DECISION TOOLS TO ASSIST IN THE ECONOMIC PLANNING OF RURAL WATER SYSTEMS

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> Two are better than one because they have a good reward for their labor; for if they fall, the one will lift up his fellow: But woe to him that is alone when he falls, for he hath not another to help him up (Ecclesiastes 4:9-10).

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CHAPTER I

INTRODUCTION

Statement of the Problem

A major determinant of the quality of life in rural areas is an abundant supply of high quality water for domestic use. Agriculture and industry water requirements must also be met if rural areas are to flourish (56). Rural residents have for years relied on groundwater or have hauled water for their needs. Some rural areas do not have adequate supplies of quality water. Indications are that the water supply problem will continue or perhaps become worse in the future due to population growth.

The 1980 Census of Population indicates that there is currently a trend toward increased rural settlement. In Oklahoma, for example, rural population declined from 1950 to 1960. During the 1970's, rural population increased by 17.3 percent. With population growth comes the accompanying need for improvement in the quality and quantity of water services. Planning which addresses the very difficult problems of providing adequate quantity and quality of water and financially stable water systems for the future is imperative. It is important in the planning process that community leaders consider appropriate sizing and placement of water treatment and distribution facilities since these components are fixed and capital intensive. Cost effectiveness of the water system is also an important criteria in planning. A system must be cost effective to ensure its financial stability in future years. Therefore, it is imperative that community leaders involved in planning new or expanded systems have at their disposal as much information as possible to assist them in avoiding financial and operational difficulties.

National Policies to Assist Rural Water Systems

In 1937, the Water Facilities Act (WFA) was passed to provide loans for individual and association farm water systems in 17 Western states where drought and water shortage were familiar hardships. The first loan was made in 1940 to a small group of Idaho farmers for $1,600. The first major change in legislation occurred in 1954 when the WFA was amended to cover the entire nation. The amendment also allowed systems to accept nonfarm customers in rural communities. In 1961, the United States Congress enacted the Consolidated Farmers Home Administration Act to enable Farmers Home Administration (FmHA) to make loans and grant monies available to all rural areas for establishment of rural water systems. Loan limits of $500,000 and $1 million were set for direct and insured FmHA loans, respectively. Incorporated towns of up to 2,500 population were made eligible for loans. In 1965 the loan limit was increased to $4 million per project and the size restriction was increased to 5,000. The last major change was made in 1970 when legislation was passed to remove the technical barriers which had prevented the use of private investors' funds. This change allowed the use of direct appropriated funds for tax-exempt bodies and marked the beginning of a paeriod of rapid water system growth and increased service to small towns. With the advent of the Rural Development Act of 1972, the limitation of $4 million per project was abolished and the national grant authorization for water and waste disposal was increased from $100 million to $300 million per year. In addition, the population limit on towns was increased to 10,000 (27).

Oklahoma Policies to Assist Rural Water Systems

The first Oklahoma legislation allowing organization, formation and operation of public nonprofit rural water districts was passed in 1963 by the 29th legislature in the form of the "Rural Water Districts Act." The purpose of this enabling legislation was to allow establishment of rural water districts (RWD) and provide water supply facilities adequate to service the needs of rural residents (47). Nowata County RWD 2 was organized in 1963 as the first nonprofit RWD in Oklahoma and was financed by a $65,760 FmHA loan at 3.8 percent interest. In subsequent years, enabling legislation to include sewer, natural gas and solid waste systems for eligibility has been passed.

In 1980 the Oklahoma Legislature empowered the Oklahoma Water Resources Board (OWRB) to issue loans to RWD's for expansion or improvement of their systems. The amount, length, and interest rates of loans is to be determined by the bond market. In July, 1982, three systems in Oklahoma were under OWRB consideration for loans in fiscal year 83. The bonds were expected to have a 2-year term at 9.5 percent interest after which they would be refinanced at the prevailing rate (57).

The 1982 Oklahoma Legislature has presented Senate Bill 145 (SB145), a referrendum for consideration as State Question 558, to strengthen the abilities of the OWRB in granting monetary assistance to rural water districts. Provisions of SB145 are: (1) OWRB will be empowered to pursue adequate funding in the bond market to meet current loan requests by RWD's; (2) $25 million will be appropriated for inclusion in Oklahoma's water development fund as bonding collateral from excess unearmarked funds; and (3) OWRB will be empowered to use these monies for planning research, cost sharing with federal reservoirs, construction of state funded reservoirs and pledges to meet obligations of FmHA and other federal agencies for storage and supply facilities.

Current Status of Rural Water Systems

As of April, 1982, FmHA had made 11,157 unduplicated loans (borrowers) nationally. In fiscal 1981, $750 million were appropriated for loans and an additional $200 million for grants for rural water districts across the U.S. Through fiscal 82, FmHA had provided $7.9 billion in loans and loan guarantees to rural systems (30).

Since 1963, FmHA offices in Oklahoma have loan and grant obligations to 1,176 borrowers in excess of $275 million. These loans and grants serve over 400,000 families in the state. Oklahoma ranks third in the total number of unduplicated loans with 528. There are presently 425 rural water systems in Oklahoma (57).

Planning Needs of Community Leaders

Community leaders are particularly concerned with the water issue, not only because of rapid rural growth, but also due to weather variations and the possibility of drastic depletion of water supplies which have historically been relied upon as water sources. Several problems confront these leaders as they attempt to plan and develop water supply and distribution systems to adequately meet their present and future needs. These include a need to: estimate water demand; identify reliable water sources; determine proper system design; determine the existence of economies of size; and estimate capital and operating costs and alternative revenue sources.

Information to assist community leaders in addressing these questions is of major importance. A more accurate method of estimating future water needs of systems is needed in order to plan for future system size. In addition, system size may be partially determined on the basis of existence of economies of size. Determination of system costs is also vital. It would be useful for leaders to consider any alternative organizational structures such as consolidation or merger which might lend additional operational or financial efficiency to the current system.

Objectives of the Study

The primary objective of this study is to develop methods which will allow decisionmakers in rural water districts to better utilize available information in evaluating alternatives for water system planning. Specifically, this will be accomplished by:

1. Developing a method to estimate water system capacity and future water use based on historical water use trends, socio-demographic data and population projections;

2. Identifying the existence or non-existence of economies of size in rural water districts;

3. Developing a method to evaluate possible advantages and disadvantages of system consolidation; and

4. Identifying factors which influence settlement patterns in rural areas.

Numerous opportunities exist for use of these research results and methods by community leaders. Combined with information currently available, five specific uses are outlined here. First, planning of future system water distribution, storage capacity, line size, water source, treatment and/or well capacity and water purchase contracts can be facilitated. Second, planning for capital outlays for lines and treatment facilities and projection of costs and revenues is also possible. Third, advantages and disadvantages of consolidation can be effectively analyzed. Fourth, a program exists which allows water districts to analyze the effects of changing rate structures on their revenues. Fifth, budgetary analysis of individual systems based on cost and revenue information and economies of size is also possible. These functions, combined with other potential applications of this research, should afford community leaders additional information on which to make knowledgable policy decisions to ensure the efficient operation of their water districts in years to come.

CHAPTER II

ESTIMATION OF SYSTEM CAPACITY AND FUTURE WATER USE

In planning for the future of their communities, decisionmakers are confronted with the very difficult task of trying to ensure adequate water services for future generations. There are essentially two facets of the planning process--estimating system capacity and estimating water use. A method which would assist decisionmakers in the initial phases of the planning process would be extremely beneficial. Proper system design, involving over-sizing lines in growth areas and economical utilization of current facilities, could save communities large sums of money and provide higher quality water service to their residents.

Estimating Water System Capacity

In estimating system capacity, four primary areas of concern surface. First, the supply of raw water may limit system capacity. Reliable yields for reservoirs or other supply sources should be estimated either from engineering reports or contractual agreements with water suppliers. Treatment capacity is another area of limitation. Again, this information can generally be obtained from engineering reports. A third limiting area is storage capacity. FmHA recommends that each water system have a storage capacity equal to twice its daily use to help insure adequate water volume and pressure. Distribution is the final limiting factor, involving both pumping and distribution lines. FmHA and/or any reputable engineering firm can calculate pumping requirements and the maximum number of families which can be served by any particular size line.

Estimating Water Use

Methods employed in analyzing historical water use and estimating future water use are presented below. Water use is estimated on a per customer basis and then extended to apply on a system wide basis. Before expounding on these methods, a selected review of the literature concerning water use estimation techniques will be summarized.

A Selected Review of Literature

Three methods have been employed in past research to estimate water demand. These include: (1) the cross-sectional average use approach; (2) regression analysis; and (3) a combination of cross-sectional and time-series approaches.

Sloggett and Badger (55) sampled 57 rural water systems in a study designed to delineate the economics and growth of rural water districts in Oklahoma. Of the 15,875 hookups included in their study, 96.4 percent were residential. Monthly water use per hookup was divided into four groups according to consumption level. Overall, the largest percentage of customers--34.2 percent--used 2,000 gallons or less per month, 31.9 percent used between 2,000 and 5,000 gallons per month and 23.8 percent used between 5,000 and 10,000 gallons per month. Only 10 percent of the group used in excess of 10,000 gallons per month. Average monthly water use per hookup for the rural systems was found to be 4,588 gallons.

In 1979, Goodwin et al. (18) estimated monthly water use as the initial step in a budget study. Information was obtained from state and county FmHA offices and water system managers. Number of each type of user (rural household, farm, commercial, and industrial) and volume of water sold annually for 1976 and 1977 were used to estimate average monthly use. Preliminary analysis of water use by the four types of users revealed few differences. In further analysis, user types were aggregated into only two groups: (1) rural households and farms, and (2) commercial and industrial users. Averages for 30 systems showed the two categories to have monthly water usages of approximately 6,900 and 17,000 gallons per month, respectively. A comparable study Kuehn (35) in Missouri indicated the average monthly residential water consumption per user to be 5,504 gallons.

Regression analysis to estimate future water use was conducted by Burns and Goode in a 1980 study (7). Although development of appropriate rate structures for rurual systems was the objective of the project, a necessary part of this was development of a reliable water use estimator. Burns and Goode sought to identify and adequately quantify factors affecting water use variations in rural systems. Household factors utilized in estimating water use in a case study for Indiana County, Pennsylvania, were: number and age of persons; home ownership status; presence of washer and dishwasher; number and type of bathrooms; garden maintenance; type of dwelling; and family income. They found significant relationships existed between each of these household factors and water use. As hypothesized, all relationships were positive with regard to water use with the exception of age, which was negatively related.

Estimating of Per Customer Water Use

Four methods are employed in estimating water use. They are referred to as: (1) constant; (2) percentage increase; (3) trended increase; and (4) regression estimation.

The study area consists of Okmulgee County and portions of seven adjacent counties: Tulsa, Wagoner, Muskogee, Creek, Okfuskee, Hughes, and McIntosh. For ease in discussion the study area will be referred to as Okmulgee County. Okmulgee County currently has 11 rural water districts (RWDs) and 5 municipal systems. Current service areas of the 11 RWDs, excluding areas in adjacent counties, are shown in Figure 1. The data used to estimate water use for the first four methods were obtained through interviews with system managers and clerks, health department officials and board members. Historical water use data are presented in Tables I and II for selected systems. In the case of regression analysis, data were obtained by mail questionnaires. Details concerning the collection of the soci-economic data are presented in Chapter IV.

The Constant Method. Daily per customer water use in 1980, based upon historical data for rural Okmulgee County, was 240 gallons. It is assumed in the constant method that the per hookup (customer) use reamins constant to the year 2000. This method uses the average daily water use derived from dividing total water use by the number of rural customers.

The Percentage Increase Method. This method utilizes percentage increases in daily per customer water consumption provided by the Corps of Engineers in the Phase One Oklahoma Comprehensive Water Plan (48) to

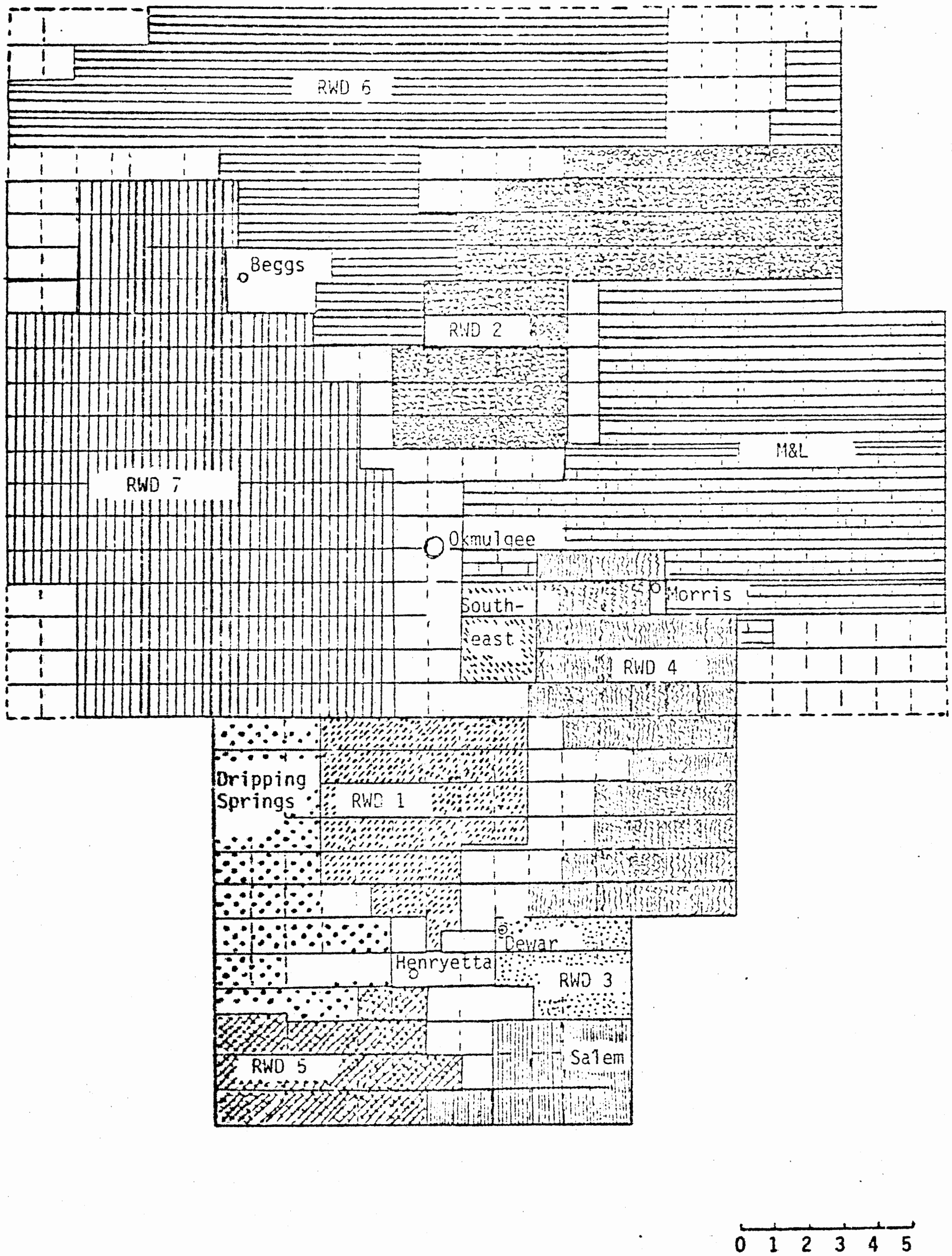

Figure 1. Current Service Areas of Rural Water Districts in Okmulgee County

TABLE I

ANNUAL HISTORICAL WATER USE INFORMATION FOR RWD'S #3, #4, #5, #6, DRIPPING SPRINGS AND SALEM, 1969-1980[a]

	1969	1970	1971	1972	1973	1974
RWD #3						
Customers[b]	26	32	37	37	38	38
Gallons[c]	1,200	1,429	4,241	1,275	1,275	1,799
RWD #4						
Customers	186	201	214	238	246	324
Gallons	6,962	7,940	9,210	9,837	14,733	18,782
RWD #5						
Customers	87	95	d	d	d	d
Gallons	3,208	d	d	d	d	d
RWD #6						
Customers	d	d	d	d	d	d
Gallons	d	d	d	d	d	d
Drippings Springs						
Customers	d	d	d	d	d	d
Gallons	d	d	d	d	d	d
Salem						
Customers	d	d	68	d	85	107
Gallons	d	d	1,657	2,510	3,426	4,070

TABLE I (Continued)

	1975	1976	1977	1978	1979	1980
RWD #3						
Customers	38	38	39	39	39	47
Gallons	1,838	2,023	3,671	2,246	2,786	2,307
RWD #4						
Customers	345	363	379	411	435	450
Gallons	19,608	d	20,548	22,674	23,802	d
RWD #5						
Customers	128	141	157	160	175	215
Gallons	11,042	11,775	9,485	10,827	16,856	12,674
RWD #6						
Customers	897	1,004	1,121	1,249	1,367	1,419
Gallons	63,509	81,130	76,531	109,662	107,544	75,721
Drippings Springs						
Customers	94	99	107	118	123	126
Gallons	4,332	7,652	5,999	8,325	10,920	8,120
Salem						
Customers	109	111	105	114	118	360
Gallons	5,716	6,120	6,667	7,371	9,957	17,095

[a]Information for RWD #6 was not available for years prior to 1975.

[b]Number of customers (taps) at end of the specified year.

[c]Number of total gallons, in thousands, used for the specified year.

[d]Denotes missing data.

TABLE II

ANNUAL HISTORICAL WATER USE INFORMATION FOR HENRYETTA, MORRIS, BEGGS, AND DEWAR, 1975-1980

	1975	1976	1977	1978	1979	1980
Henryetta						
Customers[a]	2,620	2,655	2,709	2,776	2,854	2,900
Gallons[b]	255,329	263,332	320,831	366,440	388,491	388,520
Morris						
Customers	556	558	568	558	565	564
Gallons	21,588	27,189	35,526	34,540	41,693	27,950
Beggs						
Customers	532	541	547	552	559	570
Gallons	22,857	27,606	30,328	28,215	32,559	23,546
Dewar						
Customers	348	355	359	368	375	377
Gallons	23,105	22,557	24,613	25,829	25,963	26,306

[a]Number of customers (taps) at end of the specified year.

[b]Number of total gallons, in thousands, used for the specified year.

derive water use estimates. The Corps estimates that during the four five-year periods from 1980 to 2000, daily per customer water use will increase 5 percent, 4 percent, 3.5 percent and 3 percent, respectively. These estimated increases, when applied to the base water use figure of 240 gallons, give dailly per customer water uses of 252, 262, 271, and 279 gallons for the year 1985, 1990, 1995, and 2000, respectively.

The Trended Increase Method. The third estimation method utilizes data provided by water systems in Okmulgee County in developing models for three areas: (1) all rural areas; (2) Beggs, Morris, and Dewar; and (3) Okmulgee and Henryetta. These models extend the past trends for daily water use for each of the entity groupings. Results of these models are presented in Tables III and IV. Both past trends and future estimates of daily per customer water use are shown. Daily per customer water use for rural areas, for example, has increased from 146 gallons in 1970 to 240 gallons in 1980 (Table III). If this trended increase in water use continues through the year 2000, daily per customer water use for rural areas will then be 409 gallons.

The Regression Method. The fourth estimation method employs multiple regression analysis to arrive at estimates for water use. The theoretical basis for the regression analysis utilized is contained in Appendix A.

For purposes of this study, the average monthly water use per customer is functionally specified as follows:

Monthly Water Use = f(Number of persons in household, Presence of modern conveniences, Price of water, Educational attainment of household head, Non-domestic water uses, Annual family income).

TABLE III

PAST TRENDS AND FUTURE ESTIMATES IN DAILY PER CUSTOMER WATER USE FOR ALL RURAL AREAS, AND BEEGS, MORRIS, AND DEWAR, SELECTED YEARS

Year	All Rural Areas[a]	Beggs, Morris and Dewar[b]
	gallons per day	
1970	146.08	c
1975	187.03	128.88
1976	197.10	145.75
1977	190.41	165.53
1978	231.37	164.20
1979	224.03	186.03
1980	239.56	191.70
1985	277.53	256.60
1990	321.31	318.54
1995	365.09	386.49
2000	408.87	442.43

[a]Estimates of annual change in water use from the base year 1970 are made using a model developed from historical water use data for rural areas, 1970-1980.

$$\Delta \text{ USE} = -17,102.77 + 8.7588 \text{ YEAR}$$

$$R^2 = .9562$$

$$\sigma = 30.3619$$

[b]Estimates of annual change in water use from the base year 1975 are made using a model developed from historical water use data for Beggs, Morris and Dewar, 1975-1980.

$$\Delta \text{ USE} = -24,335.28 + 123,889 \text{ YEAR}$$

$$^2 = .9758$$

$$\sigma = 23.7523$$

[c]Denotes missing data.

TABLE IV

PAST TRENDS AND FUTURE ESTIMATES IN DAILY PER CUSTOMER WATER USE FOR OKMULGEE AND HENRYETTA, SELECTED YEARS[a]

Year	Okmulgee	Henryetta
	gallons per day	
1975	b	267.00
1976	b	271.74
1977	b	324.47
1978	b	361.65
1979	416.71	372.94
1980	352.88	410.10
1985	503.28	560.99
1990	654.67	711.89
1995	805.56	862.78
2000	956.46	1,013.68

[a]Estimates of annual change in water use from the base year 1975 are made using a model developed from historical water use data for Henryetta, 1975-1979. Adequate data for an Okmulgee model were not available.

$$\Delta \text{ USE} = -49{,}344.32 + 30.170 \text{ YEAR}$$

$$R^2 = .9693$$

$$\sigma = 49.2301$$

[b]Denotes missing data.

Hypotheses concerning each variable's relationship to monthly water use are:

1. Number of persons in household (NOPERS) - The first characteristic thought to have an influence on the amount of water used is the number of persons in the residence. It is hypothesized that an increase in number of persons per residence would increase the amount of water used.
2. Modern conveniences (BUILT) - Past works, such as the one by Burns and Goode (7), indicate that use of such modern conveniences as washing machines, dishwashers, and garbage disposals, as well as additional bathroom and shower facilities, contribute to a larger water use. Inclusion of these conveniences in homes built in the last several years is more common than for older homes. The year in which the residence was built proxies for the presence of any modern conveniences. Theoretically, one would expect water use to be higher the newer the residence.
3. Price (BILL) - Theoretically a negative relationship should exist between water use and price. However, the nature of the rate structure for water systems is such that as use increases, cost per additional gallon decreases. A typical rate structure, such as the one for RWD 5, Okmulgee County, is as follows:

0 - 1000 gallons	$9.50 minimum
1001 - 2000 gallons	$3.00/1000 gallons
2001 - 5000 gallons	$2.20/1000 gallons
Over 5000 gallons	$1.00/1000 gallons

Therefore a positive relationship between water use and price is hypothesized.

4. Education (TOTED) - It is anticipated that total years of education of the head of household would be a factor in determining water use. In general, people with a higher level of education tend to demand better services and more conveniences. Thus, it is hypothesized that total years of education and water use are positively related.

5. Non-domestic use - This factor accounts for the number of stock watered and the irrigation of home gardens.

   a. Water for stock (STOCK1, STOCK2) - Cattle and horses are often watered from water provided by the RWD. STOCK1 and STOCK2 are the variables designated to account for the number of cattle and horses, respectively, watered from rural water services.

   b. Gardens (G1, G2) - Each respondent to the questionnaire was asked whether they maintained a family garden which was irrigated from rural water services. G1 is structured, therefore, as a dummy variable, receiving a value of 1 if the garden was irrigated and zero otherwise. The contribution of G2 is included in the intercept term. It is anticipated that a positive relationship exists between the presence of an irrigated garden and water use.

6. Annual family income (XL, XU) - Household income is believed to be positively related to the total gallons of water used in the home. Data for incomes were collected by income ranges rather than as a continuous variable. The family gross annual income ranges were: $0-$2,500, $2,501-$5,000, $5,001-$10,000, $10,001-$20,000, $20,001-$40,000, $40,001-$60,000, and over

$60,000. The irregularity of the range intervals precluded the variable's use as a class variable, a matrix of seven dummy variables, X1 through X7 was structured. Preliminary analysis indicated that it might be appropriate to group income into two categories, XL for the five income ranges below $40,000 annually and XU for the two income ranges exceeding $40,000 annually. In the analysis, XU received a value of 1 if the income exceeded $40,000 and zero otherwise. The contribution of XL is included in the intercept term. As previously mentioned, income and water use are hypothesized to be positively related.

The general form of all models tested was:

MOGAL = f(NOPERS, BUILT, BILL, TOTED, STOCK1, STOCK2, G1, XU)

where MOGALS = Average monthly water use per user,

NOPERS = Number of persons per household,

BUILT = The year in which the currently occupied structure was built,

BILL = Dollar amount of the average monthly water bill per user,

TOTED = Total number of years of education for the head of household,

STOCK1 = Number of cattle watered from rural water service,

STOCK2 = Number of horses watered from rural water service,

G1 = Garden dummy variable indicating whether there was a garden irrigated from rural water service or not, and

XU = Income dummy variable indicating whether annual family income exceeded $40,000 or not.

Regression analysis results for six equations estimating water demand thought to be most appropriate on the basis of statistical reliability and economic consistency are presented in Tables V and VI.

TABLE V

SUMMARY OF WATER USE ESTIMATION EQUATIONS FOR RURAL WATER DISTRICTS, INCOMES SEPARATE

Variables	Model 1[a]	Model 2[a]	Model 3[a]
INCOME			
X2	-74.12 (.9264)[b]	-123.32 (.8786)	-159.84 (.8437)
X3	-400.79 (.5060)	-437.38 (.4708)	-484.74 (.4261)
X4	-607.84 (.2151)	-612.18 (.2148)	-677.68 (.1712)
X5	480.88 (.2935)	527.44 (.2521)	493.35 (.2861)
X6	1,568.77 (.0104)	1,701.13 (.0057)	1,656.21 (.0073)
X7	3,541.62 (.0001)	3,855.47 (.0001)	3,939.97 (.0001)
G1	915.34 (.0053)	864.17 (.0088)	896.76 (.0068)
NOPERS	948.59 (.0001)	944.57 (.0001)	953.54 (.0001)
BILL	134.26 (.0001)	133.54 (.0001)	134.62 (.0001)
BUILT	32.06 (.0002)	31.28 (.0003)	28.70 (.0010)
TOTED	72.38 (.1739)	80.07 (.1346)	100.46 (.0592)
STOCK1	51.00 (.0108)	53.94 (.0073)	
STOCK2	165.66 (.0023)		
INTERCEPT	-3,041.67 (.0003)	-2,992.41 (.0004)	-3,020.06 (.0004)

TABLE V (Continued)

Variables	Model 1[a]	Model 2[a]	Model 3[a]
R^2	.400	.391	.385
N	660	660	660

[a]None of the models presented include users (taps) which were installed for future use but currently pay the minimum water charge to maintain service without using any water.

[b]Numbers appearing in parentheses represent the observed significance level of the variable as determined by the "student-t" values (28).

TABLE VI

SUMMARY OF WATER USE ESTIMATION EQUATIONS FOR RURAL WATER DISTRICTS, INCOMES GROUPED

Variables	Model 4[a]	Model 5[a]	Model 6[a]
XU	2,221.92 (.0001)[b]	2,424.60 (.0001)	2,469.80 (.0001)
G1	953.86 (.0038)	900.23 (.0067)	935.21 (.0051)
NOPERS	954.86 (.0001)	952.88 (.0001)	961.71 (.0001)
BUILT	33.85 (.0001)	33.15 (.0001)	30.19 (.0004)
BILL	130.22 (.0001)	129.25 (.0001)	130.20 (.0001)
TOTED	102.76 (.0451)	114.67 (.0262)	137.60 (.0073)
STOCK1	55.49 (.0057)	59.12 (.0035)	
STOCK2	183.60 (.0007)		
INTERCEPT	-3,423.92 (.0001)	-3,517.08 (.0001)	-3,579.22 (.0001)
R^2	.387	.376	.368
N	660	660	660

[a]None of the models presented include customer taps which were installed for future use but are currently charged the minimum water rate to maintain service without using any water.

[b]Numbers appearing in parentheses represent the observed significance level of the variables as determined by the "student-t" values (28).

Models 1, 2, and 3 (Table V) are specified with separate income classifications. Models 4, 5, and 6 estimated using grouped income classifications (Table VI).

Grouping the data into the two income classes, below \$40,000 annually and above \$40,000 annually, draws attention to the question of the specification accuracy of these models. To test for appropriateness in specification, an F-test was formulated as follows for the two classes of models:

$$F_c = \frac{ESS_r - ESS_u/\text{number of restrictions}}{ESS_u/(\text{number of observations - number of regressors})}$$

where H_0: $B_2 = B_3 = B_4 = B_5$, $B_6 = B_7$ (restricted)

H_a: $B_i \neq B_j$ for all $i \neq j$ (unrestricted)

Alternatively expressed, the null hypothesis was that the coefficient for income groups above \$40,000 were equal. This was the restricted model. The alternative hypothesis was that coefficeints for all income groups were not equal. This was the unrestricted model. The appropriate F-tests were performed on models 1 and 4, 2 and 5, and 3 and 6. In all three instances, there was insufficient support to reject the null hypothesis at the .05 significance level. Therefore, it may be concluded that a proper functional form of the water use estimator model is one with income grouped into two classes, above and below \$40,000 annual family income (models 4, 5, and 6).

It can be seen from model 4 that for each additional person in a rural household, monthly water use will increase by 954.86 gallons. The presence of a garden which is irrigated will add 953.86 gallons per month. Each cow and horse watered from a rural water system will require 55.49 and 183.60 gallons per month, respectively. A family whose annual income is equal to or above $40,000 annually will use an additional 2,221.92 gallons of water per month. Each additional year of formal education for the household head is projected to increase monthly water consumption by 102.76 gallons. The coefficient which relates age of the residence to water use indicates that water consumption increases by 33.86 gallons per month the newer the house. As the monthly water bill increases by one dollar, water use will increase by 130.22 gallons per month.

If the mean value of each independent variable is applied to the equation resulting from model 4, an average monthly water usage of 5,887 gallons is estimated. This is well within the bounds of recent studies (18) (35). Based on model 4, a typical rural family of four with a household head who has a college education and an annual income of $30,000, maintains a family garden, has a cow and horse and lives in a home built in 1975 with a monthly water bill of $25.00 will use 7,737 gallons.

Estimation of Total System Water Use

Estimates of water use are developed for the Okmulgee County study area using the constant, percentage increase and trended increase methods. Population data utilized in estimating total system use for Okmulgee County are taken from the 1980 Census of Population (60). A summary of population by town and rural areas, number of customers and water use for the year ending December 31, 1980, is presented in Table VII. As of 1980, Okmulgee County had a population of 39,062 and 15,306 water customers or an average of 2.62 persons per customer. Annual total water use was 1.73 billion gallons.

TABLE VII

SUMMARY OF EXISTING WATER SYSTEM CONDITIONS IN OKMULGEE COUNTY, 1980

Entity	Population	Number of Taps	Persons Per Tap	Annual Water Use (1,000 Gallons)
Okmulgee	16,221	6,144	2.64	791,392
Henryetta	6,328	2,900	2.18	430,397
Beggs	1,650	570	2.89	39,884
Morris	1,450	575	2.52	40,234
Dewar	1,050	378	2.78	26,448
Rural	12,363	4,634	2.67	405,016
Total	39,062	15,306	2.62	1,733,331

One critical assumption involved in estimation of water use for Okmulgee County is that number of persons per tap (Table VII) remain contant for each entity through the year 2000. Using this assumption it is possible to derive the number of taps in futures years by dividing total estimated population by persons per tap. Population estimates through the year 2000 for the study were made by use of a demographic model developed by Oklahoma State University Extension Service (46). This model considers initial 1980 population of the various entities within the county and age cohorts to arrive at its projections over time. Since 1980 cohorts are presently not available from the Census Bureau, 1970 data were used. The population for each was then allocated according to age and sex. An annual in-migration rate of 0.467 percent, the actual migration rate of the country for 1970 through 1979 was employed to project future growth.

Results of the demographic analysis are presented in Table VIII. The county is projected to have a net population increase of 4,280 or 11 percent from 1980 to 2000. Rural areas are projected to have the largest relative growth, a 14.4 percent increase. This rural population growth is largely anticipated to occur in the northern end of the county, where large numbers of workers are expected to settle and commute to Tulsa and Muskogee.

Future water use estimates for Okmulgee County are presented in Table IX. (Identical information for rural Okmulgee County, Beggs, Morris, Dewar, Okmulgee and Henryetta are presented in Tables XXXIV through XXXIX, Appendix B.) In Table IX, it is illustrated that Okmulgee County had a 1980 population of 39,062 and a daily water use of 4,750,550 gallons. For the year 2000, the "constant" model projects a population of 43,343 and a daily water use of 5,216,180 gallons. The "percentage increase" and "trended increase" models project 5,537,850 and 12,466,520 gallons, respectively.

Application of Water System Capacity and Total System Water Use Estimates

Base figures for population growth and trends in increasing water use for all 16 systems in the county have been estimated in preceding sections. The same county-wide growth trend information was extended to apply to all RWDs. It was assumed that each water purchaser could obtain the required volume of water from Henryetta or Okmulgee upon demand. Current water service area configurations were maintained

TABLE VIII

POPULATION PROJECTIONS, OKMULGEE COUNTY, BY ENTITY, 1980-2000, SELECTED YEARS[a]

Year	Population Projections						
	Okmulgee	Henryetta	Beggs	Morris	Dewar	Rural	Total
1980	16,221	6,328	1,650	1,450	1,050	12,363	39,062
1985	16,584	6,300	1,700	1,493	1,081	12,760	39,882
1990	16,964	6,329	1,757	1,543	1,118	13,183	40,894
1995	17,433	6,405	1,819	1,597	1,158	13,648	42,096
2000	17,931	6,522	1,886	1,655	1,201	14,147	43,432
Percentage Increase 1980-2000	10.54	3.07	14.30	14.14	14.38	14.43	11.19

[a]The in-migration rate for each entity is assumed to remain constant at .467 percent per year, the actual migration rate of the county for 1970 through 1979.

TABLE IX

ESTIMATED DAILY WATER USAGE FOR OKMULGEE COUNTY, 1980-2000, SELECTED YEARS

Year	Population	Constant[a]	Percentage Increase[b]	Trended Increase[c]
		Gallons Per Day		
1980	39,062	4,750,550	--	--
1981	39,227	4,765,300	4,801,030	5,089,570
1982	39,376	4,779,970	4,848,060	5,439,320
1983	39,535	4,795,980	4,896,520	5,792,580
1984	39,705	4,813,370	4,945,490	6,149,520
1985	39,882	4,832,110	4,994,940	6,507,880
1990	40,894	4,941,140	5,194,740	8,376,500
1995	42,096	5,071,680	5,376,550	10,359,310
2000	43,342	5,216,180	5,537,850	12,466,520

[a]Assumes base year 1980 daily water use per customer remains constant at 240 gallons (page 10).

[b]Assumes base year 1980 daily water use per customer increases to 252, 262, 271, and 277 gallons in 1985, 1990, 1995, and 2000, respectively (page 10).

[c]Utilizes regression equations developed from historical trend data to estimate daily per customer water use (page 15).

through the analysis. Information developed from methods presented earlier in this chapter has been summarized in Table X. Water use for each RWD and community system was estimated in both gallons per day and gallons per year based upon historical growth rates in population and trended increase estimation of water use.

Henryetta and Okmulgee function as water service suppliers in the county. Five RWDs and Dewar are dependent upon Henryetta for their water; Okmulgee services the remaining six RWDs and Morris. Bearing this in mind, Henryetta and Okmulgee are evaluated as water service "groups". Distribution capabilities of each of the 16 systems in Okmulgee County were evaluated with respect to pumping and storage capacity and size of water supply lines.

Information regarding the number of users and the volume of water demanded from the water suppliers through the year 2000 is presented in Table XI. For example, in 1990 Henryetta, given the current service group configuration, will be responsible for supplying 4,691 users 2.64 million gallons of water per day.

A summary of water use estimates and current water supply conditions obtained from system managers for each water system is presented in Table XII. Average projected daily water use, storage capacity, water source, size of incoming line, pumping capacity and treatment plant capacity are reported. In this analysis water treatment plant capacity is the limiting factor. Comparing results shown in Tables XI and XII for the Henryetta service group, it can be seen that sometime between the years 1990 and 1995 demand for water will exceed the available supply. Total water requirements in the Henryetta service group are 3,212,092 gallons per day in 1995; the current treatment capability of

TABLE X

ESTIMATED NUMBER OF CUSTOMERS AND WATER USE FOR OKMULGEE COUNTY, BY ENTITY, 1980-2000, SELECTED YEARS

Entity	Year	Number of Customers	Water Consumption Daily	Water Consumption Annually
			Gallons	
RWD #1	1980	544	130,266	47,547,178
	1985	564	156,527	57,132,326
	1990	584	187,645	68,490,440
	1995	605	219,064	79,958,524
	2000	627	256,361	93,571,944
RWD #2	1980	417	99,855	36,447,009
	1985	432	119,893	73,760,490
	1990	447	143,626	52,423,490
	1995	464	169,402	61,831,730
	2000	480	196,258	71,643,170
RWD #3	1980	47	11,255	4,107,936
	1985	49	13,599	4,963,624
	1990	50	16,066	5,863,908
	1995	52	18,829	6,872,468
	2000	54	22,079	8,058,828
RWD #4	1980	450	107,757	39,331,305
	1985	466	129,329	47,205,078
	1990	483	155,193	56,645,346
	1995	500	181,045	66,081,425
	2000	518	211,795	77,305,050
RWD #5	1980	215	51,484	18,791,624
	1985	223	61,889	22,589,554
	1990	231	74,223	27,091,253
	1995	239	86,540	31,586,921
	2000	248	101,400	37,101,912
RWD #6	1980	1,419	339,794	124,024,175
	1985	1,470	407,969	148,907,722
	1990	1,523	489,355	178,614,622
	1995	1,578	571,378	208,552,978
	2000	1,635	668,502	224,003,394
RWD #7	1980	485	116,138	42,390,407
	1985	502	139,320	50,851,800
	1990	520	167,081	60,984,565
	1995	539	196,784	71,826,160
	2000	558	228,510	83,274,750

TABLE X (Continued)

Entity	Year	Number of Customers	Water Consumption Daily	Water Consumption Annually
			Gallons	
M & L	1980	510	122,125	44,575,479
	1985	528	146,536	53,485,582
	1990	547	175,757	64,151,148
	1995	567	205,305	74,936,336
	2000	588	240,416	87,751,682
Salem	1980	360	86,206	31,456,044
	1985	373	103,519	37,784,322
	1990	386	124,026	45,269,366
	1995	400	144,836	52,865,140
	2000	415	169,681	61,933,583
Dripping Springs	1980	126	30,172	11,012,765
	1985	131	36,356	13,270,097
	1990	135	43,377	15,832,550
	1995	140	50,693	18,502,799
	2000	145	59,286	21,639,448
Southeast	1980	61	14,607	5,331,577
	1985	65	18,039	6,584,399
	1990	70	22,492	8,209,470
	1995	75	27,382	9,994,399
	2000	81	33,118	12,099,242
Beggs	1980	570	109,270	39,883,550
	1985	588	150,880	55,071,200
	1990	608	193,670	70,689,550
	1995	629	239,330	87,355,450
	2000	653	288,910	105,452,150
Dewar	1980	378	72,460	26,447,900
	1985	389	99,820	36,434,300
	1990	402	128,050	46,738,250
	1995	416	158,280	57,772,200
	2000	432	191,130	69,762,450
Morris	1980	575	110,230	40,233,950
	1985	592	151,910	56,447,150
	1990	612	194,950	71,156,750
	1995	634	241,230	88,040,950
	2000	657	290,680	106,098,800
Okmulgee	1980	6,144	2,168,090	791,352,850
	1985	6,268	3,157,690	1,152,556,850
	1990	6,462	4,206,910	1,535,522,150
	1995	6,603	5,319,110	1,941,475,150
	2000	6,792	6,496,280	2,371,142,200

TABLE X (Continued)

Entity	Year	Number of Customers	Water Consumption Daily	Water Consumption Annually
			Gallons	
Henryetta	1980	2,900	1,179,170	430,397,050
	1985	2,890	1,621,260	591,759,900
	1990	2,913	2,066,620	754,316,300
	1995	2,938	2,534,850	925,220,250
	2000	2,992	3,033,930	1,107,019,450
Total	1980	14,631	4,748,879	1,733,340,339
	1985	14,942	6,514,536	2,378,805,394
	1990	15,355	8,389,041	3,061,999,158
	1995	15,750	11,364,058	4,147,881,170
	2000	16,222	12,488,336	4,558,242,640

TABLE XI

NUMBER OF CUSTOMERS AND WATER REQUIREMENTS FOR OKMULGEE COUNTY, BY SERVICE GROUPS, 1980-2000, SELECTED YEARS

	Supply System By Year	Number of Customers			Gallons Per Day Required		
		Supplier	Buyers	Total	Supplier	Buyers	Total
Henryetta	1980	2,900	1,670	4,570	1,179,170	381,843	1,561,013
	1985	2,890	1,729	4,619	1,621,260	471,710	2,091,970
	1990	2,903	1,788	4,691	2,066,620	573,387	2,640,007
	1995	2,938	1,852	4,790	2,534,850	678,242	3,212,092
	2000	2,992	1,921	4,913	3,032,930	799,937	3,832,867
Okmulgee	1980	6,144	3,917	10,061	2,168,090	910,506	3,078,596
	1985	6,268	4,055	10,323	3,157,690	1,112,996	4,270,686
	1990	6,462	4,202	10,664	4,206,910	1,348,454	5,555,364
	1995	6,603	4,357	10,960	5,319,100	1,592,526	6,911,636
	2000	6,792	4,517	11,309	6,496,280	1,869,279	8,365,559

TABLE XII

SUMMARY OF WATER USE AND SUPPLY CONDITIONS FOR OKMULGEE COUNTY, BY ENTITY, 1980-2000, SELECTED YEARS

Entity	Estimated Average Water Use					Storage Capacity	Water Source	Size of Incoming Line	Pump Capacity
	1980	1985	1990	1995	2000				
	Gallons per day					Gallons		Inches	GPM
RWD #1	130,300	156,500	187,600	219,100	256,400	75,000	Henryetta	8	120
RWD #2	99,900	119,900	143,600	169,400	196,300	a	Okmulgee	a	a
RWD #3	11,300	13,600	16,100	18,800	22,100	None	Henryetta	3	0
RWD #4	107,800	129,300	155,000	181,000	211,800	148,000	Okmulgee	4	130
RWD #5	51,500	61,900	74,200	86,500	101,400	120,000	Henryetta	6	250
RWD #6	339,800	408,000	489,400	571,400	668,500	156,000	Okmulgee	10 6	500 250
RWD #7	116,100	139,300	167,100	196,800	228,100	43,000	Okmulgee	4 2	80 80
Dripping Springs	30,200	36,400	43,400	50,700	59,300	32,000	Henryetta	4	140
M&L	122,100	146,500	175,800	205,300	240,300	165,000	Okmulgee	6	2@100
Salem	86,200	103,500	124,000	144,800	169,700	a	Henryetta	6	80
Southeast	14,600	18,000	22,500	27,400	33,100	None	Okmulgee	4	0
Dewar	72,500	99,800	128,000	158,300	191,100	500,000	Henryetta	8	0
Morris	110,200	151,900	195,000	241,200	290,700	50,000	Okmulgee	8	80
								Treatment Capacity	
Beggs	109,300	150,900	196,700	239,300	288,900	200,000	Treatment	175,000	600
Henryetta	1,179,200	1,621,300	2,066,600	2,534,800	3,032,900	1,800,000	Treatment	3,000,000	3@750
Okmulgee	2,168,100	3,157,700	4,206,900	5,319,100	6,496,300	2,500,000	Treatment	10,000,000	7,000

[a]Data not available.

the Henryetta plant is only 3,000,000 gallons per day. Okmulgee currently has a water treatment plant capacity of 10,000,000 gallons per day, well in excess of the projected water use by the year 2000 of 8,365,559 gallons per day.

Information in Table XII indicates that only RWD 5, Beggs and Dewar do currently meet the FmHA recommendations regarding storage capacity. RWD 4, RWD 7, M & L, Dripping Springs, Henryetta and Okmulgee have storage capacity equal to or somewhat greater than their average daily use, while RWD 1, RWD 6 and Morris have less than their average daily use in storage capacity. RWD 3 and Southeast have no storage.

Potential Application of the Regression Method of Water Use Estimation

Estimation for water system use can be facilitated by the regression method as well as the three methods utilized for the Okmulgee County example just presented. The regression method is particularly useful in instances where small additions in number of customers served or expansions to new service areas are under consideration. In such cases it is likely that characteristics of income, educational level, number of persons per household, age of home and water use for garden irrigation can be obtained. These data can be used to estimate water use for the additional customers.

Appropriate application of the regression method is not restricted to small scale additions or expansions. Accurate water use estimates may be made on a district-wide basis or for large scale expansions substituting mean values for rural residents of a county from 1980 Census Reports into the regression equation developed in this chapter.

This eliminates the need for collection of large quantities of primary data which are necessarily site specific. An example using the regression method is presented in a case study in Chapter VI.

CHAPTER III

ECONOMIES OF SIZE IN RURAL WATER SYSTEMS

Rural water systems are currently being affected by increasing economic pressures. Demand for water is increasing due to increasing customer numbers and increasing per capita water consumption. As a result, many rural systems are confronted with choosing to serve additional customers through expansion or limiting their systems to serve only current customers. Expansion is often the selected alternative. This generally requires enlarged facilities to treat, store or distribute adequate volumes of water to the customers. The factors affecting increased system capacity, when coupled with rising costs, place additional strain on systems which may already be at the limit of their operational, managerial and financial capacities.

Several questions repeatedly surface in the decisionmaking process involved with water system planning. Should the policy-making body adopt an expansion strategy or elect to maintain the system at its current size? What is the optimal size in terms of technical efficiency? Can the number of customers be increased within the bounds of existing system capacity? Can economic advantages be gained with expansion? Is it possible that higher quality water service can be provided with a larger system? Is consolidation a viable vehicle for attaining managerial, operational or financial improvements in the system? What can be expected in the political, physical, legal and financial senses if the option of consolidation is selected? It is the intent of this chapter to address these and other pertinent questions by investigating the existence of possible economies of size in rural water systems. A discussion of advantages and disadvantages of water system consolidation is also presented.

Economies of Size

Size economies exist at some point for virtually every local government service, although there appear to be diseconomies for very large sizes (27). Morris (43), in 1973, found that economies for various services exist in communities with populations between 10,000 and 500,000. Hirsch (22) found economies to exist in communities with 50,000 to 100,000 populations. Fox (16) poses three issues regarding economies of size research: (1) Do results of economies of size research suggest that service districts be consolidated? (2) What happens to costs as population changes? (3) What happens to costs if services are expanded to serve an increasing population?

Analyses have been conducted to determine whether economies of size exist in service provision in rural areas. Of particular interest has been research focusing on the cost structures of rural water systems. The review of economies of size research which follows should be useful to local decisionmakers as they seek to properly plan for adequate water services in the future by expansion or consolidation of service districts.

A Selected Review of Literature

Much of the research on economies of size has involved the estimation of average cost (AC) curves where AC is dependent upon a series of factors representing price and quantity of inputs, service conditions such as population and weather, state of technology and scale of output. Ordinary least squares regression has been the most widespread technique employed in economies of size research.

Bourcier and Forste (5) estimated costs curves for ten water systems in New Hampshire and Maine based on accounting data for the period 1955 to 1965. Cost economies were found when water works expanded capacity by adding wells, pumps, auxiliary equipment or transmission mains. Diseconomies were indicated when capacities were increased by adding to surface supply or extensive treatment facilities. Their conclusions were that these apparent cost economies were a result of time trends related to costs but did not indicate whether costs were standardized over time.

Research by Daugherty and Jansma (13) involved a sample drawn from 246 Pennsylvania water authorities ranging in size from 55 to over 42,000 customers. This 1973 study employed cross-sectional data and used stepwise regression to estimate average cost curves. To check for the existence of economies of size, Daugherty and Jansma estimated the AC as dependent upon population and water volume produced. Results indicated that very slight economies existed when customers served and water sold increased by the same rate. Economies exhibited were more apparent for surface water systems than for groundwater systems. If water use per customer increased, however, substantial size economies resulted.

Johnson and Hobgood (27) examined 62 rural systems in Louisiana. Sizes of the systems ranged from 23 to 686 customers. Stepwise multiple regression was used to estimate cost curves for three groups of systems:

(1) those with less than 100 customers; (2) those with 100 to 199 customers; and (3) those with 200 or more customers. Cost curves were estimated for annual fixed, variable and total costs. Constant economies were found for groups 1 and 3 while no economies of size were apparent for group 2. Criticisms of this study include the limited sample size, arbitrary nature of the size divisions and use of debt payment as a measurement of fixed costs.

In a 1974 study of Oklahoma rural water systems, Sloggett and Badger (55) investigated the economies of size question by employing a per capita cost approach. They found that for both investment and annual costs, the number of customers appeared to have no significant effect on costs. It was found, however, that as density of customers increased by one customer per mile, annual costs per customer would decrease by $1.45 for systems on well and $2.25 for systems which purchased treated water. Due to their sample (only 8 of the 57 systems had over 500 customers), no conclusion could be drawn with respect to economies of size.

In a 1979 study of 82 Oklahoma rural water systems, Goodwin et al. (18), attempted to detect possible economies of size within each system type and for all systems considered. Upon analyzing the available data, average costs did not differ by system type. For purchased, groundwater, and water treatment systems average annual operating costs were $70.25, $68.01 and $53.24 per customer, respectively. There was not conclusive evidence to indicate economies of size existed over the range of observations (89 to 1,285 customers) involved in this study. The researchers hypothesized that economies of size might be detected if larger systems had been analyzed or if more observations had been available.

Another research effort by Kuehn et al. (35) investigated rural water systems in Missouri for possible economies of size. No significant differences were found in capital costs to indicate the presence of economies of size. Differences were noted in annual operating costs between groundwater and purchased water systems. In addition, a considerable difference was detected between Ozark and non-Ozark costs. Briefly, Kuehn's findings were that average cost per customer were: (1) $52.62 for non-Ozarks groundwater (no treatment) systems; (2) $71.39 for Ozarks groundwater (no treatment) systems; (3) $77.49 for non-Ozarks groundwater (treatment) systems and (4) $99.05 for systems purchasing treated water. Operating costs per customer were nearly constant for districts purchasing water and for groundwater districts with fewer than 700 customers. No definite conclusions could be drawn concerning possible economies of size because the sample of 72 contained very few large districts.

Service District Consolidation

Economies of size is a long-run concept. It measures the costs of providing services to an area of given size excluding any short-run size adjustments. In many ways, it is appropriate to view consolidation of water districts in light of economies of size. It may be that a district with high average costs would consolidate with a district with lower average costs and a constant cost structure. This might lower costs of the first district without appreciably affecting the costs of the second.

Operation, construction and maintenance costs which change as a result of consolidation may be evaluated. The effect of increased customer numbers and change in customer density might also be analyzed. However, expenditures for service provision respond to such changes in a lagged fashion and as a result may either understate or overstate initial changes in expenditures (16).

Size-economies research addresses only the cost side of service provision. Population changes due to consolidation might change the income of the area, thereby changing demand for water services and resultant revenues. These revenues must be considered in evaluating net results of changes in average costs related to consolidation.

It is evident that not all potential benefits and costs of consolidation are revealed through the strict economic analysis of economies of size research. Consolidation may result in changes in service quality, a factor which must be considered when evaluating consolidation. Also to be considered are factors such as political feasibility, technical and financial constraints to consolidation, and legal questions which may arise as a result of consolidation. Economies of size research does not fully address these very important components in the local decisionmakers determination of whether service district consolidation is a viable planning alternative.

Empirical Results

Since decisionmakers of many RWDs are faced with the problem of providing quality service at least cost to their customers, the option of combining rural water districts is often evaluated. FmHA personnel will frequently suggest consolidation as an alternative.

Methodologies which can be used to evaluate consolidation include economies of size studies as well as case studies. Economies of size studies summarize expected savings as size of system increase. Case studies can provide insight into technical, political, financial and legal problems related to the consolidation process.

Economies of Size Analysis

Data for economies of size analysis were gathered from 111 systems throughout Oklahoma and Missouri. Information for each system was obtained through interviews with system clerks and managers, district audits, and State Health Department and FmHA records. Annual costs were categorized as either capital or operating. Capital expenditures were those going toward equipment purchase and system debt service. All other expenditures were considered to be operating costs. Cost data were for FY 1978, 1979 and 1980 but were adjusted to 1980 dollars by use of the Consumer Price Index.

The RWDs in the study area were classified by one of three water sources: groundwater; water treatment; or treated water purchase. Size of the systems in terms of customers served ranged from 98 to 1,585. The average system size was 483 customers. Of the 111 systems, 69 had fewer than 500 customers, 29 had between 500 and 999 customers, and 13 systems had 1,000 or more customers. In all, 28 systems utilized a groundwater source, 18 utilized water treatment, 57 purchased treated water and 7 systems used a combination of groundwater and purchased treated water.

Data for the study area were analyzed to detect any economies of size which might exist in annual total, capital or operating costs. A regression analysis was carried out for all systems in the aggregate and for each of the system classifications. Models run for each classification were:

Annual total cost per customer = f(number of customers),

Annual capital costs per customer = f(number of customers),

Annual operating costs per customer = f(number of customers).

Data in Table XIII indicate that none of the three models reflecting all systems had a high R^2-value or statistically significant coefficients. Therefore, it was concluded that for the range of observations in this study, no economies of size existed in total costs, capital costs, or operating costs.

Results for regression analysis for systems by water source are shown in Table XIII. Quick inspection of these results reveals that, as in the case for all systems in the aggregate, statistical analysis lends little support for the hypothesis that economies of size exist in certain types of systems. R^2-values were extremely low and the coefficient for the SIZE variable was not significant. One possible exception is the equation for total costs for water treatment systems.

Based on results of the analyses, no economies of size appear to exist in water systems over the range of observations included in this study. A plot of the total average costs per customer with number of customers is presented in Figure 2. If the points on Figure 2 are thought to be points on the long-run average cost curves, the envelope of the curves could be nearly flat as it joins the minima of curves.

From this analysis, one conclusion seems plausible. The districts are probably operating in that portion of the cost structure for all systems which appears to be relatively constant. The study may be criticized for not having enough observations in the large categories. If larger rural systems were avilable for inclusion in the analysis perhaps economies of size would have evidence themselves.

TABLE XIII

RESULTS OF ECONOMIES OF SIZE ANALYSIS, BY COST CATEGORY AND WATER SYSTEM CLASSIFICATION

System Type	N	Variables: Size	Variables: Intercept	R^2
All Systems				
Total Costs	111	-.026	66.275[c]	.015
Capital Costs	111	-.012	22.122[c]	.016
Operation Costs	111	-.016	27.470[c]	.024
Groundwater				
Total Costs	13	-.142	227.183[b]	.030
Capital Costs	13	-.120	140.386[b]	.035
Operating Costs	28	-.032	46.491[b]	.043
Water Treatment				
Total Costs	6	.042	55.201[a]	.435
Capital Costs	6	.012	-3.162	.172
Operating Costs	18	.008	2.102	.050
Purchased Water				
Total Costs	22	-.008	123.094[c]	.002
Capital Costs	22	-.024	62.928[c]	.024
Operating Costs	57	-.016	23.966[c]	.028
Combination System				
Total Costs	7	-.119	87.298	.159
Capital Costs	7	-.039	29.253	.110
Operating Costs	7	-.080	58.045	.185

[a]Statistically significant at the .1 level.

[b]Statistically significant at the .05 level.

[c]Statistically significant at the .01 level.

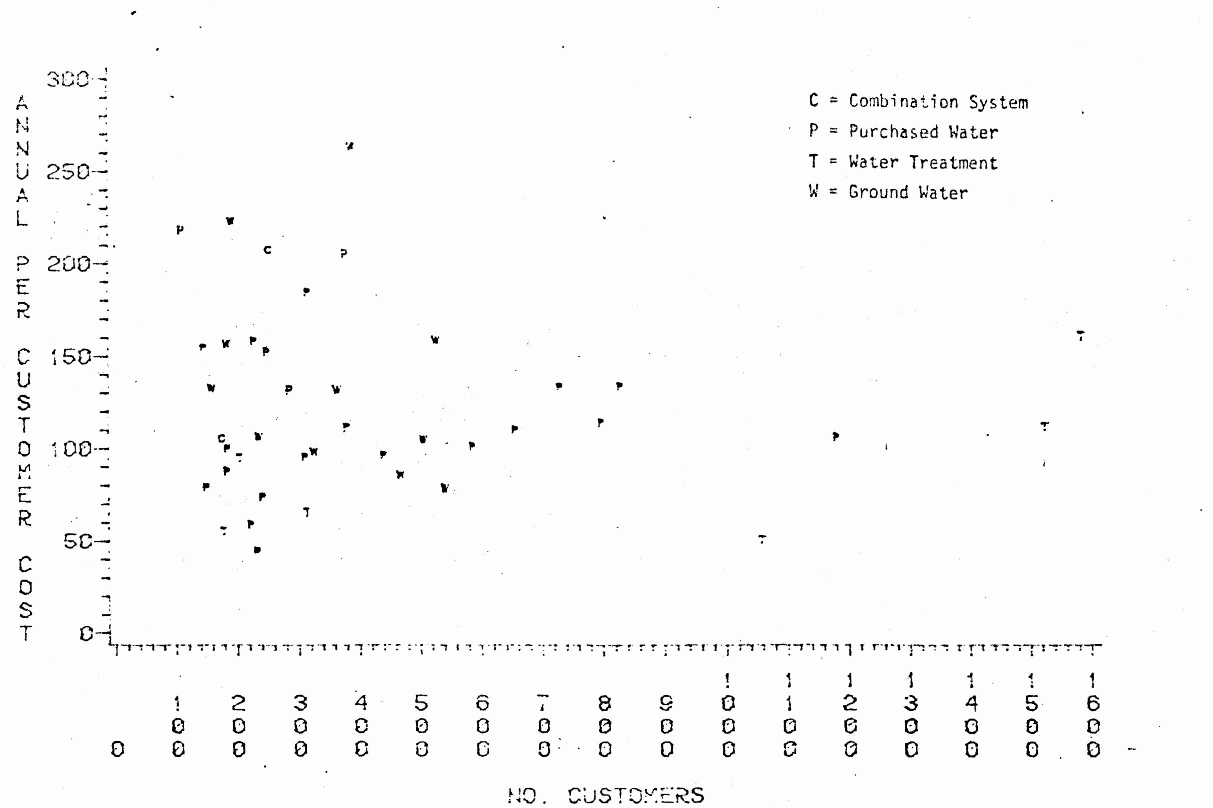

Figure 2. Average Total Cost Per Customer for 111 Rural Water Districts in Oklahoma and Missouri

Case Study of Consolidated Rural Water Districts

Very few consolidated rural water systems exist in Oklahoma and Missouri. Only seven consolidated districts located in these states serve rural areas. These districts range in size from 264 to 3,813 hookups (customers). Their dates of creation, or consolidation, range from March, 1975, to April, 1980. Four of the districts are in Oklahoma and three are in Missouri. A summary of selected characteristics by district is shown in Table XIV. Data for each district appear in Appendix C.

Data were obtained through interviews with individual water system boards and employees and from FmHA records. The data for each district include: (1) reasons for consolidation; (2) the consolidation process; (3) changes in physical operation; and (4) financial status. These data were analyzed to discern changes within the districts which might have resulted from consolidation.

FmHA altered its regulations to allow the merger process as it currently exists in 1973. According to FmHA Instruction 451.5, State Directors are authorized to approve mergers or consolidations (hereafter referred to as mergers) when the resulting association will be eligible for an FmHA loan and assumes all the liabilities and acquires all the assets of the merged borrowers. Mergers are allowed when: (1) they are in the best interests of the Government and borrower; (2) the borrower can meet operating and maintenance expenses, debt repayment and maintain required reserves; (3) all property can be transferred to the borrower; and (4) the membership of each organization is involved and a majority of their members approve the merger (30).

TABLE XIV

SUMMARY OF SELECTED CHARACTERISTICS OF CONSOLIDATED WATER DISTRICTS

Name of District	Date of Consolidation	Number of Districts Consolidating	Number of Customers	Water Source	Full-Time Equivalent Employees
Oklahoma					
Alfalfa County 1	7/75	2	546	Wells	2
Dewey County 3	4/75	2	306	Wells	2
Jefferson County 1	7/75	2	931	Purchased Water	4
Nowata County 4	3/76	2	264	Purchased Water	1
Missouri					
Boone County 1	3/75	County-wide	3,813	Wells	8
Pemiscot County 1	10/76	3	2,026	Wells	6
Vernon County 1	4/80	2	1,354	Purchased Water	1

Reasons for Consolidation. Interviews with board members and personnel of the seven consolidated districts indicated that the idea of consolidation was posed to them by FmHA in three of the seven districts; FmHA encouraged all seven consolidations. The four districts which considered consolidation of their own accord cited several reasons for this approach to organization. Many of the original districts (16 before consolidation, seven after) realized that increased size would enable them to hire full-time employees for management and maintenance, thereby improving the service quality and financial stability of the system. There was an expressed desire to be in the position to extend services to new areas or increase them in current service areas of increasing settlement. Two of the districts in the study consolidated to secure adequate water supplied by drilling wells and cancelling unappealing water purchase agreements. Others wished to stabilize water pressure by interconnecting distribution lines. Two districts cited consolidation as an instrument by which they could become more competitive for state and federal assistance through grants and loans. In one district, FmHA strongly suggested consolidation due to the apparent inability of the districts to provide appropriate service or financial management.

The Consolidation Process. Not all districts approached concerning the possibility of consolidation agreed to it. In Nowata County, for example, four other districts were afforded the opportunity to merge with the two that did. In Vernon County one of the districts approached concerning consolidation refused. Their reason was fear of loss of local control or autonomy of their water district. FmHA officials indicate that this is the primary stumbling block to the consolidation process. In many rural areas the only governmental form present is a rural water district.

The districts which chose to consolidate expressed the same concerns, but thought the potential advantages in consolidation outweighed their fears of loss of control. Only one of the seven districts experienced any problems in obtaining cooperation and harmony between the formerly independent RWDs. This happened to be the district which FmHA reprimanded for poor operation and management, but all problems of this nature have been overcome and now no apparent jealousy or dissension exists.

Changes in the Physical Operation. The primary changed occurring in the consolidation of districts were: (1) hiring full-time management and maintenance personnel; (2) installation of interconnecting lines between districts; and (3) adding to or changing their water source. Before consolidation, only five of the 16 districts had full-time personnel. Upon consolidation, all of the districts were served by full-time employees or several part-time employees engaged in billing, management and maintenance. These employees can now be expected to detect and repair malfunctions in the system with a higher degree of efficiency than the volunteers which were previously relied upon. All but one of the consolidated systems own their own equipment (backhoes, ditchers, trucks) which may be utilized to repair system breakdowns or extend facilities. This, coupled with the existence of personnel availability, greatly improves the rapidity and quality of repair and maintenance. The presence of full-time management assists in coordination of operational functions, purchasing, billing, handling of complaints and obtaining information on sources of aid.

Interconnection of lines helped to stabilize water pressure and quantity of water available in the systems for their customers. Looping lines so that a continuous circuit of water existed was a major improvement in many of the districts. By interconnecting lines, it was possible to achieve increased service capability in terms of water quantities throughout the consolidated districts. In three of the seven districts, distances as short as one mile separated existing distribution lines of independent districts.

The third major area of improvement was in the addition or changing of water sources. This was a particularly important aspect for the Vernon County district, which was able to obtain its own water source by drilling wells. The establishment of these wells enabled them to no longer be reliant on other communities through purchased water contracts. For the four other districts using groundwater as their water source, it was possible to drill additional wells to meet increased demand in the areas where the best and most reliable water existed. This was not possible before consolidation. The systems utilizing purchased water are also in a better bargaining position now than before because they are larger single purchasers and can be relied upon to provide revenues to their water suppliers through increased purchases.

Financial Status. Six of the seven districts reported positive net revenues of the year ending December 31, 1980. Before consolidation, there were five districts reporting negative net revenues. Rate structures were greatly simplified in most instances through consolidation, as were the debt structures of the systems. (It was possible for all outstanding loans to be refinanced by FmHA.) Details of the financial situations of the districts may be found in Appendix C.

More interesting than net revenues and rate or debt structures is the cost per customer information that was generated through data obtained from the districts. This information is supplemental to the economies of size analysis reported earlier in the chapter and may be combined with it to draw implications concerning the value of consolidation with respect to cost savings. The cost per customer information for the consolidated districts appears in Table XV. Cost figures were obtained from system records. The costs for systems before consolidation were obtained from the audit of the last year's operation and were adjusted to 1980 dollars using the Consumer Price Index. Cost figures for consolidated districts were from audits for the year ending December 31, 1980, and are also in 1980 dollars.

If no consolidation had taken place and both customer numbers and cost structures remained constant, annual costs per customer for Mutual would have been $285.31 instead of the current $220.87 after consolidation. Notice that for all districts except Vernon County #1 annual costs per customer are less after consolidation than they would have been without consolidation. It is also interesting to note the wide differences in capital and operating costs between districts, especially between the first four districts (Oklahoma) and the last three (Missouri). This is due largely to accounting differences. Therefore, the figures representing annual total costs per customer are probably most valuable in drawing implications, although the change in capital and operating costs within a system are important.

Lower per customer costs in consolidated water systems are most likely the result of improved management and maintenance and elimination of duplicate services. With full-time management and maintenance

TABLE XV

SUMMARY OF ANNUAL COSTS PER CUSTOMER FOR CONSOLIDATED DISTRICTS, BEFORE AND AFTER CONSOLIDATION

Consolidated Districts	Year of Operation	Number of Customers	Costs Per Customer		
			Total	Capital	Operating
			Dollars		
Alfalfa County #1	1980	546	210.84	131.91	78.92
Alfalfa County #1	1975	190	390.59	244.08	146.51
Dewey County #3	1980	306	220.87	128.10	92.77
N. W. Dewey	1975	145	252.33	135.90	126.43
Mutual	1975	120	285.31	126.42	158.89
Jefferson County #1	1980	931	317.45	175.44	142.01
Addington	1975	56	362.80	182.45	180.35
Hastings	1975	110	387.95	159.08	228.87
Nowata County #4	1980	264	160.72	65.68	95.06
Nowata County $6	1976	115	284.01	156.19	127.82
Watova	1976	65	298.12	189.95	108.17
Boone County #1[b]	1980	3,813	151.55	54.31	97.24
Boone County #5	1975	485	124.16	90.12	34.04
Boone County #6	1975	934	267.81	36.38	231.43
Boone County #8	1975	691	193.67	34.85	158.82
Pemiscot County #1[b]	1980	2,026	111.98	32.81	79.17
Pemiscot County #1	1976	355	325.50	44.94	280.56
Pemiscot County #2	1976	419	159.47	22.49	136.98
Pemiscot County #3	1976	618	142.25	25.58	116.67
Vernon County #1[b]	1980	1,354	195.98	49.70	146.28
Vernon County #3	1980	447	183.40	70.24	113.16
Vernon County #4	1980	907	178.63	35.83	142.80

[a]All costs are in terms of 1980 dollars.

[b]Capital costs do not include depreciation or transfers to reserve funds for these districts.

personnel available, costs incurred due to water losses, less than optimal utilization of equipment, expensive contract labor and small-quantity purchasing of material can be reduced. It is also possible to eliminate costs which accrue as a result of duplicate office facilities, part-time labor and inefficient billing and record-keeping practices. Considerable cost per customer decreases, up to 85 percent in the comparison case of Watova and Consolidated Nowata County RWD #4, are shown in the case studies.

CHAPTER IV

FACTORS AFFECTING SETTLEMENT PATTERNS: THE DATA

The nature of residential development in rural areas greatly affects the characteristics of the community services provided in those areas. Settlement patterns which occur as a result of migration in rural areas to a large extent determine the demands placed upon costly services as well as the composition of those services. Out-migration may result in a community having increased per customer costs of maintaining services designed to serve a larger population while in-migration may require costly new service expansions or improvements. These difficulties are particularly evident in areas of rapid changes in population distribution.

Many rural water districts and community water systems are faced with the problem of under-capacity and inconsistent distribution of water to their customers. In planning for capital-intensive services such as water systems, it is of great importance that capacity and distribution capabilities exist in the correct places to meet current needs and allow for future growth. To facilitate proper system planning, it would be extremely important for decisionmakers to have at their disposal information which would identify the impact of various economic, sociological and demographic factors which influence settlement patterns in rural areas and, thereby, impact upon the cost and nature of service.

In order to address this objective, it is necessary to obtain an extensive amount of complete and accurate data. Much of the data relate to Okmulgee County, Oklahoma, but are utilized to develop a method for use on a widespread basis by decisionmakers. Adequate sources of secondary data are not available for the analysis desired in this study; therefore, collection of primary data is required.

A great deal of care must be taken to survey structure to help ensure quality data are obtained. Unless concepts are clearly defined and questions are unambiguously phrased, resulting data are apt to contain serious bias or misinformation. Designing a suitable questionnaire involves more than well-defined concepts and distinct phraseology. For instance, poor question sequencing and unduly long questionnaires may result in biased responses and low response rates. It is also important to present the questionnaire in an attractive and orderly manner. A careful study of research in designing a mailed survey, writing questions and sequencing questions was completed. A summary of the findings is presented in Appendix D.

The Study Area

The study area selected for administration of the survey consists of five rural water districts in Okmulgee County. The districts are Dripping Springs, Salem, RWD #5, M&L, and RWD #6. These particular districts were selected for a number of reasons. First, the districts are well dispersed geographically throughout Okmulgee County. Size of the districts range from 128 customers to 1,539 customers. Some of the districts are contiguous within Okmulgee County and some overlap into other counties. Districts are comprised of a cross-section of long-time rural residents, full- and part-time farmers, suburban commuters and retirement households. Three of the districts purchase water from Henryetta and two purchase from Okmulgee.

Dripping Springs RWD was established in 1973 and currently has 128 customers. It is located in southwest Okmulgee County. Many of the customers here are full- or part-time farmers. The district is entirely contained within Okmulgee County. Salem RWD is located in southern Okmulgee, northwestern McIntosh, eastern Okfuskee and northeastern Hughes Counties. It was established in 1970 and underwent a major expansion in 1980. The district currently serves 329 customers, most of whom are full- or part-time farmers, retirees or persons commuting considerable distances to work. RWD #5 occupies the extreme southwest corner of Okmulgee County. The district was formed in 1967 and currently serves 215 customers. Most of its customers are full- or part-time farmers or suburban commuters. These three districts purchase their water from the city of Henryetta.

M&L Water, Incorporated, is situated in east central and northeastern Okmulgee, northwestern Muskogee and southwestern Wagoner Counties. The district was established in 1969 and currently has 544 customers. Customers include suburban commuters, full- or part-time farmers, retirees and long-time rural residents. Many of these customers commute daily to jobs in Muskogee or Tulsa. The fifth district included in the survey, RWD #6, is located in northern Okmulgee and southern Tulsa Counties. It was established in 1968. Presently, there are 1,539 customers in RWD #6. This district has exhibited a rapid growth pattern and is comprised largely of suburban commuters and part-time farmers. M&L and RWD #6 purchase treated water from Okmulgee. M&L also purchases water from RWD #6 due to supply line capacities.

The Survey

Following the general guidelines of the total design method (see Appendix D), a questionnaire was structured and survey taken of the study area. A mail survey was completed and responses processed and analyzed.

The Questionnaire

Before developing this questionnaire, a number of existing research efforts were reviewed for guidance and suggestions in content and structure of the questionnaire: (1) the 1980 Census (60); (2) a Mississippi study (17); (3) a U.S.D.A. study (53); and (4) an Iowa study (37). The 1980 Census (60) was selected due to its comprehensive nature and also because its structure is familiar to respondents. A study of perceived quality of life changes of open-country residents in Mississippi by Frese (17) in 1980 revealed that quality of life was devised on the basis of seven characteristics. A questionnaire was devised to identify the following quality of life characteristics: (1) county government; (2) education; (3) income; (4) employment; (5) environment; (6) services; and (7) sub-populations, e.g., elderly, poor, minorities. Ross (53), in a 1979 U.S.D.A. study, used survey data to determine a series of socio-economic indicators such as income, education and plumbing of households as well as health and family status which contributed to social well-being. Factors affecting land use changes at the urban-rural fringe were investigated by Lee (37) in a 1979 study of Urbandale, Iowa. Lee found that during the period of 1950 to 1974, factors important in urbanization of land were availability of water and sewer service, distance to water and sewer trunk lines, distances to schools, commuting time to downtown

Des Moines and distance from interstate access roads. More specific to this study were surveys of farmers and rural residents in Kentucky, New York and Oklahoma (9) (11) (59). These surveys concentrated on perceptions of community structure, agriculture and quality of life as well as gathering a wide variety of pertinent socio-economic and demographic data.

These surveys, as well as survey theory, were employed to devise a questionnaire. It appears in Appendix E. The questionnaire contains a combination of open and close-ended questions which gather information on attitudes, beliefs, behavior and attributes of the respondents. Four pages of questions and a one-page map comprise the total length of the questionnaire. Introductory phrases accompany each section. Note that all questions may be answered with a numbered response which is either circled or provided by the respondent. This facilitates analysis and is less demanding on the part of the respondent. Questions 5 and 7 ask the respondent to assign a "score" or value to factors which influenced the decision to move to a rural area and determined their exact locational choice. The scoring range was from 1 to 99, with 1 being the least important. Follow-up questions for 5 and 7 are 6 and 8, respectively; these questions ask the respondent to rank the three most important factors in migration and settlement from most to least important.

Implementing the Questionnaire

Implementation of the questionnaire was begun by obtaining a cover letter printed on the letter-head of each RWD and signed by the respective operator or president. This letter was sent with the questionnaire and a postage paid envelope (Appendix E). Ten days after the initial mailing, a reminder postcare was sent to each RWD customer included in the survey process to encourage response.

Survey Response

A total of 2,558 questionnaires were mailed. Since current mailing addresses were obtained from the RWDs, none were returned by the U.S. Postal Service due to incorrect addresses. Of these 2,558 questionnaires, 1,172 were returned, a response rate of 45.8 percent. Only 33 of the questionnaires were excluded from the analysis due to uninterpretability. Research by Dillman (14) on response rates to TDM mail questionnaires showed an average of 74 percent for 48 surveys. These ranged from 50 to 94 percent. The surveys in the Dillman study, however, involved two mail follow-ups, a telephone follow-up and supplying the respondent replacement questionnaires if desired, which may explain the higher response rates.

Response rates for each RWD are shown in Table XVI. It is interesting that 53 percent of all responses came after the reminder postcard was sent, while only 47 percent of the questionnaires were returned after the first mailing. This implies the need for a follow-up reminder.

Analysis of the Data

Returned questionnaires were checked for consistency in response, uniformly coded and entered into the computer. Three methodologies were employed in analysis of this data. First, simple summary statistics, including frequency, mean and standard deviation were derived. Second, regression analysis was employed to achieve analysis of variance (ANOVA) tests on means of sample characteristics by classifications of the data by RWD, customer status and service importance. Third, the chi-square goodness-of-fit procedure was applied to questions 6 and 8. A frequency count of each factor cited as one of the three most important was made and compared against the expected frequency of that factor. Expressed mathematically:

$$E_j = p_j N, \qquad j = 1, 2, \ldots, n$$

where p_j = probability of a random observation being from some hypothesized distribution,

E_j = expected number of observations in class j given the distribution, and

N = number of observations.

TABLE XVI

QUESTIONNAIRE RESPONSE RATES FOR OKMULGEE COUNTY SURVEY BY RWD

RWD	Number Mailed	Number Returned	Response Rate (%)
Dripping Springs	123	64	52.0
M&L	511	276	54.0
Salem	317	165	52.0
No. 5	179	83	46.4
No. 6	1,428	584	40.9
Total	2,558[a]	1,172	45.8

[a]The number of questionnaires is less than the total number of customers due to elimination of duplicate billings and multiple hook-ups at customer residences.

The test statistic T (a chi-square) is given by:

$$T = \sum_{j=1}^{n} \frac{(O_j - E_j)^2}{E_j}$$

where O_j is the number observed in class j.

The criterion for rejection of the hypothesis of normal distribution would be a calculated chi-square greater than the tabulated chi-square for any given number of degrees of freedom (10).

Empirical Results

Means and Standard Deviations

The number of responses, the means, and the standard deviations obtained from responses to the questionnaire are shown in Table XVII. It may be necessary to refer back to the questionnaire when interpreting these characteristics. For example, a mean of 2.2979 for the "County of Residence" suggests that most respondents are from Okmulgee or Tulsa Counties, as they gave values of 1 and 2 respectively on the questionnaire. Average length of residence is just over 14 years, while average length of move is roughly 95 miles. Means and standard deviations of the next 31 items (Job Promotion through Other Reasons) relate to the score assigned to each variable as to its importance in determining migration and settlement. The factors of home ownership, rural living, environment and rural atmosphere have the largest mean scores. The average water consumption per month is 5669.96 gallons and the average monthly water bill is $14.73. These are 3.05 persons per household, each family having an annual income of between $20,000 and $39,999. The head of household has 12.49 years of formal education and a total daily

TABLE XVII

SUMMARY STATISTICS FOR RESPONSES TO SURVEY REGARDING REASONS FOR MIGRATION AND RESPONDENT CHARACTERISTICS

Variable Name	Frequency	Mean	Standard Deviation
County of Residence	1119	2.2979	2.1260
Length of Residence (Years)	1101	14.3642	15.3832
Length of Move (Miles)	1139	94.8885	330.7692
Job Promotion	1139	5.8560	18.6302
Job Transfer	1139	4.7875	17.1356
Job Change	1139	8.7937	24.7532
Seeking Employment	1139	3.7779	14.6418
Other Employment Reasons	1139	5.4276	18.0716
Entered or Left Armed Forces	1139	2.7858	11.5876
Entered or Left School	1139	2.8727	11.8610
Retirement	1139	8.7866	25.0612
Climatic Changes Desired	1139	4.7015	16.3222
Health Problems	1139	4.1422	15.3763
Change in Marital Status	1139	6.6839	21.5149
Closer to Relatives	1139	11.5961	27.7942
Desired Home Ownership	1139	29.4960	45.8430
Desired Rural Living	1139	59.9403	45.0443
Attend Elderly/Ill Relatives	1139	5.2353	17.9640
Nature of Job	1139	11.9947	28.1036
Cost of Housing	1139	22.8288	36.2842
Family Considerations	1139	33.1370	41.5563
Police and Fire Protection	1139	6.3837	17.2656
Water System	1139	23.1449	36.9402
Septic System	1139	10.0483	24.3419
Health Care Services	1139	6.9868	18.8747
Schools	1139	23.6234	37.1608
Paved Roads	1139	15.4153	39.7372
Driving Time to Work	1139	15.2151	29.9997
Recreational Oppotunities	1139	12.3582	26.5790

TABLE XVII (Continued)

Variable Name	Frequency	Mean	Standard Deviation
Environment	1139	38.4249	43.0099
Rural Atmosphere	1139	56.4618	44.4749
Low Land Availability	1139	16.8420	31.8468
Inheritance	1139	7.6172	23.2244
Other Reasons	1139	9.3099	26.9155
Customer Status	991	2.8163	1.8474
Service Importance	1015	1.4187	.4936
Garden Irrigation	1093	1.7109	.4536
Number of Cattle	1139	1.2335	6.2665
Number of Hogs	1139	.3204	3.4745
Number of Horses	1139	.5136	2.4204
Number of Poultry	1139	2.7682	10.2412
Monthly Water Use (Gallons)	946	5669.9651	6195.8016
Place of Work	1107	5.3957	3.0728
Daily Commuting Time	1030	2.1806	1.7603
Types of Quarter	1068	1.5112	1.1260
Lot Size	1069	2.8466	.9436
Persons Per Household	1071	3.0476	1.4249
Residence Constructed (Year)	839	1963.9630	19.2838
Total Education (Years)	975	12.4902	3.2889
Annual Family Income	835	4.3988	1.4328
Monthly Water Bill ($)	946	14.7304	15.3256
Ownership Status	1028	1.0739	.3508

commuting time of between 20 and 60 minutes. The average residence was built about 1964 as a single-unit dwelling and is on a lot of between 10 and 40 acres. A very slight majority of the respondents stated that if water service had not been available, they would still have moved to their current residence.

A summary of selected characteristics of respondents by variable appears in Table XVIII. Both frequencies and percentage contribution of variables by subcategories are presented. Just under 50 percent of all respondents were from RWD #6. Over 78 percent of all respondents live in Okmulgee and Tulsa Counties and 40.78 percent have lived at their current residence five years or less. Most of the respondents (45.11 percent) were original customers of their RWD and 41.87 percent would not have moved if water service were not available. Almost half of all respondents work in Tulsa County. The annual family income of 36.7 percent is between $20,000 and $39,999, with 32.51 percent of all household heads having at least some education beyond the high school level. Better than 60 percent of all respondents' households use 5,000 gallons of water or less per month and 69.34 percent have monthly water bills of less than $15.

Analysis of Variance

Results of ANOVA procedures on the survey data are reported in Tables XIX and XX. Tests for differences in the mean values for selected variables by water district are shown in Table XIX. The same testing procedure for selected variables by customer status and service importance groupings is shown in Table XX.

TABLE XVIII

SUMMARY OF SURVEY RESPONSES BY VARIABLE

Variable	Frequency	Cumulative Frequency	Percent	Cumulative Percent
District				
Dripping Springs	62	62	5.44	5.44
M&L	273	335	23.97	29.41
Salem	164	499	14.40	43.81
RWD #5	78	577	6.85	50.66
RWD #6	562	1139	49.34	100.00
County				
No Response	20	--	--	--
Okmulgee	609	609	54.42	54.42
Tulsa	267	876	23.86	78.28
Muskogee	74	950	6.61	84.89
Other	169	1119	15.11	100.00
Length of Residence				
No Response	38	--	--	--
0-5 years	449	449	40.78	40.78
6-10 years	190	639	17.26	58.04
11-20 years	197	836	17.89	75.93
21-40 years	188	1024	17.07	93.00
Over 40 years	77	1101	7.00	100.00
Length of Move				
0-10 miles	580	580	50.92	50.92
11-20 miles	155	735	13.61	64.53
21-50 miles	233	968	20.46	84.99
51-100 miles	59	1027	5.18	90.17
101-250 miles	29	1056	2.54	92.71
Over 250 miles	83	1139	7.29	100.00
Customer Status				
No Response	148	--	--	--
Original Service Area	447	447	45.11	45.11
Service Area Expanded	346	787	34.30	79.41
Moved into Service Area	204	991	20.59	100.00
Service Importance				
No Response	124	--	--	--
Would Move	590	590	58.13	58.13
Would Not Move	425	1015	41.87	100.00
Garden Irrigation				
No Response	46	--	--	--
Irrigate	316	316	28.91	28.91
Do Not Irrigate	777	1093	71.09	100.00

TABLE XVIII (Continued)

Variable	Frequency	Cumulative Frequency	Percent	Cumulative Percent
Monthly Water Use				
No Response	193	--	--	--
1-1000 gallons	83	83	5.54	4.54
1001-2000 gallons	145	228	19.56	24.10
2001-5000 gallons	351	579	37.10	61.20
5001-10000 gallons	288	867	30.45	91.65
Over 10000 gallons	79	946	9.35	100.00
Place of Work				
No Response	32	--	--	--
Home or Farm	160	160	14.45	14.45
Tulsa County	368	528	33.24	47.69
Okmulgee County	158	686	14.27	81.92
Retired	221	907	19.96	81.92
Other	200	1107	18.08	100.00
Daily Commuting Time				
No Response	169	--	--	--
0-10 minutes	386	386	37.48	37.48
11-30 minutes	104	490	10.10	48.58
31-60 minutes	223	713	21.65	69.23
61-120 minutes	257	970	24.95	94.18
Over 120 minutes	60	1030	5.82	100.00
Persons per Household				
No Response	68	--	--	--
1	94	94	8.78	8.78
2	379	473	35.39	44.17
3	224	697	20.91	65.08
4	217	914	20.26	85.34
5	109	1023	10.18	95.52
Over 5	48	1071	4.48	100.00
Lot Size				
No Response	70	--	--	--
Less than 1 acre	47	47	4.40	4.40
1-9 acres	429	476	40.13	44.53
10-39 acres	234	710	21.89	66.42
40 acres or more	359	1069	33.58	100.00
Residence Constructed				
No Response	300	--	--	--
Before 1940	112	112	13.35	13.35
1940-1949	43	155	5.08	18.47
1950-1959	75	230	8.94	27.41
1960-1969	123	353	14.66	42.07
1970-1979	387	740	46.13	88.20
After 1979	99	839	11.80	100.00

TABLE XVIII (Continued)

Variable	Frequency	Cumulative Frequency	Percent	Cumulative Percent
Annual Family Income				
No Response	304	--	--	--
Less than $2,500	36	36	4.31	4.31
$2,500-$4,999	58	94	6.95	11.26
$5,000-$9,999	99	193	11.85	23.11
$10,000-$19,999	193	386	23.11	46.22
$20,000-$39,999	302	688	36.17	82.39
$40,000-$59,999	87	775	10.42	92.81
Over $60,000	60	835	7.19	100.00
Total Education				
No Response	164	--	--	--
8 years or less	139	139	14.26	14.26
9-12 years	425	564	43.59	57.85
13-16 years	317	881	32.51	90.36
Over 16 years	94	975	9.64	100.00
Monthly Water Bill				
No Response	193	--	--	--
Less than $15	656	656	69.34	69.34
$15-$19.99	83	739	8.78	78.12
$20-$29.99	137	876	14.48	92.60
$30 or more	70	946	7.40	100.00

TABLE XIX

MEAN VALUES OF SELECTED VARIABLES FOR RESPONDENTS, BY RURAL WATER DISTRICT

Variables	Dripping Springs	M&L	Salem	RWD 5	RWD 6
Length of residents (years)	16.4426	15.7462[a]	20.2387	17.5333[b]	11.3608[c]
Length of move (miles)	103.3710	106.0293	122.7439	119.7692	76.9591
Job promotion	3.1935	5.6667	4.1280	6.0385	6.7026
Job transfer	4.0161	3.4505	6.1036	4.6410	5.1584
Job change	3.8548	12.1758	7.0305	10.5513	7.9662
Seeking employment	4.1612	4.8718	5.4756[c]	6.2564	2.3648[a]
Other employment reasons	5.4355	8.9597[b]	6.1158	3.6282	3.7598[c]
Entered or left Armed Forces	2.7258	3.0879	4.5243	3.5128	2.0373
Entered or left school	3.8387	2.4505	2.6707	1.0000	3.2900
Retirement	17.5806[b]	9.0623[b]	13.9451[c]	8.2820[b]	6.2473[c]
Climatic change desired	4.9355	4.6447	4.9573	3.2051	4.8363
Health problems	8.8548	4.6740	4.5671	2.2564	3.5018
Change in marital status	6.8548	6.7839	8.5427	4.5384	6.3719
Closer to relatives	9.3710	13.0146	15.2744	13.9872	9.7473
Desired home ownership	40.7903	39.5897	38.1098	43.0513	39.2189
Desired rural living	61.4032	52.8425	39.9756	62.4744	65.7829
Attend elderly/ill relatives	2.3387[a]	5.7472	9.7134[c]	5.2436	3.9982
Nature of job	10.3387	16.0037	13.9817	10.6795	9.8327

TABLE XIX (Continued)

Variables	Dripping Springs	M&L	Salem	RWD 5	RWD 6
Cost of housing	18.4839	17.4762	23.2988	24.0769	25.5679
Family considerations	25.7581	28.5971	30.8171	35.1538	36.5534
Police and fire protection	3.8064	5.0952	4.7134	5.3718	7.9217
Water system	22.9839	22.9524	18.2988	20.8077	24.9947
Septic system	12.9677	8.6703	7.7988	7.6026	11.3914
Health care services	8.3387	7.3004	7.1890	6.2564	6.7278
Schools	25.3064	23.0733	16.1402	24.5897	25.7544
Paved roads	18.3710	12.5055	10.8598[b]	18.3846	17.4199[a]
Driving time to work	14.8226	14.5897	9.3963	11.7051	17.7473
Recreational opportunities	12.9677	7.9634	15.5549	15.1154	13.1103
Environment	42.4516	30.5788[b]	35.5488	39.5769	42.4715[a]
Rural atmosphere	50.2581	49.0183	46.8658	59.0897	63.1975[c]
Low land availability	16.9516	13.7436	14.7439	16.0513	19.0569
Inheritance	4.6290	5.6593	12.3902	15.4614	6.4164
Other reasons	16.2097[b]	10.5018[b]	8.1463	7.1667	8.6068[a]
Customer status	2.5283	2.7617	2.2966	2.6197	3.0575[c]
Service importance	1.3333	1.3719	1.1942[c]	1.3151	1.5266[c]
Garden irrigation	1.7966	1.8161	1.7742	1.7922	1.6211
Monthly water use (gallons)	4521.5472	5283.9000[b]	4612.3077	4231.4478	6395.5491[c]
Daily commuting time (minutes)	1.5789[a]	1.6230	1.8759	2.0685	2.6203[c]

TABLE XIX (Continued)

Variables	Dripping Springs	M&L	Salem	RWD 5	RWD 6
Persons per household	2.7797	2.9846	2.9320	2.9067	3.1601
Residence constructed (year)	1955.9189[a]	1961.7930	1956.6697	1955.3333[a]	1968.3829[c]
Total education (years)	11.7647[a]	12.3898[b]	11.5211	12.0000	12.9708[c]
Annual family income	4.1489[b]	4.2374[b]	3.6555[c]	4.1967	4.7512[c]
Monthly water bill ($)	17.9924[a]	25.3505[n]	20.9410	19.9707	4.7547[c]

[a]Statistically significant at the .1 level.

[b]Statistically significant at the .05 level.

[c]Statistically significant at the .01 level.

TABLE XX

MEAN VALUES FOR SELECTED VARIABLES FOR RESPONDENTS, BY CUSTOMER STATUS AND SERVICE IMPORTANCE

Variable	Customer Status			Service Importance	
	Original Customers	Expansion Area Customers	Moved to Service Area	Would Move	Would Not Move
Length of residence (years)	20.6968[c]	9.6257	6.9751[a]	17.5486[c]	6.2596
Length of move (miles)	75.8546	104.8000	105.6373	89.2458	116.1388
Job promotion	5.2796	7.1294	7.4706	5.4949	7.5906
Job transfer	4.0134	5.1265	6.8431	5.1047	4.9412
Job change	7.6040	10.4735	9.7843	8.9814	10.1812
Seeking employment	3.8367	4.1500	4.0833	4.2339	3.4941
Other employment reasons	4.9843	6.8853	6.7500	6.6152	5.0494
Entered or left Armed Forces	2.6868	3.2088	3.5490	3.2830	2.5953
Entered or left school	2.2282	3.4000	3.8971	3.2424	2.6988
Retirement	7.8143	8.1324	10.1569	10.1661	8.7153
Climatic change desired	3.8054	4.6529	6.8725	4.0237	6.4235
Health problems	4.2908	2.7853	5.3284	4.6441	4.3142
Change in marital status	6.7562	7.6118	7.1324	7.2830	6.5224
Closer to relatives	11.3714	12.4029	11.4657	12.4627	11.4753
Desired home ownership	38.5928	47.8824	41.7941	42.6491	41.0824
Desired rural living	52.2327	69.3118	74.7451	58.8508[c]	72.6706[c]
Attend elderly/ill relatives	5.8031	5.0382	6.5049	6.7508[b]	4.1365[b]
Nature of job	12.8859	12.6147	12.5588	14.5492	10.7576

TABLE XX (Continued)

Variable	Customer Status: Original Customers	Customer Status: Expansion Area Customers	Customer Status: Moved to Service Area	Service Importance: Would Move	Service Importance: Would Not Move
Cost of housing	19.4698	28.0735	32.2549	22.1152	27.9929
Family considerations	30.5884	38.9559	40.0441	34.3169	36.9671
Police and fire protection	5.3244	6.7705	9.6522	5.6712	8.6024
Water system	21.5638	22.4824	34.5049	17.5051[b]	35.8329[b]
Septic system	9.2148	7.6412	12.6863	8.5220[b]	14.3506[b]
Health care services	5.9418	7.6412	11.4657	6.6949[b]	8.9647[b]
Schools	20.9284	27.9647	30.0098	22.6136	29.4776
Paved roads	14.1834	13.4176	26.2941	13.2949[b]	21.8306[b]
Driving time to work	12.9217	17.0235	21.1324	13.9305	19.8529
Recreational opportunities	10.1029	16.6471	13.9657	12.0847[c]	15.7553
Environment	32.7897	43.7706	54.0196	36.3424[c]	48.7412[c]
Rural atmosphere	48.6085	67.6941	70.9314	56.2847[c]	67.6470[c]
Low land availability	15.2483	19.9441	22.8431	17.2441	18.7553
Inheritance	9.6823	8.5853	5.2734	9.5542	6.1670
Other reasons	9.3714	11.6971	10.2206	10.2627	8.8635
Customer status	d	d	d	2.4844[c]	3.5108[c]
Service importance	1.2718	1.4251[c]	1.6350[c]	d	d
Garden irrigation	1.7773	1.6834	1.6207	1.7800[c]	1.5891[c]
Monthly water use (gallons)	5407.3920	5848.0836	6290.6444	5454.2576	6252.6233

TABLE XX (Continued)

Variable	Customer Status: Original Customers	Customer Status: Expansion Area Customers	Customer Status: Moved to Service Area	Service Importance: Would Move	Service Importance: Would Not Move
Daily commuting time (minutes)	1.8015[b]	2.4472	2.7835	1.9044[c]	2.7229[c]
Persons per household	2.8585	3.2036	3.3266	2.9841	3.1917
Residence constructed (years)	1957.2624[b]	1967.5625	1972.6036	1959.5490[c]	1972.7788[c]
Total education (years)	12.2776	12.6532	13.1868[b]	12.1868[c]	13.1741[c]
Annual family income	4.2651	4.4247	4.9130[b]	4.2110[c]	4.7812[c]
Monthly water bill	16.0087[a]	14.1662	14.0485	16.0907[b]	12.9765[b]

[a]Statistically significant at the .1 level.

[b]Statistically significant at the .05 level.

[c]Statistically significant at the .01 level.

[d]Mean value not appropriate for comparison.

Referring to Table XIX, it can be seen that there are significant differences in mean values between water districts for 18 of the 42 variables. RWD 6 appears to differ most from other districts as it has significant differences in means for 17 of the 18 variables. M&L, Dripping Springs, Salem and RWD 5 differ in 9, 8, 6, and 3 variable means respectively. Residents in RWD 6 have, in general, lived at their current residence a shorter time, value rural atmostphere and environment very highly, use more water, live in newer homes, and have higher educational levels and annual family incomes than the sample as a whole. However, for many of the characteristics considerable differences exist between the other four districts. On a variable by variable basis, the most differences appear to be in the mean values for: (1) length of residence; (2) retirement; (3) monthly water use; (4) residence construction; (5) total education; (6) annual family income; and (7) monthly water bill.

Very few differences exist in the means as related to customer status (Table XX). In fact, only seven variables showed any significant difference at all: length of residence; service importance; garden irrigation; residence construction; daily commuting time; total education; annual family income and monthly water bill. Persons who moved into a service area have higher educational attainment, greater annual family income and regard availability of water service as more important than do the other two groups. As might be expected, residents who were original customers of the district have lived in their current residence longer, live in older structures and commute less than residents in the other two categories.

The most evident differences appear between mean values for variables when grouped in terms of service importance. The groups, once again, are those who would have moved if water service were not available and those who would not. Those residents who indicated they would not have moved if water services had not been available value all aspects of rural living, water, sewer and health care services, and paved roads much higher than the other group. In addition, they have lived at their current residence a much shorter time, commute greater lengths of time, have higher income and educational levels and live in much newer homes than those who would have moved irrespective of water service availability.

Chi-Square Goodness-of-Fit Analysis

A chi-square goodness-of-fit analysis was performed on data obtained from responses to questions 6 and 8. These questions asked the respondent to rank the three most important factors influencing their migration and settlement decisions from most to least important. The analysis is summarized in Tables XXI and XXII. Three groupings of these columns appear in each table. This was done in the analysis to facilitate respondents which ranked only one or two factors as well as those who ranked three as requested. The expected frequencies (E_i) represent the total number of times each variable is selected as either one of the three, two or one most important factors in determining the respondent's decision. The actual or observed frequency (O_i) is a frequency count of each variable as it appeared in the ranking of importance factors.

Inspection of Table XXI reveals that when only the 15 variables listed are considered, a distribution other than the normal exists in

TABLE XXI

RESULTS OF CHI-SQUARE GOODNESS-OF-FIT ANALYSIS OF RANKED FACTORS DETERMINING MIGRATION TO A RURAL AREA

Variable	3 Ranked Factors			2 Ranked Factors			1 Ranked Factor		
	E_i[a]	O_i[b]	T[c]	E_i	O_i	T	E_i	O_i	T
Job promotion	74.6	39	16.99	27.5	10	10.99	12.2	1	10.28
Job transfer	74.6	22	37.09	27.5	5	18.25	12.2	1	10.28
Job change	74.6	49	8.78	27.5	7	15.13	12.2	8	1.44
Seeking employment	74.6	4	66.81	27.5	1	25.37	12.2	0	12.2
Other employment reasons	74.6	42	14.25	27.5	7	15.13	12.2	4	5.51
Entered or left Armed Forces	74.6	12	52.53	27.5	0	27.33	12.2	3	6.94
Entered or left school	74.6	13	50.80	27.5	1	25.37	12.2	0	12.2
Retirement	74.6	59	3.69	27.5	16	4.70	12.2	5	4.25
Climatic change desired	74.6	48	9.48	27.5	5	18.25	12.2	1	10.28
Health problems	74.6	30	26.66	27.5	5	18.25	12.2	1	10.28
Change in marital status	74.6	48	9.48	27.5	5	18.25	12.2	2	8.53
Closer to relatives	74.6	129	39.67	27.5	11	9.76	12.2	2	8.53
Desired home ownership	74.6	263	475.80	27.5	148	532.70	12.2	30	25.97
Desired rural living	74.6	336	915.95	27.5	187	955.00	12.2	122	988.20
Attend elderly/ill relatives	74.6	31	25.48	27.5	2	23.48	12.2	3	6.94
Total	1119	1119	1753.52[d]	410	410	1695.68[d]	183	183	1121.83[d]

[a]Expected response frequency.

[b]Observed response frequency.

[c]Absolute contribution to the overall chi-square statistic.

[d]Significant at a level greater than .01.

TABLE XXII

RESULTS OF CHI-SQUARE GOODNESS-OF-FIT ANALYSIS OF RANKED FACTORS DETERMINING EXACT LOCATIONAL CHOICE IN A RURAL AREA

	3 Ranked Factors			2 Ranked Factors			1 Ranked Factor		
Variable	E_i[a]	O_i[b]	T[c]	E_i	O_i	T	E_i	O_i	T
Nature of job	125.44	72	22.77	7.75	3	2.91	4.06	6	.93
Cost of housing	125.44	172	17.28	7.75	12	2.33	4.06	3	.28
Family considerations	125.44	268	162.02	7.75	13	3.56	4.06	4	0
Police/fire protection	125.44	3	119.51	7.75	1	5.88	4.06	0	4.06
Water service	125.44	152	5.62	7.75	3	2.91	4.06	1	2.31
Septic service	125.44	14	99.00	7.75	1	5.88	4.06	0	4.06
Health care services	125.44	8	109.95	7.75	0	7.75	4.06	0	4.06
Schools	125.44	171	16.55	7.75	2	4.27	4.06	0	4.06
Paved roads	125.44	68	26.30	7.75	3	2.91	4.06	0	4.06
Driving time to work	125.44	78	17.94	7.75	2	4.27	4.06	0	4.06
Recreational opportunities	125.44	33	68.12	7.75	1	5.88	4.06	0	4.06
Environment	125.44	247	117.80	7.75	20	19.36	4.06	3	.28
Rural atmosphere	125.44	493	1077.01	7.75	44	169.56	4.06	21	70.68
Low land availability	125.44	107	2.71	7.75	11	1.36	4.06	3	.28
Inheritance	125.44	38	60.95	7.75	2	4.27	4.06	4	0
Other reasons	125.44	82	15.04	7.75	6	.40	4.06	20	62.58
Total	2007	2007	1938.57[d]	124	124	243.50[d]	65	65	165.76[d]

[a]Expected response frequency.

[b]Observed response frequency.

[c]Absolute contribution to the overall chi-square statistic.

[d]Significant at a level greater than .01.

determining importance in decisionmaking. This is evidenced by the extremely large chi-square values (T). The vast majority of this chi-square magnitude is contributed by the variables "Desired home ownership" and "Desired rural living". Data in Table XXI also indicate that a non-normal distribution exists in responses to question 8 dealing with factors affecting exact locational choice of migrants. The overwhelming majority of contribution to the chi-square statistic is from the variable "Rural atmosphere". Considerable contributions are also made by other variables. This is true for variables with a very low observed frequency. It is therefore, extremely important to remember that this procedure tests for normality. If one wishes to draw inferences concerning the importance of factors in general, only the observed frequencies should be regarded and compared with their expected frequencies.

Summary

Analysis of data obtained revealed some differences between respondents by water district, customer status and evaluation of service importance. In general, residents living nearer Tulsa (RWD 6), customers moving into a water service area from outside and those who would not have moved if water service were not available exhibited very similar socio-economic characteristics. When only three or fewer factors were cited as important reasons for migration and settlement, rural atmosphere, rural living and environment were discovered to be the most important by chi-square analysis and frequency of observations.

These results imply the importance of identifying the nature of residents in a district in projecting potential growth of an area and planning for adequate services. The individuals identified as being close to a metropolitan area and relatively new residents in a service area, valued quality and availability of community services as important in their migration and settlement decisions (Tables XIX and XX).

CHAPTER V

FACTORS AFFECTING SETTLEMENT PATTERNS: THE ANALYSIS

Rural water systems are capital intensive and once installed are not easily changed or moved. For planning and cost effectiveness it is imperative that future growth and expansion of a system be considered when the rural water district is designed. Identification of conditions which explain and predict growth in a rural area are crucial. A method will be developed to identify factors which determine settlement patterns. Several studies explaining rural growth are discussed prior to the development of the method.

In the 1950s and 1960s some community development research focused on population change, specifically net migration from rural areas, and the increasing difficulty of providing quality community services to the remaining residents. Research indicated that low income and unemployment caused out-migration (20). During the 1970s the trend toward out-migration reversed. Many rural communities grew in population (23). The strong net in-migration and growth of nonmetropolitan areas in the South and West during the 1970s has renewed interest in migration patterns. In 1979, Long and Hansen (39) observed that the population shifts have been to areas where: (1) per capita income is below the national average; (2) unemployment is above the national average; (3) climate is mild; and (4) retirement or recreational facilities are present.

Beale (3), however, observes that economic factors have recently become less reliable in determining population growth. His 1975 study discovered that a large number of migrants cited reasons such as climate, environmental quality, amenities, and retirement as the prime motivation for relocation.

Long and Hansen (39) used data gathered from the 1978 Annual Housing Survey of the Census Bureau to determine if people are not more willing to move due to personal preferences such as climate and amenities. Thirty possible reasons for moving were given by respondents. Inspection of the data revealed that 23.8 percent of interstate migration was attributed to job transfer and 23.6 percent cited new jobs or employment search as the major reason for migration. Economic considerations alone, therefore, accounted for 47.4 percent of all interstate migration. Non-economic factors such as retirement, educational choices, family considerations, climate, and service preferences accounted for the remainder of the reasons for migration. Respondents reported that 7.5 percent moved to be closer to relatives, 5.4 percent to attend school, 5.1 percent desired a change of climate and 4.8 percent to enter or leave the U.S. Armed Forces. The remainder moved for a myriad of reasons including retirement, neighborhood considerations, desire to own their own home, or improvement in quality of services. The prevailing opinion, they conclude, is that reasons for migration are changing from previous survey years of 1948 and 1963, with greater emphasis on quality of life considerations as suggested by Beale in 1975 (3). If preservation or creation of environmental amenities and secondary considerations are becoming more important in determining where people live then local attractiveness may be of major importance in sustaining economic growth and stability.

Reasons for migrating within a region from urban to rural areas may not be the same as those for interstate migration. People choosing to change residences but maintain current employment may weight non-economic factors such as neighborhood, environment, services, and commuting conditions more heavily than interstate migrants. Hu (23) studied characteristics of Oklahoma intercouty commuters employing multiple regression analysis and analysis of variance methods. Twelve demographic and soci-economic characteristics were thought to be important in determining commuting characteristics. Of these 12, only seven proved to be statistically significant. Hu concluded that the average Oklahoma commuter would have a relatively low educational level, live in a county with relatively low wage rates and high population growth, own his/her own home, live close to an SMSA central city, and value availability of good roads.

Bearing in mind the capital intensive and highly fixed nature of water systems and the reversing trend in rural out-migration, it would be useful to rural decisionmakers to identify factors which influence settlement patterns in rural areas. Such information could be employed in the planning process to assist in optimal design and placement of systems with respect to treatment, storage, and distribution facilities. This chapter deals with identification of factors important to rural settlement patterns by presenting results of a factor analysis based on survey responses by residents in Okmulgee County. Results of regression analyses and analysis of variance by variable and socio-economic grouping are presented which exhibit the specific relationships among variables as well as differences which exist based on the socio-economic groupings.

Methodology

Factor analysis was selected as the primary method of analysis to determine factors influencing rural settlement patterns.[1] It is most widely employed as either an exploratory or confirmatory device. Factor analysis may be used as a way of minimizing the number of variables by ascertaining the appropriate number of hypothetical factors that can account for the observed variance in the data. This is the exploratory nature of factor analysis. On the other extreme, the researcher may have *a priori* hypotheses as to which factors are responsible for the covariance. In this case factor analysis may be considered confirmatory in nature. In this study, both exploratory and confirmatory uses are employed. Regression analysis and analysis of variance procedures are models which are subsequently used to identify specific relationships between variables and socio-economic groups. These results may be used as both explanatory and predictive planning tools.

Factor Analysis

The basic assumption underlying factor analysis is that observed variables are linear combinations of some hypothetical or underlying factors. Some of these factors may be assumed to be common to two or more variables and some are uniquely related to single variables. Unique factors are considered to be orthogonal to each other and, therefore, do not contribute to the covariance in the data. Only common factors contribute to the existing covariance between the observed variables.

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[1]Excellent discussions on the basic theory factor analysis may be found in Kim and Mueller (31) (32) and Gorsuch (19). For a considerably more detailed presentation of factor analysis, one may wish to refer to Harman (21) or Rummel (54).

Finding the common factor structure of a linear system assumed in factor analysis presents problems. The uncertainties involved in error-free identification are not results of statistical estimation and must be dealt with and resolved on the basis of factoral causation and parsimony (32). Given relationships among variables, the postulate of factorial causation imposes on the data a causal order which implies that observed variables are linear combinations of some underlying causal variables. The postulate of parsimony simply states that, given a series of factor models consistent with the data, the researcher accepts the most parsimonious of the models. Given the postulates of causation and parsimony and the properties of linear systems, it becomes possible to exactly identify the underlying factor pattern, provided the pattern is relatively simple and satisfies the requirements of simple factor structure.

Three steps are employed in obtaining solutions in factor analysis. First, a statistically and theoretically appropriate covariance or correlation matrix is prepared. The type of matrix prepared depends upon the method of factor analysis chosen. Second, the extraction of the initial factors is achieved. Third, these factors are rotated about their axes to arrive at an acceptable final solution.

Developing the Matrix. Upon collection of relevant data, an appropriate covariance or correlation matrix is developed. The matrix desired in factor analysis is one consisting of relationships among variables. In situations whereby the variables are standardized, or normal, all have a mean of zero and variance of one. No generality is forfeited in dealing with only normalized variables. The covariance between normal variables has a special name, the correlation coefficient ρ (32). Recalling covariance as follows:

$$\begin{aligned} \operatorname{cov}(X,Y) &= E(X_i - \bar{X})(Y_i - \bar{Y})/N \qquad i = 1, 2, \ldots, N \\ &= E(X - \bar{X})(Y - \bar{Y}) \end{aligned}$$

The correlation coefficient may be expressed as:

$$\operatorname{cov}(X,Y) = E(XY); \ \bar{X} = \bar{Y} = 0; \ \sigma_x^2 = \sigma_y^2 = 1.$$

$$\rho = \frac{\sigma_x^2 \ \sigma_x^2}{\sigma_x \ \sigma_y} .$$

The practical advantage in using the correlation coefficient matrix is that many of the computer analysis packages use it rather than the covariance matrix. Widespread use of correlation matrix analysis in previous research makes comparison and interpretation easier.

Extracting the Primary Factors. The objective of the second step in factor analysis, the extraction of primary factors, is to determine the minimum number of common factors that would satisfactorily product the correlations desired among the variables. A basic strategy which prevades the majority of all extraction methods involves hypothesizing the minimum number of common factors necessary to reproduct the observed correlations. Despite the straight-forward nature of this strategy, its application can take various forms due to the numerous criteria for maximum fit or minimum discrepancy. Two major types of solutions are the maximum likelihood method and the least squares method. The maximum likelihood method has variants of canonical factoring and procedures based on maximizing the determinants of a residual partial correlation matrix and is the method of choice for this study. The least squares method has variants including principal axis factoring with iterated communalities (33). There are three other major methods of factor extraction: alpha factoring; image analysis; and principal components. For discussion of major methods of factor extractions see Harman (21).

Maximum Likelihood (M-L) solutions center on the best estimation of factor loadings rather than on the reduction of residuals. Since there are many choices for estimating a function, the following statistical criteria are generally employed in choosing among them:

1. An estimator $\hat{\theta}$ is said to be consistent if it converges to the true parameter as the sample increases without limit.

2. An estimator is said to be efficient if it has the smallest limiting variance. Efficiency implies consistency.

3. An estimator is said to be sufficient if it utilizes all the information in the sample concerning the parameter.

4. An estimator is said to be unbiased if its expected value is the true parameter, i.e., $E(\hat{\theta}) = \theta$ (34).

The M-L estimation method satisfies the first three criteria. M-L estimators will generally be biased, but an unbiased statistic can be derived by obtaining the expected value of the estimator. The overall objective of the M-L solution is to find the factor solution which would best fit the observed correlations. The model to be used in M-L estimation for any variable irrespective of its measurement unit may be represented as follows:

$$X_j = A_{j1}F_1 + A_{j2}F_2 + \ldots + A_{jm}F_m + d_jU_j$$

where X_j = variable j, j = 1, 2, 3, ..., n,

A_{ji} = coefficient on variables X_j with factor F_i, i = 1, 2, 3, ..., m,

F_i = common factor for variables, $i = 1, 2, 3, \ldots, m$,

d_j = coefficient on unique factor, $j = 1, 2, 3, \ldots, n$, and

U_j = unique factor for variable X_j, $j = 1, 2, 3, \ldots, n$.

Without loss of generality, it may be assumed that all A_{ji} have zero means and that all factors are independent with zero mean and unit variance (44). Consequently, all X_j must be drawn from a multivariate normal distribution. Under this assumption, it is possible to determine the distribution function of the elements in the matrix. Given this result, the likelihood function of the Wishart distribution is obtained, and so the procedure for determining the covariance or correlation matrices and the factor patterns may be given. For a detailed mathematical presentation of the maximum likelihood procedure, see Harman (21), Chapter 10.

The calculation procedure for an M-L estimator begins with the limiting assumption that the factors are uniquely determined. The result of this assumption is that the factors have similar characteristics to principal factors in that they minimize the residuals within the restriction of being M-L estimators. All M-L factor solution procedures iterate from appropriate communalities. If communalities are too great, factor loadings for eliminated variables in the reduced variables situation are calculated using the principal component procedure, an appropriate technique since principal components are actually M-L estimates if the communalities are 1.0. Both sets of factor loadings are combined to give the complete factor matrix (19).

Rotating the Factors. Rotation of initial factors, the third step in factor analysis, involves finding simpler and more easily interpreted factors while keeping the number of factors and communalities of the variables at the same level. There are three approaches to the problem of factor rotation: (1) graphical; (2) analytical; and (3) targetting. Graphical rotation relies on rotating the axis through clear clusters of variables well separated from each other such that an easily detectable pattern is achieved. The more widely used method is the analytical approach in which algorithms are employed, free of subjective bias, to achieve more readily interpreted results. The third approach to rotation is to define a target matrix before rotation, and then find factor patterns closest to the target matrix. This method implies a certain a priori knowledge of factor patterns and is most often associated with confirmatory factor analysis.

Analystic procedures for establishing the positions of factors are preferred for several reasons. First, the relicability and quality of analytic simple structure can be easily investigated. Second, visual or graphical rotation can only be considered objective if it is carried out without any knowledge of the identity of the variables. If the investigator knows which variable is which he can easily manipulate the rotation to confirm his hypotheses or support his biases. The third reason is practicality. In cases where large volumes of data are present, graphical rotation becomes cumbersome and prone to error (32). Numerous procedures have been suggested as analytic tools for rotation. Most of the rotations are orthogonal in nature; some oblique rotations do exist. The most well-known orthogonal procedures are: (1) quartimax, which concentrates on simplifying factor rows; (2) varimax, which concentrates on simplifying factor columns; and (3) equimax, a weighted combination of the two. Varimax is widely used, and is the method selected for use in this analysis.

The problem in explanatory factor analysis is to simplify a factor since the interest lies in learning more about factors rather than individual variables. Kaiser (30) suggested a technique based upon the premise that the variance of the squared loadings within a factor be maximized rather than the variance of the squared loadings for the variables. This rotation position is sought where the variance is maximized across all factors in the matrix and is called the varimax solution. Maximizing the varimax function means that the tendency toward a general factor in a solution, a major drawback of the quartimax procedure, is minimized. Application of the varimax procedure does not guarantee maximum interpretability. Kaiser (30) found that the problem arose with variables having higher communalities and as a result over-influencing the final solution. To dampen or adjust for this, the squared loadings of each may be divided by its communality. It is this normalized varimax which is employed in contemporary varimax rotation procedures.

Multiple Regression Analysis

Multiple linear regression techniques are applied to data resulting from the factor analysis procedures. This regression analysis is intended to identify the interrelationships between individual dependent variables and the independent variables consisting of factor patterns. Once a factor pattern has been determined, the factors are quantified for explanation or prediction of future settlement patterns. The data must be transformed before this is possible. Alteration of the data is a three-stage process, involving standardization, weighting of factor loads, and summation of these weights into independent variables as factors.

Initially, all the data to be used in the analysis must be standardized by subtracting the mean of the variable from its observed value and dividing by its standard deviation. Once this is complete, the factor loads for each variable are multiplied by the standardized value of the variable to obtain a weighted factor load. These weighted factor loads are then summed to obtain the appropriate independent factor variable, i.e., F_1, F_2, F_3 or F_4, after which the regression analysis is possible.

Analysis of Variance

Analysis of variance (ANOVA) is employed to determine differences between the mean values of resulting factor structures classified by various characteristics of the survey respondents. Since there were uneven numbers of observations in each class, a simple linear regression was performed upon each mean by class. Any differences which exist between the mean of the groups will be indicated by significance levels as determined by the "student-t" values.

Data and Study Area

Data employed in the analysis to follow in this chapter is derived from the survey procedure of the five rural water districts discussed in Chapter IV. The districts are: (1) Dripping Springs RWD in southwestern Okmulgee County; (2) Salem RWC encompassing southern Okmulgee County and adjacent portions of Hughes, Okfuskee and McIntosh Counties; (3) RWD 5, which is south and west of Henryetta; (4) M&L Water Inc. in northeastern and east central Okmulgee County and adjacent portions of Wagoner and Muskogee Counties; and (5) RWD 6 in northern Okmulgee County and southern

Tulsa County. These districts have 128, 329, 215, 534, and 1529 customers respectively. M&L and RWD 6 are composed largely of part-time farmers and rural residents commuting to Tulsa or Muskogee for employment while the other three are largely made up of farmers and long-time rural area residents.

Empirical Results of Factor Analysis

Factor analysis using the data obtained from the survey of water customers in five RWD's was carried out employing various extraction and rotation techniques. The maximum likelihood procedure with a varimax rotation was selected for use in presentation of final results. Discussion of the criteria used in selecting the number of factors, determining non-trivial variables as factor loadings and identifying and interpreting the factor patterns is presented next.

Selection of Relevant Factors

Several guidelines are applied in determining the proper number of factors to retain. The most important guidelines involve: (1) significance tests; (2) variations of the eigenvalue criterion; (3) the criterion of substantive importance; (4) the Scree-test; and (5) the criterion of interpretability and invariance. The significance, eigenvalue and Scree-test criteria were used in combination to arrive at a suitable number of factors for interpretation.

At first all factors with eigenvalues greater than one were retained and rotated. In this instance, M-L "saved" only five factors for rotation out of the possible 45 created by the procedure. One factor is created for each variable included in the analysis. Preliminary eigenvalues for the five factors selected were 5.08, 2.39, 1.60, 1.50 and 1.26. The chi-square test for significance in checking for appropriate number of factors was 2006.74 at a probability level of .0001. Interpretation of the factors was difficult with five factors, so it was decided that additional procedures should be employed to help ensure interpretability. A plot of the eigenvalues for each factor, known as the Scree-Test,[2] revealed that the appropriate number of factors to be extracted and rotated was four (Figure 3).

Determination of Non-Trivial Factors

Once the appropriate factor pattern has been selected, it is necessary to determine which variables "load" on the factors in a non-trivial fashion. Non-triviality may be determined in many ways. Three of the more commonly used methods are stated below.

1. A variable may be considered as non-trivial in the factor if it "loads" at a level greater than .60 for one factor and less than .40 for all other factors. This is referred to as the 60-40 method.

2. A variable may be considered as non-trivial in the factor if it "loads" at a level greater than .50 for one factor and less than .30 for all other factors. This is referred to as the 50-30 method.

3. A variable may be considered as non-trivial in the factor if the difference between the greatest loading and all other loadings is greater than .20. This is referred to as the difference method.

Since to date there is no sound statistical basis for verifying these determination methods, they should be regarded only as guidelines.

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[2]Scree is a geological term referring to the manner in which rubble collects at the base of a cliff, steeply sloped at first and then flattening out to a nearly level curve.

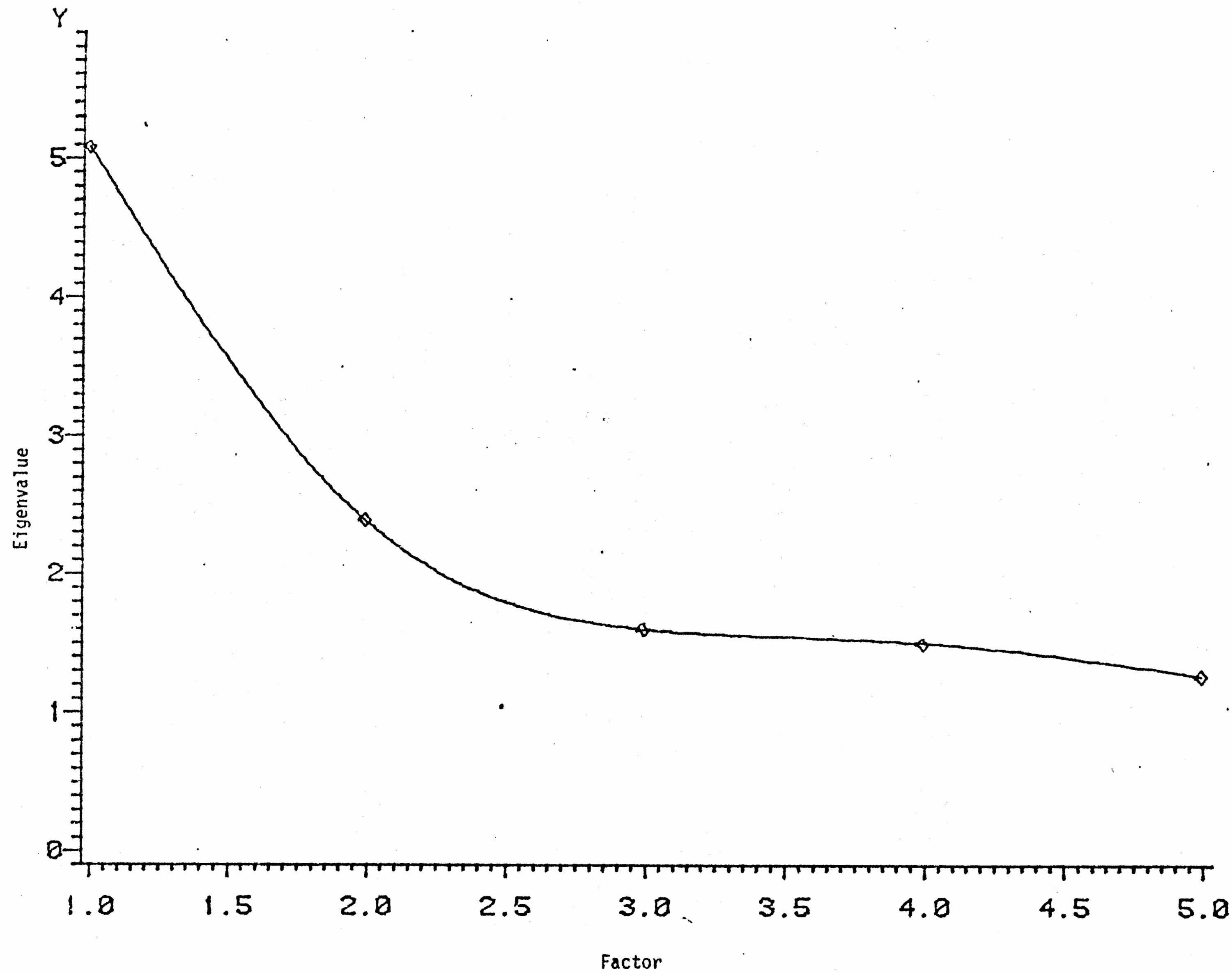

Figure 3. Plot of Factor Eigenvalues: The Scree Test

The 60-40 and 50-30 methods are traditionally the most widely used. However, recent work has given added credence to the difference method. Reinsch (50) (51) maintains that a difference method requiring only .15 difference between the greatest and all loads is adequate. Recent literature also indicates numerous researchers are now finding these difference methods to hold with expectations and theory in their fields (6) (19) (25).

In this study, a modification of the 50-30 and difference method as criterion for determining non-trivial variables will be used. Essentially, a variable is considered to be non-trivial if it loads at a level greater than .40 and has a difference of at least .20 between the greatest load and all other loads. Each loading squared and multiplied by 100 represents the percentage of variance in the variable attributed to the respective factor, so that a .40 load would translate to 16 percent of the variance of any particular variable being explained by the factor.

Inspection of Table XXIII reveals that for Factor 1, seven variables load as non-trivial. For Factors 2, 3, and 4 there are four, three and four non-trivial variables, respectively. Note that seven of the variables exceed the 60-40 method of determining non-trivial variables, six exceed the 50-30 method and the remaining five non-trivial variables exceed the .20 differcent criteria set forth in this study.

Identification and Interpretation of Factor Patterns

The most important step in any factor analysis is the identification and interpretation of factor patterns resulting from the analysis. In order to effectively perform the final step for this research, it may

TABLE XXIII

RESULTS OF FACTOR ANALYSIS, MAXIMUM LIKELIHOOD METHOD, VARIMAX ROTATION, 4 FACTORS

Variables	Quality of Services	Age of Home/ Water Service	Rural Atmosphere	Job and Relatives
County of residence	-.08889	-.25536	-.03086	.19496
Length of residence	-.06688	-.75357[a]	-.19185	-.01458
Length of move	-.05842	.10629	-.00995	.29059
Job promotion	.29958	.18808	-.04948	.21168
Job transfer	.22455	.12332	-.10816	.23642
Job change	.16500	.15115	-.11337	.40374[a]
Seeking employment	.05823	.03541	.08945	.49330[a]
Other employment reasons	.25050	-.00020	-.05832	.29103
Entered or left armed forces	.16722	.01108	.03821	.18669
Entered or left school	.28471	-.03431	.07207	.14129
Retirement	.03765	-.04763	.01966	.17545
Climatic change desired	-.02237	.10619	.12224	.16771
Health problems	.08063	.01781	-.02677	.14320
Change in marital status	.10510	-.03521	.04658	.20683
Closer to relatives	.02777	-.02124	.18719	.60861[a]
Desired home ownership	.06049	-.00338	.37903	.16971
Desired rural living	.02641	.22962	.72842[a]	.02221
Attend elderly/ill relatives	-.20963	-.13227	.13380	.50444[a]
Nature of job	.39393	.01234	-.11620	.23315
Cost of housing	.33631	.20050	.15603	-.21282

TABLE XXIII (Continued)

Variables	Quality of Services	Age of Home/ Water Service	Rural Atmosphere	Job and Relatives
Family considerations	.27614	.09046	.35785	.24804
Police/fire protection	.63422[a]	.04802	.08163	.11026
Water system	.51720[a]	.11756	.25658	-.01232
Septic system	.47841[a]	.06807	.17125	-.00780
Health care services	.66378[a]	.08638	.03204	.15828
Schools	.52450[a]	.08739	.22326	.01404
Paved roads	.55639[a]	.08109	.17020	-.06326
Daily commuting time	.59869[a]	.07640	.03589	.05467
Recreational	.29848	.08852	.25300	.07617
Environment	.29072	.16907	.57372[a]	.03642
Rural atmosphere	.16999	.23599	.71625[a]	-.00236
Low land availability	.27036	.04745	.22065	.15972
Inheritance	.12567	-.14027	.08179	.36146
Other reasons	-.06216	.00795	.02834	-.01102
Customer status	.08355	.41943[a]	.04857	-.04960
Service importance	.07821	.53222[a]	.07031	-.13755
Garden irrigation	-.02231	-.27993	-.11736	-.01129
Place of work	-.10102	-.05331	-.06046	.03441
Type of quarters	-.05564	.28712	-.00455	.11131
Persons per household	.01875	.29725	.05764	.08534
Residence constructed	.05991	.67411[a]	.05001	.03965

TABLE XXIII (Continued)

Variables	Quality of Services	Age of Home/ Water Service	Rural Atmosphere	Job and Relatives
Lot size	.01265	-.38688	.00098	-.13540
Annual family income	.16071	.37980	.10381	-.19177
Ownership status	-.04725	-.17008	-.08631	.10910
Total education	.14770	.36093	-.01593	-.01643

[a]Denotes non-trivial factor loading (absolute value greater than .4) retained for regression analyses.

be necessary to make frequent references to the survey instrument presented in Chapter IV (Appendix E). Each of the four revealed factors will be dealt with individually, first identifying and naming the factor with respect to non-trivial variable components and then interpreting their bearing on settlement patterns in rural areas.

Factor 1 is comprised of seven variables dealing with various services available to residents. Respondents assigned a "score" or value to each of a series of questions connected with why people moved to and settled in a specific area. The scores actually reflected the respondent's perception of quality or importance of each variable on their resulting settlement location. Variables loadings as non-trivial in Factor 1 are: (1) police and fire protection; (2) water system; (3) septic system; (4) quality of health care services; (5) quality of schools; (6) paved roads; and (7) driving time to work. Clearly each of these seven variables relate to services available and important to immigration to the five RWDs. It may be seen in Table XXIV that the weighted eigenvalues for the preliminary and rotated factor patterns of Factor 2 are 8.27 and 5.16 respectively. Since the square of the eigenvalue is actually a variance term, this infers that Factor 1 alone accounts for 68.4 and 26.3 percent of the common variance in the factor system.

Perception of complimentary services appear to be an important determinant in the settlement patterns of rural in-migrants. Since 26.3 percent of common variance in the system is explained by Factor 2, this implies that approximately one-fourth of the weight given to inputs in the settlement pattern decision process is attributed to the perceived quality of community services available in the area. This does not include any spurious variance due to the implementation of the maximum likelihood estimation procedure in factor analysis. The positive signs on all seven factor loads indicate that, if services are perceived to be of high quality and important, then settlement into an area is encouraged. In all following discussion Factor 1 will be called "Quality of Services".

TABLE XXIV

EIGENVALUES OF EACH FACTOR, PRELIMINARY AND ROTATED FACTOR PATTERNS

	Quality of Services	Age of Home/ Water Services	Rural Atmosphere	Job and Relatives
Weighted				
Preliminary[a]	8.27	3.71	2.42	2.12
Rotated[b]	5.16	4.47	4.27	2.73
Unweighted				
Preliminary[a]	4.97	2.33	1.47	1.46
Rotated[b]	3.39	2.63	2.19	2.03

[a]Eigenvalues of factors before rotation.

[b]Eigenvalues of factors after varimax rotation.

Four non-trivial variables are included in Factor 2: (1) length of time at current residence; (2) whether a respondent lived in the original service area, was an original customer, or moved in at some later date (customer status); (3) whether the respondent would have moved to his/her residence if water service were not available; and

(4) the year in which the current residence was built. The weighted eigenvalues for preliminary and rotated factor patterns are 3.71 and 4.47 respectively, which indicate that 13.76 and 19.98 percent of the common variation in the factor system is explained by Factor 2.

The four variables loaded on Factor 2 will be referred to as the "Age of Home/Water Services". Unlike Factor 1, this factor does not rely on perception of quality or importance of variables, but is comprised of quantifiable or yes/no responses. Signs of the factor loadings indicate that the length of residence is negatively related to settlement. A positive sign on the variable relating the age of home implies tnat newer homes are more likely to be occupied by in-migrants to the area. Positive signs on the remaining two variable factor loads imply that availability of water service encourages in-migration or settlement into an area.

Factor 3 of the revealed factor pattern is made up of three ariables. All three of these variables required that survey respondents assign a score to them indicating once again their perception of that variable in quality and importance as in Factor 1. The three variables are: (1) desired rural living; (2) environment (clean air and water); and (3) rural atmosphere. It should be clarified that the difference in (1) and (3) above relate to the question in which they were asked.

Weighted eigenvalues for preliminary and rotated factor patterns are 2.42 and 4.27 respectively, 6.36 and 18.23 percent of all common variance in the factor system. Positive signs on all three variables indicate that the general factor, termed "Rural Atmosphere", is a positive influence on settlement increases, or that a positive perception of the quality and importance of rural atmosphere is tied directly to encouraging settlement into the area.

The final factor is termed "Job and Relatives" and is identified by four non-trivial variables, all of which are based on scores assigned to the variables. These variables are: (1) different job; (2) seeking employment; (3) desired to be closer to relatives; and (4) attend elderly or ill relatives. The four variables accounted for 4.46 and 7.47 percent of the total common variance in the factor system as indicated by the eigenvalues (Table XXIV). Once again, all variables have positive signs assigned to their factor loads, as would be expected. People changing or seeking employment or having strong family ties in an area are more likely to settle there.

Empirical Results of Multiple Regression

Regression models for all variables in the factor analysis were formulated and statistically tested. These models are of the general form:

$$X_i = f(F_j)$$

where X_i = variable i, i = 1, 2, 3, ..., n, and

F_j = factor j, j = 1, 2, 3, 4.

Results of the regression models tested appear in Table XXV. See Appendix F for additional results.

Two characteristics of the regression results reported herein separate them from the usual types of regression models most often tested. Since the regressions are performed on dependent and independent

TABLE XXV

REGRESSION RESULTS USING FACTOR SCORES

Dependent Variables	R^2 [a]	Independent Variables: Quality of Services	Age of Home/ Water Services	Rural Atmosphere	Job and Relatives
Water service	.31	.1006 (.0001)[b]	.0657 (.0001)	.0057 (.0001)	-.0054 (.6760)
Police/fire protection	.32	.1490 (.0001)	.0046 (.8109)	-.0056 (.6263)	.0329 (.0235)
Septic service	.25	.0977 (.0001)	-.0021 (.8979)	.0151 (.1112)	-.0053 (.6596)
Health care services	.35	.1724 (.0001)	.0028 (.8876)	-.0200 (.0938)	.0352 (.0199)
Schools	.24	.0953 (.0001)	-.0094 (.6035)	.0443 (.0001)	.0069 (.6126)
Paved roads	.30	.1219 (.0001)	.0227 (.2112)	.0286 (.0075)	-.0196 (.1537)
Driving time to work	.24	.1241 (.0001)	-.0123 (.5448)	.0133 (.2653)	.0138 (.3665)
Length of residence	.44	-.0007 (.9429)	-.3624 (.0001)	-.0927 (.0001)	-.0095 (.5926)
Desired rural living	.41	-.0086 (.3723)	.0210 (.3728)	.4453 (.0001)	.0521 (.0034)
Environment	.37	.0559 (.0001)	.0093 (.6151)	.2038 (.0001)	.0061 (.6610)
Rural atmosphere	.50	.0221 (.0088)	-.0174 (.4041)	.4358 (.0001)	-.0178 (.2594)

TABLE XXV (Continued)

Dependent Variables	R^2 [a]	Independent Variables: Quality of Services	Age of Home/ Water Services	Rural Atmosphere	Job and Relatives
Closer to relatives	.19	.0061 (.4764)[b]	-.0294 (.1616)	.0275 (.0267)	.2567 (.0001)
Attend elderly/ill relatives	.19	-.0055 (.4176)	-.0156 (.3535)	.0120 (.2262)	.1968 (.0001)
Cost of housing	.18	.1158 (.0001)	-.0042 (.9056)	.0938 (.0001)	.0757 (.0456)
Family considerations	.24	.0897 (.0001)	-.0602 (.0847)	.1564 (.0001)	.1564 (.0001)
Recreational	.17	.1001 (.0001)	.0019 (.9583)	.1250 (.0001)	.0152 (.5727)
Daily commuting time	.17	.0255 (.1101)	.0348 (.3811)	.2216 (.0001)	.0501 (.0915)

[a]All regression models were tested based upon 689 observations.

[b]Numbers in parentheses represent the observed significance level of the variables as determined by the "student-t" values.

variables which may be interrelated.[3] It is necessary that the dependent variable be removed from the factor before the analysis is done. This prevents simultaneous bias. Additionally, the models tested in this analysis contain no intercept term. Rummel (54) states that if the data are standardized, then the intercept of a multiple regression is zero and all regression coefficients will vary between plus and minus one. In the regressions formed by a factor analysis procedure, the intercept is of no value and is therefore dropped.

The first equation reported in Table XXV may be expressed as follows:

$$\text{Water service} = 0.1006F_1 + 0.0657F_2 + 0.0057F_3 - 0.0054F_4 .$$

where F_1 = quality of services,
F_2 = age of home/water services,
F_3 = rural atmosphere, and
F_4 = job and relatives.

This equation represents the relationship between the "score" assigned to water services with the four factors of quality of services, age of home/water service, rural atmosphere, and job and relatives. A one unit increase in quality of services (F_1) results in a .1006 unit increase in the value for water service. This implies that as perceived ratio faction with quality of services increases the perceived satisfaction with water service increases. One unit increases in age of home/ water service (F_2) and rural atmosphere (F_3) will result in .0657 and .0057 increases in the value for water service. In other words, as

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[3]It is the case in 18 of the 45 models tested that a variable selected as dependent is also found to be in one of the factors used as an independent variable.

length of residence increases, or houses are built in later years, or the importance of water service in determining migration increases, the perceived quality of water service increases as well. Increased value attached to rural atmosphere has a like effect. Nothing can be said of job and relatives (F_4) as it relates to water service because of the highly insignificant t-values attached to it.

Interpretation of any of the remaining regression results in Table XXV or Appendix F may be made in the same manner as presented above. While most of the regression models tested contained only two or three of the four variables as statistically significant, considerable insight may be gained from them. Obviously, some large portion of the variation in the models tested was not detected by the number of variables on which data were obtained. Even so, results reinforce theory which suggests certain explanatory and causal relationships exist among the specified variables and factors.

Empirical Results of Analysis of Variance

It is hypothesized that a significant difference exists in weighting of the four previously identified factors by residents before a settlement decision is made. Five variables were used as criteria for classification of the respondents into two classes so that a one-way ANOVA procedure could be used to test the series of a priori hypotheses. The five pairs of classes were: (1) respondents who have lived at their current residence no more than five years and those who have lived there longer than five years; (2) respondents who moved into the water district service area and those who were in the original service area; (3) respondents who would not have moved to their current residence if water service were not available and those who would; (4) respondents whose annual family income is at least $40,000 and those who annual family income is below $40,000; and (5) respondents with more than 12 years of formal education and those with 12 or fewer years of formal education.

A priori hypotheses for the first of these five groupings were:

(1) those who have lived in their current residence five years or less would weight the quality of services and age of home/water services factors more heavily than longer term residents and that long term residents would weight the rural atmosphere and job and relatives factor more heavily than the newcomers;

(2) respondents making up the group of people moving into a rural water service area weight all factors more heavily than respondents living in the original service area;

(3) those willing to move only if rural water service is available weight all factors more heavily than their counterparts; and

(4) the higher income and more highly educated groups are hypothesized to weight quality of services and age of home/water services more heavily and the lower income, less educated groups are hypothesized to weight rural atmosphere and job and relatives more heavily.

Results of the one-way ANOVA comparison for differences between means are shown in Table XXVI. Only tests which indicated differences between means which were significant at the ten percent level were reported. In interpreting these results, it is required that the means of the groups be determined for each of the four factors. The group with the larger mean for the respective factor weight that factor more heavily. For example, newcomers weighted quality of services more heavily than long-time residents, but weighted job and relatives as a factor lower than those who have lived there longer than five years. These results confirm the a priori hypotheses. No differences were detected in the means for age of home/water services and rural atmosphere. Groups 2 and 3, which relate water customer status and availability of

TABLE XXVI

RESULTS OF TESTING BETWEEN MEANS FOR SIGNIFICANT DIFFERENCES BY FACTORS FOR SELECTED VARIABLES

Variables	Factors: Quality of Services	Age of Home/ Water Service	Rural Atmosphere	Job and Relatives
Length of Residence				
Five years of less	-.0802	b	b	-.2933
More than five years	-.4918			-.0725
	(.0593)[a]			(.0440)
Water Customer Status				
Moved into water district	-.3280	b	-.3756	-.0764
Lived in original service area	-1.1830		-1.4791	-.2638
	(.0001)		(.0001)	(.0858)
Availability of Water Service				
Would not have moved without service	-.2848	-.0196	-.3094	-.0662
Would have moved without service	-1.7022	-1.3724	-2.2340	-.3835
	(.0001)	(.0001)	(.0001)	(.007)
Annual Family Income				
$40,000 or above	.3862	b	.2025	b
Below $40,000	-.5614		-.6258	
	(.0001)		(.0001)	
Education Attainment				
More than 12 years formal education	.0399	.0719	-.0710	b
Twelve or fewer years formal education	-.7094	-.0881	-.7719	
	(.0001)	(.0310)	(.0001)	

[a]Denotes observed significance level of statistical analysis of differences between means of the respective variable grouping.

[b]No statistically significant difference was found between the means of the respective variable grouping.

water service, have empirical results which also substantiate the a priori hypotheses. Analysis of the two income groups revealed that families with greater than $40,000 annual income weighted quality of services and rural atmosphere more heavily in their settlement decisions than those below $40,000. No differences were detected between groups for age of home/water services and job and relatives. The final grouping, based upon educational attainment, indicated that respondents with greater than 12 years formal education put greater emphasis upon quality of services, age of home and water service and rural atmosphere than did those with 12 or fewer years of education. Factor 4, the job and relatives factor, revealed no differences between the means of the two groups.

CHAPTER VI

APPLICATION OF DEVELOPED METHODS: A CASE STUDY FOR THREE WATER DISTRICTS

Thus far, this study has developed methods to estimate water system capacity and water use, detect economies of size, evaluate advantages and disadvantages of consolidation, and identify factors influencing settlement patterns. Local decisionmakers involved with planning rural water systems may find some or all of these tools useful. The objective of this chapter is to demonstrate the application of these tools using them in a case study in Okmulgee County. The application should illustrate to decisionmakers how the tools can be used to aid in planning a rural water system.

The case study includes Rural Water District #6 (RWD #6), Rural Water District #7 (RWD #7), and M&L Water Inc. (M&L) in Okmulgee County. These districts were selected because they are considering consolidation. To aid the decisionmakers in this evaluation, tools developed in this study are employed to formulate:

1. an inventory of the existing systems;
2. an estimate of water system capacity;
3. an estimate of water use;
4. an estimate of the financial condition of the proposed consolidated district (Consolidated Okmulgee County RWD #1); and
5. an evaluation of per customer costs with and without consolidation.

Inventory of the Existing System

RWD #6 is in northern Okmulgee and southern Tulsa Counties. As of July, 1982, there were 1,553 customers in RWD #6. Treated water is purchased from the City of Okmulgee. In 1981, 149,000,000 gallons were purchased, 40,741,000 of which were resold to M&L Water, Inc. A grant of $600,000 and a five percent loan for $775,000 has been approved by FmHA for construction of treatment plant facilities on Brown Creek Reservoir in RWD #6. Plant capacity is 400,000 gallons per day; reservoir capacity is 250,000 gallons per day. Therefore, additional water supply for the district as a result of the treatment facilities will be 250,000 gallons per day or 91 million gallons per year. The project includes construction of 30,000 feet of ten-inch transmission lines and 90,000 gallons of storage.

The service area of RWD #7 is comprised of northwestern Okmulgee County. There were 520 customers being served as of July, 1982. Treated water was purchased from Okmulgee in the amount of 31,999,500 gallons in 1981. Currently, RWD #7 has a loan application pending with FmHA for $255,000 for improvements to incoming supply lines and distribution lines. An additional incoming four-inch supply line is proposed for the western side of the district as well as a nine-mile section of four-inch line to create a loop for increased water flow. RWD #7 can accept no new customers at the present time. Fifty-five applications for new service pending which can be filled only upon completion of the improvement project. Engineering estimates show that an additional 250 customers can be added with the new supply and distribution line project.

M&L Water, Inc., serves 544 customers in northeastern and east central Okmulgee, northwestern Muskogee and southwestern Wagoner Counties.

Treated water is purchased from RWD #6 and the City of Okmulgee. In 1981, M&L purchased 40,741,000 gallons from RWD #6 and 7,462,200 gallons from Okmulgee. Planned improvements for M&L consist of eight- and six-inch incoming supply lines from Okmulgee, some minor line loops, new 150 gallon per minute booster pumps in the present pump station and construction of a 70,000 gallon storage tank. The purposes of this project are to increase water quantity and pressure available to customers and become independent of RWD #6 for water through direct purchase from Okmulgee to lower costs. In 1981, water from Okmulgee cost $.80 per 1000 gallons and water from RWD #6 cost $1.25 per 1000 gallons. Engineers for the district project that the improvements will enable the district to serve 900 total customers.

The financial situation for each of the three districts for 1981 is presented in Table XXVII. Income, capital and operating expenditures, and net income are shown. All three districts had positive net incomes for 1981. Water sales comprise the majority of income, but annual membership charges of $25, $20, and $20 for RWD #6, #7, and M&L, respectively, do contribute to total income. Major expenditure items include wages and salaries, repair and maintenance and water purchases. The debt payment expenditures shown are to FmHA for loan obligations. Depreciation varies by district according to the amount of equipment owned for repair and maintenance and the original value of the system facilities. Overall, procedural differences in accounting may make comparison of individual cost categories inappropriate, but the broad categories of capital and operating expenditures should be reliable for such comparison.

TABLE XXVII

FINANCIAL STATUS OF RWD #6, #7, M&L, YEAR ENDING JUNE 30, 1981

Financial Component	RWD #6	RWD #7	M&L
		Dollars	
Income			
Water Sales	299,367.84	129,861.25	128,243.99
Membership	36,400.00	9,600.00	10,800.00
Interest	27,806.08		
Other	13,900.00	2,642.00	3,049.15
Total	377,473.92	142,103.25	142,093.14
Expenditures			
Operating			
Wages & Salaries	50,059.51	15,571.02	16,500.00
Office & Administrative[a]	21,882.38	3,512.37	14,441.33
Utilities	18,728.35	8,952.32	439.12
Repair & Maintenance	24,579.32	8,461.17	14,328.27
Water Purchases	102,405.74	24,712.75	56,134.29
Other	3,167.17		
Total Operating	220,822.47	61,209.73	101,843.01
Capital			
Debt Payment	51,453.32	29,092.99	20,628.60
Depreciation	85,342.34	b	16,899.82
Total Capital	136,795.66	29,092.99	37,528.42
Total Expenditures	357,618.13	90,302.72	139,371.44
Net Income	26,619.23	51,800.53	2,721.71

[a]Includes office supplies, telephone, legal and accounting fees, taxes, employee benefits and insurance.

[b]Not available.

Estimation of System Capacity

System capacity for the Consolidated Okmulgee County RWD #1 may be calculated following the procedure outlined in Chapter II. The limiting factors in determining water system capacity are raw water supply, treatment facilities, storage and pumping capacity and distribution lines.

Water supply for Consolidated RWD #1 will be from two sources: (1) raw water from Brown's Creek Reservoir and (2) treated water from the City of Okmulgee. Brown's Creek is a Soil Conservation Service structure with storage capacity of 280 acre feet (91 million gallons). This storage represents the useful capacity for water supply. On a daily yield basis, this reservoir will supply 250,000 gallons. The remainder of the supply will come from the City of Okmulgee, which has long-term contracts with each of the three districts at present to supply them with unlimited quantities of treated water on demand.

Treatment capacity of the Brown's Creek plant is 400,000 gallons per day, well above the actual yield of the reservoir. As was shown in Table XII, Okmulgee has adequate capacity to provide the remainder of water demanded through the year 2000. The pumping facilities, which are now adequate for distribution, will be improved in the M&L project and should be more than adequate to meet demand.

Storage facilities in Consolidated RWD #1 will be increased from the current 364,000 gallons to 524,000 gallons by the addition of 160,000 gallons storage in the RWD #6 and M&L projects. Interconnection and looping of distribution lines will establish adequate water pressures throughout the new district. Incoming supply lines will also be of adequate size to provide that water from the treatment facilities and the City of Okmulgee will be available throughout the district. Table XXVIII summarizes water system characteristic, including maximum capacities of water source, treatment, storage and distribution for the districts.

Estimation of Water Use

To estimate water use for Consolidated RWD #1 it is necessary to determine water use per customer as well as the number of customers in the service area. The results of the procedure for estimating water use per customer are summarized in Table XXIX. This method is selected based on results of regression analysis for individual systems presented in Chapter II. To arrive at the monthly water use per customer, mean values of the sample for each source variable are multiplied by the coefficient for that variable and then summed. For instance, for the total education variable, the mean of 12.490 years is multiplied by 102.76 to obtain a total education source contribution of 1,283.49 gallons per month. A similar procedure is followed for each variable. The dummy variables pertain to garden irrigation and annual family incomes. Thirty percent of respondents indicated they maintained an irrigated garden, so the total possible contribution in water use due to garden irrigation was multiplied by .30 to allow for this. The same procedure was followed for the income dummy variable. A summation of all source variables indicates that monthly water demand per customer is 5,684.75 gallons.

An alternative approach could be used in deriving this monthly water use. This approach involves utilizing county mean values for rural residents for all source variables which may be obtained from the

TABLE XXVIII

SUMMARY OF WATER SYSTEM CAPACITY FOR RWD #6, #7, M&L AND CONSOLIDATED OKMULGEE COUNTY RWD #1[a]

System Component	District			Consolidated RWD #1
	RWD #6	RWD #7	M&L	
	Capacity in Gallons			
Water Supply	as needed[b]	as needed	as needed	as needed plus 400,000 daily
Water Treatment	0	0	0	250,000 daily
Water Storage	156,000	43,000	165,000	524,000
Pressure Pumps	1 @ 500 gpm[c] 1 @ 250 gpm	2 @ 80 gpm	2 @ 100 gpm	1 @ 500 gpm 1 @ 250 gpm 2 @ 150 gpm 2 @ 80 gpm
	Size in Inches			
Incoming Supply Lines	2-10 inch	1-4 inch 1-2 inch	1-6 inch	1-12 inch 2-10 inch 2-4 inch

[a]Capacities are before consolidation and improvement projects for RWD #6, #7, and M&L and after consolidation and improvement for Consolidated Okmulgee County RWD #1.

[b]Assumes the current agreement with the City of Okmulgee to supply treated water to the RWDs on demand will continue.

[c]Gallons per minute.

TABLE XXIX

DERIVATION OF ANNUAL WATER USE PER CUSTOMER FOR CONSOLIDATED OKMULGEE COUNTY RWD #1, DECEMBER 31, 1983

Source	Mean Value[a]	Coefficient Value[b]	Total Contribution
	Gallons per Month		
Garden Irrigation[c]	.300	953.86	286.16
Annual Family Income[d]	.176	2,221.92	391.16
Year Residence Built[e]	63.963	33.85	2,165.15
Total Education	12.490	102.76	1,283.49
Number of Cattle	1.234	55.49	68.45
Number of Horses	.514	183.69	94.30
Monthly Water Bill	14.730	130.22	1,918.19
Persons per Household	3,048	954.86	2,902.77
Correction for Mean			3,423.92
Total Monthly Water Demand (per customer)			5,685.75

[a]Mean value of study sample for each source contributor, Table XVII.

[b]Coefficient value as determined by regression analysis, Table VI.

[c]Thirty percent of the sample maintained gardens, therefore .300 was used for the mean value of the dummy variable G1.

[d]Seventeen and six-tenths percent of the sample had annual family incomes over $40,000, therefore, .176 was used for the mean value of the income variable XU.

[e]The mean value of the study sample minus 1,900 yields the mean value of 63.963 used here.

U.S. Census of the Population and the U.S. Census of Housing (60). The procedure was followed and employed 1970 Census data. A monthly per customer water use figure of 5,089.32 was obtained. In practical application of this research, this latter approach will most likely be easier to conduct due to data availability. Census data for rural residents by county are available and will enable extension workers to predict monthly water consumption. Monthly water consumption estimates per customer for Consolidated Okmulgee County RWD #1 are presented in Table XXX. Six alternative estimation methods are employed, each of which can be utilized to address comparable problems in other rural systems.

Data in Table XXXI may be reviewed to obtain the total annual water use for proposed Consolidated RWD #1. The number of customers in the service area in 1982 is 2,627. Upon completion of the RWD #7 project, 55 additional customers will be served, bringing the total to 2,682. If the historical growth trends and demographic model identified in Chapter II are applied for the period 1982 to 1984 there will be a total of 3,057 customers by 1984, which is the projected date of the completion of the improvement projects for RWD #6, #7, and M&L. This figure is then multiplied by the monthly water use for the regression-based constant estimate selected from Table XXX. Conversion to an annual basis yields a total annual water consumption of 208,576,053 gallons for the proposed consolidated district.

A comparison of water system capacity and total water use for 1984 may be made by comparing information obtained in Tables XXVIII and XXXI. If total annual water use (Table XXXI) is converted to a daily basis, a figure of 571,441 gallons results. It can be readily seen that this

TABLE XXX

MONTHLY PER CUSTOMER WATER USE ESTIMATES FOR CONSOLIDATED OKMULGEE COUNTY RWD #1, 1981-2000, SELECTED YEARS

Year	Historically Based[a]			Regression Based[b]		
	Constant[c]	Percentage Increase[d]	Trended Increase[e]	Constant[c]	Percentage Increase[d]	Trended Increase[e]
	Gallons per Month					
1981	7187	7187	7187	5686	5686	5686
1985	7187	7560	8326	5686	5800	6587
1990	7187	7860	9639	5686	6032	7626
1995	7187	8130	10953	5686	6243	8645
2000	7187	8370	12266	5686	6430	9684

[a] 1981 figure based upon historical data.

[b] 1981 figure based upon regression results.

[c] Assumes no change in water consumption per customer.

[d] Assumes changes of 5, 4, 3.5, and 3 percent in water consumption per customer in each five-year period 1980-2000, respectively.

[e] Assumes changes in water use per customer will follow the increasing trends of the past years.

exceeds the storage capacity of 524,000 gallons. FmHA recommends 1,142,882 gallons of storage capacity. Of the total daily water use, 44 percent (250,000 gallons) can be provided by the systems' own treatment facilities. Engineering estimates derived from FmHA guidelines show that pumping and distribution capabilities are adequate to meet daily water use.

TABLE XXXI

TOTAL ANNUAL WATER USE FOR CONSOLIDATED OKMULGEE COUNTY RWD #1, DECEMBER 31, 1983

Current number of customers, July 1, 1982	2,627
Additional customers with RWD #7 line extension and loop	+ 55
	2,682
Additional growth, 1982 to 1984[a]	+ 375
Total number of customers, July 1, 1984	3,057
Water use per customer per month (gallons)	x 5,685.75
	17,381,337.73
Conversion to an annual basis	x 12
Annual water use (gallons)	208,576,053.76

[a]Derived from using historical growth rate and demongraphic model for the period 1982 to 1984 (Chapter II).

Estimation of Financial Status

Having determined the water use for Consolidated RWD #1 and knowing the current revenues and costs of the individual systems, it is possible to estimate the financial status for the district for its first year of operation in 1984. This financial status is summarized in Table XXXII.

Revenues

Revenues for the district are estimated to be $749,644.15 for the year. This figure is obtained by identifying revenues from water sales, memberships and other sources. Water sales revenues are based upon an average monthly water bill of $17 per customer for 3,057 customers. An average bill under the rate structure proposed for RWD #6, after improvements, is applied to the monthly per customer water demand to arrive at the $17 estimate. The proposed monthly rate structure is:

0-1000 gallons	$7.50 minimum
1001-5000 gallons	$2.00/1000 gallons
Over 5000 gallons	$1.50/1000 gallons

This monthly water bill represents a slight increase in the payment by RWD #6 and RWD #7 and a considerable decrease in the payment by M&L customers.

An annual membership fee of $25 per customer will add $76,425 to revenues. Currently there are membership fees of $25, $20, and $20 for customers in RWD #6, #7, and M&L. Revenues from interest on investments and other sources such as late fees and penalties are assumed constant from 1981 to 1984.

TABLE XXXII

ESTIMATED FINANCIAL STATUS FOR CONSOLIDATED OKMULGEE COUNTRY RWD #1, DECEMBER 31,1983

Income		
Water Sales	$623,628.00	
Membership	76,425.00	
Interest	30,000.00	
Other	19,591.15	
Total Income		$749,644.15
Expenditures		
Operating		
Wages & Salaries	$ 99,377.94	
Office & Administrative	43,951.69	
Utilities	24,768.24	
Repair & Maintenance	57,316.20	
Water Purchases	118,576.00	
Other	3,832.28	
Total Operating		$347,822.35
Capital		
Debt Payment	$180,110.91	
Depreciation	162,232.16	
Total Capital		$342,343.07
Total Expenditures		-690,165.42
Net Income		$ 59,478.73

Operating Expenditures

Operating costs are also shown in Table XXXII. Wages and salaries are increased by 10 percent annually from the 1981 total for 1982 and 1983. It is assumed that the consolidated district will employ one system manager, two sub-region operators, one repairman, one administrative secretary and two billing clerks. Office and administrative costs for one office and repair and maintenance costs are also increased by 10 percent annually from the 1981 figure for 1982 and 1983. Utility expenditures in Table XXXII are for maintenance of one office rather than the present two offices and have been inflated 15 percent annually. Water purchases total $118,576 based on a charge of $1.00 per 1000 gallons for 118,576,000 gallons. This amount was obtained by subtracting the 90 million gallons annual water treatment capacity of the system from the 208,576,000 gallons annual water demand of the system. Currently the City of Okmulgee charges $.90 per 1000 gallons but is expected to increase their charge by 1984. Total operating expenditures for the year ending December 31, 1983 are $347,822.35. Water purchases make up 32 percent of this cost and wages and salaries 27 percent.

Capital Expenditures

Annual capital expenditures total $342,343,07 (Table XXXII). Debt payment (obligation to FmHA for loans) for the new district is calculated by summing the current debt of RWD #6, #7, and M&L and the new debt of the three districts after their respective improvement projects are completed. Current annual debt payment is $101,174.91. New annual debt payment with five percent FmHA loan funds will be $78,936, for a total of $180,110.91. Depreciation comprises $162,236.16 of the annual capital expenditures. This figure includes current depreciation in the three districts of $102,242.16 plus depreciation over a 40-year life of all improvements.

Consolidation and Economies of Size

The discussion has highlighted the physical and operational advantages which can be attained through consolidation of RWD #6, #7, and M&L. Increased leverage for obtaining FmHA loans is possibly one of their major advantages. FmHA has related that consolidation of the districts would improve their chances of receiving financing. In addition, however, it is necessary to investigate the districts on an annual cost per customer basis both before and after consolidation.

Annual costs per customer for each of the districts is presented in Table XXXIII. For each district, the number of customers is given along with annual per customer operating, capital and total costs. Costs for all districts are based on 1983 dollars. This was done by using estimated costs for Consolidated RWD #1 and applying an assumed annual inflation rate of 10 percent to the 1981 operating cost figures for RWD #6, #7 and M&L. Capital costs were not inflated. FmHA payments are the same each year and depreciation of facilities and equipment was assumed to be based on the straight-line method.

A comparison of annual per customer capital costs indicates that each of the three original districts will have higher costs after consolidation than before. Major expansion or revision of distribution lines and addition of treatment, storage and pumping facilities are capital intensive in nature and should be expected to increase annual per customer capital costs even though customer numbers increased.

TABLE XXXIII

COMPARISON OF ANNUAL PER CUSTOMER COSTS FOR RWD #6, #7, M&L AND CONSOLIDATED OKMULGEE COUNTY RWD #1

	RWD #6	RWD #7	M&L	Consolidated RWD #1
Number of Customers[a]	1,553	520	544	3,047
Operating Costs[b]	$172.05	$142.43	$226.53	$113.78
Capital Costs[c]	$ 88.08	$ 55.95	$ 68.99	$111.99
Total Costs	$260.13	$198.38	$295.52	$225.77

[a]Number of customers for RWD #6, #7, and M&L are for 1981. Only cost figures are put on a 1983 basis.

[b]Operating costs were inflated by 10 percent annually from 1981 through 1983 for RWD #6, #7, and M&L.

[c]Capital costs for RWD #6, #7, and M&L are assumed constant from 1981 to 1983. Debt payments to FmHA are the same each year and the assumed depreciation method is straight-line.

Annual per customer operating costs on the other hand, decreased significantly for all three districts after consolidation. For example, per customer operating costs for M&L, Inc., declined 50 percent from $226.53 before consolidation to $113.78 after consolidation. The majority of this decrease results from elimination of the office facility M&L now maintains and lower prices paid for their purchased water. Currently, M&L purchases 80 percent of their water from RWD #6 at $1.35 per 1000 gallons. This would be replaced by a purchase of water from Okmulgee at $1.00 per 1000 gallons through the new consolidated district. Additional savings for the districts probably resulted from more efficient utilization of existing repair and maintenance equipment. The excess capacity of some equipment may be used in cases where expensive contract labor hire was once needed, as in the case of backhoes or ditching equipment.

It would appear that the lower costs per customer which are reflected in this case study after the districts consolidated may be due to the same economies of size components as were evidenced in the case studies presented in Chapter III. Economies are hypothesized to be a result of more efficient management, repair, and maintenance of the physical and financial operation of the district after consolidation. Elimination of duplicate functions such as office and billing procedures could lower per customer costs. Data are not currently available to substantiate further or more explicit suppositions regarding the existence of economies of size in consolidated rural water districts.

CHAPTER VII

SUMMARY AND IMPLICATIONS

Local decisionmakers are responsible for planning which will determine growth patterns in their communities. One of the major determinants of community growth is the quality of services which are provided to businesses and residents in the communities. Of particular concern to decisionmakers is the provision of quality water service in their communities both now and in the future. Proper planning of water systems involves optimal placement of the capital intensive, limited capacity components of a water system. System planning processes must include determination of water system capacity and estimates of total system water use. Accordingly, it would be advantageous if decisionmakers had at their disposal a method to evaluate the results of water district consolidation and some indication of what the nature of their community's growth might be as the result of water service availability. It is the primary objective of this study to develop a system of methods which allow decisionmakers in rural water districts to better utilize available information in evaluating alternatives for water system planning.

Summary of Water Use Analysis

Information utilized in estimating water use was obtained from rural water districts in Okmulgee County through system records and a mail questionnaire. Two procedures were used to estimate water use. The first estimated water use per customer in four ways: (1) the constant method; (2) the percentage increase method; (3) the trended increase method; and (4) the regression method. The constant method indicates that current daily water use of 239.56 gallons will remain constant through the year 2000. The percentage increase method adds 5, 4, 3.5, and 3 percent for each five year period between 1980 and 2000 and results in daily water use estimates of 240, 252, 262, 271 and 278 gallons for 1980, 1985, 1990, 1995, and 2000 respectively. The trended increase method utilizes historical water use information via regression analysis to arrive at plausible estimates. Results indicate that based on prior water use trends, daily water use for rural areas in 1985 will be 277.53 gallons per customer, compared to 239.56 in 1980. By the year 2000, daily water use per customer is estimated to be 408.87 gallons.

The regression method was developed using survey responses from selected RWDs in Okmulgee County. Multiple regression results indicate that a family whose annual income exceeds $40,000 will use 2,221.92 gallons per month more than families with annual incomes below $40,000. Maintenance of an irrigated garden will add 953.86 gallons per month to water use. A one unit increase in persons per household will increase monthly water use by 954.86 gallons, while each year of formal education accounts for 102.76 gallons monthly. Cattle and horses watered from rural service account for 55.49 and 183.60 gallons per month. An increase of 130.22 gallons can be expected for each dollar increase in the average monthly water bill and 33.85 gallons additional water is consumed for each year nearer the current one that the residence was constructed. The mean water use for the sample was found to be 5,685 gallons per month per customer when values for each variable were substituted into the equation at the mean.

The second estimation procedure utilized the daily per customer water use of the constant, percentage increase and trended increase methods and population estimates for the period 1980 through 2000 to obtain total system water use. The regression method may also be used if county average data are available for use in the regression equation. This procedure is useful for estimating water use for county-wide or regional water systems or suppliers of rural systems on the whole.

Summary of Economies of Size Analysis

Economies of size analysis was carried out in two ways. First, general economies of size analysis was performed using regression analysis on information provided by 111 rural water systems in Oklahoma and Missouri. Second, results of case studies of seven consolidated rural water districts in Oklahoma and Missouri were presented.

General Economies of Size Analysis

Annual per customer costs were estimated as a function of number of customers in the district for total, capital and operating costs for all systems. A similar analysis was also completed by system type: purchased water; water treatment; groundwater; or a combination of purchased and groundwater.

No economies of size were evidenced by research results using regression analysis. Equations analyzing total annual costs, total capital costs or total operating costs proved to have very low R^2-values and highly insignificant coefficients. No economies were shown to exist for any water source. These equations also had extremely low R^2-values and very low "student-t" values for the variable coefficients. Lack of evidence of economies of size may be due to the size range of the systems sampled, the largest being only 1,585 customers.

Case Study Analysis

Seven consolidated rural water districts were investigated for advantages and disadvantages resulting from consolidation. Major advantages include improvements in quality of water service, management, operation and financial stability. Managers of systems investigated commented that the quality of water service as measured by quality and quantity of water, service interruptions, and water pressure had improved since consolidation. Efficiency in repair and maintenance is precipitated by the better management made possible through consolidation. Leaders in the districts attributed these improvements to full-time employees who were hired after consolidation. Most districts were unable to afford sufficient full-time assistance before consolidation and were forced to pay high prices for contract labor.

The financial status of the consolidated RWDs before and after consolidation were compared using annual cost per customer based on 1983 dollars. In six of the seven districts, total annual costs per customer were lower after consolidation. No consistent trends were identified for annual capital and operating costs per customer. In general, these costs were lower after consolidation.

Summary of Settlement Pattern Analysis

Information was obtained through a mail survey of five Okmulgee

County RWDs. The RWDs, ranging in size from 128 to 1,539 customers, were utilized to derive descriptive characteristics of the sample data. In addition, analysis was performed to identify factors which affect rural settlement patterns.

The Data

ANOVA procedures which were carried out on the survey data reveal that differences do exist between districts. Residents in RWD #6 are most different from the mean of other districts. They have, in general, lived at their current residences a shorter time, value rural atmosphere and environment highly, use more water, live in newer homes, and have higher educational levels and annual incomes than those in other districts. RWD #6 is the most suburban of all districts included in the sample.

Few differences were revealed by ANOVA with respect to customer status, but major differences appear between mean values for variables when grouped in terms of service importance. Residents who indicated they would not move if water service had not been available value all aspects of rural living as well as water, sewer and health care services and paved roads much higher than the residents who would have moved even if water service were not available. In addition, they have lived at their current residences a much shorter length of time, commute great distances to work, have higher incomes and educational levels and live in newer homes than those who would have moved irrespective of water service availability.

The Analysis

Factor analysis was utilized to identify factors which influence rural settlement patterns. The maximum likelihood approach (M-L) was employed as the specific method of factor analysis and varimax was selected as the rotation procedure for extraction of relevant factors.

Upon completion of the factor analysis procedure for 1,139 responses, four general factors were identified as important in determining decisions for rural migration and exact locational choice by in-migrants. These factors are: (1) quality of services; (2) age of home and availability of water service; (3) rural atmosphere; and (4) job and relatives. In terms of weighted eigenvalues of the rotated factor patterns, a total of 26.3, 19.98, 18.23, and 7.47 percent of common variance between factors is explained by the four factors, respectively.

Numerous regression equations were developed and tested which relate individual variables in the analysis to the four identified factors. Analysis of variance was utilized to identify any differences in weighting of factors based on length of residence, water customer status, availability of water service, annual family income and educational attainment. Briefly stated, it was revealed that rural residents who have lived in their residences five years or less, have annual family incomes of greater than $40,000 and more than 12 years of formal education weight the factors of quality of services, age of home and water service, and rural atmosphere more heavily in their decisions to migrate and settle in specific areas than their counterparts. All factors are weighted more heavily by residents who move into rural water services areas and those who would not move if water service were not available than by their counterparts.

Limitations of the Study

One major limitation of this study was the necessity to use only cross-sectional data rather than including time series data in analyzing water use and economies of size. Due to a lack of historical information of variables included in regression estimation of water use and cost components of economies of size analysis, there seemed to be no viable alternative to employment of cross-sectional data.

Another limitation was the lack of consistently reported cost information. Differences in accounting procedures from district to district make it difficult to accurately estimate individual income and expenditures items such as membership revenue, labor costs, repair and maintenance, and depreciation. Standardization of procedures would enable researchers to make more reliable estimates of individual financial items. Even so, total annual income and expenditures as well as capital and operating cost figures are considered to be sufficiently accurate for acceptance.

Reliance on survey response data for a sizable portion of the research may have introduced bias and misinformation due to the respondents' perceptions of the questions and answers provided. A corollary to this is the fact that many of the responses required subjective judgments to be made, a drawback of many studies of this nature. By virtue of cost, manpower and time constraints, the sample had to be limited as it was. A broader geographic and larger numeric sample would infer that results could be applied on a more widespread basis.

A final limitation of the study was the inability to develop an equation which will estimate where in-migrats to a rural area will settle.

It was hoped that the locational information available could facilitate this, but such was not the case. It was possible, however, to obtain a relationship between factors which influence settlement patterns through regression analysis applied to the factor patterns identified through factor analysis.

Implications for Extension and Local Policies

Several implications can be drawn from the results of this research. Utilization of the tools developed to address planning problems related to water system and rural area growth can definitely affect the direction extension and local policy will take. These policies will influence the operational and financial status of water systems.

Determination of water use is necessary so that an adequate supply of water can be secured for future needs. Districts which purchase treated water must be able to obtain purchase contracts from their suppliers to meet future demand. Districts which depend upon their own treatment facilities or on groundwater must be able to meet future demand from their own raw water supply and treatment facility capacity. In either case, ability to supply adequate water is in question. Limits may be placed on growth and expansion of districts due to the inability or unwillingness of suppliers of treated water to expand their own facilities to sell water to rural districts. Financial or physical conditions may place limitations on growth or expansion of districts which treat their own water or rely on groundwater for their supply. Decisionmakers may choose to restrict growth by purposely limiting water system capacity to a level below future demand. Systems now reliant upon treated water purchased from outside sources may wish to achieve an independence and direct their growth by acquiring their own water source.

Consolidation of rural water systems is an option for achieving improved service and financial stability. Financial incentives in the form of preferred consideration of loan and grant applications may be available. Special educational programs to point out the operational and managerial advantages of consolidation may also be beneficial. Finally, community interaction programs to help alleviate the political and social drawbacks expressed by local leaders should be formed. If it is decided by leaders of rural water districts that consolidation is acceptable and advantageous to them, positive steps must be taken in the policies of the local area to encourage such an alternative organizational structure.

Results of the factor analysis performed on survey data concerning settlement patterns reinforce Census data and previous research indicating positive growth rates in rural areas since 1970. A major factor accounting for migration into rural areas has been shown to be quality of services. Policy-making bodies must decide whether to continue programs which have encouraged the development of rural services comparable to services in urban areas. For example, availability of low interest loans for development of rural water and sewer systems has certainly encouraged people to migrate to rural areas. Major improvements in roads, health care services and police and fire protection have also taken place as a result of governmentally financed and supported development programs. Many rural residents can now enjoy the aesthetic benefits of rural living without sacrificing the quality of services provided in non-rural settings. It would seem that one avenue for encouraging or discouraging "rural sprawl" would be the continuance or severance of programs which subsidize improvement of rural services.

Implications for Research

The development of an economically and statistically sound model to estimate actual numbers of in-migrants into a specific rural area would be of great value. This would allow rural decisionmakers to identify areas within their districts where growth might occur. It would then be possible to properly design a system for future growth by oversizing water distribution lines and storage facilities in that area to allow for future growth or expansion. If adequate locational data could be obtained with regard to exact place and time of settlement, a probability based approach such as a probit or logit model could be employed in predicting the location of new settlement. This, coupled with an approach similar to the factor analysis taken in this research, could provide meaningful estimation of growth patterns.

Further research should be conducted on the advantages and disadvantages of consolidation. It would be useful to solidify the conclusion drawn from the descriptive data in this study by adding more observations. Inclusion of data from consolidated rural water systems in other parts of the country would lend statistical support for the acceptance or rejection of hypotheses concerning consolidation. This would be particularly true in the areas of annual costs per customer and annual net income determination.

More research should be conducted in the area of economies of size which may exist in rural water systems which have consolidated. This need is especially apparent in light of the inconsistencies revealed in the general economies of size analysis and the case studies analysis conducted in this study. Perhaps additional investigation into this area of economies of size would effectively clarify factors responsible for these differences.

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APPENDICES

APPENDIX A

A BRIEF DISCUSSION OF THE THEORY OF MULTIPLE LINEAR REGRESSION

One theoretical approach typically used in economic analysis states that changes in any one variable can be either partially or totally explained by changes in various other variables. This type of relationship is described in simple terms as a multiple linear regression equation of the form,

$$Y_i = B_0 + B_1X_{i1} + B_2X_{i2} + . . . + B_KX_{iK} + \varepsilon_i$$

where Y denotes the dependent variable, the X's denote the explanatory variables, and ε is a stochastic disturbance (34). The subscript i refers to all ith observations with the next subscript identifying the variable in question. The coefficients (B_0, B_1, B_2, ..., B_K) are unknown parameters, the value of which can be estimated by least squares regression. This method minimizes the variance of the error terms or maximizes the portion of variation explained by the independent variables. In order for these least squares estimates to be unbiased and have minimum variation, the following assumptions concerning the basic model must be made (28):

1. ε_i is normally distributed.
2. $E(\varepsilon_i) = 0$.
3. $E(\varepsilon_i^2) = \sigma^2$.
4. $E(\varepsilon_i\varepsilon_j) = 0$ $(i \neq j)$.
5. Each of the explanatory variables is nonstochastic with values fixed in repeated samples and such that, for any sample size, $\Sigma_1^N = 1(X_{ij} - \bar{X}_k)^2/n$ is a finite number different from zero for every k = 1, 2, ..., K.
6. The number of observations exceeds the number of coefficients to be estimated.
7. No exact linear relationship exists between any of the explanatory variables.

With the above assumptions specifying the basic multiple linear regression model, the distribution of Y_i is normal, as follows:

$$E(Y_i) = B_0 + B_1X_{i1} + B_2X_{i2} + \ldots + B_KX_{iK}$$

In this framework, B's are not known but may be estimated. The resultant equation,

$$\hat{Y}_i = b_1X_{i1} + b_2X_{i2} + \ldots + b_KX_{iK} ,$$

where b_0, b_1, b_2, ..., b_K are estimates of B_o, B_1, B_2, ..., B_k describes the general multiple regression model.

APPENDIX B

FUTURE WATER USE ESTIMATES FOR OKMULGEE COUNTY, BY ENTITY, 1980-2000, SELECTED YEARS

TABLE XXXIV

ESTIMATED DAILY WATER USE FOR RURAL OKMULGEE COUNTY, 1980-2000, SELECTED YEARS

Year	Population	Number of Taps[a]	Constant[b]	Percentage Increase[c]	Trended Increase[d]
			Gallons Per Day		
1980	12,363	4,641	1,111,330	--	--
1981	12,460	4,667	1,117,560	1,124,430	1,131,780
1982	12,532	4,694	1,124,020	1,135,680	1,179,430
1983	12,606	4,721	1,130,490	1,147,030	1,227,550
1984	12,682	4,750	1,137,440	1,158,500	1,276,680
1985	12,760	4,779	1,144,380	1,170,090	1,326,320
1990	13,183	4,937	1,182,210	1,216,890	1,586,300
1995	13,648	5,112	1,224,120	1,259,480	1,866,330
2000	14,147	5,299	1,268,900	1,297,270	2,166,590

[a]2.67 persons per tap.

[b]Assumes water usage per tap will increase as it has since 1970.

[c]Assumes water usage per tap will remain constant.

[d]Corps of Engineers projects water usage will increase by 5 percent, 4 percent, 3.5 percent, and 3 percent, respectively, for five year intervals, 1980-2000.

TABLE XXXV

ESTIMATED DAILY WATER USE FOR BEGGS, 1980-2000, SELECTED YEARS

Year	Population	Number of Taps[a]	Constant[b]	Percentage Increase[c]	Trended Increase[d]
			Gallons Per Day		
1980	1,650	570	109,270	--	--
1981	1,659	574	110,040	110,360	118,840
1982	1,669	578	11,0800	111,470	126,830
1983	1,679	581	111,380	112,580	134,690
1984	1,689	584	111,950	113,710	142,620
1985	1,700	588	112,720	114,840	150,880
1990	1,757	608	116,550	119,440	192,670
1995	1,819	629	120,580	123,620	239,330
2000	1,886	653	125,180	127,330	288,910

[a]2.89 persons per tap.

[b]Assumes water usage per tap will increase as it has since 1975.

[c]Assumes water usage per tap will remain constant.

[d]Corps of Engineers projects water usage will increase by 5 percent, 4 percent, 3.5 percent and 3 percent, respectively, for five year intervals, 1980-2000.

TABLE XXXVI

ESTIMATED BAILY WATER USE FOR MORRIS,
1980-2000, SELECTED YEARS

Year	Population	Number of Taps[a]	Constant[b]	Percentage Increase[c]	Trended Increase[d]
			Gallons Per Day		
1980	1,450	575	110,230	--	--
1981	1,458	579	110,990	111,322	119,880
1982	1,466	582	111,570	112,450	127,710
1983	1,475	585	112,140	113,570	135,610
1984	1,484	589	112,910	114,710	143,840
1985	1,493	592	113,490	115,850	151,910
1990	1,543	612	117,320	120,490	194,950
1995	1,597	634	122,540	124,700	241,230
2000	1,655	657	125,950	128,440	290,680

[a]2.52 persons per tap.

[b]Assumes water usage per tap will increase as it has since 1975.

[c]Assumes water usage per tap will remain constant.

[d]Corps of Engineers projects water usage will increase by 5 percent, 4 percent, 3.5 percent, and 3 percent, respectively, for five year intervals, 1980-2000.

TABLE XXXVII

ESTIMATED DAILY WATER USE FOR DEWAR, 1980-2000, SELECTED YEARS

Year	Population	Number of Taps[a]	Constant[b]	Percentage Increase[c]	Trended Increase[d]
			Gallons Per Day		
1980	1,050	378	72,460		
1981	1,056	380	72,850	73,180	78,680
1982	1,962	382	73,230	73,920	83,820
1983	1,962	384	73,610	74,660	89,020
1984	1,075	386	74,000	75,400	94,260
1985	1,081	389	74,570	76,160	99,820
1990	1,118	402	77,060	79,200	128,050
1995	1,158	416	79,750	81,970	158,280
2000	1,201	432	82,810	94,430	191,130

[a]2.78 persons per tap.

[b]Assumes water usage per tap will increase as it has since 1975.

[c]Assumes water usage per tap will remain constant.

[d]Corps of Engineers projects water usage will increase by 5 percent, 4 percent, 3.5 percent, and 3 percent, respectively, for five year intervals, 1980-2000.

TABLE XXXVIII

ESTIMATED DAILY WATER USE FOR OKMULGEE, 1980-2000, SELECTED YEARS

Year	Population	Number of Taps[a]	Constant[b]	Percentage Increase[c]	Trended Increase[d]
			Gallons Per Day		
1980	16,221	6,144	2,168,090	--	--
1981	16,276	6,165	2,175,500	2,189,770	2,361,560
1982	16,337	6,183	2,183,620	2,211,670	2,557,130
1983	16,503	6,213	2,192,440	2,233,780	2,754,970
1984	16,474	6,240	2,201,970	2,256,120	2,955,260
1985	16,548	6,268	2,211,850	2,278,680	3,157,690
1990	19,694	6,462	2,267,610	2,369,830	4,206,910
1995	17,433	6,603	2,330,070	2,452,780	5,318,110
2000	17,931	6,792	2,396,760	2,526,360	6,496,280

[a]2.64 persons per tap.

[b]Assumes water usage per tap will increase as it has since 1975.

[c]Assumes water usage per tap will remain constant.

[d]Corps of Engineers projects water usage will increase by 5 percent, 4 percent, 3.5 percent, and 3 percent, respectively, for five year intervals, 1980-2000.

TABLE XXXIX

ESTIMATED DAILY WATER USE FOR HENRYETTA, 1980-2000, SELECTED YEARS

Year	Population	Number of Taps[a]	Constant[b]	Percentage Increase[c]	Trended Increase[d]
			Gallons Per Day		
1980	6,328	2,900	1,179,170	--	--
1981	6,318	2,898	1,178,360	1,190,960	1,278,830
1982	6,310	2,894	1,176,730	1,202,870	1,364,400
1983	6,304	2,892	1,175,920	1,214,900	1,450,740
1984	6,301	2,890	1,175,100	1,227,050	1,536,960
1985	6,300	2,890	1,175,100	1,239,320	1,621,260
1990	6,329	2,903	1,180,390	1,288,890	2,066,620
1995	6,405	2,938	1,194,620	1,334,000	2,534,850
2000	6,522	2,992	1,216,580	1,374,020	3,032,930

[a] 2.18 persons per tap.

[b] Assumes water usage per tap will increase as it has since 1975.

[c] Assumes water usage per tap will remain constant.

[d] Corps of Engineers projects water usage will increase by 5 percent, 4 percent, 3.5 percent, and 3 percent, respectively, for five year intervals, 1980-2000.

APPENDIX C

SUMMARY OF INFORMATION CONCERNING CONSOLIDATED

RURAL WATER DISTRICTS IN

OKLAHOMA AND MISSOURI

Alfalfa County, District 1

I. <u>General Information</u> - Alfalfa County Rural Water, Sewer and Solid Waste Management District No. 1, as of 1981, served 655 customers in northern Alfalfa County and the towns of Burlington, Byron and Amorita. The district is essentially divided into two parts by the Salt Fork River and has a total of 235 miles of distribution lines. The board is made up of seven members.

II. <u>Consolidation Process</u> - Alfalfa County RWD #1 was formed in July of 1975 by joining the existing Alfalfa County RWD #1 with a planned new district south of the Salt Fork River. Both local residents and FmHA officials realized that it would be a better idea to "merge" the existing Alfalfa RWD #1 with the proposed new district before it was actually formed. The additional size would enable the district to hire full-time employees to maintain the system. No problems were encountered during the consolidation process.

III. <u>Financial Situation</u> - As of December 31, 1980, the audits for Alfalfa County RWD #1 revealed the following:

Revenues	$130,015
Expenditures	115,118
Capital	72,025
Operating	43,093
Net Revenues	14,897
Total Indebtedness	882,960

There is a $125 charge for each new customer to begin service. The rate structure for all residential and commercial customers is shown below. All pasture taps are 25,000 gallons minimum for $135 per year and $1 per 1000 gallons over 25,000.

0-1000 gallons	$9.00 minimum
1001-2000 gallons	$4.00/1000 gallons
2001-3000 gallons	$3.50/1000 gallons
3001-4000 gallons	$2.50/1000 gallons
4001-5000 gallons	$2.00/1000 gallons
over 5000 gallons	$1.00/1000 gallons

IV. Physical Situation - Water supply for the district comes from two well fields and requires no treatment; three wells east of Amorita with 150 gallons per minute (gpm) capacity serve the north end and two wells north of Jet with 150 gpm capacity serve the south end. Six storage facilities totalling 246,000 gallons are located throughout the district. The district sold just under 72 million gallons of water in FY 1981. Water pressures range from 35 to 100 pounds per square inch (psi) with mean pressure of 50-60 psi in the north end and 50 to 100 psi with mean pressure of 65-70 psi in the south end. Service interruptions are infrequent and minor and are generally related to brief power outages or pump breakdowns.

V. Personnel - There are two full-time employees in the distrct, a clerk and an operator. The clerk maintains records only. All maintenance and management of the district is performed by the operator with occasional outside assistance when heavy equipment is necessary for repairs. The district customers read their own water meters each month, but there is an annual reading on each meter by the operator.

Dewey County, District 3

I. General Information - Dewey County Rural Water District No. 3, as of 1981, served 306 customers in southeast Woodward County and northern Dewey County, the towns of Mutual and Taloga and provides supplemental water to Camargo. The board is comprised of five members; representatives from each area in the district are encouraged.

II. Consolidation Process - Dewey County RWD #3 was formed in July of 1975 by joining the Mutual Water Corporation with Northwest Dewey County RWD #3. The consolidation of these districts was encouraged by FmHA for financial reasons. It was also the case that Dewey County #3 near Taloga had too little pressure and Mutual Water Corporation had too much. Local residents realized that consolidation would enable them to justify the purchase of equipment for maintenance, hire at least part-time personnel and lessen the administrative burden of keeping two separate districts.

III. Financial Situation - As of December 31, 1980, the audit for Dewey County RWD #3 revealed the following:

Revenues	$ 90,941.94
Expenditures	67,585.27
Capital	39,198.31
Operating	28,386.96
Net Revenues	23,356.67
Total Indebtedness	497,271.35

There is a $200 charge for each new customer to begin service. The rate schedule for all residential and commercial customers is as follows:

0- 499 gallons	$7.50 minimum
500-2499 gallons	$2.50/1000 gallons
over 2500 gallons	$1.50/1000 gallons

IV. Physical Situation - Water supply for the district comes from six wells and requires no treatment; four wells near Mutual with an average capacity of 110 gpm serve the northern portion of the district and two wells near Taloga with capacity of 145 gpm serve the southern end. Five storage facilities with a total capacity of 172,000 gallons are scattered throughout the district. There are 200 miles of distribution lines, 30 of which were added upon consolidation. Pressure ranges from 30 to 75 psi but is on the average 40 to 60 psi. There is virtually no problem with service interruptions in Dewey County, but the northern end of the district near Mutual suffers frequent line breaks, about 40 for the year 1980.

V. Personnel - All employees of Dewey County RWD #3 work on a part-time basis. The bookkeeper handles all billings and transactions. The operator and his assistant have responsibility for system maintenance. The district does own a backhoe, Ditch Witch and pickup which were purchased after the 1975 merger. Occasionally, outside labor is hired for major repairs or construction.

VI. Comments - Board members are in agreement that consolidation has improved both the financial stability of the system and the quality of service. They cite having a person on call as the operator as vital to the success of the system, as it frees them from reliance on volunteers for maintenance and repair of the system facilities.

Jefferson County, District 1

I. General Information - Jefferson County Consolidated Rural Water and Sewer District No. 1 served 931 customers as of 1981. The district's service area includes western Jefferson and southwestern Stephens Counties as well as the towns of Hastings, Addington, Ryan, Empire and the suburban area around Comanche. There are 300 miles of distribution line in the district. Its governing board is made up of five members from throughout the service area. Lake Waurika has an extensive development area which comprises a large number of the total customers.

II. Consolidation Process - Consolidation was brought about by pressures from FmHA due to loan delinquency and general system mismanagement. Some problems also existed with water supply from the wells at Addington. Jefferson County RWD #1 currently exists due to consolidation of Hastings Rural Water District and Addington Rural Water Association. Only 12 miles of line were present in these two districts; 288 miles were added by incorporating the surrounding rural areas into the service area. The only real problems encountered during consolidation were political in nature; neither community wished to give up the autonomy of their water district. Spreading of board representation over the service area has caused this friction to dissipate significantly.

III. Financial Situation - As of December 31, 1980, the audit for Jefferson County RWD #1 revealed the following:

Revenues	$ 189,082
Expenditures	295,545
Capital	163,334
Operating	132,211
Net Revenues	(106,463)
Total Indebtedness	1,999,514

There is a $350 total charge for new membership and meter installation. The rate structure for all residential and commercial customers is shown below:

0-1000 gallons	$15.00 minimum
1001-3000 gallons	$2.50/1000 gallons
2001-5000 gallons	$2.00/1000 gallons
5001-7000 gallons	$1.50/1000 gallons
over 7000 gallons	$1.25/1000 gallons

IV. Physical Situation - Water supply for the district comes from Duncan and Waurika through purchase contracts. There are five storage facilities in the district with a total capacity of 400,000 gallons. In 1980, the district purchased 62,278,400 gallons and sold 51,742,850 gallons. Average water pressure throughout the district is 40 to 60 psi and no problems currently exist in this regard. The system has been engineered to supply up to 2,500 customers, according to board officials. Service interruptions are somewhat frequent, but due to the placement of valves in the district only four or five customers are affected at each interruption. Line splits due to faulty pipe in part of the district comprise the vast majority of service interruptions.

V. Personnel - There are four full-time employees, a clerk, a manager and two operators. The clerk is responsible for all billings and recording transactions. All complaints, operational decisions and personnel management are duties of the manager. Operators maintain and repair the system with assistance from the manager when required. The district owns a backhoe, truck and trailer and two pickups. Meters are read by the customers except for one annual reading by the operators.

VI. Comments - Board members and district employees stressed the importance of using high quality materials, having rigid inspection of the engineering and having full-time personnel available in maintaining a quality water system. They also mentioned the need for over-design in growing rural areas. It was pointed out that everything possible should be done to prevent divisive political squabbles caused by excessive desire for community autonomy.

Nowata County, District 4

I. General Information - Nowata County Consolidated Rural Water District No. 1 served 264 customers as of the end of 1980. The service area covers roughly the southeast quarter of Nowata County. The governing board consists of five members elected for staggered three year terms.

II. Consolidation Process - Nowata County RWD #4 was formed in March, 1976, by consolidating Nowata County RWD #6 and Watova Rural Water Corporation. Local decisionmakers saw consolidation as an avenue to improve the service quality and financial stability of the districts in Nowata County. Districts other than #6 and Watova were approached regarding consolidation but opted not to participate mainly due to fear that they would lose control of their district. At the time of consolidation, Watova had 65 customers and RWD #6 had 115 customers. No real problems were encountered during the consolidation process.

III. Financial Situation - As of December 31, 1980, the audit for Mowata County RWD #4 revealed the following:

Revenues	$ 43,163.07
Expenditures	42,430.21
Capital	27,338.20
Operating	25,092.01
Net Revenue	733.26
Total Indebtedness	148,486.96

The district received a grant of $153,900 in 1979 which helped keep their debt figure down. There is a $200 charge for each new customer to begin service. Water rates for all district customers are shown below:

0-1000 gallons	$10.50 minimum
over 1000 gallons	$.50/1000 gallons

IV. Physical Situation - Water supply for the district comes from the City of Nowata. Total water use for the district in 1980 was 15,951,000 gallons. Water pressure averages 35 to 50 psi throughout the district, with variations occurring due to elevation differences and proximity to storage facilities. There are three storage facilities with a total of 158,000 gallons capacity. A major expansion/revision project costing $321,852 was completed in 1979. Service interruptions are relatively infrequent and are due largely to line breaks. Repair time generally ranges from two to 12 hours.

V. Personnel - There are no full-time personnel for Nowata County RWD #4. Both the operator and accountant are paid on a part-time basis. The accountant handles billings and transactions. Responsibilities of the operator include troubleshooting, maintenance and repairs and handling complaints.

Boone County, District 1

I. General Information - Consolidated Public Water and Sewer District #1, Boone County serves 3,813 customers in west central and southern Boone County as well as Hartsburg, Midway and Harrisburg. There are approximately 800 miles of distribution lines. The district is governed by an elected board with representatives from each of the three old districts.

II. Consolidation Process - Boone County Public Water and Sewer District #1 was established March 25, 1975 by consolidating Public Water and Sewer Districts #5, #6, and #8. According to the district manager, consolidation was instigated to: (1) achieve economies of size to be self-supporting and capable of handling growth; (2) acquire full time management and maintenance personnel to improve service to all customers; and (3) improve the financial position of the districts. Upon a majority vote of approval from customers each of the district's consolidation was completed. At the time of consolidation there were 2,110 customers.

III. Financial Situation - The December 31, 1980 audit for Boone County Public Water and Sewer District #1 is summarized as follows:

Revenues	$ 744,501.79
Expenditures	577,859.90
Capital	207,071.69
Operating	370,788.21
Net Revenues	166,641.89
Total Indebtedness	2,339,580.00

A $300 fee is charged for new customer connection. The rate structure for customers is:

0-1000 gallons	$6.00 minimum
over 1000 gallons	$1.60/1000 gallons

IV. Physical Situation - Water supply for the district comes from five wells and a supplemental purchase contract from Columbia. The wells have capacities of 150, 160, 500, 510 and 850 gpm--- the purchase contract is a carryover from old Public Water and Sewer District #8. The 850 gpm well was added at the time of consolidation. The district has nine storage facilities with a total capacity of 780,000 gallons, 500,000 of which were added upon consolidation. In 1980 Public Water and Sewer District #1 pumped 385,415,500 gallons and sold 309,854,000 gallons. A major expansion/improvement was completed in 1979 at a total cost of $605,204. In a typical year, customers will have five to six service interruptions of water of up to eight hours and about the same number of up to three hours, generally caused by line breaks or pump shutdowns.

V. Personnel - There are eight full-time employees in the district. They are a manager, a superintendent, an assistant, a billing clerk and four repairmen. Each residential meter is read by the customers. Billings are handled through Boone Co. Water Service Company which serves the other RWDs in the county. The district owns a a full compliment of repair equipment and vehicles.

VI. Comments - The overall size of the district and increased density of customers appears to have made consolidation a wise choice here. Debt for the three old RWDs was combined and rate structures for each were greatly simplified. No apparent problems have arisen since consolidation and service has improved drastically due to full-time employees and ownership of equipment.

Pemiscot County, District 1

I. General Information - Consolidated Public Water and Sewer District #1, Pemiscot County, serves all of rural Pemiscot County and the towns of Bakersville, Bragg City, Braggadocio, Deering, Hometown, Netherlands and Pascola. There are 2,026 customers on the 400 miles of distribution line. The board consists of five representatives selected from board members of the three original districts.

II. Consolidation Process - Pemiscot Co. PWSD #1 was formed in October of 1976 by joining Pemiscot Co. Districts #1, #2 and #3. Local leaders decided to consolidate in order to: (1) improve service to existing customers; (2) replace and purchase equipment; (3) increase management effectiveness through better billing and purchasing; (4) gain advantages in FmHA financing as they gave priority at the time to consolidated districts; (5) manage investment funds more effectively; and (6) extend service to future customers. Consolidation was accomplished through petition by landowners and a majority vote approving consolidation in each of the three districts. No problems were encountered during consolidation.

III. Financial Situation - The December 31, 1980 audit for Pemiscot Co. PWSD #1 revealed the following:

Revenues	$ 245,627.79
Expenditures	226,862.51
Capital	66,458.29
Operating	160,404.22
Net Revenues	19,765.28
Total Indebtedness	2,827,086.61

The district has received $955,600 in grants from FmHA and the Missouri Department of Natural Resources since the consolidation. There is a $75 charge for installation of a meter on the same side of the road as the main. Charges are $105 and $175 if a gravel or paved road must be crossed for installation. Current water rates for all customers are:

0-1000 gallons	$4.50 minimum
1001-2000 gallons	$2.50/1000 gallons
2001-4000 gallons	$2.00/1000 gallons
over 4000 gallons	$1.00/1000 gallons

IV. Physical Situation - Water supply for the district comes from three wells of 200, 275 and 300 gpm capacity and a purchase agreement from Caruthersville. Nine storage facilities exist in the district totaling 395,000 gallons capacity. Two of these facilities were added after consolidation and have 105,000 gallons capacity. Approximately 109,500,000 gallons were sold in 1980. Average water pressure in the district is 50 psi with extremes of 35 and 100 psi. Very few service interruptions occurred during 1980, those being minor and lasting no more than three hours. There have been excessive iron levels in the water periodically, but this is attributed to filtering malfunctions.

V. Personnel - There are six full-time employees in the district; one manager, two clerks and three repairmen. The manager handles complaints and maintains the record system. Responsibilities of clerks include billings and assisting with complaints and records. Repairmen repair and maintain facilities in the district. Each customer is responsible for reading their own meter for monthly billings.

VI. Comments - Quality of water and water service has improved since consolidation. Additional leverage for financing in the form of loans and grants has also been achieved through consolidation.

Vernon County, District 1

I. General Information - Consolidated Public Water and Sewer District No. 1, Vernon County, served 1,354 customers as of December 1980. The service area of Vernon County PWSD #1 includes central, northeast and east central Vernon County and the towns of Dederick, Fair Haven, Ellis and Harwood. The district also sells water to Vernon County PWSD #5. A five member elected board governs the district.

II. Consolidation Process - Consolidation of Vernon County PWSD #3 and #4 occurred in April of 1980. The desire for consolidation was primarily due to water supply difficulties. Both districts purchased water from municipalities. Schell City and Walker were reluctant to renew contracts with PWSD #3 and Nevada was to raise the price of water sold to PWSD #4. As a result, the two districts merged and drilled for groundwater as their source. Both districts also expressed a need for full-time maintenance personnel. Vernon County PWSD #1 was approached to join in the consolidation process but refused because they feared loss of local control of their water system.

III. Financial Situation - The December 31, 1980, audit of Consolidated Vernon County PWSD #1 yielded the following:

Revenues	$ 329,004.25
Expenditures	265,359.47
Capital	67,294.78
Operating	198,065.47
Net Revenue	63,644.78
Total Indebtedness	1,641,720.00

The current rate structure for all customers is:

0-1000 gallons	$6.50 minimum
1001-2000 gallons	$4.00/1000 gallons
2001-3000 gallons	$3.00/1000 gallons
3001-4000 gallons	$2.50/1000 gallons
4001-5000 gallons	$1.75/1000 gallons
over 5000 gallons	$1.65/1000 gallons

IV. Physical Situation - Water supply comes from two wells with capacity of 200 gpm. The district sold a total of 103,379,700 gallons of water in 1980. The water met bacteriological standards but exceeded recommended levels of chlorides and secondary contaminants. Water pressure in the district averages around 45 psi. Service quality as judged by service interruptions and water quality and quantity has improved since the consolidation.

V. Personnel - There is currently only one full-time employee, that being an operator. A part-time clerk and two repairmen are also available as needed. The clerk takes care of billings and records. The operator maintains and manages the district with the assistance of the repairmen. Customers read their own meters.

APPENDIX D

SUMMARY OF MAIL SURVEY DESIGN PROCEDURES

Surveys can be classified by the specific method of data collection employed, that is, face-to-face interview, telephone interview or mail survey. Face-to-face surveys have traditionally been quite reliable with respect to high response rates and accuracy of responses to questions posed. A committee convened by the American Statistical Association in 1973 noted, however, that it appears that survey firms face increased difficulty in getting cooperation from respondents. The conference also concluded that some surveys based from university settings faced higher refusal rates and increasing resistance to their interviews (14). In addition, face-to-face interviews are costly and very time consuming.

Telephone interviews are somewhat less successful in terms of response rate than are personal interviews and the responses are far less reliable (61). Misinterpretation of question and answer alternatives is likely. There are also other biasing factors such as reaction to regional accents and tonal inflections of the interviewer and various other distracting circumstances. As is the case in personal interviews telephone interviews can be costly and quite time consuming.

Mail surveys are generally regarded as being the least effective by the majority of researchers. Response rates are usually lower than for the other two types of surveys. Costs are lower and time involved in the survey process is greatly reduced. It would appear, then, that each method has its advantages and disadvantages. If the drawbacks of a mail survey could be diminished or eliminated, however, this method would be attractive due to cost and time savings. Considerable work has been done in the area of mail surveys to improve their quality. Noteworthy among this work is the Total Design Method (TDM) developed by Dillman (14). TDM includes information on: (1) selecting question structure; (2) proper wording of questions to minimize biased responses and provide clarity; (3) sequencing questions; (4) making the survey "appealing" to the respondent through "packaging"; (5) drawing the sample; (6) writing appropriate lead-in phrases and cover letter; (7) follow-up procedures; and (8) recording and processing of responses. Specific aspects of the survey procedure, survey data and characteristics of the sample are presented below.

Designing a Survey

Once the information need is identified and it is determined that existing data are inadequate, the next step is to properly design the survey questionnaire. Of utmost importance is fulfillment of research objectives through the survey data collection. In order to accomplish this, a great deal of care in question structure, ordering of questions, length of survey, and "packaging" or presentation of the questionnaire. Unless concepts are clearly defined and the questions unambiguously phrased, the resulting data are apt to contain serious biases or misinformation. Designing a suitable questionnaire entails more than well-defined concepts and distinct phraseology. Attention must also be given to the ordering of questions and the overall sequencing of the survey. Poor sequencing of questions and unduly long questionnaires may result in biased individual responses and low response rates by those completing the survey. Presentation of the questionnaire in a neat, attractive and orderly manner is also an important factor in helping to increase response rates.

Writing the Questions

Three general principles are considered when writing questions. First, the kind of information being sought must be determined. Is the researching seeking responses which are attitudinal or belief oriented or responses which reflect behavior or attributes of the respondent? Clearly, the first two types of responses require value judgments and abstract thought and the second two types deal only with recollection or evaluation of concrete situations. It is not uncommon to have a mixture of all four types of responses, however, since research often requires input of all types to effectively address the study objectives.

The second principle in writing questions is deciding question structure. This involves the way in which answers are obtained from the respondents. Questions may be either open-ended, close-ended with ordered choices, close-ended with unordered choices or partially close-ended. Open-ended questions are generally used in situations where it is desireable for respondents to express themselves freely or when specific pieces of information with many possibilities are desired. These types of questions are demanding on the respondent and often result in erroneous, incomplete, uninterpretable or irrelevant answers. Also, it is difficult in many cases to construct meaningful variables which can be statistically analyzed. Close-ended questions of both types are much more restrictive and place greater burdens on the researcher than open-ended questions. Use of close-ended questions makes it necessary for the researcher to provide as complete a list of answers as possible. If properly structured, close-ended questions can be very useful in that answers are easily transformed into meaningful variables due to their specificity. The major drawback in utilizing close-ended questions is that unless a complete list of responses is provided, information may be misrepresented or omitted by the restrictive nature of the questions. This drawback may be overcome in part by using the partially close-ended questions. Questions of this type give as complete a list of answers as possible but provide a blank space for answers not listed by the researcher.

The third principle in appropriate question writing concerns wording the question. Verbage must be precise. Leading language should be avoided to avoid biasing answers. Questions should be as brief as possible and avoid confusing things such as double negatives or double questions. Technical accuracy is imperative. It is also important not to assume too much knowledge of the subject or too much about the behavior of the respondent. Questions involving time periods should have specific time references. Answers should be mutually exclusive and be readily comparable to existing information. Following these guidelines in wording of questions and answers helps to assure responses which will be useful in accomplishing research objectives.

Question Sequence and Presentation

Proper sequencing of questions in a questionnaire will not only increase response rate but also improve the accuracy of responses to individual questions (15). It is important in sequencing that the questions follow a logical order. In addition, any personal or possibly controversial or offensive questions should be placed toward the end of the questionnaire. Respondents should be asked easily answered, neutral questions at the beginning to set a positive attitude in completing the questionnaire. Questions which involve a great deal of thought or value judgment are advisedly put near the beginning of the questionnaire. Ending the questionnaire with a neutral question will help ensure that the completed questionnaire is returned (24).

Any technique which will make a questionnaire appear more attractive and less intimidating to the respondent should be employed in presentation of the questionnaire. Questions should be well spaced on the page to avoid the appearance of over-crowding and difficulty. Answers to questions should be easily identified and set apart by indentation, upper case typing, boxes or bold print. Use of high quality paper and ink lends credence to the questionnaire. When cost permits, presentation of the questionnaire in a cover of colored folder is beneficial.

Summary

Numerous references exist which are useful in designing surveys. Several have been reviewed in formulating this synopsis. An excellent bibliography pertaining to survey design is available in Dillman (14). Other references which contain information and procedures in designing a survey are Ferber et al. (15), Hansen (24), and Williams (61).

APPENDIX E

SURVEY INSTRUMENT FOR OKMULGEE COUNTY SURVEY

MAIL QUESTIONNAIRE SENT TO CUSTOMERS IN THE STUDY AREA

The two major purposes of this study are to determine why rural residents choose to live where they do and to predict what amount of water will be used in the future. The results of this study will be used to assist water district officials in planning for the future adequacy of your district. Therefore, it is important that you fill out and return this questionnaire. IF THERE ARE ANY QUESTIONS YOU FEEL UNCOMFORTABLE ABOUT ANSWERING, OMIT THEM, BUT PLEASE FILL OUT AND RETURN THE QUESTIONNAIRE.

1. Please indicate the county in which you live (cicle number).

1. OKMULGEE	5. WAGONER
2. TULSA	6. OKFUSKEE
3. MUSKOGEE	7. HUGHES
4. CREEK	8. McINTOSH

2. On the back page is a map of your water district. Please place an "X" on this map at your place of residence.

3. How many years have you lived at your current address? ___________

4. If you moved to this address from another place, what was the distance of your move? ___________(miles)

5. Listed below are different events which may have occurred in the year prior to your move. Rate each of the events according to its importance to your decision to move. These questions are answered by placing scores from the range 1 to 99 in the blanks below. The higher the score, the more important the event. The lower the score, the less important the event.

Level of Importance

1 — 10 — 20 — 30 — 40 — 50 — 60 — 70 — 80 — 90 — 99

not important at all ... extremely important

1. Primary wage earner received job promotion _____
2. Primary wage earner received job transfer _____
3. Different job _____
4. Seeking employment _____
5. Other employment reasons _____
6. Entered or left Armed Forces _____
7. Entered or left school _____

(continued)

8. Retired
9. Climatic change desired ______
10. Health problems ______
11. Change in marital status ______
12. Desired to be closer to relatives ______
13. Desired to own home ______
14. Desired rural living ______
15. Attend elderly or ill relatives ______

6. Indicate by number the three factors most important in influencing your move and rank them first, second and third in order of importance.

______ (first) ______ (second) ______ (third)

7. In determining where you chose to live, many factors may have influenced your decision. Please rate the following as to level of importance to your decision on where to live by placing scores from the range of 1 to 99 in the blanks below. The higher the score, the more important the factor. The lower the score, the less important the factor.

Level of Importance

1	10	20	30	40	50	60	70	80	90	99

not important at all — extremely important

1. Nature of job ______
2. Cost of housing ______
3. Family considerations ______
4. Police and fire protection ______
5. Water system ______
6. Septic system ______
7. Quality of health care services ______
8. Quality of schools ______
9. Paved roads ______
10. Driving time to work ______
11. Recreational opportunities ______
12. Environment (clean air and water, etc. ______
13. Rural atmosphere ______
14. Availability of alternative land was low ______
15. Inheritance of current residence ______
16. Other (specify) ______________ ______

8. Indicate by number the three factors most important in influencing your decision and rank them first, second and third in order of importance.

_____ (first) _____ (second) _____ (third)

Next we would like to ask you some questions about the availability and use of your water services.

9. Circle the number of the response which best describes when rural water service became available to you at your current residence?

   1. We were original customers of the district.
   2. We lived in the original district's service area but hooked up to water some time after the original customers.
   3. After we had moved into our current residence we received water service.
   4. Rural water service became available within one year after our move to our current residence.
   5. We bought our residence from someone within the service area who did not have water and hooked up at the time of our move.
   6. We moved into our current residence from another place as water service became available.

10. If rural water service had not been available, would you have moved to your current residence?

    1. Yes 2. No

11. Do you generally maintain a family garden which you irrigate from rural water service?

    1. Yes 2. No

12. If you use rural water service for watering livestock, please indicate the number of head you water.

    1. _____ Cattle 3. _____ Horses
    2. _____ Hogs 4. _____ Poultry

13. What is your average monthly water use? __________(gallons)

Characteristics of employment are often important in determining settlement patterns. Please respond to the following questions concerning employment.

14. Please indicate your primary place of work. (circle number)

1. Operate a farm
2. Business in the home
3. Tulsa
4. Muskogee
5. Oklahoma City
6. Henryetta
7. Okmulgee
8. Retired
9. Unemployed
10. Other (Specify) ________

15. If you work away from your place of residence, on the average how long does it take you to drive to work one way?

1. 1-5 minutes
2. 6-15 minutes
3. 16-30 minutes
4. 31-60 minutes
5. Over 60 minutes

Finally, we would like to obtain some general information which will assist in estimating future water use patterns. ALL INFORMATION IS CONFIDENTIAL.

16. What type of living quarters do you occupy? (circle number)

1. Single unit dwelling (house)
2. Duplex
3. Apartment
4. Mobile home

17. How many persons occupy your living quarters? __________

18. About when were your living quarters originally erected? ______ (year)

19. Are your current living quarters: (circle number)

1. On a lot or place of less than one acre?
2. On a place of one to nine acres?
3. On a place of ten to 39 acres?
4. On a place of 40 or more acres?

20. What is the highest grade (or year) of education the head of the household has completed?

Elementary through High School 1 2 3 4 5 6 7 8 9 10 11 12
College 1 2 3 4 5 6 7 8
Technical School 1 2 3 4 5 6 7 8

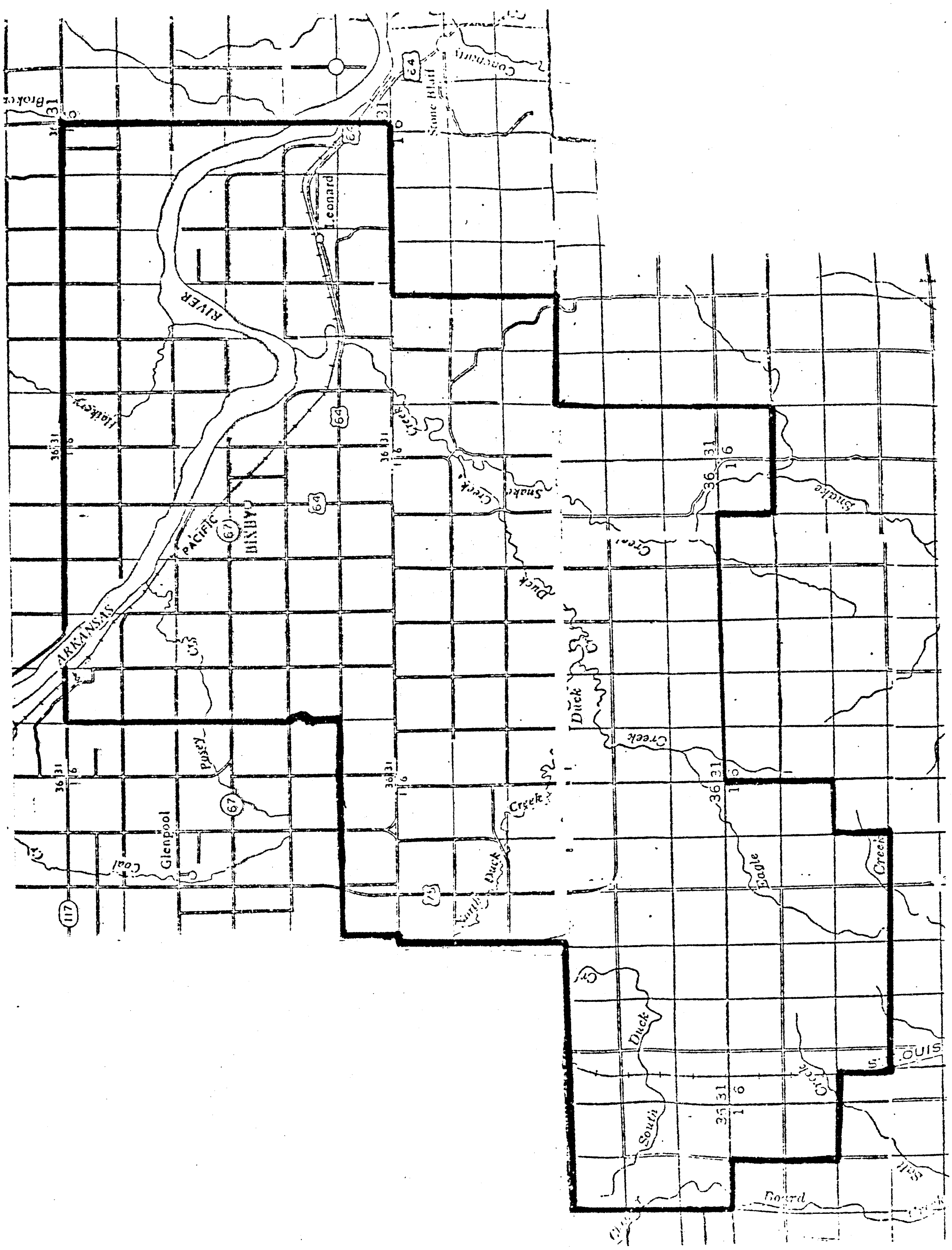
21. What was your approximate family income (before taxes) in 1981? (circle number)

1. Less than $2,500
2. $2,500-$4,999
3. $5,000-$9,999
4. $10,000-$19,999
5. $20,000-$39,999
6. $40,000-$59,999
7. Over $60,000

22. Are your living quarters: (circle number)

1. Owned or being bought by you or someone else in this household?
2. Rented for cash rent?
3. Occupied without payment of cash rent?

RWD #6


ARKANSAS
RIVER
PACIFIC
BIXBY
Leonard
Glenpool
Stone Bluff
Snake
Creek
Duck
Eagle
South
Pusey
Coal
64
67
117
75

COVER LETTER SENT ACCOMPANYING QUESTIONNAIRE SENT TO CUSTOMERS IN STUDY AREA

Rural Water District No. 6, Inc.
OFFICE: 1 Mile East of U.S. 75 on 221st Street
Route 2, Box 59
MOUNDS, OKLAHOMA 74047
(918) 827-6350
Emergency No. 827-6321

Dear Customer:

One of the major factors in determining our quality of living is the availability of good water. You may remember when adequate water from a water system was not available and had to be obtained from a well, cistern or even by hauling. Providing water in the form you now enjoy is a difficult task. We must plan ahead to ensure that enough good water will be available in the future.

The rural water district boards and city officials in Okmulgee County contacted Oklahoma State University Extension Service in late 1979 to ask for help in planning for the future. At this time, OSU Extension has provided us with estimates of population and water use growth for our district and has nearly completed work to help us in budgeting to keep our district in good financial condition. It is also important that we be able to anticipate where additional growth in our district will occur.

Our district has been asked to provide information to assist in this study. In order that the information accurately represent the conditions in our district, I would like to emphasize how important it is that this questionaire be completed by the head of the household or his/her spouse and returned. If you do not feel comfortable about answering a particular question, please omit it. You may be assured of confidentiality.

The results of this study will assist our planning for the future. If you have any questions about this questionaire, please contact Don Taylor, Okmulgee County Extension Agent, (918) 756-1958 or H. L. Goodwin, OSU Extension Service, 555 Agricultural Hall, Stillwater, Oklahoma 74078, (405) 624-6086. Thank you for your assistance.

Sincerely,

Jerry Shands

Jerry Shands,
Manager

APPENDIX F

ADDITIONAL REGRESSION RESULTS USING FACTOR SCORES

TABLE XL

ADDITIONAL REGRESSION RESULTS USING FACTOR SCORES

Dependent Variables	R^2 [a]	Independent Variables F1	F2	F3	F4
Residence constructed	.08	.0282 (.0099)[b]	-.1114 (.0013)	.0769 (.0001)	-.0150 (.4622)
Customer status	.05	.0108 (.0970)	.0435 (.0195)	.0409 (.0001)	-.0206 (.0909)
Service importance	.06	.0235 (.0048)	.0477 (.0626)	.0469 (.0001)	-.0404 (.0094)
Police/fire protection	.11	.0064 (.3651)	.0033 (.8535)	.0162 (.1262)	.1513 (.0001)
County of resident	.04	-.0207 (.1908)	-.1419 (.0003)	-.0370 (.1103)	.0590 (.0458)
Length of move	.06	-.0190 (.2189)	.0551 (.1495)	-.0146 (.5181)	.1875 (.0001)
Desired home ownership	.12	-.0012 (.9364)	-.0494 (.1904)	.1896 (.0001)	.0581 (.0416)
Nature of job	.10	.1112 (.0001)	-.0284 (.4366)	-.0394 (.0682)	.0994 (.0003)
Low land availability	.11	.0818 (.0001)	-.0194 (.5980)	.0883 (.0001)	.0468 (.0923)
Annual family income	.08	.0236 (.1540)	.1139 (.0092)	.1381 (.0001)	-.0624 (.0459)
Other employment reasons	.10	.0666 (.0001)	.0285 (.4082)	-.0401 (.0490)	.1675 (.0001)
Total education	.04	.0383 (.0221)	.0878 (.0352)	.0603 (.0148)	.0428 (.1625)
Inheritance	.09	.0362 (.0125)	.0209 (.5580)	-.0178 (.3997)	.2050 (.0001)
Other reasons	.01	-.0146 (.3645)	-.0301 (.4489)	-.0008 (.9712)	-.0352 (.2409)
Garden irrigation	.04	-.0015 (.9327)	-.1338 (.0007)	-.0804 (.0006)	-.0026 (.9307)

TABLE XL (Continued)

Dependent Variables	R^2 [a]	Independent Variables			
		F1	F2	F3	F4
Place of work	.01	-.0090 (.5786)	.0341 (.3937)	-.0436 (.0660)	-.0102 (.7346)
Type of quarters	.03	-.0050 (.7499)	.1534 (.0001)	.0485 (.0329)	.0407 (.1613)
Lot size	.04	-.0092 (.5657)	-.1816 (.0001)	-.0208 (.3775)	-.0342 (.2553)
Persons per household	.04	.0063 (.6871)	-.0645 (.0945)	.0739 (.0013)	.0697 (.0173)
Ownership status	.03	.0070 (.6520)	-.1173 (.0022)	-.0640 (.0049)	.0395 (.1705)
Job promotion	.07	.0826 (.0001)	.0050 (.8891)	.0072 (.7337)	.0770 (.0044)
Job transfer	.04	.0528 (.0003)	-.0037 (.9178)	-.0046 (.8268)	.0963 (.0004)
Entered/left Armed Forces	.03	.0562 (.0007)	-.0337 (.4067)	-.0231 (.3346)	.0885 (.0040)
Entered/or left school	.07	.0879 (.0001)	-.0250 (.5011)	-.0051 (.8175)	.0718 (.0108)
Retirement	.02	.0329 (.0443)	-.0915 (.0236)	-.0117 (.6244)	.0738 (.0158)
Climatic changes desired	.03	.0131 (.4194)	.0242 (.5470)	.0602 (.0113)	.0880 (.0038)
Health problems	.02	.0474 (.0030)	-.0261 (.5058)	-.0254 (.2741)	.0704 (.0178)
Change in marital status	.02	.0282 (.0855)	-.0164 (.6848)	.0042 (.8592)	.0833 (.0066)

[a]All regression models were tested based upon 689 observations.

[b]Numbers in parentheses represent the observed significance level of the variable as determined by the "student-t" values.

VITA [2]

Harold Lloyd Goodwin, Jr.

Candidate for the Degree of

Doctor of Philosophy

Thesis: DECISION TOOLS TO ASSIST IN THE ECONOMIC PLANNING OF RURAL WATER SYSTEMS

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