Valuing Water Quality Monitoring: A Contingent Valuation Experiment Involving Hypothetical and Real Payments

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This paper studies the preferences and willingness-to-pay of individuals for volunteer water quality monitoring programs. The study involves supporting water quality monitoring at two ponds in the state of Rhode Island. The paper uses both a hypothetical and a real-payment contingent valuation survey to directly measure individual preferences and willingness-to-pay (WTP) for volunteer water quality monitoring at the two ponds. The overall results of the study suggest that hypothetical WTP is not statistically greater than real WTP, and that the average survey respondent is willing to support water quality monitoring on one of the two ponds. The study also finds that the specified purpose of water quality monitoring and certain socioeconomic characteristics of a respondent significantly affect the respondent's decision to support volunteer water quality monitoring.

Since passage of the Federal Water Pollution Control Act (FWPCA) of 1972, water quality has improved in some U.S. water bodies (Freeman 1990). Clean water yields positive dividends in terms of ecosystem health, quality of life for humans, and economic prosperity (U.S. Environmental Protection Agency 1995). Federal, state, and local governments have enacted environmental policies and programs to meet the regulatory requirements of the FWPCA, as well as the regulatory requirements of the Safe Drinking Water Act and the Ocean Dumping Act. Economic analysis of the potential benefits associated with these policies and programs has focused on valuing the benefits of water quality improvements, such as the associated recreational benefits (Bockstael, McConnell, and Strand 1989; Freeman 1995; Needelman and Kealy 1995). Achieving and maintaining "good" water quality, however, entails various costs, including administrative, capital, labor, enforcement, and monitoring costs. Though these costs can be quite significant, certain costs, particularly monitoring costs, can be reduced with volunteer help and donations.

The purpose of this paper is to consider the preferences and willingness-to-pay of individuals for volunteer water quality monitoring programs. Our study involves supporting water quality monitoring at two ponds in the state of Rhode Island. As explained below, the two ponds differ in several respects, including the purpose of water quality monitoring. We use the contingent valuation method (CVM) to directly measure individual preferences and willingness-to-pay for volunteer water quality monitoring at the two ponds.

Moreover, because previous research suggests differences between individual hypothetical and real willingness-to-pay (WTP) for goods and services (Brown et al. 1996; Cummings, Harrison, and Rutström 1995; Cummings et al. 1997; Loomis et al. 1996; Neill et al. 1994; Seip and Strand 1992),[1] we consider both a hypothetical and a real payment format for our CVM study. In an experi-

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[1] See Hanemann (1994) for a review of studies which report no statistical differences between hypothetical and real WTP.

mental economic setting, we randomly assign respondents to one of two groups. One group receives a CVM survey involving hypothetical payments, while the other group receives a CVM survey involving real money. In valuing public goods, such as water quality monitoring, incentive-compatibility remains an issue for both payment formats. In the hypothetical payment format, respondents may overvalue their WTP if they do not fully appreciate the financial obligations (i.e., costs) behind their decisions. Conversely, in the real payment format, respondents may undervalue their WTP if incentives to "free-ride" exist.

Efforts to address the so-called hypothetical bias (i.e., the difference between hypothetical and real WTP) are currently following three main directions: (1) adjusting or calibrating hypothetical WTP (Blackburn, Harrison, and Rutström 1994; Champ et al. 1997; Fox et al. 1995; Harrison et al. 1998; Shogren 1993), (2) designing hypothetical contingent valuation surveys that yield results similar to real payments (Cummings and Taylor 1997), and (3) developing incentive-compatible contributions mechanisms for obtaining real-money values, which provide more accurate reference points for assessing hypothetical bias (Rondeau, Poe, and Schulze 1996). The third direction suggests that hypothetical bias will be overstated if real-money payments are solicited with a contributions mechanism that provides little economic incentive to contribute to the public good. That is, calibration of hypothetical WTP may not be needed if real WTP is truthfully revealed.

Although all three directions remain important to the study of hypothetical bias, we approach the current study more in the spirit of the third direction.

Consequently, our study will interest not only environmental agencies and citizen groups involved with water quality but also researchers and agencies interested in experimental-economic approaches to CVM (Fisher, Wheeler, and Zwick 1993; Shogren 1993). Our overall results suggest that hypothetical WTP exceeded real WTP; however, given that our hypothetical WTP estimates have high standard errors, we cannot conclude that hypothetical WTP is statistically greater than real WTP. In terms of respondent preferences for water quality monitoring, we find that the average respondent is willing to support water quality monitoring on one of the two ponds. We also find that the specified purpose of water quality monitoring and certain socioeconomic characteristics of a respondent significantly affect the respondent's decision to support volunteer water quality monitoring. Although our respondent sample does not permit us to make inferences about the general public, our results nevertheless may be of interest to volunteer monitoring groups and environmental agencies in their efforts to educate the public, recruit new volunteers, and seek financial support.

Background on Volunteer Water Quality Monitoring

Water quality monitoring is a key component in efforts to protect water resources. Information provided by water quality monitoring can help identify the actual environmental impacts resulting from pollution, detect trends in water quality, warn of potential problems, and, at times, locate sources of pollution and stimulate corrective action in problem areas (Keeney 1996; U.S. Environmental Protection Agency 1990).

Though water quality monitoring is important, public budgets, staff size, and/or geographic scope have represented limitations to governmental efforts at state, federal, and local levels. However, with an increasing awareness that volunteer monitoring programs can offer a cost-effective way to obtain credible information on water quality, many states are turning to volunteer programs (U.S. Environmental Protection Agency 1990). Moreover, volunteer water quality monitoring programs help develop an educated and involved citizenry dedicated to protecting water resources (Simpson 1991; U.S. Environmental Protection Agency 1990).

In Rhode Island, volunteer water quality monitoring is coordinated by the University of Rhode Island's Watershed Watch Program. Watershed Watch provides volunteers with both classroom and field training, and it supplies the volunteers with all necessary equipment. The annual cost for water quality monitoring is $500 per water body (Green and Gold 1993). Funding for Watershed Watch has come from a variety of sources, including donations by individual citizens, local citizen associations, local and state governments, private corporations, and nonprofit organizations (Herron and Green 1996). The stated goals of Watershed Watch are (1) to promote active citizen participation in water quality protection, (2) to educate the public about water quality issues, (3) to obtain multiyear surface water quality information both to ascertain current conditions and to detect trends, and (4) to encourage management programs based upon water quality information (Green and Gold 1993, p. 1).

Currently, over 90% of Rhode Island's data concerning the conditions of its lakes and ponds is supplied by volunteer monitors. Following structured weekly, biweekly, and seasonal schedules, volunteers monitor several water quality parameters, including water clarity, algal density, dissolved oxygen, water temperature, alkalinity and pH, nutrient levels, salts, and bacteria (Green and Gold 1993).

Random Utility Model

Public contributions to support volunteer monitoring under the University of Rhode Island Watershed Watch Program come in two forms: (1) donations to support the general operation of Watershed Watch and (2) contributions to support water quality monitoring on specific water bodies. For the present study we focus on the second type of contribution; that is, we investigate public preferences and WTP for volunteer monitoring on specific water bodies.

Numerous water bodies exist throughout Rhode Island, and each water body has its own characteristics in terms of size, water quality, location (e.g., near the coast versus inland), surroundings (e.g., rural versus urban setting), and type (e.g., lake, pond, river, stream, or other). In modeling an individual's preferences for water quality monitoring on specific water bodies, we assume an individual's utility (i.e., satisfaction or happiness), U_{in}, associated with monitoring any particular water body depends on the characteristics of the water body, the socioeconomic characteristics of the individual, and the individual's net income after contributing to a volunteer monitoring program on the water body:

$$(1) \qquad U_{in} = U(\boldsymbol{X_n}, \boldsymbol{S_i}, M_i - C_{in}) = V(\boldsymbol{X_n}, \boldsymbol{S_i}, M_i - C_{in}) + \varepsilon_{in},$$

where U_{in} = individual i's utility associated with monitoring water body n; $\boldsymbol{X_n}$ = a vector of the attribute variables (i.e., characteristics) associated with water body n; $\boldsymbol{S_i}$ = a vector of characteristics describing individual i; M_i = individual i's income; C_{in} = individual i's required monetary contribution to help support monitoring on water body n; $V(\cdot)$ = the deterministic component of utility that is econometrically measurable by the researcher; and ε_{in} = the random or unobservable component of individual i's utility associated with monitoring water body n.[2] Since U_{in} contains a random component, ε_{in}, model (1) is called a "random utility model."

[2] Although unobservable to the researcher, ε_{in} is known to individual i.

The establishment of water quality monitoring on a water body depends on the collective contributions of individuals. That is, Watershed Watch can add a water body to its list of monitoring sites if

$$\sum_{i=1}^{G} C_{in} \geq TC,$$

where G = group size and TC = total costs of monitoring. Our discrete-choice survey design, explained later, relies on variation in C_{in} among individuals, generating a range of prices from which to estimate average WTP.

Next, the probability that individual i will choose to contribute to volunteer monitoring on a particular water body is modeled as follows. First, we define the set of available alternatives (including the set of water bodies plus an option not to contribute to any water body) as W.[3] Individual i will (by assumption) maximize his or her utility by choosing alternative n if

$$(2) \qquad U_{in} > U_{im} \text{ for all } m \neq n \text{ in } W.$$

Under decision rule (2), the probability that individual i will choose alternative n is

$$(3) \quad P_i(n) = \Pr(U_{in} > U_{im}, \text{ for all } m \neq n \text{ in } W),$$

where $\Pr(\cdot)$ represents the probability operator. Following the definition of utility in model (1), (3) can be written as

$$(4) \quad P_i(n) = \Pr(V_{in} + \varepsilon_{in} > V_{im} + \varepsilon_{im}, \text{ for all } m \neq n \text{ in } W)$$

or

$$(5) \quad P_i(n) = \Pr(\varepsilon_{in} - \varepsilon_{im} > V_{im} - V_{in}, \text{ for all } m \neq n \text{ in } W),$$

where $V_{in} = V(\boldsymbol{X_n}, \boldsymbol{S_i}, M_i - C_{in})$. Next, it can be shown that if we assume the ε's are independent and identically Type I Extreme Value distributed in standard form, then $P_i\,(n)$ can be defined as the following multinomial logit model (McFadden 1974):

$$(6) \qquad P_i(n) = \frac{\exp(V_{in})}{\sum_{m \in W} \exp(V_{im})}.$$

[3] In the experiment explained below, individual i faces a choice set consisting of three alternatives: contribute to volunteer monitoring on Pond A, contribute to volunteer monitoring on Pond B, or contribute to neither pond. The "neither pond" alternative allows for the possibility that individual i either (1) receives no utility from having a pond monitored or (2) simply receives greater utility from not having a pond monitored.

Estimation of model (6) requires specification of the functional form for V_{in}, for all $n \in W$. We assume V_{in} is linear in its parameters[4] so that

(7a) $$V_{in} = \boldsymbol{\beta}'\mathbf{Z}_{in} + \beta_C(M_i - C_{in})$$

and

(7b) $$P_i(n) = \frac{\exp(\boldsymbol{\beta}'\mathbf{Z}_{in} - \beta_C C_{in})}{\sum_{m \in W} \exp(\boldsymbol{\beta}'\mathbf{Z}_{im} - \beta_C C_{im})},$$

where $\mathbf{Z}_{in} = z(\mathbf{X}_n, S_i)$, $\boldsymbol{\beta}'$ is a vector of parameters, and β_C is the marginal utility of income. Note that the term $\beta_C M_i$ drops out in estimation because it appears in the utility function of every choice alternative.[5] Finally, estimates of $\boldsymbol{\beta}'$ and β_C can be obtained through maximum likelihood estimation.

Experimental Design

Our sample consisted of 140 students from three classes at the University of Rhode Island: two separate classes of a course entitled "Introduction to Resource Economics" and one class from a mixed graduate-undergraduate course entitled "Interdisciplinary Topics in the Coastal Environment." The experimental sessions took place during regular class hours, and *none* of the students were forced or pressured to participate in the experiment.[6] Those who participated were given a cash payment of $10.

Preliminary Procedures and Survey Materials

At the beginning of each experimental session, student-respondents sat in rows and were verbally told that the experiment was not a class assignment, but that it would involve them in making "real-life" decisions concerning environmental goods. The experimenter also instructed the respondents to remain quiet and not to communicate with other respondents during the experiment. Next, the respondents were randomly split into two groups. Respondents were asked, row-by-row, to count-off 1, 2, 3, 4, ... Then, by the flip of a coin, either even or odd numbered respondents were escorted to another classroom; these respondents were assigned to the hypothetical-money survey, while the respondents remaining in the original classroom participated in the real-money survey. In order to control for interrespondent communication and to give each respondent some privacy while making decisions, respondents in both classrooms were separated by at least one desk space.

After the respondents were separated into different classrooms, each respondent, in both groups, was given a survey and a ten-dollar cash payment in an unsealed envelope. The survey contained four sections. The introduction summarized various aspects of volunteer water quality monitoring in Rhode Island, including its role in environmental protection, its alternative funding sources, who volunteers in Rhode Island, and what the volunteers do. Part A asked respondents about their recreational use of water bodies and contained several attitudinal questions related to water quality and water quality monitoring. The questions in Part A were primarily used to motivate respondents to think about what water quality monitoring means to them, personally. Part B presented two "adopt-a-pond" scenarios in Rhode Island, followed by a trichotomous choice question that elicited a respondent's preference and willingness-to-pay for water quality monitoring at either pond. Part C contained standard demographic and socioeconomic questions.

The Adopt-a-Pond Scenarios

Through Watershed Watch, we were able to offer, for sale, a water quality monitoring program at two ponds in Rhode Island. At the time of this experiment, neither pond was being regularly monitored; thus, our respondents (in the real-money survey) had a real opportunity to add one or both ponds to Watershed Watch's monitoring program. Specifically, each respondent was asked to evaluate whether he/she believed it was worthwhile for him/her to pay a specified amount so that Watershed Watch could add one of the ponds to its monitoring program for one year. If a respondent found it worthwhile to "adopt a pond," then the respondent actually paid the specified contribution in the real-money survey, whereas in the hypothetical-money survey, a respondent simply stated his/her preference to adopt a pond.[7]

[4] A linear form is computationally convenient and may be interpreted as a first-order approximation to a general utility function. Nonlinear functional forms were not found superior in the data analysis discussed below.

[5] Interaction terms involving M_i, however, will not drop out. In our data analysis, we investigated several terms involving income interacted with alternative specific dummies (i.e., constants) and the individual required contribution, but none of the terms added explanatory power to our models.

[6] Only one student opted to leave, citing physical illness.

[7] Since we made no promises to continue monitoring beyond one year, our focus was on obtaining the value for adding a pond to Watershed Watch's list of monitoring sites for the first year only. If a respondent did not think one year's worth of data was helpful, the respondent may have decided not to contribute to any pond.

The ponds chosen for this study were Wakefield Pond, located inland in northwestern Rhode Island, and Melville Pond, located near Narragansett Bay in southeastern Rhode Island. However, in order to develop a more general model for water quality monitoring preferences, we arbitrarily labeled Wakefield Pond as Pond A and Melville Pond as Pond B. Table 1 lists the general characteristics of Ponds A and B. Pond A is relatively large (72 acres), surrounded by wooded area, with no obvious water clarity problem. In contrast, Pond B is relatively small (5.5 acres), surrounded by housing development, with an apparent water clarity problem.

In designing our contingent valuation survey,[8] we maintained a particular interest in how an individual's preference for water quality monitoring might be affected by a pond's surroundings and the purpose of monitoring (table 1). Since water quality is directly affected by what happens on the land's surface, one might suspect that a pond surrounded by housing development remains more susceptible to pollution problems (e.g., urban runoff) than a pond surrounded by wooded area. A choice between monitoring a pond surrounded by wooded area versus housing development represents a tradeoff between protecting a water resource in a relatively pristine/wooded area versus a problem-prone/suburban area. This choice may also represent a tradeoff between protecting wildlife health versus (human) public health. As for the purpose of monitoring, we found no economic studies that investigated individual preferences for water quality monitoring, let alone individual preferences for specific water quality monitoring objectives.

In order to measure the effect of pond surroundings and the purpose of monitoring on an individual's preference for water quality monitoring, we implemented these characteristics as variable information. That is, some respondents were not given information on pond surroundings and the purpose of monitoring, while other respondents were given this information. The other pond characteristics (table 1)—size, water clarity, and location—were used to give a basic description of the ponds. Every respondent was given these basic descriptions, which represented fixed, base information.

Table 1. General Characteristics of Ponds A and B

Characteristics	Pond A	Pond B
Size	72 acres	5.5 acres
Water clarity	Good	Poor
Location	Inland	Near coast
Surrounded by	Wooded area	Housing development
Purpose of monitoring	To warn of any problems	To help find source of current problem

In addition to the pond characteristics in table 1, each monitoring/choice alternative required an individual monetary contribution. The required contribution for Ponds A and B never equaled each other, and not every respondent faced the same required contributions as other respondents.

We followed the Addelman and Kempthorne (1961) fractional factorial design method to create nine different combinations of the variable pond attributes: required contributions for Ponds A and B, pond surroundings, and purposes of monitoring. This resulted in nine versions of our trichotomous choice question of choosing to monitor Pond A, Pond B, or neither pond. Each respondent, however, faced only one choice question. Figure 1 shows the format of a typical trichotomous choice question used in the surveys.

Prior to the trichotomous choice question, respondents were informed that a minimum total contribution from each of the three experimental sessions was needed for either pond to be added to Watershed Watch's monitoring program. Specifically, the experimental instructions for the real-money surveys read:

> In order to add either pond to Watershed Watch's monitoring program, we need a certain minimum total contribution from each of the three courses. For the people in this room, the minimum total contribution needed is **\$Y for Pond A** and **\$Y for Pond B.** If we do <u>not</u> collect **\$Y for Pond A** and/or **\$Y for Pond B,** then anyone who contributed to Pond A and/or Pond B will have their money contribution refunded **today.** However, if we collect **\$Y for Pond A** and/or **\$Y for Pond B,** then Pond A and/or Pond B will become a candidate for the Watershed Watch monitoring program, conditional on the contributions collected from the other courses.
>
> That is, <u>if we collect the minimum</u> for Pond A and/or Pond B <u>in all three courses</u>, then Pond A and/or Pond B will be added to Watershed Watch's monitoring program; <u>otherwise</u>, Pond A and/or Pond B will <u>not</u> be added to Watershed Watch's monitoring pro-

[8] The overall development of the survey involved several steps. First, we talked with representatives from Watershed Watch and Trout Unlimited (another volunteer monitoring organization in Rhode Island) to learn about water quality monitoring issues in general and at specific water bodies. Next, we pretested a hypothetical-money version of the survey on 166 students from a course entitled "Introduction to Philosophy" at the University of Rhode Island. The last page of the pretest surveys asked for comments regarding the survey's difficulty. Based on the pretest results and comments, we shortened the survey's introduction, and we made some modifications to better clarify the adopt-a-pond scenarios.

Given the following choices, I would prefer to (please check only **one** box)

❑ Pay the required contribution and have **Pond A** monitored.	❑ Pay nothing and have **neither** Pond A nor B monitored.	❑ Pay the required contribution and have **Pond B** monitored.

MONITORING FOR POND A	**NEITHER POND A NOR B**	**MONITORING FOR POND B**
Description of Pond A: • 72 acre Pond, • Good water clarity, • Located inland, • Surrounded by wooded area, and • Monitoring will warn of any problems.	I am not willing to pay for water quality monitoring for either pond A or B.	**Description of Pond B**: • 5.5 acre Pond, • Poor water clarity, • Located near coast, • Surrounded by Housing Development, and • Monitoring will help find source of current problem.
Required Contribution: You would have to pay **$15** to help fund monitoring for the year 1997.	**Required Contribution**: You would have to pay **$0** to help fund monitoring for the year 1997.	**Required Contribution**: You would have to pay **$3** to help fund monitoring for the year 1997.

Figure 1. Example of Trichotomous Choice Question

gram and all who contributed to Pond A and/or Pond B will have their money contribution refunded on **Tuesday November 12**.

Based on the choices made by **individuals** in all three groups, it is possible for one, both, or neither pond to be added to the Watershed Watch program.[9]

The instructions for the hypothetical surveys paralleled the above instructions, except we added the wording "if payments were collected today," and we used the words "did" and "would" instead of "do" and "will." More details on the experimental instructions are available from the authors upon request.

The minimum total contributions for each experimental session were set based on pretest information and class size. A pretest of the survey yielded an approximate $7.00 per person estimate of *anticipated* average WTP, estimated as the sum of required (individual) contributions times the proportion of pretest respondents who chose a pond at that contribution level. However, given the National Oceanic and Atmospheric Administration's (1993) suggestion that hypothetical CVM dollar values be divided by a factor of 2, we calibrated our estimate of *anticipated* WTP to $3.50.[10] Next, we multiplied the (calibrated) *anticipated* WTP for either pond by the anticipated number of participants in each experimental session to derive

[9] The likelihood of cross-contamination between the experimental sessions was low. Session 2 began ten minutes after session 1. Session 3 was run several weeks later. Most of the subjects in sessions 1 and 2 were freshmen and sophomores, while the subjects in session 3 were juniors, seniors, and graduate students. None of the students in sessions 1 and 2 were enrolled in the class that represented session 3. Moreover, the subjects in session 3 were first asked if they had heard of the experiment. None said yes.

[10] Because of different class schedules, we had the opportunity to adjust our estimate of *anticipated* WTP after our initial day of experimentation. Based on the survey results from sessions 1 and 2, we obtained an approximate $2.94 and $2.96 per person estimate of (calibrated) *anticipated* WTP for the hypothetical-money and real-money surveys, respectively. We used these latter estimates to determine the minimum total contributions for session 3.

the minimum total contributions for that session.[11] This approach attempted to create a situation where the public provision of funds for water quality monitoring depended on the marginal person. That is, if any one person actually valued monitoring at or above the required (individual) contribution for a pond but chose not to contribute (i.e., to free-ride), then the chance of raising the funds needed to establish a monitoring program at the pond would be low.

Incentive-Compatibility of Our Contributions Mechanism

Standard economic theory predicts that individuals will not voluntarily contribute to the provision of a public good because each individual has an incentive to free-ride on the contributions of others. Despite this prediction, one still finds that individuals voluntarily contribute to public goods, such as charities, public television, and wildlife conservation. Experimental tests of the ability of the voluntary contributions mechanism (VCM) to provide public goods appear mixed (for an overview, see Davis and Holt [1993, section 6.3] and Ledyard [1995]): free-riding inhibits the ability of the VCM to provide public goods in some scenarios, while it does not inhibit the provision of public goods in other scenarios. Such mixed results call into question the incentive-compatibility of the VCM to eliminate free-riding and truthfully reveal the demand for public goods. Recently, research has turned to the development of incentive structures that, when added to the VCM, will significantly reduce the free-rider problem. The voluntary contributions mechanism used in this study incorporates two structures that have been shown theoretically and empirically to reduce the incentive to free-ride.

Specifically, our contributions mechanism contains a provision point (PP) and a money-back guarantee (MBG). The *minimum total contribution* required for each experimental session represents a conditional PP, whereby the provision of water quality monitoring on a pond remains conditional on all three groups reaching their predetermined PPs. If the sum of the individual contributions for a pond in any group falls short of the group's conditional PP, then anyone who contributed to that pond will receive a full refund. This money-back guarantee reduces any concern that too few contributions will be collected to permit provision of the good at the specified level, in which case respondents would have incurred costs for an undeliverable benefit.

Bagnoli and Lipman (1989) and Davis and Holt (1993, section 6.4) provide game-theoretic arguments that show that the use of a PP with an MBG reduces the incentive to free-ride. In fact, for games of complete but imperfect information, free-riding is not a sensible strategy when a PP with an MBG exists (Bagnoli and McKee 1991). Isaac, Schmidtz, and Walker (1989) report experimental evidence that adding an MBG to a PP significantly increases contribution rates. And Bagnoli and McKee (1991) offer experimental evidence that suggests a PP with an MBG provides incentives for individuals to successfully provide a public good. Rose et al. (1997) also offer evidence that suggests a PP mechanism induces demand-revealing behavior for public goods.

Although our contributions mechanism parallels the basic nature of the mechanisms used in the above studies, it is somewhat more complicated. Participants in our study face several provision points: a group-specific PP for each pond and an aggregate PP for each pond, where the latter equals the sum of the group-specific provision points. Participants are fully informed about their group-specific PP and the number of groups participating in the study, but they do not know the aggregate PP or the group-specific PP for other groups. Additionally, participants are not told the size of their group or other groups, although nothing prevents participants from taking a head-count of their own group, if so desired. Incomplete information about group size and the PP may not, however, hinder the effectiveness of provision point mechanisms in providing public goods (Rondeau, Schulze, and Poe 1997).[12] However, since we do not use induced values and run treatments without a PP and an MBG, we cannot test the incentive compatibility of our contributions mechanism. Here, we attempt to value a real, deliverable, environmental, public good, which precludes the use of induced values. Rather than formally test our contributions mechanism in an induced value framework, we

[11] As mentioned earlier, Watershed Watch requires $500 per year to monitor any water body (Green and Gold 1993). For the real-money survey groups, the minimum total contributions required from each experimental session totaled $255 per pond. Since these funds fell short of $500, we set aside $490 (= $245 × 2) from our budget to cover the additional cost of monitoring at each pond.

[12] Rondeau, Schulze, and Poe (1997) use a PP in conjunction with an MBG and proportional rebate (PR) rule. Under the PR rule, all contributions in excess of the PP are divided among, and refunded to, individuals in proportion to the amount of their contribution relative to the total contributions collected in their group. Using induced values in a laboratory experiment, the authors report high levels of aggregate demand revelation regardless of incomplete information about the PP or group size.

rely more on the findings of previous laboratory experiments to defend the incentive compatibility of our mechanism.

Champ et al. (1997) argue that, without the use of an incentive-compatible contributions mechanism, actual voluntary donations to the provision of a public (environmental) good represent a "lower bound" on the value of the public good. Given this argument in conjunction with the aforementioned findings that provision point mechanisms reduce free-riding behavior, we argue that our contributions mechanism should, at least, elicit lower bound estimates of the value for water quality monitoring on each pond in the real-money survey treatment.

Logistics of the Real-Money Survey Treatment

In addition to a survey and envelope filled with ten dollars, respondents in the real-money survey treatment received an identification card. The identification card contained an arbitrarily assigned identification number, which also appeared on the money envelope and the survey. We used the identification number to keep track of monetary exchanges while ensuring the anonymity of individual decisions. Respondents were instructed to keep their identification cards and use the envelopes to make monetary exchanges.

For example, if a respondent chose to support water quality monitoring on one of the ponds, the respondent was instructed to pay the listed program cost by placing the exact amount of money in the envelope. Payment could be made in cash, check (payable to Rhode Island Watershed Watch), or partially cash and IOU. The cash/IOU payment option was available only for program costs exceeding the ten-dollar participation fee. The IOU entailed signing a promissory note that was payable within one week.[13] For convenience, a self-addressed stamped envelope was provided for paying an IOU.

When all the respondents finished the survey, the experimental monitors collected all the money envelopes and surveys; respondents who chose neither pond handed in an empty envelope. Next, the experimental monitors checked that each envelope contained the correct cash, check, or cash/IOU contribution required by the monitoring program chosen by each survey respondent. If a monitoring program was chosen, but the envelope did not contain the correct money contribution, then the survey was excluded from the results.[14] Then the monitors summed the valid contributions for each monitoring program. If the sum of the individual contributions for any program equaled or exceeded the minimum aggregate contribution required for that experimental session, the respondents were instructed to keep their identification cards until a specified date. In this case, the pond(s) became a candidate for the Watershed Watch program, conditional on the contributions collected from the other experimental sessions; thus, the respondents needed to retain their identification cards in order to receive a future refund in the event that the other experimental sessions failed to contribute enough money to the monitoring program. However, if the sum of the individual contributions for any program was less than the minimum aggregate contribution required for that experimental session, then the respondents who contributed to the program received a refund immediately. Refunds were handled by matching identification cards with envelopes. As each respondent left the room, he or she presented his or her identification card to an experimental monitor, who in turn gave the respondent an envelope that matched the number on the respondent's identification card. In this case, respondents who had chosen not to contribute received an empty envelope in order to avoid signaling their private decisions to fellow participants.

Results and Discussion

Contributions Collected for Each Pond

Table 2 summarizes the hypothetical and real contributions for each pond. Except for group 3 in the real-money survey, a relatively small number of respondents chose neither pond. A comparison of the *required group contribution* versus the *contributions collected* suggests that, in several instances, the marginal person determines whether the group reaches its target. For example, in the hypothetical-money survey, group 2 fails to reach the required fund for Pond B by $2. In the real-money survey, group 3 surpasses the required fund for Pond B by only $4, but group 1 fails to raise the required fund for Pond B by $5, and group 2 fails to raise the required fund for Pond A by $12. All of

[13] Other uses of the IOU payment option can be found in Harrison et al. (1998), Loomis et al. (1996), and Neill et al. (1994).

[14] Only 5 out of 76 respondents in the real-money survey treatment neglected to make the correct money contribution for their chosen pond. We examined several approaches for including these respondents in our analysis. None of these approaches altered our basic conclusions below, although some numerical estimates changed slightly.

Table 2. Summary of Hypothetical and Real Contributions for Each Pond

	Hypothetical-Money Survey			Real-Money Survey		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Required group contribution for each pond[a]	$98	$77	$53	$98	$77	$80
Total contributions collected for[b]						
Pond A	$70	$50	$84	$40	$65	$42
Pond B	$149	$75	$72	$93	$44	$84
Number of subjects who chose neither pond	5	1	3	4	4	11
	(17%)[c]	(6%)	(18%)	(15%)	(18%)	(50%)
Actual sample size	30	16	18	27	22	27
Number of usable surveys[d]	30	16	17	26	22	22

[a]This number represents the minimum total contribution required from each group (i.e., experimental session), for each pond. Groups 1 and 2 represent the two undergraduate classes, and group 3 represents the interdisciplinary graduate-undergraduate class. The required contributions are based on anticipated group sizes of 28, 22, and 18 for groups 1, 2, and 3, respectively, in the hypothetical-money survey, and 28, 22, and 27 for groups 1, 2, and 3, respectively, in the real-money survey.
[b]For the hypothetical survey, these are stated/hypothetical contributions.
[c]Numbers in parentheses represent the number of neither-pond choices as a percentage of usable surveys.
[d]Some surveys were excluded from the analysis because the respondent either chose both ponds or actually contributed an insufficient amount of money and IOU.

these amounts fall within the range of individual cost variables included in the survey.

In total, the respondents in the hypothetical survey raised $204 and $296 for water quality monitoring on Ponds A and B, respectively. The respondents in the real-money survey actually contributed a total of $147 and $221, respectively, for Ponds A and B. However, since the real-money respondents failed to reach the required group contribution in every group, each respondent received a full refund and neither pond was added to the Rhode Island Watershed Watch monitoring program.

Analysis of Individual Preferences

Table 3 describes all the variables used in our analysis of individual preferences for water quality monitoring. The *SURROUND_A* and *SURROUND_B* attribute variables represent, respectively, a choice between monitoring a pond in relatively natural (i.e., wooded) versus nonnatural (i.e., housing area) surroundings (table 1). The *PURPOSE_A* and *PURPOSE_B* variables measure the effect of including information on the purpose of monitoring, with purposes to "warn of any problems" in Pond A or to "help find the source of [a] current problem" in Pond B (table 1). We developed no a priori hypothesis concerning which purpose might be important to an individual. We did, however, hypothesize that the inclusion of information on the monitoring purpose will have a positive effect on an individual's probability of choosing a pond over choosing the neither-pond option.

The required contribution/cost variable is separated into *HYPOTHETICAL COST*, which equals the respondent's required payment for programs chosen in the hypothetical-money surveys and which equals zero for programs chosen in the real-money surveys; and *REAL COST*, which equals the respondent's required payment for programs chosen in the real-money surveys and which equals zero for programs chosen in the hypothetical-money surveys. *HYPOTHETICAL COST* and *REAL COST* are expected to have a negative effect on an individual's probability of choosing a pond. Lastly, we consider several socioeconomic variables, characterizing a respondent's gender, academic major, residence, and attitude toward social responsibility for water quality. We interact the socioeconomic variables with the *NEITHER POND* alternative. These interactions indicate how the socioeconomic variables affect an individual's decision to choose a pond over choosing the neither-pond option. Specifically, a negative coefficient on any of the socioeconomic–*NEITHER POND* interactions (table 3) indicates that a respondent with a higher value for that socioeconomic characteristic is more likely to choose to monitor one of the ponds, while a positive coefficient indicates a respondent is less likely to choose to monitor a pond.

Table 4 reports the estimation results for four specifications of the multinomial logit model (7a and 7b). For each specification, the χ^2-statistic for a likelihood ratio test of the model is significant at $P < 0.001$. Specification 1 includes all the variables from table 3, except the *NEITHER POND* constant. As expected, the coefficients on the cost variables are negative. The *REAL COST* variable is highly significant, with $P < 0.001$ for a one-tailed

Table 3. Description of Variables

Variable	Description
Alternative specific constants	
POND A	Dummy variable = 1 for monitoring on Pond A; = 0 otherwise.
POND B	Dummy variable = 1 for monitoring on Pond B; = 0 otherwise.
NEITHER POND	Dummy variable = 1 for monitoring on neither pond; = 0 otherwise.
Pond/program attribute variables[a]	
SURROUND_A	Dummy variable = 1 if information on the surroundings of Pond A is given; = 0 otherwise.
SURROUND_B	Dummy variable = 1 if information on the surroundings of Pond B is given; = 0 otherwise.
PURPOSE_A	Dummy variable = 1 if information on the purpose of monitoring Pond A is given; = 0 otherwise.
PURPOSE_B	Dummy variable = 1 if information on the purpose of monitoring Pond B is given; = 0 otherwise.
HYPOTHETICAL COST	The required contribution/cost for an individual in the *hypothetical-money survey treatment* to support monitoring on chosen pond.[b]
REAL COST	The required contribution/cost for an individual in the *real-money survey treatment* to support monitoring on chosen pond.[b]
Alternative specific socioeconomic variables[c]	
WQATTITUDE_N	Discrete variable recorded as 2 = strongly agree, 1 = agree, 0 = neutral, −1 = disagree, and −2 = strongly disagree with the statement: "Everyone is responsible for water quality, even if they do not directly use a water body."
GENDER_N	Dummy variable = 1 if female; = 0 if male.
ECOLOGY_N	Dummy variable = 1 if ecology/environmental major[d]; = 0 otherwise.
RESIDENT_N	Dummy variable = 1 if a Rhode Island resident; = 0 otherwise.

[a]In all the choice questions, the surrounding and/or monitoring information either appeared for both ponds or did not appear at all.
[b]For both the hypothetical-money and real-money survey treatments, groups 1 and 2 faced individual costs of \$5, \$10, or \$15 for Pond A, and \$2, \$7, or \$12 for Pond B. Group 3 faced individual costs of \$6, \$11, or \$14 for Pond A, and \$4, \$12, or \$16 for Pond B.
[c]The socioeconomic variables are interacted with the *NEITHER POND* dummy variable.
[d]Ecology/environmental majors included animal science, aquaculture and fishery technology, biology, botany, environmental management/science, natural resources science, plant science, soil and water resources, wildlife biology/management, and zoology.

test, but the *HYPOTHETICAL COST* variable is only significant at $P < 0.18$ for a one-tailed test.[15] Another expected result from specification 1 is that the coefficients on the monitoring variables are positive, although a one-tailed test reveals that only *PURPOSE_B* is significant ($P < 0.06$). This suggests that respondents are more likely to support volunteer water quality monitoring when they are given information on the purpose of monitoring, especially in the case of Pond B. We return to this issue below.

The *SURROUND_A* and *SURROUND_B* variables are negative but insignificant (two-tailed $P > 0.45$). The insignificance of these variables suggests that the respondents value volunteer water quality monitoring, but they remain indifferent between monitoring ponds in a relatively natural versus a nonnatural setting. The alternative specific constants, *POND A* and *POND B*, also are negative but insignificant (two-tailed $P > 0.25$). These negative constants would (if significant) tend to suggest that monitoring on either pond is not preferred to leaving both ponds unmonitored; however, a preference for monitoring at either pond depends on the average effect of other variables that alter the constant/intercept terms, and we see below that respondents prefer monitoring at least one pond (compare specifications 1 and 3, table 4).

As for the socioeconomic–*NEITHER POND* interaction variables, all are negative and, except for *RESIDENT_N*, all remain influential in the model, although *GENDER_N* is significant at only the 11% level (table 4). The negative coefficient on *WQATTITUDE_N* is expected, since one would expect people who agree that everyone is responsible for water quality to be more likely to support volunteer water quality monitoring. Similarly, the

[15] We also estimated the model with a nonlinear/quadratic cost structure (Boyle 1990). This functional form, however, made no significant improvement ($P > 0.70$) in our model.

Additionally, one might suspect that the ten-dollar participation payment, given to each respondent, might produce a small income effect. That is, individuals might be more willing to pay for monitoring when the required contribution is less than or equal to ten dollars. However, by conducting a number of alternative nested and nonnested tests, we find no evidence for such an income effect. All tests were insignificant ($P > 0.20$).

Table 4. Estimation Results for Various Specifications of the Multinomial Logit Model

	Specification 1		Specification 2		Specification 3		Specification 4	
Variable	Parameter Estimate	Pr>|Z| (*P*-value)[a]	Parameter Estimate	Pr>|Z| (*P*-value)	Parameter Estimate	Pr>|Z| (*P*-value)	Parameter Estimate	Pr>|Z| (*P*-value)
POND A	−1.223 (−1.117)	0.264						
POND B	−1.186 (−1.135)	0.256						
NEITHER POND			1.309 (1.458)	0.145	−1.445 (−3.050)	0.002	1.266 (1.487)	0.137
HYPOTHETICAL COST	−0.037 (−0.936)	0.350	−0.039 (−1.005)	0.315	−0.043 (−1.153)	0.249	−0.039 (−1.003)	0.316
REAL COST	−0.177 (−4.087)	<0.001	−0.182 (−4.217)	<0.001	−0.187 (−4.518)	<0.001	−0.182 (−4.244)	<0.001
SURROUND_A	−0.422 (−0.610)	0.542						
SURROUND_B	−0.432 (−0.678)	0.498						
PURPOSE_A	0.111 (0.188)	0.851	0.085 (0.156)	0.876	0.097 (0.196)	0.845		
PURPOSE_B	0.869 (1.557)	0.119	0.871 (1.678)	0.093	0.877 (1.860)	0.063	0.801 (3.163)	0.002
WQATTITUDE_N	−1.129 (−2.515)	0.012	−1.097 (−2.490)	0.013			−1.106 (−2.531)	0.011
GENDER_N	−0.833 (−1.608)	0.108	−0.766 (−1.519)	0.129			−0.761 (−1.514)	0.130
ECOLOGY_N	−1.064 (−2.047)	0.041	−1.088 (−2.144)	0.032			−1.079 (−2.145)	0.032
RESIDENT_N	−0.237 (−0.459)	0.646						
Log-likelihood	−114.299		−114.618		−121.676		−114.630	
χ^2-statistic	63.632 (*d.f.* = 12)	<0.001[b]	62.995 (*d.f.* = 8)	<0.001	48.880 (*d.f.* = 5)	<0.001	62.971 (*d.f.* = 7)	<0.001

NOTE: Numbers in parentheses represent *Z*-statistics.

[a]The *P*-values reported in this table correspond to a *two*-tailed test of H_0: $\beta = 0$ versus H_A: $\beta \neq 0$.

[b]The level of significance (i.e., *P*-value) for the χ^2-statistic.

negative coefficient on *ECOLOGY_N* is expected because student-respondents in ecology/environmental majors have expressed a preference to address environmental problems as professionals, and this attitude may correlate with a positive willingness to support pond monitoring. This result is consistent with Kuitunen and Törmälä's (1994) finding that students with more knowledge about nature and conservation issues are more willing to support endangered species conservation.

The negative coefficient on *GENDER_N* suggests that the female respondents are more likely than the male respondents to support volunteer water quality monitoring. Similar differences in preferences between genders is noted in other studies (Kuitunen and Törmälä 1994; Swallow et al. 1994; Day and Devlin 1996).

Finally, the insignificance of *RESIDENT_N* ($P > 0.60$, specification 1, table 4) indicates that Rhode Island residents were not significantly more likely than non–Rhode Island residents to support volunteer monitoring in their own region of residence.

Given the statistical insignificance of the "surround" variables and *RESIDENT_N*, we reestimate the multinomial logit model (7a and 7b) without these variables in specification 2 (table 4). Note that we use the *NEITHER POND* constant, instead of the *POND A* and *POND B* constants jointly. This specification more directly measures an individual's preference for a pond over the neither option.[16] Estimation of specification 2 results in no substantive changes in the sign, magnitude, and significance of the remaining variables. A likelihood ratio test between specifications 1 and 2 reveals no statistically significant difference ($\chi^2 = 0.638$, 4 *d.f.*, $P > 0.95$). Thus, we conclude that the respondents value volunteer monitoring regardless

[16] The use of *NEITHER POND*, instead of *POND A* and *POND B* jointly, imposes the restriction that respondents view these ponds as equivalent, a priori, so that pond acreage, clarity, and location differences (table 1) did not significantly affect respondents' choices. The restriction is not significant ($P > 0.90$).

of either pond's surroundings and the respondent's state of residence.

Next, realizing that the socioeconomic–*NEITHER POND* interaction terms may alter the *NEITHER POND* constant term, we reestimate specification 2 without the socioeconomic-*NEITHER POND* interactions, using specification 3 (table 4). No major change in the cost and monitoring variables occurs, but the *NEITHER POND* constant becomes negative and statistically significant ($P < 0.003$). This suggests that the respondents prefer to monitor one of the ponds over leaving both ponds unmonitored. A likelihood ratio test between specifications 2 and 3, however, reveals the restriction is statistically significant ($\chi^2 = 14.116$, 3 *d.f.*, $P < 0.005$). This implies that different socioeconomic groups maintain different preferences for volunteer pond monitoring.

Subsequently, we include the socioeconomic–*NEITHER POND* interaction terms in our final, fourth specification.[17] Specification 4 differs from specification 2 by excluding the *PURPOSE_A* variable. Given that *PURPOSE_A* remains insignificant in specifications 1, 2, and 3 ($P > 0.80$), it does not appear influential in the respondents' decisions over volunteer pond monitoring; thus, we drop *PURPOSE_A* from our final analysis. A comparison of specifications 4 and 2 reveals no major differences in the sign, magnitude, and significance of the parameter estimates, except that the significance of *PURPOSE_B* improves from a one-tailed $P < 0.05$ to $P < 0.001$ in specification 4.

The insignificance of *PURPOSE_A* but significance of *PURPOSE_B* suggests a "catch the polluter(s)" preference among the respondents. Recall, the purposes of monitoring Ponds A and B are, respectively, "to warn of any problems" and "to help find source of [a] current problem"; hence, the respondents appear willing to tradeoff trying to detect any unknown and uncertain problem(s) for finding the source of a known and certain problem. Several explanations for this result may exist. First, the respondents may view the benefits of monitoring Pond A as less certain than the benefits of monitoring Pond B. A preference for more certain benefits over less certain benefits remains consistent with Kahneman and Tversky's (1979) "prospect theory" and with Macmillan, Hanley, and Buckland's (1996) finding that people prefer environmental projects with certain gains over projects with uncertain gains. Second, the respondents may deem a current environmental problem more important than monitoring to establish a baseline from which to detect possible future problems. Indeed, these results suggest that, in the absence of more information, respondents assumed monitoring was intended only to detect possible future problems. While respondents value monitoring services, in general, their value for monitoring a particular pond increased when monitoring could identify a current pollution source.

Estimated WTP for Volunteer Water Quality Monitoring

Following Hanemann (1984), we can obtain a utility-theoretic welfare measure, or willingness-to-pay, for volunteer pond monitoring. A respondent's maximum willingness-to-pay, *WTP*, is calculated as the program cost, *C*, that will make the individual indifferent between monitoring the pond chosen and the status quo (i.e., the neither pond alternative), which has zero cost. The indifference between choosing Pond *k* and the neither pond option can be represented symbolically as follows:

$$(8) \quad U(X_N, S_i, M_i) = U(X_k, S_i, M_i - WTP_k) \quad \text{for all } k \neq N,$$

where *N* denotes the neither pond option, which has zero cost; *k* denotes the chosen pond; WTP_k equals the maximum willingness-to-pay for monitoring on Pond *k*; and ***X***, ***S***, and *M* are as defined in equation (1). Next, using our empirical utility function, as in equation (1) with (7a, 7b)–(8), we can solve for WTP_k as follows:

$$(9) \qquad WTP_k = -\frac{\boldsymbol{\beta}'}{\beta_C}(\mathbf{Z}_{ik} - \mathbf{Z}_{iN}).$$

Estimates of WTP for Ponds A and B can be obtained by using the parameter estimates in table 4.

Table 5 reports WTP estimates for the average respondent based on equation (9) and the parameter estimates for specification 4 (table 4). For Ponds A and B, hypothetical-money WTP exceeds real-money WTP by a factor of 4.67.[18] This factor lies well within the range of factors reported across the few other discrete choice studies that compare hypothetical-money and real-money WTP for a public good (Foster, Bateman, and Harley 1997);

[17] For our fourth specification, we used the Hausman-McFadden test (Hausman and McFadden 1984; Green 1995, pp. 500–501) to test for violations of the independence of irrelevant alternatives (IIA) assumption. The resulting chi-square of 0.66 ($P > 0.85$) indicates that the IIA assumption is satisfied and suggests that the current specification represents the respondents' decision-making process.

[18] Because of the linearity in specification 4 (table 4), the ratio of hypothetical-money *WTP* to real-money *WTP* (for Ponds A and B) reduces to a ratio of the *REAL COST* coefficient (–0.182) to the *HYPOTHETICAL COST* coefficient (–0.039).

Table 5. Willingness-to-Pay Estimates for the Average Respondent

	Hypothetical WTP	Real-Money WTP
Pond A	\$42.69	\$9.15*
	(\$38.24)	(\$1.79)
Pond B	\$63.23	\$13.55*
	(\$58.67)	(\$2.42)
Difference		
$(WTP_B - WTP_A)^a$	\$20.54	\$4.40**
	(\$21.78)	(\$1.76)

NOTE: The WTP estimates reported here are based on the parameter estimates to specification 4 in table 4 and the average respondent, identified by the sample mean of the variables *WQATTITUDE*, *GENDER*, and *ECOLOGY*, which are, respectively, 1.6692, 0.4662, and 0.6767. The numbers in parentheses represent standard errors for the WTP estimates.

[a]Given the definition of WTP in equation (9), the difference $(WTP_B - WTP_A)$ can be written as $(-\boldsymbol{\beta}'/\beta_C)(\mathbf{Z}_{iB} - \mathbf{Z}_{iA})$.

*Significant at P-value <0.001 for a *one*-tailed test of H_0: $WTP_k = 0$ versus H_A: $WTP_k > 0$.

**Significant at P-value <0.01 for a *one*-tailed test of H_0: $WTP_B = WTP_A$ versus H_A: $WTP_B > WTP_A$.

however, it exceeds the National Oceanic and Atmospheric Administration's (1993) suggested correction factor of 2. This suggests that the average respondent in our sample may have overstated his/her WTP for volunteer monitoring in the hypothetical survey. However, because of the high standard errors on the hypothetical-money WTP estimates, we cannot conclude that these WTP estimates are statistically greater than the real-money WTP estimates.[19]

Next, given specification 4, a comparison of the WTP estimates for Ponds A and B reveals how much the average respondent is willing to pay to help identify a current pollution source in Pond B. The average respondent appears willing to pay an extra \$20.54 hypothetical dollars, or \$4.40 real dollars, to help find the source of the water clarity problem in Pond B. The real-money difference is statistically significant ($P < 0.01$), while the hypothetical-money difference is not statistically significant ($P > 0.15$). These results suggest, especially in the real-money surveys, that respondents value monitoring at Ponds A and B equally until they are informed that monitoring on Pond B will help identify a current source of pollution. This information motivated respondents to raise their WTP by about 48%. Without this information, the differences between Ponds A and B (table 1), including the size, water clarity, and location differences, left respondents statistically indifferent between the ponds.

Concluding Remarks

While most economic studies of water quality focus on estimating the benefits of water quality improvements, this paper initiates study of the preferences and willingness-to-pay of individuals for volunteer water quality monitoring programs. The paper uses both hypothetical and real payment contingent valuation formats to directly measure individual preferences and willingness-to-pay for volunteer monitoring at two ponds in Rhode Island. An analysis of the contingent valuation survey responses suggests that our sample of respondents values pond monitoring regardless of whether a pond is surrounded by wooded area or housing development, and that a respondent's state of residence plays no significant role in determining the respondent's probability of choosing to support monitoring on one of the Rhode Island ponds.

Factors that appear to influence a respondent's decision to support volunteer water quality monitoring include (1) the stated purpose of monitoring, (2) the individual cost of monitoring, (3) the respondent's attitude toward social responsibility for water quality, (4) the respondent's gender, and (5) the respondent's academic major. The respondents appear willing to tradeoff monitoring "to warn of any problems" (as in Pond A) in exchange for monitoring "to help find [the] source of current problem" (as in Pond B). In terms of WTP, the average respondent values the two ponds equally when information on the purpose of monitoring is not given; however, the average respondent is actually willing to pay 48% more in real money to monitor a pond for the purpose of helping identify the source of current water quality problems. This may reflect a preference for more tangible/certain environmental gains, an ethical preference to catch the polluter(s), or a higher concern for ponds with current problems.

In terms of the socioeconomic characteristics of the student-respondents, those who believe everyone is responsible for water quality, females, and ecology/environmental majors are more likely to support pond monitoring. The ecology/environ-

[19] Each standard error in table 5 is based on an estimate of the variance of WTP_k, $\text{Var}(WTP_k)$. Here, we followed Kmenta's (1971, p. 444) approximation formula based on a Taylor series expansion, as follows:

$$\text{Var}(WTP_k) \approx \left(\frac{1}{\beta_C}\right)^2 \cdot \text{Var}(\mathbf{D}_k) + \left(\frac{-\mathbf{D}_k}{\beta_C^2}\right)^2 \cdot \text{Var}(\beta_C) + 2 \cdot \left(\frac{1}{\beta_C}\right) \cdot \left(\frac{-\mathbf{D}_k}{\beta_C^2}\right) \cdot \text{Cov}(\mathbf{D}_k, \beta_C),$$

where $\mathbf{D}_k = -\boldsymbol{\beta}'(\mathbf{Z}_{ik} - \mathbf{Z}_{iN})$ and $\text{Cov}(\mathbf{D}_k, \beta_C)$ equals the covariance between $\mathbf{D}_k$ and β_C. Note that the elements of $\text{Var}(WTP_k)$ account for the sample size, through the variance-covariance matrix of estimators; in this case, $\sqrt{\text{Var}(WTP_k)}$ is the standard error of WTP_k.

mental major effect suggests that monitoring programs might obtain more public support if environmental agencies better educate the public about the importance of water quality monitoring.

Overall, water quality monitoring is a key element in efforts to protect water resources, and states are finding that volunteer monitoring programs are a cost-effective way to obtain credible information on water quality. In Rhode Island, volunteer water quality monitoring data aids environmental managers to set priorities for various management or enforcement actions for watersheds and water bodies. Supplementing monitoring data with information on public preferences and WTP could help environmental managers identify the water body types that both the public and water resource specialists consider important and worthy of investment.

To accomplish this task, future research might investigate a two-stage process for setting priorities for monitoring and management actions for water bodies. The first stage would involve water resource specialists using monitoring data and other scientific information to identify environmentally important water body types. In the second stage, environmental economists could use the first-stage results to build a model of public preferences for water quality monitoring on various water body types. Based on information from both steps, environmental managers could identify a list of water bodies that better satisfies the preferences of both water resource specialists and the public.

Lastly, environmental economists may gain insights from this case application comparing hypothetical-money and real-money contingent valuation surveys. For our sample of respondents, hypothetical-money costs are less influential than real-money costs in determining a respondent's probability of choosing to support monitoring on one of the ponds. The present study used a split-sample design wherein respondents in each sample received either a hypothetical-money or a real-money survey, but the actual differences between the surveys were quite minimal. This design implied that the hypothetical survey contained extensive details concerning how money would have been collected and, if necessary, refunded if real money had actually been solicited from the respondents. Further research might involve comparing real-money surveys with two versions of the hypothetical survey, wherein the additional hypothetical survey follows a more traditional, and briefer, format for the payment vehicle, such as payments of hypothetical new taxes. Without such additional research, and especially in light of our statistical tests, we believe it is premature to conclude that hypothetical and real contingent valuation estimates of WTP necessarily will differ by the factor of four obtained here.

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