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PUBLIC RESPONSE TO THE DISCOVERY OF WATER CONTAMINATION

by
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October, 1985

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ABSTRACT

This study examines data from public opinion surveys regarding water supply pollution and protection issues. The surveys were conducted in several New England communities with ongoing or potential water quality problems. Results show that people generally place a high priority on water protection, even in communities where no recent crisis has raised public awareness. Where no crisis has occurred, more educated and environmentally active citizens are the group with the deepest concern. After a crisis, concern is much broader, and does not correlate with education. Younger adults, parents of young children, and women are the groups most concerned after contamination has been discovered.

The pattern of change in the demographic predictors of concern about water quality suggests that there is a shift in the way this issue is perceived. Before a crisis has occurred, water quality is typically viewed as an "environmental" issue. After a crisis, water quality becomes viewed as a "safety" issue, and particularly as a threat to the safety of one's children. Public concern is greatly intensified as a result of this shift. Conflicts may arise when authorities responding to the crisis misunderstand the sources and intensity of such safety related concern.

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CHAPTER 1:

INTRODUCTION

Contamination of public water supplies is widely recognized as a major problem, with complex social, economic, and political dimensions in addition to more basic natural and technical aspects. These social dimensions have been studied much less than technical issues, so there is little systematic understanding of them.

The purpose of this research is to examine social and public-opinion aspects of water contamination problems. Two phases in the development of such problems are addressed: a preventative phase, when serious contamination has not yet occurred and might be prevented by protective action; and a reactive phase, when contamination has already been discovered, and the public must deal with conflicting reports about potential hazards, clean-up strategies, and blame. In both phases, public support for possible water-protection actions can be crucial to their chances of success. To some extent, such public support follows predictable patterns. These patterns should be understood by those interested in formulating water protection policies; if not understood, they may overwhelm seemingly rational plans. To bring out such patterns, this research studies the social bases of citizen concern about water protection problems, before and after a real crisis has occurred.

The principal method of this research is the statistical analysis of survey questionnaire data. Six different surveys are involved. Three of these surveys were conducted with participants at household hazardous waste pick-up operations, in the communities of Dover, Exeter, and Salem, New Hampshire. These surveys examine the opinions of environmentally-concerned citizens who are participating in a voluntary, experimental program to reduce the possibility of future water contamination. Household use of hazardous chemicals is a substantial, but little-recognized, contribution to the waste stream that leads to overflowing municipal dumps and "nonpoint-source" pollution of groundwater. To control this problem, it is important first that people recognize it <u>is</u> a problem. The organizers of the household waste pick-up days sought to instill this recognition in the communities they targeted. Citizens who participated in the pick-up are those who were convinced by the publicity or by prior beliefs that casual disposal of household chemical wastes was innappropriate. Studying the surveys filled out by these people may indicate what publicity influenced them, and also may suggest whether some groups in the population are more likely to respond to these programs than other groups are.

The fourth survey is more extensive, mailed to a random sample of adult residents in Dover, New Hampshire. Although

household wastes contribute to water pollution, the problem cannot be solved by household clean-ups alone. Like many local governments in New England, the city of Dover has been considering a number of possible steps to protect existing water supplies from future threats. The questionnaire sent to Dovere residents asked about a variety of possible water-protection policies presently being debated by the Dover City Council and other bodies; and about general support for funding the water-protection activities of federal, state, and local government. The purpose of this questionnaire was to obtain data on the depth of public support for water-protection steps in the absence of an immediate crisis. These data also shed light on possible demographic correlates of concern about water pollution.

The fifth and sixth questionnaires were sent to random samples of residents in Williamstown, Vermont, and Acton, Massachusetts. In contrast to the other communities surveyed, Williamstown and Acton had already experienced substantial water pollution. In Acton's case, this had led to the closing of several municipal wells, years of legal action, and an expensive new purification system. In Williamstown, several private wells had been closed, and low-level contamination was found in the town's main well, dump, and two schools. Thus Williamstown and Acton are communities where significant water contamination had already occurred, and been heavily publicized and discussed, at the time the surveys were conducted. The surveys focussed on issues that had been at the center of public debate, and sought to measure both how much concern their was, and who was most and least concerned about the contamination problems. These surveys sought citizens' opinions about a variety of possible remedial measures, and assessed their attitudes towards some of the public agencies involved.

All of the questionnaires were subjected to extensive statistical analyses, summarized in over two dozen tables and figures in the technical completion report that follows. Survey data was supplemented by information from personal interviews and newspaper clippings, and discussions with some of the policy-making officials involved. In addition to these analyses of public-opinion issues, an analysis of five years of well-test data, for the town of Lee, New Hampshire, is included as an appendix to the completion report. This last analysis was conducted at the request of some of the citizens and officials being interviewed for opinion purposes.

The three surveys conducted with household toxics pick-up participants are described in Chapter 2. Chapter 3 examines results from the opinion survey of Dover residents. The Williamstown survey, and a comparative analysis of the Williamstown and Acton data are discussed in Chapter 4. Chapter 5 summarizes major findings from all six surveys, and points out possible directions for future research. The surveys themselves are reproduced in Appendices A-D, followed by Appendix E (the Lee well test data) and selected references.

CHAPTER 2:

HOUSEHOLD TOXIC WASTE PICK-UPS: DOVER, EXETER, AND SALEM

On April 20, 1985, the New Hampshire Division of Public Health, with support from private industries and the League of Women Voters, sponsored a clean-up day for household toxic wastes in Dover. People from Dover, Durham, Lee, Madbury, and Rollinsford were invited to bring in hazardous household materials, up to a ten-gallon limit, that they did not know how to dispose of properly. The Dover clean-up was very successful; more than 214 people participated, contributing some 47 drums of waste.

After participants dropped off their materials, League volunteers asked them a series of questions from a questionnaire. Results from these questionnaires will be described below. Only one questionnaire was completed for each car, and some people did not answer some or all questions. A total of 178 usable questionnaires was obtained, which forms the basis for the Dover analyses below.

Similar clean-up days were held on May 18 in Exeter, and on May 19 in Salem, under the auspices of the Rockingham Planning Commission. These latter two clean-ups were funded largely by contributions from the municipalities involved, private sector donations, and a grant from the New Hampshire Charitable Fund. The Rockingham Planning Commission provided staff support and did much of the extensive fund-raising effort; The League of Women Voters and many private individuals voluteered time for the projects. An estimated 2000 gallons of hazardous wastes were collected, despite heavy rain during the Exeter clean-up and the Sunday scheduling in Salem. A questionnaire, similar to that used in Dover, was administered to participants at both Exeter and Salem. At Exeter, 109 usable questionnaires were collected; at Salem, 39 more were collected. These data also form the basis for the analyses below, where the Dover, Exeter, and Salem surveys are examined side by side.

As shown in Table 2.1, most of the participants in all three clean-up days traveled ten miles or less to reach the pickup site. They came mainly from the host and surrounding communities where publicity had been targeted, with a few from more distant towns. Although the pick-ups were intended to draw only from specifically limited areas, people from outside of these areas were not turned away if they showed up. The way people heard about the clean-up varied depending on how publicity had been done in their town. For example, Dover residents were most likely to cite newspapers (71%) as their source of information; in nearby Durham, which has no paper of its own, flyers (78%) were the most common source. These flyers had been sent out through the mail on a community-wide basis in Durham. Newspapers were cited by most of the repondents in both Exeter (71%) and

TABLE 2.1: How Many Miles Did You Travel to This Disposal Site?

	Disposal Site			
distance	Dover	Exeter	Salem	all
0-5 miles	66%	66%	62%	66%
6-10 miles	31%	30%	15%	29%
11-15 miles	2%	4%	10%	4%
16+ miles	1%	1%	13%	2%
count	178	108	39	325

Salem (69%). Flyers were the second most-cited source of information in both Dover (44%) and Exeter (17%), but they did not play a role in Salem. Other sources of information were cited by smaller minorities in each community. On this evidence, local newspapers and widely mailed flyers are the two most effective ways of publicizing such clean-ups. Apart from publicity issues, the relatively high turnout from Durham and from Exeter suggests that these "academic" communities may have been particularly receptive to the idea of a toxics clean-up day.

Several items on the questionnaire sought information on the need for the clean-up program. Tables 2.2 and 2.3 summarize these items, which show that the need for such programs is fairly strong. Most of the participants (91%) felt that the ten-gallon limit was sufficient, but many (29%) also said that they had additional hazardous waste materials at home, that they did not know how to dispose of properly. There was almost unanimous agreement that the pick-ups should be scheduled on a regular basis (99%); when asked "how often," the average response was about once a year. Table 2.3 dramatizes the need for the clean-ups by showing what people said they otherwise would have done with their hazardous wastes. Nearly everyone said that they would have either thrown them in the trash (29%), or continued to store them (72%). It seems safe to assume that either of these alternatives would eventually lead to the wastes being dumped on the ground, either at the local landfill or in someone's backyard, since they could not be stored there forever. Thus the large amounts of waste collected (47 drums from Dover alone) would virtually all be disposed of improperly, in ways that could seriously impact groundwater quality.

Although everyone wants to have regular clean-ups, not everyone wants to pay for them. Table 2.4 contains responses to a question about how they should be funded. Many people put down more than one answer, but many others did not check any funding source. Some crossed out the word "matching" in the response "state matching funds." State funding was generally the most popular choice (44%), probably because it sounds cheaper from the viewpoint of the respondents. Town taxes and a fee system were about equally popular (34% and 35%, respectively). Interestingly Durham and Exeter residents, who already have relatively high town taxes, were more likely to favor town-tax funding than were residents of Salem or Dover.

The demographic profile of people appearing at the clean-ups is noticeably different from the picture provided by Census data for their communities as a whole. Comparisons in terms of age group and type of housing are shown in Table 2.5. Census data are from the 1980 Census, with estimation used to make Census categories correspond to those used on the clean-up questionnaires.

Environmentalism has often been identified as a "youth movement." The data in Table 2.5 show that younger people were

TABLE 2.2: Need for Household Toxics Clean-Up Programs.

question	Disposal Site Dover	Exeter	Salem	all
Was the 10-gallon limit sufficient? (yes)	93%	85%	95%	91%
Do you have other materials at home? (yes)	23%	37%	28%	29%
Should pickups be made regularly? (yes)	99%	99%	100%	99%
How often? (every ___ months, on average)	14	10	9	12

TABLE 2.3: If This Program Had Not Been Held, What Would You Have Done With the Material You Brought?

	Disposal Site			
dispose in	Dover	Exeter	Salem	all
Trash	32%	28%	21%	29%
Backyard	1%	0%	0%	0%
Household Drain	1%	0%	0%	1%
Storm Drain	1%	0%	0%	0%
Continue to Store	77%	72%	64%	72%

TABLE 2.4: If These Pickups Are Made on a Regular Basis, How Should They Be Funded?

	Disposal Site			
funded by	Dover	Exeter	Salem	all
Town Taxes	35%	37%	26%	34%
State Matching Funds	48%	35%	50%	44%
Some Fee System	37%	34%	29%	35%

TABLE 2.5: What Age Group Do You Fit In?, and, Please Check Your Type of Residence: Survey respondents compared with population estimates based on 1980 Census data.

	Disposal Site*			
age group	Dover	Exeter	Salem	All
20-39 years	37(49)%	28(41)%	36(48)%	34%
40-59 years	25(29)%	28(30)%	38(34)%	27%
60 and over	38(22)%	44(29)%	26(18)%	39%
type of residence				
Apartment	6(33)%	5(26)%	3(16)%	5%
House	94(66)%	85(72)%	87(82)%	90%
Farm	0(1)%	10(2)%	10(1)%	5%

*Percentages of survey respondents, with corresponding population estimates from Census data in parentheses.

in fact substantially less likely to participate in these clean-ups, however. For example, 49% of the adult population of Dover, and 73% of the adult population of Durham, fall in the 20-39 age group. Only 37% of those participating in the Dover clean-up fell in this group. On the other hand 22% of the adult Dover population is 60 years old or more (and only 9% of the population of Durham), but this group made up 38% of those participating in the clean-up. Relative to their respective numbers, older people were more than twice as likely as young people to respond to the clean-up program. This pattern is consistent for all three towns shown in Table 2.5. In all three cases, there were more older people and fewer younger people than would be expected based on the population of the general community. Middle-aged people (40-59) fell in between, and showed up in numbers approximately proportional to their numbers in the population.

Table 2.5 also shows that, as might be expected, people living in houses or farms were much more likely to show up than people living in apartments, where there are presumably fewer reasons to accumulate household toxic wastes. The proportions coming from apartments are very small in all three communities, despite the sizable fractions (in Dover, one-third) of the general populations that live in apartments. Most of the repondents live in houses. Although only a small fraction of the population lives on farms, these people made up 10% of the participants at Exeter and Salem.

All three clean-up day surveys asked respondents their ages and type of residence, but only the Dover survey also included a more sensitive question asking respondents' educations. This makes the Dover survey more useful for research purposes. A large majority of the respondents at the Dover pick-up (69%) said that they were college graduates. According to 1980 Census data, only 18% of the adults in Dover, and 57% of the adults in the nearby university town of Durham, have college degrees. On this evidence, people with college educations were disproportionately likely to be participants in the household toxics clean-up program. Since education was not asked for on the Exeter or Salem surveys, we can only speculate whether the same pattern would have occurred in those communities.

Previous studies have established that environmentally-related attitudes and behavior often vary systematically with demographic factors such as age and education. Although everyone who came to the clean-up days was showing a commendable degree of concern for environmental protection, there was still a fair amount of variation, as described above, in their responses to individual questionnaire items. Some of this variation was related to demographic differences.

Table 2.6 shows an exploratory regression analysis of seven survey questions on age and education, for the 178 Dover survey respondents. The numbers in Table 2.6 are standardized partial

TABLE 2.6: Beta Weights from Regression of Dover Clean-Up Day Questionnaire Items on Respondent Age and Education.

Questionnaire Item	Demographic Predictors	
	Age	Education
How many miles did you drive?	.014	.184*
Was 10-gallon limit sufficient?	.089	.169*
Have other materials at home?	-.000	-.198*
How often should pickups be?**	.163*	.224*
Should be funded by town taxes?	-.090	.163*
Should funds be matched by state?	-.166*	-.073
Should be funded by fee system?	-.098	.019

*Denotes first-order partial regression coefficients (beta weights) significant at $p<.05$, two-tailed test.

**This question was coded as months between suggested pickups. For example, yearly pickups would be coded as 12, monthly pickups as 1. Thus a high response indicates that pickups are desired infrequently, and the positive relationship with age means that older people wanted less-frequent pickups.

regression coefficients (called "beta weights"), which reflect the net influence of age and education on each questionnaire item. Significance tests reported with these coefficients are for exploratory purposes only; some of the dependent variables are dichotomies, for which such significance tests do not strictly apply.

As would be expected from previous research, education and age were indeed influential; one or both was a significant predictor for six of the seven items. It is important to note that these are net effects. Average education levels tend to be higher among younger respondents, due to the general expansion of educational opportunities in the U.S. over most of this century. Hence the "effects" of age are reported here only after controlling for the effects of education, and vice versa. Net of education, age is significantly related to responses on how often the pickups should be, and whether state matching funds should be used. Older people thought that pickups should be made less often, and that state matching funds should not be used. They did not particularly favor other funding schemes either; generally, the older respondents were less likely to approve of any of the funding arrangements suggested on the questionnaire.

Controlling for age, better-educated respondents were: likely to have driven farther to get to the clean-up; more likely to say that the ten-gallon limit was sufficient; less likely to say they had other hazardous materials at home; likely to think that pick-ups could be made somewhat less often (about every fifteen months, on average, instead of about every twelve); and more likely to approve of using town taxes to fund these clean-ups.

Table 2.6 suggests that more educated households and communities may be easier to persuade of the value of household hazardous waste clean-ups. The table also suggests, however, that such households may have less waste per household to clean up. This paradoxical finding deserves further study, since it implies that some of the people whom it is most important to reach, are also the most difficult to reach.

CHAPTER 3:

DOVER WATER-PROTECTION SURVEY

Water contamination issues are often local issues, with specific local water supplies and pollution sources at stake. Much of the local-level research on these issues has taken place in communities where a crisis was already occurring. Chapter 4 describes several studies of this type. As these studies show, the discovery of water contamination has a traumatizing effect on people, moving water protection to the top of the local agenda and sensitizing citizens to a whole range of water-protection issues. In the wake of such a crisis, water protection becomes an urgent public priority.

The crises would be less likely to occur at all, however, if water protection had been a priority before serious contamination could develop. Here one runs into an important problem in public policy: support for strong or costly measures is often mobilized only after some crisis has occurred. Without such pressure, protective measures may be postponed or ignored indefinitely.

This problem presents an important area for research. It seems likely that the experience of a water crisis changes public opinion in a community, particularly by making many previously unconcerned citizens more worried about water quality. Other citizens, however, may have been concerned about water quality well before the crisis occurred. How do the social bases of concern before a crisis compare and contrast with the social bases of concern after a crisis? Whose opinions are most changed by crisis, and whose opinions does the crisis merely confirm? Answers to these questions could shed light on how public support for water-protection measures may be built up before some costly and hazardous emergency arises.

This chapter reports on a survey aimed at assessing public opinion about a variety of realistic water-protection measures, in a community where such measures were under discussion but no crisis had yet occurred. The community, Dover, NH, (population 22,377 in 1980) has a well-based public water supply system. Although no major problems had developed at the time of this survey, city officials privately admitted that all of the town's wells were under some potential threat, and that contamination could be discovered in any of them at any time. Within the past year, one of these wells had been taken off line due to benzene contamination, then placed back in service when the contamination declined. A variety of possible water-protection actions affecting Dover were under discussion by agencies including the City Council, the regional planning commission, the state Water Supply and Pollution Control Commission, state legislature, and the U.S. Environmental Protection Agency, at the time this survey was conducted. Several of these possible water-protection actions were included on the survey questionnaire.

A random sample of Dover adults was chosen for the survey based on the city's checklist of registered voters. A total of 566 names and addresses was chosen in this way, and questionnaires with return-postage envelopes were mailed to each. (See Appendix C for a copy of this questionnaire.) Eight of these questionnaires were returned as undeliverable, leaving a total of 558 presumably delivered questionnaires. After follow-up mailings of a reminder postcard and, subsequently, a replacement questionnaire (in both cases, sent only to those who had still not responded), 200 completed questionnaires were returned. This effective response rate of about 36% is substantially lower than that experienced using similar survey methods in other communities were a crisis had occurred; in those other situations, response rates between 54% and 70% have been obtained. I suspect that the relatively low response here is another indication of the difference between the pre- and post-crisis salience of water-protection issues. After a crisis, many people have opinions and want to express them. Before a crisis, as in the Dover survey, many people have not thought about the issues enough to have opinions, or simply consider the whole topic unimportant. Unfortunately this lack of pre-crisis concern has the side effect of making it harder to do pre-crisis survey research. Although the 36% response rate is less than ideal, the 200 questionnaires do provide an analyzable data set, from which at least some preliminary conclusions might be drawn. A description of findings from this survey follows.

Characteristics of the Sample

Table 3.1 shows a comparison between the original random sample, and the subset of this sample that responded to the survey. Data for the original sample were obtained from the voters checklist. As the table indicates, survey respondents were not significantly different from the original sample in terms of sex or voting ward. There was a significant difference in terms of political party, however: Republicans appear to have been more likely to return their questionnaires. About 41% of the respondents were Republican, and 54% of the respondents were women.

Other demographic characteristics of the respondents are shown in Figures 3.1-3.3. These people were, on the average, 45 years old, and residents of Dover for the last 22 years. A minority (37%) were college graduates, and 35% had at least one child under 18 living in their household. A large majority (77%) grew up in relatively non-urban communities of 50,000 people or less.

TABLE 3.1: Comparison of Original Random Sample and Returned Questionnaires.*

Characteristic		Random Sample (n=566)	Questionnaires (n=200)	95% c.i.**
Voting Ward	1	17.3%	17.3%	16.7-23.0%
	2	14.3%	16.8%	11.2-22.3%
	3	18.7%	22.0%	15.8-28.1%
	4	20.1%	18.5%	12.7-24.3%
	5	17.3%	15.0%	9.7-20.4%
	6	12.2%	10.4%	5.9-15.0%
Party	Democrat	35.2%	30.6%	23.8-37.5%
	Republican	32.2%	41.0% **	33.7-48.4%
	undeclared	32.7%	28.3%	21.6-35.0%
Sex	male	49.5%	45.7%	38.7-52.6%
	female	50.5%	54.3%	47.4-61.3%

*The variables Ward and Party are explicit on the original voter checklist from which the sample was drawn; they have been imputed to questionnaire respondents following this list. Sex was determined by voters' first names, from the checklist (no determination was possible in 20 cases, or about 3.5% of the total; these have been ignored in the analyses above). Survey respondents reported their sex on the questionnaire.

**These are 95% confidence intervals for the percentages based on returned questionnaires. If the original-sample values do not lie within these intervals, then there is less than a 5% chance that the response process is random with respect to that variable. The single instance where a significant difference occurred, an over-representation of Republicans among those who returned questionnaires, is marked by a double asterisk in the table.

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0	41	**********
10	46	**********
20	36	*********
30	29	*******
40	19	*****
50	7	**
60	10	***
70	6	**
80	2	*

Years Resident in Dover: mean=21.8, s.d.==18.9, median=18.5

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
20	7	**
25	19	*****
30	23	******
35	21	*****
40	28	*******
45	16	****
50	11	***
55	13	***
60	31	********
65	10	***
70	7	**
75	8	**
80	2	*

Respondent's Age, in Years: mean=45.5, s.d.=15.3, median=42.5

FIGURE 3.1: Respondent Age, and Years Resident in Dover

```
     MIDDLE OF    NUMBER OF
     INTERVAL     OBSERVATIONS
       8          5     *****
       9          3     ***
      10          1     *
      11          2     **
      12         43     *******************************************
      13         18     ******************
      14         38     ***************************************
      15          8     ********
      16         42     *******************************************
      17          5     *****
      18         20     ********************
      19          3     ***
      20          5     *****
Respondent's education (years):  mean=14.38; s.d.=2.55,
median=14.0
```

```
     MIDDLE OF    NUMBER OF
     INTERVAL     OBSERVATIONS
       7          1     *
       8          4     ****
       9          1     *
      10          0
      11          3     ***
      12         46     ***********************************************
      13          7     *******
      14         33     *********************************
      15          4     ****
      16         29     ******************************
      17          3     ***
      18          5     *****
      19          1     *
      20          3     ***
Spouse's education (years):  mean=13.79; s.d.=2.38; median=14.0
```

FIGURE 3.2: Education in Years, for Respondent and Respondent's Spouse.

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0	130	**********
1	31	*******
2	30	******
3	8	**
4	1	*

Number of children under 18 living in household: mean=.59, s.d.=.92, median=0

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
under 2500	34	**********
2500-15,000	51	**********
15,000-50,000	78	**********
over 50,000	26	**********

Population of city or town respondent lived in at age 16: mean=2.5, s.d.=.94, median=3.0

FIGURE 3.3: Number of Children in Household, and Population of Respondent's Residence at 16.

Opinions about Water-Protection Activities

Most of the respondents expressed opinions favoring strong water-protection measures. When asked how much money should be spent on water-protection activities, the majority favored increased spending for Federal (64%), State (63%), and local (66%) governments. This support was strong across all demographic lines, but particularly so among people with college educations, as shown in Table 3.2.

The opinions shown in Table 3.2 were all measured on five-point scales. Figure 3.4 shows the distribution of the sums of these scales, adding each person's responses on the three individual government-spending questions together. The highest possible score, 15, would result from saying that Federal, State, and local governments should all be spending "much more money" on water-protection activities. To get a sum of 13 or higher, one would have to have favored "much more" spending for at least one level of government, and "somewhat more" spending for the other two. A sizable minority (31%) of those answering these questions scored 13 or higher, another indication of strong support for water protection.

Specific actions being considered by Dover City government also received strong, in some cases overwhelming, support in this survey. Table 3.3 shows the distributions of these opinions. The strongest support (91%) was for regulation of potentially hazardous chemicals. Special aquifer zoning (83%), a Superfund cleanup of Dover's major hazardous waste site (77%), and inter-municipal agreements with neighboring communities (82%) were also strongly favored. Smaller majorities favored using less road salt in the winter (52%), and mapping Dover's underground water supplies (53%).

The six local-action variables in Table 3.3 were all measured on three-point scales, so the maximum sum for all six items is 18. Like Figure 3.4, Figure 3.5 shows how much opinions are skewed in this sample, in favor of strong water-protection measures. Fully 35% of those answering these questions gave the highest priority to all six water-protection actions.

Other relevant attitudes and beliefs are shown in Table 3.4. Eight percent of the respondents said that they participated in the Household Toxic Wastes clean-up held recently in Dover (see Chapter 2). A little over 12% reported belonging to any local or national organization which had been active on water or other natural-resource issues. A majority (64%) of those using city water felt that rates were not too high.

When toxic waste contamination problems are discovered, they often generate coverage and attention by a variety of news media. Some people have complained that the press exaggerates the importance of such incidents, and devotes too much attention to toxic waste problems in general. Most of the Dover sample

TABLE 3.2: Opinions about Government Spending on Water-Protection Activities, for All Respondents and for College Graduates and Non-College Graduates, Separately (percentages).

	We Should be Spending:				
Question/Respondents	no money	some less	about same	some more	much more
Federal Govt./all	0.5	4.3	31.0	42.4	21.7
college graduates	0.0	4.2	23.9	39.4	32.4
non-college grads.	0.9	4.4	35.4	44.2	15.0
N.H. State Govt./all	0.5	4.3	31.9	42.2	21.1
college graduates*	0.0	2.9	24.3	40.0	32.9
non-college grads.*	0.9	5.2	36.5	43.5	13.9
Dover City/all	1.1	0.0	32.6	39.7	26.6
college graduates*	0.0	0.0	22.9	37.1	40.0
non-college grads.*	1.7	0.0	38.6	41.2	18.4

*Indicates that the difference in opinions between college graduates and non-college graduates is statistically significant at $p<.05$ (chi-square test).

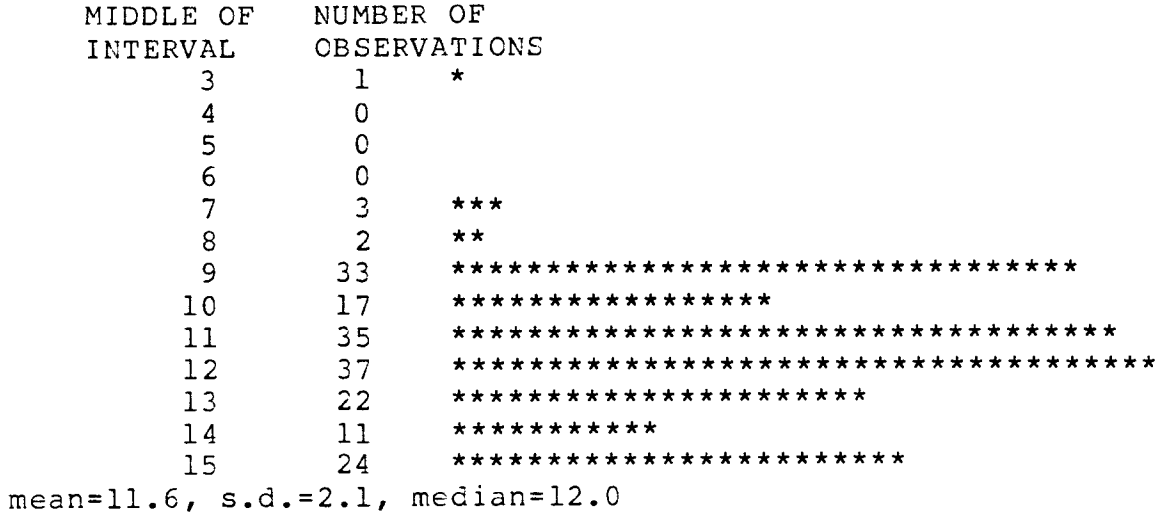

FIGURE 3.4: Distribution of Responses on Federal, State, and City-Government Funding (all five-point scales), Combined. (Note: for the regression analysis shown in Table 3.5, the low outlier visible in this distribution was temporarily deleted.)

TABLE 3.3: Opinions about What Dover Should Do to Protect Present and Future Dover Water Supplies, for All Respondents and for College Graduates and Non-College Graduates, Separately (percentages).

Question/Respondents	should not be done	done-low priority	done-high priority
Regulate chemicals/all	0.5	8.9	90.6
college graduates	1.3	9.5	89.2
non-college grads.	0.0	8.6	91.4
Aquifer zoning/all	3.6	13.0	83.3
college graduates	0.0	10.8	89.2
non-college grads.	5.9	14.4	79.7
Superfund clean./all	1.0	21.8	77.2
college graduates*	0.0	13.3	86.7
non-college grads.*	1.7	27.1	71.2
Intertown agree./all	1.0	16.7	82.2
college graduates	1.3	10.8	87.8
non-college grads.	0.8	20.5	78.6
Less road salt/all	7.3	40.3	52.4
college graduates	6.8	40.5	52.7
non-college grads.	7.7	40.2	52.1
Aquifer mapping/all	1.0	45.6	53.4
college graduates	1.3	41.3	57.3
non-college grads.	0.9	48.3	50.9

*Indicates that the difference in opinions between college graduates and non-college graduates is statistically significant at $p<.05$ (chi-square test).

```
    MIDDLE OF    NUMBER OF
    INTERVAL     OBSERVATIONS
         10          1     *
         11          2     *
         12          4     **
         13          5     ***
         14         13     *******
         15         21     ***********
         16         28     **************
         17         44     ************************
         18         63     *********************************
mean=16.4, s.d.=1.7, median=17
```

FIGURE 3.5: Distribution of Responses on Regulations, Zoning, Agreement, Superfund, Mapping, and Media Questions (all three-point scales), Combined.

TABLE 3.4: Additional Actions and Beliefs Relevant to Dover's Water Resources.

Question		Number	Percent**
Did you participate in the Household Toxic Wastes clean-up conducted on April 20 in Dover?*			
	yes	16	8.0%
	no	180	90.0%
Are you a member of any local or national organization which has been active on water or other natural-resource issues?			
	yes	25	12.5%
	no	171	85.5%
Do you believe water pollution and toxic waste problems have received too much or too little news media attention, in recent years?			
	too much attention	10	5.0%
	neither too much nor too little	54	27.0%
	need more attention	121	60.5%
If your household recives Dover city water, do you think present rates are too high?			
	no, not too high	100	64.1%
	yes, are too high	56	35.9%

*A survey conducted during this clean-up is described in Chapter 2.
**Percentages for the first three items are based on the entire sample, n=200. For the fourth item, only those households answering this question (n=156) were used, since most others did not have city water.

(87%) believed otherwise, however, and 60% actually thought that the press should give more attention, and make the public more aware of contamination problems and threats.

Demographic Background Variables and Opinions

In Chapter 2, it was found that demographic background variables, particularly education and age, were related to the opinions people had about the Dover Household Toxic Wastes clean-up program. On the opinion survey described in this chapter a more extensive set of demographic variables are available. Table 3.5 shows a series of multiple regression analyses, where seven such background variables are entered as possible predictors of a variety of opinion measures. Asterisks are used in Table 3.5 to indicate those effects that are statistically significant, after controlling for the other six background variables.

The "government funding" opinion variable in Table 3.5 is the 15-point scale, obtained by summing three items about the need for local, state, and federal spending, shown in Figure 3.4. Factor analysis suggested that these three separate questions could reasonably considered as indicators of a single underlying dimension. A high score on this dimension would mean that an individual favored increased or greatly increased levels of funding for water-protection activities at all levels of government. This variable had three significant predictors: sex, education, and membership in environmental organizations. Women were more inclined to favor increased spending than men were, though both favored it by large majorities. Support for government spending for water protection also increased with respondents' education. Both of these findings are consistent with previous research on environmental protection in general (where education has often been found to play a key role), and on water contamination in particular (which is sometimes viewed more seriously by women). The third significant predictor is organizational membership: people who belonged to environmental or natural-resource organizations were more likely to favor increased government spending.

The next six items in Table 3.5 are the questions also described in Table 3.3, about what steps the city of Dover should take to protect its present and future water supplies. Perhaps the most pressing of these issues, since it was under active debate by the city manager and council, was the question of special zoning to protect Dover's wells. As seen in Table 3.5, support for such zoning is significantly higher among older respondents, more educated respondents, and parents of children under 18. The latter two findings are again consistent with earlier research on support for environmental protection (often related to education) and concern about water contamination

TABLE 3.5: Regression of Dover Water-Protection Opinions on Demographic and Background Variables.**

Opinion Variables	Background Variables						
	sex	lived	age	educ.	urban	member	kids
govt. funding	.56*	-.01	-.00	.17*	.21	.97*	-.47
regula-tions	.03	.00	-.00	.00	-.02	.07	-.03
zoning rules	-.02	-.00	.01*	.04*	-.03	.13	.16*
reach agreement	-.02	.00	-.00	.01	-.00	.12	.02
super-fund	-.04	.00	-.00	.02	.06	.06	-.00
road salting	.06	-.00	-.00	.00	.02	.15	-.22*
aquifer mapping	.01	-.00	.01*	.01	-.05	.17	-.09
media atten.	.06	-.00	.00	.01	.01	.03	-.12
water rates	.13	.00	.00	-.02	.02	-.01	.08

*Denotes partial regression coeffient significant at $p<.05$ (one-tailed tests) or $p<.10$ (two-tailed tests).

**See text for definitions of variables.

(often higher among parents). Interestingly one of the water-protection steps, "use less road salt in winter," had significantly less support among parents than among other respondents. Road salting may elevate the sodium content of nearby water supplies, a problem particularly important to people on low-sodium diets. The parents of young children appear to be less concerned with this problem, however, and more concerned that less-salted roads may be more hazardous to drive on. This finding illustrates the complexities of opinions on environmental issues. Environmental protection, or even water protection, is not "one thing" in the public's mind, but rather a diverse set of problems and trade-offs that affect different groups of people in very different ways.

Although the relationships described above, and several others, are statistically significant, in general the relationships between background variables and water-protection opinions were surprisingly weak. This is evident from the many non-significant coefficients seen in Table 3.5, and the five opinion questions that had no significant predictors at all. On a more basic level, Tables 3.2 and 3.3 showed many of these same opinion items broken down by education. Consistently, people with college educations were likely to give somewhat higher priority to water protection, but the differences were not huge. For example, going back to Table 3.2, 72% of college graduates said that the federal government should be spending more money on water protection, whereas only 59% of the non-college graduates thought so. This difference by education should not obscure the fact that majorities of both groups favored increased spending; it is a difference of degree, rather than a basic difference of opinion. The same is true of all the other water-protection steps examined in this survey: although there were sometimes significant differences among population groups, these were differences between small and large majorities, not substantial disagreements. The finding is important as an indication of the broad-based and cross-cutting nature of support for government action to protect water quality.

Further evidence that support for water protection cuts across social and political boundaries is shown in Table 3.6. The voters checklist, from which the sample was originally drawn, included political party registration for each voter. Questionnaires may not always have been answered by the person to whom they were addressed, but we may assume that they usually were, and if not, that they were more often answered by persons of the same political party as the addressee (most likely, a spouse). Therefor the voters registration gives us a reasonable approximation of the questionnaire respondents' political affiliation. Table 3.6 shows the percentage of people supporting increased federal, state, or local spending, broken down by political party. Differences regarding federal spending are negligible: 64% of Democrats, 65% of Republicans, and 67% of undeclared voters favored increased federal spending. This runs contrary to the belief that Republicans favor a less active role

TABLE 3.6: Opinions about Government Spending on Water-Protection Activities, by Political Party: Percentage Favoring Increased Government Spending.

	Political Party Affiliation		
Question	Democrat	Republican	undeclared
Federal government	64.0%	64.7%	66.7%
State government	67.3%	63.2%	59.6%
Dover city government	65.3%	73.5%	59.6%

(and less funding) for the Federal, as opposed to state and local, government. Differences with regard to state and local spending are slightly larger, but still do not approach statistical significance, meaning that these small differences could easily be due to chance. Support for increased spending at any level of government is high in all three groups, and not consistently higher in any one group. Thus there is no correlation between support for governmental water protection activities, and political party. Democrats, Republicans, and undeclared voters are all strongly in favor of such activities, supporting increased government funding despite the current climate of emphasis on reducing other government functions and expenditures.

CHAPTER 4:

WILLIAMSTOWN OPINION SURVEY

Williamstown is a small (population 2200), rural community in the Green Mountains of Vermont. At first glance it seems a most unlikely place for an incident of chemical contamination; a visitor can drive through the town without seeing any more industry than the one general store. Town residents may have shared the view that they were far from such big-city problems as industrial pollution. In August of 1983, however, routine state testing detected trace amounts of tetrachloroethylene (TCE) and other chemical solvents in the town's major well. Other tests subsequently revealed much higher concentrations of the same chemicals in several private wells, at levels up to 45 times higher than the "maximum safe level." The most contaminated private wells were near the property of one of Williamstown's largest businesses, an industrial dry cleaning firm. This firm is located in an otherwise residential area, between the town's elementary and high schools. When it was learned that water from a contaminated spring below the firm's property ran past the elementary school, some townspeople became concerned that the schools might be unsafe for their children.

The known scope of the contamination problem expanded in a fashion one resident compared to widening ripples on a pond. Soil around the elementary school was found to be contaminated, and air tests revealed detectable levels of TCE within the school buildings themselves. Student and faculty complaints of chemical odors and unexplained illnesses began to surface. Solvents similar to those in the water system were also reported to be present in the town dump, over a mile away, where they were apparently leaching out and threatening other wells. In addition, it turned out that possibly contaminated dirt and gravel, taken from near this dump, had been used as construction fill at several locations around town. It proved difficult to pinpoint the source of the contamination affecting the main town well, which was at some distance from either the dump or the dry-cleaning firm. Many residents became uneasy as the dimensions of the problem continued to grow. The formerly benign Williamstown environment suddenly seemed fraught with invisible danger.

Not everyone viewed the situation as serious. Some were content to let the local, state, and federal governments take care of the situation, and counted on them to do whatever must be done. Other residents were more alarmed, and felt that those in authority were not doing nearly enough. A Health and Safety Committee (HSC) was formed by some concerned residents. During the fall of 1983 it held almost weekly meetings, and played an activist and informational role parallel to that of the Love Canal Homeowners Association (see Gibbs, 1982; Levine, 1982) or other grass-roots local organizations formed in reaction to toxic

wastes. The Health and Safety Committee lobbied for more extensive health, water, and soil testing; organized a school boycott and urged that the schools should be closed until proven safe; criticized the actions or inactions of local, state, and federal governments; organized demonstrations, sought publicity, and distributed pamphlets; and brought in outside experts to provide information about the chemicals and the hazards involved. These actions won the Health and Safety Committee the support of many residents, and the hostility of many others. The contamination discovery and subsequent developments had a polarizing effect on the community, in which the HSC represented one extreme.

The Williamstown Survey

During the fall of 1983 I attended many of the HSC meetings, and designed a survey to assess public opinion about the crisis. A copy of this survey is reproduced in Appendix A. This survey was mailed to a sample consisting of 214 residents chosen randomly from a check list of all eligible Williamstown voters. Only 22 known HSC members could be identified in this first random sample. Questionnaires were also sent a second, nonrandom sample consisting of all identifiable HSC members on the voter checklist, bringing the total sent to HSC members up to 90. 156 of the 282 questionnaires were returned, with both HSC and general-public subsamples responding at about the same rate, 55%. Case weighting is employed as necessary below, to adjust for the deliberate oversampling of HSC members.

Opinions on both sides of the issues were abundantly represented among the respondents, and many people volunteered additional opinions about the villany of the other side, on open-ended questions included in the questionnaire. Although the 55% response rate is less than ideal, it does provide a substantially broader data base than that used in earlier qualitative studies of community reactions to contamination discoveries. With these data it is possible to take an exploratory look at the social bases of the Health and Safety Committee and of the the divisive arguments over what to do about chemical contamination in Williamstown.

Who Attended the Meetings

One questionnaire item asked respondents whether they had attended HSC meetings never, once, or more than once. A breakdown of background characteristics by meeting attendance is shown in Table 4.1. Attenders and non-attenders were similar with respect to sex and education. The latter finding is particularly interesting because critics from both the left and right have often claimed that environmentalists tend to be well-educated elites (Gale, 1983; Harry et al., 1969; Tucker, 1983). The data in Table 4.1 show that the average HSC member,

like the average Williamstown resident, had a high school education.

HSC members differed from other citizens in being younger, more recent residents, more likely to have children, and more likely to have reason to believe that their own land or water had been contaminated by the chemicals. There was some perception among Williamstown residents that the town's division was along old-young, oldtimer-newcomer, or traditionalist-hippy lines. Table 4.1 shows that there is a grain of demographic truth to these perceptions; the split was partly a generation gap.

The nature of this gap is shown in more detail in Figure 4.1, which contains box plots of the age distributions for each level of meeting attendance. The plus signs within each box denote medians; boxes enclose the interquartile range, and outliers are shown individually as asterisks (mild outliers) or zeroes (severe outliers). Box plots are a graphic technique for exploratory data analysis (EDA), developed by John Tukey (1977). See Hoaglin et al. (1983), McNeil (1977), or Velleman and Hoaglin (1981) for additional details on their construction and interpretation. Figure 4.1 confirms the finding from Table 4.1, that HSC members tend to be younger: in Figure 4.1, as meeting attendance increases, the median age goes down. It is also interesting to note that the variation in ages (indicated by the box widths or interquartile ranges) declines as attendance goes up. In other words, those atending HSC meetings were both younger and more homogeneous than those not attending. More than half the HSC members were in their thirties, whereas the middle 50% of the non-members stretched from thirty to sixty years of age. The handful of older HSC members show up as outliers in Figure 4.1, and they were indeed conspicuous at HSC meetings. Their presence there was sometimes cited by younger HSC members as evidence that the HSC did not have a narrow generational base.

The negative relationship between age and concern about general environmental issues has been well established by other researchers (see reviews by Buttel, 1979; Van Liere and Dunlap, 1980). It is also widely reported that rural residents are less concerned than urban residents (Glenn and Hill, 1977; Lowe and Pinhey, 1982; Tremblay and Dunlap, 1978; Van Liere and Dunlap, 1980). Both age and rural-urban differences in environmental concern are consistent with the analysis above, since more recent residents are less likely to have been socialized in the rural Williamstown environment. Too much should not be made of these bivariate findings, however. Age, length of residence, and having children under 19 are not independent phenomena; they are highly interrelated. It must be left to multivariate analysis to sort these relationships out, and to identify which demographic variables have nonspurious effects on attitudinal and behavioral reactions to the crisis.

Opinions About the Crisis

As might be expected, all of the opinion measures included on the survey were correlated with whether respondents had attended meetings of the Health and Safety Committee. This is shown in Table 4.2, which gives the percentage distributions of opinion responses for three levels of HSC meeting attendance: never, once, or attended two or more meetings. The actual numbers of respondents involved are given at the bottom of Table 4.2.

People who attended HSC meetings of course had a higher opinion of the HSC, and were much more likely to believe that the HSC had done a good or excellent job in protecting the interests of the people of Williamstown. They had a notably low opinion of the town government: only 17% of the frequent attenders thought that local government was doing a good or excellent job. Even among non-attenders, support for the local government's handling of the situation was weak (27%). In general, HSC members were more critical of all levels of government than other residents were. The difference between frequent attenders and others was particularly sharp in their views of the federal government. The Health and Safety Committee, more than other citizens, was unhappy with the limited extent of federal action.

Perhaps the most divisive issue in Williamstown, at the time this survey was taken, concerned what should be done about the town's two schools. As mentioned above, both schools were near to the suspected source of the contamination, and there was some evidence of air, water, and soil contamination within school grounds or buildings. The HSC organized a parent boycott of the schools, and urged that they be closed until it could be proven that they were safe. Closing the schools would have been an expensive and disruptive step, however, and many other Williamstown residents felt that it was too extreme--no action should be taken unless it was proven that the schools were unsafe. As shown in Table 4.2, opinions on this question divide almost along "party lines:" 75% of the frequent HSC attenders thought the schools should be closed, but only 25% of the non-attenders agreed.

The last item included in Table 4.2 concerns the importance of studying the causes and effects of the Williamstown pollution. The original responses were in the form of numerical magnitude estimates, open-ended numbers with which respondents could indicate "how important" they thought a pollution study to be. For consistency with the percentage analysis of other variables in Table 4.2, these estimates were split at their median into "high-importance" and "low-importance" groups. About two-thirds (66%) of the frequent HSC attenders, but less than half (40%) of the non-attenders, gave above-average importance to performing such a study.

In previous research, two demographic variables, parenthood and sex, have been identified as consistent predictors of the degree of concern over toxic waste contamination. Typically parents of young children are more concerned than non-parents, because of the obvious potential threat to their childrens' safety. For less obvious reasons, women are more concerned than men. In combination, these two effects mean that female parents are notably more concerned about contamination problems than are other demographic subgroups. This observation is supported by the Williamstown data, as seen in Tables 4.3 and 4.4.

In Tables 4.3 and 4.4, the percentages of Williamstown respondents assigning high importance to a pollution study, or believing that the schools should be closed, are shown broken down by sex and parenthood. In both tables, nonparent males are the group with the lowest level of concern, and female parents are the group with the highest. As will be seen later, this tendency for toxic wastes to become a "motherhood" issue persists in multivariate analysis, even when controlling for the effects of age.

Several months after the Williamstown survey was completed, a second independent survey was conducted by Professor Margaret Ottum, of nearby Johnson State College. This second survey, conducted by telephone, was carried out on February 1, 1984. Principal findings from this survey, based on 344 respondents, were:

(1) A little over half (58%) of the Williamstown residents sampled think there is a serious pollution problem in Williamstown. Among people with children (school or pre-school age) the percentage is markedly higher, with 72% of them thinking it's serious.

(2) Most Williamstown residents had received information about the pollution problem from a variety of sources: 89% had read about it in the newspaper, 78% had heard about it on radio or television, 70% had discussed it with friends or neighbors, 59% had received information from the Williamstown Health and Safety Committee, 36% had received information from the Town Selectmen, and 28% had information from the state agencies.

(3) As a follow up question people were asked in which source of information they would put the most trust. State agencies were ranked first in the trust category followed by the Williamstown Health and Safety Committee. A considerable number (almost a quarter), however, didn't know who they trusted and a small but significant number didn't trust any of the sources of information.

(4) Approximately a quarter (26%) of the people indicated they had attended one or more public meeting where the pollution problem had been discussed.

(5) When asked what action, if any, it was thought the school board should take regarding the reported pollution near the elementary school, the responses from the people with children were somewhat different from those without. Considerably more of the parents (27% v. 9%) thought the school should be closed (and children moved). Far more of the people without children favored more monitoring and testing, said they didn't know, or saw no problem. A considerable number in each group (13%) responded with clean up the problem. On a second part of this question when asked if it was thought the problem near the school would become greater with the spring thaw, 57% of all responses was yes; among those with children it was 72%.

(6) When asked if they thought the current situation had lowered property values in Williamstown the response was an overwhelming yes with 262 people (76%) thinking it had, 41 people (12%) said no and another 41 people (12%) either said they didn't know or gave no answer.

(7) Twenty-six percent of the people surveyed were connected to the Williamstown water system and 88% of these were currently using the water for drinking.

Despite substantial differences in timing, methodology, and question wording, there is general agreement between the conclusions from the two surveys on a number of important points. These points include the widespread but not universal concern about the pollution problem; the ranking of the state and the Health and Safety Committees as the first and second most-trusted organizations, respectively, with town government far behind; and the association between parenthood and the degree of concern.

Multivariate Analysis: Three Demographic Predictors

Parenthood effects on toxic waste concerns are entangled with the effects of age, which previous research has found to be the single most consistent predictor of environmental concern in general (e.g., Buttel, 1979; Van Liere and Dunlap, 1980). Parents of young children are likely to be younger than the remainder of the adult population. Consequently, it is plausible that any bivariate parenthood effects are partly spurious, and should really be attributed to age. It is equally possible,

however, that the well-known age effect is partly due to parenthood. This uncertainty highlights the importance of including both variables in any multivariate analysis of the predictors of environmental concern.

Figure 4.2 shows a schematic causal model for demographic predictors of concern over toxic wastes. From previous research, the paths are expected to have the signs shown associated with each arrow: concern will be higher among women and parents, and should decline with age. Parents tend to be younger; there is no theoretical or empirical reason to specify correlations between age and sex, or between parenthood and sex.

The Williamstown study, together with previous research in Acton, Massachusetts (see Hamilton, 1984), provides survey data with which to estimate the paths in Figure 4.2. A set of such estimates is given in Table 4.5. In each of the two towns, the most salient and divisive issues were identified with the help of local activists and journalists. Responses concerning these four issues are the dependent variables, or measures of toxic-waste concern, employed in the analyses of Table 4.5. The position of the local antipollution activist group with respect to each issue is used to identify the pole of "most concern." The four issues chosen are: should two possibly contaminated Williamstown schools be closed until proven safe; is a study of the Williamstown pollution's causes and effects a high priority; should Acton's water quality standards be kept strict, or relaxed; and should an epidemiological health study of Acton residents be conducted?

Estimates shown in Table 4.5 are logit regression coefficients, calculated using Leo Goodman's ECTA log-linear program (Goodman, 1978). Logit regression is necessary here because both dependent and independent variables are mostly categorical. Interpretation of these coefficients is mathematically straightforward, but intuitively confusing. A positive coefficient means that, controlling for other independent variables, a given independent variable increases the odds of a high-concern response. The larger the coefficient, the stronger this effect. More precisely, the logit coefficients represent differences in the logarithm of the odds ratio, when the first level of each variable is compared with the average effect. Alternatively, the antilogs of these coefficients give the amounts by which the corresponding odds should be multiplied. In view of this definition, the sex/parenthood interaction observed with the Williamstown school issue in Table 4.5 should actually be interpreted not so much as an indication of unusually high concern among female parents, but rather as an indication of unusually low concern among male non-parents. See Table 4.4 for a less technical confirmation of this interpretation.

Significance tests for individual coefficients were performed by dividing each one by the corresponding

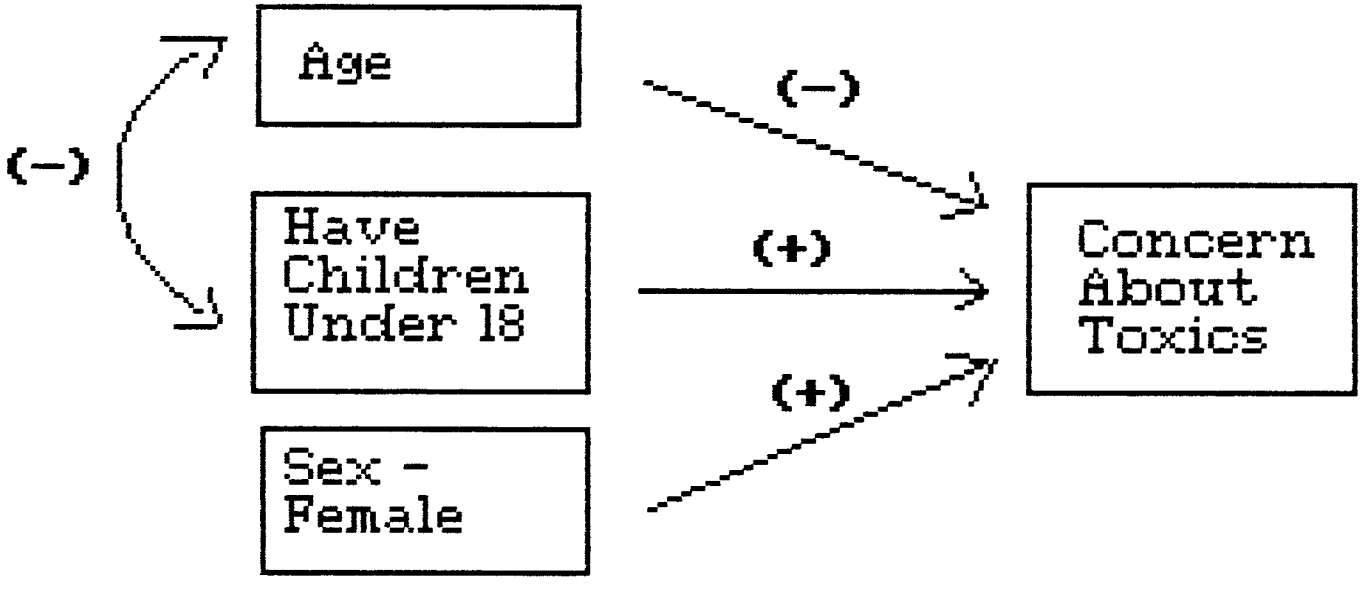

FIGURE 4.2: Principal Demographic Predictors of Concern over Toxic Waste Discoveries.

Table 4.5: Logit Analysis of Demographic Predictors of Opinions on Four Issues Measuring Concern about Toxic Wastes (W=Williamstown, Vermont; A=Acton, Massachusetts).

Y Variables-Issues	Age-Over 40	Sex Female	Parent-Kids<18	Female Parent	L.R. χ^2 p-value	Partial r^{2**}
Close contaminated schools - W	-0.42*	0.43*	0.14	0.40*	>0.50	.85
Study causes and extent - W	-0.22	0.42*	0.26	---	0.34	.54
Strict water standards - A	-0.21	0.64*	0.41*	---	0.26	.71
Epidemiological health study - A	-0.42*	0.32	0.41*	---	0.30	.73

*Logit parameter estimate is significant at $p<.05$ (one-tailed test based on standardized value).

**The coefficients of partial determination for the models shown, as compared with baseline models containing no age, sex, or parenthood effects (see Goodman 1978:78-79). Coefficients of multiple determination, analogous to regression multiple R^2, are much closer to 1.0 for all models.

saturated-model standard error. Since the actual standard errors will usually be less than those for the saturated model, this significance test is conservative. Two measures of overall fit are also given for each equation in Table 4.5: the p-value for a likelihood-ratio chi-square test (the higher this probability, the better the model fits); and Goodman's partial r-squared statistic. The latter is analogous to the squared partial correlation coefficient in multiple regression analysis. In this logit analysis, the partial r-squares measure proportionate reduction in error, for these models as compared with logit models containing no age, sex, or parenthood effects on the dependent variables.

Because of the uncertainty noted above about whether sex and parenthood effects should be modeled as additive or interactive, both specifications were tried with each of the four dependent variables. For three of these, the sex-parenthood interaction term was not significant, and a simpler additive model was sufficient. The interaction was significant for a fourth issue, close Williamstown schools until proven safe.

The following observations may be made with respect to Table 4.5:

(1) All four equations provide a very good fit ($p>.25$) to the observed data;

(2) The coefficients of partial determination (r-squared statistics) show large reductions in error, ranging from 54% to 85%, when age, sex, and parenthood effects are used to predict toxic-waste concern;

(3) Eight of the parameter estimates are individually significant ($p<.05$), based on the conservative standardized values test; in every instance either sex, or parenthood, or both effects are significant even after controlling for age; and

(4) Whether significant or not, all thirteen of the parameter estimates are of the expected sign. The probability of this occurring by chance is remote.

These findings, together with those reported earlier (in Hamilton, 1984, 1985), show sex and parenthood effects on toxic-waste concern that are consistent across three different communities, a variety of specific local issues, measurement methods ranging from simple dichotomies to factor analysis and numerical magnitude estimation, and both regression (continuous-variable) and log-linear (discrete-variable) estimation strategies. Such consistency provides strong evidence that these variables do generally influence individual reactions to the discovery of toxic waste contamination.

Discussion

The disaster that resulted from contamination of a residential area at Love Canal, New York, during the late 1970's is often viewed as the beginning of our nationwide crisis with toxic wastes. In fact, however, the production of such wastes had been going on for centuries, and it had particularly surged forward with the rise of the petrochemical industry following World War II. Many other communities had experienced known or unknown contamination over this history. Love Canal gained its unique prominence not because it was contaminated, but because a local citizens' group, the Love Canal Homeowners Association, organized to forcefully and effectively protest this contamination. It was the activities of this group, not the seriousness of the actual contamination, that first brought Love Canal to national attention and inspired a new concern about toxic wastes.

There is a parallel between this aspect of the Love Canal incident, and the situation that developed in Williamstown, Vermont. From the outset, the Williamstown Health and Safety Committee made every effort to keep the pollution problem in the public eye, and to keep the pressure on state authorities to do something about it. Partly as a result of this publicity, there was a growing awareness of potential problems in other Vermont communities, including Barre, Bennington, Burlington, Colchester, Lyndonville, Poultner, Springfield, and Windsor. Concerned residents from each of these communities were present at a meeting of Vermonters Organized for Clean-Up (VOC), held in Barre in May of 1985. The VOC grew directly out of the Williamstown Health and Safety Committee, when HSC leaders realized that a larger, umbrella organization was needed to coordinate the efforts of scattered local activists. From identical imperatives, the original leader of the Love Canal Homeowners Association, Lois Gibbs, has since gone on to organize the national Citizens Clearinghouse on Hazardous Wastes. The Clearinghouse is dedicated to assisting local groups like the HSC; at this writing, it maintains a list of over 600 such groups, in all 50 U.S. states and Canada. Lois Gibbs was the featured speaker at the VOC meeting, where she praised the Vermont organizations for their accomplishments, and described her own and other groups' similar experiences elsewhere.

Despite the recent emergence of statewide and national networks, the opposition to toxic wastes is essentially a grass-roots social movement, often led by people with no previous political or organizational experience. There is little evidence that such activists are from any sort of "elite." The demographic bases for this movement, as examined in the survey analysis above, have several other important implications, however.

First, it appears that those most concerned tend to be somewhat younger than those least concerned. This does not make toxic wastes a "youth movement;" as seen in Figure 1, the typical HSC member is in his or her thirties. Levine (1982), writing about Love Canal, noticed a similar phenomenon, and attributed it to the individual's place in his or her life cycle: this is the age at which people have young children, are concerned about their future, and are still relatively capable of moving or changing jobs. Several other correlates of age may also be important: younger people have grown up in an era of heightened concern about the environment in general; and in a rural New England town such as Williamstown, they are more likely to be relatively recent arrivals from a more urbanized, perhaps more environmentally-conscious, area. Whatever the origins of the relationship between age and concern about toxic wastes, such a relationship makes it likely that the general level of concern will continue to grow in the future.

The second demographic predictor of concern about toxic wastes is sex. Previous studies of environmentalist beliefs have not found any consistent relationship between sex and views about the environment in general. Toxic waste problems are a special kind of environmental problem, however. Unlike energy conservation, wilderness preservation, or oil spills, toxic waste contamination presents an immediate and obvious threat to safety. Where environmental issues become "safety" issues, as they do in the case of chemical contamination or nuclear accidents, there is increasing evidence that women have a particularly strong response (for example, see Dohrenwend et al., 1981; Flynn, 1981; also sources cited by McStay and Dunlap, 1983). Their interest in safety may not be for themselves, but for their families and children, as attested in countless journalistic interviews of hazardous waste victims including those aired on ABC (8/5/83), PBS (9/21/83), and WBZ-TV (3/20/83).

Parenthood is the third demographic predictor of concern about toxic wastes, and it is clearly the most important. As described above, it is intimately tied to age and sex, the two other major predictors. Parenthood is particularly important because fears about the safety of one's children are the driving force behind the movement against toxic wastes. These fears account for the intensity of feeling that arises in contamination incidents, an intensity that has frequently been underestimated by officials and scientists brought in to deal with the situation. Such outsiders usually are trying to balance a number of competing priorities, including political, economic, administrative, or technical considerations. These different considerations seem unimportant, if not corrupt, to people who believe that their childrens' health is at stake. The result is that government and scientific authorities who come in intending to help the situation, find themselves becoming the object of citizen anger and distrust. Well described in Levine's (1982) book on Love Canal, this scenario has occurred over and over again in the wake of contamination discoveries.

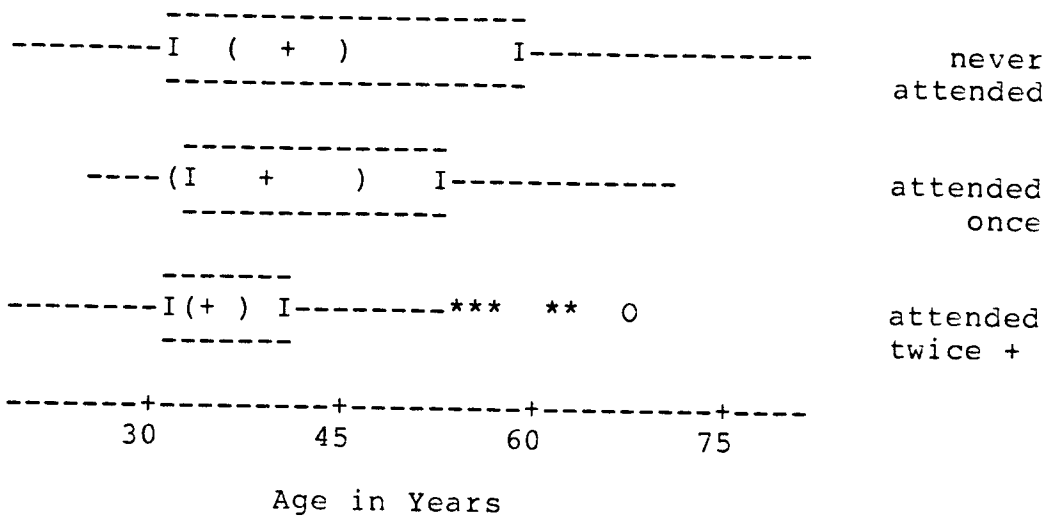

Figure 4.1: Box Plots of Respondent Age, by Health and Safety Committee Attendance.*

Plus signs denote medians; confidence intervals in parentheses, boxes enclose interquartile ranges, outliers denoted by "" (mild outliers) or "O" (severe outliers). See Tukey (1977); Velleman and Hoaglin (1981) for full discussion of box plot conventions and use.

Table 4.1: Background Characteristics and HSC Meeting Attendance of Williamstown Survey Respondents.

Characteristic	HSC Meeting Attendance*			
	Never	Once	Twice+	all
Median Age	42 (42)	40 (42)	36 (38)	40 (41)
Median Years in Williamstown	18 (19)	15 (15)	9 (12)	15 (17)
Median Years of Education	12 (12)	13 (13)	12 (12)	12 (12)
Median Number of Children	0 (0)	1 (1)	2 (2)	1 (1)
Percent with Children <19	47 (45)	71 (70)	77 (73)	58 (60)
Percent Female	62 (60)	53 (48)	62 (54)	61 (57)
Percent with Contamination	17 (18)	24 (23)	49 (57)	28 (27)
actual number of cases	92	17	47	156
weighted number of cases	(78)	(14)	(24)	(116)

*Medians or percentages for the actual, unweighted sample are given first in each cell. Medians or percentages for the weighted sample, correcting for sample bias, are shown beneath them in parentheses.

Table 4.2: Opinions about Williamstown Pollution Problem, by HSC Meeting Attendance.

Opinions	HSC Meeting Attendance*			
	Never	Once	Twice+	all
% Approve of HSC	32 (27)	65 (68)	87 (82)	53 (43)
% HSC doing good job	35 (31)	82 (78)	85 (80)	56 (45)
% Local govt. good job	25 (27)	19 (22)	11 (17)	20 (22)
% State govt. good job	54 (57)	56 (54)	30 (26)	47 (45)
% Federal govt. good job	46 (49)	62 (67)	14 (13)	38 (37)
% Schools should close	25 (25)	31 (27)	81 (75)	43 (35)
% Study is important	43 (40)	37 (35)	72 (66)	44 (43)
actual number of cases	92	17	47	156
weighted number of cases	(78)	(14)	(24)	(116)

*The upper number in each cell is the percentage of people at each level of meeting attendance, who expressed the opinions shown. The lower number in each cell, in parentheses, is the corresponding percentage after weighting to remove sample bias.

Table 4.3: Importance of Williamstown Pollution Study, by Sex and Parenthood.

Percentage Assigning Above-Average Importance to Studying the Causes and Effects of Williamstown Pollution:*

	male	female
no children under 19	27 (16)	56 (50)
have children under 19	44 (46)	64 (57)

*Upper percentage in each cell is the percentage of males or females, who have children under 19 and gave the study above-average importance. Lower percentage in each cell, in parentheses, is the corresponding percentage after using case weighting to correct for sample bias.

Table 4.4: Believe Williamstown Schools Should be Closed, by Sex and Parenthood.

Percentage Believing that Williamstown Schools Should be Closed Until Proven Safe:*

	male	female
no children under 19	15 (8)	43 (43)
have children under 19	47 (42)	54 (44)

*Upper percentage in each cell is the percentage of males or females, who have children under 19 and said that the schools should be closed until proven safe. Lower percentage in each cell, in parentheses, is the corresponding percentage after using case weighting to correct for sample bias.

CHAPTER 5:

CONCLUSIONS

The preceeding chapters have reported numerous detailed findings about public opinion and water protection before, during, and after serious pollution problems occur. From these detailed findings, three broader conclusions have emerged:

(1) Public support for water-protection activities by all levels of government appears to be fairly strong, across all major demographic groups and political parties in the samples studied here. Such support is not restricted to "environmentalists," Democrats, college graduates, or other identifiable subgroups. Concern about water protection is often widespread even before a crisis; after a crisis, such concern becomes both more widespread and emotionally intense.

(2) Although public support for water-protection activity is generally strong, it is stronger in some groups than in others. Before a crisis occurs, people who are well-educated, or are already members of an organization involved in natural-resource protection, are likely to be the ones who assign the highest urgency to protecting water quality.

(3) After a crisis occurs, these characteristics no longer clearly distinguish the most from the least-concerned. Once water contamination has been discovered, it is primarily viewed as a safety issue, rather than an environmental or economic issue. The people who are likely to be most concerned about this safety issue are parents of young children, younger or more recent community residents, and women. Conversely, those who are least concerned when water contamination is discovered tend to be elderly, less-educated men, who are long-term residents of the community.

Some of the findings have practical as well as theoretical implications. It appears that there is broad public support for water-protection policies. Where water supplies are not adequately protected, and serious contamination occurs, there is a strong tendency to blame government and scientific authorities for failing to protect the population. Since this failure results in what is perceived as a threat to children's health, any further hesitation to take decisive action gives rise to anger and alarm, often directed more at government agencies than at the individuals or corporations who were initially responsible for the contamination.

Public opinion evidently does not regard water protection as one "thing." For example, in Chapter 3 we saw evidence that contamination by road salt evoked a different response than contamination by organic chemicals; the latter was of less concern to young parents, perhaps because they balanced the

dangers of a high sodium level against the dangers of icier roads. Thus issues that may be related in a policy or orgfanizational sense, may not be strongly related in the public's mind.

By the same token, policy makers need to be aware that public opinion is not one "thing," either. Individuals respond differently to pollution problems and attempts to prevent them, and these differences are to some extent predictable. The experiences of the household toxic pick-up programs suggest that communities may also differ in predictable ways. Within communities, similar differences may occur at the neighborhood level. Knowledge of such differences could be helpful in planning education or publicity campaigns for clean-up programs, water conservation, underground tank identification, and other public-participation water protection activities. The cumulative effect of such programs may contribute to the growing public sophistication about the fragility of our water resources.

These findings leave open many avenues for future research. The work should be replicated and extended in a wider variety of communtities, to ascertain how generally such conclusions apply. The surveys described in Chapters 2-4 should also be subjected to further study, including additional statistical exploration and an examination of the subjective comments that many respondents wrote on the backs or margins of their questionnaires. The most important area for improvement is in study design. The changes in public opinion, before and after contamination is discovered, have been inferred from indirect evidence drawn from communities where contamination either has or has not occurred. A theoretically better design would be to conduct an ongoing study that involved baseline data over many years before any water problems developed, then followed attitudinal and behavioral changes during a period of crisis. Although many communities face predicaments where an eventual water crisis seems almost inevitable, it is difficult to predict the timing of such events in advance.

DOVER

SURVEY - HOUSEHOLD HAZARDOUS WASTE CLEANUP DAY

1. What town are you from?
2. How many miles did you travel to this disposal site?
   - 0-5 miles _____
   - 6-10 miles _____
   - 11-15 miles _____
   - 16+ miles _____
3. Was the ten gallon limit sufficient?
4. Do you have other materials at home that you do not know how to dispose of properly?
5. If this program had not been held, what would you have done with the material you brought?

   Trash _____ Backyard _____ Household Drain _____ Storm Drain _____

   Continue to store _____
6. Should this pickup be made on a regular basis? _____ How often? _____
7. How should it be funded?

   Town taxes _____ State matching funds _____ Some Fee system _____
8. What age group do you fit in?

   20-39 _____ 40-59 _____ 60 and over _____
9. What is your educational background?

   high school graduate _____ college graduate _____

   vocational technical graduate _____ other _____
10. Please check your type of residence

    Apartment _____

    Single-Family Home _____

    Farm _____
11. How did you hear about "Toxic Cleanup Day"?

    Flyer _____

    Newspaper _____

    Radio _____

    Neighbor _____

    Other _____

EVALUATION SURVEY: HOUSEHOLD HAZARDOUS WASTE COLLECTION DAY

_____ Exeter _____ Salem

1. What town are you from?_____

2. How many miles did you travel to this disposal site?

   0 - 5 miles _____ 6 - 10 miles _____

   11 - 15 miles _____ 16 or more miles _____

3. Was the ten-gallon limit sufficient? Yes_____ No_____

4. Do you have other materials at home that you do not know how to dispose of properly? Yes_____ No_____

   If yes, what are they?_____

5. If this program had not been held, what would you have done with the material you brought?

   Trash_____ Back Yard_____ Household Drain_____

   Storm Drain_____ Continue to store_____ Other (specify):_____

   _____

6. Should this pickup be made on a regular basis? _____

   How often?_____

7. How should it be funded? Town Taxes_____

   State matching funds_____ Some fee system_____

   Other:_____

8. What age group do you fit in?

   20-39_____ 40-59_____ 60 and over_____

9. Please check your type of residence:

   Apartment_____ House_____ Farm_____

10. How did you hear about the Collection? Flyer_____ Radio_____

    Newspaper_____ Neighbor_____ Poster_____

    Town Meeting_____ Other (specify):_____

11. Do you have any other suggestions or comments?_____

    _____

    _____

UNIVERSITY OF NEW HAMPSHIRE

Department of Sociology and Anthropology
College of Liberal Arts
Horton Social Science Center
Durham, New Hampshire 03824
(603) 862-1800

May 13, 1985

Dear Dover Resident:

The attached questionnaire is part of a study of New England citizens' opinions about water pollution and water supply protection. Your name has been selected at random for this survey, which can be returned in the postage-paid envelope enclosed. Results from the survey will be published and made widely available. To get the most accurate picture of public opinion, however, we need responses from as many people as possible. Please take the time to read and fill out this questionnaire, and let us know what you think on these issues. Space is provided at the end of the questionnaire for any additional comments you may have. The confidentiality of your responses is assured.

Some of the questions deal specifically with Dover's present and future water supply situation. Other questions cover broader issues, including the actions of state and national agencies. All of the water-supply questions concern problems and possible actions which are being debated right now among legislators, local governments, planners, and other citizens. While these questions are being debated, it would be particularly valuable to hear from a cross-section of the general public.

If you have any questions, please write or call me at (603) 862-1800. Thank you for your participation.

Sincerely,

Lawrence Hamilton

Lawrence Hamilton, Ph.D.
Project Director

Enclosure

WATER ISSUES SURVEY

A. The first set of questions asks for background information about you and your household, which is needed for statistical purposes.

1. The person filling out this questionnaire is (check one):

_ male (1) _____ female (2)

2. How long have you lived in the city of Dover? _____

3. What is your age? _____

4. What is the current occupation of:

yourself? _____

your spouse (if married)? _____

5. What is the highest year of schooling completed by:

yourself? _____

your spouse (if married)? _____

6. How many children, under the age of 18, are presently living in your household? _____

7. How large was the city or town you were living in, when you were 16 years old? (Check one.)

_____ Under 2500 people (1)

_____ Between 2500 and 15,000 people (2)

_____ Between 15,000 and 50,000 people (3)

_____ Over 50,000 people (4)

B. The remainder of this questionnaire asks about issues related to Dover's present and future water supply situation.

8. Water-quality protection activities such as inspection, testing, and clean-up are often expensive. Some people believe that we are already spending too much on such activities. Other people believe that we are not spending nearly enough. With respect to the water-protection activities of each of the following levels of government, state whether you think that we should be spending more, less, or about the same amount of money as we are now.

Federal government, including Environmental Protection Agency (EPA) and Superfund (check one):

____ No money at all should be spent for these purposes (1)

____ Somewhat less money should be spent for these purposes (2)

____ Funding for these purposes should stay about as is (3)

____ Somewhat more money should be spent for these purposes (4)

____ Much more money should be spent for these purposes (5)

New Hampshire state government, including Water Supply and Pollution Control Commission (check one):

____ No money at all should be spent for these purposes (1)

____ Somewhat less money should be spent for these purposes (2)

____ Funding for these purposes should stay about as is (3)

____ Somewhat more money should be spent for these purposes (4)

____ Much more money should be spent for these purposes (5)

Dover city government, including land purchase and special zoning restrictions to protect areas around city wells and underground water supplies or aquifers (check one):

____ No money at all should be spent for these purposes (1)

____ Somewhat less money should be spent for these purposes (2)

____ Funding for these purposes should stay about as is (3)

____ Somewhat more money should be spent for these purposes (4)

____ Much more money should be spent for these purposes (5)

9. Did you participate in the Household Toxic Wastes clean-up conducted on April 20 in Dover?

____ No (1) ____ Yes (2)

If yes, what waste did you bring?

10. Are you a member of any local or national organization (for example, Conservation Commission, Sierra Club, League of Women Voters, Audubon Society, Society for Protection of N.H. Forests, etc.) which has been active on water or other natural-resource issues?

____ No (1) ____ Yes (2)

If yes, which organization(s)?

11. Below are some suggestions that have been made concerning what Dover might do to protect present and future water supplies. For each suggestion, indicate whether you think that it should not be done, should be done as a low priority, or should be done as a high priority.

Pass stronger regulations concerning the storage and disposal of potentially contaminating chemicals (check one):

____ should not be done (1)

____ should be done but as low priority (2)

____ should be done as a high priority (3)

Pass zoning ordinances that restrict development over important underground water supplies or aquifers (check one):

____ should not be done (1)

____ should be done but as low priority (2)

___ should be done as a high priority (3)

Seek to reach agreements with neighboring municipalities such as Madbury, Barrington, and Rochester concerning protection for water supplies that are not wholly within any one town (check one):

____ should not be done (1)

____ should be done but as low priority (2)

___ should be done as a high priority (3)

Press for a clean-up of the Superfund site at the Tolend Road Landfill (check one):

____ should not be done (1)

____ should be done but as low priority (2)

____ should be done as a high priority (3)

Try to reduce the amount of salt used during winter snow removal (check one):

____ should not be done (1)

____ should be done but as low priority (2)

____ should be done as a high priority (3)

Conduct detailed mapping of underground water supplies or aquifers (check one):

____ should not be done (1)

____ should be done but as low priority (2)

____ should be done as a high priority (3)

12. In recent years water pollution and toxic waste problems have been receiving increasing attention in newspapers, television, and other news media. Do you believe that these problems have received too much attention, so the problems have been exaggerated? Or do you believe that they are still receiving too little attention, and the public needs to be made more aware? (check one):

____ Too much attention, problems are exaggerated (1)

____ Neither too much nor too little attention by news (2)

____ Need more media attention, make public aware (3)

13. Water for this household is mainly provided by (check one):

____ Dover city water (1)

____ Private well (2)

14. If your household does receive Dover city water, do you think that the present rates charged for this water are too high?

____ No, present water rates are not too high (Ø)

____ Yes, present water rates are too high (1)

15. Whether city or well water, do you know of any reason to be concerned about the present quality of your household's water supply? If so, briefly explain.

If you have any additional comments or explanations concerning this questionnaire, please write them below.

unh
UNIVERSITY OF NEW HAMPSHIRE
DURHAM, NEW HAMPSHIRE 03824

Department of Sociology and Anthropology
College of Liberal Arts
Horton Social Science Center
Durham, New Hampshire 03824

October 4, 1983

Dear Williamstown Resident:

In recent months there have been a series of announcements and controversies regarding the discovery of chemical contamination in Williamstown water and soil. Different opinions have been expressed about how serious the problem is and what should be done about it. I would like to know your opinions, in the form of responses to the enclosed survey questionnaire.

This survey is part of a broader study of community reactions to toxic waste contamination. As you probably know, Williamstown is by no means the only New England community to suffer from such contamination. Lessons from the Williamstown experience may be of great help elsewhere.

Your name, and that of about 300 other Williamstown residents, was chosen from a checklist of Williamstown voters. The questionnaires are anonymous. Certain items of background information, such as age and sex, are requested for comparison with other surveys and to help in analyzing the results. This background information will not be released or published in any way that would allow the identification of individuals; it is needed solely for statistical purposes.

I hope you will fill out and return this questionnaire, taking time to answer each question as freely and as honestly as you can. General findings from this survey will be reported later this fall. Thank you for your participation; if you have any questions, please write or call me at (603) 862-1800.

Sincerely,

Lawrence C. Hamilton

Lawrence C. Hamilton, Ph.D.
Project Director
Water Survey Project

WILLIAMSTOWN SURVEY

1. The person filling out this questionnaire is: ___ Male ___ Female

2. How many years have you lived in Williamstown? _____

3. What is your age? _____

4. The main source of water for this house is:

   ____ town water system
   ____ private well
   ____ other (specify) _____

5. Do you have children under 19 living in Williamstown? ___ No ___ Yes
   If yes, how many? _____

6. Do you have any children attending the Williamstown Elementary or High School?

   ____ No
   ____ Yes

7. What is the highest year of schooling you completed? _____

8. Do you have any reason to believe that your own property or water might have been contaminated?

   ____ No
   ____ Yes

   If yes, please explain.

9. Have you attended any of the meetings of the Williamstown Health and Safety Committee?

   ____ No, never
   ____ Once
   ____ Two or more times

10. From what you know, do you approve or disapprove of the activities of the Health and Safety Committee?

    ____ Approve
    ____ Disapprove
    ____ Neither, not sure

Since the chemical contamination was discovered, local, state, and federal governments, as well as a group of Williamstown citizens called the Health and Safety Committee, have tried to improve the situation. For each of these four organizations, indicate how good a job you think they have done so far, in protecting the interests of the people of Williamstown. Then, tell us what, if anything, they could be doing better.

11. Local government, including Town Manager and Selectmen (circle one)

very poor job	poor job	so-so	good job	excellent job
1	2	3	4	5

What could local government be doing better?

12. State government, including Environmental Conservation Agency (circle one)

very poor job	poor job	so-so	good job	excellent job
1	2	3	4	5

What could state government be doing better?

13. Federal government, including Environmental Protection Agency (circle one)

very poor job	poor job	so-so	good job	excellent job
1	2	3	4	5

What could the federal government be doing better?

14. The Williamstown Health and Safety Committee (circle one)

very poor job	poor job	so-so	good job	excellent job
1	2	3	4	5

What could the Committee be doing better?

15. Which of these four organizations (local, state, federal, Health and Safety Committee) do you trust the most, when it comes to determining what is or is not safe? _____

16. Which organization do you trust the least? _____

PLEASE READ CAREFULLY:

At the March 1983 town meeting, Williamstown residents discussed issues including election procedures, highway repairs, property appraisals, and additions/repairs for town buildings. Let us give these items of "routine town business" an importance number of 20. Compared to this number, how important do you think it is to study the causes and extent of the chemical contamination? If you think such study is twice as important as "routine town business," give it an importance number of 40. If you think such study is one hundred times as important as routine town business, give it an importance number of 2000. The number can be as high as you want. On the other hand, if you think studying the causes and extent of chemical contamination is half as important as routine town business, give it a 10. If such study is not important at all, give it an importance number of 0.

20 Importance number of "routine town business." (for comparison)

_____ Importance of "study the causes and extent of chemical contamination in Williamstown." (your number)

Below are two statements about what should be done with the Williamstown Elementary and High Schools. Check the statement you most agree with.

_____ Williamstown schools should be kept open unless it is proved that they are unsafe.

_____ Williamstown schools should be closed unless it is proved that they are safe.

Have you personally made any changes in your activities, or any important decisions, as a result of the discovery of contamination in Williamstown?

Have the events of the last few months caused you to change your views about water supplies, the environment, local businesses, or any level of government? If so, explain how.

If you have any additional comments, please write them below.

LEE WELL TEST DATA

The New Hampshire Water Supply and Pollution Control Commission (WSPCC) maintains written records of the results from thousands of water tests. Until recently, none of this information had been computerized or systematically analyzed. Some of the problems and prospects for such analysis are examined below, using well test data from the town of Lee. The original data describe the results from 73 well tests. All of these tests were conducted by the WSPCC during 1979-84, on samples collected by private parties in Lee, and submitted to the WSPCC for analysis. Much more data, for years before 1979, is available from the WSPCC but was not included in this exploratory study.

Most of the cases involved testing for some or all of the following:

coliform bacteria	chloride
non-coliform bacteria	iron
nitrates	manganese
flourides	hardness
copper	pH

Results from these tests were coded by hand from the original WSPCC cards into a computer data base, and then statistically analyzed. In the discussion below, reference is often made to the "maximum contaminant level", or MCL, recommended for any given drinking water impurity. These MCL's are based on the recommendations given in The WaterTest User's Manual (WaterTest, New London, NH, 1985), which also contains more extended discussions of the problems and uncertainties regarding actual "safe levels" for each contaminant.

Parameters of Health Significance

Coliform Bacteria Count: 71 of the 73 wells were tested for coliform bacteria. Seven wells (10% of those tested) had counts above the recommended MCL of 1/100ml. The distribution of these counts is in the following histogram:

COLIFORM BACTERIA COUNTS
EACH * REPRESENTS 2 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.	65	**********
20.	0	
40.	4	** MCL = 1/100ml
60.	1	* 7 of 71 (10%) exceed MCL
80.	0	
100.	0	
120.	0	
140.	0	
160.	1	*

In these data, coliform bacteria were about three times more likely to be a problem with shallow dug wells, than they were with deeper drilled wells:

	# of wells exceeding MCL	% of wells exceeding MCL	maximum
drilled wells	3	6%	160/ml
dug wells	3	18%	53/ml

Non-Coliform Bacteria: 71 wells were also examined for non-coliform bacteria; such bacteria exceeded the MCL (i.e., were too numerous to count) in 9 of these wells (13%). Non-coliform bacteria problems were much more common in dug than in drilled wells:

	# of wells exceeding MCL	% of wells exceeding MCL	maximum
drilled wells	3	6%	t.n.t.c.
dug wells	5	28%	t.n.t.c.

Coliform and non-coliform bacteria counts are often related: a well too high in one type of bacteria is likely also to be contaminated by other types. Both kinds of bacteria are most common in dug wells because many of these are improperly constructed. Bacterial contamination of bedrock wells is most likely to occur in newly-drilled wells, where some surface contamination entered the well during the process of drilling or setting up the well; in such cases, the contamination is only a short-term problem. Presumably many of the wells tested here had been recently drilled, so the figures above may overstate the frequency of bacteria problems in bedrock as opposed to dug wells.

Nitrates: 71 wells were tested for nitrates, and none of them exceeded the MCL of 10 mg/l. The distribution of nitrates is shown below:

NITRATES

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.0	36	************************************
0.5	19	*******************
1.0	7	*******
1.5	3	***
2.0	0	
2.5	0	
3.0	1	*
3.5	1	*
4.0	2	**
4.5	1	*
5.0	1	*
5.5	0	
6.0	1	*

MCL = 10 mg/l
no wells exceeding

Fluorides: Only 40 wells were tested for fluorides, and one of these exceeded the recommended MCL of 2.4 mg/l. The distribution of fluorides is shown in the following histogram:

FLOURIDES

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.0	23	**********
0.5	2	**
1.0	11	**********
1.5	1	*
2.0	2	**
2.5	0	
3.0	0	
3.5	0	
4.0	1	*

MCL=2.4 mg/l
1 well (2.5%) exceeding

Flouride is one of the few parameters examined here, that is generally much more likely to be a problem in bedrock wells than in dug wells. The single high-flouride case in these data, for example, came from a bedrock well.

Copper: Only 33 wells were tested for copper, and none of these exceeded the MCL of 1 mg/l:

COPPER

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.00	19	**********
0.05	0	
0.10	10	**********
0.15	0	
0.20	2	**
0.25	0	
0.30	1	*
0.35	0	
0.40	1	*

MCL = 1 mg/l
no wells exceeding

Parameters of Aesthetic and Environmental Significance

Chloride: 72 wells were tested for chloride, and four of these (6%) exceeded the MCL of 250 mg/l:

CHLORIDE
EACH * REPRESENTS 2 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.	55	**********
100.	8	****
200.	5	***
300.	0	
400.	0	
500.	1	*
600.	1	*
700.	1	*
800.	1	*

MCL = 250 mg/l
4 wells (6%) exceeding

Chloride problems were relatively more common in dug than in drilled wells:

	# of wells exceeding MCL	% of wells exceeding MCL	maximum
drilled wells	2	4%	760 mg/l
dug wells	2	11%	680 mg/l

Iron: Of the 71 wells tested for iron, nine (13%) exceeded the MCL of 0.3 mg/l:

IRON

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.0	26	**********
0.2	31	**********
0.4	8	********
0.6	2	**
0.8	1	*
1.0	1	*
1.2	0	
1.4	0	
1.6	1	*
1.8	1	*

MCL = 0.3 mg/l
9 wells (13%) exceeding

Excessive iron was most common in dug wells:

	# of wells exceeding MCL	% of wells exceeding MCL	maximum
drilled wells	4	8%	1.8 mg/l
dug wells	5	28%	1.6 mg/l

Manganese: 70 wells were tested for manganese, and 11 of these (16%) were over the MCL of 0.05 mg/l:

MANGANESE
EACH * REPRESENTS 2 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.0	61	**********
0.2	6	*** MCL = 0.05 mg/l
0.4	1	* 11 wells (16%)
0.6	0	exceeding
0.8	0	
1.0	1	*
1.2	0	
1.4	0	
1.6	0	
1.8	1	*

Manganese problems were also more likely in dug wells:

	# of wells exceeding MCL	% of wells exceeding MCL	maximum
drilled wells	6	12%	1.73 mg/l
dug wells	5	28%	1.01 mg/l

Hardness: Of the 71 wells tested for hardness, 29 (41%) would be considered to have low hardness; 32 (45%) to have moderate hardness; 5 to be hard (7%); and 5 to be very hard (7%).

HARDNESS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.	18	******************
100.	43	**
200.	5	*****
300.	4	****
400.	0	
500.	0	
600.	0	
700.	0	
800.	1	*

low: 0-75.....41%
moderate: 76-150.45%
hard: 151-250....7%
very hard: >251..7%

Most of the dug wells (56%) had low hardness. The majority of drilled wells (53%), on the other hand, were moderately hard. All of the wells with very hard water were drilled wells. Partly for this reason, the bedrock wells were also less likely to be acidic: hardness neutralizes the acids present in rain and surface waters. The hardness of well water gives rise to another environmental trade-off, however. Because hard water seems undesirable to many people, they invest in water-softening equipment. These softeners are often powered by salt, and may use as much as half a ton per year. The salt then goes back into groundwater through the septic system, giving rise to potential problems with chloride and sodium concentrations. Thus an effort to "improve" household water quality, by softening it, may in the long run cause more damage by increasing its salinity. This possibility has not been widely mentioned in the growing concern about road salting and its effects on drinking water.

pH: Three of the 71 wells tested were too acidic, and three others were too basic. The remaining 65 wells (92%) fell within acceptable levels of pH.

PH

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS		
6.2	1	*	
6.4	2	**	
6.6	1	*	
6.8	7	*******	recommended level: 6.5-8.5
7.0	3	***	
7.2	6	******	3 wells too low (acidic)
7.4	9	*********	3 wells too high (basic)
7.6	5	*****	
7.8	13	*************	
8.0	9	*********	
8.2	12	************	
8.4	0		
8.6	1	*	
8.8	2	**	

Although there were an equal number of wells with too-high and too-low pH, these problems occurred in different types of wells. All of the too-high pH measurements (meaning that the water was too basic) occurred in drilled wells. Two thirds of the too-low (too acidic) measures occurred in dug wells.

For any one of the contaminants described above, the great majority of the Lee wells tested were well within the recommended safe levels. If all of these contaminants are considered together, however, a somewhat different picture emerges. Out of 73 wells, only 40 (55%) did not exceed MCL's on <u>any</u> of the following nine parameters: coliform bacteria, non-coliform bacteria, nitrates, fluorides, copper, chloride, iron, manganese, or pH. Thus nearly half of the wells that were tested appear to be of questionable quality, on at least one parameter. The distribution of the <u>number</u> of different parameters on which each well exceeded the MCL's, out of a possible total of nine, is shown in the histogram below:

NUMBER OF PROBLEMS/WELL

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.	40	**
1.	24	************************
2.	6	******
3.	1	*
4.	2	**

This histogram shows that, of the 73 wells, 33 (45%) exceeded MCLs on at least one parameter; 9 (12%) exceeded MCLs on two or more parameters; and 3 (4%) exceeded MCLs on three or more parameters. Although no one type of contamination predominates, water quality problems appear to be very common among these tested wells. It should be emphasized that the high rate of water-quality problems among these tested wells does not mean that we should expect an equally high rate of problems among Lee wells in general. Presumably, many of these wells were tested in the first place, because some problem was suspected. Other wells were tested because they had just been dug or drilled; as mentioned above, the act of drilling itself causes disturbances that may temporarily worsen the water quality. The wells tested here are not a random sample of all Lee wells. The tested wells are more likely to be problem wells. Problems are probably less frequent in the general population of wells, than they are in the nonrandom sample considered here. While it is not possible to infer population rates from this sample, the occurance of one or more problems in 45% of the wells tested gives little reason for complacency about ground water quality.

In the single-parameter analyses shown earlier, there were often differences between the problem rates for deeper, bedrock wells, and shallow, dug wells. These differences are also noticeable when all nine parameters are considered together, as shown in the table below:

	% with at least one problem	average # of problems	maximum # of problems	total # of wells
drilled wells	38%	0.4	2	53
dug wells	67%	1.2	4	18

As this table indicates, two-thirds of the shallow, dug wells had at least one parameter that exceeded the recommended MCL. All of the cases with with three or more such problems were shallow wells. In contrast, problems were much less common in deeper wells; only 38% of such wells had any deficiencies, and none had more than two.

The analyses above have focused on well type (shallow or deep) as one important correlate of water quality parameters. Three other possible correlates are also available in the WSPCC well test data: the wells' distance from the nearest salted road; distance from the nearest fertilized field; and distance from the nearest septic system. Below is a table of correlations between each of these four predictor variables, and the ten

water-quality measures described above. Statistically significant correlations ($p < .10$) are shown with an asterisk. For statistical reasons, most of the variables have been transformed by taking natural logarithms.

	shallow well	distance to road	distance to field	distance to septic
coliform bacteria (log)	.22*	.10	-.04	.27*
non-coliform bacteria	.30*	-.16	-.28	.13
nitrates (log)	.07	.25*	.00	-.05
fluorides (log)	-.07	.07	.24	-.29*
copper (log)	.20	-.11	.23	-.39*
chloride (log)	.19	-.09	-.32	-.18
iron (log)	.26*	-.04	.04	.08
manganese (log)	.19	-.38*	-.16	-.09
hardness (log)	-.14	-.02	-.07	-.21*
pH	-.39*	.12	.52*	-.04

The table confirms that the differences between shallow and dug wells are significant, in the cases of bacteria, iron, and pH. Fluorides and copper are also significantly higher in wells that are closer to a septic system, and chloride is close to being signficantly higher in these wells. If there were more data, this chloride-septic correlation would be significant as well. Some of the correlations that are shown as "significant'

in this table should be interpreted with caution, because they may have been produced mainly by a few unusual cases. These questionable correlations include those between roads and nitrates, roads and manganese, septic systems and hardness, and septic systems and coliform bacteria. The last correlation has the opposite sign from what one would expect, due to the distorting influence of several extreme cases. Such "outlier" problems were common in these data, and pose a challenge to traditional statistical methods. With modern robust methods and with much more extensive data sets, it should nonetheless be possible to construct multivariate models that would be useful in predicting likely water quality problems on the basis of well characteristics.

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