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ABSTRACT: Many water systems in small cities and rural areas throughout the United States are facing water quality and supply problems. These problems are typically not the result of an unexpected event, but are the result of growth trends or decreasing water quality experienced over several years. This analysis uses the contingent valuation and benefit transfer methods to evaluate the willingness to pay for a rural water system in northcentral Montana. Both of the procedures resulted in similar values, ranging from about $4.05 to $7.50 per household per month for urban residents and $5.40 to $11.50 per household per month for rural residents, which is equal to 11 percent to 23 percent of current average water costs. The willingness to pay estimates do not include non-household water users. This analysis shows that useful planning information can be obtained from relatively inexpensive contingent valuation mail survey data and the benefit transfer method as long as the limitations of the data are understood. The willingness to pay for ensuring good quality rural water supplies in the future is likely to be low compared to the costs of extensive diversion and treatment systems. Willingness to pay estimates provide decision makers with information that can be used to avoid building a large water supply system that water users do not want to connect to because of high costs.
(KEY TERMS: domestic water supplies; willingness to pay; contingent valuation; benefit transfer.)

INTRODUCTION

Many water systems in small cities and rural areas throughout the United States are facing water quality and supply problems due to decreasing groundwater supplies, population growth, increasing water treatment requirements, the ability to better measure pollutants, or the desire to attract and retain businesses and industry. These problems are typically not the result of an unexpected event, but are the result of growth trends or decreasing water quality experienced over several years. In order to avoid costly water supply problems in the future, water utilities and government agencies need to develop methodologies for evaluating the feasibility of proposals that would help meet future demand. One important consideration is the willingness of water users to pay for a proposed improvement. The willingness to pay for water supply improvements is a measure of economic benefit and can also be used to evaluate the acceptability of projects with varying costs.

This analysis demonstrates two methods that are available to small rural water suppliers for evaluating the feasibility of water supply improvements: the contingent value method (CVM) and the benefit transfer method. A CVM application is presented for a potential rural water system in northcentral Montana. A previously estimated willingness to pay model is applied to the same area to illustrate the benefit transfer technique and the results are compared. Due to the financial constraints of most rural water supply systems, only relatively inexpensive methods are presented. The willingness to pay estimates are compared to cost estimates for other rural domestic water systems to illustrate how willingness to pay can be used to evaluate the acceptability and success of a proposed water supply project.

STUDY AREA

A coalition of state, tribal, and local officials have proposed a pipeline that would bring water to the Rocky Boy's Indian Reservation located approximately 230 miles northwest of Billings, Montana, and would also deliver water to existing non-tribal water

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systems, including the cities of Havre and Conrad, Montana. The system would provide good quality water to a large rural area and would provide water for municipal, rural, and industrial uses. There is concern that the current groundwater supplies will not support future economic growth in the area and many systems are faced with potentially high costs of providing safe drinking water from current supplies in the future.

In 1990 there were an estimated 37,400 people and 13,687 households in the proposed project area (Bear Paw Development Corporation, 1995). The population of the area is expected to increase by 2.5 percent by the year 2015 (Bear Paw Development Corporation, 1995). Agriculture, education, health care, and retail trade are major employers in the area. Income and unemployment in the area compare favorably with the State of Montana as a whole. The median 1989 household income in the study area was $24,050 per year compared to $23,000 per year for all of Montana. Unemployment was 6.5 percent in the study area in 1990, compared to 7.0 percent for the entire state. The economy of the study area is relatively healthy and capable of supporting future economic growth, which could lead to an increase in future water demand.

LITERATURE REVIEW

Previous studies have used a variety of techniques to estimate the benefits associated with preventing future water supply problems or addressing current problems. Averting expenditures have been used to estimate the willingness to pay for reduced bacteria, mineral, and organic chemical contamination of rural water supplies in West Virginia (Collins and Steinback, 1993) and the economic losses from groundwater contamination in central Pennsylvania (Abdalla, 1990). Averting expenditures have also been used to estimate the benefit from preventing Giardia in Pennsylvania (Laughland *et al.*, 1993). The averting expenditures approach can be used to measure the effect of a current problem on behavior, but cannot be used to measure the benefits from addressing future problems.

The contingent valuation method (CVM) has also been used to measure the benefits of reliable and good quality water supplies. These studies have generally been limited to evaluating the benefits from protecting groundwater supplies or variation in the reliability of existing supplies. The willingness to pay of Georgia residents for improved drinking water was estimated to range from $10.07 to $11.28 per household per month for city/county water users and $12.38 to $16.06 per month for private well users (Jordan and Elanagheeb, 1993). A contingent valuation study of four Massachusetts towns assessed the willingness to pay for increased groundwater supply protection (Powell and Allee, 1990). Two of the towns had experienced contamination problems. Average willingness to pay for water supply protection ranged from $5.30 to $10.45 per household per month. The average for those who had experienced problems was $10.03 per month while willingness to pay for those who had not experienced problems was $6.40 per month. In another New England study, the willingness to pay for groundwater protection in Dover, New Hampshire was estimated to range from $3.33 to $10.75 per household per month (Schultz and Lindsay, 1990).

Several willingness to pay studies for domestic water supplies have also been conducted in developing countries (see Whittington *et al.*, 1989; Briscoe *et al.*, 1990; Whittington *et al.*, 1990; Whittington *et al.*, 1991; Altaf *et al.*, 1992; Griffin *et al.*, 1995). The primary focus of the international literature has been on the relatively high cost of water supply projects. In many cases, water systems are too expensive for many households and the need for good quality water supplies remains unmet (Whittington *et al.*, 1993). The problem of building expensive and unused water supply systems can be addressed by understanding how much the prospective water users are willing to pay for water (Whittington *et al.*, 1993).

The problem of high water supply costs compared to willingness to pay is also experienced in some rural areas of the United States. Widely dispersed home sites in rural areas result in very high costs per household which may exceed the willingness to pay for the supply improvements.

USING CONTINGENT VALUATION TO ESTIMATE WILLINGNESS TO PAY

There is evidence that carefully worded surveys presenting realistic scenarios can elicit meaningful resource values. The National Oceanographic and Atmospheric Administration (NOAA) has identified the contingent valuation method as an acceptable approach to measuring natural resource values in their proposed rules for estimating natural resource damages (NOAA, 1994). However, the hypothetical nature of the market and the use of surveys for eliciting values are shortcomings of CVM.

Several types of bias related to the use of CVM and survey methods in general have been identified in the literature, including: non-response bias, strategic bias, hypothetical bias, procedural bias which includes compliance and starting point bias, information bias, and payment vehicle bias (Cummings *et al.*, 1986; Griffin *et al.*, 1995; Mitchell and Carson, 1989; Smith and Desvousges, 1986). In order for CVM based estimates to be reliable, these potential sources of bias must be recognized and addressed.

Non-response bias occurs when the likelihood of a household returning a survey is influenced by a characteristic that also affects the willingness to pay response (or other response) sought in the survey. For example, if willingness to pay and the probability of responding to a survey both increase as income increases, then the survey responses will have an upward income bias. Non-response bias can also occur if households do not return the survey because they place no value on the resource under consideration. However, households fail to return surveys for a variety of reasons which may be independent of information sought after in the survey. Non-response bias can be addressed through the use of in-person or telephone surveys, extensive follow-up surveys, or modeling the decision to return a questionnaire.

Strategic bias will not occur or will be minor if there is no cost associated with telling the truth and nothing is gained if the respondent does not tell the truth. The rural water supply survey used in this analysis was implemented by a local water utility which influences water supply and pricing decisions. Therefore, respondents would expect the answers they provide to influence future water supply and rate decisions. Indicating a willingness to pay that is higher than the true willingness to pay risks construction of a project and water rates that are greater than the true willingness to pay. Indicating a willingness to pay that is lower than the true willingness to pay risks the project not being built when in fact the respondent would be willing to pay for the project. Therefore, the cost of acting strategically is greater than the cost of telling the truth and strategic behavior would not be expected for a rural water supply survey.

Avoiding hypothetical bias requires the presentation of believable and familiar scenarios for the resource under consideration. The water supply questionnaire used as a basis for this analysis incorporates concerns about the availability of good quality water for current and future households. The solution is a surface water supply provided through a pipeline and water treatment plant. The solution is an action that is commonly taken to improve water supplies, enhancing the believability of the scenario provided.

The various types of procedural bias and payment vehicle bias can be addressed by properly wording the questionnaire and presenting the payment choices and type of payment in a fashion. The questionnaire should be worded so respondents do not feel obligated to comply with the good or service in question and the method of payment should be neutral. For example, increased taxes should be avoided as a payment vehicle.

Information bias is addressed by presenting factual information and describing conditions that are likely to occur with and without the project. The survey used for this analysis included a description of the potential impacts from continued use of current supplies and the source of potential surface water supplies.

The Willingness To Pay for the NorthCentral Montana Water System

A mail survey was implemented by the Rocky Boy/North Central Montana Regional Water Supply System in November 1995. A total of 1,560 questionnaires were mailed to randomly selected households in the project area, which represents about 11.4 percent of the households in the study area. Each mailing included a cover letter and questionnaire which asked a variety of water cost, water use, and demographic questions in addition to a willingness to pay question. A total of 100 questionnaires were returned as undeliverable. There were 411 questionnaires returned for an effective response rate of 28.2 percent. Those sent surveys were reminded about the survey. However, there was not a second survey mailing due to time and budget constraints. Although a similar response rate (33.9 percent) was obtained in a previous willingness to pay study for rural water supplies (Jordan and Elanagheeb, 1993), the relatively low response rate indicates a potential problem with non-response bias.

The willingness to pay question described the current water supply conditions in the area and the proposed regional water supply system. The general question format was based on a previous CVM application in the Navajo Reservation in New Mexico (Piper, 1996). Modifications were made to the questionnaire to represent local conditions. The willingness to pay question is shown below. A copy of the full questionnaire is available from the author.

> A coalition of state, tribal, and local officials have proposed a water system that would provide good quality water to a large rural area in Northcentral Montana. The system would include a water intake and treatment system located at Tiber Reservoir and a core pipeline from Tiber Reservoir to the Rocky Boy's Reservation. The pipeline would also deliver water to existing non-tribal water systems. The system would provide water for municipal, rural, and industrial uses.

The Chippewa Cree Tribe is seeking the pipeline as a settlement of the Tribe's water rights and has proposed the pipeline as the most cost effective method of meeting their domestic water needs. Existing water systems face a variety of water quality and supply problems. Some systems are confronted with potentially high costs from meeting new federal water quality standards. Combining existing systems could allow these systems to meet water quality standards with reduced operating costs. The proposed regional water system could be a cost effective solution to these water supply problems.

Given the above information, please circle the highest **additional** amount you would be willing to pay each **month** through higher water bills for a water supply system. Your individual responses will not be reported and will be used only to develop an overall indicator of willingness to pay for the proposed project area. Assume that if there is an overall unwillingness of water users to pay for the system, a project will not be completed. Without the system, water supplies and quality would remain at their current levels.

(Circle one)

$0	6	20	50
1	7	25	60
2	8	30	70
3	9	35	80
4	10	40	90
5	15	45	100

If your true willingness to pay falls between two of the categories above or is greater than $100, please indicate your full willingness to pay each month.

$______ total willingness to pay each month

A summary of the survey averages for water cost, water quality, the use of water filters, and willingness to pay is presented in Table 1.

The willingness to pay question was followed by a question designed to indicate protest zero responses. The protest question asked:

If you indicated zero willingness to pay, please circle the one statement that best describes your reason. (Circle the answer that best applies to you)

a. Because I feel we have enough good quality water to meet current and future needs.
b. Because I cannot afford to pay any more for water.
c. Because I believe I am already paying my fair share of the cost for water.
d. Because I do not believe I should have to pay more to have access to good quality water.
e. I do not feel increased bills are an appropriate funding source.
f. Other (please specify)______________

Responses d and e represent a negative reaction to the use of increased water bills to pay for increased water supply costs or a belief by the respondent that they should not have to pay more for access to good quality water (protest zero responses). None of the respondents specified choice f. There were a total of 39 protest zero responses.

TABLE 1. Survey Averages.

Question	Urban	Rural
Water Cost/Month	$30.36	$49.50
Water Quality*	$3.29	$3.36
Use Filters	35%	26%
Willingness to Pay/Month		
Average	$7.62	$14.99
Top 25%	$10.00	$20.00
Median	$2.25	$5.00

*Water quality is based on a scale of 1 to 5, where 1 represents very poor quality, 3 represents fair quality, and 5 represents very good quality.

The water use questions consisted of an open-ended question asking for average household water use in gallons per month and yes/no questions about the use of domestic water supplies for lawns, gardens, livestock, and ponds/wetlands. Only about 55 percent of the respondents answered the water use question, compared to 84 percent who answered the cost of water question, and there was little variation in the other use related responses.

The low response rate was a concern due to the potential for a non-representative survey sample. To test the representativeness of the survey sample, the survey responses to the age, education, income, and household size questions were compared to the 1990 U.S. Bureau of the Census Data. This comparison indicated that the survey respondents had higher incomes and more years of education than reported in the 1990 Census. The age of the survey respondents also appeared to be somewhat higher than reported in the 1990 Census for individuals 18 years of age or older. The average household size from the survey and the 1990 Census were essentially the same. Although the survey data and 1990 Census estimates represent different years, those returning questionnaires have a higher income, are older, and are better educated than the study area population. Assuming the respondents answered truthfully, the willingness to pay survey responses may not be truly representative of the survey area.

Unfortunately, time and budget constraints did not allow a follow-up of non-respondents. As a lower bound estimate of willingness to pay, it can be assumed that all of those who did not respond actually have a zero willingness to pay. However, there are many possible reasons for not responding other than having zero willingness to pay. Therefore, the willingness to pay estimates are adjusted using an estimated willingness to pay model and substituting the 1990 Census values for household income and age for the survey estimates. This adjustment reduces willingness to pay, but by far less than assuming all non-respondents have zero willingness to pay. It must be noted that using the Census estimates for income and age will better represent these variables for the region but will not correct any possible bias in the estimated willingness to pay model coefficients.

Modeling Willingness to Pay

The willingness to pay question format used in the questionnaire allows for a variety of estimating techniques. The open-ended willingness to pay responses can be used to model willingness to pay using ordinary least squares or tobit estimation. The checklist responses can be used to estimate a multiple bounded logit model. Unfortunately, there was not a sufficient number of responses to estimate a logit model. Therefore, only the ordinary least squares and tobit results are presented in this analysis.

Both of these modeling techniques have advantages and disadvantages. The ordinary least squares technique is relatively simple to apply and interpret and requires a relatively small number of observations for significant results. However, open-ended data are censored at a willingness to pay of $0 and least squares estimation yields biased and inconsistent estimates (Maddala, 1983). Maximum likelihood based tobit models provide unbiased and consistent estimates because the censored nature of the data is accounted for by the parameter estimates (Maddala, 1983). The Tobit model is essentially divided into two different sets of observations. The first set includes those observations for which willingness to pay equals zero and the second set includes all positive values. The model includes a probability that the respondent has a positive value and an estimation of the likelihood function.

Willingness to pay values that would be estimated to be negative if the data were not censored, are actually clustered together at the zero bound. The zero values correctly indicate the number of observations below the point of truncation but do not accurately represent the position of the observations. This is not a severe problem if there are few observations with a value of zero. However, approximately 46 percent of the northcentral Montana willingness to pay responses were zero.

Coefficient values estimated using Tobit analysis may differ substantially, both in magnitude and sign, from those estimated using ordinary least squares. Tobit analysis is a more theoretically correct method for willingness to pay data sets with large numbers of zero bids (Halstead *et al.*, 1991). However, the ordinary least squares estimates are presented as a base to which the tobit estimates can be compared.

The hypothesized willingness to pay models for the proposed regional water supply are presented below.

$$WTP = f(Cost, Filters, Age, Rural, Income)$$

where Cost is the monthly cost of water to the household; Filters indicates the use of water filters (1 = yes, 0 = no); Age is the age of the respondent; Rural indicates if the household lives in a rural setting (1 = yes, 0 = no); and Income is the gross household income.

The current cost of water would have some negative impact on willingness to pay because households would be less likely to pay higher costs if water is already expensive and because the household income available to spend on water is reduced as water costs increase. However, water payments represent a very small percentage of total household expenses and increasing water costs may be less of a concern than the impact of not having enough water to maintain desired lifestyles. The amount spent for water is also an indication of use and dependency on water supplies, which would have a positive effect on willingness to pay. Due to the low cost of water as a percentage of total household costs and income, the cost of water variable is included as a proxy for water use and is expected to have a positive sign.

The use of water filters is an indication of problems with the current water supply and is a proxy for water quality. Many respondents did not answer the water quality question but did answer the water filter question, indicating some difficulty in evaluating water quality. The water filter variable is expected to have a positive sign, where those using filters have a higher willingness to pay.

Previous willingness to pay studies have indicated a negative relationship between age and willingness to pay. However, older residents may have a better understanding of water quality changes that have occurred over several years and may recognize problems that would not be apparent to younger residents. Therefore, the expected sign for the age variable is uncertain. Age was asked in terms of categories on the questionnaire. Therefore, age was estimated by taking the midpoint of each range and 68 years was used for the 65+ age category.

The overall quality and reliability of rural water supplies is lower in the study area than in urban supplies. Therefore, households in the rural areas are expected to have a higher willingness to pay than households in the urban areas and the expected sign for the rural variable is positive. Higher income allows a household the opportunity to pay more for water if necessary, resulting in a higher willingness to pay. Household income was asked in terms of income categories. The midpoint of each income range was used and $175,000 was used for the over $150,000 category. A total of 61 respondents did not answer the household income question. In order to increase the number of observations available for estimating the willingness to pay model, an income model was estimated using income as a function of age, gender, and education. The income model was then used to estimate missing income values for observations which had all three of the explanatory variables. This procedure added 18 income observations.

The initial models were estimating with ordinary least squares using data from the open-ended willingness to pay models. The results were tested for heteroskedasticity using the Park-Glejser test (Glejser, 1969 and Park, 1966). This test indicated that heteroskedasticity was not a problem. The regression results are presented in Table 2.

All of the estimated coefficients had the expected signs. The water filters, income, and rural variables were significantly different from zero as indicated by the t-statistics for both models at the 5-percent level of significance and the water cost variable was significant in the ordinary least squares model. The age variable was not significant in either model. The F-statistic is an overall measure of significance for the ordinary least squares regression and the likelihood ratio is a measure of overall significance for the tobit equation and is based on a Chi-Square distribution. Both of the equations are significant at the 5-percent level of significance.

Using the willingness to pay model and Census values for age and income, willingness to pay is estimated to range from $5.50 per household per month to $7.20 per household per month for urban residents and $11.50 per household per month for rural households.

TABLE 2. Willingness to Pay Regression Results.

Variable	Estimated Coefficient	t-Value	Expected Sign
Ordinary Least Squares Model			
Cost	0.0951	2.57*	Yes
Filters	5.8360	2.84*	Yes
Age	0.0669	0.87	–
Rural	5.3520	3.67*	Yes
Income	.00017485	2.62*	Yes
Constant	-6.9950	–	–
265 Observations	Adjusted R-Squared = .104		
F-Statistic = 7.16*			
Tobit Model			
Cost	0.0845	1.40	Yes
Filters	8.0373	2.44*	Yes
Age	0.0183	0.15	–
Rural	7.5392	2.28*	Yes
Income	.00022883	3.07*	Yes
Constant	-15.2830	–	–
265 Observations	Likelihood Ratio = 21.6*		

*Significant at the 5 percent level of confidence.

USING BENEFIT TRANSFER TO ESTIMATE WILLINGNESS TO PAY

Benefit transfer is the application of a model estimated for one site or group of sites to another site where detailed data are not available to estimate a model (see Boyle and Bergstrom, 1992; Brookshire and Neill, 1992; Loomis, 1992). The benefit transfer method assumes that a relationship exists between the value of a resource and variables related to that resource which is consistent for all geographical areas. If a model can be estimated which includes the important factors that influence the value of the resource, then benefit transfer can be completed by applying the model to the study area.

The model used in this analysis is based on willingness to pay data sets from four areas – the Lewis and Clark Rural Water System in southeast South Dakota, the Fort Peck County Rural Water District in Montana, the northwest Oklahoma area, and the New Mexico portion of the Navajo Indian Reservation (Piper, 1996). These areas have a variety of water supply problems, which improves the flexibility of the model. The willingness to pay model transferred to the northcentral Montana site was estimated to be:

Willingness to Pay = f(HHSize, Cost, Age, Income, Haul, Ceremony),

where HHsize is the number of people in the household; Cost is the monthly cost of water to the household; Age is the age of the respondent; Income is the gross household income; Haul shows if the household hauls water for domestic supplies (1 = yes and 0 =no); and Ceremony shows if the household participates in ceremonies that require water (1 = yes and 0 =no).

Four different models were estimated with varying levels of sophistication. Weighted models were estimated to account for potential heteroskedasticity problems. Tobit models were estimated to correct problems created by a large number of zero responses. The estimated variable coefficients from the willingness to pay regressions are presented in Table 3. The major difference between the least squares and tobit results is that age was consistently significant and cost of water was not generally significant for the tobit models, while the opposite was true for the least squares modeling results.

Benefits are estimated using the least squares models by simply substituting the mean values for the explanatory variables to the transfer models and calculating willingness to pay. Using the tobit models to estimate benefits is not as straight forward as for the least squares models. The estimated coefficients from the tobit models cannot be applied using the mean values for the explanatory variables because the tobit model estimates are based on probabilities of a dependent variable exceeding a threshold. The expected value of willingness to pay can be estimated using the tobit coefficients along with the density function estimates and predicted probabilities (Maddala, 1983). The variable values used to estimate household willingness to pay for good quality water supplies in the northcentral Montana study area and the willingness to pay estimates using benefit transfer are presented in Table 4. Approximately 50 percent of the respondents in the Navajo Indian Reservation study used water for ceremonial purposes (Piper, 1996). Therefore, one-half of the native american population percentage was used as an approximation of ceremonial water use. The average water costs from the survey shown in Table 1 were used for the water cost variable in the willingness to pay models.

WILLINGNESS TO PAY COMPARED TO COSTS

Cost estimates are not available for the potential northcentral Montana project. However, preliminary cost estimates for two projects included in the benefit transfer model are available which can be used to understand the potential costs of building a rural water system pipeline and treatment facilities. A

TABLE 3. Willingness to Pay Models Used for Benefit Transfer.

Variables	Coefficients: Ordinary Least Squares	Weighted Least Squares	Tobit	Weighted Tobit
Household Size	0.21501	0.56524	0.39963	0.87753
Water Cost	0.027961	0.026304	0.01754	0.01487
Age	-0.02543	0.010241	-0.09166	-0.06769
Income	0.00005212	0.00003661	0.0001136	0.0000983
Haul Water	6.5487	6.2499	9.4052	9.9653
Ceremonial Use	5.4301	6.1324	6.5031	7.1392
Constant	3.4718	1.0068	-0.34105	-4.3824

TABLE 4. Willingness to Pay Estimates Using Benefit Transfer.

Group	Household Size	Age	Mean Household Income	Households Hauling Water	Native American Population	Range of Willingness (hh/month)
Rural	2.78	47.4	$30,000	9.8%	9.5%	$5.40-$8.25
Urban	2.55	45.8	$29,650	0.1%	6.0%	$4.05-$7.45

project proposed for the Lewis and Clark Rural Water System included a diversion system, water treatment facilities, and a distribution system which would bring water service to approximately 54,000 households. The system includes the City of Sioux Falls, South Dakota, which reduces the average cost per household. Preliminary cost estimates indicate capital costs of about $283 million and annual operation and maintenance costs of about $4.7 million (Banner Associates, Inc., 1993). Annualizing capital costs over 50 years at a 7.75 percent rate results in annualized capital costs of about $23 million per year and total annual costs of about $27.7 million. The annual cost per household is a little under $46 per household per month.

The San Juan River Gallup/Navajo water supply project in western New Mexico includes a diversion structure, pipeline, water treatment facilities, and a distribution system that would serve about 10,000 households. The system would include the City of Gallup, New Mexico and several small towns. Preliminary cost estimates indicate capital costs of about $283 million and annual operation and maintenance costs of about $4.7 million and total capital costs of $115 million (U.S. Bureau of Reclamation, 1993b). The annual cost per household is estimated to be about $115 per household per month. The per household costs for Gallup/Navajo project are higher due to the length of the pipeline and the lower population density of the area.

The costs per household of the northcentral Montana system could be lower than the estimates described above. However, the cost range for the two projects combined with the northcentral Montana willingness to pay estimates indicates relatively low cost supply alternatives should be considered in the study area.

BENEFITS NOT CONSIDERED IN THIS ANALYSIS

The benefit estimates presented above do not include all of the benefits that would be generated by the water system. The willingness to pay of businesses and the population of the Rocky Boy's Indian Reservation for water supply improvements are not included in the estimates. Approximately 85 percent of water use in the study area is attributable to domestic household use, 10 percent is commercial and industrial use, and 5 percent is agricultural use. Approximately 3,200 people lived on the Rocky Boy's Reservation in 1992. Therefore, the willingness to pay of a significant portion of water users is not accounted for in the household willingness to pay estimates presented in this analysis.

A study of the benefits from construction of a regional surface water supply system based in Sioux Falls, South Dakota, included an analysis of the willingness to pay of businesses for water supply improvements (U.S. Bureau of Reclamation, 1993a). The survey responses indicated water quality and adequate supplies are important to businesses in the Lewis and Clark area. Approximately 70 percent of the business responses indicated water quality is important or very important and 80 percent indicated adequate supplies is important or very important. A total of 50 percent of the businesses surveyed in the Lewis and Clark are were willing to pay something for a new water supply system, with an average business willingness to pay of $28.93 per account per month or about $350 per account per year. The average willingness to pay represented 9.4 percent of the average annual business water bill.

The Lewis and Clark survey results indicate businesses can have a substantial willingness to pay for improved water supplies. Commercial, industrial, and agricultural water users in the northcentral Montana would also be expected to be willing to pay for water supply improvements, and the Lewis and Clark business results support the belief that the benefits estimated in the household willingness to pay section underestimate the benefits of water users.

POLICY IMPLICATIONS AND CONCLUSIONS

Households are willing to voluntarily pay a significant amount in increased water costs for reliable and good quality water supplies. Both of the procedures used to estimate the willingness to pay for water supply improvements resulted in similar values, ranging from $4.05 to $7.45 per household per month for urban residents and $5.40 to $11.50 per household per month for rural residents, which is equal to 11 percent to 23 percent of current average water costs. This is not a reaction to a specific event or immediate severe problem which is creating a severe hardship, but is a willingness to pay for general water supply improvements or protection of future supplies. The willingness to pay estimates do not include non-household water users. Therefore, the total benefit of providing a reliable and good quality water supply is higher than the willingness to pay estimates presented in this analysis.

Due to the limited amount of follow-up work done in the CVM study to account for non-response bias, the willingness to pay estimates are likely to be biased upward (assuming a significant portion of non-respondents did not return questionnaires due to a zero or very low willingness to pay). Therefore, the benefit transfer estimates may be more representative of true willingness to pay than the CVM based estimates. However, the assumption of benefit transfer that the underlying factors affecting willingness to pay are the same across different sites can also result in errors. Still, the range of estimates using both methods provides decision makers with detailed enough information to avoid the problem of building a large water supply system that water users do not want to connect to because of high costs.

The modeling results presented in this analysis were generally good. The explanatory variables had the expected signs and most were statistically significant. However, there are several shortcomings with the data used in this analysis which need to be addressed in future rural water supply benefit analyses. The water quality variables need to be improved and better defined in future studies. The water quality ratings obtained from the survey were not statistically significant, but the responses to the use of water filters were significant, indicating water quality is important in explaining the willingness to pay for water supplies. Therefore, some other method of indicating water quality, such as site specific water quality monitoring data, could improve the modeling results. The water cost variable was used as a proxy for water use because there were very few answers to the average monthly water use question asked in the questionnaire. Perhaps other questions related to outside watering and water use habits could be asked from which water use could be estimated. Respondents could be asked to refer to previous water bills or water utility records could be correlated with households surveyed to estimate use.

The biggest problem with the CVM analysis is the low response rate. The survey results indicate CVM can be used to derive reasonable estimates of the benefits from rural domestic water supply improvements. However, the general nature of the problem described is likely to have contributed to the low response rate. Individuals are more likely to respond to a questionnaire that addresses an immediate danger or need. Concerns about supplying water to households and businesses in the future or to an Indian Reservation are not likely to be perceived as a crucial immediate need. As a result, in-person or telephone survey techniques should be used to estimates rural water supply benefits. These techniques are considerably more expensive and labor intensive than mail surveys, which is why a mail survey was used for this analysis. Other benefit estimation techniques such as benefit transfer may be as accurate as a mail survey if response rates are not improved.

This analysis shows that useful planning information can be obtained from relatively inexpensive CVM mail survey data and the benefit transfer method as long as the limitations of the data are understood. The willingness to pay for ensuring good quality rural water supplies in the future is likely to be low compared to the costs of extensive diversion and treatment systems. Willingness to pay estimates based on CVM data or benefit transfer can be very useful in helping planners choose water supply alternatives.

DISCLAIMER

The views expressed in this paper are those of the author and do not necessarily represent policies or views of the U.S. Department of the Interior, Bureau of Reclamation.

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