. Benefits from water-based recreation activities are the focus of the study. The results provide an empirical test and confirmation of Weisbrod's proposal that option value and other preservation values represent important social benefits, and should be added to the aggregate consumer surplus of recreation activities to determine the total benefit of environmental amenities to society. In the absence of such an estimate, insufficient resources would be allocated by society to preservation of unique environments such as pristine mountain streams where mineral and energy development may irreversibly degrade water quality.

INTRODUCTION

The environmental economics literature identifies several possibilities of willingness to pay for preservation of public non-market aspects of environmental quality which are distinct from the direct or immediate consumer surplus benefit from use of the natural environment. These preservation benefits include option, bequest, and existence demands as outlined by Krutilla [1967]. Option value is defined as the willingness to pay for the opportunity to choose from among competing alternative uses of a natural environment in the future. Existence value is the willingness to pay for the knowledge that a natural environment is preserved. Bequest value is defined as the willingness to pay for the satisfaction derived from endowing future generations with a natural environment. Unfortunately, no empirical evidence bearing on the monetary significance of such benefits has been forthcoming to assist in the development of environmental policy. This paper provides what we believe to be the first measurement of option value, arising in this case from the assured choice of recreational use of preserved water quality in the presence of potential irreversible water quality degradation due to mining activity in the South Platte River Basin, Colorado.

Weisbrod [1964] originated the concept of option value. He wrote in rebuttal to Friedman's [1962] advocacy of a policy of cutting down the ancient redwoods in Sequoia National Park in the event that the present value of the stream of annual net benefits accruing to park visitors was found to fall below the current commercial value of redwood lumber. According to Weisbrod, option value was the amount of money economic

men who anticipate visiting the park, but are uncertain and in fact may or may not make such a visit, would be willing to pay for an option which would guarantee their future access. If this value could be estimated, its magnitude would influence the public choice of whether or not the park should be preserved. An uncertain supply and demand situation coupled with prohibitively high costs of renewing production, once stopped, were identified as necessary conditions for the existence of option value.

Weisbrod's article generated a lengthy theoretical debate. Long [1969] argued that option value was equivalent to expected consumer surplus. Lindsay [1969] pointed out that Long had neglected Weisbrod's assumption of uncertainty of purchase. Using a game theoretic framework, Byerlee [1971] concluded that in the face of uncertain future demand, option value could be greater than, equal to, or less than consumer surplus. Cicchetti and Freeman [1971] responded by showing that when uncertainty in supply is also considered, a risk-averse individual would be willing to pay to preserve his future option of use. Schmalensee [1972] argued that an alternative risk is also borne if a natural environment is preserved -- that of a very small future demand. Since the sign and magnitude of associated risk premiums are not generally known, he concluded that consumer surplus should serve as the appropriate proxy for option value.

Two later articles [Arrow and Fisher, 1974; Henry, 1974] showed that option value is distinct from consumer surplus and may attain significance even for a risk-neutral individual. Arrow and Fisher examined the question of whether or not the existence of option value for a risk-neutral individual necessarily led to a similar situation for society. They formulated a "quasi-option" value model in terms of the aggregate benefits and costs

that would be incurred by choosing various alternative environmental uses. It was concluded that even in the aggregate, society should take cognizance of the presence of option value. The Henry model was based on individual willingness to pay for the assurance of selecting the preservation of an irreplaceable environmental asset facing an imminent irreversible commitment, until such time that sufficient information becomes available affecting the future option decision of selecting from among alternative uses.

We adopted the Henry model for our study. The specific objective of the study was to empirically test the application of the Henry framework in the measurement of benefits of water quality improvement. The benefits measured include:

- (1) Consumer surplus from enhanced enjoyment of water-based recreation activities;
- (2) Option value of assured choice of recreation use in the future by avoidance of irrevocable pollution by mineral and energy development; and
- (3) Existence and bequest values for non-users.

Empirical estimates were derived using a simulated market bidding game.

THEORETICAL MODEL

After Henry, consider a two time-period model defined in accordance with the following symbols:

- N = The Nth individual
- U = N's utility function
- Y = N's income
- CS = N's consumer surplus generated from use of the natural environment
- D = Availability of the irreplaceable natural environment
 - D = d, the natural environment which is available
 - D = d*, the natural environment has been appropriated for an alternative irreversible use and is unavailable
- OV = Option value

- i = States of the world, $i = 1, 2$
 j = Time period, $j = 1, 2$
 P_i = Probability that state i will occur (where $\sum P_i = 1$ for $i = 1, 2$)
 C^j = Opportunity cost to retain the natural environment

The model is predicated on the following assumptions: (1) the future is uncertain, (2) one use of the natural environment is more irreversible than the other, (3) a decision is imminent as to which of the two competing uses of the natural environment will be chosen, and (4) sequential decision making takes place based on improved information acquired through time. Let

$$(1) \quad U = \sum_{j=1}^2 \sum_{i=1}^2 P_i^j U_i^j(Y_i^j, D^j)$$

be N 's two period probability-weighted utility function. Assume an opportunity cost C^j must be paid to obtain $D^j = d$, that is, a cost is imposed in the form of foregone alternatives if the natural environment is to remain available. C^1 and C^2 must be financed at instant 1 and instant 2, respectively, if $D^j = d$ is chosen. For simplicity of exposition C^j and Y^j are assumed known with certainty. The notation may then be simplified to $U_i^j(Y^j, d^*) = U_i^j(d^*)$ and in later equations, $U_i^j(Y^j - C^j, d) = U_i^j(d)$.

Finally, assume that

$$(2) \quad \sum_{i=1}^2 P_i^1 U_i^1(d) < \sum_{i=1}^2 P_i^1 U_i^1(d^*)$$

This assumption specifies that if only the first period is considered, N will choose d^* so that the natural environment is not available. In this case the cost, C^1 , of preserving the natural environment is greater than the associated benefits in period 1.

In the following case no new information is expected to become available between instant 1 and instant 2. A decision is made as if a "timeless world" existed. Consumer surplus for N can be defined as the equating factor in

$$(3) \quad \sum_{i=1}^2 P_i^1 U_i^1(Y^1 - CS, d) + \sum_{i=1}^2 P_i^2 U_i^2(d) = \sum_{j=1}^2 \sum_{i=1}^2 P_i^j U_i^j(d^*)$$

N will be willing to pay an amount CS at instant 1 to have d. Even after payment of CS, the individual will still receive the same expected utility as if the natural environment were not available.

N will choose the preserved natural environment as opposed to the development alternative if $CS > C^1$. No CS term need appear in the second period term of the preservation alternative since no change in information occurs between the two periods. As long as C^1 is paid at instant 1 the natural environment will be available in all following periods because of the static situation. In this case CS is the present worth to N of the preserved natural environment for all time.

Now assume that new information enters between instant 1 and instant 2. Individual N will know with certainty at instant 2 which state of the world will obtain. Assuming a sequential decision-making process takes place the following question must be answered: How much will N be willing to pay at instant 1 to (1) enjoy the natural environment through period 1 and (2) to have the option of choosing under conditions of certainty at instant 2 whether or not to retain the natural environment?

The preceding question can be answered by referring to the following equation

$$(4) \quad \sum_{i=1}^2 P_i^1 U_i^1(Y^1 - CS^1 - OV, d) + \sum_{i=1}^2 P_i^2 \max[U_i^2(d), U_i^2(d^*)]$$

$$= \sum_{j=1}^2 \sum_{i=1}^2 P_i^j U_i^j(d^*)$$

The terms CS^1 and OV balance equation (4). At instant 1 individual N will be willing to pay CS^1 to enjoy the natural environment during period 1. In addition, N is willing to pay an amount OV to choose, at instant 2, either the preserved environment or the irreversible alternative with full knowledge of which state of the world will obtain. In equation (4) CS^1 results from the enjoyment of the preserved natural environment through period 1 only. The magnitude of OV in period 1 is a function of P_i^2 , $U_i^2(d)$, and $U_i^2(d^*)$ in period 2 as they exist at instant 1.

In considering the term $(\max [U_i^2(d), U_i^2(d^*)])$ four possible cases can occur:

- (a) $U_1^2(d) > U_1^2(d^*)$ and $U_2^2(d) < U_2^2(d^*)$
- (b) $U_1^2(d) < U_1^2(d^*)$ and $U_2^2(d) > U_2^2(d^*)$
- (c) $U_1^2(d) < U_1^2(d^*)$ and $U_2^2(d) < U_2^2(d^*)$
- (d) $U_1^2(d) > U_1^2(d^*)$ and $U_2^2(d) > U_2^2(d^*)$

For example, if situation (a) evolves then:

$$(5) \quad \sum_{i=1}^2 [P_i^1 U_i^1(Y^1 - CS^1 - OV, d)] + P_1^2 U_1^2(d) + P_2^2 U_2^2(d^*)$$

$$= \sum_{j=1}^2 \sum_{i=1}^2 P_i^j U_i^j(d^*)$$

The inequality

$$(6) \quad P_1^2 U_1^2(d) + P_2^2 U_2^2(d^*) > \sum_{i=1}^2 P_i^2 U_i^2(d^*)$$

exists because maximum values of $U_1^2(d)$ and $U_1^2(d^*)$ were chosen. Therefore, $OV > \text{zero}$ and d will be chosen at instant 1 if $CS^1 + OV > C^1$. The magnitude of OV is determined precisely by the difference between the right and left-hand expressions of inequality (6). In cases (b) and (c) OV will likewise be positive. Only in case (d) will option value equal zero. None of the four possible situations will produce a negative option value.

Option value is irrelevant to the decision-making process as long as $CS^j > C^j$. The option to use the environment in the future has been preserved free of cost. Option value is a free by-product as long as the user benefit of the preserved environment exceeds the opportunity costs of preservation. It is for this reason that inequality (2) is required. This expression states that if the first period is considered by itself, development is preferred over preservation. Under this condition it is necessary to include explicit consideration of the second period in order to determine the proper course of action at the beginning of period one. Henry extended the original analysis to an infinite number of sequential decision-making time periods. This empirical investigation, however, was limited to two time periods.

EMPIRICAL PROCEDURES

The contingent valuation approach was utilized in this study. The U.S. Water Resources Council [1979] has approved use of the method for valuation of recreation resources. Respondents answered "yes" or "no" to dollar increments in willingness to pay, contingent on hypothetical changes in water quality with the highest acceptable value presumed to correspond to the point of indifference between income and the environ-

mental amenity. Many economists share Freeman's [1979] reservations about the approach, primarily because of the potential for strategic behavior by respondents, which may bias the results in the direction of a preferred policy. Utilizing market-related data has been preferred by most analysts in the past, since such analyses are based on actual behavior rather than responses to hypothetical situations.

It is notable that objections to the contingent valuation approach have been primarily theoretical, as empirical evidence of systematic bias is at best inconclusive. Davis, who pioneered the iterative bidding procedure in a study of the recreation benefits of the Maine woods, concluded that the reported values were not significantly different from those obtained by the market-related travel cost approach [Knetsch and Davis, 1966]. Randall and associates developed refinements in the contingent valuation technique and presented a persuasive case for its effectiveness in the valuation of environmental quality. They studied the benefits from improved air quality and other environmental amenities in the Four Corners area of New Mexico [Randall et al., 1974] and the Glen Canyon National Recreation Area [Brookshire et al., 1976]. They found no measurable strategic behavior by environmentalists compared to other respondents. Replication of the studies resulted in similar values. Bohm [1972] conducted a controlled experiment comparing five alternative measures of willingness to pay for a public good, including actual immediate payment in cash of the stated willingness to pay. He found no significant difference in values reported by five groups, each presented with an alternative willingness to pay format. Bohm [1979] concluded that the theoretical objections to the contingent valuation approach could be resolved by application of an interval method.

Two benefit functions would be derived, based on minimum and maximum incentives to misrepresent willingness to pay. The midpoint of the interval would represent the most acceptable value.

The willingness to pay measure of the value of improved water quality was selected over the alternative, willingness to sell or accept compensation for reduced quality. The appropriate question depends on the resource decision to be made. Congress in P.L. 92-500 determined that polluting rights are not for sale. Thus, the question of what level of compensation would be required to allow recreationists to remain no worse off than before pollution of recreation water resources is of only peripheral interest. A number of studies including Bishop and Heberlein [1979] have found that willingness to sell values including actual cash sales are considerably higher than willingness to pay, whether the latter is measured by contingent valuation or the travel cost approach. This would be the expected result, as willingness to pay would be constrained by limited household income and time budgets as well as other variables [Gordon and Knetsch, 1979].

A random sample of 202 resident households in Denver and Fort Collins, Colorado, were interviewed in their homes during the summer, 1976. A comparison of sample and population demographic characters of Denver and Fort Collins showed little sample bias. Racial minorities and young adults between 18 and 24 years of age were slightly under-represented. At the outset of the interview, respondents were shown color photos of three stream sites (labeled A, B, and C) in the River Basin and were provided technical information about the degree of heavy metal pollution at the sites. The color photos were selected to represent the range of water

quality in the River Basin and to limit variations in composition so that water quality would be the sole basis for differentiation. Technical information about heavy metal concentration served as an index of water quality. The U.S. Geological Survey [Wentz, 1974; Moran and Wentz; 1974] found that Site C exceeded heavy metal concentration recommended for drinking water; Site B exceeded heavy metal concentration recommended for fish and wildlife survival; and no heavy metals were present at Site A. Ideally, color photos should include a visual depiction of all water quality parameters which could influence perception of suitability for water-based recreation. Color photos can realistically depict evidence of visual pollution such as heavy metal mine drainage, algae, weeds, and sediment but not odor nor the presence of harmful chemicals and bacteria which can only be inferred from visual attributes. Color photos have the advantage of allowing respondents to choose the specific characteristics of water quality which relate to their recreation experience.

The two methods of payment employed lend realism and credibility to the simulated market situations. The general sales tax and the residential water-sewer fee represent established routinized methods of paying for public services such as water quality improvement. Most respondents could readily conceive that pollution abatement may be financed by either approach. The sales tax measure was considered superior to the water-sewer fee in reducing the effects of the free-rider problem. Tourism is the third largest industry in the River Basin and sales taxes paid by tourists are an important source of revenue to state and local units of government. While payment of water-sewer fees are a monthly routine for property owners, renters do not pay directly. Of course, water-sewer fees are paid indirectly

by renters and tourists alike in the purchase prices of goods and services. Nonetheless, residential property owners are likely to conceive of a proper range for water-sewer charges and recent experience with escalating fees may have resulted in understatement of their willingness to pay for water quality. To avoid these possible biases, Davis [1963] recommended the general cost of recreation activities as a hypothetical payment method. However, this was not deemed a suitable approach for measuring non-use preservation values.

We hypothesized that the starting point at which the bidding began would not produce any significant bias. If the starting dollar amount resulted in a negative response, it simply would be lowered until an acceptable level was reached. The starting point was 50 cents per month for the water-sewer fee with incremental changes of 50 cents per month. The sales tax iteration began at one-half cent per dollar of expenditure with incremental changes of one-fourth cent. Respondents were shown an Internal Revenue Service tax rate schedule with the estimated annual sales tax paid by household size and income categories. The starting points generated revenue of \$6 per year in water-sewer fees and \$25 per year in sales tax for a typical household of four with an average income of \$13,500 per year.

Respondents were informed that the payment reported would be used for water quality improvements to enhance recreational enjoyment. The definition of recreational enjoyment was left to each individual. Any definition of water-based activities provided might have omitted an activity for which the respondent would be willing to pay. As a result, respondents conceived of water-based recreation broadly to include

swimming, boating, fishing, sightseeing, picnicking, camping, hiking, driving, and other leisure time activities within view of lakes and streams.

It was specified that all waterways in the River Basin would be improved to level A by 1983 and preserved at that level indefinitely. The Federal Water Pollution Act Amendments of 1972 designated recreation as one of the principle benefits of the water quality program and set a national goal of providing water suitable for contact recreation by 1983. This deadline has since been extended.

The hypothetical situation posited was designed to be as realistic as possible. Irreversible water quality conditions exist in several areas of the state, as a result of past mining practices and the prohibitive cost of rectifying the damage.^{1/} The imminent possibility of expanding mining development and the incumbent high probability of irreversible water quality impairment in the River Basin provided an appropriate setting for investigating the empirical significance of option value. Bishop [1977] noted that a similar potential exists in the adjacent Colorado River Basin.

An introductory scenario explained the potential mining development and the probable consequences to water quality. The two alternative uses of the waterways were set forth and substitution possibilities were minimized. The option value questions took the following form:

In the near future, one of two alternatives is likely to occur in the South Platte River Basin. The first alternative is that a large expansion in mining development will soon take place, creating jobs and income for the region. As a consequence, however, many lakes and streams would become severely polluted. It is highly unlikely, as is shown in Situation C, that these waterways could ever be returned to their natural condition. They

could not be used for recreation. Growing demand could cause all other waterways in the area to be crowded with other recreationists.

The second possible alternative is to postpone any decision to expand mining activities which would irreversibly pollute these waterways. During this time, they would be preserved at level A for your recreational use. Furthermore, information would become available enabling you to make a decision with near certainty in the future, as to whether it is more beneficial to you to preserve the waterways at level A for your recreational use or to permit mining development. Of course, if the first alternative takes place, you could not make this future choice since the waterways would be irreversibly polluted.

Given your chances of future recreational use, would you be willing to pay an additional _____ cents on the dollar in present sales taxes every year to postpone mining development? This postponement would permit information to become available enabling you to make a decision with near certainty in the future as to which option (recreational use or mining development) would be most beneficial to you.^{2/} Would it be reasonable to add _____ to your water bill every month for this postponement?

Similar although much abbreviated questions were asked separately with respect to benefits from enhanced enjoyment of current water-based recreation use and non-use preservation values including the existence and bequest of clean water resources in the River Basin [Walsh et al., 1978].

RESULTS

Table I summarizes the responses to the survey. The sales tax values will be emphasized for ease of exposition, followed by a comparison with water-sewer fee estimates. Willingness to pay additional sales taxes for the option to choose to engage in water-based recreation activities in the future was estimated as \$23 annually per household. This is the mean population-weighted value for the 80 percent of sample households who expect to continue to use waterways in the River Basin for recreation

activities in the future. Of the 202 households surveyed, about 20 percent were unwilling to pay because they did not expect to engage in water-based recreation activities in the future. About 60 percent were willing to pay some positive amount of sales tax for option value. Thus, the mean option value of \$23 includes 20 percent who reported zero values. Those reporting zero values felt that water quality preservation was unnecessary, as their households were not believed to be harmed by water pollution. Others rejected the bidding game itself. Some considered it unfair to expect those adversely affected by water pollution to pay the costs of improvement. Others said taxes were already too high and expressed little confidence in the ability of responsible government entities to implement an effective program of water quality preservation. Some were dissatisfied with the hypothesized mechanism of payment for water quality.

Water quality improvement shifts the demand curve for water-based recreation activities. The economic benefit generated is consumer surplus delineated as the area between demand curves with and without water pollution [Freeman, 1979]. The 80 percent of households interviewed who engage in water-based recreation activities in the River Basin reported they were willing to pay an average of \$57 for water quality to enhance the enjoyment of these activities. This figure is quite similar to Oster's [1977] estimate of the annual recreation benefits from improved water quality in the Merrimack River Basin as \$12 per resident or \$48 for a family of four in 1973. Adjusted for inflation to 1976, that estimate is well within the 95 percent confidence interval of our estimate for the South Platte River Basin.

The economic significance of option value and the other preservation values is that they shift the vertical intercept of the demand curve for water quality preservation. The inclusion of option value shifted the demand curve for water quality preservation in the River Basin by an average of \$23 per year, equal to a 40 percent increase in the current recreation use value of water quality. Summing the two values, the total recreation-derived benefit of improved water quality to the 80 percent of the households who expect to continue to use waterways in the River Basin for recreation activities averaged \$79 annually. To put this in perspective, it was equivalent to approximately \$5 per household recreation activity day in 1976.

Additional preservation benefits to the general population residing in the River Basin (existence and bequest value) were defined to include the satisfaction derived from knowledge of the existence of a natural waterway ecosystem and its bequest to future generations. About 20 percent of the households interviewed who do not use the River Basin for recreation activities reported they were willing to pay an average of \$25 annually for knowledge of the existence of the natural aquatic ecosystem and \$17 annually to bequest clean water to future generations, for a total non-user value of \$42 annually. Estimates of these values also were obtained from recreation users, premised on the hypothetical assumption of certain knowledge they would not engage in water-based recreation activities in the River Basin. Not surprisingly, responses of present users were larger than for non-users. Average existence value of recreation users was \$34 and bequest value \$33, for a total non-use value of \$67 annually, or 60 percent more. Existence and bequest value estimates reported by

recreation users are the values which would remain in the absence of recreation use. We believe these preservation values should not be added to recreation use and option values because of the high probability of upward bias. As a first approximation, the existence and bequest value estimates for non-user households were extrapolated to all residents of the River Basin, including recreation users.

Table II shows our estimates of total annual recreation and aesthetic benefits of water quality aggregated over the 576,435 households residing in the River Basin. Based on willingness to pay an additional sales tax, total annual benefits were estimated as \$61 million, including option value of \$10.5 million, recreation use value of \$26.4 million, existence value of \$14.4 million, and bequest value of \$9.8 million.

Assuming a 6 3/8 percent discount rate and an infinite time horizon, the present value of annual benefits from water quality improvement in the River Basin was calculated as nearly \$1 billion. This estimate includes option value of \$165 million, recreation use value of \$414 million, existence value of about \$226 million and bequest value of \$153 million.

These present value estimates are premised on the assumption of constant annual benefits. This may be a reasonable forecast of recreation and aesthetic benefits for the foreseeable future in an economy beset with energy shortages, high prices, and near stable incomes. However, outdoor recreation has grown at an average annual rate of 5 percent per year during the previous decade. If the historic 5 percent annual growth rate continued to the year 2000, the present value of water quality in the River Basin would increase by about 15 percent to \$1.1 billion.

Tables I and II show that willingness to pay for water quality was quite sensitive to the method of hypothetical payment. Residents sampled reported willingness to pay only about one-fourth as much in water-sewer fees as in sales tax for the option value of water quality. Respondents were more reluctant to participate in the water-sewer bill estimation procedure, and may have perceived inequities. Everyone, including tourists, pays sales taxes whereas only property owners and indirectly renters, pay water-sewer bills. Moreover, recent experience with escalating water-sewer fees may have resulted in understatement of willingness to pay for water quality.

CONCLUSION

The purpose of this study was to develop and apply a procedure for measuring option value and other preservation values of water quality, compared to benefits from water-based recreation activities. The results of the study provide an empirical test of Weisbrod's [1964] proposal that option value and other preservation values should be added to the aggregate consumer surplus of recreation activities to determine the total benefit of environmental amenities to society. In the absence of such an estimate, insufficient resources would be allocated by society to preservation of unique environments such as pristine mountain streams in the South Platte River Basin. The Henry [1974] model of option value was successfully tested in which respondents reported willingness to pay for the option to choose between two environmental alternatives, either clean water or polluted water from mining development, at some future time under conditions

of sufficient knowledge as to the relative benefits of each.

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FOOTNOTES

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1. Historically, gold, silver, lead, and zinc mines have been major sources of water pollution, including sediment, acidity, and heavy metals. Irreversible drainage of pollutants flow from both abandoned and active mine shafts, mill sites, slag piles, and tailing ponds. Uranium, molybdenum, and other metals are extensively mined in the River Basin. Recently, gold and silver mining have also expanded in response to higher prices. The River Basin also contains two large coal fields. Increased diversion for irrigation, industrial, and domestic consumption concentrates effluent load.

2. This scenario does not identify the specific time interval necessary for the attainment of full knowledge of the economic impact of the optional environmental choices available if the second alternative is selected. The interval required for the collection and dissemination of the appropriate information was uncertain. The question explicitly specifies that the option benefit assessment would continue for an indefinite period until the required information was available. This approach is consistent with the theoretical model which requires that the first period in state 2 be of sufficient length to allow for collection of the necessary information.

TABLE I

Resident Household Willingness to Pay Additional Sales Tax and Water Service Assessments for Water Quality Preservation in the South Platte River Basin, Colorado (mean values in 1976 dollars)

Water Quality Preservation Values	Water Fee/ Month (dollars)	Tax Rate (cents)	Annual Dollars	
			Water Fee	Sales Tax ^{a/}
<u>Denver Metropolitan Area</u>				
Option Value	0.50	0.39	6.00	18.31
95% Confidence Interval			(4.58-7.51)	(13.27-23.36)
Percent of Total Value	17.7%	15.5%	17.7%	16.5%
Number Reporting	83	88		
Bequest Value ^{b/}	0.46	0.42	5.52	16.43
95% Confidence Interval			(3.93-7.22)	(6.67-26.19)
Percent of Total Value	16.3%	16.7%	16.3%	14.8%
Number Reporting	14	15		
Existence Value ^{c/}	0.54	0.70	6.48	26.03
95% Confidence Interval			(4.78-8.07)	(1.78-50.29)
Percent of Total Value	19.1%	27.9%	19.1%	23.5%
Number Reporting	14	15		
Recreation Value ^{d/}	1.32	1.00	15.84	50.18
95% Confidence Interval			(12.99-18.69)	(42.94-57.43)
Percent of Total Value	46.8%	39.8%	46.8%	45.2%
Number Reporting	85	85		
Total Preservation and Recreation Value	2.82	2.51	33.84	110.95
<u>Fort Collins</u>				
Option Value	1.00	0.85	12.00	22.60
95% Confidence Interval			(5.68-18.14)	(20.11-47.99)
Percent of Total Value	24.0%	25.1%	24.0%	22.9%
Number Reporting	78	89		
Bequest Value ^{b/}	0.42	0.40	5.04	18.42
95% Confidence Interval			(2.70-7.31)	(-9.70-46.53)
Percent of Total Value	10.1%	11.8%	10.1%	12.4%
Number Reporting	9	9		
Existence Value ^{c/}	0.58	0.50	6.96	22.17
95% Confidence Interval			(5.37-8.63)	(5.33-49.66)
Percent of Total Value	13.9%	14.8%	13.9%	14.9%
Number Reporting	9	9		

(continued on following page)

Table I (continued)

Water Quality Preservation Values	Water Fee/ Month (dollars)	Tax Rate (cents)	Annual Dollars	
			Water Fee	Sales Tax ^{a/}
Recreation Value ^{d/}	2.16	1.63	25.92	74.00
95% Confidence Interval			(11.79-40.06)	(51.07-96.94)
Percent of Total Value	51.9%	48.2%	51.9%	49.8%
Number Reporting	89	89		
Total Preservation and Recreation Value	4.16	3.38	49.92	148.64
<u>South Platte River Basin^{e/}</u>				
Option Value	0.64	0.52	7.68	22.60
Percent of Total Value	20.1%	19.0%	20.1%	18.6%
Number Reporting	161	177		
Grouped T-Value ^{f/}	1.01	1.51		
Bequest Value ^{b/}	0.45	0.41	5.40	16.97
Percent of Total Value	14.1%	15.0%	14.1%	14.0%
Number Reporting	23	24		
Grouped T-Value ^{f/}	0.88	1.55		
Existence Value ^{c/}	0.55	0.64	6.60	24.98
Percent of Total Value	17.2%	23.3%	17.2%	20.6%
Number Reporting	23	24		
Grouped T-Value ^{f/}	0.99	1.69		
Recreation Value ^{d/}	1.55	1.17	18.60	56.68
Percent of Total Value	48.6%	42.7%	48.6%	46.8%
Number Reporting	174	174		
Grouped T-Value ^{f/}	0.81	1.32		
Total Preservation and Recreation Value	3.19	2.74	38.25	121.23

a. From U.S. Internal Revenue Service [1974].

b. Willingness to pay estimate for a sub-sample of non-recreationists for the benefit derived from the assurance that future generations will have access to a preserved natural environment in the South Platte River Basin, Colorado.

c. Willingness to pay estimate for a sub-sample of non-recreationists for the benefit derived from the knowledge that a preserved natural reserve exists as a habitat for various species of potentially unique flora and fauna.

d. Defined as any water-associated recreation benefit derived from preservation of a high level of water quality by 1983.

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Table I - Notes (continued)

- e. Weighted by population. The Denver Metropolitan Area population of 1,267,000 persons excluding Boulder County was 72.7 percent of the 1,742,900 persons in the South Platte River Basin in 1976.
- f. Tests the significance of difference between grouped mean values. At the 5 percent level, there is no statistically significant difference between the Denver and Fort Collins mean option value estimates.

TABLE II

Annual and Present Values from Water Quality Preservation in the South Platte River Basin, Colorado (1976 dollars)

Water Quality Preservation Values	Denver Metropolitan Area		Fort Collins		South Platte River Basin	
	Annual Value	Present Value ^{a/}	Annual Value	Present Value ^{a/}	Annual Value	Present Value ^{a/}
Option Value						
Water Fee	2,042,682	32,042,078	193,236	3,031,153	3,581,687	56,183,321
Sales Tax	6,161,700	96,654,102	548,307	8,600,896	10,526,153	165,116,132
Bequest Value						
Water Fee	2,366,693	37,124,596	94,615	1,484,157	3,118,513	48,917,856
Sales Tax	6,981,107	109,507,561	348,562	5,467,634	9,782,102	153,444,736
Existence Value						
Water Fee	2,732,107	54,920,408	132,461	4,125,956	3,792,942	59,497,134
Sales Tax	11,060,147	173,492,502	419,523	6,580,752	14,399,346	225,872,099
Recreation Value						
Water Fee	5,330,492	83,615,571	417,390	6,547,290	8,658,460	135,818,977
Sales Tax	16,886,624	264,888,216	1,191,622	18,692,110	26,399,220	414,105,414
Total Recreation and Preservation Value						
Water Fee	12,471,974	207,702,653	837,702	15,188,556	19,151,602	300,417,288
Sales Tax	41,089,578	644,542,381	2,508,014	39,341,392	61,106,821	958,538,381

a. Discounted at 6.3/8 percent. This was the discount rate recommended for water resource development projects in 1976 [U.S. Water Resources Council, 1979].

REFERENCES

- Arrow, K. J. and A. C. Fisher, "Environmental Preservation, Uncertainty, and Irreversibility," Quarterly Journal of Economics, LXXXVIII (May 1974), 312-19.
- Bishop, A. Bruce, "Impact of Energy Development on Colorado River Water Quality," Natural Resources Journal, XVII (Oct. 1977), 649-71.
- Bishop, Richard C., and Thomas A. Heberlein, "Measuring Values of Extra-market Goods: Are Indirect Measures Biased?" American Journal of Agricultural Economics, LXI (Dec. 1979), 926-30.
- Bohm, Peter, "Estimating the Demand for Public Goods: An Experiment," European Economic Review, III (June 1972), 111-30.
- _____, "Estimating Access Values," in Lowdon Wingo and Alan Evans, eds., Public Economics and the Quality of Life (Baltimore: The Johns Hopkins University Press for Resources for the Future and the Centre for Environmental Studies, 1977).
- _____, "Estimating Willingness to Pay: Why and How?" The Scandinavian Journal of Economics LXXXI (1979), 142-53.
- Brookshire, David S., Berry C. Ives, and William D. Schultze, "The Valuation of Aesthetic Preferences," Journal of Environmental Economics and Management, III (Fall 1976), 325-46.
- Byerlee, D. R., "Option Demand and Consumer Surplus: Comment," Quarterly Journal of Economics, LXXXV (Aug. 1971), 523-27.
- Cicchetti, C. J. and A. M. Freeman III, "Option Demand and Consumer Surplus: Further Comment," Quarterly Journal of Economics, LXXXV (Aug. 1971), 529-39.
- Conrad, Jon M., "Quasi-Option Value and the Expected Value of Information," Quarterly Journal of Economics, XCIV (1980), 813-20.
- Davis, Robert K., "Recreation Planning as an Economic Problem," Natural Resources Journal, III (Oct. 1963), 239-49.
- Freeman, A. Myrick III, The Benefits of Environmental Improvement: Theory and Practice (Baltimore: The Johns Hopkins University Press for Resources for the Future, 1979).
- Friedman, Milton, Capitalism and Freedom (Chicago: University of Chicago Press, 1962).
- Gordon, Irene M., and Jack Knetsch, "Consumer's Surplus Measures and the Evaluation of Resources," Land Economics, LV (Feb. 1979), 1-10.

- Greenley, Douglas A., "Recreation and Preservation Benefits from Water Quality Improvement," Ph.D. Thesis, Colorado State University, Fort Collins, 1979.
- Henry, Claude, "Option Values in the Economics of Irreplaceable Assets," The Review of Economic Studies: Symposium on the Economics of Exhaustible Resources (1974), 89-104.
- Knetsch, J. L., and R. K. Davis, "Comparison of Methods for Recreation Evaluation," in Allen V. Kneese and Stephen C. Smith, eds., Water Research (Baltimore: The Johns Hopkins University Press for Resources for the Future, 1966).
- Krutilla, John V., "Conservation Reconsidered," American Economic Review, LVII (Sept. 1967), 777-86.
- Lindsay, C. M., "Option Demand and Consumer's Surplus," Quarterly Journal of Economics, LXXXIII (May 1969), 344-45.
- Long, M. F., "Collective Consumption Services of Individual Goods: Comment," Quarterly Journal of Economics, LXXXI (May 1967), 351-52.
- Moran R. E., and D. A. Wentz, Effects of Metal-Mine Drainage on Water Quality in Selected Areas of Colorado, 1972-73, Colorado Water Resources Circular No. 25, Colorado Water Conservation Board, Denver, 1974.
- Oster, Sharon, "Survey Results on the Benefits of Water Pollution Abatement in the Merrimack River Basin," Water Resources Research, XIII (Dec. 1977), 882-84.
- Randall, Alan, Barry Ives, and Clyde Eastman, "Bidding Games for Valuation of Aesthetic Environmental Improvement," Journal of Environmental Economics and Management, I (1974), 132-49.
- Schmalensee, R., "Option Demand and Consumer's Surplus: Valuing Price Changes Under Uncertainty," American Economic Review, LXII (Dec. 1972), 814-24.
- U.S. Internal Revenue Service, 1975 U.S. Individual Income Tax Returns, 1975 Optional State Sales Tax Tables, Washington, D.C., 1974, 185.
- U.S. Water Resources Council, Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resource Planning, Federal Register, Washington, D.C., Dec. 14, 1979.
- Walsh, R. G., D. A. Greenley, R. A. Young, et al., Option Values, Preservation Values and Recreational Benefits of Improved Water Quality: A Case Study of the South Platte River Basin, Colorado, U.S. Environmental Protection Agency, Socioeconomic Environmental Studies Series, EPA-600/5-78-001, Research Triangle Park, Jan. 1978.

Weisbrod, B. A., "Collective-Consumption Services of Individualized-Consumption Goods," Quarterly Journal of Economics, LXXVIII (Aug. 1964), 471-77.

Wentz, D. A., Effect of Mine Drainage on the Quality of Streams in Colorado, 1971-72, Colorado Water Resources Circular No. 21, Colorado Water Conservation Board, Denver, 1974.