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Household Demand For Water And Policies To Encourage Conservation

W. L. Miller
R. L. Clouser

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HOUSEHOLD DEMAND FOR WATER AND POLICIES TO ENCOURAGE CONSERVATION

by

Rodney L. Clouser
William L. Miller

August 1979

PURDUE UNIVERSITY
WATER RESOURCES RESEARCH CENTER
WEST LAFAYETTE, INDIANA
HOUSEHOLD DEMAND FOR WATER AND POLICIES
TO ENCOURAGE CONSERVATION

BY
Rodney L. Clouser
and
William L. Miller

Department of Agricultural Economics
School of Agriculture
Purdue University
W. Lafayette, Indiana 47907

August 1979

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WEST LAFAYETTE, INDIANA
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SUMMARY

Recent droughts in the western portion of the United States have called attention to how water is used by the residential, commercial, industrial, and agricultural sectors. While the Midwest has not been confronted with widespread drought conditions, the research was undertaken to improve demand models previously estimated, and to determine how water is used and can be managed in the residential sector.

The objectives of the research were:

1) To estimate the household's demand for water in rural Indiana communities. The household demand function is postulated to be a function of 1) income, 2) population, and 3) technology (swimming pools, washing machines, dishwashers, and showers).

2) Determine if adopted household technologies are significant explanatory variables for estimating the household's demand.

3) Discuss possible water issues that could arise from increasing the use of present technologies, and new technological developments that would decrease water use.

4) Discuss alternative policies of water management to encourage conservation.

Data to estimate the household demand for water were obtained from a mailed questionnaire sent to two small rural communities. A double-log formulation was chosen to estimate the household demand for water...
in three distinct periods. The first period covered the winter months, the second period included the spring and summer seasons, and the final period included the later summer and fall.

When individual community equations were estimated the following per capita daily increases resulted from the various appliances or technologies: the washing machine increased use by four to 23 gallons, the dishwasher increased use by one to 16 gallons, and watering the lawn or garden increased use by six to 19 gallons. Combined community data yielded similar results. The washing machine increased per capita daily use by seven to 11 gallons, the dishwasher increased use by four to nine gallons, watering lawns or gardens increased use by nine to 12 gallons, and filling swimming or wading pools increased use by three gallons.

The analysis indicated that 1) household activities are significant explanatory variables in determining household water use, 2) water use varies considerably among the three seasonal periods, and 3) combining community data did not result in a major change in estimated water consumption.

Subsidizing water saving devices and regulation (building codes) are two policy tools that appear to have the greatest potential to reduce water use. It was determined that a simple subsidy program in one community studied could be implemented for less than $2,000. Individual homes would save approximately $41/year, and total community water use would be reduced by 7.4 million gallons. This reduction in water use might not solve the entire supply problem in the community. However, it would result in a substantial reduction and would be considerably less expensive than the projected cost of approximately $1 million for drilling a new well.
Regulation can be effective as a policy tool, since water saving appliances for sale in the market have prices comparable to conventional appliances. In order for regulation (building codes) to be effective, attitudes of individuals may require altering, and water customers must be encouraged to reduce use.
CHAPTER I

INTRODUCTION

Traditionally, water has been managed as a plentiful resource with an infinite supply to meet all demands. Adequate annual rainfalls, ample surface water, and new technologies in drilling have led to this false conclusion. Over the past few years, the public has become aware that it is not always possible to obtain as much water as desired. Problems with water quality and droughts are creating the greatest concern.

Degradable and nondegradable pollutants are the main factors affecting water quality. Sewage is the most common degradable pollutant and may not be detrimental to future water quality if not found in high concentrations. Common nondegradable pollutants include radiological, organic (2, 4-D, etc.), and suspended (sediment) materials. It has been estimated that as many as 18 million people served by wells may be using contaminated water. Droughts such as those experienced in the West (California) have also caused state officials, planners, government decision makers, engineers, and economists to re-evaluate past and future water policy.

Since the demand for high quality water has increased, economic tools of analysis are becoming essential in evaluating water policy. The pressure of increasing demand on relatively fixed supplies requires that water be valued and allocated. Both allocation and valuation are basic functions of economics.

A limited number of water demand studies have been conducted. The majority of these studies are concerned with determining the price elasticity of demand. Demand is normally postulated to be function of price, income,
and population. Rarely was any consideration given to potential demand shifters other than population and income.

The concept of technology as a potential demand shifter is mentioned by some scholars. William Butcher believes that "we can try to make the per capita use of water go down by better designs that are less water consumptive..."1/ Cosgrove and Hushak [19] comment that "water use per capita is increasing due to the increasing utilization of water using devices in the home..."2/ In a study completed by Waelti and Gardner [40] technology is mentioned as a potential water demand shifter.

In the past 25 years several appliances which are water-intensive have been purchased by households. A few of these items are washing machines, dishwashers, water heaters (tendency to use more hot water), and complete indoor plumbing. There are also a limited number of technological innovations which have the potential to reduce household water use. A brief shower uses less water than bathing, and chemical bathroom toilets are now available for use. However, few demand studies incorporate these technologies in household estimation techniques.

Technological innovations which increase or decrease the household's demand for water will continue to be developed and adopted. Adoption by the household will occur because of affluence, convenience, and


household labor savings. As long as household members, especially women, are able to attract substantial wages in the labor market, it is to their benefit to conserve time spent doing household chores (because the opportunity cost of their labor time is high).

Indiana has not been confronted with the serious water problems that have plagued other states. Communities within the state may be able to avoid serious water crises by eliminating unnecessary water usage or by projecting possible future changes in water consumption patterns. Accomplishment of this objective can only be fulfilled by determining relevant explanatory variables that affect water demand.

Therefore, the objectives of this study are:

1) To estimate the household’s demand for water in rural Indiana communities. The household demand function is postulated to be a function of 1) income, 2) population, and 3) technology (swimming pools, washing machines, dishwashers, and showers).

2) Determine if adopted household technologies are significant explanatory variables for estimating the household’s demand.

3) Discuss possible water issues that could arise from increasing the use of present technologies, and new technological developments that would decrease water use.

4) Discuss alternative policies of water management to encourage conservation.

This research differs from previous studies since primary household data (including information from water companies) will be collected and the seasonality of household water use will be incorporated into the
estimation. Pope, et al., [37] suggests improvements in water research can be accomplished by collecting monthly data. Gruenwald, et al., recommends that improvements in estimation can be attained by collecting individual household data and estimating separate demand functions (e.g., industrial, commercial, and residential).

A new household economic approach will be used to estimate the demand for water. Approximately five percent of all water used within the household is for human consumption. The remaining ninety-five percent of water used within the household is used as an input in household production processes (see Table 1.1). The household production process includes needs for personal hygiene, washing clothes, cleaning, etc. The environment in which the production takes place (e.g., dishwashers versus hand washing) will be accounted for within the household. The "knowledge" of a household with regard to water saving devices, and the impact of this knowledge on household water use will be incorporated into the estimation.

Table 1.1 Domestic Water Use, Great Lakes Basin.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percent of Water Use by Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flushing bathroom stool</td>
<td>41</td>
</tr>
<tr>
<td>Washing and bathing</td>
<td>37</td>
</tr>
<tr>
<td>Kitchen use</td>
<td>6</td>
</tr>
<tr>
<td>Drinking</td>
<td>5</td>
</tr>
<tr>
<td>Washing clothes</td>
<td>4</td>
</tr>
<tr>
<td>Cleaning</td>
<td>3</td>
</tr>
<tr>
<td>Lawn watering</td>
<td>3</td>
</tr>
<tr>
<td>Washing auto</td>
<td>1</td>
</tr>
</tbody>
</table>

CHAPTER II

Literature Review

A limited number of demand studies were conducted prior to the 1970's. The majority of these studies were concerned with determining the price elasticity of demand. Rarely was any consideration given to water intensive appliances or activities that increased household water use.

A review of literature reveals that demand studies for water were first published in the middle 1920's. The earliest studies were supervised by engineers, and economists did not begin to publish material on water demand until the 1950's. A number of the articles focusing on water demand and price elasticity of water will be reviewed.

Carey and Haan [17] offer an explanation of why more water demand studies have not been undertaken. They suspect the demand side lacked emphasis "due in part to the relative abundance of water and the general notion that water is a necessity of life and must be supplied at any cost."1/ Other individuals argue that water demand studies are limited because only a small amount of water data is available.

In 1958 Louis Fourt presented a paper concerned with the problem of forecasting domestic water demand. He estimated a linear demand function for small cities, large cities, and a combined equation. Fourt determined price elasticity was -.4 at the mean. The model developed by Fourt was annual, and significant explanatory variables were price and the number of days of rainfall in June, July, and August.

---

Gardner and Schick studied the demand for water in northern Utah counties. They estimated demand with linear and linear logarithmic equations. Variables considered in both models were price of water, per capita median income, per capita value of homes, per capita lot area, percentage of homes with complete plumbing, average precipitation for the months of May through October, and average maximum daily temperatures for May through October. Significant explanatory variables were price, per capita lot area, and percentage of homes with complete plumbing. The percentage of homes with complete plumbing was highly correlated with per capita lot size and was eliminated from the model.

Grunewald, et al., [22] completed a study on water demand in Kentucky (1975). A linear demand, log-linear demand, and power type demand function were estimated. Price was a significant explanatory variable at the .01 level in all of the models. Evaporation in inches from June through September was significant at the .01 level in the log-linear model.

Howe and Lineweaver conducted one of the most detailed and exhaustive studies of residential water use. The study was completed at Johns Hopkins University over a five-year period (1961-1966). Howe and Lineweaver compared meter readings during the winter months and summer days. They concluded that there was no difference between winter and summer in house use. By subtracting winter daily use from summer daily use they obtained an approximation of water used outside the home (lawn sprinkling).
In 1972 Wong studied residential water demand in northeastern Illinois. The study was divided into a time series and cross-sectional analysis. A multiplicative form was used to represent the demand function. Explanatory variables included in the study were price per unit, average household income, and average summer temperature. Income and average summer temperature were determined to be significant explanatory variables. Price was significant at the 5 percent level outside the Chicago area.

A recently completed Virginia study [6] estimated that an average single family home (four people) uses 88,000 gallons of water per year. This amounts to 240 gallons daily. The study concluded that the bathroom toilet probably accounts for the greatest water waste. Every time the bathroom toilet is flushed it requires 3 to 6 gallons of water. The toilet is wasteful because it is often used to flush facial tissue and non-human waste items.

Rural water use budgets were developed for the Great Lakes Basin Framework Study [9] which indicates water consumption will continue to increase over time. Projected water uses for the next 40 years are presented in Table 2.2.

Pope, Stepp, and Lytle [36] terminated a time series analysis on price elasticity of water in 1975. The authors mentioned that "existing appliances and lawn size, for example, may influence water consumption in the short run". Variables included in the study were number and age of persons in the household, occupation, ownership of pool, frequency of washing the auto, number of bathrooms in the dwelling, lawn or garden sprinkling, ownership of washing machine, ownership of dishwasher, level

---

Table 2.2. Projected Water Use for the Great Lakes Basin, 1980-2020.

<table>
<thead>
<tr>
<th>Water Use</th>
<th>1980</th>
<th>2000</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family (1 person)</td>
<td>65(^a/)</td>
<td>70</td>
<td>75</td>
</tr>
<tr>
<td>Car</td>
<td>200(^b/)</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Lawn</td>
<td>300(^c/)</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Pool</td>
<td>16,030(^d/)</td>
<td>30,000</td>
<td>30,000</td>
</tr>
</tbody>
</table>

\(^a/\) gallons per day per person  
\(^b/\) gallons per year per household  
\(^c/\) gallons per hour watered per household  
\(^d/\) gallons per year for each household with a pool during 1980, 2000, and 2020 assuming for those years 1 pool/100 families, 1 pool/60 families, 1 pool/40 families, respectively.


of family income, and summer precipitation deficit. The number of persons in the household, the number of bathrooms, lawn or garden sprinkling, ownership of washing machine and dishwasher, and level of family income were all significant explanatory variables at the .01 level. The study later concluded that "as more labor saving devices (which use water) are owned by a city's population, the demand for water will increase".\(^3/\) The main objective of the annual model was to determine the price elasticity for water

\(^3/\) Ibid., p. 83.
using time series data. Throughout the publication the authors alluded that technological development could affect the demand for water. However, they failed to pursue this option.

Batchelor published results of a study concerned with household technology and the demand for water in 1975. Batchelor developed his model by using the conceptual framework presented by Lancaster in 1966. He claims the household demand for water arises mainly for sanitation purposes (e.g., bathing, dishwashing, clothes washing, and removal of human waste).

Batchelor assumes that the household is the decision unit and all the above-mentioned sanitary activities are mutually independent. He postulates that the frequency of these activities will increase with the size of the household which can be measured by the number of household occupants and their wealth.

Data collected by Batchelor included 1) the total household consumption of water in 1968, 2) the number of occupants in the household, 3) the net annual value of property, 4) the age of the home, 5) whether the household possessed indoor plumbing, 6) if there was a garden, and 7) the number and types of washing machines, car washes, dishwashers, showers, and garden sprinklers. Batchelor concluded that household appliances would increase the demand for water at different levels of wealth.
CHAPTER III

This chapter includes three major sections. The variables which are used in the empirical model are described and measurement problems related to these variables are discussed. Then the empirical model used in the research is specified. The last section presented is the characteristics of the communities which provide the data base for the model.

Model Variables

Boehm (13) noted the theoretical model is not necessarily the correct model because "previous research...must be utilized fully to determine which variables should be included in the specific measurement attempt and how, or in what form, they should be measured and introduced." 1/ Hicks (26) also stated that data availability and manpower should be considered in addition to the concepts developed by economic theory.

Variables discussed in this chapter include income, population, household facilities (showers, bathroom toilets, bathtub), and water using appliances owned by the household (washing machines, dishwashers, swimming pools, and lawn sprinklers).

Income

Income is postulated to effect the quantity of water used by the

household. It is frequently assumed that households with high volume water use are synonymous with high income households. This assumes that water complementary devices (washing machines, dishwashers, etc.) are dependent upon the level of household income. Grunwald [23] proposes that the ownership of these items may identify households that will not be responsive to price changes. After spending several hundred dollars of the family budget on these appliances, a small increase in water prices may have little or no effect on the amount of water used.

After tax, net, or disposable income actually represents the amount of money the household has available to purchase goods, if savings are ignored. Income is normally expected to have a positive effect on the amount of water used by consumers.

Family Size

Population is known to act as a demand shifter, and the same result can be expected in water demand analysis. This study will focus on the micro unit of a household, and population will be replaced in the estimation procedure by family size. A larger family unit is expected to require more water for personal hygiene needs. However, no more water should be required for appliances like the washing machine and the dishwasher unless they are already used at full capacity. The number of family members is expected to have a positive effect on the amount of water used by the household.

Water Intensive Activities

Several other items are postulated to have a positive effect on the amount of water used by rural households. These variables include
certain rooms within the home as well as appliances owned by households. The bathroom represents the most intensive room in the household in terms of water use. Muller[38] estimated that a typical family of four would use 73 percent of all water required by the household in the bathroom. Appliances or other household activities that require water include the clothes washer, dishwasher, lawn sprinkler, and swimming or wading pools.

The bathroom contains many fixtures which require extensive amounts of water. It is obvious that households with complete bathrooms should use more water than homes without the fixtures. A more pertinent question is: Do additional bathrooms increase household water use or redistribute use among the various bathrooms? If an additional bath is constructed a considerable distance from the hot water source, water use could be expected to increase because water will be allowed to run longer to reach the desirable temperature. Adding bathrooms might encourage some families to install larger water heaters which could induce family members to remain in the tub and shower longer. It is postulated that the sign of the coefficient on the number of baths in the household will be positive.

Appliances or technologies to be included in this study are washing machines, dishwashers, lawn or garden watering, and swimming or wading pools. All these appliances are anticipated to have a positive effect on the amount of water used by rural households.

Technologies can be geographic specific and may not be useful explanatory variables in all locations. This may be true of lawn or garden watering and swimming or wading pools in Indiana. If
the climate is cool swimming pools may not be purchased, and if rain-
fall is abundant laws or gardens will not require watering. Indiana's
climate is cool during the winter, and warm with high humidity during
the summer. The Great Lakes Study referred to in Chapter I estimated
that by 2000 A.D. there would be a swimming pool for every 40 house-
holds. The southern two-thirds of Indiana is outside the Great Lakes
Basin area and was not included in the estimate. However, it is not
unrealistic to assume that the portion of Indiana excluded from the
Great Lakes Study is similar to the included area. The importance
of pools and lawn watering in explaining water use in rural Indiana
communities remains unknown.

Substitutes

Water represents an unusual case with respect to the possibility
of close substitutes. For several household uses there are not poten-
tial substitutes for water (especially bathing and other personal
hygiene needs). Bottled water represents one substitute available
in many local supermarkets or drugstores. However, the cost of bottled
water prohibits extensive use of this alternative by the household
(in Lafayette, Indiana, the price exceeds $1.00 per gallon in super-
markets and drugstores). This alternative represents an increase in
cost to the household which is considerably above the normal rate
they would pay to purchase water from a municipal utility company.

Assuming that households have no alternative for using water
within the home is also a naive approach. Many communities have
laundry facilities available where washing machines are supplied,
and water is purchased by the commercial laundry (these commercial industries may have lower water rates). Municipal swimming pools are also available in some communities and can be used by household members for summer recreation. These two examples represent a restricted means of substituting outside activities for water used by the household.

A major problem is encountered when attempting to incorporate potential water substitutes in demand analysis. Assume that residential and commercial water users are required to pay identical rates. Even with this simplified assumption, the cost to the consumer for doing laundry at home versus a commercial establishment is not identical. Additional costs such as transportation to the facility, the value of the individual's time, and covering the fixed and variable expenses of the establishment, are encountered by the consumer. Determination of the proper value of time, transportation, etc., represents a tedious data collection problem. Therefore, these substitution alternatives for the household will not be included in the model.

**Seasonality of Water Use**

The use of water throughout the year is subject to fluctuations in climate and temperature. The amount of water necessary for personal hygiene (baths, showers) could decrease during the winter months because people are constrained to less physical activity and more indoor recreation. Similar fluctuations could occur during the summer months when lawns and gardens require watering, more strenuous physical activity increases the amount of water used for personal hygiene, and children are home from school. It is not unusual for children to spend
a considerable amount of time in small wading pools during the summer months. A small rectangular pool two feet deep, eight feet wide and six feet long requires over 700 gallons to be filled. Water usually is not allowed to remain in these pools for sanitary reasons, and daily filling requires a substantial amount of water.

This information implies that water demand studies should account for seasonal factors which affect water use. For the purpose of this study the annual demand for water was divided into three seasonal periods. December, January, February and March represent the winter period when temperatures can drop very low (into the minus twenties). April, May, June and July comprise the summer period. The average temperature increases each month during this period, and by late July the mercury has reached the 90 degree mark several times. During this period of the year individuals water lawns and gardens to insure proper growth. The fall period includes August, September, October, and November. The temperature is still quite warm in August and declines over the remainder of the months. More complete information on weather conditions at one location in Indiana in 1977 is provided in Table 3.1.
Table 3.1. Temperature and Precipitation for West Lafayette, Indiana, 1977.

<table>
<thead>
<tr>
<th></th>
<th>Average Temperature&lt;sup&gt;a/&lt;/sup&gt;</th>
<th>Precipitation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Snow/Sleet&lt;sup&gt;b/&lt;/sup&gt;</td>
<td>Total&lt;sup&gt;c/&lt;/sup&gt;</td>
</tr>
<tr>
<td>January</td>
<td>8.9</td>
<td>9.9</td>
<td>.81</td>
</tr>
<tr>
<td>February</td>
<td>27.2</td>
<td>3.8</td>
<td>1.12</td>
</tr>
<tr>
<td>March</td>
<td>44.5</td>
<td>2.0</td>
<td>4.34</td>
</tr>
<tr>
<td>April</td>
<td>55.6</td>
<td>Td&lt;sup&gt;d/&lt;/sup&gt;</td>
<td>1.61</td>
</tr>
<tr>
<td>May</td>
<td>69.7</td>
<td>0</td>
<td>2.31</td>
</tr>
<tr>
<td>June</td>
<td>69.5</td>
<td>0</td>
<td>2.30</td>
</tr>
<tr>
<td>July</td>
<td>77.8</td>
<td>0</td>
<td>1.87</td>
</tr>
<tr>
<td>August</td>
<td>71.6</td>
<td>0</td>
<td>10.45</td>
</tr>
<tr>
<td>September</td>
<td>67.0</td>
<td>0</td>
<td>4.94</td>
</tr>
<tr>
<td>October</td>
<td>51.0</td>
<td>0</td>
<td>2.11</td>
</tr>
<tr>
<td>November</td>
<td>43.5</td>
<td>2.0</td>
<td>1.83</td>
</tr>
<tr>
<td>December</td>
<td>26.7</td>
<td>17.1</td>
<td>2.17</td>
</tr>
</tbody>
</table>

<sup>a/</sup> Farenheit.

<sup>b/</sup> Inches

<sup>c/</sup> Inches (liquid)

<sup>d/</sup> T = trace, an amount too small to measure.

Source: Climatological Data Indiana, Volume 82, No. 1-12, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Ashville, North Carolina.
The Complete Model

Model Specification

The economic model for the winter period (January, February, March, and December) is:

(1) \( WD_1 = f( FSi_1, NBi_1, K_i_1, Y_i_1, A_i_1 ) \)

where:

- \( FSi_1 \) = family size (the number of people residing in the household) of household \( i \) during period 1,
- \( NBi_1 \) = the number of bathrooms in household \( i \) during period 1,
- \( K_i_1 \) = household knowledge of water saving appliances,
- \( Y_i_1 \) = total net income of household \( i \) during period 1,
- \( A_i_1 \) = appliances owned by household \( i \) during period 1.

The model for period two (April, May, June, and July) is

(2) \( WD_2 = f( FSi_2, NBi_2, K_i_2, Y_i_2, A_i_2 ) \)

where:

all variables retain the same definitions, except that consideration will be given to various household technologies that would be used during the summer period.

The model for the third period is identical to the second period and all variables retain the same definitions.

(3) \( WD_3 = f( FSi_3, NBi_3, K_i_3, Y_i_3, A_i_3 ) \).
Community Characteristics

A brief description of pertinent water facts for both communities will be provided. To insure the confidentiality of the communities, public officials, and individuals in the study, no names or references will be provided. Both communities participating in the study were concerned with various water problems during 1977 and both had engineering reports prepared for them in early 1978. These reports attempted to identify water problems, develop suggestions to eliminate the problems, and estimate the cost of implementing the engineering suggestions. Both communities are located in rural areas and are within a 30 minute drive of a larger urban population. Town officials in both communities indicated that the majority of those employed work outside of the community where they reside because of limited employment opportunities. The majority of households in both communities were classified as middle class ($12,000 to $15,000) by those interviewed, and each community had a considerable number of elderly residents (one official estimated that one-third of all households were widowed individuals or elderly couples). Weather patterns for the communities should be similar to the statistics presented for West Lafayette, Indiana (Table 3.1), since both are located in the central region of Indiana.

Community A Water Data

Community A has contracted for two engineering studies in the last five years. The original report was concerned with 1) source of supply, 2) treatment facilities, 3) storage facilities, and 4) distribution system. Supply and treatment facilities were upgraded in 1976 as suggested by the engineering report. This upgrading took place exactly 50 years after water service was initiated by the community.
The community replaced two well pumps with turbine pumps capable of pumping 300 gpm (gallons per minute). The water distribution system consists of over 85,000 feet of two through eight inch diameter water mains. In 1977 water was stored for distribution in a 60,000 gallon elevated water tower. The water tower was part of the original water system, and had been serviced twice (painting, cleaning, and structural repair) in the 50 year period.

Over a five year period, Community A established that the water utility company experienced 1) a 24 percent increase in the number of water users (commercial and residential), 2) a 25 percent increase in the amount of water purchased (from over 38,000,000 to 48,000,000 gallons), 3) a 60 percent increase in the amount of water pumped daily (162,400 to 260,000 gallons), 4) an increase in revenues by 119 percent (attributed to an increase in water prices of 100 percent), and 5) an increase in expenses of 55 percent. Additional water facts for Community A in 1976 and 1977 are presented in Table 3.2.
Table 3.2. Water Data Information, Community A, 1976 and 1977.

<table>
<thead>
<tr>
<th></th>
<th>1976 a/</th>
<th>1977 b/</th>
<th>Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of water users</td>
<td>675</td>
<td>697</td>
<td>3.1</td>
</tr>
<tr>
<td>Total water purchases</td>
<td>43,432,000</td>
<td>48,140,000</td>
<td>9.7</td>
</tr>
<tr>
<td>Total water pumped</td>
<td>76,153,000</td>
<td>94,889,000</td>
<td>19.7</td>
</tr>
<tr>
<td>Average amount pumped/ day</td>
<td>208,600</td>
<td>260,000</td>
<td>19.7</td>
</tr>
<tr>
<td>Water pumped in minimum month</td>
<td>5,515,000</td>
<td>6,569,000</td>
<td>16.0</td>
</tr>
<tr>
<td>Minimum month</td>
<td>February</td>
<td>February</td>
<td>--</td>
</tr>
<tr>
<td>Water pumped in maximum month</td>
<td>6,971,000</td>
<td>8,701,000</td>
<td>19.8</td>
</tr>
<tr>
<td>Maximum month</td>
<td>July</td>
<td>May</td>
<td>--</td>
</tr>
</tbody>
</table>

a/ Water use in gallons.

b/ Water use in gallons.

Community A charges the following rates for water use:

Table 3.3. User Charges, Community A, 1977.

<table>
<thead>
<tr>
<th>Usage a/</th>
<th>Charge b/</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 3333</td>
<td>$1.00</td>
</tr>
<tr>
<td>Next 4667</td>
<td>.90</td>
</tr>
<tr>
<td>Next 8000</td>
<td>.80</td>
</tr>
<tr>
<td>Next 17,000</td>
<td>.60</td>
</tr>
<tr>
<td>Next 26,000</td>
<td>.50</td>
</tr>
<tr>
<td>Over 59,000</td>
<td>.40</td>
</tr>
</tbody>
</table>

a/ Gallons per month.

b/ Charge per 1,000 gallons used.
Table 3.3 illustrates that Community A charges its customers according to the declining block rate structure. It is also obvious from Table 3.2 that the water company is confronted with some type of leakage problem since 30,000,000 more gallons of water was pumped than purchased by water users. The engineering study concluded that a 250,000 gallon water storage tower would eliminate future problems created by increased demand and growth. No consideration was given to decreasing demand rather than increasing supply.

Community B Water Data

Community B contracted for its engineering study because it was concerned about a shortage of clean water supply. Four wells were in operation for Community B in 1977: an emergency well, a well used to flush mains in the water system, an alternative main well, and the main well. Community B has a population of over 1,000 and services over 540 metered customers. The water company pumps an average of 135,000 gallons per day or 94 gallons per minute. During the peak demand period 294,000 gallons per day or 142 gallons per minute were pumped. In 1977 Community B had its largest monthly use in January when 4,718,000 gallons were pumped and the minimum monthly pumpage was May when 1,918,000 gallons were required. Weather conditions probably created this pattern (i.e., when the temperature is low, individuals may leave water running to prevent pipes from freezing).

The water use charge of Community B is much more complicated than the rates used by Community A. The different rate structure between the two communities is created because Community B includes
a sewage charge in the total water bill. Water rate charges for Community B appear in Table 3.4.

Table 3.4. Water Use Charges, Community B, 1977

<table>
<thead>
<tr>
<th>Gallons b/</th>
<th>Minimum charge for water = $3.00</th>
<th>Rate b/</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3,000</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>Next 2,500</td>
<td></td>
<td>.50</td>
</tr>
<tr>
<td>Over 5,500</td>
<td></td>
<td>.40</td>
</tr>
</tbody>
</table>

a/ Gallons per month.

b/ Charge per 1,000 gallons used.

However, this does not represent the total water bill paid by the household. The sewage charge paid by households in Community B is directly linked to the amount of water used by the household. Sample water and sewage charges for selected use levels are presented in Table 3.5. Also, Tables 3.4 and 3.5 confirm that Community B uses the declining block rate structure to calculate water charges. This is true even though the sewage charge is always greater than the water charge, and increases at a faster rate than water charges for each additional block purchased. The engineering study concluded that the community problem was not one of decreasing supply, but of increasing demand. Once again no feasible alternative for influencing the rate of increase in demand was mentioned in the engineering report.
Table 3.5. Water and Sewage Charges, Community B, 1977.

<table>
<thead>
<tr>
<th>Gallons</th>
<th>Water</th>
<th>Sales Tax</th>
<th>Sewage</th>
<th>Total Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>$ 3.00</td>
<td>$.12</td>
<td>$ 4.00</td>
<td>$ 7.12</td>
</tr>
<tr>
<td>2,000</td>
<td>3.00</td>
<td>.12</td>
<td>4.00</td>
<td>7.12</td>
</tr>
<tr>
<td>3,000</td>
<td>3.00</td>
<td>.12</td>
<td>5.68</td>
<td>8.80</td>
</tr>
<tr>
<td>4,000</td>
<td>3.50</td>
<td>.14</td>
<td>7.36</td>
<td>11.00</td>
</tr>
<tr>
<td>5,000</td>
<td>4.00</td>
<td>.16</td>
<td>9.04</td>
<td>13.20</td>
</tr>
<tr>
<td>6,000</td>
<td>4.45</td>
<td>.18</td>
<td>10.72</td>
<td>15.35</td>
</tr>
<tr>
<td>7,000</td>
<td>4.85</td>
<td>.19</td>
<td>12.40</td>
<td>17.44</td>
</tr>
<tr>
<td>8,000</td>
<td>5.25</td>
<td>.21</td>
<td>14.08</td>
<td>19.54</td>
</tr>
<tr>
<td>9,000</td>
<td>5.65</td>
<td>.23</td>
<td>15.76</td>
<td>21.64</td>
</tr>
<tr>
<td>10,000</td>
<td>6.05</td>
<td>.24</td>
<td>17.44</td>
<td>23.73</td>
</tr>
<tr>
<td>15,000</td>
<td>8.05</td>
<td>.32</td>
<td>24.44</td>
<td>32.61</td>
</tr>
<tr>
<td>20,000</td>
<td>10.05</td>
<td>.40</td>
<td>31.04</td>
<td>41.49</td>
</tr>
<tr>
<td>25,000</td>
<td>12.05</td>
<td>.48</td>
<td>37.84</td>
<td>50.37</td>
</tr>
<tr>
<td>30,000</td>
<td>14.05</td>
<td>.56</td>
<td>44.64</td>
<td>59.25</td>
</tr>
<tr>
<td>35,000</td>
<td>16.05</td>
<td>.64</td>
<td>49.84</td>
<td>66.53</td>
</tr>
<tr>
<td>50,000</td>
<td>20.00</td>
<td>.80</td>
<td>65.44</td>
<td>85.44</td>
</tr>
<tr>
<td>60,000</td>
<td>26.05</td>
<td>1.04</td>
<td>75.84</td>
<td>101.89</td>
</tr>
</tbody>
</table>

A more detailed breakdown of daily and monthly water use in Community B appears in Table 3.6.

Table 3.6. Water Data Information, Community B, 1975 and 1977.

<table>
<thead>
<tr>
<th></th>
<th>1975</th>
<th>1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Served</td>
<td>1,174</td>
<td>1,220</td>
</tr>
<tr>
<td>Maximum Month of Water Pumpage</td>
<td>July</td>
<td>January</td>
</tr>
<tr>
<td>Maximum Water Pumpage in Million Gallons</td>
<td>5.5</td>
<td>4.718</td>
</tr>
<tr>
<td>Minimum Month of Water Pumpage</td>
<td>March</td>
<td>May</td>
</tr>
<tr>
<td>Minimum Water Pumpage in Million Gallons</td>
<td>3.209</td>
<td>1.918</td>
</tr>
<tr>
<td>Peak Daily Demand</td>
<td>--</td>
<td>200,000 gal.</td>
</tr>
<tr>
<td>Minimum Daily Demand</td>
<td></td>
<td>83,000 gal.</td>
</tr>
</tbody>
</table>
In summarizing this discussion of the participating communities, it should be noted that 1) the communities are similar in size and have a comparable number of users, 2) Community A pumped about 60 percent more water, some of which can be accounted for by leakage, 3) Community B has a base total water bill double that of Community A because of a sewage charge, and 4) the maximum month of usage occurs during the summer in Community A and during the winter in Community B in the periods explored.
CHAPTER IV

ANALYSIS

This chapter has three major sections: section one specifies the double-log functional form of estimation; section two provides a detailed analysis of Community A for three periods using the double-log functional form, and the third section contains estimates for combined data for communities A and B.

Data for this research were obtained from a questionnaire mailed to two communities. A random sample of 406 individual households in Community A (225) and Community B (181) received the first mailing of the questionnaire. One hundred and twenty-six households responded to the first mailing; only 280 questionnaires were sent in the second mailing to both communities. A total of 231 questionnaires were returned after the completion of both mailings. One hundred and thirty-four of these questionnaires were from Community A, (this represented a response rate of 60 percent) and the remaining 97 were from Community B (a response rate of 54 percent).

Data collected by the questionnaire were: 1) ownership or rental of the home, 2) size of the swimming or wading pool, 3) frequency of bathing, washing, dishwashing, and lawn watering, 4)
the period in which the household experienced its largest water bill, 5) water practices and water saving techniques used frequently, 6) familiarity with appliances that could possibly reduce the amount of water used by the household, and 7) opinions about how the household would react to a water shortage. A copy of the mailed questionnaire is presented in the appendix.

**Model Formulation**

**Period One**

In the first period it is postulated that the demand for water is dependent upon the washer, dishwasher, family size, the number of bathrooms, knowledge, and income. The dishwasher and washing machine are incorporated into the model as dummy variables (0,1; or vanish, one variables).

The double log model for period one is:

(1) \[ \ln QWD = \alpha + W + DW - K + \beta_1 \ln FS + \beta_2 \ln NB + \beta_3 \ln Y \]

where:

- \( QWD \) = total water use by the household during the first period
- \( W \) = washing machine, 0 = no, 1 = yes,
- \( DW \) = dishwasher used by the household, 0 = no, 1 = yes, and all variables previously defined retain their same definitions.

If a household had no appliances (i.e., the dummy variables would be 0, \( W = 0, DW = 0 \)), the equation would appear as:

\[ \ln QWD = \alpha - K + \beta_1 \ln FS + \beta_2 \ln NB + \beta_3 \ln Y \]

if \( (W=1, DW=0) \); the household has a washing machine

\[ \ln QWD = \alpha + W - K + \beta_1 \ln FS + \beta_2 \ln NB + \beta_3 \ln Y \]

if \( (W=0, DW=1) \); the household has a dishwasher

\[ \ln QWD = \alpha + DW - K + \beta_1 \ln FS + \beta_2 \ln NB + \beta_3 \ln Y \]

and if \( (W=1, DW=1) \), both activities present) the equation is identical with equation one.

**Period Two**

Household water demand for period two was expected to be dependent
upon the washer, dishwasher, swimming or wading pool, lawn watering, family size, the number of bathrooms, knowledge and income.

The complete model for period two is:

\[
\ln QWD = \alpha + W + DW + SP + WL - K + \beta_1 \ln FS \\
+ \beta_2 \ln NB + \beta_3 \ln Y
\]

where:

The variables retain their previous definitions, and

SP = (dummy variable) if swimming pool is filled, 0 = no, 1 = yes,
WL = (dummy variable) if lawn is watered, 0 = no, 1 = yes.

If the household has neither appliance, it does not fill a pool, and the lawn is not watered (W = 0, DW = 0, SP = 0, WL = 0) the equation becomes:

\[
\ln \hat{QWD} = \alpha - K + \beta_1 \ln FS + \beta_2 \ln NB + \beta_3 \ln Y
\]

if (W=1, DW=0, SP=0, WL=0)

\[
\ln \hat{QWD} = \alpha + W - K + \beta_1 \ln FS + \beta_2 \ln NB \\
+ \beta_3 \ln Y
\]

if (W=0, DW=1, SP=0, WL=0)

\[
\ln \hat{QWD} = \alpha + DW - K + \beta_1 \ln FS + \beta_2 \ln NB \\
+ \beta_3 \ln Y
\]

if (W=0, DW=0, SP=1, WL=0)

\[
\ln \hat{QWD} = \alpha + SP - K + \beta_1 \ln FS + \beta_2 \ln NB \\
+ \beta_3 \ln Y
\]
if \( W = 0, \text{DW}=0, \text{SP}=0, \text{WL}=1 \)

\[
\ln QWD = \alpha + WL - K + \beta_1 \ln FS + \beta_2 \ln NB \\
+ \beta_3 \ln Y
\]

and if all activities are present in the household the equation is identical to equation two.

**Period Three**

The model for period three is identical to the second period model, except the swimming pool variable has been omitted. This conclusion was reached after reviewing the questionnaires and determining that only a very small proportion of people filled pools during this period.

The equation to be estimated for period three is:

\[
(3) \quad \ln QWD = \alpha + W + \text{DW} + WL - K + \beta_1 \ln FS + \beta_2 \ln NB \\
+ \beta_3 \ln Y,
\]

and potential variable combinations are identical to the second period excluding the swimming pool.

**All Periods**

It should be apparent that there are many more model combinations than those discussed in the previous section. Several alternative combinations can be developed for each period (e.g., the combination of washer, dishwasher, and lawn watering could be explored in period two rather than the various alternatives discussed), but those discussed in the previous section will be the only combinations evaluated. All variables have been previously defined and will retain those previous
definitions. All variables will be tested at the 10 percent, 5 percent, and 1 percent level of significance. The t tests will be used to determine the significant variables, and one-sided hypothesis tests will be conducted on all variables. Two-tailed tests are not used because of theoretical foundations (e.g., appliances should increase water use).

The estimated equation in Community A for period one is

\[
\ln \hat{QWD} = 1.85 + 0.18 W + 0.12 DW + 0.02 K + 0.55 \ln FS + 0.16 \ln NB \\
(0.13) (0.12) (0.08) (0.02) (0.07) (0.10)
+ 0.04 \ln Y \\
(0.05)
\]

\[R^2 = 0.56.\]

Variables significant at the 10 percent level were the washing machine, dishwasher, family size, and the number of bathrooms. Family size and the number of bathrooms remained significant at the 5 percent level, but only family size is significant at the 1 percent level. The signs on all coefficients were positive.

The model indicated that a household with no appliances would use 11,759 gallons over the four month period. This represents a monthly use of 2,939 gallons, or a per capita daily consumption of 39 gallons. Households with a washing machine would require 14,111 gallons for the entire period, 3,528 gallons per month, 118 gallons per day, or 47 gallons/capita/day. The washing machine would increase per capita daily consumption by 8 gallons. Households using a dishwasher require 44 gallons/capita/day, which represents an increase of 5 gallons/capita/day compared to the no appliance case. Includ-
ing both activities would increase period use to 15,945 gallons.
This increases per capita daily consumption to 53 gallons, and repres-
sents an increase of 14 gallons/capita/day compared to the household
with no appliances.

The estimated equation in Community A for period two is:

\[
\hat{\ln QWD} = 1.85 + .23 W - .01 DW + .18 WL + .18 SP - .007 TP2
\]
\[
(1.16) (1.15) (1.10) (1.09) (1.11) (1.02)
\]

\[
+ .6 \ln FS + .23 \ln NB + .13 \ln Y
\]
\[
(1.10) (1.12) (1.06)
\]
\[ R^2 = .57. \]

Variables significant at the 10 percent level were the wash-
ing machine, watering the lawn, swimming pool, family size, number
of bathrooms, and income. All variables remained significant at
the 5 percent level except the washing machine and the swimming
pool. The only variable significant at the 1 percent level was
family size.

A household with no appliances would use 13,691 gallons of
water during the second period. This represents an average of 3,423
gallons per month, 114 gallons per day, or 44 gallons/capita/day.
Households with washing machines would require 17,251 gallons dur-
ing the period. Daily per capita use would be 56 gallons. This
represents an increase of 12 gallons/capita/day compared to the no
appliance case. Evaluating the model including the dishwasher
variable indicates that daily per capita consumption remains identi-
cal to the no appliance case (44 gallons/capita/day). Watering the
lawn increases second period water use to 16,429 gallons. This
represents an increase in per capita daily consumption of nine gallons. Households filling swimming pools have identical results. Per capita daily consumption would increase by nine gallons. When the model is evaluated with all activities, period use increases to 24,592 gallons. Monthly use would be 6,148 gallons, daily use would be 205 gallons, and per capita daily use would be 79 gallons. If all activities are included in the model, per capita daily consumption would increase by 35 gallons.

The estimated equation for the third period is:

\[
\ln QWD = 1.64 + .49 W + .04 DW + .21 WL - .006 TP2 + .57 \ln FS \\
(1.18) (1.18) (1.11) (1.14) (1.02) (1.10) \\
+ .09 \ln NB + .16 \ln Y \\
(1.14) (1.07) \\
R^2 = .48.
\]

Variables significant at the 10 percent level were the washing machine, watering the lawn, family size, and income. The washing machine, family size, and income remained significant at both the 5 and 1 percent levels.

The model indicated that a household with no appliance would require 35 gallons/capita/day, or 10,844 gallons during the entire period. Households operating a washing machine increase third period use by over 7,000 gallons (17,893 compared to 10,844 with no appliances). Daily per capita use would increase to 58 gallons, which represents an increase of 23 gallons/capita/day. The dishwasher variable only increases daily per capita consumption by one gallon.
(from 35 to 36) compared to the no appliance case. The dishwasher, however, was not a significant explanatory variable. Watering the lawn would increase third period use to 13,338 gallons. This results in daily per capita consumption increasing by eight gallons compared to the no appliance case (from 35 to 43 gallons). Households with all activities would require 22,888 gallons during the entire period. This represents a monthly rate of 5,722 gallons, a daily rate of 191 gallons, or 74 gallons/capita/day. In the all activity case, daily per capita consumption increases by 39 gallons compared to the no appliance situation.

Identical equations were estimated for Community B, and the results were consistent with those obtained in Community A. The estimated per capita consumption is presented in Table 4.1 for both communities in each time period.

Per capita increases in daily use varied from 4 to 23 gallons with a washing machine, one to 16 gallons with a dishwashers and six to 19 gallons when the lawn was watered. The addition of a swimming pool increased per capita daily consumption by nine gallons in one community but reduced it by 4 gallons in the other community.

**Combined Community A and B Data**

As mentioned previously, separate models were estimated for each community because of slight differences in community characteristics (e.g., differences in residences, ages, etc.). Data from both communities will be combined and estimated; the double-log formulation will be used to determine if the separate models provide quite different results than the combined data from both communities.
Table 4.1. Estimated Per Capita Consumption Excluding Price.

<table>
<thead>
<tr>
<th></th>
<th>Community A</th>
<th>Community B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Period 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Appliances</td>
<td>39</td>
<td>40</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>47</td>
<td>44</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>44</td>
<td>56</td>
</tr>
<tr>
<td>All Activities</td>
<td>53</td>
<td>61</td>
</tr>
<tr>
<td><strong>Period 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Appliances</td>
<td>44</td>
<td>46</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>56</td>
<td>51</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>44</td>
<td>60</td>
</tr>
<tr>
<td>Watering Lawn</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>Swimming Pool</td>
<td>53</td>
<td>42</td>
</tr>
<tr>
<td>All Activities</td>
<td>79</td>
<td>73</td>
</tr>
<tr>
<td><strong>Period 3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Appliances</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>58</td>
<td>44</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>36</td>
<td>59</td>
</tr>
<tr>
<td>Watering Lawn</td>
<td>43</td>
<td>64</td>
</tr>
<tr>
<td>All Activities</td>
<td>74</td>
<td>83</td>
</tr>
</tbody>
</table>
The estimate for period one is:

\[
\ln QWD = 1.78 + 0.15 W + 0.21 DW + 0.02 TP2 + 0.59 \ln FS \\
(0.09) \quad (0.09) \quad (0.07) \quad (0.01) \quad (0.06)
\]

\[
+ 0.19 \ln NB + 0.05 \ln Y \\
(0.08) \quad (0.04)
\]

\[R^2 = .55.\]

Variables significant at the 10 and 5 percent levels were the washing machine, dishwasher, family size, and the number of bathrooms. The dishwasher, family size, and the number of bathrooms remained significant at the 1 percent level.

Households without any appliances would use 11,512 gallons during the first period. Monthly use would be 2,878 gallons, daily use would be 96 gallons, and per capita daily consumption would be 39 gallons. Households with washing machines would increase per capita daily consumption by seven gallons (46 gallons/capita/day). Total water use during the period would increase by approximately 1,800 gallons. If a dishwasher was used in the home, total water use would be 14,160 gallons. Daily use would be increased by 15 gallons, and per capita daily consumption would increase by nine gallons compared with the no appliance case. When both activities are considered, total water use would increase to 16,425 gallons. The per capita daily consumption level of 56 gallons represents an increase of 17 gallons compared to a household level with no appliances.

The estimated equation for the second period is:

\[
\ln QWD = 1.82 + 0.18 W + 0.09 DW + 0.19 WL + 0.07 SP - 0.002 TP2 \\
(0.10) \quad (0.09) \quad (0.08) \quad (0.07) \quad (0.09) \quad (0.02)
\]

\[
+ 0.66 \ln FS + 0.3 \ln NB + 0.08 \ln Y \\
(0.07) \quad (0.09) \quad (0.04)
\]

\[R^2 = .58.\]
Variables significant at the 10 and 5 percent levels were the washing machine, watering the lawn, family size, the number of bathrooms, and income. All these variables except the washing machine and income remained significant at the 1 percent level.

Households with no appliances or water intensive activities would use 13,414 gallons during the second period. Per capita daily consumption would be 45 gallons. Households operating a washing machine would increase total period use by approximately 2,600 gallons (16,096 gallons). This is a monthly average of 4,024 gallons, or 54 gallons/capita/day. The dishwasher would increase per capita daily consumption by four gallons (49 gallons). However, the dishwasher was not a significant explanatory variable. Watering the lawn would increase second period use to 16,231 gallons. This increase of approximately 1,800 gallons, compared to the no appliance case, increases per capita daily consumption to 54 gallons. The swimming pool variable was not significant, but would still increase per capita daily consumption by three gallons (48 gallons). If a household uses all these activities total use would increase to 22,716 (an increase of 9,302 gallons). This represents a monthly average of 5,679 gallons, a daily average of 189 gallons, and a per capita daily consumption level of 76 gallons.

The estimated equation for the third period is:

\[
\ln QWD = 1.7 + .24 W + .13 DW + .27 WL + .007 TP2 + .63 \ln FS \\
(\cdot10)(\cdot10)(\cdot08)(\cdot12)(\cdot02)(\cdot07)
\]

\[
+ .18 \ln NB + .13 \ln Y \\
(\cdot09)(\cdot05)
\]

\[ R^2 = .53. \]
Variables significant at the 10 percent level were the washing machine, dishwasher, watering the lawn, family size, number of bathrooms, and income. All these variables remained significant at the 5 percent level except the dishwasher. Family size and income were the only significant variables at the 1 percent level.

A household with no appliances would use 11,961 gallons during the last period. This represents an average of 100 gallons per day, or 40 gallons/capita/day. The washing machine would increase per capita daily consumption by 11 gallons (51 gallons/capita/day). Total water use during the period with the washing machine would be 15,190. The dishwasher would also increase water use during the last period. Total period use would be 13,636, monthly use would be 3,409, and per capita daily consumption would be 46 gallons. Watering the lawn would increase water use during the last period by the largest increment. Per capita daily consumption would increase by 12 gallons if lawns are watered (52 gallons/capita/day). If all activities are evaluated, water use would increase to 22,685 gallons. This represents an average of 5,761 gallons per month, 189 gallons per day, and 76 gallons/capita/day.

The per capita consumption levels for the combined community data are presented in Table 4.2. The results of this analysis indicate little change from the per capita consumption levels with the separate community data bases. In this case the washing machine increased per capita daily use from seven to eleven gallons, the dishwasher increased consumption by four to nine gallons, watering the lawn increased use from nine to 12 gallons, and adding a swimming pool increased water consumption by three gallons.
Table 4.2. Per Capita Consumption Levels, Combined Data Excluding Price.

<table>
<thead>
<tr>
<th></th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Appliances</td>
<td>39</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>46</td>
<td>54</td>
<td>51</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>48</td>
<td>49</td>
<td>46</td>
</tr>
<tr>
<td>Watering Lawn</td>
<td>—</td>
<td>54</td>
<td>52</td>
</tr>
<tr>
<td>Swimming Pool</td>
<td>—</td>
<td>48</td>
<td>—</td>
</tr>
<tr>
<td>All Activities</td>
<td>56</td>
<td>76</td>
<td>76</td>
</tr>
</tbody>
</table>
CHAPTER V
CONSERVATION

Implications for Water Conservation

The research indicates that at the present time, the potential to
decrease water use by households adopting water saving devices is ex-
tremely high (most homes did not use water saving devices). However,
the households sampled did not realize nor recognize water saving
devices on the market, and even with improved knowledge may not purchase
these devices since the private economic benefits are low.

There are several appliances available on the market, and in many
cases they are comparable in terms of cost. Several retail outlets were
contacted, and the majority of them had water saving devices in stock.
One major retailer had several washing machines available where the wash
water level ranges from 10 to 26 gallons. Another retailer markets an
"Ener-Gen-Eration" washer (front loading), which they claim reduces water
use by 36 percent compared to top loading machines. They also have dish-
washers, water saving toilets, washerless faucets, and pulsating shower
heads. Humus biological toilets (which require no water) are available
through commercial outlets and range in price from $850 to $900. A major
consumer magazine suggests several different methods of conserving water,
ranging from changing household attitudes to inserting plastic containers
in toilet tanks. A list of suggested methods to reduce water use is
practically unlimited. It is apparent that information concerning water
saving devices is available to households, and the cost of obtaining the
information is inexpensive (most of it is free except for the individual's
time).
Another question confronting the household is whether private economic benefits from water conserving appliances exceed private economic cost. Potential benefits based on an average water price of $1.10 in Community A and $3.00 in Community B can be computed for households. 1/

If a water saving toilet was installed that reduced water use by one-half Community A residents would save $8 per year and Community B residents $22 per year in water bills. However, the benefits of replacing a functional conventional toilet with a water saving toilet exceeds the costs only in Community B with the higher priced water. If a bathroom was added (or a new home built) and consumers choose to install a water saving toilet, rather than a conventional one, benefits would exceed the cost in both communities. The most cost effective system to reduce water use in toilets would be a weighted gallon jug placed in the storage tank.

Conventional shower heads release water at a rate of three to eight gallons per minute (GPM). Water use can be reduced by 50 percent if a flow restrictor is installed. These restrictors range in price from one to five dollars, and could reduce water use by approximately 10,100 gallons annually. If an average restrictor costs three dollars, Community A residents could save $78.14, and Community B residents could reduce water bills by $217.98. Pennsylvania State University [3] conducted a study on flow control devices, and determined that an average flow of 2.1 gallons per minute was satisfactory without affecting the "quality" of a shower.

Potential benefits for larger appliances are difficult to calculate. Large appliances (washing machines, dishwashers) can vary substantially in

1/ Assumptions include: 1) daily per capita consumption is 60 gallons, 2) family size is 2.5 individuals, 3) all devices can be installed at zero cost, 4) 40 percent of all water used is required for the toilet, 5) 37 percent of all water used is required for bathing (estimated by Great Lakes Basin Study), and 6) 6 percent rate of interest and a 10 year life.
price due to quality differences and features available on the various appliances. It appears that any money saved would be extremely small, and cost would exceed benefits over a 10 year period in most cases. If a moderately priced tri-water level washing machine is purchased, benefits may exceed cost. Infinite water level machines increase cost considerably (about $100 minimum or 50 percent) compared to automatic water level machines. The price of water in the sampled communities is low enough that the increased cost would not be recovered.

For example, the Great Lakes Basin Study allocates four percent of total household water use to cleaning clothes (approximately 2.4 gallons per capita per day with the prevailing assumptions). If a household reduced this level of use by 25 percent, only 500 to 1,000 gallons per year could be saved.

The water saving devices available to households can reduce water use, but the returns to the household from reduced water bills would be small. This may partially account for individuals not seeking information concerning these devices. Potential household savings have been based on the assumption that decreased water use will not result in higher water prices. However, some water companies develop rates by determining average total cost (yearly expenses) divided by the projected amount of water purchases. If this rate structure is practiced water rates could increase.

An aspect often overlooked is that additional benefits might accrue to households besides a reduction in water use and water bills. Probably the greatest benefit to society would be a reduction in energy use. Muller [38] estimates that residential water heating in the United States requires 1.1 million barrels of oil per day (BPD). Muller believes this total could be reduced up to 50 percent by replacing inefficient water
heaters, using cold water to wash clothes, inserting flow restrictors in showers, etc. Water heating represents the second largest use of energy in the home, and the combination of residential and commercial heating accounts for four percent of the country's total energy consumption.

Alternative Policy Instruments to Reduce Demand

Five policy approaches appear to have the greatest potential to reduce household water use in Community A and B. They are 1) subsidizing water saving devices, 2) providing the household (public) with information concerning water saving devices, 3) taxation plans, 4) regulation, and 5) price.

Subsidies

The government (local, state, national) or water companies could subsidize water saving devices in the home. This approach is often criticized because of the expense involved in providing subsidies. However, expenses incurred for subsidy programs may be less than other alternative costs (e.g., drilling new wells, increasing storage capacity) confronting communities with water problems.

Marin County, California was confronted with a water shortage and established several water conservation programs. The county had mandatory bans on car washing, per capita consumption of water was limited (quotas), and water saving kits were provided free to customers. These kits consisted of low flow shower heads, and bottles to be placed in toilet tanks (more than 90 percent of water users in the county requested the kits). In one year water use was reduced by 65 percent. Although the drought ended and control measures were removed (or relaxed) residential consumption remained 45 percent below pre-drought levels. Some proportion of this reduction can be attributed to the water saving kits. The encouraging aspect of this
subsidy program (water saving kit) is its inexpensiveness. Flow restrictors for showers can be purchased for as low as one dollar, and plastic bottles can be collected from salvage.

If a similar program (water kits) was established in Community B, aggregate community benefits could be large. Community B serves approximately 540 customers, and all previous assumptions will be retained. If the average cost for a flow restrictor is three dollars, total cost for the water saving kit would be $1,620 (excluding any administrative cost). It has been previously established that flow restrictors would save approximately 10,000 gallons, and plastic jugs 3,650 gallons per household per year. Households would save approximately $41 per year in reduced water bills. The aggregate impact of this program would be a reduction in water use of 7,371,000 gallons per year, and water bills would be reduced by $22,140 per year. Potential aggregate benefits would also increase from a reduction in energy use (less water heating would be required).

A scenario of a subsidy program can be developed for Community B residents. The engineering report prepared for Community B suggested an additional source of supply be developed and treated for iron and disinfection. The engineering report suggested a new well be drilled that would be capable of providing 200 gallons of water per minute at maximum capacity. Three forms of financing this project were suggested and are presented in Table 5.1.

The total cost for the first system is $981,240; the second is $1,197,680; and the third system cost is $1,235,280. The minimum monthly bill would increase by 85 percent, 78 percent, and 104 percent, respectively, for each new system.

However, the engineering report offers only one alternative: increasing the supply. The other alternative is to decrease demand
Table 5.1. Suggested Financing for Water Improvements, Community B.

<table>
<thead>
<tr>
<th>Financing</th>
<th>FMHA</th>
<th>FMHA</th>
<th>Municipal Water Revenue Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Financing</td>
<td>30 years</td>
<td>40 years</td>
<td>30 years</td>
</tr>
<tr>
<td>Interest Rates</td>
<td>5%</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>Total Annual Payment</td>
<td>$32,708</td>
<td>$29,942</td>
<td>$41,176</td>
</tr>
<tr>
<td>Annual Operation and Maintenance</td>
<td>$48,492</td>
<td>$48,492</td>
<td>$48,492</td>
</tr>
<tr>
<td>Annual Requirement</td>
<td>$81,200</td>
<td>$78,434</td>
<td>$89,668</td>
</tr>
<tr>
<td>Minimum Monthly Bill</td>
<td>$5.55</td>
<td>$5.34</td>
<td>$6.12</td>
</tr>
</tbody>
</table>

by subsidizing water conservation, as suggested in the water saving kit example presented previously. The community now has the option of increasing supply or decreasing demand. The alternative of increasing supply will cost the community approximately $1,000,000 and raise minimum charges by 78 to 104 percent. Decreasing demand (water saving kit) could reduce household water bills for the entire community by approximately $22,000 per year, and at the same time reduce community water use by 7.4 million gallons per year. This 7.4 million gallons would represent approximately 20 to 30 percent of the water supplied from the new well, as suggested in the engineering report. This reduction may be enough to satisfy the current water demand problem, and it may also satisfy future problems depending on the rate of growth of water consumption in Community B.
Providing information to households could be accomplished by manufacturers of water saving devices, government agencies, and educational institutions. A limited amount of advertising is conducted by commercial outlets and manufacturing companies. However, these ads may not be successful due to the size of the ad (usually only a small ad in the newspaper) and the focus of the ad (not enough information on potential savings to the household). Providing information to households is complicated by limited household savings (the suggestions mentioned earlier indicate the household could save $40 to $60 per year), and many appliances (toilets, washers, showers, etc.) are very durable and not purchased often.

If the government undertook an advertising program, most likely it would be similar to the energy conservation advertising. However, the success of advertising in reducing energy use is questionable. The logical emphasis for advertising belongs to manufacturers, who have developed water saving devices and want to sell those devices, rather than to government. Advertising provides manufacturers with feedback about cost of the devices (e.g., if cost exceeds benefits, methods could be sought to reduce cost) and how acceptable they are to consumers.

The New Jersey Department of Environmental Protection has even suggested enlisting teachers in primary and secondary schools to provide information to students about water conservation. "Measures to Reduce Water Consumption in Southeastern New York" was published in 1973 by the New York Temporary State Commission, and stressed that for an educational program to be effective it should not be centered on a crisis. Rather the program should be directed to changing attitudes. Households need to be warned that the potential for a water shortage does exist if they
use water wastefully, and water companies need to be exposed to the alternative of decreasing demand rather than always increasing supply.

**Taxes**

Another alternative to decrease demand for water is the formulation of a tax plan. The tax could be placed on the household through higher prices (according to appliances owned), or the tax burden could be placed on manufacturers. If a large enough increase was levied consumers might be encouraged not to purchase water intensive appliances. If the tax is reflected through the price system, a reduction in water use could occur. However, if a lump sum was administered all commodities in the market basket might be reduced, rather than water. Taxing the appliance manufacturer may be inefficient if they are forced to alter production plans (this tax would be similar to the tax on auto manufacturers if their total car fleet does not meet specified gas mileage). Other taxes suggested by individuals include penalty taxes for "excessive" use or penalty fines for certain activities (lawn watering, car washing). However, problems arise in determining "excessive use" (since per capita consumption varies throughout the country), what is an equitable fine, and how large the penalty should be.

**Regulation**

One final policy instrument is regulation. Regulation of water use can take various forms, and could be enforced through water quotas or building and housing codes. Regulations may be necessary because cost of new appliances cannot be recovered in a short period of time, especially if the price of water is low. Many individuals and state agencies are
suggesting building codes requiring water saving toilets, low flow shower heads, flow restrictors, and washerless faucets to reduce water use. The impact of a building code in the communities studied would be limited in its effectiveness because the majority of homes are older, and bathrooms, kitchens, etc. are not replaced or repaired frequently. In order for regulation to be effective, individual's attitudes toward regulation may require altering, and water customers must be interested in reducing use. Regulation may reduce water bills, in addition to preventing costly drilling and storage capacity increases.

Price

The use of price as an effective policy tool may have only a limited potential. A factor that may account for this situation is that water represents a small part of consumer's total expenditures. Consequently, consumers may be less responsive to price changes. Perhaps larger changes in price could create significant changes in consumption, but state regulation of water companies make it extremely difficult to institute large price changes.

Two possible changes in price within the water system's current operation might potentially reduce consumption. If increases in price were large enough, peak period pricing could be used during the summer months to decrease demand. However, this may not be practical in small communities. Complaints from customers, developing an additional rate structure, limited staffs, hand calculated bills, etc., complicate peak seasonal pricing in small communities. Furthermore, a reversal of the declining block rate structure (to increasing block rates) might curb water use since cost would be a larger proportion of total consumer expenditures.
Summary

In conclusion, issues presented in this chapter can be summarized in the following manner. Potential household dollar savings from reducing water use and energy use are small. These savings increase as water and energy prices increase, and aggregate benefits could be large. Subsidies and regulation are policy instruments that may be the most effective in reducing water use at minimal cost. However, households must be informed of the cost and savings of these programs so they will not be rejected. It must also be emphasized that household water use represents one aspect of total water use by the community; commercial, industrial, and agricultural use should also be considered.
CHAPTER VI
CONCLUSIONS AND POLICY ISSUES

This study has focused on incorporation of water intensive appliances or activities in estimating water demand. Ordinary Least Squares regression analysis was used to estimate rural household water demand over three periods. Interpretation of results and hypotheses tested to determine significant variables for Community A were previously discussed. This chapter will provide a synthesis of conclusions and policy issues available that could encourage water conservation if desired in both communities studied.

The chapter is divided into three major sections: 1) the conclusions reached in the research, 2) the potential for household consumption increases, and 3) policy instruments which have the most potential for encouraging consumers to conserve water.

Conclusions

This section indicates that 1) household activities studied in the research are significant explanatory variables in determining household water use, and 2) water use varies considerably among the three periods. One of the main objectives of this research was to determine if household appliances (or activities) are significant variables in determining household water use. The estimated equations verify that these activities are significant in most cases, and increase per capita consumption levels (note the per capita data referred to below were presented earlier in Tables 4.1 and 4.2).

The washing machine increased per capita consumption in 8 of the 9 equations estimated. This variable was significant at the 5 percent level
in three cases, the 10 percent level in two cases, the 1 percent level in one case, and not significant in three cases estimated. The large number of households owning machines may have contributed to these results. The per capita per day increases ranged from four gallons to 23 gallons. The accuracy of these increases are reasonable, considering the wide range of water required for washing (a wash cycle can require anywhere from 10 to 40 gallons). A more precise calculation would require knowledge of the model, age, and capacity of the machine.

The dishwasher increased daily per capita consumption in 8 of the 9 equations estimated. Daily per capita consumption increases ranged from 1 to 16 gallons. The increases appear acceptable as there is a wide variety of dishwashers available (11 to 30 gallons) for purchase. The dishwasher is significant at the 1 percent level in two cases at the five percent level in two cases, at the 10 percent level in two cases and not significant in three cases. Contrary to manufacturing reports and some government agencies, the dishwasher increased water use in the sampled households. Not only will the household increase water use, but presence of a dishwasher should also increase household energy consumption, causing a rise in utility expenses.

Watering the lawn increased per capita daily consumption in all of the equations which included this variable. Consumption increases ranged from 6 gallons to 19 gallons per capita per day. Watering lawns or gardens was a significant variable at the 1 percent level in one of the six cases, at the 5 percent level for three, and at the 10 percent level for one of the cases. It must be recognized that this variable is subject to climatic conditions and could vary greatly during different years.
The swimming pool variable had the correct sign in only two of the three equations estimated which included this variable. The swimming pool variable was significant at the 10 percent level in one of the three equations. The reason this variable did not perform properly is attributed to 1) the swimming pool entering the mode as a dummy variable when the amount of water necessary to fill pools ranged from about 100 to 25,000 gallons, and 2) a limited number of observations.

The study indicates there is no correlation between appliances and income (correlation coefficients ranged from .2 to .5). Households with low incomes in the sample were as likely to own appliances as wealthier households, which is contrary to other publications (Lineweaver, Batchelor). Therefore, re-evaluation of water rates in communities may be justified to determine their impact on low income consumers. The study also indicates a greater potential for increased water use if low income homes are purchasing these appliances.

It is apparent from the tables presented in Chapter IV that household water use varies over the three periods. A household in Community A with no appliances uses 39 gallons per capita per day in period one, 44 gallons in period two, and 35 gallons in the third period (Table 4.1). Daily per capita use increased by 13 percent from period one to period two, and decreased by 20 percent from period two to period three. If all activities are considered, per capita daily consumption increased by 49 percent from period one to period two. A similar pattern was also present in Community B. Comparing all no appliance cases, use increased by 15 percent from period one to two, and decreased by 2 percent from period two to three.
Therefore, communities would require excess water storage or pumping capacity in the first and third periods. This would most likely require more productive wells, increases in storage tanks (water towers), larger reservoirs, etc., unless the peak seasonal demand of the second period could be decreased to the level of the remaining periods.

Consumption Increases

From the data collected and the estimated equations, it appears there is potential for increased water use. Increased usage depends upon future adoption of appliances and water intensive practices, the amount of water required by the appliances, and attitudes of individuals.

In the sampled communities a large proportion of households operated washing machines. If all remaining households purchased machines, water use would only increase slightly (on a per day basis). The washing machine increased per capita daily consumption by four to 23 gallons. However, this most likely will not be true in all communities. If a large proportion of households did not own machines, the potential for increases in water use could be large.

If the trend for convenience appliances continues, the dishwasher could increase water demand. There is greater potential for households to purchase dishwashers because only 25 percent of the homes had this appliance. The questionnaire received indicated the possibility of this occurring because 18.1 percent of the households in Community A and 22.1 percent of the households in Community B agreed that they preferred convenience appliances and did not care if they were water intensive. The estimates indicate the dishwasher would increase per capita daily consumption approximately one to 16 gallons.

Lawn and garden watering could also increase water demand. The estimates indicate that per capita daily consumption could increase by
6 to 19 gallons, and only 25 percent of the Community B residents and 37 percent of Community A residents watered lawns. However, since climatic conditions can vary considerably over time, it is difficult to determine the total impact this activity might have on water use.

One final point that should be recognized is that total water use per household may decrease. This could occur even though per capita consumption is increasing because of small family size. Projections based on a family size of four individuals are not typical for the sampled households. It is important that small communities ignore the "typical" household projections and explore the per capita consumption levels. Small communities may be able to avoid unnecessary cost (increasing storage, drilling new wells, etc.) if per capita levels are considered.

Policy Instruments to Encourage Conservation

Two basic policy approaches appear to have the greatest potential to reduce household water use in rural communities. They are 1) subsidizing water saving devices, and 2) regulation. These policy instruments may be attractive to rural communities experiencing moderate population and industrial growth, and expanding demands for water.

Benefits to individuals and communities could accrue by several different methods if a subsidy program was adopted. First, households would reduce water use which would decrease water bills. Second, there is the potential to decrease energy bills if less water is heated by household members. Finally, if households reduce water use communities may be able to avoid cost of drilling new wells, expanding storage capacity, etc.

Benefits to individual households are relatively small (approximately $40 - $60). However, aggregate benefits could be large as noted in
Chapter V. The main advantage of subsidy programs in that for small communities the programs represent an inexpensive method of reducing community water demand.

Regulation of water saving devices in the household can take various forms, and could be enforced through water quotas or building and housing codes. Regulations may be necessary because cost of new appliances cannot be recovered in a short period of time, especially if water charges are low. The impact of regulation in small communities may be limited in reducing water use. The majority of homes are often older and bathrooms, kitchens, etc., are not replaced frequently.

It should be emphasized that household water use represents one aspect of total water use by the community; commercial and industrial use must also be considered for water management to achieve conservation.
BIBLIOGRAPHY
BIBLIOGRAPHY


APPENDIX

MAILED QUESTIONNAIRE
INSTRUCTIONS: Please try to answer all questions.

Do not sign your name.

(1) Does your water bill indicate water use by your household only?
    Yes ____    No ____

If your water bill includes a household that you rent to someone else or a house trailer drawing from your water supply return this form in the provided envelope. Thank you.

If your water bill includes only your household, please answer the remaining questions.

(2) Do you own or rent the house you are presently living in?
    Own ____    Rent ____

(3) If you rent your house who pays the water bill?
    Renter ____    Landlord ____

(4) Please list the number of people residing in your household for all the following periods in 1977.

    Number residing in household
    January-March ____
    April-August ____
    September-November ____
    December ____

(5) What are the ages and highest education level of all family members?

    Age     Education
    1)
    2)
    3)
    4)
    5)
    6)
(6) Did you fill a swimming pool or a wading pool during any of the following periods in 1977?

<table>
<thead>
<tr>
<th>Period</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-March</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April-August</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September-November</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(7) If you answered "yes" to question 6 please list the approximate dimensions.

If square or rectangular: Width ___ ft./length ___ ft./depth ___ ft.

If circular: Diameter ___ ft., depth ___ ft.

(8) How many bathrooms are there in your home? Number _____

(9) Does your bathroom contain both a bathtub and a shower?

Yes _____ No _____

(10) Approximately how many baths were taken per week in 1977?

____ 1-5   ____ 6-10   ____ 11-15   ____ 16-20   ____ over 20

(11) Approximately how many showers were taken per week in 1977?

____ 1-5   ____ 6-10   ____ 11-15   ____ 16-20   ____ over 20

(12) Did your household have a washing machine during any of the following periods in 1977?

<table>
<thead>
<tr>
<th>Period</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-March</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April-August</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September-November</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(13) How many loads of laundry did you wash per week in 1977?

____ 1-3   ____ 4-6   ____ 7-9   ____ over 10
(14) Did your household have an electric dishwasher during any of the following periods in 1977?

<table>
<thead>
<tr>
<th>Period</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-March</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April-August</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September-November</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(15) On the average how many times was your dishwasher used per week in 1977?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>6-10</td>
<td></td>
</tr>
<tr>
<td>11-15</td>
<td></td>
</tr>
<tr>
<td>over 15</td>
<td></td>
</tr>
</tbody>
</table>

(16) Did you water your lawn during any of these periods in 1977?

<table>
<thead>
<tr>
<th>Period</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>April-August</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September-November</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(17) How often did you water your lawn each week?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>3-4</td>
<td></td>
</tr>
<tr>
<td>5-7</td>
<td></td>
</tr>
</tbody>
</table>

(18) Please indicate in which period your water bill is the highest.

<table>
<thead>
<tr>
<th>Period</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-March</td>
<td></td>
</tr>
<tr>
<td>April-August</td>
<td></td>
</tr>
<tr>
<td>September-November</td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
</tr>
</tbody>
</table>

(19) Normally, how much is your water bill per month?

$ _____________

(20) Do you practice any of the following water saving techniques in your household?

<table>
<thead>
<tr>
<th>Technique</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not using the toilet to flush away kleenex and facial tissue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit time spent in the shower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td>Filling the tub only one-fourth full</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn off the water while brushing your teeth &amp; shaving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use the dishwasher only when it is full</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When hand-washing dishes do you turn off the water?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(21) Are you familiar with any of the following appliances which could reduce water use?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressurized shower heads</td>
<td></td>
</tr>
<tr>
<td>Suds-saving washing machines</td>
<td></td>
</tr>
<tr>
<td>Chemical toilets</td>
<td></td>
</tr>
<tr>
<td>Shallow trap water saving toilets</td>
<td></td>
</tr>
<tr>
<td>Low volume dishwashers</td>
<td></td>
</tr>
<tr>
<td>Dual flush toilet tank</td>
<td></td>
</tr>
<tr>
<td>Washerless faucets</td>
<td></td>
</tr>
</tbody>
</table>

(22) Were any new fixtures such as a new bathroom, shower, dishwasher, washing machine, washerless faucets, etc., purchased by your household in 1977 that would increase or decrease past water use? Please list these items. Also list month they were installed.

(23) What was your approximate total family take-home pay or after tax income in 1977? (please check)

| 0 to $ 999 | $15,000 to $19,999 |
| $ 1,000 to $4,999 | $20,000 to $24,999 |
| $ 5,000 to $9,999 | $25,000 to $29,999 |
| $10,000 to $14,999 | Over $30,000 |
Please indicate your opinion on the following statements.

(24) If there was a severe water shortage I would reduce my household's water consumption and would not return to my present water use level.

1) Strongly agree  
2) Agree  
3) Neutral  
4) Disagree  
5) Strongly disagree  

(25) I have a preference for appliances that save work time, add convenience to my schedule, etc. and I do not care if they are water intensive or not.

1) Strongly agree  
2) Agree  
3) Neutral  
4) Disagree  
5) Strongly disagree  

(26) If there was a water shortage in Indiana I think many people would be willing to conserve.

1) Strongly agree  
2) Agree  
3) Neutral  
4) Disagree  
5) Strongly disagree  

(27) If you have any comments related to water use in your home please tell us about them on the space provided on this page.