

CHAPTER 8

EMPIRICAL RESULTS

8.1 Survey Response Rates

Nineteen hundred and ninety-four surveys were mailed to residents of Western Massachusetts (to Berkshire, Franklin, Hampden, and Hampshire counties). A list of the towns included in the survey is presented at the end of the chapter in Table 8.1. The total number of surveys was split approximately equally between the three versions of the survey: 665 households were mailed the CJ / traditional dichotomous choice (DC) CVM / modified dichotomous choice (DC) CVM version (Versions A and AA - see Appendix B, Figure B.1), 667 households were mailed the CJ / modified DC CVM versions (Versions B and BB - see Appendix B, Figure B.2), and 662 households were mailed the traditional DC CVM / modified DC CVM versions (Versions C and CC - see Appendix B, Figure B.3). Sixty-six of the returned surveys had been inadvertently mailed to Western Massachusetts households that do not use a private well as their primary drinking water supply. These individuals were excluded from the sample. Thirty-eight of the mailed surveys were not deliverable, and were returned by the US postal service. Thus, 1890 surveys were delivered to the target sample-households in Western Massachusetts whose primary source of drinking water is a privately owned well.

The survey response rate obtained was 26.67% (504 usable surveys), after adjusting for the surveys that reached non-private well households and the surveys that were not deliverable. However, we expect that response rates may differ by survey type; a longer survey may have a lower response rate relative to a shorter survey. Our mailing consisted of three different survey types. The longest versions of the survey, Versions A

and AA, required the respondent to consider the conjoint ratings analysis, traditional dichotomous choice (DC) contingent valuation (CVM), and modified DC CVM format questions. Only 23% of the sample that received either Version A or Version AA of the survey responded (144 surveys). Versions B and BB of the survey contained the conjoint ratings analysis and modified DC CVM questions only; this survey had a 29.89% response rate (188 surveys). Finally, Versions C and CC contained the traditional DC and modified DC CVM questions; these versions yielded a response rate of 27.09% (172 surveys). These results are as expected; the relatively lengthiest version of the survey, the combined CJ / traditional DC CVM/ modified DC CVM format, has the lowest response rate. One week after the survey was mailed to selected residents of Western Massachusetts, a reminder postcard was sent to households that had not yet responded; approximately 50% of the respondents returned their surveys prior to receiving the reminder postcard. A set of hypothesis tests was performed to test the null hypothesis that the mean characteristics of those that responded before receiving the reminder postcard are equal to the mean characteristics of those that responded after receiving the reminder postcard. We fail to reject the null hypothesis for all characteristics except the respondent's age; early respondents were significantly younger (with a mean age of 51.62 years) than late respondents (with a mean age of 54.25 years). The results of these hypothesis tests suggest that non-response bias is not likely to be a significant problem for this study, since the characteristics of those who did not respond are not likely to be very different from those who needed to be prompted to respond.

8.2 Descriptive Statistics

While 504 usable surveys were returned, many respondents did not answer each question. Thus, the number of responses used to calculate the descriptive statistics is presented for each variable; in many cases this number is less than 504.

8.2.1 Socioeconomic Characteristics

Table 8.2, presented at the end of this chapter, contains descriptive statistics for each socioeconomic variable; the descriptive statistics for variables that were collected as dummy variables are followed by the descriptive statistics for the variables that were collected as continuous variables. A majority of the respondents to the survey were male (66.2%). The average age of the survey respondents was 52.16 years. The respondents were, on average, highly educated. The majority of respondents had attained at least a college level of education (63.78%). Average gross annual household income fell between \$50,000 and \$59,000. However, respondents seem particularly hesitant to reveal their income level; 74 of the respondents were not willing to provide the range of their annual gross income.

Most survey respondents received the survey at their primary residence (97.8%) and were the owners of that residence (94.2%). One may argue that individuals would be most concerned about, and willing to pay for, groundwater protection at their primary residence. Homeowners may be especially likely to invest in groundwater protection. Individuals who plan to move from their current residence in the near future may be less likely to make investments in groundwater quality, particularly public investments, as they will not be able to benefit directly from such investments for very long. On the other hand, homeowners that expect to sell their home in the near future may be eager to

purchase some form of groundwater protection, in the hope that such protection will increase the value of their home. About 17% of the households that responded to the survey had either definite or tentative plans to move within two years.

One may also argue that households that have children are more likely to be willing to invest in groundwater protection. The average number of infants (children under the age of 1 year) living in respondents' households was 0.08, while the average number of children between the ages of 1 and 18 years was 0.69. Almost 39% of the responding households had at least one infant or child living there; 37.19% of the households had at least one child between the ages of one and eighteen years living in the household, while 5.35% of the responding households had a least one infant (a child under one year of age) living in the household.

Data on the race of the respondents was collected with the goal of comparing this study's results with previous research that indicates that Non-Caucasians tend to have higher discount rates than Caucasians, even when other socioeconomic characteristics such as income and education are held constant. We are also interested in whether or not a respondent's race has a significant effect on his willingness-to-pay for groundwater protection. However, given the demographics of small, rural Western Massachusetts towns, the results from these hypotheses tests will not be reliable; only 2.94% of survey respondents were Non-Caucasian.

It is useful to compare the sample of survey respondents to that of the general public in the four Western Massachusetts counties of interest. Table 8.3, located at the end of this chapter, provides a summary of the socioeconomic characteristics of interest for the four counties based on U.S. Census data. The Census does not provide median

and mean age estimates in the county population estimates, but a frequency distribution of age is available. A quick comparison of the summary statistics for this study's sample and a random sample of Western Massachusetts residents suggests that this study's sample does not reflect the general population. For example, the median age of survey respondents was 52.16 years, while the median age in all four Western Massachusetts counties is well below 44 years. However, the frequency distribution of age from the Census includes Western Massachusetts residents under the age of eighteen; these individuals were not included in the target sample for this study. While 63.78% of survey respondents attained at least a college education, the mean percentage of persons with at least a college education is 23.65% for the four counties. The survey respondents also appear to be wealthier on average than the typical Western Massachusetts resident. On average, 5.75% of Western Massachusetts residents are Non-Caucasian, while only 2.94% of the survey respondents were Non-Caucasian. Approximately 47.77% of the residents of the four Western Massachusetts counties are male, but 66.2% of the survey respondents were male.

However, when considering the differences between the summary statistics reported in Table 8.3 (US Census) and those reported in Table 8.2 (this study), one must remember that the goal of this study was not to survey the general public in Western Massachusetts, but rather to survey Western Massachusetts residents that use a privately-owned well for their primary drinking water supply. It is reasonable to believe that individuals who use a private well as their primary source of drinking water are more likely to be older, affluent, well-educated homeowners than persons in the general population. It is also not surprising that most of the respondents to this survey were male.

If we consider that traditional gender roles may often continued to be assumed in the typical rural family, it is likely that the male head of household is more knowledgeable about the mechanics of the household's drinking water supply and thus may have been the more likely partner to respond to the survey. Also, the household's mail is often primarily in the male head of household's name. For example, in many households, telephone and utility accounts (e.g. electricity, gas, etc.), as well as other financial accounts, are often listed solely in the male head of household's name. Thus, we make no argument that the results of this study reflect the preference of the general public in Western Massachusetts or that they can be extrapolated to that population.

8.2.2 Attitudes towards Groundwater Quality Issues

Table 8.4, located at the end of this chapter, summarizes the data collected from the survey respondents about their primary water supply, feelings about groundwater quality (including their perception of the current quality of their own water), knowledge about groundwater quality issues, and actions the household may have taken to prevent groundwater contamination. All of these variables were coded as dummy variables. These variables were collected to examine their effect, if any, on the respondent's valuation of groundwater protection programs.

The first survey question regarding groundwater quality issues asked the respondent to indicate the household's primary source of water (see Appendix C, Figure C.2, Question 6). All returned surveys that indicated the household's source of water was not either a private spring, well, or artesian well were excluded from the sample. Slightly less than 1% of the sample households (5 respondents) were unsure of their primary water source.

Respondents were also asked to indicate whether or not their local government had established a groundwater protection district (see Appendix C, Figure C.2, Question 7). Thirty-nine percent of respondents believed that a groundwater protection district had been established, and about 13% of the respondents believed that a groundwater protection district had not been established in their community. Almost half of the respondents (47.57%) were uncertain whether a groundwater protection district had been established in their community. Of the 231 respondents that claimed to know whether or not a groundwater protection district had been established in their town, 59.31% respondents correctly indicated whether or not a groundwater protection district had been established.

The survey asked households if their drinking water had been tested within the past five years (see Appendix C, Figure C.2, Question 8). 44.2% of the responding households had their water tested within the past five years, 53.6% had not had their water tested, and 2.2% were uncertain whether their household's water had been tested within the past five years. Respondents were also asked to rate the current quality of their household's water; the possible ratings were "very pure", "quite pure", "just adequate for drinking", and "contaminated" (see Appendix C, Figure C.2, Question 9). The majority of respondents felt quite confident about the quality of their water; 32.24% of the responding households rated their current water quality as "very pure" and 52.65% felt their water was "quite pure". However, 14.08% of respondents indicated their water was "just adequate for drinking", and 1.02% felt their water was "contaminated".

Respondents were also asked to indicate any changes in their water quality over the past year (see Appendix C, Figure C.2, Question 10). The intent of this question was

to identify respondents who were experiencing water quality problems during the time period in which they received the groundwater quality survey; such problems could significantly affect willingness-to-pay for groundwater protection. Most of the respondents (82.3%) did not observe a change in their water quality. A small percentage of respondents (4.02%) felt that their water quality had worsened over the past year and a small number (4.83%) felt their water quality had improved over the past year. Almost nine percent of the respondents were uncertain about changes in their water quality over the past year.

The survey asked the respondents to indicate the entity they believe is primarily responsible for the quality of their household's well water (see Appendix C, Figure C.2, Question 11). Since the sample was restricted to private well owners, the respondents are primarily responsible for the quality of their well water. However, it is possible that many households that have a private well as their primary source of water may not realize that they must be vigilant about their water quality; they may believe that the government also concerns itself with the quality of their well water. Most of the responding households (81.47%) realized that responsibility for their well water quality falls primarily upon them. However, a small percentage of responding households felt that primary responsibility for their water quality fell upon some form of government; 5.09% cited the town, 1.02% cited state government, and 0.41% cited the federal government. These results suggest that groundwater education efforts may be desirable in an effort to ensure that private well-owners are fully aware of the active role they must take regarding their well water quality.

Respondents were asked to indicate any measures they had taken within the past 5 years to protect their water quality (see Appendix C, Figure C.2, Question 12). The survey asked specifically about measures taken to reduce the household's risk of exposure to groundwater contamination in an effort to avoid the inclusion of activities that were primarily related to improving the taste of water. Households that have engaged in averting behavior within the past five years may have significantly different willingness-to-pay values for groundwater protection than households that have not taken such measures. The respondents indicated that they engage in significant averting behavior: 25.5% of responding households had installed a water filtration device, 4.65% had installed a new well, 3.03% had boiled tap water, 14.14% had purchased bottled water, 6.26% had limited the amount of water consumed and 10.51% had taken some other measure within the past five years to reduce the risk of groundwater contamination. Respondents were also asked to indicate how concerned they were about the quality of their well water (see Appendix C, Figure C.2, Question 13); 36.67% stated they were "very concerned", 36.78% stated they were "somewhat concerned", and 26.87% said that they were "not concerned". The hypothesis that the household's level of concern is related to willingness-to-pay for groundwater project will be tested in the econometric estimation.

The level of knowledge about one's well water quality and about the adverse health effects that may stem from groundwater contamination may affect an individual's willingness-to-pay for groundwater protection. When survey respondents were asked if they felt that they had enough information about the quality of their well water (see Appendix C, Figure C.2, Question 14), 33.6% indicated that they felt that had enough

information, 35.85% indicated that they have some information, but not as much as they would like, and 30.55% indicated that they did not have enough information.

Respondents were also asked to indicate if they felt that they were knowledgeable about the possible adverse health effects of groundwater contamination (see Appendix C, Figure C.2, Question 15); 23.53% stated that they felt “very knowledgeable”, 54.36% indicated that they were “somewhat knowledgeable”, and 22.11% stated that they felt that had “very little knowledge” about the health effects of groundwater contamination.

These results suggest that groundwater education, and perhaps subsidized water quality tests, are deserving of serious consideration; a majority of Western Massachusetts residents desired further knowledge about water quality issues.

8.2.3 Attitudes towards Risk-Money Trade-offs

Individuals may be reluctant to make conscious trade-offs between risks and income, balking at the idea of accepting a small increase in risk in exchange for increased income. This may be especially true when the risks being valued are health-related; individuals may feel that they should not be compensated for a loss of human life. In an effort to identify individuals that appear unwilling to make such trade-offs, survey respondents were presented with the following statement in Question 16 of the survey (see Appendix C, Figure C.2):

I am willing to accept a very small health risk increase if it means that some additional money would be available for my personal use.

Respondents were then asked to indicate whether they “strongly agree”, “agree”, “disagree”, “strongly disagree” with, or are “uncertain” about, this statement.

Respondents were reluctant to acknowledge a conscious willingness to make risk-money

trade-offs; 2.05% indicated that they “strongly agreed” with the statement and 10.47% of respondents indicated that they “agreed” with the statement, while 36.35% of respondents indicated that they “disagreed” with the statement and 37.78% indicated that they “strongly disagreed” with the statement. Many respondents (13.35%) felt “uncertain” about the statement. A set of hypothesis tests was performed to test for differences in the means of respondent characteristics between those that “strongly disagreed” or “disagreed” with the above statement, and those that “strongly agreed” or “agreed” with the above statement. The results of these hypothesis tests are presented in Table 8.5, located at the end of this chapter. The null hypothesis of equality can be rejected for four variables: age, gender, race, and strong agreement with the statement that “technology will develop to eliminate many types of groundwater pollution problems within the next 50 years” (the fourth variable is discussed in detail in the next section of this chapter). Respondents who indicated unwillingness to make trade-offs between levels of health risks and money by disagreeing, or strongly disagreeing, with the above statement were significantly younger (mean age of 50.87 years) than those who strongly agreed, or agreed, with the above statement (mean age of 55.18 years). The group of respondents who indicated that they were unwilling to make trade-offs between their level of risk and income had a significantly smaller percentage of racial minorities (1.74% Non-Caucasian) than the group who indicated that they would consider such trade-offs (6% Non-Caucasian). The percentage of women respondents was significantly higher in the group of respondents that stated they were unwilling to make risk-income trade-offs (36.36% female) than in the group who appeared more willing to consider trading off money with their level of risk (26.05% female). Finally, the group of respondents who

indicated they would not make risk-money trade-offs had a significantly lower percentage of respondents that strongly agreed that technology is the solution to future groundwater pollution problems (7.22%) than the group of respondents who stated they were more apt to make risk-money trade-offs (12.7%).

8.2.4 Beliefs about the Role of Technology

Cropper et al. (1991) found that many people expressed an infinite discount rate. The results of the Cropper et al. study suggest that many people felt that they would always choose a present-oriented life-saving program over a future-oriented life saving program because, somehow, technology would develop in the future to address possible threats to human life. This study uses a modified version of the elicitation question used in Cropper et al. (1991), and consequently, we also included a question designed to identify individuals that pin their hopes on the development of technology to solve the groundwater pollution problems of the future in the survey. Respondents were presented with the following statement in Question 17 of the survey (see Appendix C, Figure C.2):

Technology will develop to eliminate many types of groundwater pollution problems within the next 50 years.

Respondents were then asked to indicate whether they “strongly agree”, “agree”, “disagree”, “strongly disagree” with, or are “uncertain” about the statement. The data collected via this study’s survey instrument suggests that this sample may be similar to Cropper et al.’s in its optimism about technology; 8.96% “strongly agreed” and 36.66% “agreed” with the statement. Such individuals may have significantly lower values for programs that address health risks in the future than they do for programs that have more immediate benefits. However, a substantial number of respondents did not share the

same confidence that technology would solve future problems; 19.35% “disagreed” and 6.31% “strongly disagreed” with the statement. A large number of respondents (28.72%) were “uncertain” about the statement. Hypothesis tests were performed to determine if there are significant differences in the means of respondent characteristics for respondents who are “pro-technology” versus those that were not. For ease of discussion, a respondent is considered “pro-technology” if he strongly agreed or agreed with the above statement. The results of the hypothesis tests are presented in Table 8.6 at the end of this chapter. We can reject the null of equality of the means for five variables: age, gender, whether or not the respondent has a graduate level degree, the number of children over one year of age living in the household, and whether or not the respondent is willing to make trade-offs between health risks and money. Respondents that expressed strong faith in the ability of technology to address future groundwater pollution problems were significantly older (their mean age is 53.23 years) than respondents who disagreed or strongly disagreed with the above statement (their mean age is 50.93 years). There was a significantly lower percentage of females in the “pro-technology” group; 28.57% of the pro-technology group is female, while 37.6% of the respondents in the remainder of the sample are female. Respondents with a graduate level education represented a significantly lower percentage of respondents in the pro-technology group (16.98%) than in the rest of the sample (27.09%). The mean number of children living in the households where the respondent expressed pro-technology beliefs (mean = 0.61 children) was significantly lower than the mean number of children in households where the respondent did not express such beliefs (mean = 0.77 children). Finally, the percentage of respondents that stated they were unwilling to make trade-offs between

health risks and income was significantly lower in the “pro-technology” group (68.64%) than in the remainder of the sample (78.57%).

8.3 Preferences for Present- Versus Future-Oriented General Life-Saving Programs

Implicit discount rates were calculated from responses to the modified Cropper et al. (1991) question. This question is presented in Figure 8.1, located at the end of this chapter. Recall that X in the question in Figure 8.1 represents time horizon; time horizons of 10, 25, and 50 years were used. Approximately one-third of the sample received the same time horizon. Six hundred and sixty-two of the mailed surveys had a time horizon of 10 years; 172 of these surveys were returned. Six hundred and sixty-seven of the mailed surveys specified a time horizon of 25 years; 188 of these surveys were returned. Six hundred and sixty-five of the mailed surveys used a time horizon of fifty years; 144 of these surveys were returned.

8.3.1 Responses to the Valuation of Two General Life-Saving Programs

Table 8.7, presented at the end of the chapter, summarizes responses to the survey question that was modified from Cropper et al. (1991). Five hundred and four surveys were returned. However only 458 of the survey respondents made a choice between Programs A (the present-oriented life-saving program), and B (the future-oriented life-saving program); 9.13% of the sample did not indicate their preferred program. This is not surprising, as participants in both the actual mail survey and pre-test sessions expressed extreme discomfort with this question. Thirty-four of the respondents to the mail survey indicated some sort of difficulty or objection to the question in the section of the survey that gave the respondent the opportunity to express comments and concerns.

Transcripts from the pre-test sessions are presented in Appendix A; the reader can see the reactions of the pre-test subjects to this question. Of those respondents who did choose between the two programs, 61.35% chose Program A and 38.65% chose Program B.

After choosing between Programs A and B, respondents were asked to indicate their level of indifference between the two programs. For example, if the individual chose Program A, she was asked how many lives Program B would have to save for her to be indifferent between the two programs. However, 21.43% of the total number of respondents did not indicate their point of indifference between the two life-saving programs. 62.61% of the respondents who chose Program A indicated that they would never choose Program B (suggesting an infinite discount rate), while 35.44% of the respondents who chose Program B indicated that they would never choose Program A (suggesting a negative discount rate).

Hypothesis tests were performed to determine if the means of the respondents' socioeconomic characteristics are the same for those who would choose between Program A and Program B, and those who would not make such a choice. For ease of discussion, these two groups will be referred to as "choosers" and "non-choosers", respectively. The socioeconomic characteristics examined were the respondent's age, gender, race, and education level, as well as the household's income level, the total number of persons living in the household, the total number of children (age ≥ 1 year) living in the household, and the total number of infants living in the household (age < 1 year). The respondent's beliefs about the role of technology were also included in the hypothesis test (see section 8.2.4 for further description of these variables). The results of these hypothesis tests are summarized in Table 8.8, presented at the end of the chapter.

The null hypothesis to be tested is that the means of the socioeconomic characteristics are the same for choosers and non-choosers, i.e. not significantly different from each other. As can be seen from Table 8.8, we fail to reject the null hypothesis for most characteristics. However, non-choosers (with a mean age of 57.24 years) are significantly older than choosers (with a mean age of 51.72 years). In addition, a significantly greater percentage of choosers (37.78%) than non-choosers (24.39%) agree that technology will develop in the future to address many types of groundwater pollution problems. This faith in technology may make it easier for individuals to choose between present- and future-oriented life-saving programs if such faith in the ability of technology to address groundwater pollution problems in the future also extends to other future threats to human health and safety. Finally, it appears that choosers have a higher percentage of people whose highest level of education attained is middle school than non-choosers. However, this result is to be viewed with skepticism because of the very small number of respondents with who fall into this category.

A second set of hypothesis tests examine whether there are differences in the characteristics of those respondents who indicated a point of indifference between Program A (the present-oriented program) and program B (the future-oriented program), and those respondents who failed to indicate their point of indifference. The results of these hypothesis tests are presented at the end of this chapter in Table 8.9. Again, the null hypothesis is that the mean characteristics are the same for the two groups of respondents - - those that did indicate a point of indifference between Program A and Program B, and those that did not. The results of the hypothesis tests show that we can only reject the null hypothesis for one variable, the age of the respondent. Respondents

that did not indicate a point of indifference between Program A and Program B are significantly older (their mean age is 54.25 years) than respondents that did indicate their point of indifference between Program A and Program B (these respondents have a mean age of 51.62 years). For all other variables, there is no significant difference in the mean characteristics of those that did indicate their indifference point and those that did not.

A final set of hypothesis tests examines if there is a significant difference in the mean characteristics of those respondents willing to make trade-offs between savings lives now and saving lives in the future, and those who said they would never choose Program B (the future-oriented life-saving program). The results of these hypothesis tests are presented in Table 8.10. We reject the null hypothesis of no difference in the means for four variables: age, gender, race, and “pro-technology” beliefs. Respondents that indicated they would never choose the future-oriented life-saving program, no matter how many lives it saved, were significantly older (with a mean age of 53.32 years) than those who did not indicate unwillingness to choose the future-oriented program (with a mean age of 49.15 years). Males were much more likely than females to indicate that they would never choose Program B; only 22.76% of the respondents who would never choose Program B were female, while females represented 40.91% of the remainder of the sample. Interestingly, all of the minority respondents that indicated a choice between the two programs chose Program A and indicated they would never choose program B, suggesting they have an infinite rate of discount. This finding is not surprising given Cropper et al.’s findings (1991, 1994) that Non-Caucasians have higher discount rates than Caucasians. However, minorities were such a small percentage of the total number of respondents that this result is likely to be unreliable. Of the respondents who stated

they would never choose Program B, 40.41% agreed with the statement that “technology will develop to eliminate many types of groundwater pollution problems within the next 50 years”. Only 27.91% of the respondents who did not indicate that they would never choose Program B agreed with this statement. Thus, it appears that beliefs that technology will develop to address future groundwater pollution problems may also extend to other future threats to human health and safety; respondents who hold such beliefs appear more likely to choose the present-oriented program.

Age appears to play a role in the individual’s response to both the choice between the two life-saving programs and the indication of his point of indifference between these two programs. In addition, respondents who are unwilling to choose the future-oriented program under any circumstances are significantly older than the remainder of the sample. It is not clear why age plays a role here. One may argue that older respondents are more likely to be confused by the survey. However, the average age of respondents who did not respond to these particular items is in the mid-to-late 50s; it is unlikely that cognitive abilities are impaired in most of these respondents. A second possible explanation is that the value one places on future-oriented programs is related to one’s expected number of remaining years of life; older individuals may not be alive to enjoy the benefits of future-oriented programs. Thus, older respondents may be more likely to favor present-oriented programs than their younger counterparts. We shall further explore the influence of age on preferences for particular programs and implicit discount rates shortly.

8.3.2 Implicit Discount Rates for General Life-Saving Programs

Implicit discount rates for the general life-saving programs were calculated from responses to the valuation question modified from Cropper et al. (1991); the modified question is presented in Figure 8.1 at the end of this chapter. The calculations assume a linear, additive, and separable utility function, as well as constant exponential rate discounting. The implicit discount rates were calculated using the following formula:

$$MRS = e^{-dX} \quad (8.1)$$

where d is the implicit discount rate, MRS is the marginal rate of substitution between lives saved today and lives saved at some future date, and X is the specific future date involved (i.e. 10, 25, or 50 years). For example, suppose an individual chose Program A, which saves 100 lives now, over Program B, which saves 200 lives in 50 years. Suppose further that he then indicated that Program B would have to save 500 lives in 50 years for him to be indifferent between Program A and B. This implies

$$U_A = U_A(100L_t, 0L_{50}) \quad (8.2)$$

$$U_B = U_B(0L_t, 500L_{50}) \quad (8.3)$$

where U_A is the utility of Program A and U_B is the utility of Program B if it saves 500 lives in 50 years. Calculating the difference in the utilities of the two programs yields:

$$dv = U_A - U_B = 100L_t - 500L_{50} \quad (8.4)$$

Setting dv equal to zero to indicate the respondent's point of indifference yields:

$$100L_t = 500L_{50} \quad (8.5)$$

This implies that 1 life saved today is equal to 5 lives saved in 50 years. Thus the MRS is:

$$MRS = \frac{L_{50}}{L_t} = \frac{1}{5} \quad (8.6)$$

Thus, assuming constant exponential discounting, we substitute into equation 8.1 for the marginal rate of substitution and time horizon:

$$\frac{1}{5} = e^{-50d} \quad (8.7)$$

Rewriting to solve for d yields:

$$d = \frac{\ln(1) - \ln(5)}{50} \quad (8.8)$$

Thus, in this case, d is approximately 3.22%.

The estimated mean implicit discount rates are presented at the end of this chapter in Table 8.11. Table 8.12 presents the summary statistics for the estimated discount rates (mean, median, standard deviation, minimum, maximum, and 95% confidence intervals for the mean). The average rates are obtained by pooling the responses of those who choose Program A and those who chose Program B. The overall rates are obtained by pooling the three time horizons.

The estimated mean discount rates for the ten year, twenty-five year, and fifty year time horizons are 10.35%, 2.9%, and 3.82%, respectively. However, the estimated mean discount rates for the twenty-five and fifty-year time horizons are not significantly different from each other. Thus, assuming that respondents' discount rates are normally distributed, we can reject the null hypothesis of constant rate exponential discounting based on the estimated mean discount rates for the 10 and 25 year time horizons, but

cannot reject the null hypothesis of constant rate exponential discounting based on the mean estimates for the 25 and 50 year time horizons. For those respondents that chose Program A (the present-oriented program), the estimated mean discount rates for the ten year, twenty-five year, and fifty year time horizons are 26.3%, 9.42%, and 6.56%, respectively. Mean implicit discount rates were also estimated for those respondents that chose Program B, the program that saved lives at some future date; these rates are – 0.997%, -2.085%, and -0.234% for the ten year, twenty-five year, and fifty year time horizons, respectively. All estimated mean implicit discount rates are significantly different from zero except for the rates for the ten year, twenty-five year, and fifty year time horizons that were elicited from individuals that chose Program B, the program that saved lives at some future date.

The estimated median implicit discount rates for the ten year, twenty-five year, and fifty year time horizons are 0%, 0%, and 3.22%, respectively. For those respondents that choose Program A, the present-oriented program, the estimated median discount rates for the ten year, twenty-five year, and fifty year time horizons are 23.03%, 9.21%, and 4.61%, respectively. For those respondents that chose the future-oriented program, Program B, the estimated median discount rate is 0% for all three time horizons. The lowest discount rate expressed by an individual was -52.49%, while the highest was 85.17%. However, this range does not include respondents who suggested that they have an infinitely positive discount, by indicating that they would never choose Program B (the future-oriented program), or those respondents who suggested that they have an infinitely negative discount rate, by indicating that they would never choose Program A

(the present-oriented program), because one cannot estimate an implicit discount rate for such individuals.

We can see from the estimated median implicit rates of discount that many respondents expressed discount rates of zero, or negative discount rates. A zero discount rate implies that the individual values present and future benefits equally, while a negative discount rate suggests that the individual places greater value on future benefits than on present benefits. Information concerning the percentages of respondents expressing zero and negative discount rates is summarized in Table 8.13, located at the end of this chapter. A total of 191 respondents indicated their point of indifference between Program A and B; 39.23% of these respondents indicated that they had a discount rate of zero, while 9.9476% indicated that they had a negative discount rate. Of the seventy-seven respondents who were presented with a time horizon of 10 years and indicated a point of indifference between Programs A and B, 45.5% expressed a discount rate of zero, and 7.79% expressed a negative discount rate. Sixty-seven of the respondents presented with a time horizon of 25 years provided their point of indifference between Programs A and B; 43.28% indicated a discount rate of zero and 13.43% indicated a negative discount rate. Of the forty-seven respondents who were presented with a 50-year time horizon and indicated their point of indifference, 23.4% suggested that they have a zero discount rate and 8.51% suggested they have a negative discount rate. These results suggest that, in the context of life-saving programs, many individuals may place equal weight on saving lives in the future as they do on saving lives immediately. A small percentage of respondents appear to place greater weight on saving future lives than they do on saving present lives.

Let us compare this study's results with the results of Cropper et al. (1991, 1994). Cropper et al. (1991) estimated mean discount rates of 8.6%, 6.8%, and 3.4% for the 25 year, 50 year, and 100 year time horizons, respectively. In Cropper et al.'s 1991 work, the estimated means were all significantly different from each other, allowing rejection of the null hypothesis of constant rate exponential rate discounting in all cases. In their later work, Cropper et al. (1994) used the same framework to elicit discount rates with a larger sample. The estimated median discount rates for the 5, 10, 25, 50, 100 year time horizons are 16.8%, 11.2%, 7.4%, 4.8%, and 3.8%, respectively. The mean and median rates of discount estimated by Cropper et al. (1991, 1994) are generally somewhat higher than those estimated by this study. This may be due in part to the presence of more minorities in the Cropper et al. sample, as there is substantial evidence that Non-Caucasians have significantly higher rates of discount than Caucasians (Cropper et al., 1991, 1994; Leigh, 1986; Lawrence, 1991; Kurtz et al., 1973). Cropper et al. (1991, 1994) also found that about 10% of respondents had negative discount rates. This study's findings are very similar to those of Cropper et al. (1991) with respect to negative discount rates; 9.95% of this study's respondents expressed negative discount rates.

Cropper et al. (1991, 1994) cited individuals' faith in the role of technology to address future programs as one reason individuals offered for expressing high or infinite discount rates. In our study, respondents were given the opportunity to provide written comments on different aspects of the survey. Thirteen respondents (12 males and 1 female) made explicit reference to technological progress in the context of the survey question that elicited preferences for present and future oriented life-saving programs. Their comments are presented in Table 8.14, located at the end of this chapter. Mean

implicit discount rates for life-saving programs were then re-estimated, eliminating these thirteen respondents from the sample; this resulted in a sample of 491 observations. The elimination of these thirteen respondents changes the estimated mean discount rates only very slightly; these rates are not significantly different from those presented in Tables 8.11 and 8.12. Another option would be to re-estimate the implicit discount rates, eliminating all the “pro-technology” respondents. However, this option was not explored because almost half of the respondents (45.62%) indicated “pro-technology beliefs”; removing the “pro-technology” respondents would drastically reduce the sample size.

8.3.3 Econometric Models of Discounting Behavior

In addition to the estimation of implicit discount rates elicited from the respondent’s preferences for a program that saves lives now versus a program that saves lives at some future date, econometric models were estimated in an attempt to shed light on discounting behavior. Specifically, we are concerned with the influence the respondent’s socioeconomic characteristics, attitudes towards risk-money trade-offs, and beliefs about technology may have on his discount rate, and the hypothesis that the discount rate declines linearly with time.

However, before choosing which explanatory variables to include in the econometric estimations, it was necessary to examine the correlations between variables. Table 8.15, located at the end of this chapter, presents the Pearson correlation coefficients for the explanatory variables of interest. Many of these correlation coefficients are significantly different from zero. In particular, the total number of persons living in the household is highly positively correlated with the number of children (age greater than or equal to 1 year) living in the household ($r = 0.81$). Thus, we choose to include a dummy

variable for the presence of at least one child or infant in the household. In addition, we excluded the variable representing the number of persons living in the households, which is insignificant, from the final estimation; excluding this variable does not significantly change the parameter estimates of the remaining explanatory variables. While many other correlations are significantly different than zero, they do not appear large enough to cause serious multicollinearity problems. Thus, the explanatory variables chosen for inclusion in the estimations were the respondent's age, gender, whether or not the respondent is a member of a minority racial group, whether or not he or she had attained at least a college education, household income, whether or not there was at least one child living in the household, whether or not the respondent expressed strong faith in the ability of technology to address future groundwater pollution programs, whether or not the respondent expressed unwillingness to make trade-offs between levels of health risk and income, and the time horizon of the future life-saving program.

First, we model the probability that the respondent will never choose the future-oriented program (Program B), i.e. the probability that he is unwilling to make trade-offs between saving lives in the present and in the future. Such unwillingness suggests an infinite discount rate. Table 8.16, presented at the end of this chapter, contains the results of the binary logistic estimation. This model has weak overall significance; a log likelihood ratio test indicates that we cannot reject the null hypothesis that all the slope coefficients are equal to zero at the 5% significance level (χ^2 p-value = 0.07). However, two explanatory variables proved to be significant at the 10% significance level or less – the respondent's gender (χ^2 p-value = 0.05) and beliefs about the ability of technology to address future pollution problems (χ^2 p-value = 0.07). A woman is approximately 50%

less likely to indicate unwillingness to trade-off present and future lives (or an infinite discount rate) than her male counterpart, holding all other variables constant.

Respondents who “agree” and “strongly agree” that “technology will develop to eliminate many types of groundwater pollution problems within the next 50 years” (Question 17 of all versions of the survey) are 1.74 times more likely to indicate that they will never undertake the future program than those without such strong faith in the role of technology, all other variables held constant. Note that the variable to indicate that a respondent is a member of a minority racial group is not included in this estimation because all of the minority respondents indicated that they would never choose Program B. If we evaluate the logit at the means of all explanatory variables, we estimate that the probability the average respondent will express complete unwillingness to sacrifice present lives for future lives is 0.62. This probability is quite large, but not surprising given the significant effects of gender and pro-technology beliefs; 66.2% of the sample was male and 45.6% of the sample expressed pro-technology beliefs. The mean of the estimated sample probability that respondent is unwilling to make trade-offs between present and future lives is 0.60, while the mean actual sample probability that the respondent is unwilling to make such trade-offs is 0.63. Thus, the model presented in Table 8.16 appears to have considerable predictive capabilities despite its lack of overall significance. In addition, the Hosmer-Lemeshow test (discussed in detail below in section 8.4.3) suggests that the fit of the model is adequate (χ^2 p-value=0.33).

Secondly, we estimate a linear discount function using ordinary least squares regression. The linear discount rate model assumes that the slope of the discount function is constant for all respondents. Cropper et al. (1994) note that this type of model

can be viewed only as an approximation to the discount rate function, since it will eventually imply negative discount rates. The following equation was estimated:

$$\mathbf{d}_i = \mathbf{b}_0 + \mathbf{b}_1 \mathit{age}_i + \mathbf{b}_2 \mathit{female}_i + \mathbf{b}_3 \mathit{racial}_i + \mathbf{b}_4 \mathit{highed}_i + \mathbf{b}_5 \mathit{income}_i + \mathbf{b}_6 \mathit{child}_i + \mathbf{b}_7 \mathit{protech}_i + \mathbf{b}_8 \mathit{notradeoffs}_i + \mathbf{b}_9 t_i + \mathbf{e}_i \quad (8.9)$$

where \mathbf{d} is individual i 's discount rate and t is the time horizon individual i was presented with in the modified Cropper (1991, 1994) question. We are particularly interested in testing the hypothesis that $\mathbf{b}_9 < 0$; i.e. that the discount rate declines linearly with the time horizon involved. The results of this ordinary least squares estimation are presented in Table 8.17 at the end of this chapter. As indicated by the p-value of 0.17 for the F -test of overall significance, we fail to reject the null hypothesis that all the coefficients on the explanatory variables are jointly equal to zero. However, the coefficient on t , the time horizon, is negative ($b_9 = -0.002$) and statistically different from zero (p-value=0.002); suggesting that if we hold the respondent's characteristics constant, a one year increase in the time horizon leads to a 0.2% fall in the discount rate. If we hold the respondents' characteristics constant at their means, we are able to predict the discount rate for any time horizon; the linear model's predictions are presented in Table 8.18 at the end of this chapter for the 0 year, 10 year, 25 year, and 50 years time horizons. The estimated discount rates from the linear model are $\mathbf{d}^*(0) = 11.85\%$, $\mathbf{d}^*(10) = 9.88\%$, $\mathbf{d}^*(25) = 6.93\%$, $\mathbf{d}^*(50) = 2\%$. Using this estimated function, we obtain a mean discount rate of zero at 60.17 years.

Let us compare this study's results regarding the effect of respondent characteristics on the discount rate with those obtained by Cropper et al. (1991, 1994). In both their studies, Cropper et al. found certain socioeconomic characteristics did indeed

have an effect on the discount rate. In 1991 Cropper et al. found that the discount rate declines with age, that Non-Caucasians have higher rates of discount than Caucasians, and that respondents with children under the age of 18 have higher rates of discount than those without young children. Income and education levels were found to have no significant effect on the discount rate. In 1994, Cropper et al. extended their prior work, estimating two linear discount rate functions, one for time horizons of five and ten years, and one for time horizons of twenty-five and one hundred years. They found that age and race continued to be significant factors in the individual's rate of discount. In the model estimated for time horizons of five and ten years, respondents with children under the age of 18 had significantly higher discount rates than those without young children. However, in the model estimated for time horizons of twenty-five and one hundred years, Cropper et al. found no significant difference in the discount rates of those with and without young children. They speculate that parents may be more concerned about protecting their children while they are young. In twenty-five years or more, their children will be adults that are, in theory, capable of taking care of themselves. Another possible reason for this result is that many parents believe that children are more vulnerable to the adverse health effects associated with groundwater contamination than adults. With respect to the effect of income and education on the discount rate, Cropper et al.'s 1994 results echoed their earlier work; income and education did not have a significant effect on the discount rate.

This study finds that all the included respondent characteristics (age, race, level of education, income, having children under the age of 18, having pro-technology beliefs, and an unwillingness to make trade-offs between health risks and income) did not have a

significant effect on discount rates in the linear discount model. Our findings concur with those of Cropper et al. (1991, 1994) for the effect of income and education, but contradict Cropper et al.'s results with respect to the effects of age, race, and whether or not one has children under the age of 18. We expected that age would positively and significantly affect the respondent's discount rate, and were surprised to find that the coefficient on age in the linear discount model did not have the expected sign and was insignificant. However, we suspect this may be partially due to the fact that we were unable to calculate a discount rate for three groups of respondents: those who did not choose between the two programs, failed to indicate their point of indifference between the two programs, or indicated that they would never choose the future-oriented program. The respondents in these groups were significantly older than the rest of the sample (see Tables 8.8-8.10). Our inability to include these respondents in the linear discount rate model may explain the unexpected and insignificant coefficient for age. In addition, we speculate that this study's sample may have been more homogeneous than the Cropper et al. samples. For example, this study found the coefficient on the racial minority dummy variable to be negative, suggesting that, in contrast to Cropper et al.'s work (1991, 1994) that racial minorities have lower discount rates than their Caucasian counterparts, all else held equal. However, this result is not significant and is to be viewed with considerable skepticism given the very small percentage of minorities in this sample. While Cropper et al. sampled individuals in the general public, this study's sample was restricted to private well-owners.

Cropper et al.'s (1991, 1994) estimated linear discount functions generally predicted higher discount rates than this study's model. In 1991, they estimated discount

rates for the 0, 50, and 100 year time horizons, of 8.7%, 5.2%, and 1.7%, respectively. After eliminating respondents who refused to choose the future-oriented program, under any circumstances, the estimated discount rates for the 0, 50, and 100 year time horizons fell to 7%, 3.5%, and 0%, respectively. In 1994, Cropper et al. discovered that the coefficient on the time horizon differed dramatically between the model estimated for horizons of 5 and 10 years, and the model estimated for 25 and 100 years. The slope of the function estimated for the shorter time horizons was much steeper than the slope of the function estimated for the longer time horizons; the former model resulted in a mean discount rate of 0% at 11.65 years, while the latter model did not yield a mean discount rate of 0% until 122 years. Although this study's model cannot be compared directly with the Cropper et al. model (1994), it is encouraging to note that this study's model, estimated from time horizons of 10, 25, and 50 years, yields a discount rate function whose "steepness" falls between the two models Cropper et al. estimated from short (5, 10 years) and long time horizons (25,100 years).

8.4 Valuation of Groundwater Protection Programs

We now turn to the valuation of the groundwater protection programs. Each respondent was asked to evaluate a status-quo scenario of no groundwater protection and four proposed groundwater protection programs. Each groundwater protection program is characterized by four attributes: a one-time cost for the program that is paid this year, a risk reduction this year, a risk reduction in ten years, and the extent of protection. The risk reduction is the difference in the probability of exposure to unsafe levels of chemical contaminants in the household's well water under the status quo and under the proposed program. The status quo, or baseline, risks of exposure to unsafe levels of chemical

contaminants are the same for each respondent: 20/1000, or 2%, this year and 30/1000, or 3%, ten years from now. The attribute “extent of protection” has two levels—a groundwater protection program protects either the respondent’s household only or all Massachusetts residents.

The responses to the four different protection programs were pooled, and dummy variables were used to differentiate between the various groundwater protection programs. Two of the four programs presented to each individual protect the individual’s household only and are essentially private programs, while the remaining two programs protect all Massachusetts residents and are essentially public programs. Thus, one dummy variable was created to indicate a program that protects all Massachusetts residents. In addition, two of the programs offer the relatively larger risk reduction this year and a smaller risk reduction in ten years, while the other two programs offer a relatively small risk reduction this year and a larger risk reduction in ten years. To examine whether or not individuals had preferences for a present-oriented program versus a future-oriented program, regardless of the absolute size of the risk reductions in both time periods, a dummy variable was created to indicate a program that offers the relatively larger risk reduction in ten years, i.e. a program that emphasizes future risk reductions. If this dummy variable is positive and significant, it may be interpreted as indicating a greater willingness-to-pay for programs that stress reducing risk in the future, independent of the absolute levels of risk reduction this year and in ten years, as well as all other program attributes. Such an effect would suggest a preference for future-oriented groundwater protection programs, regardless of the absolute levels of risk reduction offered this year and in ten years. It is important to note that pooling the

responses in this manner, using only dummy variables to account for program differences, imposes the restriction that all the regression coefficients are equal for both private and public programs. Differences in willingness-to-pay for private versus public programs, and present-oriented versus future-oriented programs, are accounted for only by a parallel shift in the willingness-to-pay function.

Four different econometric models of willingness-to-pay for groundwater protection were estimated. The first two models are contingent valuation models: the familiar traditional dichotomous choice CVM model and the modified dichotomous choice CVM model. Recall that in the modified DC CVM model, the dependent variable takes the value “1” only if the respondent chose the program as the ONE program she would be willing to undertake and be willing to pay for, and gave a certainty rating of at least “8” on a scale on “1” (Very Uncertain) to “10” (Very Certain). Thus, the criteria for a response to be interpreted as a ‘yes’ vote for the program are much more stringent in the modified DC CVM model than in the traditional DC CVM model. The remaining two models are conjoint models. One of these models translates the conjoint ratings data into binary response data; the dependent variable takes on the value “1” if the respondent assigns a rating of “10” to the program and “0” otherwise. This model is also examined for the sensitivity to different ratings “cut-off” points. The other conjoint model also translates the conjoint ratings data into binary response data; in this model the dependent variable takes on the value “1” if the rating given to the alternative program exceeds the rating given to the status quo and “0” otherwise. For the conjoint models, the requirements for a response to be interpreted as a ‘yes’ vote for the program are much stricter in the CJ binary response ratings model with a “cut-off” point of a rating of “10”

than in the CJ binary response ratings difference model, where the rating assigned to the program simply has to exceed the rating assigned to the status quo. Descriptive statistics for the mean of each model's dependent variable are presented at the end of this chapter in Table 8.19.

8.4.1 Model Specification

The probability that the respondent undertakes a groundwater protection program is a function of three sets of variables: the attributes of the program, the respondent's (or household) characteristics, and the respondent's attitudes towards groundwater quality issues. An initial dichotomous choice CVM model included all possible explanatory variables; variables were then eliminated one at a time, based upon a series of log-likelihood ratio tests. The null hypothesis of the log-likelihood ratio test is that $\mathbf{b}_j = 0$.

The log-likelihood ratio statistic is:

$$LR = -2[\ln L_R - \ln L_{UR}] \quad (8.9)$$

where L_R is the likelihood from the restricted model (in which the coefficient on the variable of interest is constrained to be equal to zero), and L_{UR} is the likelihood estimate from the unrestricted, or full, model. The log-likelihood ratio test for maximum likelihood estimation is analogous to the F test in linear regression (Hosmer and Lemeshow, 1989). One restriction was tested at a time; thus, the log-likelihood ratio statistic has an approximately chi-squared distribution under the null hypothesis, with one degree of freedom. The series of log likelihood ratio tests results in the elimination of the following variables: a dummy variable indicating the residence to which the survey was mailed was a vacation home, a dummy variable to indicate the respondent was renting the residence to which the survey was mailed, a dummy variable to indicate the respondent

felt his water quality has worsened over the past year, a dummy variable to indicate that the respondent took some measure to reduce the risk of groundwater contamination in the past five years, the number of people living in the household, the respondent's gender, and a dummy variable to indicate that the respondent had at least a college education. Thus, the final set of models specified the probability of undertaking a groundwater protection program as a function of the variables listed in Table 8.20.

Several dummy variables were included in the model. As noted earlier, two dummy variables were included to account for different types of groundwater protection programs. One of these dummies takes the value "1" if the program protects all Massachusetts residents, and "0" if the program protects the respondent's household only; inclusion of this dummy allows us to test for differences in WTP for private versus public groundwater protection. A second dummy, which takes the value "1" if the risk reduction in ten years is larger than the risk reduction this year and "0" otherwise, allows us to determine if WTP is significantly different for programs that emphasize future risk reduction and programs that emphasize risk reduction this year. The program's other attributes were represented by the continuous variables for the one-time cost of the program (which is to be paid this year), the risk reduction this year, and the risk reduction in ten years.

Dummy variables were also created to represent respondent and household characteristics. Dummy variables that indicate that the respondent is a member of a racial minority group and the presence of a child in the household were included in the estimation. Dummies were also included to indicate either definite or tentative plans to move. The household's income level was also analyzed as a categorical variable based

upon the eleven ranges of income in Question 6 in the section of the survey that collected the household's socioeconomic characteristics (see Appendix C, Figure C.6). Two continuous variables representing respondent and household were also analyzed—the respondent's age in years and the number of years the respondent had lived at the residence to which the survey was sent.

Several dummy variables were created to represent the respondent's attitudes towards groundwater quality issues. Respondents were asked to rate their household's water quality as "very pure", "pure", "just adequate for drinking" or "contaminated" (Question 9 of the survey-see Appendix C, Figure C.2). The model includes a dummy variable that takes on the value "1" if the respondent rated her water as "contaminated" and "0" otherwise; this dummy was included to test if those with perceived water quality problems have significantly different willingness-to-pay values for groundwater protection. Respondents were also asked to indicate their level of concern about the quality of their well water by checking one of three responses "I am very concerned", "I am somewhat concerned", or "I am not concerned" (Question 13 of the survey-see Appendix C, Figure C.2). Using the intermediate response ("I am somewhat concerned") as the reference category, two dummy variables were created for these responses. The survey also asked the respondents "Do you believe that you have enough information regarding about the quality of your well water?" (Question 14 of the survey-see Appendix C, Figure C.2). There were three possible responses: "Yes, I feel that I have enough information", "I have some information, but not as much as I would like", or "No, I do not have enough information". The intermediate response was taken to be the reference category; two dummies were created to indicate the responses of "enough

information” and “not enough information”. Dummy variables were created to represent responses to the question regarding the respondent’s beliefs about her level of knowledge about adverse health effects from groundwater contamination (Question 15 of the survey—see Appendix C, Figure C.2). Respondents were asked to check one of the three following responses: “Yes, I feel that I am very knowledgeable about the health effects of well water contamination”, “I have some knowledge about the health effects of well water contamination,” or “I have very little knowledge about the health effects of well water contamination”. The intermediate response was taken as the reference category. Two dummy variables were created to represent the “very knowledgeable” and “very little knowledge” responses.

Finally, dummy variables were used to keep track of the version of the survey. The reference category was the longest versions of the survey, the CJ / traditional DC CVM / modified DC CVM versions (Versions A and AA). Two dummy variables for the relatively shorter versions of the survey were created; a dummy for the CJ / modified DC CVM versions (Versions B and BB) and a dummy for the traditional DC CVM / modified DC CVM versions (Versions C and CC). In addition, a dummy variable to test for order effects was included; this dummy variable takes the value “1” if the respondents is presented with the two programs that protect all Massachusetts residents first, and the value “0” if the respondent is presented with the programs that protect only his household first.

8.4.1.1 Traditional Dichotomous Choice CVM

The results of the estimation of the traditional, dichotomous choice CVM model are presented in at the end of this chapter in Table 8.21. This estimation used 891

observations. The dependent variable in this estimation is “1” if the respondent undertook the groundwater protection program (439 observations), and “0” otherwise (452 observations). The parameters of the model were estimated using binary logistic regression. The model has overall significance; we may reject the null hypothesis that all the coefficients on the explanatory variables are equal to zero. The effects of the program attributes are generally consistent with economic theory. The size of the present and future risk reductions significantly and positively affect the probability that the respondent undertakes the groundwater protection program. Interestingly, a cursory examination of the model results suggests that respondents may place greater weight on future risk reductions than on present risk reductions. To explore this possibility, the null hypothesis that the coefficient on the present risk reduction equals the coefficient on the future risk reduction was tested. The result of this hypothesis test indicates that we cannot reject the null hypothesis that the two coefficients are equal (see Table 8.25, located at the end of this chapter). Thus, we cannot argue that individuals place greater weight on future risk reductions than on present risk reductions when deciding whether or not to undertake the proposed program. The negative coefficient on the cost variable indicates that as the cost of the groundwater protection program rises, the respondent is less likely to undertake the program. The dummy variable for public programs that protect all Massachusetts residents is positive and significant, suggesting that respondents favor public programs over private measures to reduce risk; the respondents is 1.664 times more likely to undertake the groundwater protection program if it protects all Massachusetts residents than if the program protects only her household. The coefficient on the dummy variable for a program that emphasizes future risk reductions is positive,

but not significant. This suggests WTP for a future-oriented program is not statistically different from WTP for a present-oriented program.

Several respondent characteristics significantly affect the probability that the respondent would undertake the groundwater protection program. As expected, income significantly and positively affects the likelihood that the respondent undertakes the program, suggesting that groundwater protection is a normal good. Members of minority racial groups are significantly less likely to undertake groundwater protection programs, even when holding other socioeconomic characteristics, such as income, constant. The reason for this result is not clear. In addition, this result may not be reliable because the sample contained so few minorities (2.94%). Interestingly, definite or tentative plans to move to another area within the next two years positively and significantly affect the probability that the respondent will undertake the program. Perhaps people believe that they will be able to take private protection systems along with them, or intend to move within Massachusetts, where they would continue to benefit from public forms of protection. Alternatively, perhaps some respondents believe they will be long gone from the area should they actually be asked to undertake some form of groundwater protection program; thus, hypothetical bias may be present in their responses. Finally, respondents who plan to move from their current residence in the near future may be more likely to undertake groundwater protection because they may be selling their home soon and believe that such protection will significantly increase the value of the home. The respondent's age, the presence of a child in the household, and the number of years the respondent has lived at the residence did not significantly affect the probability that the respondent undertakes groundwater protection.

The respondent's level of concern about the quality of his well water, the amount of information he feels he has about his well water quality, and the amount of knowledge he feels he has about potential adverse health effects from groundwater contamination all significantly affect the probability that the respondent undertakes the groundwater protection program. Those who describe themselves as "very concerned" about the quality of their well water are 1.441 times more likely to undertake the groundwater protection program than those who describe themselves as only "somewhat concerned". Respondents were also asked to indicate if they feel that they have enough information about the quality of their well water. A respondent who indicated that he has enough information is significantly less likely to undertake a groundwater protection program than those that indicated that they have some information, but not as much as they would like. A respondent who feels that he does not have enough information about his well water quality is 1.71 times more likely to undertake the groundwater protection program than a respondent who believes that he has some information, but not enough. Finally, respondents that feel they are not knowledgeable about the health effects of groundwater contamination are 0.7 times less likely to undertake groundwater protection programs than respondents who feel that they have some knowledge about the health effects of groundwater contamination.

The traditional, dichotomous choice, contingent valuation model included respondents to Versions A and AA (the traditional DC CVM/ CJ / modified DC CVM versions) and Versions C and CC (the traditional DC CVM / modified DC CVM versions). The dummy variable for the shorter survey versions (traditional DC CVM / modified DC CVM) was negative and significant, indicating that those respondents who

received the version of the survey without the conjoint ratings section are significantly less likely to undertake the groundwater protection program than those who received the versions of the survey that included the conjoint ratings section. However, the dummy variable for order effects is not significant, indicating the order in which the public and private groundwater protections programs are presented to the respondent does not significantly affect the probability that she undertakes groundwater protection.

8.4.1.2 Modified Dichotomous Choice CVM

The modified, dichotomous choice, contingent valuation format requires a much more firm commitment on the part of the respondent to a given groundwater protection program than does the traditional DC CVM format. In order for the response to a particular groundwater protection program to be counted as a 'yes' vote for the program, the respondent had to choose the ONE program she would "undertake and be willing to pay for" in the modified DC CVM format (See Appendix B). In addition, the respondent was asked to indicate her degree of certainty on a scale of "1" (Very Uncertain) to "10" (Very Certain). Only responses with a certainty rating of at least "8" were counted as 'yes' responses in this modified format (53.17% of all respondents who indicated their certainty level gave a certainty rating of at least "8"). This criteria resulted in 163 'yes' votes and 1277 'no' votes, for a total of 1440 observations for the estimation. The parameters of this model were estimated using binary logistic regression.

The results of the estimation are presented at the end of the chapter in Table 8.22. The model has overall significance, leading us to reject the null hypothesis that all the coefficients on the independent variables are jointly equal to zero. The coefficients on the program attributes have the expected signs. The size of the future risk reduction

positively and significantly affects the probability that the respondent will undertake the program. The size of the present risk reduction also positively affects the likelihood the respondent will undertake the program; however, the estimated coefficient is not significant. A test of the linear restriction that the coefficients on the present and future risk reductions are equal indicates that we cannot reject the null hypothesis of equality (see Table 8.25, located at the end of this chapter). Thus, in spite of the difference in the estimated coefficients, we cannot claim that the weight respondents place on risk reductions in ten years is significantly greater than the weight they place on risk reductions this year. The cost of the groundwater protection program negatively and significantly affects the probability that the respondent will undertake the groundwater program protection. The estimated coefficient on the dummy variable for a program that protects all Massachusetts residents is positive and significant; a respondent is 2.93 times more likely to undertake a groundwater protection program that protects all Massachusetts residents, as opposed to her household only. The dummy variable to indicate that the program stressed future risk reduction is not significant. This result indicates that WTP for future-oriented programs is not significantly different than WTP for programs that emphasize immediate risk reduction.

The results of this estimation differ significantly from the estimation of the traditional DC CVM model in that, with one exception, none of the respondent's characteristics significantly affect the likelihood that he undertakes the groundwater program. While the respondent's income positively affects the probability that he undertakes the program, this result is not significant. However, as in the traditional DC CVM model, a respondent who has definite plans to move within the next two years is

significantly more likely (1.8 times as likely) to undertake a groundwater protection program than a respondent who has no plans to move within the next two years. To explain this result, we appeal to the arguments made in Section 8.4.1.1 in the discussion of the results from the traditional DC CVM model. The results of the traditional DC CVM model and the modified DC CVM model differ in that, in the modified DC CVM estimation, none of the variables representing the respondent's attitudes towards groundwater quality issues significantly affect the likelihood that he undertakes groundwater protection. Finally, the estimated coefficients on the dummy variables for the version of the survey the respondent took, and the order in which the groundwater protection programs are presented, are not significant, indicating that these factors do not affect the likelihood the respondent undertakes groundwater protection in the more stringent, modified DC CVM format.

8.4.1.3 CJ Binary Response Ratings Model

The conjoint binary response ratings model is estimated by choosing a "cut-off" rating for which the rating is considered to be a 'yes' vote for the groundwater protection program. In the conjoint ratings portion of the survey, respondents are asked to rate each program, including the status quo scenario, on a scale of "1" (Least Attractive) to "10" (Most Attractive). For this estimation, a rating of "10" for a groundwater protection program was interpreted as a 'yes' vote for the program, while any rating less than "10" was interpreted as a 'no' vote for the program. Thus, the dependent variable in this model is "1" if the respondent assigned a rating of "10" to the groundwater protection program, and "0" otherwise. This coding scheme led to 126 'yes' votes and 811 'no'

votes, for a total of 937 observations. Binary logistic regression was used to estimate the model's parameters.

The results of the estimation are presented at the end of the chapter in Table 8.23. The model has overall significance; we may reject the null hypothesis that the parameters on the explanatory variables are jointly equal to zero. The estimated coefficients on the program attributes have the expected signs and are significant. Both the risk reduction offered by a groundwater protection program this year, and the risk reduction provided in ten years, significantly and positively affect the likelihood that the respondent undertakes the program. While the estimated coefficient for the risk reduction in ten years is greater than the estimated coefficient for the risk reduction this year, a hypothesis test of the equality of the two parameters suggests that we cannot reject the null hypothesis that the two parameters are equal (see Table 8.25). Consequently, we cannot argue that respondents give significantly greater weight to the future risk reduction than the present risk reduction when considering whether or not to undertake a groundwater protection program. As the cost of the groundwater protection program rises, the respondent is significantly less likely to undertake the program. Respondents are 3.26 times more likely to undertake the groundwater protection program if it protects all Massachusetts residents versus their household alone, indicating that WTP is significantly greater for public groundwater protection programs than private programs. The dummy variable for future-oriented programs is positive, but insignificant. This suggests that WTP for programs that emphasize risk reduction in the future is not significantly different than WTP for programs that stress risk reduction this year.

In this estimation, most of the respondent's characteristics had no significant effect on the probability that she undertook the groundwater protection program. There were two exceptions. As the respondent's income rises, she is less likely to undertake groundwater protection. This result is puzzling, as it suggests that groundwater protection is an inferior good. The estimated coefficient is very weakly significant (p-value = 0.10). It is possible that those respondents with higher income levels were simply less likely to assign a rating of "10" to the groundwater protection program. A respondent with definite plans to move in the next two years is significantly more likely to undertake a groundwater protection program; section 8.4.1.1 offers some explanations for this result.

None of the variables included in this estimation to represent the respondent's attitudes towards groundwater quality issues had a significant effect on the likelihood that she undertakes groundwater protection. In addition, the dummy variables included to represent the version of the survey the respondent took, and the order in which the groundwater protection programs were presented to her, were insignificant.

8.4.1.4 CJ Binary Response Ratings Difference Model

The conjoint binary response ratings difference model is estimated by coding a response as a 'yes' vote for a program if the rating assigned to that program by the respondent exceeds the rating she assigned to the status quo scenario of no protection. Otherwise, the response is interpreted as a 'no' vote for the program. The model is then estimated using binary logistic regression. The results of the estimation of the CJ binary response ratings difference model are presented in Table 8.24 at the end of the chapter. The estimation used 936 observations (645 'yes' votes and 291 'no' votes). The model

has overall significance; we fail to reject the null hypothesis that the coefficients on the explanatory variables are jointly equal to zero.

The estimated coefficients on the program attributes have the expected signs. The size of the risk reduction both this year and ten years from now positively affects the probability that the respondent undertakes groundwater protection. However, while the estimated coefficient for the size of the future risk reduction is significant, the estimated coefficient for the size of the present risk reduction is not significant. In addition, a test of the linear restriction that the two coefficients are equal indicates that we cannot reject the null hypothesis of equality (see Table 8.25). As the cost of the groundwater protection program increases, the probability that the respondent undertakes the program significantly falls. Although the likelihood that the respondent undertakes the groundwater protection program increases if the program protects all Massachusetts residents, rather than his household only, this effect is not significant. The coefficient on the dummy variable that indicates programs that stress risk reduction in ten years is positive, but not significant; this result suggests that WTP for future oriented-programs is not significantly different than WTP for present-oriented programs.

Several respondent characteristics appear to significantly affect the probability that the respondent undertakes groundwater protection. The older a respondent is, the less likely she is to undertake groundwater protection. Members of a racial minority group are also less likely to undertake groundwater protection, but the reader is once again cautioned that this result may not be meaningful given the small number of minorities in this sample. Respondents that have at least one child living in the household appear significantly less likely to undertake groundwater protection than respondents who

do not have children living in their household. The reason for this unexpected result is not clear; however, many parents may feel that they simply cannot afford to pay for groundwater protection, though they may support it. Once again, a respondent who is definitely planning to move within the next two years is significantly more likely to undertake groundwater protection program than respondents who are not planning to move in the near future (See Section 8.4.1.1 for possible explanations for this result). The respondent's income level, the number of years he has lived at the residence, and tentative plans to move do not significantly affect the probability that he undertakes groundwater protection.

The effect of the respondent's feelings about groundwater quality issues on the likelihood that he undertakes groundwater protection was also examined. In this estimation, only one of these variables was significant. Respondents who indicated that they had "enough" information about the quality of their well water were significantly less likely to undertake groundwater protection than those who indicated they "have some information, not as much as I would like".

Finally, we turn to an examination of the significance of the dummy variables that were included to indicate the version of the survey the respondent took, and the order in which the groundwater protection programs were presented. Interestingly, those that took the CJ / modified DC CVM versions of the survey (Version B and BB) were significantly more likely to undertake groundwater protection than those that took the lengthier CJ / traditional DC CVM / modified DC CVM versions of the survey (Versions A and AA). However, the order in which the groundwater protection programs were

presented to the respondent did not have a significant effect on the probability that she undertakes a groundwater protection program.

8.4.2 Predicting the Probability of Undertaking a Groundwater Protection Program

The four econometric models allow us to predict the probability that a respondent will be willing to undertake some form of groundwater protection program. First, let us compare the predicted probabilities that the “average” respondent undertakes the “average” groundwater protection program. To obtain the estimated probabilities from the econometric models, the mean values of the respondent characteristics and attitudes towards groundwater quality issues, and the mean values of the program attributes were plugged into the estimated logistic equation. The mean values for the respondent characteristics may be found in Tables 8.2 and 8.4, while the mean values of the groundwater protection program attributes are presented in Table 8.26. These mean values, represented by the vector \bar{X} , are plugged into the following equation:

$$p^*(X) = \frac{e^{b_i \bar{X}_i}}{1 + e^{b_i \bar{X}_i}} \quad (8.10)$$

where p^* is the estimated probability, and b_i are the estimated regression coefficients.

Table 8.27 presents the estimated probability that the “average” respondent undertakes the “average” level of groundwater protection for each of the four econometric models.

The estimated probability that the “average” respondent undertakes the “average” level of groundwater protection is lowest in the modified dichotomous choice CVM model ($p^* = 0.09$) and highest for the CJ binary response ratings difference model ($p^* = 0.68$). It is interesting to note that the models in which the criteria for a ‘yes’ response are less strict, the traditional dichotomous choice CVM and CJ binary response ratings

difference models, result in similar, relatively high estimated probabilities ($p^* = 0.49$ and $p^* = 0.68$, respectively). On the other hand, the models in which the criteria for a ‘yes’ response are more strict, the modified dichotomous choice CVM and the CJ binary response ratings model with a “cut-off point” of a rating of “10”, yield similar estimates probabilities that are quite low ($p^* = 0.09$ and $p^* = 0.10$, respectively). The sensitivity of the CJ binary response ratings model to the “cut-off” rating was also examined; the estimated probability that the “average” respondent undertakes the “average” level of groundwater protection ranges from a low of $p^* = 0.10$ (using a “cut-off” point of a rating of “10”) to a high of $p^* = 0.62$ (using a “cut-off” point of a rating of “5”).

Now let us consider the probability that the “average” respondent undertakes specific types of groundwater protection programs. Table 8.28, located at the end of the chapter, presents eight different groundwater protection programs and the estimated probability that the “average” respondent undertakes that program. These predicted probabilities are calculated for all four econometric models. The table makes it clear that respondents are more likely to undertake programs that protect all Massachusetts residents than they are to undertake a program that protects only their household. The model estimation results (Tables 8.21-8.24) confirm that this effect is significant for all models except the CJ binary response ratings difference model. In the CJ binary response ratings difference model the dummy variable for programs that protect all Massachusetts residents is positive, but insignificant. A quick examination of the table might lead one to conclude that respondents are more likely to undertake programs that offer the greatest risk reduction in the future (ten years from now) than they are to undertake programs where the greatest risk reduction comes immediately (this year).

However, this effect is not significant; the dummy variable for programs that offer the relatively larger risk reduction ten years from now is positive, but insignificant, in all four models. Thus, if we hold all other program attributes, as well as the respondent characteristics and attitudes towards groundwater quality issues, constant, WTP for the programs that stress risk reduction this year versus programs that stress risk reduction ten years from now is not significantly different.

8.4.3 Measuring Goodness-of-Fit of the Econometric Models

Let us now turn to an assessment of how effective each econometric model is in predicting the probability that the individual undertakes a specific groundwater protection program. Goodness-of-fit for each model is measured using the Hosmer and Lemeshow test (see Hosmer and Lemeshow, 1989; Hosmer and Lemeshow, 1980; Lemeshow and Hosmer, 1982). To conduct this test, the predicted probability of undertaking the program for each respondent is calculated by inserting each respondent's personal characteristics and attitudes toward groundwater quality issues, as well as the groundwater protection program attributes and characteristics of the particular survey the respondent took, into the estimated logistic regression equation. The predicted probabilities are then ranked from smallest (least likely to undertake the program) to largest (most likely to undertake the program), and the respondents are placed into g (usually $g = 10$) groups based on the percentiles of these estimated probabilities. For example, the first group consists of n/g respondents having the smallest estimated probabilities and the g^{th} group consists of n/g respondents having the largest estimated probabilities. The Hosmer-Lemeshow test statistic, C , is then calculated by examining the difference between the expected frequencies (based on the predicted probabilities)

versus the observed frequencies (based on the actual data) in each group. The formula for calculating the test statistic C is:

$$C = \sum_{k=1}^g \frac{(o_k - n_k \bar{p}_k)^2}{n_k \bar{p}_k (1 - \bar{p}_k)} \quad (8.11)$$

where n_k is the total number of respondents in the k^{th} group, o_k is the frequency of an actual yes response to a groundwater protection program in the k^{th} group, and \bar{p}_k is the average predicted probability of undertaking a groundwater protection program in the k^{th} group. The distribution of the Hosmer-Lemeshow test statistic, C , is approximately χ^2 , with $g-2$ degrees of freedom. A high p-value indicates that there is little difference between the expected and observed frequencies; i.e. that the logistic regression model fits the data well.

Table 8.29, located at the end of this chapter, summarizes the results of the Hosmer-Lemeshow goodness-of-fit tests for each econometric model. All the models appear to do a reasonable job of fitting the survey data, although some do better than others. The results indicate the traditional dichotomous choice CVM model fits the data quite well (p-value = 0.88); there is little difference between the observed and expected columns for both the respondents that did and those did not undertake the groundwater protection program. For the modified dichotomous choice CVM model, we also fail to reject the fit of the model (p-value = 0.35), but it does not fare as well as the traditional DC CVM model. A possible explanation for this is the small number of ‘yes’ responses (163 observations) relative to ‘no’ responses (1277 observations) in this model. The fit of the conjoint binary response ratings model ($R^{GWPP}=10$), with a p-value of 0.65, is adequate, but this model does not fit the data as well as the conjoint binary response

ratings difference model, which fits the data quite well with a p-value of 0.84. However, the conjoint ratings model is similar to the modified DC CVM model in that there are a relatively small number of ‘yes’ responses (126 observations) to ‘no’ responses (811 observations). This may account for the weak performance of the CJ binary response ratings model ($R^{GPPP}=10$) relative to the CJ binary response ratings difference model.

8.4.4 Estimating Median Willingness-to-Pay

Median willingness-to-pay for the “average” level of groundwater protection was estimated for each of the four econometric models. Median WTP is estimated by inserting the mean groundwater protection program attributes (see Table 8.26), and the mean levels of the respondents’ characteristics and attitudes towards groundwater quality issues (see Tables 8.2 and 8.4, respectively) into the estimated logit equation, and setting the probability that the respondent undertakes the program equal to ½ the respondent’s point of indifference:

$$Pr(\text{undertakes GWP}) = \frac{1}{2} = \frac{1}{1 + \exp[-[b_0 + b_1 \overline{RRT} + b_2 \overline{RRF} + b_3 \overline{EP} - b_4 C + b_j \overline{S} + b_k \overline{T}]} \quad (8.12)$$

where b_0, \dots, b_4 are the estimated parameters for the groundwater protection program attributes RRT , RRF , EP , and C ; b_j is a vector of estimated parameters for the vector of respondent characteristics, S ; b_k is a vector of estimated parameters for the vector of respondent attitudes towards groundwater quality issues, T ; \overline{RRT} is the mean risk reduction this year; \overline{RRF} is the mean risk reduction ten years from now; \overline{EP} is the mean level of extent of protection; \overline{S} is a vector of the mean levels of the respondent characteristics S , and \overline{T} is a vector of the mean levels of the attitudes toward

groundwater protection, T . We can then solve for the one-time cost, $\$C^*$, at which the respondent is indifferent between undertaking the “average” level of groundwater protection and remaining at the status quo of no protection. This yields the following equation:

$$\$C^* = \frac{b_0 + b_1 \overline{RRT} + b_2 \overline{RRF} + b_3 \overline{EP} + b_j \overline{S} + b_k \overline{T}}{b_4} \quad (8.13)$$

$\$C^*$ is the median willingness-to-pay estimate. Median willingness-to-pay estimates are generally preferred over the mean willingness-to-pay estimates because the median is less sensitive to outliers in the stated preference responses (Hanemann, 1984).

Table 8.30, located at the end of the chapter, presents the median willingness-to-pay estimates for the “average” level of groundwater protection. The traditional DC CVM model results in a median WTP estimate of \$608.24, while the CJ binary response ratings difference model results in a median WTP of \$2063.62. These two estimates are directly comparable, as they are based on the same random utility framework (see Chapter Six). However, the median WTP point estimate from the CJ binary response ratings difference model exceeds the point estimate from the traditional DC CVM model by over threefold. Prior work has also found that CJ estimates tend to exceed CVM estimates (see Chapter Three). Many have argued that CJ estimates may be more valid measures of WTP because the ratings format is more familiar to individuals and because it allows the respondent to express ambivalence. However, it may be that the individual views the CJ ratings task very differently than the CVM format, where the price of the proposed good is arguably made more explicit. We shall return to this point shortly. The valuation formats that require a higher level of commitment from the respondent, the modified DC CVM model and the CJ binary response ratings model with a “cut-off”

rating of “10” results in much lower median WTP estimates: -\$1951.48 and -\$1621.69, respectively. These estimates suggest that when respondents are confronted with a valuation format that demands a firm commitment to a particular program, they may be more conservative in their support of groundwater protection. In addition, Table 8.30 indicates that the CJ binary response ratings model is very sensitive to the choice of the rating “cut-off” point: median WTP estimates from this model range from -\$1621.69 ($R^{GWPP} = 10$) to \$1311.53 ($R^{GWPP} \geq 5$).

Determining whether or not these four models produce significantly different median willingness-to-pay requires us to obtain a distribution of median WTP values, so that confidence intervals may be calculated for each model’s median WTP point estimate. To obtain the distribution of median WTP estimates, we attempted to implement Efron’s bootstrapping procedure (Efron, 1979; Efron and Tibshirani, 1994). One thousand observations were continuously selected with replacement, which were then used to estimate 1,000 sets of logistic regression parameter estimates. This set of 1,000 parameter estimates resulted in 1,000 median WTP estimates. We then constructed 95% confidence intervals for the mean point estimate of median WTP. However, a severe problem occurred while performing the bootstrap iterations. Two of the categorical explanatory variables had very few observations (i.e. very few “1”s relative to “0”s, or vice versa) - - the dummy variables used to indicate that the individual was a member of a racial minority group and that the respondent rated his water as “contaminated”. Once the sample size was reduced to 1,000 observations, quasi-separation of the data occurred in many of the 1,000 iterations of the logistic regression, which resulted in inflated parameter estimates and standard errors for the problem variables. The confidence

intervals calculated from the bootstrapped estimates suggest that median WTP in the traditional DC CVM and the CJ binary response ratings difference model is significantly different; i.e. median WTP in the traditional CVM format is significantly lower than median WTP in the CJ binary response ratings difference model. In addition, the confidence intervals indicate that median WTP in the modified DC CVM and the CJ binary response ratings model with a “cut-off” rating of “10” is significantly lower from median WTP in the traditional CVM and CJ ratings differences models. The confidence intervals for median WTP in the modified CVM and the CJ binary response ratings model ($R^{GWPP}=10$) overlap, suggesting that median WTP in the two conservative valuation formats is not significantly different. However, the estimated confidence intervals are likely invalid due to the quasi-separation problem. While we cannot make a rigorous statistical comparison between the median WTP estimates in the four valuation formats, it seem likely that the CJ binary response ratings difference model produces higher WTP estimates than the traditional DC CVM model. The more conservative models of WTP, the modified DC CVM and the CJ binary response ratings model ($R^{GWPP}=10$), appear to produce much lower median WTP estimates of roughly the same magnitude.

8.4.4.1 WTP for Private versus Public Programs

In each of the models, except for the CJ binary response ratings difference model, the dummy variable that indicates that the program protects all Massachusetts residents is positive and significant. In the CJ binary response ratings difference model, the dummy variable is positive, but insignificant (p-value = 0.11). These results indicate that individuals are more likely to undertake a groundwater protection program if it protects

all residents of the state, rather than their household alone, i.e. individuals are willing to pay more for a public program. To illustrate this point, Table 8.31 contains the median WTP estimates for private versus public programs. These median WTP estimates were calculated by inserting the mean levels of all other program attributes, the respondent characteristics S , and the respondent attitudes toward groundwater protection T into Equation (8.13). Given that the dummy variable for public programs is positive significant in three of the four models, it is reasonable to conclude that median WTP for public programs is significantly higher than median WTP for private programs, although we cannot support this point statistically by estimating confidence intervals for the median WTP estimates, due to the problem with the bootstrapping procedure. Thus due to the statistical problems encountered, we can only provide point estimates of non-use value, which in this case is composed primarily of the value for the use of others. These point estimates of non-use range from \$401.63 (the traditional DC CVM model) to \$1351.71 (the modified DC CVM model). Although our ability to make inferences is severely hindered by the lack of estimated confidence intervals for the WTP estimates, the results do suggest that individuals have a strong preference for public groundwater protection programs, rather than private protection measures such as household filtration systems, which implies that individuals have significant non-use values for groundwater protection.

8.4.4.2 Comparison of Median WTP Estimates with Prior Literature

The estimates of median WTP from this study are not directly comparable for many reasons. First, most of the prior groundwater quality studies have either emphasized protection from nitrates or failed to specify the type of contaminant the

individual would be protecting himself from. This study estimates the average individual's willingness-to-pay to reduce his risk of exposure to chemical forms of groundwater contamination. Secondly, most of the studies used the contingent valuation framework only, while this study uses the traditional DC CVM and a modified form of the DC CVM, as well as two CJ formats. Finally, the WTP estimates from prior studies are estimates of annual WTP, while this study estimates the amount of money the average individual would be willing to pay immediately in one lump sum. The author chose to use a one-time, immediate cost as the payment vehicle to avoid intertemporal choice issues on the cost side, as she was primarily interested in exploring how the individual values reducing his risk of contamination, i.e. groundwater protection benefits, over time (implications of this study with respect to intertemporal choice will be discussed in the next section of this chapter).

However, let us briefly re-examine the WTP estimates for groundwater quality found by other studies (a detailed review of prior valuation studies for groundwater quality can be found in Chapter Three, Section 3.5). Mean estimates of WTP for protection of groundwater from nitrate contamination range from \$121 (Jordan and Elnagheeb, 1993) to \$1154 (Edwards, 1988) per household per year. Powell (1991) estimated WTP to the probability of groundwater contamination in several Massachusetts, New York, and Pennsylvania communities, obtaining a mean estimate of \$70 per household per year. These studies all used the contingent valuation method.

Stevens et al. (1997) used three different forms of conjoint analysis, obtaining mean WTP estimates of \$9.05 to \$35.00 per household per year for ten years for the CJ binary response ratings model ($R=10$), and \$2.70 to \$242.70 per household per year for

ten years from the CJ ratings difference model, which was developed by Roe et al. (1996). In this model, the dependent variable is the difference between the rating assigned to the proposed program and the rating assigned to the status quo. This range of estimates reflects the method of protection -- the lowest mean WTP estimates were lowest for groundwater protection via the purchase of bottled water, while the highest mean estimates were for protection through a town-wide aquifer protection district.

Do this study's estimates fall in line with the WTP estimates from prior studies? The answer to this question depends on which estimates one chooses for comparison. First, let us examine the median WTP estimates from the traditional DC CVM (\$608.24) and CJ binary response ratings difference models (\$2063.62), the formats in which the criteria for a response to be interpreted as a 'yes' are less stringent. These results support the finding of previous studies that CJ estimates tend to be larger than CVM estimates. However, direct comparisons of the magnitude of this study's estimates to prior estimates requires that we make some assumption about the life of the protection program in this study. The median WTP estimates from the more conservative valuation formats, the modified DC CVM and the CJ binary response ratings ($R^{GWPP}=10$) models, are -\$1951.48 and -\$1621.69, respectively. These estimates are clearly much lower than those found in prior groundwater quality valuation studies. Again, it appears that when asked to make a firm commitment to a particular groundwater protection program, many respondents hesitate even though they clearly have some desire for protection, which is indicated by the much higher median WTP estimates from the less conservative traditional DC CVM and CJ binary response ratings difference models.

8.4.5 Implicit Discount Rates for Groundwater Protection

The valuation format for the groundwater protection program allows us to estimate the implicit discount rate for groundwater protection programs by examining the individual's marginal rate of substitution between risk reductions this year (*RRT*) and risk reductions ten years (*RRF*) from now. In all four stated preference models, the estimated coefficient on *RRF* exceeds the coefficient on *RRT*. This would suggest that individuals place more value on the future risk reduction when deciding whether or not to undertake the groundwater protection program, or a negative discount rate. However, a test of the null hypothesis that the two estimated coefficients are equal indicates that we cannot reject the null hypothesis for any of the four models (see Table 8.25). Because the estimated coefficient for *RRT* was insignificant in two models (the modified DC CVM and CJ binary response ratings difference models), hypothesis tests were performed to test simultaneously two linear restrictions - - that the coefficient on *RRT* is equal to zero and that the coefficient on *RRT* and *RRF* are equal ($H_0 : \mathbf{b}_{RRT} = 0$ and $\mathbf{b}_{RRT} = \mathbf{b}_{RRF}$). The results of the hypothesis tests of the two restrictions indicate that we reject the null hypothesis that the restrictions are valid for all four specifications. Thus, the results of the two types of hypothesis tests suggest that while the value individuals place on present and future risk reductions is not different, the size of the risk reduction does affect the probability that the individual undertakes the groundwater protection program, particularly in the case of the future risk reduction. Thus, we conclude that individuals place equal value on the present risk reduction and the future risk reduction, which implies an implicit discount rate of zero for groundwater protection benefits.

While examining the individual's willingness to trade-off present and future groundwater protection benefits, the author wondered if some respondents may have interpreted the timing of risk reductions offered by the groundwater protection programs in an unintended way. Although the survey did not specify what the risk of exposure would be in years 2-9 (the interim period) or after year 10, many respondents may have assumed that the risk of exposure remained constant at this year's level for years 2 through 9, and that it remained constant at the tenth year's level for some extended period after the tenth year. However, even if some respondents did interpret the timing of the risk reductions in this manner, the conclusion with respect to the implicit discount rate for groundwater protection benefits remains the same - - because we cannot reject the null hypothesis that the coefficients on *RRT* and *RRF* are equal, we must conclude that the implicit discount rate for groundwater protection benefits is zero.

Let us now compare the implicit discount rate for groundwater protection benefits with the implicit discount rates estimated from the survey question that elicited preferences for general life-savings programs (see Figure 8.1). The estimated *mean* discount rate for the ten-year time horizon in this context was 10.35% (see Table 8.11). A linear discount function was also estimated from responses to this question; it predicts a discount rate of 9.88% for a ten-year time horizon (see Table 8.18). It would appear that the implicit discount rate for general life-saving programs is higher than the implicit discount rate for groundwater protection benefits. However, the estimated *median* rate of discount for life-saving programs for the ten year time horizon is 0% (see Table 8.12). Thus, the conclusion one draws about the implicit rate of discount for groundwater protection programs relative to the implicit rate of discount for general life-saving

programs depends upon whether one compares the estimated rate of discount for groundwater protection benefits to the estimated mean, or the estimated median, rate of discount for general life-saving programs. It is not clear which comparison is more appropriate. Finally, the implicit discount rates estimated in this stated preference study for both general life-saving programs and for groundwater protection benefits are much lower than the discount rates that have been estimated from revealed preference data, such as Hausman's (1979) study of the purchase and utilization of energy-using consumer durables. There are three possible explanations for these different estimated discount rates.

The first explanation pertains to the difference between the rates estimated by this study, and the higher rates found in revealed preference studies. It may be that some form of hypothetical bias causes individuals to suggest they value the future more highly in stated preference studies such as this one and Cropper et al.'s (1991, 1994) work. However, revealed preference studies have also tended to estimate discount rates for shorter time horizons than those used by this study; since the discount rate has been shown to decline with the time horizon, this could also partially explain the discrepancies found in estimated discount rates from revealed and stated preference studies.

A second possible explanation addresses the difference between the mean implicit discount rate for general life-saving programs and the implicit discount rate for groundwater protection programs found by this study. The groundwater program valuation format was quite complex, and it is possible that, in an effort to simplify the valuation task, the respondent may have ignored or downplayed the time trade-off between present and future risk reductions, focusing more on the cost and extent of

protection attributes of the program. While we cannot draw any conclusions from the small sample of pre-test participants, many participants in the pre-test sessions seemed most concerned with the extent of protection and cost of the groundwater protection programs (see Appendix A for transcripts of the pre-test results). In addition, the elicitation format for the general life-saving programs may be more effective in highlighting the time trade-off the respondent is being asked to consider; the timing of the benefit is essentially the only attribute of the two programs since both programs cost the same amount of money, are implemented by the government, and save lives from the same unspecified threat. Cropper et al. (1991) indicate that the nature of the threat to human life was left unnamed because when specific threats were used, their pre-test participants tended to focus more on the nature of the threat than on the timing of benefits.

Finally, a third, related, explanation is that discount rates may be commodity-specific. This would explain both the difference between the mean implicit discount rate for general-life saving programs and the implicit discount rate for groundwater protection programs found in this study, and the differences in implicit discount rates estimated by stated preference studies such as this one and Cropper et al.'s (1991, 1994), and by revealed preference studies such as Hausman's (1979). It is quite reasonable to believe that the individual views future health and safety benefits quite differently than future consumer durable utilization costs. In the former case, he may be considering the welfare of other individuals; such considerations are less likely in the latter case. Other authors have also found that implicit discount rates are highly context-specific; for example,

Loewenstein and Thaler (1989) point out that implicit discount rates from observed behavior range from negative to several hundred percent per year.

8.4.6 Model Comparisons and Summary

8.4.6.1 Comparing the estimated coefficients from the four stated preference models

All four stated preference models produce estimated coefficients for the program attributes that are consistent with economic theory. In all four models, the estimated coefficients for the risk reduction this year and ten years from now are positive, indicating that as the level of chemical contaminant exposure risk under the proposed groundwater protection program decreases relative to the exposure risk under the status quo, the individual's willingness-to-pay for the groundwater protection program increases. The estimated coefficient for the one-time cost of the groundwater protection is negative and highly significant, indicating that as the cost of groundwater protection rises, the individual is less likely to undertake groundwater protection. Finally, the estimated coefficient on the dummy variable that represents public programs, which protect all Massachusetts residents, is positive in all four models. In addition, the estimated coefficient is statistically significant in every model except the CJ binary response ratings difference model. These results indicate that the individual is more likely to undertake a groundwater protection program if it protects all Massachusetts residents as opposed to his household alone; the individual is willing to pay a premium to protect other individuals. The estimated coefficient on the dummy variable that represents programs that are future-oriented (i.e. programs that offers the relatively larger risk reduction in ten years) is positive, but insignificant, in all four models. This result indicates that individuals are not willing to pay a premium for a program that emphasizes

future risk reductions, independent of the absolute magnitude of the risk reduction themselves, and supports our conclusion in Section 8.4.5 that individuals value present and future risk reductions equally.

Let us now examine how the individual's personal and household characteristics affect the likelihood that she undertakes groundwater protection. The estimated coefficient for individual's age is negative for three models and positive for one model. However, it is statistically significant in one model only: the CJ binary response ratings difference model, where it is negative. This suggests that older individuals are less likely to undertake groundwater protection. However, since the estimated coefficient is statistically significant in one model only, this reliability of this result seems questionable. The estimated coefficient on the dummy variable that indicates the respondent is a member of a minority group is positive and insignificant in the two conservative models of WTP, but negative and significant in the traditional DC CVM and CJ binary response ratings difference models. However, since minorities represented such a small percentage of the sample (2.94%), this result should be viewed with skepticism. The presence of a child in the household did not have a significant effect on WTP for groundwater protection, except for one model (the CJ binary response ratings difference model), where the estimated coefficient was negative, suggesting that individuals with children are less likely to undertake groundwater protection. The direction of this effect conflicts with the author's expectations, and she has no clear explanation for it. The individual's income positively affects his WTP for the program in the two CVM models, and the effect is statistically significant in the traditional DC CVM model. A positive effect is consistent with economic theory if we assume that

groundwater protection is a normal good. Surprisingly, the estimated coefficient for income is negative in the two CJ models, and statistically significant in the CJ binary response model ($R^{GWPP}=10$), suggesting that groundwater protection is an inferior good. One possible explanation for this unexpected result is that wealthier individuals were more conservative in the CJ ratings task, i.e. less likely to assign a rating of “10”. This explanation seems to be supported by the estimation results of the CJ binary response ratings model using different ratings “cut-off” points; the unexpected negative and significant result does not occur in any of the estimations. The estimated coefficient for the number of years the individual has lived at the residence to which the survey was sent is insignificant in all four models, indicating that the number of years the individual has lived at the residence does not affect the probability that he undertakes groundwater protection. The estimated coefficient on the dummy variable that indicates the respondent has definite plans to move within the next two years is positive and significant in all four models, indicating that an individual who plans to move shortly is more likely to undertake groundwater protection than an individual who does not plan to move within the next two years. As discussed earlier, these individuals may have greater WTP values for groundwater protection because they believe that groundwater protection will increase the value of their homes. An alternative explanation for this result is that their significantly higher WTP values reflect hypothetical bias; these individuals may think that if they are ever actually asked to pay for groundwater protection, they will have left the area by that time and therefore will not have to pay. Tentative plans to move within the next two years have a positive effect on WTP in two models, and this effect is significant in the traditional DC CVM model. However, in the CJ binary response ratings

model ($R^{GWPP}=10$) and the modified DC CVM model, the estimated coefficient for the dummy variable that indicates tentative plans to move is negative, but not significant. Thus, we cannot draw any meaningful conclusions about the effect of tentative plans to move on WTP for groundwater protection.

We now turn to a summary of the effects the individual's attitudes towards groundwater quality issues have on her willingness-to-pay for groundwater protection. The estimated coefficient on the dummy variable that indicates the respondent rated her water as "contaminated" is insignificant in all four models, indicating that individuals who perceive themselves as having well water quality problems do not have significantly different WTP for protection than those who feel their well water quality is acceptable. In all four models, the estimated coefficient on the dummy variable that indicates the individual considers herself to be "very concerned" about well water quality is positive, suggesting that such an individual is more likely to undertake groundwater protection than an individual who describes herself as "somewhat concerned". However, this estimated coefficient is significant in the traditional DC CVM only. The estimated coefficient on the dummy variable for individuals who describe themselves as "not concerned" is insignificant in all four models; such individuals are no more or less likely to undertake groundwater protection than individuals that are "somewhat concerned". The estimated coefficient on the dummy variable that indicates an individual feels she has "enough information" about her well water quality is negative in all four models, and significant in two models (the traditional DC CVM and the CJ binary response ratings difference models). Individuals who feel that they have "enough information" about their well water quality are less likely to undertake groundwater protection than those who

describe themselves as having “some information”, but not as much as they would like. Perhaps these individuals are confident that chemical forms of groundwater contamination are not likely to be present in their wells, or that the health affects associated with such contaminants have been exaggerated. The estimated coefficient on the dummy variable for respondents that feel they do not have enough information about their well water quality is negative and insignificant in the modified DC CVM and CJ binary response ratings difference models. However, this coefficient is positive in the CJ binary response ratings model ($R^{GWPP}=10$) and the traditional DC CVM model. In the traditional DC CVM model, the estimated coefficient is significant. Given these mixed results, it is difficult to draw firm conclusions about the WTP of those who describe themselves as not having enough information about their well water quality relative to those who feel that they have some information. Finally, the dummy variable that indicates an individual feels he is “very knowledgeable” about the potential adverse health effects of groundwater contamination is insignificant in all four models, suggesting that the WTP for groundwater protection of such individuals is not significantly different than that of individuals who describe themselves as having “some knowledge”. The estimated coefficient on the dummy variable for individuals who describe themselves as having “very little knowledge” is positive and insignificant in three models, but negative and significant in the traditional DC CVM model. Thus, no firm conclusions can be drawn about the WTP values of these individuals relative to individuals who feel that they have “some knowledge” about the threat groundwater contamination poses to human health.

Now let us discuss the effects of the version of the survey that the individual took on his willingness-to-pay for groundwater protection. The dummy variables for version of the survey were significant in two models. In the CJ binary response ratings difference model, individuals who took the longest version of the survey (Versions A and AA-the CJ / traditional DC CVM / modified DC CVM versions), were significantly less likely to undertake groundwater protection than those who took the relatively shorter Versions B and BB (the CJ / modified DC CVM versions). One might be tempted to argue that the longer survey version provides the individual with an opportunity to consider more seriously the likelihood that he would actually be willing to pay for a particular groundwater protection program. However, in the traditional dichotomous choice CVM model, individuals that took the longer versions of the survey (Versions A and AA) were significantly more likely to undertake groundwater protection than those who took the relatively shorter Versions C and CC (the traditional DC CVM / modified DC CVM versions). In addition, in the modified DC CVM framework, which was included in all versions of the survey, the estimated coefficient on the dummy variable for the CVM / modified DC CVM versions is negative, while the estimated coefficient on the dummy variable for the CJ / modified DC CVM versions is positive. However, both estimated coefficients were insignificant, suggesting that the version of the survey taken has no effect on the individual's WTP for groundwater protection and that it does not matter whether a single valuation format (traditional DC CVM *or* CJ ratings) or two valuation formats (traditional DC CVM *and* CJ ratings) have preceded the final valuation format (the modified DC CVM). Thus, we cannot draw any firm conclusions with respect to these dummy variables. Nonetheless, it is interesting to note that individuals

who have taken the traditional DC CVM / modified DC CVM versions (Versions C and CC) have lower WTP values than individuals who have taken the longer CJ / traditional DC CVM / modified DC CVM versions (Versions A and AA), while individuals who have taken the CJ / modified DC CVM versions (Versions B and BB) have higher WTP values than those who have take the longer versions (Versions A and AA). These effects are not always significant, but they are consistent across all four models. Finally, the estimated coefficient on the dummy variable that was included to test for order effects was insignificant in all four models, indicating that the order in which the groundwater protection programs are presented (public programs first versus private programs first) to the individual has no significant effect on her WTP for groundwater protection.

8.4.6.2 Do the WTP estimates pass the scope test?

The consistency of the results with respect to the estimated coefficients for the groundwater protection program attributes are very encouraging with respect to one issue in the controversy that continues to surround stated preference methodology—the question of “scope”, which was discussed in Chapter Three, Section 3.3.1.2.d. Some have argued that in order for WTP estimates to be considered meaningful estimates of the economic value an individual has for a particular environmental amenity, they must be sensitive to the quantity, or “scope”, of the amenity. One issue that has been raised in the valuation of health and safety benefits is whether or not willingness-to-pay estimates are sensitive to the magnitude of risk reductions (see Chapter Five, Section 5.2.5). The evidence from prior studies of the sensitivity of WTP for health and safety benefits to scope is mixed. The results of this study suggest that WTP is, in fact, sensitive to the magnitude of the risk reductions offered by the proposed groundwater program. The

estimated coefficient for the risk reduction this year is positive in all four stated preference models, and significant in two of the models (the traditional DC CVM and CJ binary response ratings models). The estimated coefficient for the risk reduction in ten years is positive and significant in all four stated preference models. Thus, the WTP estimates pass the “scope test” with respect to the size of the risk reductions; embedding effects do not seem to be a serious problem. The significance of the dummy variable for public programs can also be viewed as a “scope test”; we would expect willingness-to-pay to protect an entire states to be significantly greater than willingness-to-pay to protect a single household. The dummy variable is positive in all four models, and significant in three (the exception being the CJ binary response ratings difference model).

8.4.6.3 Exploring respondent uncertainty

The last valuation format, the modified DC CVM, is used in all versions of the survey and asks respondents to choose the ONE program he would undertake and be willing to pay for (the respondents may choose to pay nothing, thereby maintaining the status quo scenario of no protection). The respondent is then asked to indicate his degree of certainty on a scale of “1” (Very Uncertain) to “10” (Very Certain). Respondents appear, on average, quite certain about their preferences for groundwater protection; the mean certainty rating is 7.22 (with a standard deviation of 2.41) and 53.17 % of the respondents gave a certainty rating of at least “8” on the “1” to “10” scale. However, we shall see shortly that a substantial portion of individuals in the sample responded to the valuation tasks in ways that standard economic theory would deem irrational and inconsistent.

Differences in the mean characteristics of respondents who were “certain” (certainty rating = 8) and respondents who were “uncertain” (certainty rating < 8) were examined using a series of t-tests. The null hypothesis is that there is no difference in the means of the two groups. Table 8.32, located at the end of the chapter, presents the means for each group of respondents and the results of the hypothesis tests. The null hypothesis of equality of the means is rejected for several of the respondent characteristics. The difference in the mean age of the “certain” and “uncertain” groups is weakly significant; respondents that indicated they were certain about their decision in the modified DC CVM question were, on average older (mean age of 51.61 years) than respondents who indicated that they were uncertain about their decision (mean age of 50.6 years). The percentage of female respondents was significantly higher in the “uncertain” group (38.05% female) than in the “certain group” (27.07% female). Respondents with at least one child living in their household were significantly more likely to be uncertain about their decision than respondents without children in the household. A significantly higher percentage of “certain” respondents had attained at least a college education (66.37%) than “uncertain” respondents (59.6%). The respondents in the “certain” group had a significantly higher gross annual income than the respondents in the “uncertain” group. Given that many respondents cited cost as one reason they were uncertain about their top choice of program, this result is not surprising. A significantly higher proportion of respondents in the “certain” group (6.84%) had definite plans to move in the next two years than in the “uncertain” group (4.88%). However, the percentage of respondents with tentative plans to move in the next two

years was significantly higher in the “uncertain” group (13.66%) than in the “certain” group (10.68%).

Differences in the means of the variables representing the respondent’s feelings towards groundwater quality issues were also examined. The null hypothesis of equality is rejected for several of these variables. The percentage of respondents who described themselves as “very concerned” about the quality of their well water was significantly higher in the “certain” group (39.49%) than in the “uncertain” group (35.47%). In addition, the percentage of respondents who described themselves as “not concerned” about the quality of their well water was also significantly higher in the “certain” group (27.47%) than in the “uncertain” group (21.18%). This implies that there was a higher percentage of respondents who stated that they are “somewhat concerned” in the “uncertain” group (43.35%) than in the “certain” group. These results suggest that having the two extreme levels of concern about well water quality may make it easier for respondents to be confident about their most preferred program, while having an intermediate level of concern causes the respondent to be more ambivalent about his top choice in the modified DC CVM format. The percentage of respondents who stated that they have enough information about their well water quality was significantly higher in the “certain” group (35.62%) than in the “uncertain” group (27.14%), while the percentage of respondents who indicated that they do not have enough information was significantly higher in the uncertain group (36.68%) than in the certain group (27.47%). This result seems quite reasonable—a lack of information about one’s well water quality is likely to create uncertainty as to what level, if any, of groundwater protection is needed, while the respondent’s feeling that she has adequate information may bolster her

confidence in her choice for the most preferred program. The percentage of respondents who stated that they were “very knowledgeable” about potential adverse health effects from groundwater contamination was significantly higher in the “certain” group (27.9%) than in the “uncertain” group (17.91%), while the percentage of respondents described themselves as “not very knowledgeable” was significantly higher in the “uncertain” group (24.38%) than in the certain “group” (20.6%). From this, we can infer that the percentage of respondents who choose the intermediate response of “I have some knowledge” is higher in the “uncertain” group (57.71%) than in the “certain” group (51.5%). Again, these results are not surprising -- the respondent’s belief that he is very knowledgeable about potential health effects from groundwater contamination make it easier for him to feel certain about his most preferred form of groundwater protection, while respondents who feel that they have limited knowledge are more likely to be uncertain about which program is the best choice for their household, given their budget constraint.

Finally, differences in the versions of the survey taken for the two groups of respondents were examined. In the group of respondents who took a survey that included only the traditional DC CVM format, followed immediately by the modified CVM format (Versions C and CC of the survey), the percentage of respondents in the “uncertain” category (36.71%) is significantly higher than in the “certain” category (33.19%). However, in the group of respondents that took the versions of the survey that included only the conjoint ratings format, followed by the modified DC CVM format (Versions B and BB), the percentage of respondents in the “certain” category (38.72%) is higher, but not significantly different, from the percentage of respondents in the

“uncertain” category (36.71%). This implies that in the group of respondents who took the longest versions of the survey (Versions A and AA, which included all three valuation formats: CJ / traditional DC CVM / modified DC CVM), the percentage of respondents in the “certain” category (28.09%) was higher than the percentage of respondents in the “uncertain” category (26.58%). These results may suggest that the longer versions of the survey, by taking the respondent through a process that stresses increasing commitment to a particular program, results in greater respondent certainty when they reach the third and final valuation format, the modified DC CVM, where they are asked to choose the one program they would undertake and be willing to pay for.

8.4.6.4 Different stated preference models, very different WTP estimates

The vast differences in the median estimates of willingness-to-pay from the four models raise several questions about stated preference methodology; median WTP estimates for the average groundwater protection program are clearly highly dependent upon the estimation technique used (see Tables 8.30 and 8.31).

The survey design was in part motivated by a desire to take the respondent through a process in which he is asked to make an increasing commitment to one of the program options (of course, the respondent is allowed to “commit” to maintaining the status quo of no protection). This is especially true in the longest versions of the survey, Versions A and AA, where the respondent is asked to evaluate the groundwater protection programs in all three formats (CJ ratings, traditional DC CVM, and modified DC CVM). This design allowed us to explore respondent consistency in the different valuation formats. Standard economic theory would suggest that the respondent would choose the program to which she gave the highest rating (in the CJ section) as the one

program she would be undertake and be willing to pay for (in the modified DC CVM section). However, when asked to choose the one program they would undertake and being willing to pay for, 22.18% of the respondents to the CJ / modified DC CVM and traditional DC CVM / CJ / modified DC CVM versions of the survey did not choose the program to which they assigned the highest rating in the CJ portion of the survey. In addition, in the longest versions of the survey, Versions A and AA (the CJ / traditional DC CVM / modified DC CVM versions), one would expect the respondent to undertake a groundwater protection program in the traditional CVM format if, in the preceding CJ format, he had just assigned that program a higher rating than the status quo scenario of no protection. However, in 20.17% of the 486 responses to both the CJ and traditional CVM format, the respondent assigned a higher rating to the groundwater protection program than he did to the status quo in the conjoint format, but did not undertake the groundwater protection program in favor of the status quo in the traditional CVM format. Therefore, conjoint studies that interpret a rating for the proposed environmental amenity that exceeds the rating for the status quo as a 'yes' vote for the program may be significantly overestimating willingness-to-pay for the environmental amenity.

Many studies (see Chapter Three), including this one, have found that the conjoint ratings format results in higher median WTP estimates than the contingent valuation format. One possible reason for the discrepancy may be that the individual views the formats very differently. She may go through a very different thought process when rating programs relative to a status quo scenario than she does when explicitly asked to undertake the program in favor of the status quo. For example, an individual may find it relatively easy to rate programs relative to a status quo scenario, viewing the CJ ratings

task as an opportunity to express what she “likes”, as opposed to what she would actually do. It is reasonable to think that a potential respondent might be quite comfortable completing the ratings task, without seriously considering whether or not she is actually in the market for the good or service that the researcher is attempting to value. However, when she is asked whether or not she would undertake a particular program in the traditional DC CVM format, and particularly in the modified DC CVM format, she may pause to ask herself whether or not she is actually in the market for the good and how much, in terms of her ability to purchase other goods and services, she is willing to give up to obtain it. The difference in the way an individual may respond to the different valuation formats is captured by the comments made by the participant in pre-testing session four (See Appendix A, Figure A.4). The difference in the WTP estimates from the CJ, traditional DC CVM, and modified DC CVM models found in this study suggest that people respond to these formats in very different ways, with dramatic results. The discrepancy between the CJ binary response ratings difference and traditional DC CVM results suggest that a significant number of respondents do not view the act of giving a groundwater protection program a higher rating than the status quo as a binding commitment to undertake and pay for that program. Although the cost attribute is clearly presented in the CJ format, it is possible that, in this format, people tend to ignore the cost attribute more than they do in the traditional and modified DC CVM formats, where it can be argued that the cost of the program is more explicit. There is also an enormous gap between the median WTP estimates obtained from the traditional DC CVM and modified DC CVM formats, suggesting that when respondents are firmly pushed to commit to a particular program in the modified CVM format, they tend to shy away from

the preferences they had expressed just moments ago in the traditional CVM format. However, the median WTP estimates from the more conservative stated preference models, the CJ binary response ratings model ($R^{GWPP}=10$) and the modified DC CVM model, are fairly close, suggesting that a 'yes' response in these models reflects similar level of commitment to a particular program.

Given the wide range of values for groundwater protection estimated by this study, the researcher using stated preference methodology would be wise to estimate several models in order to explore the sensitivity of willingness-to-pay to model specification. Though, theoretically, the WTP estimates from the traditional DC CVM model and the CJ binary response ratings difference model should be similar, we have seen that this is not the case. Individuals appear to view the CVM and CJ valuation formats quite differently. In addition, inclusion of a format similar to the modified DC CVM question, with a subsequent question regarding the individual's level of certainty, allows the researcher to obtain a conservative, lower-bound estimate of willingness-to-pay for the proposed environmental amenity.

Figure 8.1-Survey Question Modified from Cropper et al.'s (1991) Study

To help us understand how people value programs that provide benefits NOW versus programs that provide benefits in the FUTURE, please answer the following questions:

Please suppose that the government has to choose between two programs, Program A and Program B. Both programs will save lives. The two programs cost the same.

Program A will save 100 lives now, but it will not save lives in the future.

Program B will not save lives now, but it will save 200 lives X years from now.

Which program would you choose?

Please check one box:

PROGRAM A **PROGRAM B**

If you chose Program A, which saves 100 lives now, how many lives would Program B have to save 50 years from now to be as attractive to you as Program A? **YOUR ANSWER:**

"Program B would have to save _____ lives X years from now to be as attractive to me as Program A."

OR

"I would never choose Program B."

If you chose Program B, which saves 200 lives X years from now, how many lives would Program A have to save now to be as attractive to you as

Program B? **YOUR ANSWER:**

"Program A would have to save _____ lives now to be as attractive to me as Program B."

OR

"I would never choose Program A."

Table 8.1-Western Massachusetts Towns Included in the Survey Sample

Berkshire County

Alford
Becket
Cheshire
Florida
Hancock
Lanesborough
Mount Washington
New Ashford
Otis
Peru
Sandisfield
Savoy
Tyringham
Washington
Windsor

Franklin County

Ashfield
Bernardston
Charlemont
Conway
Hawley
Heath
Leverett
Leyden
New Salem
Rowe
Shutesbury
Warwick
Wendell
Whately

Hampden County

Brimfield
Granville
Hampden
Holland
Montgomery
Tolland
Wales

Hampshire County

Chesterfield
Cummington
Goshen
Granby
Middlefield
Plainfield
Worthington

Table 8.2-Descriptive Statistics: Respondent Socioeconomic Characteristics

Dummy Variables

Variable	Total No. Responses	Percentage of Respondents
Respondent is a Female	485	33.8%
Elementary Education	472	0.42%
Middle School Education	472	1.27%
High School Education	472	34.95%
College Education	472	41.11%
Graduate School Education	472	22.67%
Respondent is White	476	97.06%
Respondent is African American	476	0%
Respondent is Hispanic	476	0.21%
Respondent is Asian	476	0%
Respondent is a Pacific Islander	476	0%
Respondent is a Native American	476	0.21%
Respondent is of Another Race	476	2.52%
At least one child in HH ¹ (age 0-18 years)	487	38.60%
At least one child in HH (age 1-18 years)	484	37.19%
At least one infant in HH (less than 1 year)	486	5.35%
Household is Primary Residence	500	97.8%
Owner of the Residence	500	94.2%
Definite Move within 2 years	499	5.21%
Possible Move within 2 years	499	11.82%

Continuous Variables

Variable	n	Mean	Stan. Dev.	Min	Max
Age (years)	481	52.16	14.58	20	88
Number of Years at Resid.	491	17.28	14.85	0.50	77
Total no. HH members	486	2.75	1.33	0	10
No. Infants in HH ²	486	0.08	0.49	0	9
No. Children in HH ³	484	0.69	1.04	0	5
Income Range ⁴	430	6.16	2.79	1	10

¹ Household

² An infant is defined as a child who is less than one year of age.

³ The number of children between the ages of 1 and 18 years living in the household.

⁴ Eleven ranges of income were used. Range 6 was \$50,000-\$59,999 in gross annual income.

Table 8.3-Descriptive Statistics for the General Population in Western
Massachusetts

Variable	County			
	Berkshire	Franklin	Hampden	Hampshire
Male ¹	47.9%	48.44%	47.55%	47.2%
Non-Caucasian ²	3.4%	2.2%	11%	6.4%
College Graduates ^{2,3}	20.9%	24.2%	17.6%	31.9%
Total No. HH Members ¹	2.45	2.49	2.60	2.54
Owner of Residence ¹	65.2%	65.57%	60.22%	62.26%
Median HH Income ^{3,4}	\$32,737	\$33,418	\$34,434	\$36,587
Age Distribution ¹				
Under 5 Years	6.27%	7.23%	7.39%	5.44%
5 to 17 Years	16.47%	17.46%	17.57%	13.82%
18 to 20 Years	5.23%	3.74%	4.96%	12.28%
21 to 24 Years	5.68%	5.21%	6.07%	10.15%
25 to 44 Years	29.75%	34.23%	30.93%	31.15%
45 to 54 Years	10.13%	9.69%	9.55%	8.57%
55 to 59 Years	4.64%	3.79%	4.18%	3.43%
60 to 64 Years	4.96%	4.14%	4.59%	3.56%
65 to 74 Years	9.32%	8.16%	8.52%	6.76%
75 to 84 Years	5.63%	4.7%	4.64%	3.69%
85 Years and Over	1.94%	1.66%	1.63%	1.15%

¹ US Census Bureau, 1990 General Population and Housing Characteristics.

² US Census Bureau, 1998 U.S. Counties Estimates.

³ Percentage of persons 25 years and older that are college graduates.

⁴ Median gross annual household income in 1993 dollars.

Table 8.4-Descriptive Statistics for Groundwater Quality Issues

Variable	No. Responses	% of Households
Primary Water Source is a Private Well	501	99%
Do Not Know Primary Water Source	501	1%
Believes GWPD ¹ has been established	494	39.27%
Believes no GWPD established	494	13.16%
Uncertain whether GWPD established	494	47.57%
Household Tested Water within 5 years	500	44.2%
No Water Test within 5 years	500	53.6%
Uncertain about Water Test within 5 years	500	2.2%
Household Rated Water as Very Pure	490	32.25%
Rated Water as Quite Pure	490	52.65%
Rated Water as Just Adequate for Drinking	490	14.08%
Rated Water as Contaminated	490	1.02%
Feels Water Quality Better over Past Year	497	4.83%
Feels Water Quality Worse over Past Year	497	4.02%
Feels Water Quality Same over Past Year	497	82.29%
Uncertain about Water Quality Changes	497	8.85%
Believe HH ² has Responsibility for WQ ³	491	81.47%
Believe Town has Responsibility for WQ	491	5.092%
Believe State has Responsibility for WQ	491	1.02%
Believe Federal Govt. has Responsibility for WQ	491	0.41%
Uncertain who has Responsibility for WQ	491	12.016%
Measures Take to Reduce GWC ⁴ in Past 5 Years		
Installed a Water Filter	495	25.46%
Installed New Well	495	4.65%
Boiled Tap Water	495	3.03%
Purchased Bottled Water	495	14.14%
Limited Amount of Water Consumed	495	6.26%
Took Some Other Measure	495	10.51%
Very Concerned about Quality of WW ⁵	495	36.36%
Somewhat Concerned about Quality of WW	495	36.77%
Not Concerned about Quality of WW	495	26.87%
Feel Have Enough Info about Quality of WW	491	33.61%
Feel Have Some Info about Quality of WW	491	35.85%
Feel Do Not Have Enough Info about Quality WW	491	30.55%
Feel Very Knowledgeable about Health Effects	493	23.53%
Feel Somewhat Knowledgeable about Health Eff	493	54.36%
Feel Very Little Knowledge about Health Effects	493	22.11%

¹ Groundwater Protection District

² Household

³ Water Quality

⁴ Groundwater Contamination

⁵ Well Water

Table 8.5-Testing for Differences in the Mean Characteristics of Respondents: differences between those who stated they were unwilling to make trade-offs between health risks and money, and the rest of the sample.

$$H_0 : \mathbf{m}_x^{\text{notrade-offs}} = \mathbf{m}_x^{\text{restofsample}}$$

Variable	Mean NTO ¹	Mean RS ²	t-statistic	p-value
Age (years)	50.8657	55.1780	-2.8356	0.005***
Female	0.3636	0.2605	2.1543	0.0323**
Racial Minority	0.0174	0.0598	-1.8355	0.0685*
Elementary Education	0.0029	0	1	0.3180
Middle School Education	0.0145	0.0087	0.5390	0.5904
College Education	0.4273	0.3652	1.1850	0.2374
Graduate School	0.2209	0.2435	-0.49	0.6247
Income Level	6.1709	6.1942	-0.0735	0.9415
Total No. HH Members	2.7677	2.7227	0.3120	0.7553
No. of Children in HH	0.7094	0.6723	0.3296	0.742
No. of Infants in HH	0.0595	0.1429	-1.0218	0.3089
Strongly Agree Tech	0.0722	0.127	-1.6721	0.0963*
Agree Technology	0.3472	0.4206	-1.445	0.1499
Disagree Technology	0.2111	0.1508	1.5632	0.1193
Strongly Disagree Tech	0.0667	0.0556	0.4564	0.6485

¹ The mean of the specified variable for those respondents that indicated they were unwilling to make trade-offs between health risks and money in Question 16 of the survey (see Appendix C, Figure C.2).

² The mean of the specified variable for those respondents that did not indicate they were unwilling to make trade-offs between health risks and money.

* The null hypothesis of no difference in means can be rejected at the 90% significance level.

** The null hypothesis of no difference in means can be rejected at the 95% significance level.

*** The null hypothesis of no difference in means can be rejected at the 99% significance level.

Table 8.6-Testing for Differences in the Mean Characteristics of Respondents: differences between those who stated they were “pro-technology” and the rest of the sample.

$$H_0 : m_x^{pro-technology} = m_x^{restofsample}$$

Variable	Mean PT ¹	Mean RS ²	t-statistic	p-value
Age (years)	53.2315	50.9258	1.733	0.0838*
Female	0.2857	0.376	-2.094	0.0368**
Racial Minority	0.028	0.0316	-0.2269	0.8206
Elementary Education	0.0047	0.004	0.1187	0.9056
Middle School Education	0.0142	0.012	0.2065	0.8365
College Education	0.4528	0.3785	1.6165	0.1067
Graduate School	0.1698	0.2709	-2.6477	0.0084***
Income Level	6.2	6.1202	0.2907	0.7714
Total No. HH Members	2.7465	2.7722	-0.2118	0.8324
No. of Children in HH	0.6129	0.7743	-1.7	0.0898*
No. of Infants in HH	0.0463	0.1077	-1.4388	0.1511
No Trade-offs ³	0.6864	0.7857	-2.47	0.0139***

¹ The mean of the specified variable for those respondents that indicated they were “pro-technology”. A respondent is defined as “pro-technology” if he “strongly agreed” or “agreed” with the statement in Question 17 of the survey (see Appendix C, Figure C.2).

² The mean of the specified variable for those respondents that did not indicate they were “pro-technology”.

³ This dummy variable equals “1” if the respondent indicated unwillingness to make trade-offs between health risks and income in Question 16 of the survey (see Appendix C, Figure C.2).

* The null hypothesis of no difference in means can be rejected at the 90% significance level.

** The null hypothesis of no difference in means can be rejected at the 95% significance level.

*** The null hypothesis of no difference in means can be rejected at the 99% significance level.

Table 8.7-Respondent Preferences for General Life-Saving Programs

Variable	% of Respondents
Chose Program A (saves lives today) ¹	61.35%
Chose Program B (saves lives at some specified future date, X) ¹	38.65%
Would Not Choose Between Program A and Program B ²	9.13%
Would Not Indicate a Point of Indifference between A and B ²	21.43%
Would Never Choose Program B ³	62.61%
Would Never Choose Program A ⁴	35.44%

¹ Of those respondents that chose between the two programs ($n=458$).

² Of the total number of survey respondents ($n=504$).

³ Of those respondents that choose program A and responded to the question eliciting point of indifference ($n=238$).

⁴ Of those respondents that choose program B and responded to the question eliciting point of indifference ($n=158$).

Table 8.8-Testing for Differences in the Mean Characteristics:
differences between those respondents who indicated their choice
between the two life-saving programs and those that did not.

$$H_0 : m_x^{\text{choosers}} = m_x^{\text{non-choosers}}$$

Variable	Mean C ¹	Mean NC ²	t-statistic	p-value
Age (years)	51.72	57.24	-2.8203	0.0069***
Female	0.3303	0.425	-1.1510	0.2558
Racial Minority	0.0228	0.1081	-1.6334	0.1109
Elementary Education	0.0046	0	1.4159	0.1575
Middle School Education	0.01376	0	2.4637	0.0141**
College Education	0.4014	0.5278	-1.443	0.1566
Graduate School	0.2271	0.2222	0.0663	0.9475
Income Level	6.1771	5.931	0.4302	0.6699
Total No. HH Members	2.7584	2.6923	0.2954	0.769
No. of Children in HH	0.7072	0.475	1.5754	0.1215
No. of Infants in HH	0.0830	0.05	0.5945	0.5545
Strongly Agree Tech	0.0867	0.1220	-0.6606	0.5123
Agree Technology	0.3778	0.2439	1.8684	0.0676*
Disagree Technology	0.1889	0.2439	-0.7818	0.4383
Strongly Disagree Tech	0.0622	0.0732	-0.2563	0.7989

¹ The mean of the specified variable for those respondents that would choose between the two life-saving programs.

² The mean of the specified variable for those respondents that would not choose between the two-life saving programs.

* The null hypothesis of no difference in means can be rejected at the 90% significance level.

** The null hypothesis of no difference in means can be rejected at the 95% significance level.

*** The null hypothesis of no difference in means can be rejected at the 99% significance level.

Table 8.9-Testing for Differences in the Mean Characteristics of Respondents:
differences between respondents that indicated their indifference point
between life-saving programs and those that did not.

$$H_0 : m_x^{\text{indicates}} = m_x^{\text{doesnotindicate}}$$

Variable	Mean IPI¹	Mean DNIPI²	t-statistic	p-value
Age (years)	51.6224	54.2449	-1.665	0.0979*
Female	0.3221	0.4	-1.4244	0.1564
Racial Minority	0.0237	0.0521	-1.1785	0.241
Elementary Education	0.0027	0.0104	-0.7215	0.4721
Middle School Education	0.0133	0.0104	0.2762	0.7830
College Education	0.4202	0.375	0.8099	0.4193
Graduate School	0.2207	0.25	-0.5932	0.554
Income Level	6.242	5.839	1.1558	0.25
Total No. HH Members	2.7461	2.78	-0.2331	0.8160
No. of Children in HH	0.6893	0.6832	0.0545	0.9566
No. of Infants in HH	0.0831	0.0693	0.3471	0.7287
Strongly Agree Tech	0.09	0.0882	0.0548	0.9564
Agree Technology	0.3753	0.3333	0.7929	0.429
Disagree Technology	0.1928	0.1961	-0.0740	0.9411
Strongly Disagree Tech	0.0591	0.0784	-0.6587	0.5112

¹ The mean of the specified variable for those respondents that indicated their point of indifference between the two life-saving programs.

² The mean of the specified variable for those respondents that did not indicate their point of indifference between the two life-saving programs.

* The null hypothesis of no difference in means can be rejected at the 90% significance level.

Table 8.10-Testing for Differences in the Mean Characteristics of Respondents: differences between respondents that stated they would never choose the future-oriented life-saving program and the rest of the sample.

$$H_0 : m_x^{neverchoosB} = m_x^{restofsample}$$

Variable	Mean NCB ¹	Mean RS ²	t-statistic	p-value
Age (years)	53.3194	49.1494	2.1884	0.03**
Female	0.2276	0.4091	-2.8701	0.0047***
Racial Minority	0.0278	0	2.0215	0.0451**
Elementary Education	0	0.0118	-1	0.3202
Middle School Education	0.0284	0.0118	0.9068	0.3655
College Education	0.3901	0.4235	-0.493	0.6226
Graduate School	0.2411	0.3059	-1.0456	0.2973
Income Level	6.3730	6.5542	-0.4734	0.6365
Total No. HH Members	2.7517	2.6705	0.4610	0.6454
No. of Children in HH	0.6364	0.6782	-0.3014	0.7635
No. of Infants in HH	0.0483	0.0795	-0.7414	0.4597
Strongly Agree Tech	0.1027	0.0814	0.5483	0.5841
Agree Technology	0.4041	0.2791	1.9703	0.0503**
Disagree Technology	0.1918	0.2326	-0.7244	0.4698
Strongly Disagree Tech	0.0548	0.0814	-0.7564	0.4506

¹ The mean of the specified variable for those respondents that indicated they would never choose Program B (the future-oriented life-saving program).

² The mean of the specified variable for those respondents that did not indicate they would never choose Program B.

* The null hypothesis of no difference in means can be rejected at the 90% significance level.

** The null hypothesis of no difference in means can be rejected at the 95% significance level.

*** The null hypothesis of no difference in means can be rejected at the 99% significance level.

Table 8.11-Mean Implicit Discount Rates for Life-Saving Programs

	Overall⁴	10 Years	25 Years	50 Years
Average Rate¹	0.0613* (n=191)	0.1035* (n=77)	0.02896* (n=67)	0.03816* (n=47)
Rate A²	0.1459* (n=89)	0.2630* (n=32)	0.0942* (n=29)	0.0656* (n=28)
Rate B³	-0.0126* (n=102)	-0.00997 (n=45)	-0.0208 (n=38)	-0.0023 (n=19)

¹ Obtained by pooling rates elicited from all respondents.

² Rates calculated from those respondents that chose Program A.

³ Rates calculated from those respondents that chose Program B.

⁴ Rates obtained by pooling the three time horizons.

* Indicates statistical significance at the 0.05 significance level.

The number of individuals in each category is indicated in parentheses.

Table 8.12-Summary Statistics for Implicit Discount Rates for Life-Saving Programs

Rate	Mean	Median	SD⁵	Min	Max	95% LCL⁶	95% UCL⁷
10 year							
Average ¹	0.1035	0	0.1716	-0.1609	0.8517	0.0645	0.1425
Rate A ²	0.2630	0.2303	0.1565	0.0693	0.8517	0.2066	0.3195
Rate B ³	-0.00997	0	0.0439	-0.1609	0.0693	-0.0232	0.0033
25 Year							
Average ¹	0.02896	0	0.0937	-0.5249	0.2763	0.0061	0.0519
Rate A ²	0.0942	0.0921	0.0564	0	0.2763	0.0728	0.1156
Rate B ³	-0.0208	0	0.0858	-0.5249	0.0115	-0.0491	0.0074
50 Year							
Average ¹	0.03816	0.0322	0.0472	-0.0461	0.1842	0.0242	0.0521
Rate A ²	0.0656	0.0461	0.0414	0	0.1842	0.0496	0.0817
Rate B ³	-0.0023	0	0.0147	-0.0461	0.0277	-0.0094	0.0047
Overall⁴							
Average ¹	0.0613	0.0027	0.1288	-0.5249	0.8517	0.0428	0.0798
Rate A ²	0.1459	0.0921	0.1345	0	0.8517	0.1176	0.1743
Rate B ³	-0.0126	0	0.0602	-0.5249	0.0693	-0.0244	-0.0008

¹ Obtained by pooling rates elicited from all respondents.

² Rates calculated from those respondents that chose Program A.

³ Rates calculated from those respondents that chose Program B.

⁴ Rates obtained by pooling the three time horizons.

⁵ Standard Deviation

⁶ Lower Limit of 95% Confidence Interval for the mean.

⁷ Upper Limit of 95% Confidence Interval for the mean.

Table 8.13-Percentages of Respondents with Zero and Negative Mean Discount Rates for Life-Saving Programs

	Overall² (n=191)	10 Years (n=77)	25 Years (n=67)	50 Years (n=47)
Average Rate¹				
Zero Rate	39.23%	45.4546%	43.2836%	23.4043%
Negative Rate	9.9476%	7.7922%	13.4328%	8.5106%

¹ Obtained by pooling rates elicited from all respondents-those that chose Program A and those that chose Program B.

² Obtained by pooling the three time horizons.

The number of individuals in each category is indicated in parentheses.

Table 8.14-Respondent Comments on the Role of Technology

Respondent #47 (Male):

States that technology is relevant for the survey question that elicits preferences for present versus future life-saving programs.

Respondent #500 (Male):

“You discount the way technology can rapidly change conditions. I assume that the technology would surpass in less than 10 years”.

Respondent #540 (Male):

“Technology will improve, hopefully”.

Respondent #738 (Male):

“Technology develops in ten years”.

Respondent #801 (Male):

“because in ten years other programs would be developed to save more lives”.

Respondent #867 (Male):

“because ten years from now, there might be another program”.

Respondent #1113 (Male):

Refuses to answer the survey question that elicits preferences for present versus future life-saving programs: “Technology will develop in twenty-five years”.

Respondent #1210 (Male):

“Policy always changes, technology increases”.

Respondent #1473 (Female):

“Technology will develop”.

Respondent #1620 (Male):

“Save 100 lives with Program A and then spend the next 50 years figuring out how to save the 200 lives Program B targeted”.

Respondent #1705 (Male):

“Survey ignores future technological refinements”. States that the survey question that elicits preferences for present versus future life-saving programs is “flawed”.

Respondent #1779 (Male):

Refers to the survey question that elicits preferences for present versus future lives: “Bogus because hopefully within 50 years other programs would evolve to address the problem”.

Respondent #1960 (Male):

“Save lives now, develop programs for future”.

Table 8.15-Correlations between Respondent Characteristics

	Female	Higher Ed	Income	No. in HH	Racial Minority
Age	-0.14704*	-0.14255*	-0.2382*	-0.4248*	-0.0198
Female		0.0232	-0.1878*	-0.0605	-0.0463
Higher Ed			0.368*	0.0454	0.0293
Income				0.1914*	-0.062
No. in HH					0.022
	No. Infants in HH		No. Children in HH		Child/Infant in HH
Age	-0.0501		0.441*		-0.5512*
Female	0.06		0.0202		0.0354
Higher Ed	0.0373		0.0776		0.1093*
Income	0.0809		0.1088*		0.1402*
No. in HH	0.0617		0.8072*		0.7536*
Racial Minority	-0.0018		-0.0227		-0.0024
No. Infants in HH			0.1936*		0.2043*
No. Children in HH					0.8211*
	Pro-Technology		No Risk-Money Trade-off¹		No Present-Future Trade-offs²
Age	0.0795		-0.1294*		0.1434*
Female	-0.0953*		0.09477*		-0.1972*
Higher Ed	-0.0277		0.0357		-0.101
Income	0.0142		-0.0036		-0.032
No. in HH	-0.01		0.0146		0.0314
Racial Minority	-0.0105		-0.1116*		0.1035
No. Infants in HH	-0.0617		-0.0727		-0.0529
No. Children in HH	-0.0767		0.0154		-0.02
Child/Infant in HH	-0.0476		0.0279		-0.0617
Pro-Technology			-0.1129*		0.142*
No Risk-Money					-0.0815

* Indicates statistical significance at the 0.05 significance level.

¹ Respondents who indicated they were unwilling to make trade-offs between health risks and income.

² Respondents who indicated they would never choose Program B, the future-oriented life saving program.

Table 8.16-Estimation of the Probability of Unwillingness to Trade Present and Future Lives

Dependent Variable is “1” if the respondent indicates he would never choose Program B (the future-oriented program) and “0” otherwise.
The model’s parameters were estimated using binary logistic regression.

Variable	Coefficient	SE	χ^2 p-value
Intercept	0.0486	1.0676	0.9637
Age	0.0154 [1.015] ¹	0.0138	0.2644
Female	-0.6470 [0.524]	0.3355	0.0538**
Higher Education	-0.2807 [0.755]	0.3617	0.4376
Income	-0.0009 [0.999]	0.0616	0.9884
At least 1 Child in HH	-0.0036 [0.996]	0.3622	0.9921
Pro-technology	0.5539 [1.74]	0.3076	0.0718*
No Risk/Money Trade-offs	-0.3859 [0.68]	0.3733	0.3012
Time Horizon	0.0029 [1.003]	0.0096	0.7629

χ^2 Likelihood Ratio Test=14.45, $df=8$, p value=0.0707

¹ The values reported in [] are point estimates of the odds ratio, $\exp(\beta)$.

* Indicates statistical significance at the 10% significance level.

** Indicates statistical significance at the 5% significance level.

Table 8.17-Estimating a Linear Discount Rate Function

Dependent variable is d_i , the i^{th} individual's discount rate.

Variable	Coefficient	SE	p-value
Intercept	0.1266	0.0705	0.0747*
Age	-0.0004	0.0009	0.6825
Female	0.0025	0.0227	0.9138
Racial Minority	-0.0568	0.0761	0.4562
Higher Education	-0.0037	0.0241	0.8794
Income	0.0001	0.0043	0.9852
Child in HH	0.0004	0.0244	0.9875
Pro Technology	-0.0097	0.0211	0.6454
No Risk/Money Trade-offs	0.0265	0.0245	0.2828
t (Time Horizon)	-0.002	0.0006	0.0023**

F-Value=1.54, $df_n=162$, $df_d=9$, p value= 0.1734

* Indicates statistical significance at the 10% significance level.

** Indicates statistical significance at the 1% significance level.

Table 8.18-Predicted Values of the Discount Rate for Life-Saving Programs Using the Estimated Linear Discount Rate Function

$$d_i^* = b_0 + b_1 \overline{age}_i + b_2 \overline{female}_i + b_3 \overline{racial}_i + b_4 \overline{highed}_i + b_5 \overline{income}_i + b_6 \overline{child}_i + b_7 \overline{protech}_i + b_8 \overline{notradeoffs}_i + b_9 t$$

Estimated Discount Rate (d^*)	Time Horizon in Years (t)
11.85%	0
9.88%	10
6.93%	25
2.00%	50

Table 8.19-Descriptive Statistics for the Dependent Variables

Model Specification	Mean	SD	Min	Max
Traditional DC Contingent Valuation ¹	0.4953	0.5002	0	1
Modified DC Contingent Valuation ²	0.1076	0.3099	0	1
CJ Binary Response ($R = 10$) ³	0.1339	0.3407	0	1
CJ Binary Response ($R \geq 9$) ⁴	0.2169	0.4123	0	1
CJ Binary Response ($R \geq 8$) ⁵	0.3415	0.4744	0	1
CJ Binary Response ($R \geq 7$) ⁶	0.4415	0.4968	0	1
CJ Binary Response ($R \geq 6$) ⁷	0.5144	0.5000	0	1
CJ Binary Response ($R \geq 5$) ⁸	0.6186	0.4859	0	1
CJ Binary Response Ratings Difference ⁹	0.6712	0.47	0	1

¹ The dependent variable is “1” if the respondent undertakes the program in the traditional DC CVM section of the survey and “0” otherwise.

² The dependent variable is “1” if the respondent chose the program as his top choice in the modified DC CVM section of the survey, and gave a certainty rating of at least “8” on a scale of 1 (very uncertain) to 10 (very certain), and “0” otherwise.

³ The dependent variable is “1” if the rating assigned to the program was “10” on a scale of 1 (least attractive) to 10 (most attractive), and “0” otherwise.

⁴ The dependent variable is “1” if the rating assigned to the program was at least “9” on a scale of 1 (least attractive) to 10 (most attractive), and “0” otherwise.

⁵ The dependent variable is “1” if the rating assigned to the program was at least “8” on a scale of 1 (least attractive) to 10 (most attractive), and “0” otherwise.

⁶ The dependent variable is “1” if the rating assigned to the program was at least “7” on a scale of 1 (least attractive) to 10 (most attractive), and “0” otherwise.

⁷ The dependent variable is “1” if the rating assigned to the program was at least “6” on a scale of 1 (least attractive) to 10 (most attractive), and “0” otherwise.

⁸ The dependent variable is “1” if the rating assigned to the program was at least “5” on a scale of 1 (least attractive) to 10 (most attractive), and “0” otherwise.

⁹ The dependent variable is “1” if the rating the respondent assigned to the groundwater protection program was higher than the rating assigned to the status quo ($R^{GWP} > R^{SQ}$), and “0” otherwise.

Table 8.20-Model Specification

The probability that the respondent undertakes the j^{th} groundwater protection program in favor of the status quo scenario of no protection is a function of:

Program Attributes

Risk Reduction Today
 Risk Reduction Ten Years From Now
 Cost
 Public Protection²
 Emphasizes Future Risk Reductions³

Respondent Characteristics

Age
 Racial Minority¹
 Child in Household¹
 Income
 Number of Years at Residence
 Definite Plans to Move¹
 Tentative Plans to Move¹

Groundwater Quality Issues

Rated Well Water as Contaminated¹
 Very Concerned about Water Quality¹
 Not Concerned about Water Quality¹
 Enough Information about Water Quality¹
 Not Enough Info about Water Quality¹
 Very Knowledgeable about Health Effects¹
 Not Knowledgeable about Health Effects¹

Survey Characteristics

CVM / Modified CVM Only¹
 CJ / Modified CVM Only¹
 Order⁴

¹ A dummy variable takes the value “1” if this characteristic of interest is present.

² This is a dummy variable that takes the value “1” if the proposed program protects all Massachusetts residents and “0” if it protects the respondent’s household only. This dummy tests for differences in WTP for private versus public groundwater protection programs.

³ This is a dummy variable that takes the value “1” if the size of the risk reduction ten years from now exceeds the size of the risk reduction this year. This dummy tests for differences in WTP for programs that stress risk reduction in the future versus programs that stress risk reduction this year.

⁴ This dummy variable equals “1” if the public groundwater protection programs are presented first and “0” if the private groundwater protection programs are presented first. This dummy tests for order effects.

Table 8.21-The Traditional Dichotomous Choice CVM Model

The dependent variable is “1” if the respondent undertakes the program.
 The model’s parameters were estimated using binary logistic regression.

Variable	Coefficient	OR ¹	χ^2 p-value
Intercept	-1.8174		0.008***
<i>Program Attributes</i>			
Risk Reduction This Year	0.0452	1.046	0.0745*
Risk Reduction Ten Years	0.0713	1.074	0.0004***
Cost (one-time paid this year)	-0.0013	0.999	<0.0001***
All Mass Residents Protected	0.5090	1.664	0.0060***
Emphasizes Future Risk Reductions	0.1574	1.170	0.7056
<i>Respondent Characteristics</i>			
Age	-0.0007	0.999	0.9452
Racial Minority	-0.9278	0.395	0.0777*
Child in Household	0.2389	1.270	0.2519
Income	0.0815	1.085	0.0081***
Years at Residence	-0.0089	0.991	0.2190
Definite Plans to Move	2.0492	7.762	<0.0001***
Tentative Plans to Move	0.6669	1.948	0.0055***
<i>Groundwater Quality Issues</i>			
Rated Well Water as “Contaminated”	-1.6716	0.188	0.1854
Very Concerned about Water Quality	0.3655	1.441	0.0401**
Not Concerned about Water Quality	0.2326	1.262	0.2590
Enough Info about Water Quality	-0.4199	0.657	0.0368**
Not Enough Info about Water Quality	0.5360	1.709	0.0040***
Very Knowledgeable about Health Effects	-0.2429	0.784	0.2375
Not Knowledgeable about Health Effects	-0.3621	0.696	0.0719*
<i>Version of the Survey</i>			
CVM / Modified CVM Only	-0.4998	0.607	0.0015***
Order	0.0198	1.020	0.9006

Likelihood Ratio Test=177.75, *df*=21, p-value<0.0001

¹ The values reported in this column are point estimates of the odds ratio, $\exp(\beta_j)$.

* Indicates statistical significance at the 10% significance level.

** Indicates statistical significance at the 5% significance level.

*** Indicates statistical significance at the 1% significance level.

Table 8.22-The Modified Dichotomous Choice CVM Model

The dependent variable is “1” if the respondent chose the program as his/her top choice (the one program he or she would be willing to undertake and pay for) and gave a certainty rating of at least “8” on a scale of 1 (very uncertain) to 10 (very certain).

The model’s parameters were estimated using binary logistic regression.

Variable	Coefficient	OR ¹	χ^2 p-value
Intercept	-4.0692		<0.0001***
<i>Program Attributes</i>			
Risk Reduction This Year	0.0288	1.029	0.3158
Risk Reduction Ten Years	0.0597	1.062	0.0215**
Cost (one-time cost paid this year)	-0.0009	0.999	<0.0001***
All Mass Residents Protected	1.0739	2.927	<0.0001***
Emphasizes Future Risk Reductions	0.6070	1.835	0.2322
<i>Respondent Characteristics</i>			
Age	-0.0041	0.996	0.6689
Racial Minority	0.088	1.092	0.8663
Child in Household	-0.2150	0.807	0.3021
Income	0.0496	1.051	0.1378
Years at Residence	-0.0044	0.996	0.6112
Definite Plans to Move	0.5873	1.799	0.0891*
Tentative Plans to Move	-0.0591	0.943	0.8374
<i>Groundwater Quality Issues</i>			
Rated Well Water as “Contaminated”	0.4798	1.616	0.5588
Very Concerned about Water Quality	0.1795	1.197	0.3807
Not Concerned about Water Quality	-0.0903	0.914	0.7159
Enough Info about Water Quality	-0.1882	0.828	0.4253
Not Enough Info about Water Quality	-0.0977	0.907	0.6524
Very Knowledgeable about Health Effects	0.1656	1.180	0.4779
Not Knowledgeable about Health Effects	0.1568	1.170	0.4954
<i>Version of the Survey</i>			
CVM / Modified CVM Only	-0.1588	0.853	0.4910
CJ / Modified CVM Only	0.0751	1.078	0.7361
Order	0.2007	1.222	0.2707

Likelihood Ratio Test=94.2, $df=22$, $p\text{-value}<0.0001$

¹ The values reported in this column are point estimates of the odds ratio, $\exp(\beta)$.

* Indicates statistical significance at the 10% significance level.

** Indicates statistical significance at the 5% significance level.

*** Indicates statistical significance at the 1% significance level.

Table 8.23-The Conjoint Binary Response Ratings Model

The dependent variable is “1” if the rating assigned to groundwater protection program was “10” on a scale of 1 (least attractive) to 10 (most attractive), and “0” otherwise.

The model’s parameters were estimated using binary logistic regression.

Variable	Coefficient	OR ¹	χ^2 p-value
Intercept	-4.9081		<0.0001***
<i>Program Attributes</i>			
Risk Reduction This Year	0.0629	1.065	0.0648*
Risk Reduction Ten Years	0.0977	1.103	0.0015***
Cost (one-time cost paid this year)	-0.001	0.999	<0.0001***
All Mass Residents Protected	1.1821	3.261	<0.0001***
Emphasizes Future Risk Reductions	0.4718	1.603	0.4254
<i>Respondent Characteristics</i>			
Age	0.0039	1.004	0.7243
Racial Minority	0.4606	1.585	0.4341
Child in Household	0.1206	1.128	0.6135
Income	-0.0654	0.937	0.0998*
Years at Residence	-0.0082	0.992	0.4141
Definite Plans to Move	0.7957	2.216	0.0359**
Tentative Plans to Move	-0.1636	0.849	0.6567
<i>Groundwater Quality Issues</i>			
Rated Well Water as “Contaminated”	-0.0003	1	0.9998
Very Concerned about Water Quality	0.3722	1.451	0.14
Not Concerned about Water Quality	-0.0552	0.946	0.8563
Enough Info about Water Quality	-0.1493	0.861	0.5836
Not Enough Info about Water Quality	0.1374	1.147	0.6028
Very Knowledgeable about Health Effects	0.3103	1.364	0.2377
Not Knowledgeable about Health Effects	0.14	1.150	0.6180
<i>Version of the Survey</i>			
CJ / Modified CVM Only	-0.1942	0.824	0.3643
Order	0.3010	1.351	0.1647

Likelihood Ratio Test=93.63, $df=21$, p-value < 0.0001

¹ The values reported in this column are point estimates of the odds ratio, $\exp(\beta)$.

* Indicates statistical significance at the 10% significance level.

** Indicates statistical significance at the 5% significance level.

*** Indicates statistical significance at the 1% significance level.

Table 8.24-The Conjoint Binary Response Ratings Difference Model

The dependent variable is “1” if the rating assigned to the groundwater protection program exceeds the rating assigned to the status quo ($R^{GWP} > R^{SQ}$).

The model’s parameters were estimated using binary logistic regression.

Variable	Coefficient	OR ¹	χ^2 p-value
Intercept	1.1090		0.0814*
<i>Program Attributes</i>			
Risk Reduction This Year	0.0360	1.037	0.1430
Risk Reduction Ten Years	0.0449	1.046	0.0157**
Cost (one-time cost paid this year)	-0.0005	0.999	0.0024***
All Mass Residents Protected	0.2941	1.342	0.1124
Emphasizes Future Risk Reductions	0.0221	1.022	0.9569
<i>Respondent Characteristics</i>			
Age	-0.0192	0.981	0.0219**
Racial Minority	-0.7987	0.450	0.0737*
Child in Household	-0.4516	0.637	0.0112***
Income	-0.0096	0.990	0.7267
Years at Residence	-0.0051	0.995	0.4569
Definite Plans to Move	1.0972	2.996	0.0044***
Tentative Plans to Move	0.1029	1.108	0.7042
<i>Groundwater Quality Issues</i>			
Rated Well Water as “Contaminated”	1.5044	4.501	0.1628
Very Concerned about Water Quality	0.0068	1.007	0.9708
Not Concerned about Water Quality	-0.1113	0.895	0.5945
Enough Info about Water Quality	-0.3536	0.702	0.0612*
Not Enough Info about Water Quality	-0.3133	0.731	0.1240
Very Knowledgeable about Health Effects	-0.2701	0.763	0.1494
Not Knowledgeable about Health Effects	0.1795	1.197	0.3955
<i>Version of the Survey</i>			
CJ / Modified CVM Only	0.2898	1.336	0.0623*
Order	0.0436	1.045	0.7818

Likelihood Ratio Test=73.17, $df=21$, $p\text{-value} < 0.0001$

¹ The values reported in this column are point estimates of the odds ratio, $\exp(\beta)$.

* Indicates statistical significance at the 10% significance level.

** Indicates statistical significance at the 5% significance level.

*** Indicates statistical significance at the 1% significance level.

Table 8.25-Testing the Null Hypothesis that the Coefficient on the Present Risk Reduction and the Coefficient on the Future Risk Reduction are Equal

$H_0 : \mathbf{b}^{RR(t)} = \mathbf{b}^{RR(t+10)}$ (1 restriction)

Model Specification	Wald χ^2	df	χ^2 p-value
Traditional DC Contingent Valuation ¹	0.4582	1	0.4985
Modified DC Contingent Valuation ²	0.4459	1	0.5043
CJ Binary Response Ratings ($R^{GWPP}=10$) ³	0.4016	1	0.5262
CJ Binary Response Ratings Difference ⁴	0.0599	1	0.8067

¹ The dependent variable in this model is “1” if the respondent undertook the groundwater protection program in favor of the status quo in the traditional DC CVM section of the survey, and “0” otherwise.

² The dependent variable in this model is “1” if the respondent choose the groundwater protection program as the one program he would undertake and be willing to pay for in the modified DC CVM section of the survey and gave a certainty rating of at least “8” on scale of “1” (Very Uncertain) to “10” (Very Certain). Otherwise, the dependent variable is “0”.

³ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program a “10” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁴ The dependent variable in this model is “1” if the rating assigned to the groundwater protection program in the conjoint section of the survey exceeds the rating assigned to the status quo ($R^{GWPP} > R^{SQ}$), and “0” otherwise.

Table 8.26-Summary Statistics for the “Average” Groundwater Protection Program

Variable	Mean	SD	Min	Max
Program Attributes				
Risk Reduction This Year (%) ¹	1.0147	0.5675	0.2	1.8
Risk Reduction in Ten Years (%) ²	1.8644	0.919	0.5	2.8
One-time Cost This Year (\$)	633.01	543.46	50	1600
Protects All Western MA Residents	0.50	0.5001	0	1
Emphasizes Future Risk Reductions	0.50	0.5001	0	1
Version of the Survey				
CVM / Modified CVM only	0.34127	0.4742	0	1
CJ / Modified CVM only	0.3730	0.4837	0	1
Order	0.5377	0.4987	0	1

¹ From a baseline risk of 2%.

² From a baseline risk of 3%.

Table 8.27-Estimated Probability
of Undertaking the Average Level of Groundwater Protection

Calculated at the mean values of respondent characteristics (see Tables 8.2 and 8.4) and at the mean values of the groundwater protection program attributes (see Table 8.26).

Model Specification	Predicted Probability
Traditional DC Contingent Valuation ¹	0.4921
Modified DC Contingent Valuation ²	0.089
CJ Binary Response Ratings ($R^{GWPP} = 10$) ³	0.1009
CJ Binary Response Ratings ($R^{GWPP} = 9$) ⁴	0.1837
CJ Binary Response Ratings ($R^{GWPP} = 8$) ⁵	0.3115
CJ Binary Response Ratings ($R^{GWPP} = 7$) ⁶	0.4062
CJ Binary Response Ratings ($R^{GWPP} = 6$) ⁷	0.4913
CJ Binary Response Ratings ($R^{GWPP} = 5$) ⁸	0.6182
CJ Binary Response Ratings Difference ⁹	0.6779

¹ The dependent variable in this model is “1” if the respondent undertook the groundwater protection program in favor of the status quo in the traditional DC CVM section of the survey, and “0” otherwise.

² The dependent variable in this model is “1” if the respondent choose the groundwater protection program as the one program he would undertake and be willing to pay for in the modified DC CVM section of the survey and gave a certainty rating of at least “8” on scale of “1” (Very Uncertain) to “10” (Very Certain). Otherwise, the dependent variable is “0”.

³ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program a “10” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁴ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least a “9” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁵ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least an “8” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁶ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least a “7” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁷ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least a “6” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁸ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least a “5” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁹ The dependent variable in this model is “1” if the rating assigned to the groundwater protection program in the conjoint section of the survey exceeds the rating assigned to the status quo ($R^{GWPP} > R^{SQ}$), and “0” otherwise.

Table 8.28-Estimated Probability of Undertaking Specific Groundwater Programs

<u>Model Specification</u>	<u>Program Attributes</u>				<u>Estimated Prob.</u> ¹
	RRT ²	RRF ³	Cost ⁴	Extent of Protection	
<u>Traditional DC CVM</u> ⁵					
	1.5%	2%	\$1600	All Mass Residents	0.352
	1.5%	2%	\$1600	Household Only	0.2461
	2%	1.5%	\$1600	All Mass Residents	0.2819
	2%	1.5%	\$1600	Household Only	0.1967
	0.5%	1%	\$50	All Mass Residents	0.5481
	0.5%	1%	\$50	Household Only	0.4217
	1%	0.5%	\$50	All Mass Residents	0.4763
	1%	0.5%	\$50	Household Only	0.3535
<u>Modified DC CVM</u> ⁶					
	1.5%	2%	\$1600	All Mass Residents	0.1057
	1.5%	2%	\$1600	Household Only	0.0388
	2%	1.5%	\$1600	All Mass Residents	0.0523
	2%	1.5%	\$1600	Household Only	0.0185
	0.5%	1%	\$50	All Mass Residents	0.1645
	0.5%	1%	\$50	Household Only	0.063
	1%	0.5%	\$50	All Mass Residents	0.0842
	1%	0.5%	\$50	Household Only	0.0305
<u>CJ Binary Response Ratings ($R^{GWPP}=10$)⁷</u>					
	1.5%	2%	\$1600	All Mass Residents	0.129
	1.5%	2%	\$1600	Household Only	0.0434
	2%	1.5%	\$1600	All Mass Residents	0.072
	2%	1.5%	\$1600	Household Only	0.0233
	0.5%	1%	\$50	All Mass Residents	0.1228
	0.5%	1%	\$50	Household Only	0.0412
	1%	0.5%	\$50	All Mass Residents	0.0684
	1%	0.5%	\$50	Household Only	0.022

Continued next page.

Table 8.28 (continued)

<u>Model Specification</u>	<u>Program Attributes</u>				<u>Estimated Prob.</u> ¹
	RRT ²	RRF ³	Cost ⁴	Extent of Protection	
<u>CJ Binary Response Ratings Difference</u> ⁸					
	1.5%	2%	\$1600	All Mass Residents	0.6537
	1.5%	2%	\$1600	Household Only	0.5844
	2%	1.5%	\$1600	All Mass Residents	0.6383
	2%	1.5%	\$1600	Household Only	0.5681
	0.5%	1%	\$50	All Mass Residents	0.6529
	0.5%	1%	\$50	Household Only	0.5836
	1%	0.5%	\$50	All Mass Residents	0.6376
	1%	0.5%	\$50	Household Only	0.5674

¹ The estimated probability that the average respondent undertakes the groundwater protection program with these attributes.

² The reduction in risk this year from the baseline risk of 2%.

³ The reduction in risk ten years from now from the baseline risk of 3%.

⁴ The one-time cost for the program, paid this year.

⁵ The dependent variable in this model is “1” if the respondent undertook the groundwater protection program in favor of the status quo in the traditional DC CVM section of the survey, and “0” otherwise.

⁶ The dependent variable in this model is “1” if the respondent choose the groundwater protection program as the one program he would undertake and be willing to pay for in the modified DC CVM section of the survey and gave a certainty rating of at least “8” on scale of “1” (Very Uncertain) to “10” (Very Certain). Otherwise, the dependent variable is “0”.

⁷ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program a “10” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁸ The dependent variable in this model is “1” if the rating assigned to the groundwater protection program in the conjoint section of the survey exceeds the rating assigned to the status quo ($R^{GWPP} > R^{SQ}$), and “0” otherwise.

Table 8.29-Results of the Hosmer and Lemeshow Goodness-of-Fit Tests

Traditional DC Contingent Valuation⁵

<u>Group</u>	<u>n</u>	<u>Undertakes Program</u>		<u>Does Not Undertake Program</u>	
		<u>Obs¹</u>	<u>Exp²</u>	<u>Obs</u>	<u>Exp</u>
1 ³	89	11	12.21	78	76.79
2	89	25	21.38	64	67.62
3	89	27	28.99	62	60.01
4	89	34	35.54	55	53.46
5	89	40	41.30	49	47.70
6	89	50	46.76	39	42.24
7	91	55	53.58	36	37.42
8	89	59	58.77	30	30.23
9	89	68	66.15	21	22.85
10 ⁴	88	70	74.33	18	13.67

<u>c² Test Statistic C</u>	<u>DF</u>	<u>c² p-value</u>
3.7268	8	0.8809

Modified DC Contingent Valuation⁶

<u>Group</u>	<u>n</u>	<u>Undertakes Program</u>		<u>Does Not Undertake Program</u>	
		<u>Obs</u>	<u>Exp</u>	<u>Obs</u>	<u>Exp</u>
1	143	3	3.39	140	139.61
2	145	7	5.45	138	139.55
3	144	9	7.22	135	136.78
4	144	9	9.26	135	134.74
5	144	10	11.84	134	132.16
6	145	16	14.69	129	130.31
7	144	12	17.60	132	126.40
8	144	29	21.22	115	122.78
9	145	21	27.59	124	117.41
10	142	47	44.71	95	97.29

<u>c² Test Statistic C</u>	<u>DF</u>	<u>c² p-value</u>
8.9055	8	0.3503

¹ Observed responses in the actual data.

² Estimated number of responses based on the estimated probabilities from the logistic regression model.

³ Decile of respondents least likely to undertake the groundwater protection program.

⁴ Decile of respondents most likely to undertake the groundwater protection program.

⁵ The dependent variable in this model is “1” if the respondent undertook the groundwater protection program in favor of the status quo in the traditional DC CVM section of the survey, and “0” otherwise.

⁶ The dependent variable in this model is “1” if the respondent choose the groundwater protection program as the one program he would undertake and be willing to pay for in the modified DC CVM section of the survey and gave a certainty rating of at least “8” on scale of “1” (Very Uncertain) to “10” (Very Certain). Otherwise, the dependent variable is “0”.

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Table 8.29 (continued)

CJ Binary Response Ratings ($R^{GWPP}=10$)⁶

<u>Group</u>	<u>n</u>	<u>Undertakes Program</u>		<u>Does Not Undertake Program</u>	
		<u>Obs</u>	<u>Exp</u>	<u>Obs</u>	<u>Exp</u>
1 ³	95	3	1.80	92	93.20
2	96	6	3.52	90	92.48
3	94	4	4.93	90	89.07
4	94	7	6.53	87	87.47
5	94	6	8.39	88	85.61
6	94	6	10.29	88	83.71
7	94	15	13.18	79	80.82
8	94	18	17.73	76	76.27
9	94	25	24.68	69	69.32
10 ⁴	88	36	34.92	52	53.08

<u>c² Test Statistic C</u>	<u>DF</u>	<u>c² p-value</u>
5.9514	8	0.6527

CJ Binary Response Ratings Difference⁷

<u>Group</u>	<u>n</u>	<u>Undertakes Program</u>		<u>Does Not Undertake Program</u>	
		<u>Obs</u>	<u>Exp</u>	<u>Obs</u>	<u>Exp</u>
1	94	44	42	50	52
2	94	52	51.54	42	42.46
3	94	54	56.98	40	37.02
4	94	62	61.10	32	32.90
5	95	62	65.31	33	29.69
6	95	71	68.26	24	26.74
7	94	68	70.38	26	23.62
8	95	75	74.42	20	20.58
9	94	82	77.42	12	16.58
10	87	75	77.59	12	9.41

<u>c² Test Statistic C</u>	<u>DF</u>	<u>c² p-value</u>
4.2225	8	0.8365

¹ Observed responses in the actual data.

² Estimated number of responses based on the estimated probabilities from the logistic regression model.

³ Decile of respondents least likely to undertake the groundwater protection program.

⁴ Decile of respondents most likely to undertake the groundwater protection program.

⁶ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program a “10” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁷ The dependent variable in this model is “1” if the rating assigned to the groundwater protection program in the conjoint section of the survey exceeds the rating assigned to the status quo ($R^{GWPP} > R^{SQ}$), and “0” otherwise.

Table 8.30-Estimates of Median WTP
for the Average Groundwater Protection Program

Calculated at the mean values of respondent characteristics (See Tables 8.2 and 8.4) and at the mean values of the groundwater protection program attributes (See Table 8.26).

Model Specification	Median WTP (one-time cost per household)
Traditional DC Contingent Valuation ¹	\$608.24
Modified DC Contingent Valuation ²	-\$1951.48
CJ Binary Response Ratings ($R^{GWPP} = 10$) ³	-\$1621.69
CJ Binary Response Ratings ($R^{GWPP} \geq 9$) ⁴	-\$1497.73
CJ Binary Response Ratings ($R^{GWPP} \geq 8$) ⁵	-\$550.57
CJ Binary Response Ratings ($R^{GWPP} \geq 7$) ⁶	-\$57.82
CJ Binary Response Ratings ($R^{GWPP} \geq 6$) ⁷	\$582.03
CJ Binary Response Ratings ($R^{GWPP} \geq 5$) ⁸	\$1311.53
CJ Binary Response Ratings Difference ⁹	\$2063.62

¹ The dependent variable in this model is “1” if the respondent undertook the groundwater protection program in favor of the status quo in the traditional DC CVM section of the survey, and “0” otherwise.

² The dependent variable in this model is “1” if the respondent choose the groundwater protection program as the one program he would undertake and be willing to pay for in the modified DC CVM section of the survey and gave a certainty rating of at least “8” on scale of “1” (Very Uncertain) to “10” (Very Certain). Otherwise, the dependent variable is “0”.

³ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program a “10” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁴ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least a “9” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁵ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least an “8” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁶ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least a “7” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁷ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least a “6” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁸ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program at least a “5” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁹ The dependent variable in this model is “1” if the rating assigned to the groundwater protection program in the conjoint section of the survey exceeds the rating assigned to the status quo ($R^{GWPP} > R^{SQ}$), and “0” otherwise.

Table 8.31-Median WTP for Private versus Public Groundwater Protection

Model Specification	Median WTP (one-time cost per household)	
	Private¹	Public²
Traditional DC Contingent Valuation ⁴	\$407 [0.429] ³	\$808.63 [0.5555]
Modified DC Contingent Valuation ⁵	-\$2548.09 [0.054]	-\$1354.87 [0.1432]
CJ Binary Response Ratings ($R^{GWPP}=10$) ⁶	-\$2231.02 [0.0585]	-\$1012.36 [0.1685]
CJ Binary Response Ratings Difference ⁷	\$1780.83 [0.6449]	\$2346.41 [0.7091]

¹ A “private” groundwater protection program reduces risk for the respondent’s household only.

² A “public” groundwater protection program reduces risk for all Massachusetts residents.

³ The values reported in [] are the estimated probabilities that the “average” respondent undertakes the program.

⁴ The dependent variable in this model is “1” if the respondent undertook the groundwater protection program in favor of the status quo in the traditional DC CVM section of the survey, and “0” otherwise.

⁵ The dependent variable in this model is “1” if the respondent choose the groundwater protection program as the one program he would undertake and be willing to pay for in the modified DC CVM section of the survey and gave a certainty rating of at least “8” on scale of “1” (Very Uncertain) to “10” (Very Certain). Otherwise, the dependent variable is “0”.

⁶ The dependent variable in this model is “1” if the respondent assigned the groundwater protection program a “10” on a scale of “1” (Least Attractive) to “10” (Most Attractive), and “0” otherwise.

⁷ The dependent variable in this model is “1” if the rating assigned to the groundwater protection program in the conjoint section of the survey exceeds the rating assigned to the status quo ($R^{GWPP} > R^{SQ}$), and “0” otherwise.

Table 8.32-Testing for Differences in the Mean Characteristics of Respondents:
certain respondents versus uncertain respondents

A “certain respondent” gave a certainty rating of at least “8” on a scale of 1 (Very Uncertain) to 10 (Very Certain) regarding his or her choice in the modified CVM question, while an “uncertain” respondent gave a rating less than “8”.

$H_0 : m_x^{certain} = m_x^{uncertain}$				
Variable	Mean CR ¹	Mean UR ²	t-stat	p-value
<i>Program Attributes</i>				
Risk Reduction Today ³	10.0043	10.3285	-1.0922	0.2749
Risk Reduction Ten Years ³	18.4713	18.7548	-0.8103	0.4179
One-time Cost (\$)	613.1383	640.8213	-1.0697	0.2849
<i>Respondent Characteristics</i>				
Age (years)	51.6096	50.5951	1.6681	0.0955*
Female	0.2707	0.3805	-5.4683	<0.0001***
Racial Minority	0.0308	0.0249	0.8388	0.4017
Child in Household	0.3772	0.4203	-2.0502	0.0405**
At Least a College Education	0.6637	0.596	3.2259	0.0013***
Income Level	6.4402	6.0541	3.0925	0.002***
Years at Residence	16.4061	15.5223	1.472	0.1412
Definite Plans to Move	0.0684	0.0488	1.9615	0.05**
Tentative Plans to Move	0.1068	0.1366	-2.1206	0.0341**
Pro-Technology ⁴	0.4464	0.4406	0.2695	0.7876
No Risk/Money Trade-offs ⁵	0.75	0.77	-1.086	0.2775
<i>Groundwater Quality Issues</i>				
Rated Water “Contaminated”	0.0087	0.005	1.0472	0.2951
Very Concerned about WQ ⁶	0.3949	0.3547	1.9349	0.0531**
Not Concerned about WQ	0.2747	0.2118	3.43	<0.0001***
Enough Info about WQ	0.3562	0.2714	4.2651	<0.0001***
Not Enough Info about WQ	0.2747	0.3668	-4.5802	<0.0001***
Very Knowledgeable about HE ⁷	0.279	0.1791	5.5892	<0.0001***
Not Knowledgeable about HE	0.206	0.2438	-2.098	0.036**
<i>Version of Survey</i>				
CVM / Modified CVM Only	0.3319	0.3671	-1.7326	0.0833*
CJ / Modified CVM Only	0.3872	0.3671	0.9721	0.3311

¹ The mean of the specified variable for “certain respondents”.

² The mean of the specified variable for “uncertain respondents”.

³ Per 1,000

⁴ A respondent is defined as “pro-technology” if he either “agreed” or “strongly agreed” with the statement in Question 17: “Technology will develop to eliminate many types of groundwater pollution problems within the next 50 years”.

⁵ This category refers to an individual that either “disagreed” or “strongly disagreed” with the statement in Question 16: “I am willing to accept a very small health risk increase if it means that some additional money would be available for my personal use”.

⁶ Water Quality

⁷ Health Effects

* The null hypothesis of no difference in means can be rejected at the 90% significance level.

** The null hypothesis of no difference in means can be rejected at the 95% significance level.

*** The null hypothesis of no difference in means can be rejected at the 99% significance level.