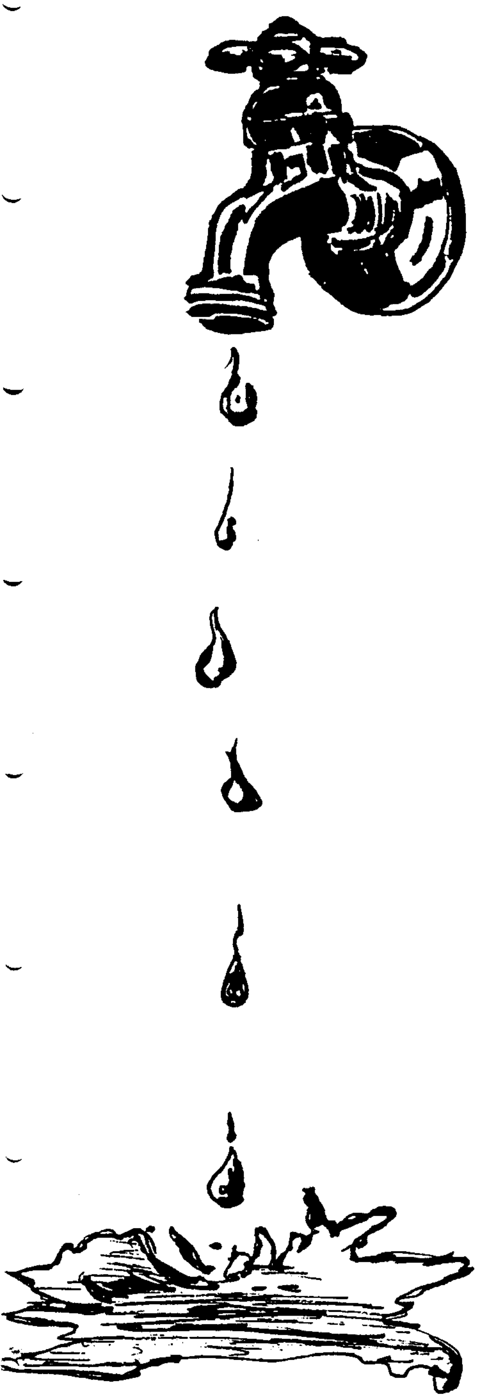
Research Report No. 44

HOUSEHOLD CONSERVATION DURING WATER EMERGENCIES



Two Case Studies

By:

Lawrence Hamilton

Department of Sociology

TECHNICAL COMPLETION REPORT

Project Number 373102

Water Resource Research Center
University of New Hampshire
Durham, New Hampshire

July, 1984

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ABSTRACT

This report describes public reactions to water conservation programs in two New England communities (Milford, New Hampshire and Acton, Massachusetts) which recently lost water suplies due to chemical contamination. In both towns, data were collected from mailed questionnaires sent to random samples of households on the town water systems. These survey data were analyzed to shed light on patterns in the adoption of water-saving behaviors by individual households, and on changes in public opinion regarding water issues following the crisis.

The Milford and Acton data confirm several findings from an earlier study (Hamilton, 1983a) regarding the underlying "types" of conservation behavior, and their demographic and attitudinal predictors. The Milford data also supported earlier conclusions that larger users make the largest absolute reductions, but middle-use households make reductions that represent a larger percentage of their total consumption. In addition, these data show that discoveries of chemical contamination are viewed with considerable alarm among the general public, and there is broad support for strong remedial measures. Town officials who took such measures met with public approval. Water resources planning and protection become high-priority issues in the wake of a contamination incident.

ACKNOWLEDGEMENTS

The groundwork for this study was done under a previous Department of the Interior grant (Project A-061-NH), and the results have been described in three publications to date (Hamilton 1982, 1983a, 1983b). The present study builds upon that work; preliminary results are scheduled for forthcoming presentation and publication (Hamilton 1984, 1985). Further papers and articles elaborating on the findings of this study are in preparation.

Support for this study was provided by the U.S. Department of the Interior, Office of Water Research and Technology, grant CT375102, administered by Gordon L. Byers, Chairman, Water Resource Research Center, University of New Hampshire.

Robert Courage, Superintendent of Public Works for the town of Milford, New Hampshire, was extremely helpful in providing information about the shortage and conservation campaign, access to water use records, and a cover letter which contributed to the survey's success. Similarly, I am indebted to John MacCleod, Manager of the Acton Water District, for his assistance in setting up the Acton, Massachusetts, survey. In collecting the data, analyzing them, and writing this Completion Report, I was helped greatly by the efforts of Leslie Hamilton, Monica Seff, and Peer Kraft-Lund. Finally, I am grateful to Gordon Byers, who has continued to be encouraging about this line of research.

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1: INTRODUCTION

Much of the research that has been done on water conservation behavior has studied this behavior in the contexts of natural droughts. Typically, water shortages have arisen when increasing water demands outstrips temporarily or chronically limited water supplies. Voluntary conservations are then often the best hope for achieving immediate, low-cost reductions in water demand. Appeals for voluntary conservation are based on altruism and collective self-interest; people are encouraged to see conservation as responsible citizen behavior. Studies of such natural-drought conservation programs include the immediate precursor of the research described below (see Hamilton, 1983a).

In recent years, a new kind of water shortage has afflicted a growing number of American communities: shortages caused not by insufficient supplies but by pollution of existing supplies, so that they become unusable. Contamination by toxic chemical wastes is the most dramatic form of such pollution. Public awareness of this problem has dawned suddenly over the last six years, spurred in part by the development of sensitive detection equipment which has revealed the wide scope of chemical contamination.

Although toxic waste contamination is a relatively new issue on the natonal agenda, it often produces water shortages that in other respects resemble the age-old problems caused by natural droughts: suddenly, there is not enough drinking water. Voluntary conservation campaigns have the same attractions during pollution-induced shortages as they do when the shortage is due to natural causes. There has been little research on the subject, though, so it is not known how public response to this new kind of water emergency compares with response to natural water shortages.

This report describes case studies of two New England communities that lost water supplies, and resorted to conservation programs, when chemical contamination was discovered in municipal wells. The first town described (Milford, New Hampshire) learned about the contamination suddenly in February of 1983. Conservation was needed to prevent overdrawing the remaining supplies until a new well could be brought on-line in July. The research design in Milford involved two stages of survey questionnaires, sent to a random sample of Milford households at early and late stages of the crisis. Data from these questionnaires, together with objective data on water used, provide the basis for a causal model of household conservation behavior.

The second community studied (Acton, Massachusetts) has a history of known water contamination going back to 1978, with periodic discoveries of new contamination in previously unaffected wells. Thus the town has been experiencing more or less continual difficulties with its water supplies for more than six years. Mandatory and voluntary conservation have been an important facet of the efforts to live with and overcome these difficulties. The research design in Acton involved a single, detailed, questionnaire, mailed to a random sample of households. This survey provided an opportunity to replicate findings from the Milford surveys. The Acton survey also provided further data on the depth of public concern over the problem of toxic waste contamination.

The findings from both case studies point to ways in which toxic waste contamination is like and unlike other water supply emergencies. They are alike in that people alter their behavior to save water in a predictable, similar fashion. They are different in that water contamination gives rise to very strong feelings and a level of citizen activism that have no parallel in natural water shortages. Both points come through very strongly when one looks at survey data such as those reported in chapters 4 and 7 below.

2: THE MILFORD WATER EMERGENCY

On February 15, 1983, citizens of Milford, New Hampshire (population 8685), found out that their drinking water contained unsafe levels of chemical contamination. Five different chemicals, chlorinated hydrocarbons commonly used as industrial degreasers, had been discovered during routine water testing by the state Water Supply and Pollution Control Commission. Town officials promptly took steps to notify the public, and closed down the well from which the contaminated samples had been drawn. With this well off line, the town lost 40 percent of its total water supply; notification of the shutdown was accompanied by a plea for voluntary conservation. Discussion soon turned to a host of difficult questions: where had the contamination come from? How long had it been there, and what effects had it already had? How would the town replace the lost water supply?

With these developments, Milford abruptly joined the long and rapidly growing list of U.S. communities struggling with the intractable problems of toxic wastes. Unlike Love Canal and other more serious pollution incidents, the Milford contamination apparently did not have health effects that were widely noticed before scientific testing confirmed the chemicals' presence. The actual concentrations reported were "only" two to five times higher than those considered safe. The problem was thus perceived as serious, but not acute, and it received little attention outside of the local area. In New Hampshire alone, there were at least 44 other sites listed as posing a similar "imminent threat" to public health at that time.

An overview of the Milford water emergency is provided in three sections below. Section 2.1 describes the pollution problem itself, and the events leading up to it. Section 2.2 describes the sequence of events that followed the discovery of the well contamination. Finally, section 2.3 looks at the effect these events had on Milford's daily water consumption, during the first half of 1983.

2.1: Groundwater Contamination in Milford

Figure 0 provides a rough map of the Milford area. The town's two main aquifers (ground water supplies) are shaded, and key locations (approximate) have been denoted by the letters A through L.

The town well which was found to be contaminated, the Savage well, is shown by G in the left center of this map. This well is located near an industrial area with four manufacturing firms (A through D), which were the principal suspects once pollution was discovered. During the period 1943-79, one or more of these firms was known to have been dumping chemicals in the town landfill (I), across the Souhegan river but within the same aquifer. This landfill dumping was suspected as a source of contamination of several nearby private wells.

In 1978, one of the industries was involved in a clean-up after heavy metals were discovered flowing from dumps on the firm's property into a drainage swale (E) that led into fields near the Savage well. At that time, it was believed that the problem was confined to heavy metals. There was no capability to test for volatile organic chemicals at the level of parts per billion, so this possibility was not investigated.

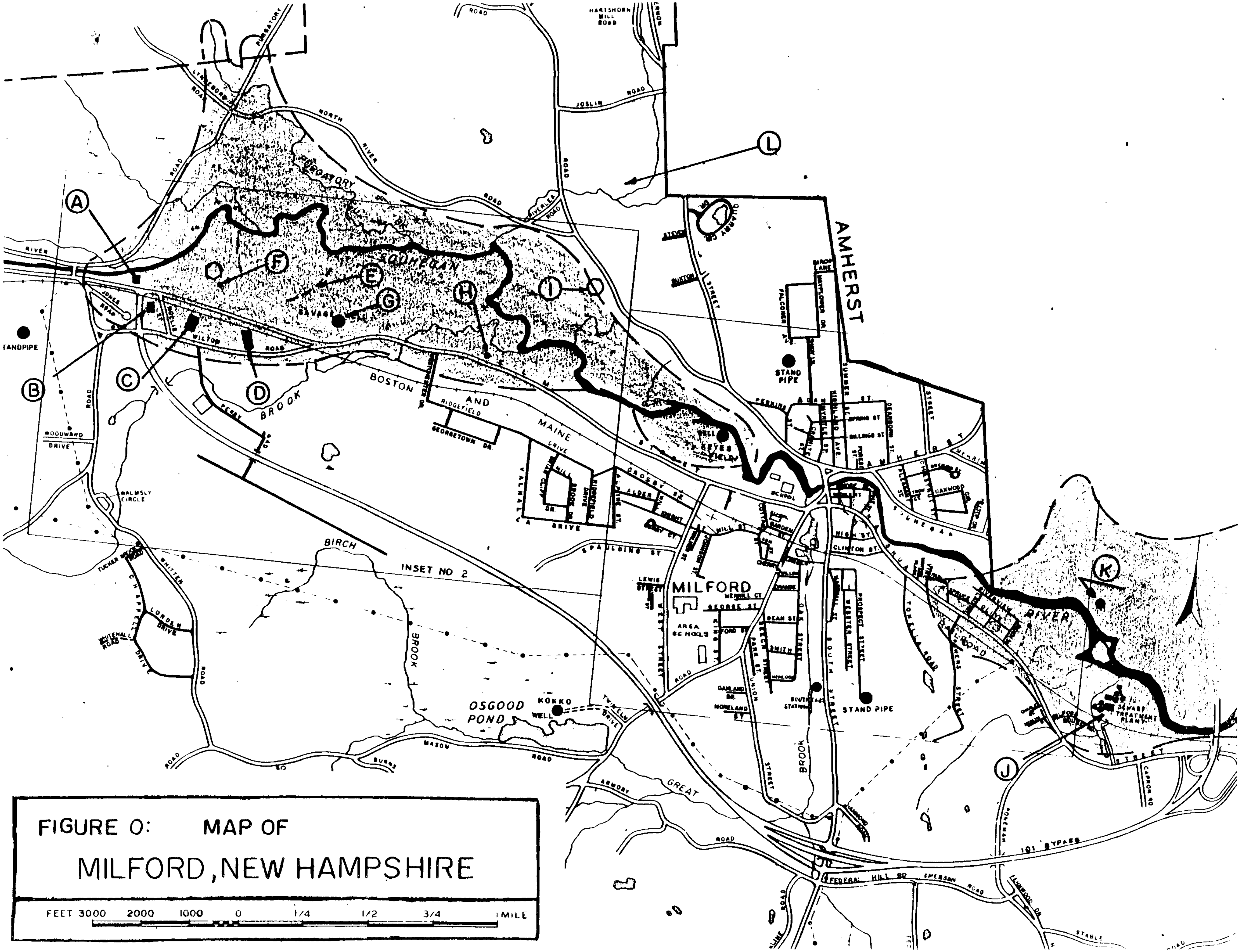


FIGURE O: MAP OF MILFORD, NEW HAMPSHIRE

In 1980, several cows died mysteriously in the field (E) near the Savage well and the previous clean-up operation. There were also reports of dumping that led to further well contamination in an area (L) on the north side of the Souhegan River. However, testing technology and consciousness of the dangers of toxic wastes were not yet at a point where such incidents evoked a strong response.

Once the Savage well contamination was discovered, in February of 1983, tests were immediately run on a number of nearby private wells that might also be affected. High levels of contamination were detected at a trailer park (F) between the Savage well and the suspected industrial area. Lower levels were found nearly a mile away, in the well of a business establishment (H) also sharing the same aquifer.

From this last discovery, it was clear that the contamination had spread some distance, and that a second town well in this aquifer might eventually be threatened as well. Furthermore, because of the landfill and other contamination, the aquifer on the north side of the Souhegan River was also at risk. A second, separate aquifer within Milford boundaries was not affected by the contamination, but it had unfortunately been chosen as the site for a sewage treatment plant (J), so was also unsuitable as a water source. Town officials had little choice but to seek a water supply in a neighboring, less polluted, town. This was done, and the resulting new well (K) finally brought an end to Milford's water shortage, about six months after it had begun.

2.2: The Water Shortage

The town was notified on February 15th, 1983, that they should take the Savage well off-line due to chemical contamination. Since the Savage well supplied 40% of Milford's water, it was apparent that action was urgently needed to avoid a serious shortage. The town normally had some surplus capacity, but this would not be sufficient unless (1) a new water supply could be found and brought on-line by June; and (2) no unexpected fires, dry weather, or water system problems arose in the meantime. The town asked industries to review their water consumption to see where they could cut back, and appeals for voluntary conservation went out to other consumers.

As consumer use began its seasonal rise with the onset of spring weather, a serious conservation program was mounted. In mid-May, the town placed restrictions on filling swimming pools and watering lawns, and asked people to voluntarily reduce other consumption. During the following month, the requests for voluntary conservation were repeated. In addition to restricting outside use, people were asked to:

(1) install water-saving devices in their toilets;

(2) use flow restrictors in showers and faucets;

(3) wash less often;

(4) use appliances only with full loads; and

(5) flush toilets less often.

Town officials reported a very good consumer response, with savings of 150,000-175,000 gallons per day.

On June 22, as the weather became hot and summer water use increased. The town instituted a ban on all outdoors water use, with a penalty of water-service cut-offs for violators. The ban was advertised in the town newspaper, and enforced by the Public Works and Police Departments. During the next week 15 warnings were issued, but no actual cut-offs occurred.

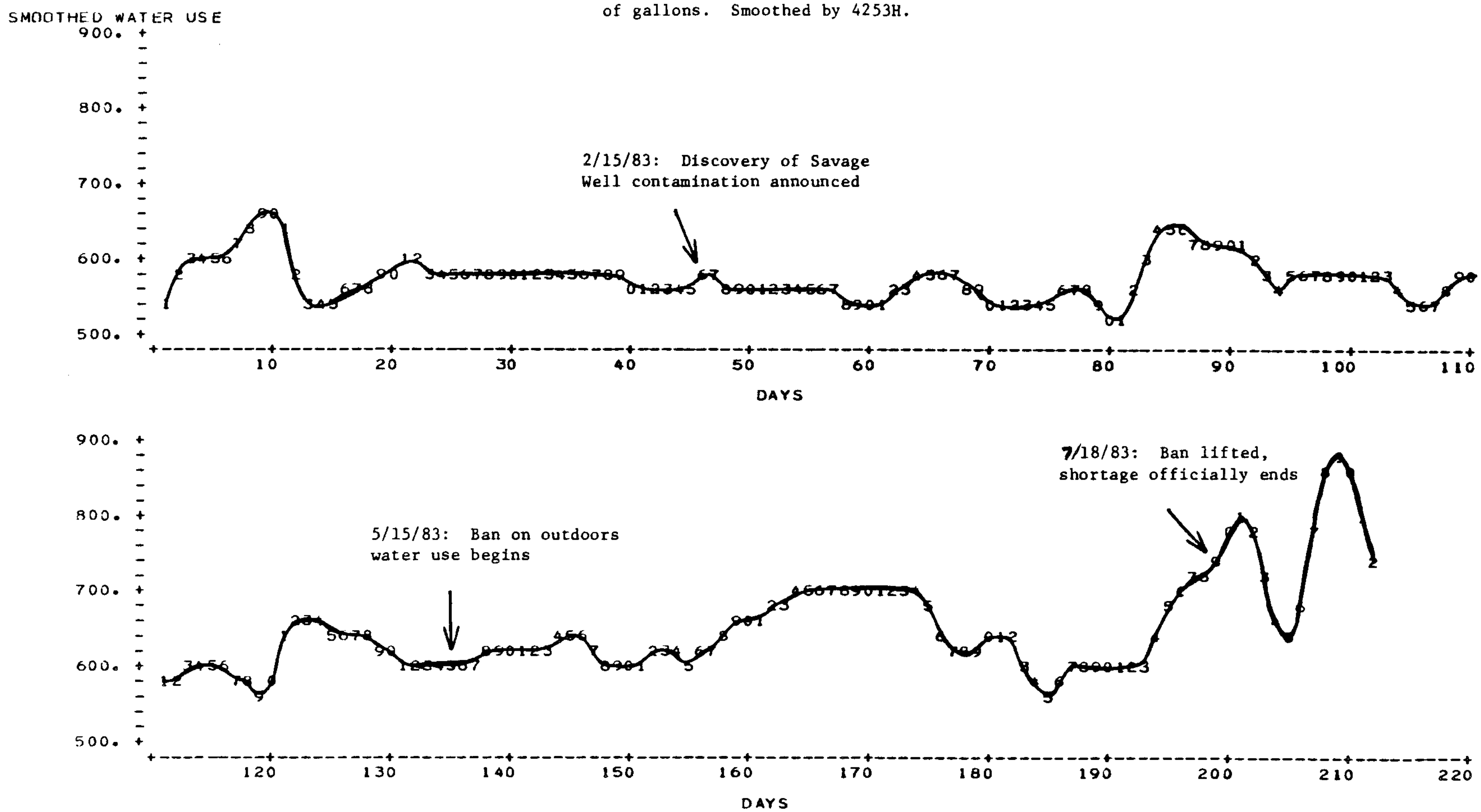
The new Amherst well (see K in Figure 1) was brought on-line in early July. Its capacity lived up to expectations, and on July 18 the water use restrictions were officially ended.

2.3: Response to the Conservation Campaign

The chronology of Milford's water shortage contains three principal events that should have affected citizen water use: the February 15 announcement that contamination had been discovered; the May 15 restrictions on outdoors water use; and the July 18 announcement that the shortage was officially over. The outdoors-use ban on June 22 was also a significant event. Time series data on town water use during this period can be used to gauge how people actually responded to these developments.

Figure 1 presents a smoothed series (using the robust 4253H smoothing algorithm described by Velleman, 1983) of Milford water use during the first seven months of 1983. This time plot shows that Milford's water use followed typical seasonal patterns during this period, with an early-January peak, low use during the rest of the winter and early spring, and use gradually increasing in May towards its usual peak in July. The February discovery of contamination was followed by a long period of fairly low use, coming to an end in about mid-March. No substantial decline followed the May 15 outdoors-use bans. Consumption began to climb steeply about a week before the July 18 announcement that the shortage was over, as newspapers carried

Figure 1: Daily Water Use in Milford, New Hampshire from from January 1 to July 31, 1983, in thousands of gallons. Smoothed by 4253H.



stories about the success of the new Amherst well that replaced Milford's lost water supply.

Figure 2 shows the series of residuals from the smoothed plot in Figure 1, and provides a more detailed look at sudden day-to-day fluctuations. The February 15 discovery was followed by a sharp fall in water use, with an equally sharp rebound coming on February 16. For the next several days, this pattern of wild fluctuations continued. Similar variability is observed surrounding the crisis' end on July 18, with the fluctuations beginning about a week in advance. There is no evidence in Figure 2 of any sudden response to the May 15 outdoors-use bans.

Figures 1 and 2 indicate that the beginning and end of the crisis had some effect on water use patterns, although there is no unambiguous evidence of a strong conservation response. For comparison, it is useful to look at water use during the crisis together with normal use patterns over these months. This is done in Table 1.

The 1971-82 averages shown in Table 1 are indeed higher than 1983 figures, despite the fact that Milford's population grew steadily during this time. This seems to provide confirmation of the conservation program's success. Two anomalous findings should be noted in Table 1, however:

(1) 1983 use in January, before the crisis materialized, was down by just as much as it was at the height of the conservation campaign. This implies that some other factor, such as unusual weather or water price increases (rates changed in the spring of 1982), may account for some of the decline in total consumption.

(2) There is no increase in water savings following the outdoors use bans in

Figure 2: Residuals from smoothed daily water use (see Figure 1) in Milford, New Hampshire, January 1 to July 31, 1983, in thousands of gallons.

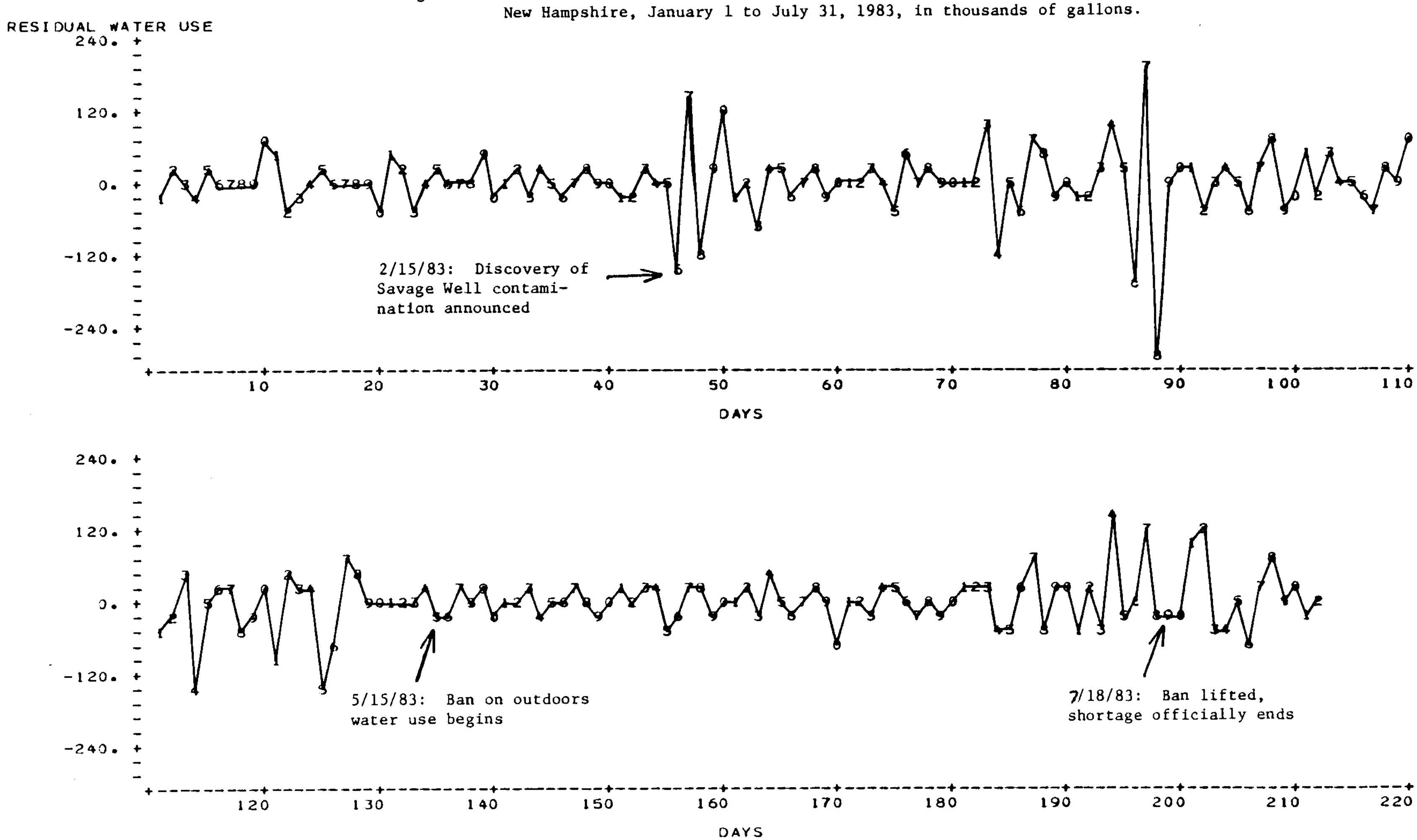


Table 1: Milford Water Use, 1971-1982 Compared with 1983

Month	1971-82 Mean Use Thousands of Gallons	1983 Use Thousands of Gallons	Decrease in Use T.G./day
January	20,471	18,290	70
February	18,035	15,750	79
March	19,971	17,660	75
April	19,246	17,280	66
May	21,301	19,120	70
June	22,091	19,770	77
July	23,064	21,682	45

mid-May. Theoretically, this should have been the period of greatest savings, but June water use in 1983 was actually higher than it was in 1982.

The findings of Figures 1 and 2, and of Table 1, can be summarized as follows:

(1) Response to developments in the water crisis can be seen in the form of erratic day-to-day fluctuations, rather than clear decreases in water consumption.

(2) Water use during the crisis period was lower than the averages from previous years. It seems reasonable to attribute at least some of the use decrease to intentional water conservation.

(3) Decreases in water use did not follow the temporal pattern that would be expected if they were entirely due to the water crisis, however. The effects of the ban on outdoors water use are not clear, since use did not decline further in the wake of this ban.

In order to explore citizen response to Milford's water crisis in more detail, it is necessary to move from aggregate to individual-level analysis. Chapters 3 and 4 describe results from a study of a random sample of Milford households.

3: MILFORD SURVEY DATA COLLECTION

Data on individual Milford households were obtained from three sources. First, water department billing records were used to select a random sample, and to record, for each household in this sample, the actual amount of water used during comparable crisis and pre-crisis periods. A survey questionnaire was designed to measure household background characteristics and opinions about the water problem. This questionnaire was mailed in April 1983, before the conservation program took effect. A second survey was mailed to the same households in August of 1983, asking about which conservation steps had actually been taken. Data from these three sources were combined into a single data set for purposes of the statistical analyses that follow.

3.1: Survey Data Collection

The initial sample consisted of 388 households chosen systematically from a list of Milford water customers. The first survey was mailed to these households on April 7, 1983. This survey (reproduced in Appendix A) was designed mainly to measure attitudes towards the crisis, including how seriously it was viewed, and household background characteristics. The design of the study dictated that these variables should be measured early in the crisis, before the full-scale conservation program came into being.

Two weeks after the questionnaires were mailed, reminder postcards were sent to households that had not yet responded. Two weeks later, a follow-up mailing of replacement questionnaires was sent to a random sample of the remaining non-respondents. Eventually 239 questionnaires were returned, for a response rate of about 62%.

After the water shortage ended, a second questionnaire was sent out asking about what water-saving steps people took. This questionnaire, reproduced in Appendix B, focused mainly on water conservation and on how opinions had changed during the course of the crisis. Since such data would be useless without the background information provided by the earlier attitude survey, we sent the second survey only to those households that had responded to the first survey. The 239 questionnaires were mailed on August 12, 1983. Follow-up procedures were similar to those used on the first survey; ultimately 177 questionnaires were returned, for a response rate of 74%.

Response rates on both surveys were encouraging, and consistent with the results from a similar study conducted earlier in a different community (Hamilton, 1983a). In survey research, response rates of over 60% are considered "good", and over 70% they are "very good" (Babbie, 1973).

3.2: Water Use Data

Household water consumption data were recorded directly from billing records. Two data points were needed for each sample household: water use during the summer of the shortage (1983), and water use during the summer preceeding the shortage (1982). For a subset of households used to estimate the "inertia effect" of pre-shortage consumption rates, data were also collected going back to the summer of 1981.

In order to conduct the follow-up procedures that insured an acceptable response rate, and to match the two questionnaires with each other and with water use data, it was necessary to employ numbered questionnaires. The lists of names corresponding to respondent code numbers were destroyed as soon as the data collection and matching was completed, however. Thus in the final data set there is no way of identifying individual respondents.

3.3: Other Data Sources

In addition to the three data sources described above, information was compiled from a variety of sources, including Public Works Department records of past water use by days and months (examined in Chapter 2), as well as from less formal sources such as newspaper clippings, personal interviews, and mapwork around the contaminated chemical sites themselves. This additional information is drawn on throughout this study as a context for the formal analyses that follow.

4: ANALYSIS OF THE MILFORD DATA

The combined Milford data set contains information on a wealth of attitudinal and behavioral reactions among people affected by the water crisis. This chapter examines how those attitudes and behaviors were distributed among the sampled Milford households. Interrelationships among attitudes, behaviors, and background demographic variables are also studied, leading to the construction of a causal model for household water conservation.

4.1: Background Demographic Variables

A number of household background variables are widely thought to affect water use or response to conservation appeals. Among the most important such variables are income, education, age of household head, length of residence in the community, and variables describing the household size. Figures 3, 4, and 5 show the distributions of these background variables for the Milford survey sample.

Figure 3 shows the distributions of income and education. Income has a mild positive skew, with a few unusually high values (up to $98,000). The mean and median incomes are fairly close together, around $25,000. Median education is one year beyond high school.

Respondent ages and lengths of residence in Milford are shown in Figure 4. Both are variables that have been found to be important predictors of environmental attitudes in other research. In the Milford sample, the average (median) respondent had lived in Milford for 17 years, and was 40 years old. Both age and length of residence have substantially skewed

STEM-AND-LEAF DISPLAY OF HOUSEHOLD INCOME (LEAF UNIT=$1,000)

```
    6    +0* 000000
   37    +0. 5555555555555555555566777778888
   53     1* 0000000000000334
   77     1. 555555555555555555556689
  115     2* 00000000000000000000000000000001112334
 (34)     2. 5555555555555555555555555666666778
   87     3* 0000000000000000000000111223444
   56     3. 5555555555555558
   40     4* 000000000000022
   25     4. 555555555555
   13     5* 000023
    7     5. 55
    5     6* 0

         HI  65, 65, 75, 98
```

MEAN=24.6 MEDIAN=25.0 S.D.=14.7 N=236

STEM-AND-LEAF DISPLAY OF RESPONDENT'S EDUCATION (LEAF UNIT=1 YEAR)

```
   1     7  0
  10     8  000000000
  13     9  000
  17    10  0000
  27    11  0000000000
  97    12  000000000000000000000000000000000000000000000000000000000000000000*
 (31)   13  0000000000000000000000000000000
 108    14  00000000000000000000000000000000000000000
  67    15
  67    16  000000000000000000000000000000
  37    17
  37    18  00000000000000
  23    19  0
  22    20  0000000000000000000000
```

MEAN=13.8 MEDIAN=13.0 S.D.=3.0 N=236

FIGURE 3: HOUSEHOLD INCOME AND RESPONDENT'S YEARS OF EDUCATION.

STEM-AND-LEAF DISPLAY OF RESPONDENT AGE (LEAF UNIT=1 YEAR)

```
  12    2* 000000000003
  15    2. 799
  70    3* 0000000000000000000000000000000000000000000000000000000
  72    3. 67
 (52)   4* 0000000000000000000000000000000000000000000000001124
 112    4.
 112    5* 00000000000000000000000000000003334
  77    5. 89
  75    6* 00000000000000000000000000002334
  43    6. 557788
  37    7* 00000000000000000000000000012224
   5    7. 56
   3    8* 23
   1    8. 5
```

MEAN=46.6   MEDIAN=40.0   S.D.=16.0   N=236

STEM-AND-LEAF DISPLAY OF YEARS LIVED IN MILFORD (LEAF UNIT=1 YEAR)

```
  28   +0* 1111222222222333333333344444
  69   +0. 55555555566666666777777777778888888899999
 107    1* 00011111111111222222222333333333444444
 (17)   1. 55555556667788889
 112    2* 0011112333333
  99    2. 556667777788999
  84    3* 00000011344
  73    3. 55555667777
  62    4* 0000111122344
  49    4. 577788
  43    5* 0000333344
  33    5. 789
  30    6* 000022334
  21    6. 557788
  15    7* 00000012224
   4    7. 56
   2    8* 3
   1    8. 5
```

MEAN=25.8   MEDIAN=17.0   S.D.=21.8   N=236

FIGURE 4: RESPONDENT AGE AND YEARS RESIDENT IN MILFORD.

distributions, so the means in both cases are well above the medians. The skewness is most noticeable with length of residence; most respondents had lived there less than 20 years, but there were also many elderly respondents who had lived in Milford all their lives.

Distributions of household size, and the number of children under 18 living there, are shown in Figure 5. The average household consisted of about three people, including two adults and one child.

4.2: Attitudes and Beliefs

It is usually assumed that behavioral changes in areas such as water use come about as a result of earlier attitudinal changes. The Milford study was explicitly designed to test this proposition. Attitudes were measured relatively early in the crisis, in April, and behavioral measures from both the second survey and the water billing records were made later in the summer.

The attitude portion of the survey asked for opinions about several issues raised in town discussions of the water problems. Responses to these opinion items are shown in Table 2. People appeared to take the problem quite seriously. A large majority (95%) agreed that town officials were right to shut down the contaminated well. Majorities also agreed that more water testing was needed (64%), and that individuals should help conserve water (96%), and majorities disagreed that they would be willing to drink the water themselves (60%), or that the seriousness of the problems had been exaggerated (57%).

Four of the five opinions shown in Table 2 were intercorrelated to the extent that they could be considered indicators of a single underlying

```
NUMBER OF PEOPLE LIVING IN HOUSEHOLD
    EACH * REPRESENTS   2 OBSERVATIONS

    MIDDLE OF    NUMBER OF
    INTERVAL     OBSERVATIONS
         0.          2      *
         1.         26      *************
         2.         75      **************************************
         3.         33      *****************
         4.         55      ****************************
         5.         34      *****************
         6.          4      **
         7.          4      **
         8.          2      *

MEAN=3.12     MEDIAN=3.00     S.D.=1.51     N=235
```

```
NUMBER OF CHILDREN UNDER 18 LIVING IN HOUSEHOLD
    EACH * REPRESENTS   5 OBSERVATIONS

    MIDDLE OF    NUMBER OF
    INTERVAL     OBSERVATIONS
         0.        122      *************************
         1.         34      *******
         2.         56      ************
         3.         18      ****
         4.          3      *
         5.          2      *

MEAN=0.94     MEDIAN=0.00     S.D.=1.15     N=235
```

FIGURE 5: TOTAL NUMBER OF PEOPLE AND NUMBER OF CHILDREN LIVING IN HOUSEHOLD

Table 2: Citizen Views of Reaction to Pollution Problem[a]

Item	Response							Mean
	1. disagree very strongly	2. dis-agree strongly	3. disagree	4. not sure, undecided	5. agree	6. agree strongly	7. agree very strongly	
RSHUT - officials were right to shut well	0	0	0	5	20	14	61	6.3
XPROB - problem has been exaggerated	19	15	23	29	9	3	1	3.1
MTEST - town should test water more thoroughly	2	2	15	17	35	16	13	4.8
DRINK - I would drink water tomorrow	28	14	18	26	11	2	1	2.8
IHELP - individuals should save water	0	0	2	2	44	22	30	5.7

a. Percentages based on n=233.

Table 3: Maximum Likelihood Factor Analysis of Views of the Official Reaction[a]

	Factor Loading	Factor Score Coefficient	Communality
RSHUT - officials right to shut well	-.60	-.20	.36
XPROB - problem has been exaggerated	.66	.25	.43
MTEST - town should test water more thoroughly	-.36	-.09	.13
DRINK - I would drink water tomorrow	.83	.56	.69

a. Chi square goodness-of-fit test for single-factor solution, $\chi^2_2 = 2.60$, $p > .25$, indicating a good fit to the observed correlation matrix. Eigenvalue of first factor = 4.68, other factors less than 1.0.

TABLE 4: MAGNITUDE ESTIMATES OF IMPORTANCE FOR NINE TOWN ACTIONS (n=201)[a]

Actions	Rank[b]	Geometric Mean	Median[c]	Interquartile Range	Maximum
SOURCE-find new water source	1	200	100±107	960	25,000
CAUSES-study pollution causes	2	99	80±27	245	50,000
ACID-reduce acid rain	3	51	40±10	93	2,000,000
AQUIFR-study ground water	4	36	33±7	63	10,000
PATROL-hire 1 more patrolman	5	23	20±3	30	2,000
buy new communications equipment-Reference	6	20	20	--	--
SALARY-public employees raised	7	16	20±2	20	2,000
CRUISE-buy police cruiser	8	15	20±2	20	2,000
FREEZE-call for nuclear freeze	9	13	10±11	100	20,000,000,000

a. All estimates are relative to a reference item, "buy new equipment for Milford Communications Center," assigned a value of 20. See Appendix for the exact questionnaire wording.

b. Ranks based on geometric means; respondents did not explicitly rank these items themselves.

c. Medians are given with approximate 95% confidence intervals, based on the interquartile ranges (see Velleman and Hoaglin, 1981:79-81). Unlike mean/standard deviation-based intervals, these estimates are robust and have good efficiency in a wide variety of non-Gaussian distributions.

supplies.

The three well-pollution magnitude items, in common logarithmic form, loaded on a single underlying dimension. This factor provided a second possible measure of attitudes concerning problem seriousness. Distributions of the two measures (the ordinal-scales factor score, from Tables 2 and 3, and the log-magnitude factor just described) are shown in Figure 6. The "over-reaction" variable was formed by factor weighting of the standardized indices; unit weighting was used with the log-importance magnitude variable.

The opinion measures just described varied systematically with respondent background characteristics. In particular, it was found that the water problems were viewed most seriously by women with young children. Table 5 shows a breakdown of geomean magnitude estimates by sex and parental status; on all pollution variables, women with children assigned the actions a much higher subjective importance than did other groups. A similar finding emerged with the opinion that officials over-reacted. As seen in the box plots of Figure 7, women with young children were least likely to believe that the official reaction was too strong; more often, they thought it was not strong enough, or not soon enough. Men without young children were the group most likely to agree that officials did over-react; this group contained individuals who were most skeptical about the seriousness of the water problem.

A more complete picture of the demographic correlates of opinion items can be obtained by multivariate analysis, as shown in Table 6. Only significant partial regression coefficients (following backward elimination) are included in this table. The view that officials over-reacted is seen to be most common among older, less affluent males. Women with children, younger and more recent residents, and people from more affluent households

STEM-AND-LEAF DISPLAY OF OPINION "OFFICIALS OVER-REACTED" (LEAF=.1)

```
 24   -1T   333333333333322222222222
 38   -1*   11110000000000
 55   -0.   99999999998888888
 74   -0S   7777777777666666666
 86   -0F   555555444444
 99   -0T   3333322222222
115   -0*   1111111111000000
115   +0*   00000111111
104   +0T   22222222333333333333
 84   +0F   44444444555555
 70   +0S   666666666666777777
 52   +0.   888888888888899999999
 31    1*   000001111
 22    1T   2222233333
 12    1F   4455
  8    1S   666677
  2    1.
  2    2*
  2    2T   2
  1    2F   5
```

MEAN=0.00   MEDIAN=0.00   S.D.=0.89   N=230

STEM-AND-LEAF DISPLAY OF MEAN LOG IMPORTANCE OF PROBLEMS (LEAF=.1)

```
       LO   -3, 1

   4   +0F   45
   4   +0S
   8   +0.   9999
  12    1*   1111
  36    1T   222233333333333333333333
  63    1F   444444444444455555555555555
  92    1S   66666666666666777777777777777
 (27)   1.   888888888888889999999999999
  73    2*   0000000001111111
  57    2T   222223333
  48    2F   44444445555
  37    2S   666666777777
  25    2.   8889999
  18    3*   001111
  12    3T   222223333
   3    3F   5

        HI   40, 42
```

MEAN=1.95   MEDIAN=1.84   S.D.=0.69   N=192

FIGURE 6: OPINIONS ABOUT OFFICIAL REACTION AND PROBLEM SERIOUSNESS.

TABLE 5: GEOMETRIC MEAN MAGNITUDE ESTIMATES, BY RESPONDENT'S SEX AND PARENTAL STATUS[a]

Actions	Male Respondents		Female Respondents	
	no children	children	no children	children
SOURCE-find new water source	176	200	154	294
CAUSES-study pollution causes	78	92	67	200
ACID-reduce acid rain	53	31	56	86
AQUIFR-study ground water	38	29	24	64
PATROL-hire 1 more patrolman	18	15	27	49
SALARY-public employees raised	13	21	9	21
CRUISE-buy police cruiser	14	10	14	27
FREEZE-call for nuclear freeze	7	9	17	33
n of cases	56	61	39	45

a. As with Table 1, all estimates shown here are relative to an uncontroversial reference item "buy new equipment for Milford Communications Center," assigned a value of 20.

```
      ---------------------
------I        (  +  )    I------------------   males, no children
      ---------------------                       median=.29, n=65

      -----------------
------I     (  +  )    I-----------             males w/children
      -----------------                           median=-.04, n=63

       -----------------
-------I       (  +  ) I----------              females, no children
       -----------------                          median=.24, n=54

   -------------------
---I  (   +  )        I-----------              females w/children
   -------------------                            median=-.55, n=48


-----+---------+---------+---------+--------
   -1.0        0       +1.0      +2.0
          Standard Deviations
```

Figure 7: Box plots of belief that town officials over-reacted (factor score with zero mean and unit variance), by respondent sex and parental status. See text and table 2 for variable definitions. Median for each group indicated by plus signs, with 95% confidence intervals in parentheses. Boxes contain the middle 50% of the cases (interquartile range).

Table 6: Regression of Views of Pollution Problem on Respondent Background Characteristics[a]

	Respondent Background Characteristics							
Dependent Variable	Female	Has Children	Female w/ Children	Age	Length of Residence	Income	Education	R^2
OVRACT - town officials over-reacted[b]	-.16 (2.36)			.20 (2.74)		-.16 (2.15)		.11
IMPORT - average log importance magnitude[c]			.19 (2.53)	.18 (1.52)	-.22 (2.02)	.22 (2.99)		.11
IHELP - individuals should save water	.18 (2.75)	-.15 (2.33)					.13 (1.94)	.06
INDUST - industry is at fault[d]				-.31 (3.03)	.17 (1.74)	.17 (2.42)		.10
TOWN - town is at fault[d]			.25 (3.93)					.06

NOTES FOR TABLE 6

a.) Standardized OLS regression coefficients (beta weights) following backward elimination. All coefficients shown are statistically significant at $p<.10$ or better, with one exception (see note c.). Absolute values of the relevant t statistics are given in parentheses.

b.) OVRACT is a factor score composite variable, constructed using the weights given in Table 3. A high value of OVRACT means that the respondent believes that the pollution problem is less serious than officially claimed.

c.) IMPORT is the mean logarithm of importance magnitudes assigned to three pollution actions. A high value of IMPORT means that the respondent gave a very high priority to town actions aimed at reducing the pollution problem, as compared with the priority of other town business. See Hamilton (1984) for further discussion of these magnitude estimates. One nonsignificant demographic variable (age) is kept in this equation because its nonsignificance is a result of multicollinearity. In addition, age is a theoretically important variable in almost all research on environmental beliefs.

d.) INDUST and TOWN are dichotomies, coded 1 if respondents volunteered these items on an open-ended "who is to blame" question. 43% of respondents blamed local industries, and 16% felt that the town was partly to blame. Some repondents blamed both, but many answered that "no one is to blame," or left the question blank.

The statistical method used here, ordinary least squares regression, is not optimal with such binary dependent variables. It is used here because of its advantages of simplicity and straightforward interpretation. OLS estimates in such cases are likely to be somewhat less efficient (have higher standard errors) than generalized least squares or maximum likelihood estimates, but the differences are usually not large. More importantly, although they are less efficient, OLS estimates remain asymptotically unbiased.

were most likely to assign the problem a high importance magnitude. Women and better-educated respondents were more convinced that individuals should help the community by conserving water during the shortage. Younger respondents, and also long-term residents and those with higher incomes, were most likely to blame specific local industries for the pollution problem. Women with children were more likely to blame the town, not because the town had literally caused the pollution, but because they felt it had failed in its responsibility to protect people.

4.3: Self-Reported Conservation Behavior

Conservation is measured two different ways in this study: from people's self reports of specific conservation steps, and from the less detailed but more objective billing record data on the amount of water actually used.

Responses to a checklist of possible conservation steps are shown in Table 7. About 90% of the respondents said that they conserved by watering their lawns less often, watering trees and gardens less, and washing cars less. These are the sorts of activities covered by Milford's mandatory outdoors-use ban, however, so the high reported rates of compliance are not surprising.

The percentages reporting that they installed water-saving devices in sinks, showers, and toilets are much lower, from 21-33%. This sort of action requires more effort on the consumer's part than simply not watering the lawn, and most residents evidently did not feel it was worth the trouble. To overcome such inertia, some communities have distributed water-saving devices for free (Morgan and Pelosi, 1980).

Table 7: Water-Saving Steps (Milford)

Step	Percent "Yes" *
Water-saving device: toilet	20.9
Water-saving device: shower/sink	32.8
Water lawn less often	90.4
Water trees/garden less	89.8
Wash car less often	88.1
Flush toilet less often	68.4
Shorter showers, shallower baths	70.6
Ran washers only when full	79.7
Kept cold water in refrigerator	56.5
Used dishwater for plants	69.5
Other behavioral changes	16.9

*Percent "yes" out of n=177 responding to second Milford Survey.

Several indoors, behavioral steps--shorter showers, less flushing of toilets, etc.--had compliance rates intermediate between those for the mandatory outdoors-use ban and the installation of conservation devices. These steps are more passive than device installation, but less susceptible to legal and peer pressure than highly visible outdoors use.

A previous study of water conservation in another New England community (Hamilton, 1983a) found roughly similar patterns of compliance. That study also found that the numerous conservation steps loaded on three underlying dimensions, or factors: a "summer-lawn" dimension, consisting of outdoors uses such as car-washing and lawn-watering; a "device" dimension consisting of the installation of water-saving devices; and an "indoors behavioral" dimension, consisting of changes in frequency of bathing and flushing, etc. The Milford data provide an opportunity to replicate this earlier analysis.

Results of the factor analysis of Milford data are shown in Table 8. These results confirm the earlier Concord finding of three underlying dimensions, for summmer-lawn, device, and indoors-behavioral conservation steps. The replication strengthens the earlier conclusion that water conservation is not a single "thing." Rather, it is a set of at least three different groups of behaviors, which may be undertaken by different people and for different reasons.

The factor analysis of Figure 8 implies that the eight conservation steps can be more parsimoniously represented as three composite variables or factor scores. The distributions of these composites, formed by unit weighting and summing the appropriate conservation steps, are shown in Figure 8. The histograms in Figure 8 make clear the low variance of the summer-lawn factor, caused by the fact that these legally-required conservation steps were claimed by almost everyone in the sample. Those who did not say they

Table 8: Factor Analysis of Eight Water-Saving Steps

Step	Factor 1: Summer-lawn		Factor 2: Devices		Factor 3: Behavior	
	Loadings	Score Coefficient	Loadings	Score Coefficient	Loadings	Score Coefficient
Device-toilet	-.10	-.01	.74*	.49	.09	.10
Device-shower	.09	.03	.74*	.46	-.06	-.01
Flush less	-.08	-.01	.00	.01	.45*	.18
Shorter showers	.06	-.00	-.01	.04	.78*	.63
Wash/full	.07	.00	.02	.02	.40*	.15
Water lawn less	.93*	.59	-.03	-.02	.03	-.00
Water trees less	.82*	.26	-.01	.02	.12	.11
Wash cars less	.76*	.17	.04	.04	-.09	-.08

*Denotes highest loading in each row. Oblique rotation, $r_{12} = .12$, $r_{13} = .13$, $r_{23} = .26$; eigenvalues Factor 1 = 10.6, Factor 2 = 3.8, Factor 3 = 2.6; X^2 from three-factor model is 13.25 with 7 degrees of freedom ($.05 < p < .10$), indicating an adequate fit.

```
SUMMER-LAWN CONSERVATION SCALE
    EACH * REPRESENTS   5 OBSERVATIONS

    MIDDLE OF   NUMBER OF
    INTERVAL    OBSERVATIONS
         0.       12    ***
         1.        4    *
         2.       12    ***
         3.      149    ******************************

MEAN=2.68    MEDIAN=3.00    S.D.=0.82    N=177


INDOORS-BEHAVIORAL CONSERVATION SCALE
    EACH * REPRESENTS   2 OBSERVATIONS

    MIDDLE OF   NUMBER OF
    INTERVAL    OBSERVATIONS
         0.       13    *******
         1.       31    ****************
         2.       43    **********************
         3.       90    *********************************************

MEAN=2.19    MEDIAN=3.00    S.D.=0.97    N=177


DEVICE INSTALLATION CONSERVATION SCALE
    EACH * REPRESENTS   5 OBSERVATIONS

    MIDDLE OF   NUMBER OF
    INTERVAL    OBSERVATIONS
         0.      112    ***********************
         1.       35    *******
         2.       30    ******

MEAN=0.54    MEDIAN=0.00    S.D.=0.77    N=177
```

FIGURE 8: DISTRIBUTIONS OF THREE MILFORD CONSERVATION SCALES.

took these steps were likely to be people who did not water lawns, wash cars, or water gardens to begin with. We should consequently not expect this dimension to be useful in explaining within-sample variations in water conservation.

The three-factor model of conservation steps, together with several significant predictors, is shown graphically in Figure 9. This figure serves to highlight the differences between the correlates of the three conservation factors. Idealistic motives (i.e., the belief expressed on the earlier attitudes survey that "individuals should help the community by saving water", were related to the device and behavioral conservation factors, but not to summer-lawn conservation. This is because the latter was legally mandated, whereas the former two were optional and hence varied with attitudes. Female respondents were more likely to say that they practiced the indoors conservation behaviors. These steps partly consist of modifications in housekeeping activities. Finally, summer-lawn conservation steps were most likely to be taken by those with higher pre-shortage use, i.e. those who previously did use the water on their lawns and gardens.

The details of these findings are consistent with those from the Concord study (see Hamilton 1983a, 1983b). Conservation consists of several independent behavioral changes, which are likely to be taken by different people, for different reasons, and at different rates. Many of these differences are systematic and predictable.

4.4: Pre- and Post-Shortage Water Use

Objective water billing data provide the best way to measure actual water savings. An intuitively obvious definition of conservation might simply be the difference between pre- and post-shortage use. This simple,

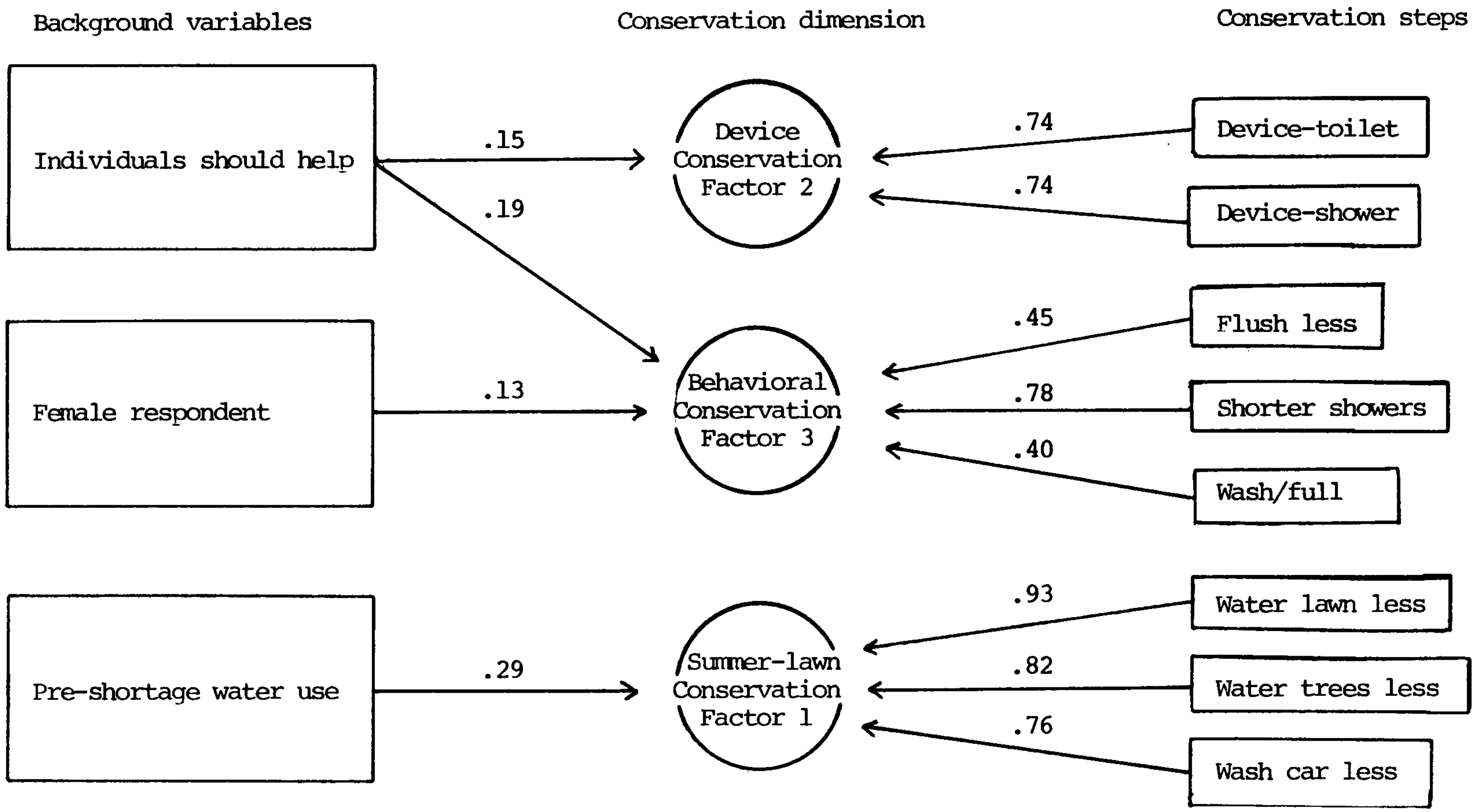


Figure 9: Three-Factor Model of Water Conservation Steps, with Significant Background Predictors

intuitive approach leads to results that are difficult to interpret, however. A more satisfactory procedure is described below.

Since summer is the time of highest discretionary water use, and Milford's conservation campaign was most intense in early summer of 1983, conservation in this case should be defined in terms of water savings during that period. The distributions of household water use, for the summers of 1982 (pre-shortage) and 1983 (post-shortage) are shown in Figure 10.

The water use distributions shown in Figure 10 are both positively skewed, with a number of outlying very-high-use cases. Previous research (Hamilton, 1983a) has indicated that square-root transformations are often successful at normalizing such distributions, whereas logarithms often go too far, converting positively skewed raw distributions into negatively skewed logarithmic ones. Square root transformation of household water use are also effective in reducing the statistical problems of outliers and heteroscedasticity. The square roots of 1982 and 1983 household water use are shown in Figure 11. As can be seen by visually comparing Figures 10 and 11, and can be verified by statistical tests, the square roots of water use are much closer to the normal-curve ideal than are the raw distributions.

The problem with a simple change score approach to measuring water conservation is best described in terms of the relationship between pre- and post-shortage water use. Pre-shortage use affects post-shortage use in two distinct ways. First, it is true that households that were intitially large users tend to stay large, and likewise with small and middle users. There is some "regression towards the mean", however: a high-use household has a higher probability of moving down, and a low-use household has a higher probability of moving up, than vice versa. This tendency of users to stay roughly where they are, with some movement towards the middle, can be termed

STEM-AND-LEAF DISPLAY OF SUMMER 1982 WATER USE (LEAF UNIT=1 CUBIC FT.)

```
   6   +0*  222344
  39   +0.  555556666666677777888888899999999
  78    1*  000000111122222222223333333344444444444
 115    1.  5555555555556666666667788888999999999
 115    2*  00000001111112222222333333334444444
  80    2.  55555556666666667777778888999999999
  45    3*  01112222334444
  31    3.  5566668889
  21    4*  0001234
  14    4.  56677889

        HI  54, 56, 62, 73, 84, 88
```

MEAN=2156 MEDIAN=1950 S.D.=1347 N=230

STEM-AND-LEAF DISPLAY OF SUMMER 1983 WATER USE (LEAF UNIT=1 CUBIC FT.)

```
   2   +0*  11
   9   +0T  2233333
  19   +0F  4444555555
  38   +0S  6666666667777777777
  53   +0.  888889999999999
  68    1*  000000111111111
  78    1T  2222233333
 103    1F  4444444445555555555555555
 113    1S  6666667777
(14)    1.  88888888999999
 103    2*  0000000001111111111111
  81    2T  2222222222333333
  65    2F  44444444
  57    2S  6666666777777
  44    2.  8889999
  37    3*  00011111
  29    3T  233
  26    3F  555
  23    3S  67
  21    3.  8899
  17    4*  011
  14    4T  22233

        HI  46, 46, 46, 47, 50, 55, 61, 69, 99
```

MEAN=1943 MEDIAN=1800 S.D.=1280 N=230

FIGURE 10: SUMMER WATER USE FOR 1982 AND 1983.

STEM-AND-LEAF DISPLAY OF SQUARE ROOT SUMMER 1982 WATER USE (LEAF=1)

```
    3    1* 444
    4    1. 7
   20    2* 0022222444444444
   32    2. 555668888888
   60    3* 0000000111111133334444444444
   91    3. 5555566677777777778888888888888
 (32)    4* 00000000011222223333333344444444
  107    4. 555555666666677777777888888
   80    5* 000000000000000001111112222333333334
   44    5. 555666677888899
   29    6* 0000111233344
   16    6. 567778899
    7    7* 034
    4    7. 8

       HI  85, 91, 93
```

MEAN=44.3 MEDIAN=44.2 S.D.=13.8 N=230

STEM-AND-LEAF DISPLAY OF SQUARE ROOT SUMMER 1983 WATER USE (LEAF=1)

```
    4    1* 0044
    9    1. 77777
   27    2* 000022222244444444
   43    2. 5555556666688888
   73    3* 000000000011111133333333344444
  103    3. 556677777777778888888888888888
 (32)    4* 00000111122222222233333344444444
   95    4. 55555555555555666666666677777788888888
   57    5* 00000001111112223333444
   34    5. 55555677999
   23    6* 001122344444
   11    6. 557778
    5    7* 04

       HI  78, 93, 99
```

MEAN=41.9 MEDIAN=42.4 S.D.=13.9 N=230

FIGURE 11: SQUARE ROOT TRANSFORMATIONS OF 1982 AND 1983 SUMMER WATER USE.

the "inertia" effect of pre-shortage use.

The second effect of pre-shortage use is a "conservation" effect: large users are able to make larger savings, in absolute terms, than smaller users can. Large users are presumably wasting more water, and find it less difficult to make substantial reductions. In order to arrive at a reasonable measure of conservation, we need to remove the "inertia" effect from post-shortage water use. For a fuller technical exposition of these issues, see Hamilton 1983b.

Estimates of the "inertia" effect can be obtained by regressing, for example, summer 1982 use on summer 1981 use for a subset of households in this sample. Records going back this distance were obtained for 52 Milford households from the survey sample. Figure 12 shows the results of this regression. The upper curve in Figure 12 is the estimated inertia effect, obtained from regressions of 1982 use on 1981 use. The lower curve is the observed relationship between 1983 use and 1982 use. The difference between these two curves is an estimate of the conservation effect. Note that this distance widens (i.e., conservation increases) with increasing levels of pre-shortage use. Although the absolute savings increase with pre-shortage use, it is also apparent that in percentage terms, greater reductions are made by middle-use households.

Since absolute water savings are greatest among high-use households, these are a particularly important group from the standpoint of achieving overall reductions in municipal water use. From a social-scientific point of view, however, the proportionately larger efforts of the middle users are also of particular interest.

For purposes of the analyses that follow, water conservation will be

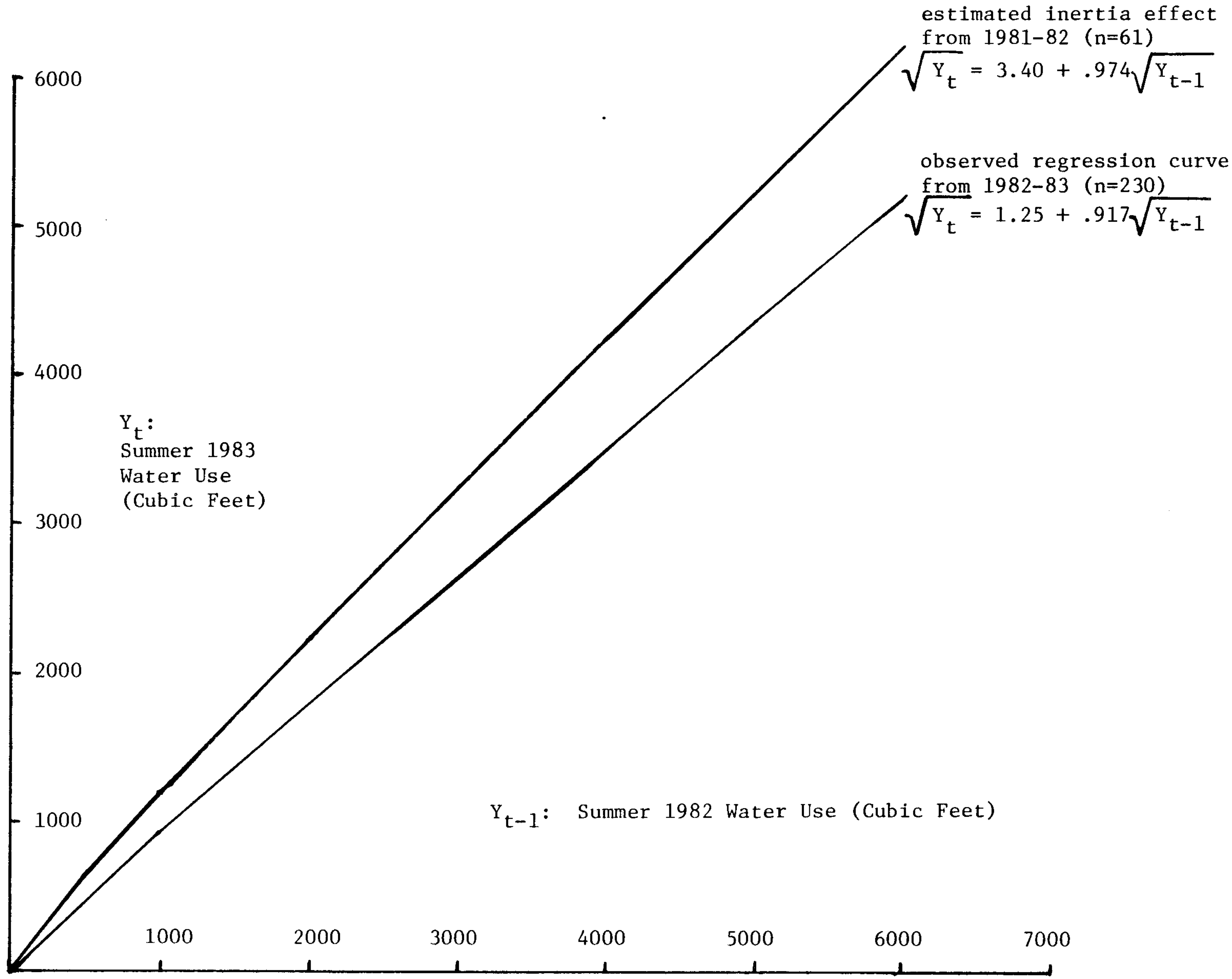


Figure 12: Relationship between Pre- and Post-Shortage Water Use

defined in residual terms: the difference between the amount of water each household would be expected to consume, under the inertia effect shown in Figure 12, and the amount of water that actually was consumed:

$$CONSRV = 3.40 + .974(SR82) - (SR83) \qquad [1],$$

where CONSRV is the measure of conservation, and SR82 and SR83 are the square roots of household water use in the summers of 1982 and 1983, respectively.

Distributions of the raw changes in water use, and the residualized conservation scores, are shown in Figure 13. In both cases, change is defined as 1982 (pre-shortage) values minus 1983 (post-shortage) values, so a positive change indicates that water actually was conserved. In raw form, the average amount saved was about 100 (median) or 212 (mean) cubic feet. For both distributions in Figure 13, the center of the distribution is clearly positive, indicating a general movement towards reduction of water use. This can be seen most dramatically if one draws a line to separate the positive (used less water) and negative (used more water) sides of these distributions.

As noted above, for statistical reasons it is best to work with the square roots of water use, rather than with the raw data themselves. The advantages of square roots are also apparent in Figure 13; the lower (square root metric) conservation distribution is much more normal than the upper (raw data metric) distribution. The raw data version produces a multimodal, long-tailed change distribution.

4.5: Causal Modeling

The Concord study (Hamilton, 1983b) presented a parallel analysis for the city of Concord, New Hampshire, and included a causal model of household water conservation. Essentially the same model is applied to the Milford

STEM-AND-LEAF DISPLAY OF CHANGES IN WATER USE, 1982 MINUS 1983 (LEAF=10 C.F.)

```
        LO  -140, -140, -120, -110, -110,  -90

   9    -7  000
  13    -6  0000
  16    -5  000
  21    -4  00000
  27    -3  000000
  44    -2  00000000000000000
  72    -1  0000000000000000000000000000
  81    -0  000000000
  91     0  0000000000
 (35)    1  00000000000000000000000000000000000
 104     2  0000000000000000000
  85     3  0000000000000000000
  66     4  0000000000000
  53     5  0000
  49     6  0000000000
  39     7  00000000
  31     8  000000
  25     9  000000
  19    10  000
  16    11  0

        HI  120, 130, 130, 140, 150, 150, 150, 150, 160, 170, 180, 190, 230,
            260, 270
```

MEAN=212   MEDIAN=100   S.D.=583   N=230

STEM-AND-LEAF DISPLAY OF RESIDUALIZED CONSERVATION (SEE TEXT)

```
        LO  -12

   2   -0.  8
   5   -0S  766
  13   -0F  55554444
  19   -0T  332222
  37   -0*  111110000000000000
  73   +0*  000000000000000000111111111111111111
 (46)  +0T  2222222222222222222222333333333333333333333333
 111   +0F  44444444444444444555555555555555555555
  74   +0S  6666666666677777777777
  52   +0.  88888899999999999
  35    1*  0000001111
  25    1T  2222333
  18    1F  45
  16    1S  666

        HI  16, 16, 17, 17, 18, 18, 18, 19, 21, 21, 22, 23, 25
```

MEAN=4.72   MEDIAN=3.75   S.D.=5.99   N=230

FIGURE 13: MEASURES OF WATER CONSERVATION

conservation program below.

Figure 14 shows this causal model with standardized regression coefficients attached to all paths that were statistically significant at $p<.05$ (or, in one case, $p<.10$). The dependent variable in Figure 14, "Water Conserved," is the residualized conservation measure described in equation [1] and Figure 13b, above. Path coefficients were estimated using multiple regression with pairwise deletion of missing values. Backward elimination was employed to simplify the model until only significant paths remained. Standard tests for leverage and unusually large residual values were used, to assess the stability of the findings (Cook and Weisberg, 1982).

Concord's water conservation program was long-running, intense, and highly successful. Milford, in contrast, experienced a much shorter-term emergency, and the conservation program did not have time to effect deep behavioral changes. Water savings in Milford were smaller, and less clearly related to the conservation efforts. They were also less related to the expected conservation predictors.

Seven propositions from the Concord study are supported by the Milford data:

(1) Pre-shortage water use has a substantial positive effect on conservation. The higher the pre-shortage use, the higher the conservation, even when a variety of other variables are controlled.

(2) The more people living in a house, the more difficult it is to conserve water. Presumably this reflects the problems of coordinating the activities of many independent individuals.

(3) More educated respondents are more likely to believe that individuals should conserve for the good of the community.

(4) Respondents with such idealistic beliefs are also most likely to engage

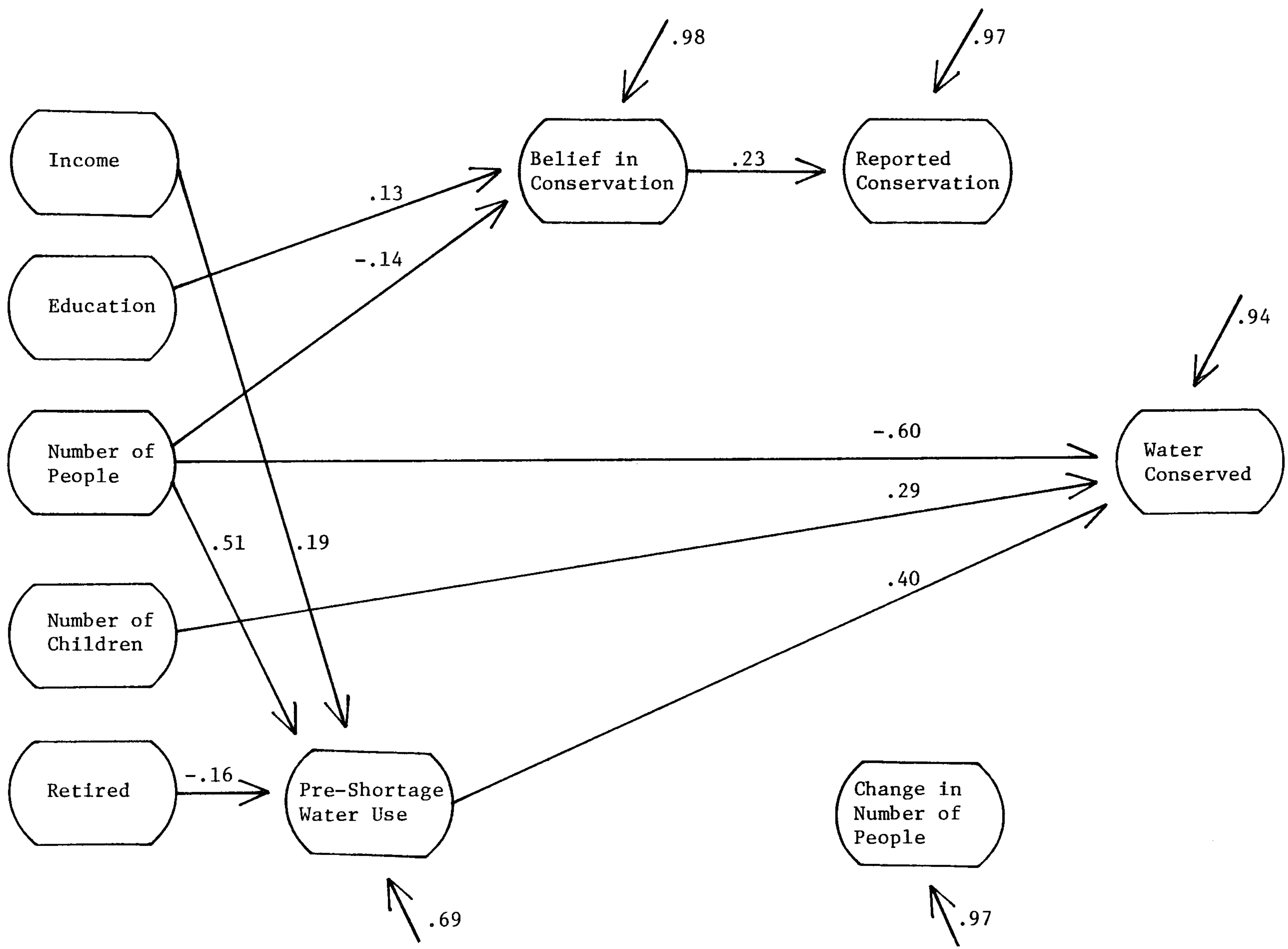


Figure 14: Path Model of Household Water Conservation

in indoors, behavioral conservation activities such as flushing less often, taking shorter showers, etc.

(5) Higher-income households tend to use more water, other things being equal.

(6) Larger households use more water.

(7) Households in which the head is elderly or retired tend to use less water than other households.

A number of other findings from the Concord study were not confirmed in Milford. In particular, there was no significant relationship between self-reported conservation behavior, and the amount of water actually conserved. There are fewer significant paths, and less explained variance, in the Milford model. These findings are consistent with the impression that citizen response to the Milford conservation campaign was somewhat weaker and less systematic than in Concord. This difference is not surprising, in view of the differences in duration and intensity of the shortages experienced by the two communities.

5: ACTON WATER EMERGENCY

Acton, Massachusetts, is a relatively affluent residential community of some 20,000 people, located 25 miles west of Boston. The population is predominately white, middle-class, and well-educated, with a high proportion of professional and technical occupations. Since 1978, problems of chemical contamination have been found affecting the town's water supply. An excellent, detailed history of these problems up to late 1980 has been provided by a group of Tufts University researchers (Krimsky et al., 1981). Readers are referred to this source for background information on Acton and its water problems.

Organic chemical contamination of two of Acton's municipal wells was discovered in fall of 1978. This discovery occurred at about the same time as the more publicized discoveries at Love Canal in New York. Acton and Love Canal were thus among the first casualties in the wave of toxic waste discoveries that swept the country over the following years. Their experiences in dealing with the problem are consequently much more extensive than those of relative newcomers such as Milford.

Soon after the Acton discoveries, a citizens group called ACES (Acton Citizens for Environmental Safety) emerged, and began to play an important role in publicizing the contamination problem. Two major studies of the contamination were commissioned, one by the town of Acton, and another by W.R. Grace Company, a chemical firm suspected of being the major source of pollution. The studies reached different conclusions about the extent of the

W.R. Grace's responsibility for the problem. Following unsuccessful negotiations and a complaint filed by the U.S. Attorney, the W.R. Grace company reached a consent decree with the Environmental Protection Agency. In this decree, the company agreed to a scheduled cleanup and monitoring of the polluted aquifer.

The contamination initially affected two town wells near the W.R. Grace chemical plant. With these wells off line, Acton faced a continuing water shortage. From 1978 to 1981, the town enforced a complete ban on outside watering. An elaborate two-stage purification system was set up for the two wells, so they could again become usable even though the groundwater remained contaminated. This made it possible to lift the absolute water ban, and replace it with an odd/even system for outside watering. In 1983, as the last stages of the purification system were completed, it appeared that it might be possible to allow unrestricted water use for the first time since the contamination was discovered. These hopes were dimmed by the discovery in 1983 of contamination in two additional wells, which also had to be taken off line. Newspaper accounts reported that chemicals had been found in all eight of Acton's wells, apparently coming from a number of different pollution sources. Water conservation again became a major concern.

In addition to the complete or partial bans on outdoor water use, Acton households were urged to adopt voluntary conservation measures. The League of Women Voters and the Acton Water District publicized many suggestions for how water savings could be achieved in the home. The most detailed list of suggestions, by the League of Women Voters, was incorporated in the Acton questionnaire shown in Appendix C. The Advisory Committee of the Acton Water

District published a quarterly newsletter informing people about the water situation and suggesting steps they should take. Citizen involvement and interest in the water situation appeared to be quite high.

The Acton survey described in the following two chapters was conducted in spring of 1984, following the disclosures of additional contamination in outlying wells, and announcements that it might be necessary to return to a full ban on outdoor water use. Several controversies regarding the water situation drew attention during this period. These included disagreement over whether W.R. Grace was responsible for the additional contamination; whether a health study of Acton residents was called for; and whether Acton's one-part-per-billion water quality standards were too strict, or not strict enough.

Because the water crisis in Acton has been drawn out over the past six years, it is not practical to track the impact of individual events as was done for Milford, New Hampshire, in Chapter 2. Instead, the continuing crisis must be regarding as having a cumulative impact on present attitudes and behavior regarding water use. In this sense, the Acton survey comes at a much "later" stage in the evolution of citizen awareness of water problems, than was the case with the relatively new and sudden crisis in Milford.

6. ACTON DATA COLLECTION

Acton's water problems, unlike those in Milford, had been going on for many years at the time of this study. It was consequently not feasible to employ the ideal design of measuring attitudes early in the crisis, and then correlating these with subsequent behavior. On the other hand, the long-running nature of Acton's water shortage meant that conservation programs had had a much longer time to take effect, and that people's attitudes had been formed over a period of years rather than weeks.

The differences between Milford and Acton dictated several changes in research design, which are described below.

6.1: The Acton Survey

A copy of the Acton survey is contained in Appendix C. This survey sought information on three kinds of variables: household and respondent background/demographic characteristics; specific conservation steps taken over the course of the crisis; and other behavioral and opinion reactions, including involvement in citizens groups, and town and water district meetings.

In Milford, the initial attitude survey preceeded the major part of the conservation campaign. In Acton, on the other hand, attitudes were measured after various conservation programs had been in effect for many years. It should not be expected that these attitudes could predict subsequent reductions in water use; presumably, most such reductions had already taken place. Objective water-use data were therefore not used in the Acton phase of this research. Because of the long-standing and well-organized nature of the Acton conservation efforts, however, it was reasonable to include a more detailed checklist of conservation steps than had been used in the earlier studies.

Apart from these differences in content, the Acton survey was conducted much as the Milford surveys had been. An initial mailing list of 517 addresses was drawn up by selecting approximately every ninth name from a complete list of Acton Water District customers. Only residential, single-family households were included, as far as could be determined, since the nature of water conservation behavior is quite different for multi-unit and nonresidential (e.g., commercial, industrial, institutional) customers.

The initial mailing of 517 questionnaires, with return envelopes, was sent out on May 7, 1984. As in previous surveys, the questionnaires were numbered, so it was possible to update the original mailing list as each questionnaire was returned. After two weeks, reminder postcards were sent out to sample households that had not yet responded. Two weeks after the postcards, a final mailing including a replacement questionnaire was sent to those still not responding. Eventually, 325 questionnaires were returned, for a response rate of 63%. This 63% response, considered "good" by survey research standards (Babbie, 1973), is very similar to the 62% response obtained in the original Milford survey described in chapters 3 and 4. As in Milford, the original mailing list and numbering system were erased once the mailings were finished, so there is no way to identify individual respondents.

6.2: Characteristics of the Sample

The ages and years-resident-in-Acton distributions for these respondents are shown in Figure 15. The Acton and Milford samples have about the same average ages (46.6 and 47 years, respectively), but the Milford sample ages are more variable. In terms of length of residence, the Acton respondents tended to be more recently-arrived (a mean residence of 14.3 years, as compared with 25.8 years in Milford). As is the case with age, length of residence is less variable in the Acton sample; in both age and length of residence, the Acton respondents are "more alike" than the Milford respondents are. Other Acton sample characteristics, including sex, likelihood of moving out of Acton, having children under 18 living in Acton, and newspaper readership, are given in Table 9.

One major difference between Acton and Milford is that Acton is a heavily professional and white-collar community. This is shown graphically in Figure 16, the distribution of occupational prestige scores. These prestige scores were coded from respondent self-reports of their occupations, using a standard occupational-prestige scale (NORC, 1982). There are few low-prestige occupations represented in the sample, and there are large peaks at scores around 50 (managerial) and 67 (engineers and related professionals). These high-status occupations are the Acton mode.

The differences between Acton and Milford samples directly correspond to differences between the communities themselves. Despite these sizable differences, there were significant similarities between the ways that citizens in these two communities reacted to their respective water problems. Some of these similarities are described in Chapter 7.

STEM-AND-LEAF DISPLAY OF RESPONDENT AGE (LEAF UNIT=1 YEAR)

1	1.	9
1	2*	
9	2.	66788899
38	3*	00000111122223333333333334444
92	3.	5555555555666666666666777777777777888888888888898[illegible]99
162	4*	0000000000000000000011111111111112222222222222333[illegible]4[illegible] *
(43)	4.	55555556666667777777777778888888[illegible]9999999
120	5*	000111111122222223333333334444444
87	5.	5555555555666666777777777888888999999999
49	6*	0000001111111122233334
27	6.	56777788888999
13	7*	0111244
6	7.	688
3	8*	0
	HI	81, 81

MEAN=47.0 MEDIAN=45.0 S.D.=11.6 N=325

STEM-AND-LEAF DISPLAY OF YEARS LIVED IN ACTON (LEAF UNIT=1 YEAR)

19	+0*	1111111111111111111
53	+0T	2222222222222222222222222333333333333
79	+0F	44444444444444455555555555555
109	+0S	66666666666666666777777777777777
137	+0.	8888888888888888888999999999999999
(27)	1*	00000000000000000111111111111
161	1T	222222222222333333333
141	1F	4444444444555555555
122	1S	66666666666677777777777777777
96	1.	8888888888999999999999
76	2*	000000011
67	2T	22222223333333
55	2F	44445555555555
43	2S	667777
37	2.	88899
32	3*	0011
28	3T	22222223
20	3F	45555
15	3S	6666
	HI	39, 40, 44, 52, 54, 60, 60, 70, 76, 77, 80

MEAN=14.3 MEDIAN=11.0 S.D.=12.5 N=325

FIGURE 15: AGE AND YEARS RESIDENT IN ACTON.

TABLE 9

CHARACTERISTICS OF 325 ACTON SURVEY RESPONDENTS*

SEX	60.3% male	38.2% female	
LIKELY TO MOVE?	17.8% very likely	34.2% somewhat likely	47.4% very unlikely
CHILDREN UNDER 18?	54.8% yes	45.2% no	
READ *BEACON*	75.4% yes	24.6% no	
READ *MIDDLESEX NEWS*	22.2% yes	77.8% no	
READ *BOSTON GLOBE*	73.2% yes	26.8% no	
READ OTHER PAPERS	9.8% yes	90.2% no	

* Percentages add to less than 100% where some people left these questions blank.

STEM-AND-LEAF DISPLAY OF RESPONDENT OCCUPATIONAL PRESTIGE (LEAF UNIT=1)

```
  1     2* 0
  7     2. 999999
 16     3* 124444444
 25     3. 555689999
 45     4* 00111122333344444444
 72     4. 556666666667777777777888999
(84)    5* 00000000000000000000000000000000000000000000000000000000000000000*
101     5. 5777788
 94     6* 0001111222222
 81     6. 677777777777777777777777777777777777777777777788[illegible]9[illegible]
 28     7* 111222222222244
 13     7. 668888888
  4     8* 2222
```

MEAN=54.6   MEDIAN=50.0   S.D.=12.4   N=257

FIGURE 16: OCCUPATIONAL PRESTIGE OF ACTON RESPONDENTS.

7: ANALYSIS OF THE ACTON DATA

Analysis of the Acton survey data is presented in two sections below. The first focuses on water conservation steps taken in response to the chronic shortages. The second section examines other attitudinal and behavioral reactions to the water problems.

7.1: Water Conservation in Acton

The Acton survey contained a checklist of twenty conservation steps, based on a list of suggestions sent out by Acton's League of Women Voters. Percentage responses to this checklist are shown in Table 10. Because previous surveys (in Concord and Milford) had found that compliance with legally-mandated outdoor water use bans is almost universally claimed by survey respondents, these items were not included in the Acton survey. The water-saving steps that were included were all voluntary.

The steps listed in Table 10 met with varied degrees of success, ranging from more than 80% (adjusted water level of washing machine to size of load) to less than 1% (purchased suds-saver attachment to re-use wash water). The steps with the highest adoption rates appear to be steps that many people would be taking anyway, even without a water shortage; these steps represented little if any sacrifice to the consumer. The least popular steps are relatively complex operations involving special supplies or hardware and work.

TABLE 10

WATER-SAVING STEPS (ACTON)

STEP	PERCENT TAKING *
Installed water-saving device or shower head in shower	63.1%
Took shorter showers/shallower baths	57.5%
Didn't leave water running while washing hands, brushing teeth, etc.	62.5%
Installed water-saving device in toilet tank	29.5%
Used dye to check for toilet leaks	5.2%
Flushed toilets less often	51.4%
Ran dishwasher only when full	77.5%
When hand-washing dishes, rinsed all at once	34.8%
Washed vegetables and fruits in a pan of water	18.2%
Kept cold drinking water in refrigerator	50.2%
Adjusted water level of washing machine to size of load	80.9%
Purchased suds-saver attachment to re-use wash water	0.9%
Purchased washing machine that uses least water per pound of wash (checked consumer ratings)	16.6%
Re-used dehumidifier water in washing machines, in steam irons, or for watering plants	13.8%
Collected rainwater for watering gardens	17.5%
Mulched garden to retain moisture	49.5%
Didn't use water pressure to remove dirt or grease; used brush or cloth instead	43.1%
Fixed leaking faucets	77.8%
Reduced water pressure with a regulator valve	16.3%
Insulated hot water pipes and heater	36.6%

* Based on n=325 respondents.

In studies of Concord, New Hampshire (Hamilton, 1983a), and Milford, New Hampshire (see Chapter 4), checklists of water-saving steps were found to have a similar underlying factor structure consisting of three dimensions, termed "indoors-behavioral", "summer-lawn", and "device" conservation. The Acton list shown in Table 10 is longer and more complex than those earlier lists, but it remains interesting to establish whether any similar factor structure can be discerned. When items with low variances and low communalities are removed, the thirteen remaining conservation steps do indeed load on three identifiable dimensions, as shown in Table 11. These three dimensions correspond closely to the three dimensions found in Milford and Concord.

The indoors-behavioral factor seen in Table 11 is particularly related to such actions as taking shorter showers, flushing toilets less often, and not allowing water to run while washing. The second, "garden", dimension is most strongly related to collecting rainwater to water garden. Note that all the weights for this dimension are negative, meaning that this dimension is literally an "unconservation" dimension. To avoid confusion, however, the sign of this dimension will be reversed (so it becomes a more understandable "conservation" dimension) in subsequent analyses. The last factor shown in Table 11 is a device or "handyman" type of factor, most related to repairing leaks, installing water-saving devices, and cleaning with a brush rather than with water pressure.

Values for the three correlated factors shown in Table 11 can be estimated using factor scores, obtained by factor weighting of each of the component variables in standardized form. Distributions of the three

TABLE 11

FACTOR ANALYSIS OF THIRTEEN WATER-SAVING STEPS (ACTON)

	Factor 1: Behavior		Factor 2: Garden		Factor 3: Devices	
Step	Loading	Score Coefficient	Loading	Score Coefficient	Loading	Score Coefficient
Shorter showers	.42*	.22	-.01	-.02	.21	.13
Not run water	.46*	.22	-.04	-.03	-.06	-.05
Flush less	.44*	.23	-.15	-.10	-.08	-.05
Refrigerate water	.38*	.17	.07	.03	.01	-.00
Adjust washer	.25*	.10	-.02	-.01	.11	.06
Collected rainwater	-.02	.00	-.58*	-.41	.01	.02
Mulched garden	.03	.02	-.38*	-.23	.18	.12
Rinsed vegetables	.32	.18	-.37*	-.25	-.14	-.10
Device - shower	-.01	-.01	.05	.02	.33*	.18
Device - toilet	-.08	-.04	-.17	-.10	.33*	.19
Clean with brush	.31	.18	-.10	-.09	.36*	.27
Repair leaks	.29	.15	.03	.01	.39*	.26
Regulator valve	.06	.02	-.05	-.03	.29*	.16

* Denotes highest loading in each row. Oblique rotation, $r_{12} = -.35$, $r_{13} = .29$, $r_{23} = -.23$; eigenvalues Factor 1 = 3.59, Factor 2 = 1.64, Factor 3 = 1.53; X^2 for three-Factor model is 40.6 with 42 degrees of freedom ($.50 > p > .25$), indicating excellent fit.

composite variables that result from this process are shown in Figures 17 and 18.

Although much of the variation in household water conservation is unpredictable, some of it is related to background characteristics of the household head or respondent. A multivariate analysis to examine these possible predictors is shown in Figure 19. Path coefficients shown in Figure 19 are standardized regression coefficients, significant at $p<.05$.

One variable that is significantly related to all three factors is whether or not the respondent attended public meetings concerning Acton's water problems. Respondents who showed this level of awareness and concern were also more likely to report that they saved water in a wide variety of ways. A related finding is that two of the three conservation factors were higher among people who did not expect to move out of Acton. These findings suggest that the most serious conservation efforts were made by people who identified most strongly with the Acton community. They point up a potential problem for more transient or "booming" communities, where the identification may not be as strong; fewer people in such communities might be motivated to make personal sacrifices for the community good. This may also suggest a reason for the negative effect that reading an out-of-town newspaper has on behavioral conservation.

Additional findings in Figure 19 are that older and (in the case of indoors-behavioral conservation) female respondents report higher levels of conservation effort.

7.2: Other Attitudes and Behaviors

```
INDOORS-BEHAVIORAL CONSERVATION SCALE
    EACH * REPRESENTS   2 OBSERVATIONS

    MIDDLE OF    NUMBER OF
    INTERVAL     OBSERVATIONS
       -1.6       15      ********
       -1.2       28      **************
       -0.8       30      ***************
       -0.4       59      ******************************
        0.0       58      *****************************
        0.4       54      ***************************
        0.8       46      ***********************
        1.2       17      *********
        1.6       18      *********

MEAN=0.00      MEDIAN=-0.02      S.D.=0.79      N=325
```

```
DEVICE INSTALLATION CONSERVATION SCALE
    EACH * REPRESENTS   2 OBSERVATIONS

    MIDDLE OF    NUMBER OF
    INTERVAL     OBSERVATIONS
       -1.6        5      ***
       -1.2       24      ************
       -0.8       35      ******************
       -0.4       70      ***********************************
        0.0       58      *****************************
        0.4       56      ****************************
        0.8       49      *************************
        1.2       22      ***********
        1.6        6      ***

MEAN=0.00      MEDIAN=-0.01      S.D.=0.71      N=325
```

FIGURE 17: ACTON BEHAVIORAL AND DEVICE CONSERVATION SCALES.

GARDEN CONSERVATION SCALE

```
MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
  -0.8        50      **************************************************
  -0.6        45      *********************************************
  -0.4        50      **************************************************
  -0.2        40      ****************************************
   0.0        33      *********************************
   0.2        22      **********************
   0.4         9      *********
   0.6        14      **************
   0.8        17      *****************
   1.0        11      ***********
   1.2        10      **********
   1.4         7      *******
   1.6         3      ***
   1.8         6      ******
   2.0         8      ********
```

MEAN=0.00 MEDIAN=-0.17 S.D.=0.73 N=325

FIGURE 18: ACTON GARDEN CONSERVATION SCALE.

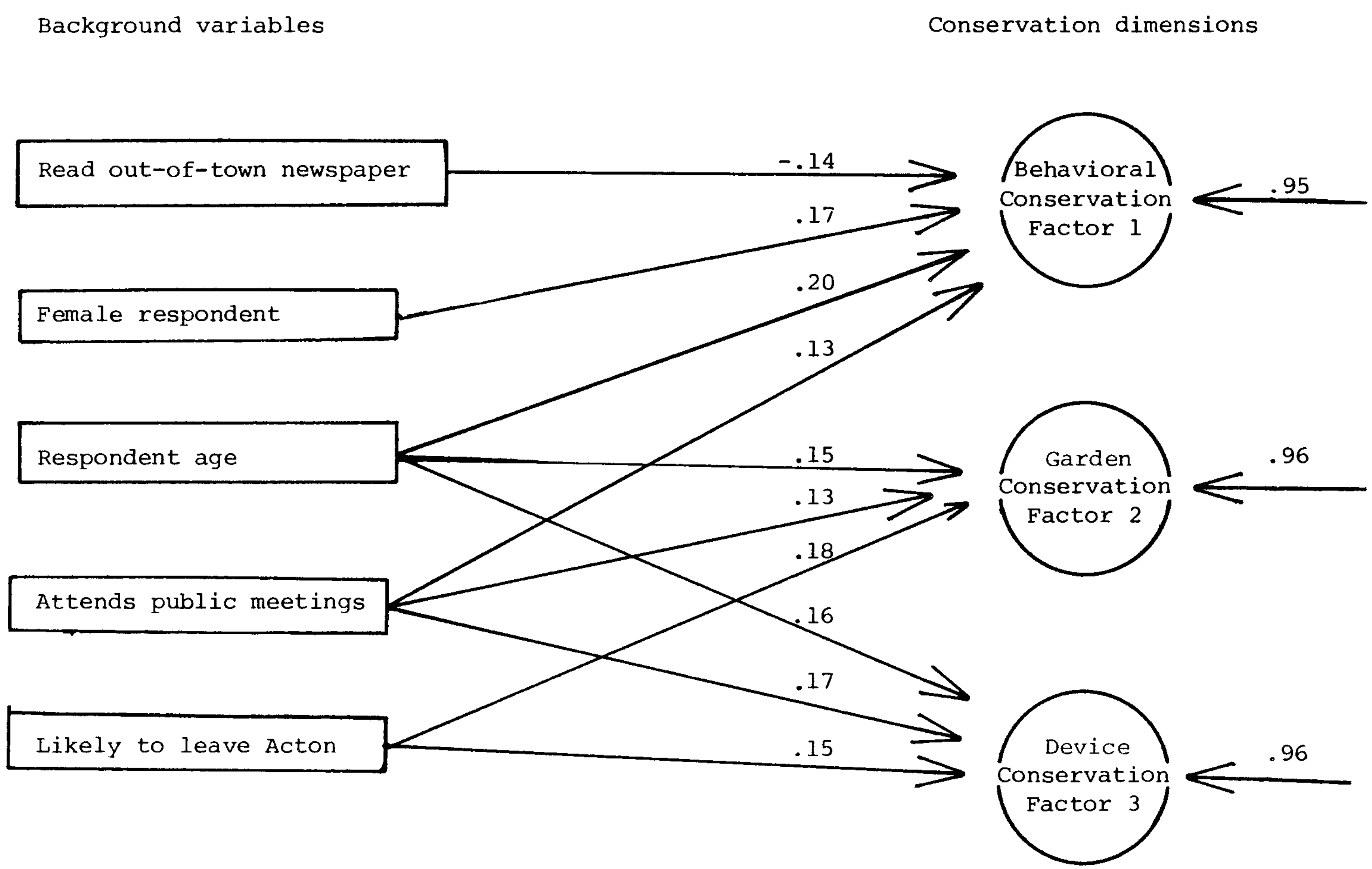


Figure 19: Background Variables Related to Acton Water Conservation Factors.
Standardized regression coefficients; all paths shown significant at $p<.05$.

Over the course of Acton's water problems, the public has heard many conflicting claims and accusations about who is responsible for the contamination, and what should be done to protect public health. Among local actors the W.R. Grace Company, the Acton Water District, the Board of Selectmen, and the Acton Citizens for Environmental Safety (ACES) have all been prominent in the public discussions. One questionnaire item asked respondents about how much they trusted each of these four groups, to protect their safety and work toward a reasonable aquifer clean-up plan. Responses to this item are shown in Table 12.

The Acton Water District and ACES come out very well on this item. The Water District was accorded "high" or "moderate" trust by more than 80% of the 325 survey respondents. ACES and the Board of Selectment each had the trust of over 70% of the respondents, with ACES' support being slightly more enthusiastic. The W.R. Grace Company, on the other hand, was not widely trusted, despite a major public-relations effort and its ongoing aquifer clean-up under the consent decree. 83% of the sample reported that they had "low trust" or "no trust at all" in this corporation. These results are particularly interesting because many respondents indicated that they had little personal knowledge about the details of the problem. Only a minority said they had attended any of the numerous public meetings held by Grace, the Water District, or the Selectmen. Thus they were in effect relying on others to look after their safety; Table 12 shows in which "others" this faith resided.

Other actions and opinions concerning the water problems are shown in Table 13. There was little public sympathy for the claim made by some that

TABLE 12

TRUST FOR GROUPS IN ACTON CLEANUP*

Group	High level of trust	Moderate trust	Low level of trust	No trust at all	No answer
Acton Water District	28.0	53.2	11.4	2.8	4.6
Acton Board of Selectmen	14.8	57.8	18.2	5.2	4.0
W. R. Grace & Company	1.5	12.3	37.2	45.8	3.1
Acton Citizens for Environmental Safety (ACES)	30.2	42.4	9.2	5.2	13.2

* Percentages based on n=325 respondents. Full question wording: "Although Acton's drinking water is now thoroughly filtered, there has been controversy about how to clean up the chemical contamination remaining in the underground water supplies (aquifer). Based on their actions of the past two years, <u>how much do you trust each of the following groups to protect your safety and work towards a reasonable aquifer clean-up plan?</u>"

TABLE 13

ACTIONS AND OPINIONS CONCERNING ACTON'S WATER PROBLEMS

Question*		Responses**	
Q32:	Acton's 1 ppb water quality standard should be:	made more strict	22.5%
		kept as is	59.1%
		made less strict	13.5%
Q33:	An epidemiological health study is:	high priority need	42.5%
		low priority need	36.6%
		not necessary	18.2%
Q34:	Does your household drink bottled water:	never	44.0%
		occasionally	23.7%
		often	8.0%
		almost always	24.3%
Q39:	Have you attended public meetings:	yes	26.2%
		no	73.8%
Q40:	Are you a member of concerned organization:	yes	9.5%
		no	90.5%

* See Appendix for full question wordings.
** Percentages out of n=325 respondents.

Acton's one part per billion water quality standards were unreasonably strict. A majority (59.1%) felt that these standards should be kept as is, and a sizable minority (22.5%) thought that they should be made even more strict. Most people (79.1%) also believed that an epidemiological health study should be done, with 42.5% saying that such a study had "high priority". A majority said that their households drank bottled water at least occasionally, as a result of Acton's water problems. Some people indicated that water taste (a problem unrelated to the chemical contamination) was also a reason for their preferring bottled water, however.

Although concern about the water problems was evidently high, only 23.2% of those surveyed had attended public meetings concerning these problems. Only 9.5% belonged to one of the environmentalist or public-service organizations that had been active in publicizing the problems. The relatively low level of citizen participation was mentioned as a problem by people in several organizations that had tried to educate and involve the public.

7.3: Summary

The Acton findings reinforce or expand upon earlier conclusions in several respects:

(1) In Acton as in Milford and Concord, a checklist of water-conservation steps was found to yield three underlying factors: indoors-behavior, device installation, and outdoors or gardening. The exact components and weights of these three factors vary with the communities and checklists employed, but despite these differences there are strong basic similarities.

(2) The indoors-behavioral conservation steps are most often reported by women.

(3) Idealism or a sense of identification with the community are important motivational factors affecting the likelihood that conservation measures will be adopted.

(4) By large majorities, people support strong steps by public officials to protect water supply quality. This support often extends to public approval of unofficial citizens' groups that are pushing for even more forceful action.

Although there are numerous differences between the various communities that have been studied to date, the similarities in their patterns are striking. The last chapter will examine some of the implications of these similarities.

8: CONCLUSIONS

The preceeding chapters have described water problems and results from surveys exploring public reactions to those problems, in the communities of Milford, New Hampshire and Acton, Massachusetts. The water problems themselves, and consequently the survey designs employed, were different in the two communities. In spite of these differences, a number of similarities emerged. The two strongest substantive conclusions supported by data from both communities are:

(1) The discovery that toxic wastes have contaminated drinking water supplies has a very strong effect on public opinion. Citizens are highly supportive of strenuous remedial actions by water providers and town officials, even if these steps are costly. Even if the official reaction is strong, many people will feel it is not strong enough. Relatively few people in Milford or Acton complained that the crisis was overstated. Although large majorities took the contamination problems seriously, there were systematic variations in who took these problems <u>most</u> seriously.

(2) Water conservation is not a unified set of behaviors. Three distinct kinds of behavior are involved: changes in daily behavior such as taking shorter showers; changes in outdoors water use on the lawn and garden; and adjustments to plumbing systems to reduce their consumption. Outdoors changes are most widely adopted, since these are visible to neighbors and susceptible to peer and legal pressure. Indoors behavioral changes are the next most likely type; these changes are more related to altruistic beliefs than to compulsions, and they are most frequently made by women. The third type of conservation, changes in plumbing, is the least popular. These

changes require more active intervention and investment on the part of the consumer; they may be most likely if someone in the house is "handy" with appliances.

In addition to these two central findings, there were a number of other results from both communities that have implications for policy or future research. These implications are discussed below.

8.1: Policy Implications of Findings

A major conclusion of the Concord water survey (Hamilton, 1983b) was that the largest reductions in water use occurred among households that were the largest users to begin with. The Milford conservation function graphed in Figure 12, above, is similar to the function found earlier for Concord (see Hamilton 1983b:365), allowing for the differences in the effectiveness of the two conservation programs. High-use households have more waste in their water budgets, and can more often make substantial reductions without serious sacrifice. Conservation campaigns should be sensitive to this fact; a widow living alone and using 300 cubic feet in a summer can't reduce her use much further, no matter how heroically she is willing to sacrifice. A household that normally uses 7000 cubic feet over the same period might cut back more than 2000 cubic feet at no cost but a browner lawn.

Since water conservation behaviors include different kinds of steps, taken by different kinds of people, conservation campaigns might also be made more effective if they thought out the targets of their various appeals. In this respect, conservation appeals might be thought of as resembling an advertising campaign, that could be made more effective by attention to "market research" into the nature of potential "customers". It is clear that the recipients of water conservation messages are not all equally likely to respond to any given suggestion.

A major goal of most conservation campaigns is to persuade the public that saving water is the ethically right thing to do. Altruistic motives, or identification with the good of the community, play a significant role in causing many water-saving behaviors. This is particularly true of those indoors behaviors that are not visible to neighbors or police. Identification with the community good may be strongest among people who recently moved to a community, but expect to stay there a long time.

When strong steps are taken by water managers or others in the wake of contamination discoveries, there are invariably some complaints that these steps are <u>too</u> strong. Judging from the Acton and Milford data, such complaints are unlikely to represent the views of more than a small fraction of the community. A much larger group is likely to feel that whatever steps are taken should be even stronger. There was a very high level of public support for the actions taken by the Milford Public Works Department and the Acton Water District. Water managers need not normally fear that they will lack public backing if they respond vigorously to water contamination problems.

8.2: Implications for Future Research

As noted above, the largest water use reductions were made by the largest household users. From a water-management point of view, these large users therefore deserve special scrutiny in times of shortage. On the other hand, middle users achieved water savings that were larger in percentage terms. This means that it was the middle users who made the largest proportional sacrifices. From a social scientific point of view, their efforts are therefore more noteworthy than those of the larger users. These highly-motivated middle users are an interesting topic for further research.

Water conservation requires changes in attitudes and behaviors, adapting to the new understanding that water is not a free or unlimited resource. Thus conservation is an important kind of social change, and one brought about by the environmental crisis of a water shortage. Shortages caused by toxic waste contamination are much more alarming than shortages caused by natural droughts, and they probably cause even greater changes in attitudes towards water and the environment. These changes may be long-lasting, and transform the climate for water resource management, planning, and protection. Such far-reaching attitudinal changes should be another topic of future research.

Unlike natural droughts, chemical contamination is usually viewed as being somebody's fault. Thus the opportunities for anger, blame, and loss of faith are much higher than they are during natural water emergencies. Public officials who respond too weakly to the perceived threat may set in motion a vicious circle of distrust that defeats their ability to handle the situation. This does not appear to have happened in Acton or Milford, where the surveys revealed high levels of public approval, but it has been observed in many other American communities. The process of official and public reaction to the discovery of water contamination is itself a worthy object of study. Knowledge about how this process typically unfolds may help to prevent the same mistakes and unproductive confrontations from being repeated in each new community where water contamination is discovered.

APPENDIX A:

MILFORD SURVEY #1

MILFORD PUBLIC WORKS
TOWN HALL
MILFORD, NEW HAMPSHIRE 03055

BUILDING INSPECTION
CEMETERIES
HIGHWAY DEPARTMENT
PARKS AND PLAYGROUNDS
SEWER DEPARTMENT
TOWN BUILDINGS
WATER DEPARTMENT

Superintendent
Tel. Milford 673-1662

March 29, 1983

Dear Water Customer,

The recent discovery of chemical contamination led to the closing of the Savage Well, which had supplied 40% of Milford's water. This presents us with a serious problem of water supply. The problem can be overcome, we hope, if Milford residents work together to use less water while progress is being made on finding an alternative supply.

Nationwide, hundreds of other communities face similar problems resulting from pollution of their water supplies. A team of researchers at the University of New Hampshire, headed by Professor Lawrence Hamilton, has been conducting research on how communities respond to such water emergencies. Milford is one of the communities they have chosen for their study. It is hoped that findings from Milford will be helpful in many other communities that may face this sort of emergency in the future.

A major part of their research will be based on survey questionnaires sent to a random sample of several hundred Milford citizens. Your household has been selected as one of these. Enclosed you will find a questionnaire which we ask that you complete and return to the UNH researchers in the envelope provided. Questions are included about your own views of the water situation, and about household background characteristics, which are needed for statistical purposes. A second, follow-up survey will be conducted this summer, asking about any water-saving steps your household was able to take. The success and usefulness of this study hinges upon the willingness of citizens such as yourself to provide candid and truthful information. The confidentiality of your responses is assured.

I want to thank you in advance for the time and effort which you will be expending in filling out the questionnaire. If you have any questions about this matter, please feel free to contact me at 673-1662.

Sincerely,

Robert E. Courage
Superintendent

/sac

____ Check here and return if this is not a residential address.

MILFORD WATER SURVEY

A. The first set of questions refers to basic characteristics of the household and the person filling out this questionnaire.

1. This residence is currently being used as a:
   (1) single-family residence
   (2) duplex or triplex
   (3) apartments
   (4) other (specify) ____________________

2. At the present time (April 1983), how many people are living in this house including yourself? __________

3. How many of the people living in this house are young children, less than 7 years old? __________

4. How many of the people living in this house are older children, from 7 to 17 years old? __________

5. How many of the people living in this house hold full-time jobs (30 hours or more a week) at the present time? __________

6. Comparing this spring (1983) with last spring (1982), has the number of people living in this house increased, decreased, or stayed the same? (Circle one answer and fill in the number of people.)
   (a) increased by ______ people
   (b) stayed the same
   (c) decreased by ______ people

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

   ____ Male ____ Female

8. Check which age group you are in:

   ____ 10-19 years old
   ____ 20-29 years old
   ____ 30-39 years old
   ____ 40-49 years old
   ____ 50-59 years old
   ____ 60-69 years old
   ____ 70 or over

9. How many years have you lived in the town of Milford? __________

B. The next set of questions asks about your views on Milford's current problems with water supply.

10. Chemical contaminants were recently found in one of Milford's three main wells. Prior to receiving this questionnaire, did you know about this problem? (check one)

    ____ No, I did not know about it.

    ____ Yes, I did know about it.

11. If your answer above was "yes", what were your main sources of information about the well contamination?

Below are five opinions about the Milford water quality and supply situation. For each statement, indicate how strongly you personally agree or disagree (circle the appropriate number). If you are unsure, don't know, or are undecided, circle (4) Not Sure.

12. Town officials took the right step in shutting down the contaminated well.

(7)	(6)	(5)	(4)	(3)	(2)	(1)
agree very strongly	agree strongly	agree	not sure	disagree	disagree strongly	disagree very strongly

13. The contamination problem has been greatly exaggerated; it is not as serious as some people have said.

(7)	(6)	(5)	(4)	(3)	(2)	(1)
agree very strongly	agree strongly	agree	not sure	disagree	disagree strongly	disagree very strongly

14. The town should appropriate funds for additional water testing by private laboratories, to check water quality more thoroughly than the state requires.

(7)	(6)	(5)	(4)	(3)	(2)	(1)
agree very strongly	agree strongly	agree	not sure	disagree	disagree strongly	disagree very strongly

15. Individual citizens should help the situation by using less water in their homes until new sources are found.

(7)	(6)	(5)	(4)	(3)	(2)	(1)
agree very strongly	agree strongly	agree	not sure	disagree	disagree strongly	disagree very strongly

16. If the Savage Well water were again mixed with water from Milford's other two wells, I would be willing to resume drinking it tomorrow.

(7)	(6)	(5)	(4)	(3)	(2)	(1)
agree very strongly	agree strongly	agree	not sure	disagree	disagree strongly	disagree very strongly

17. Do you wish to add any explanation to your opinions on questions 12-16?

18. Whom do you hold most directly responsible for the contamination of Milford's water?

19. Town officials have suggested that households should try to reduce their water use to help the town get by on the two remaining wells until a new source is found. Do you think your household will be able to save much water this spring, compared to what you normally use?

____ No, we cannot reduce our use very much. (0)

____ Yes, we can significantly reduce our use. (1)

PLEASE READ CAREFULLY: The next questions concern a number of possible actions which were discussed at the recent Milford town meetings. For each possible action, indicate how important you think it is for the town to take that action. Give each action an importance number: the more important you think an action is, the higher the number you should give it. Use "buy new equipment for the Milford Communications Center" as your reference. We have assigned this action an importance number of 20. If you think another action, such as "urge government steps to reduce acid rain" is twice as important as new Communications Center equipment, give the "acid rain" item an importance number of 40. If you think it is one hundred times as important as "buy new equipment for the Milford Communications Center", give the "acid rain" item an importance number of 2000. If you think "urge government action to reduce acid rain" is only half as important as new Communications Center Equipment, give "acid rain" a 10. Choose any numbers you wish -- they can be as high or as low as you want. Each number you choose should describe how important or unimportant you think it is for Milford to take that action, as compared with taking the action of buying new equipment for the Communications Center (20).

Your Importance Number	Actions Discussed at Milford Town Meeting	
20	Buy new equipment for Milford Communications Center	/20/
____	Urge government steps to reduce acid rain	/21/
____	Hire an additional police patrolman	/22/
____	Study the causes of the Savage Well pollution	/23/
____	Increase salaries for public employees	/24/
____	Call for a freeze on construction of nuclear weapons	/25/
____	Purchase a new police cruiser	/26/
____	Join the regional aquifer (ground water) study	/27/
____	Find a new source of town water	/28/

29. Do you wish to add any explanations to your answers above?

C. The final set of questions concerns information required for statistical purposes, about background demographic characteristics. As with the rest of this questionnaire, your answers are completely confidential.

30. What is the occupation of the head of this household? If there are two employed heads-of-household, list both occupations (indicate which is yourself). If retired or not employed, answer for last full-time job.

31. Check here if one or both heads of household are retired. ________

32. Check the highest year of school completed by the head of this household. If there are two heads-of-household, check highest year completed by each (indicate which is yourself).

____ no formal schooling (00)
____ 1st grade (01)
____ 2nd grade (02)
____ 3rd grade (03)
____ 4th grade (04)
____ 5th grade (05)
____ 6th grade (06)
____ 7th grade (07)
____ 8th grade (08)
____ 9th grade (09)
____ 10th grade (10)
____ 11th grade (11)
____ completed high school or G.E.D. (12)
____ vocational, technical, business school, etc. (13)
____ some college (14)
____ college graduate (Bachelor's degree) (16)
____ some graduate or professional school (law, medicine, etc.) (18)
____ graduate or professional degree (M.A., Ph.D., M.D., etc.) (20)

33. What is the combined, before-taxes income of all members of this household?

____ below $5,000 (00)
____ $5,000 to $10,000 (01)
____ $10,001 to $15,000 (05)
____ $15,001 to $20,000 (15)
____ $20,001 to $25,000 (20)
____ $25,001 to $30,000 (25)
____ $30,001 to $35,000 (30)
____ $35,001 to $40,000 (35)
____ $40,001 to $45,000 (40)
____ $45,001 to $50,000 (45)
____ over $50,001 (specify) ______________________ ( )

Thank you for participating in our survey. If you have any further comments you would like to make about any of the issues mentioned in this questionnaire, please write them below.

APPENDIX B:

MILFORD SURVEY #2

UNIVERSITY OF NEW HAMPSHIRE

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

August 11, 1983

Dear Milford Resident:

Last spring, your household was chosen to take part in a survey concerning water supply problems caused by the contamination of Milford's Savage Well. Your opinions provided valuable information about how important Milford residents felt these problems to be. An article describing some conclusions from this survey will soon be published in the local newspapers.

Milford has now acquired a new water supply (the Curtis well in Amherst), and the immediate crisis seems to have passed. We are contacting you again with a short follow-up survey, attached to this letter. This questionnaire will seek two kinds of information: (1) whether most households did anything different during Milford's water shortage this past summer; and (2) how Milford residents now view the town's water situation and water supply issues in general. This information will help us to understand better community reactions to water emergencies. As you probably know, Milford is by no means the only New Hampshire community to suffer from such emergencies. Lessons from the Milford experience may be of great help elsewhere.

If you have any questions or comments about this survey, please feel free to write or call me at 862-1800. I promise that all survey responses will remain completely confidential. Thank you in advance for your assistance in filling out and returning this questionnaire.

Sincerely,

Lawrence Hamilton

Lawrence Hamilton, Ph.D.
Water Survey Project Director

LH.d

MILFORD WATER SURVEY

PART TWO

A. First, we need a few pieces of background information.

1. The person filling out this questionnaire is:
   _____Male   _____Female

2. How many years have you lived in the town of Milford? _____

3. What is your age? _____

B. The next set of questions concerns things that might have been done in order to use less water.

Below is a list of possible water-saving steps. Please check any steps that your household took during Milford's water shortage this past summer.

4. _____ Watered lawn less often than usual.

5. _____ Watered trees or garden less often than usual.

6. _____ Washed cars less often than usual.

7. _____ Installed water-saving device in toilet.

8. _____ Installed water-saving device in sink or shower head.

9. _____ Took shorter showers or shallower baths.

10. _____ Flushed toilets less often.

11. _____ Ran washing machines or dishwashers only with full load.

12. _____ Kept cold drinking water in refrigerator.

13. _____ Used dishwater to water plants, etc.

14. _____ Other water-saving steps (specify):

____

C. The last set of questions asks how important you think water-related issues are, compared with other local and national issues. Questions 15, 16, and 17 also ask whether your views about water issues changed as a result of Milford's problems.

PLEASE READ CAREFULLY: The questionnaire we sent to you last spring made use of a new survey technique called "magnitude scaling," which asks you to assign numbers expressing how important you think some action is. The questions below are also of this type. You may pick any numbers you like; the higher the number, the greater the importance. If one action is twice as important as another, give it a number twice as high. It could also be ten times or one hundred times as high -- there is no upper limit. If one action is half as important as another, give it a number half as large. If an action has no importance, or you think that action should not be taken, give it a zero.

As a reference, consider the action "conduct routine town business" to have an importance of 20. "Routine town business" refers to such things as decisions about police, fire, and ambulance services, public employee salaries, public works contracts, and zoning decisions. This number for "routine town business" will be used as a comparison for the questions that follow.

20 Importance of "conducting routine town business."

Compared with this value, how important do you now think it is for the town to take actions to protect its water supply?

_____ Importance of "protect town water supply," your opinion now. (15)

Think back to the period before Milford's water problems were discovered. If we had asked you then (say, in the summer of 1982), before the crisis, how important you thought it was to protect the town water supply, what number do you think you would have given? Remember to make this number relative to the importance of "routine town business," given a 20.

_____ Importance of "protect town water supply," your opinion before you learned of recent problems. (16)

If your answers to questions (15) and (16) are not the same, can you explain why you changed your mind? (17)

18. The actions listed below are all likely to be discussed by presidential candidates campaigning in New Hampshire for the 1984 primary elections. Some of these actions deal with protection of water supplies and others are not related to water issues. We would like you to give us some idea of how important you think these actions are, using the same rating system as questions (15) and (16) above. For each action, give an "importance number" showing the importance of that action as compared with "conduct routine town business." Giving "reduce inflation" an importance of 20 would mean it is as important as "conduct routine town business." Giving it a 200 would mean it was ten times more important. Giving "reduce inflation" a zero would mean that it is not important at all -- we should not try to take that action.

Your Importance Number	Actions Discussed by Candidates
20	Conduct Milford's routine town business (for comparison)
____	Clean up existing toxic waste sites
____	Prevent future dumping of toxic wastes
____	Reduce sources of acid rain
____	Fight revolution in Central America
____	Reduce illegal immigration
____	Ratify the Equal Rights Amendment
____	Reduce unemployment
____	Reduce taxes
____	Preserve endangered species of wildlife
____	Protect wilderness areas
____	Other important U.S. actions (specify): ______________________

Thank you for your cooperation. If you have any comments or further opinions, please write them below.

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UNIVERSITY OF NEW HAMPSHIRE
DURHAM, NEW HAMPSHIRE 03824

Department of Sociology and Anthropology
College of Liberal Arts
Horton Social Science Center

September 10, 1983

Dear Water Customer:

Enclosed is a replacement questionnaire and return envelope for the follow-up Milford Water Survey. If you have not already filled out and returned one of these questionnaires, we hope that you will take the time to do so now. In order to reach sound conclusions, we need to hear from as many of the households selected for this study as possible. We are trying to learn about what Milford residents thought and did about the water crisis, and whether it changed the way you view water supply problems in general. Space is provided on the questionnaire for any additional thoughts, explanations or comments you may have.

I apologize for the necessity of this follow-up contact. Your cooperation to date has been greatly appreciated. Results from this survey will be released to local newspapers this fall, including a summary of what you and other Milford residents thought about the water problem.

Thank you,

Lawrence Hamilton

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

Enclosure

LH.d

APPENDIX C:

ACTON SURVEY

UNIVERSITY OF NEW HAMPSHIRE

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

April 26, 1984

Dear Acton Resident,

Since 1978, Acton has experienced problems resulting from organic chemical contamination of underground water supplies. Acton was among the first U.S. communities where such contamination problems were recognized. Unfortunately, today there is a growing list of hundreds of other communities facing similar situations. The patterns of discovery and reaction that Acton went through have been repeated elsewhere, many times over. Lessons from the Acton experience may be helpful in other communities, where such problems are just beginning.

A survey questionnaire concerning Acton's water problems is attached. Your household has been selected at random as one of 400 Acton households to participate in this survey. We hope that you will take the time to fill out this questionnaire and return it in the postage-paid envelope enclosed. <u>The confidentiality of all your responses is assured.</u> Three kinds of questions are asked: background demographic information (Part A); a checklist of water-saving steps (Part B); and your opinions and actions concerning the water problems (Part C).

This survey is part of an ongoing study of community reactions to water emergencies. It is hoped that the results from this research will benefit other communities facing water problems, and help us to learn from Acton's difficulties. The results will also provide information about current public opinion in Acton. We hope you will use this questionnaire to give us <u>your</u> opinions on these issues.

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

Sincerely,

Lawrence C. Hamilton

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

LCH.dn

A. Questions 1-7 ask about background information, needed for statistical purposes only.

1. The person filling out this questionnaire is: male (0) female (1)

2. In what year were you born? ________

3. How many years have you lived in Acton? __________

4. Looking ahead at the next ten years, would you say you are:

   ________ Very likely to move out of Acton (1)

   ________ Somewhat likely to move out of Acton (2)

   ________ Very unlikely to move out of Acton (3)

5. During any time in the past six years, have you had children under 18 living in Acton? ____________

6. Do you presently have children under 18 living in Acton? __________

7. What is your present occupation? __________________

B. Questions 8-27 are a list of possible household water-saving steps. Please check any steps that you or your household have actually taken in response to Acton's water shortage.

In the bathroom:

__________ Installed water-saving device or shower head in shower (8)

__________ Took shorter showers/shallower baths (9)

__________ Didn't leave water running while washing hands, brushing teeth, etc. (10)

__________ Installed water-saving device in toilet tank (11)

__________ Used dye to check for toilet leaks (12)

__________ Flushed toilets less often (13)

In the kitchen-laundry:

_________ Ran dishwasher only when full (14)

_________ When hand-washing dishes, rinsed all at once (15)

_________ Washed vegetables and fruits in a pan of water (16)

_________ Kept cold drinking water in refrigerator (17)

_________ Adjusted water level of washing machine to size of load (18)

_________ Purchased suds-saver attachment to re-use wash water (19)

_________ Purchased washing machine that uses least water per pound of wash (checked consumer ratings) (20)

_________ Re-used dehumidifier water in washing machines, in steam irons, or for watering plants (21)

General water use:

_________ Collected rainwater for watering gardens (22)

_________ Mulched garden to retain moisture (23)

_________ Didn't use water pressure to remove dirt or grease; used brush or cloth instead (24)

_________ Fixed leaking faucets (25)

_________ Reduced water pressure with a regulator valve (26)

_________ Insulated hot water pipes and heater (27)

Do you wish to <u>add any explanation</u> to your answers to 8-27 above?

C. Questions 28-41 ask about your opinions and actions concerning Acton's water problems.

Although Acton's drinking water is now thoroughly filtered, there has been controversy about how to clean up the chemical contamination remaining in the underground water supplies (aquifer). Based on their actions of the past two years, how much do you trust each of the following groups to protect your safety and work towards a reasonable aquifer clean-up plan?

28. Acton Water District

high level of trust (3)	moderate trust (2)	low level of trust (1)	no trust at all (0)

29. Acton Board of Selectmen

high level of trust (3)	moderate trust (2)	low level of trust (1)	no trust at all (0)

30. W. R. Grace & Co.

high level of trust (3)	moderate trust (2)	low level of trust (1)	no trust at all (0)

31. Acton Citizens for Environmental Safety (ACES)

high level of trust (3)	moderate trust (2)	low level of trust (1)	no trust at all (0)

32. The Acton Water District currently requires that drinking water contain less than 1 part per billion of contamination from any single volatile organic chemical, such as vinylidene chloride (VDC) or trichloroethane (TCEa). Acton's standards are much stricter than state or federal standards. Massachusetts, for example, advises limits of 70 parts per billion for VDC, and 140 parts per billion for TCEa. Some people think that Acton's 1 part per billion water standard is too strict; it should be relaxed to be more in keeping with state and federal standards. Other people think Acton's 1 part per billion standard is not strict enough; drinking water should contain 0 parts per billion of chemical contamination. In your own opinion, should Acton's water quality standards be

_________ Made more strict (to 0 parts per billion)

_________ Kept as they are (at 1 part per billion)

_________ Made less strict (e.g., to state advisory limits of 70 parts per billion for VDC, or 140 parts per billion for TCEa)

33. Do you believe that an epidemiological health study should be done, to find out whether the water problems have affected Acton residents' health?

_______ Yes, a study is high priority (3)

_______ Yes, but study is low priority (2)

_______ No, health study unnecessary (1)

34. As a result of the water problems, do people in your household drink bottled water now?

_______ Never (0)

_______ Occasionally (1)

_______ Often (2)

_______ Almost always (3)

Do you wish to add any explanation to your answers to 28-34 above?

Do you or your household subscribe to any of the following newspapers?

_______ The Beacon (35)

_______ Middlesex News (36)

_______ Boston Globe (37)

_______ Other _______________ (38)

39. Have you attended any public meetings (Town meetings, Water District meetings, etc.) concerned with Acton's water problems? _______________

If so, what meetings? ______________________________

40. Are you a member of any organization (such as Sierra Club, league of Women Voters, ACES, etc.) that has been involved in seeking solutions to Acton's water problems? ________

If so, what organizations? ________________________

41. Have you attended meetings of the Acton Citizens for Environmental Safety (ACES)?

________	Never	(0)
________	One to five times	(1)
________	More than five times	(2)

If you became active in Acton's water problems (Questions 39-41), can you briefly explain why?

Do you have any further comments or explanations you would like to make?

UNIVERSITY OF NEW HAMPSHIRE

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

June 4, 1984

Dear Acton Resident:

Enclosed is a replacement questionnaire and return envelope for the Acton Water Survey. If you have not already filled out and returned one of these questionnaires, we hope that you will take the time to do so now. In order to reach sound conclusions, we need to hear from as many of the households selected for this study as possible. Your answers are very important to us. Space is provided on the questionnaire for any additional thoughts or comments you may have.

We apologize for the necessity of these repeated mail contacts, and promise that this one will be the last.

Sincerely,

Lawrence Hamilton

Lawrence Hamilton, Ph.D.
Water Survey Project Director

LH.d

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