Rural Water Supply in the Virginia Coalfield Counties

by

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(ABSTRACT)

Due to quantity and quality problems with water sources and the relative poor condition of existing water systems, public water supply development is crucial in the Virginia coalfield counties. In order to address prevailing drinking water supply problems, this paper assessed existing water service delivery in the coalfields, identified appropriate technical and financial options to provide safe and sustainable water supplies for the region, and developed and illustrated a spreadsheet method for assessing capital costs and water rate impacts of funding options for water development projects. The research procedure incorporated literature and plan reviews, mail surveys, phone interviews, U.S. Census housing data mapping and analysis, and spreadsheet development application.

The exploratory research showed that the topographic and geologic conditions of the region limit access to quality surface and groundwater. The steep terrain inhibits water line extensions and speeds surface water runoff. Available groundwater found in coal seams and springs is subjected to potential contamination. The dominating economic activities of the region, high extraction mining and logging, have also affected surface and groundwater sources. Furthermore, some existing water systems experience unacceptable water loss due to inadequate line maintenance, old equipment, and lack of meters.

Technical solutions to these problems include water harvesting to supplement existing supplies with collected rain water. Treatment technologies appropriate for small water systems, such as oxidation filtration and aeration, can help remove contaminants typical of water supply in the coalfields but at a considerable cost. Water source

protection strategies, such as buffers and setback in zoning, also help minimize water contamination.

The choice of financing and funding for water development projects can impact existing water rates. Projects supported solely by rate-supported financing will likely yield increases in water rates beyond the means of most residences, especially when compared to those funded partially by grants. Thus, a balanced combination of financing and grant funding is essential to achieve acceptable water rate impact and project success.

Dedication

To
James A. Alloway
who never had a chance to read this paper
but his words of wisdom will be remembered

my Mom
who is always my greatest inspiration

and
my sister
for her dedicated support through the years

Acknowledgments

Matt, thanks for digging in the trenches with me. It was a roller coaster. May we never forget the bad and the ugly with the good.

My Dad and brother, thanks for always being there.

My sister and her kids, the only consistent happy thoughts in my mind during my graduate years.

My committee members, thanks for the constructive revisions and comments. Special thanks to Dr. Randolph for given me this opportunity to contribute to an important project and to produce a useful, practical document to justify all the sacrificed trees.

Special thanks to PDC 1 and 2, water utility managers, and residents of the Virginia coalfield counties for their time and cooperation .

Alanis Morisette, thanks for finally singing the words that I have been writing in my poems for years.

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Chapter I. Introduction

I. A. Problem Statement

Water supply is one of the most important components of infrastructure for community development. In particular, public water supply is critically important in the southwest Virginia coalfields due to quantity and quality problems with water sources and the relative poor condition of existing water systems. The topographic and geologic conditions of the coalfields, among the Appalachian Mountains, render limited access to surface and groundwater. The steep terrain accelerates surface water runoff and inhibits water line extensions. Subsurface geology holds few significant acquifers; available groundwater found in coal seams and springs is subjected to potential contamination. The dominating economic activities of the region, coal mining and logging, have also impacted surface waters and private sources such as wells and springs. In addition, the region lacks a comprehensive assessment of water service and supply options that would contribute to more orderly, efficient and effective water supply development.

Due to current problems in water supply development in the coalfields, local and state governments are looking for effective and efficient means of system construction, upgrade, replacement, and extension. Economic development agencies are equally interested in cost-effective water system extensions. Landowners and public health advocates are interested in safe, reliable, and sustainable supplies. Coal mining companies and their regulating agencies are interested in least-cost means of replacing water supplies impacted by mining. The purpose of this major paper is to provide an assessment of the existing water service delivery in the coalfields, to identify applicable technical and financial options to provide safe and sustainable water supplies in the region, and to develop and illustrate a spreadsheet model for assessing the water-rate impact of water supply and financing options.

I. B. Research Procedure

The major paper incorporates a variety of research methods. Literature and plan reviews were conducted for most chapters of the paper. Surveys and phone interviews were employed to gather current information on existing water systems in the coalfields, where not available from the literature review. In order to characterize geographically the water supply situation in the coalfields, U.S. Census data on household water supply were analyzed and mapped on Atlas GIS (Geographic Information System). System details, such as system component cost figures, were extracted from engineering and economic feasibility reports for water systems in the coalfields. Water rate and costing methods were consulted to develop a spreadsheet application for financial assessment of water supply options.

I. C. Objectives and Methods

Objective 1

> The first objective of the paper is to identify water supply characteristics and problems and assess existing water supply in the coalfields.

Methodology for Objective 1

First, a review of literature and planning documents provided a preliminary assessment of water systems in the coalfields. Second, this information was updated by mail and phone surveys of system officials to provide a current description of existing water supply systems. Third, household water supply data from 1970, 1980, and 1990 U.S. Housing Census Data was analyzed and mapped on Atlas GIS to characterize water sources and their change over time.

Objective 2

> The second objective of the paper is to describe water supply options available in the coalfields, including water supply system design, upgrade, replacement, and extension.

Methodology for Objective 2

First, a literature review was conducted on conventional and unconventional small water supply system technologies for system design, replacement, and extension. The assessment included water retention, source protection, supply/distribution, and treatment technologies. Second, technical opportunities and constraints associated with the listed options were identified. Third, construction costs, where available, were summarized.

Objective 3

The third objective is to develop and demonstrate an interactive, manageable, and accessible method of financial assessment and rate-setting for water systems.

Methodology for Objective 3

The *Costing and Rate-Setting Workbook for Water and Sewer Utilities*, by Shinn and Randolph (1989), was selected as a guide for this objective. First, the workbook procedure was converted into spreadsheets, using Microsoft Excel. Second, the utility of the spreadsheet for financial assessment and rate-setting was explained and illustrated. In particular, the spreadsheets were used to calculate construction costs, operation and maintenance costs, and water rate impact of a hypothetical example. Data collected in objectives 1 and 2 were incorporated into the spreadsheets as inputs. Other pertinent information, such as sources of funding and financing, are also included in appendixes.

I. D. Expected Findings

Three primary conclusions are anticipated from this paper. First, water system development and replacement is critically important for community development in the Virginia coalfields. Second, water supply options for the region face natural and technical challenges that demand cost-effective solutions. Finally, the information and costing spreadsheets provided in this study can aid communities and organizations with limited resources to assess the rate impacts of technical and financial water supply options.

I. E. Major Paper Layout

The paper is organized into five main chapters. The sixth chapter contains the list of literature cited. Figure 1.1 summarizes the outline of paper.

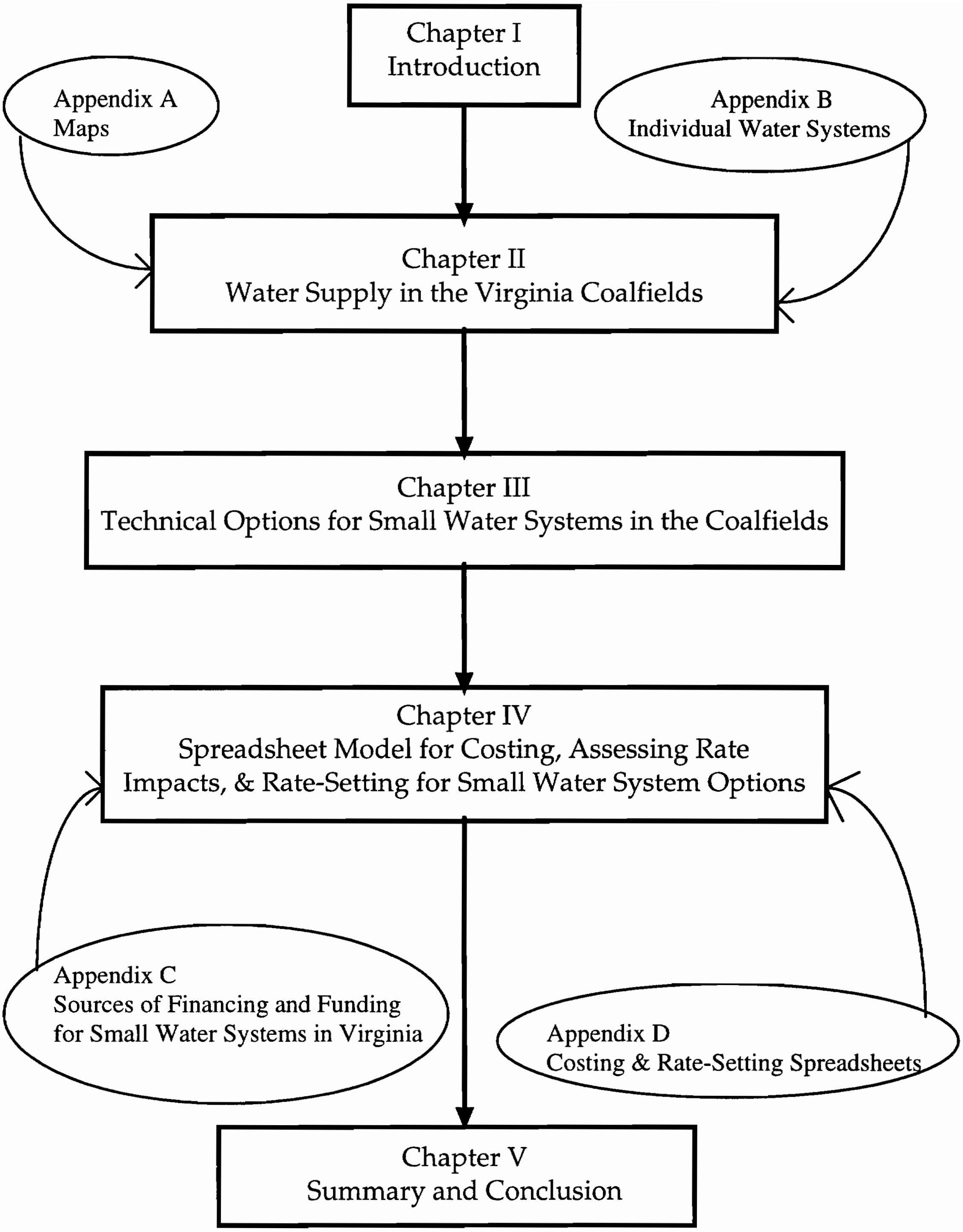

Figure 1.1: Outline Map of Major Paper

Chapter II. Water Supply in the Virginia Coalfields

This chapter provides an overview of the Virginia coalfields and an inventory of existing water supply systems in the region. The first section summarizes general characteristics of the region. The second section addresses drinking water quality problems. The final section highlights existing water supply systems.

II. A. The Virginia Coalfields

Incorporated into Planning District Commission 1 and 2, the Virginia coalfields consist of coal-producing counties: Buchanan; Dickenson; Wise; Lee; Russell; Scott; Tazewell; and the independent city of Norton in Wise County (Figure 2.1). Characterized by rugged mountains and V-shaped valleys with steep slopes and narrow ridges, this area lies in two physiographic provinces. All of Wise, Dickenson, and Buchanan Counties and adjacent areas of Lee, Scott, Tazewell, and Russell counties lie within the Appalachian or Cumberland Plateau. This physiographic province is underlain by massive sandstone rock units, shale, and coal. The remainder of the coalfields are located within the Ridge and Valley physiographic province where limestone valleys dominate. A thrust fault separates the two physiographic provinces.

Coal development was responsible for attracting migrants to the region in the latter part of the nineteenth century and the early twentieth century. Population growth in the coalfields was far above that of other areas in Southwest Virginia. This trend continued through the hard times of the depression in the 1930s and World War II. The demand for labor, however, was reduced with the mechanization of mines in the 1950s. From the 1950s to the 1960s, the net out-migration from the coalfields continued as people moved to urban and suburban areas. When the energy crisis increased the demand for coal in the 1970s, people were lured back to the region in search of high-wage jobs in the coal industry. Fluctuation in population migration continued through the 1980s when the population in the coalfields dropped. A gradual downward trend is expected to continue.

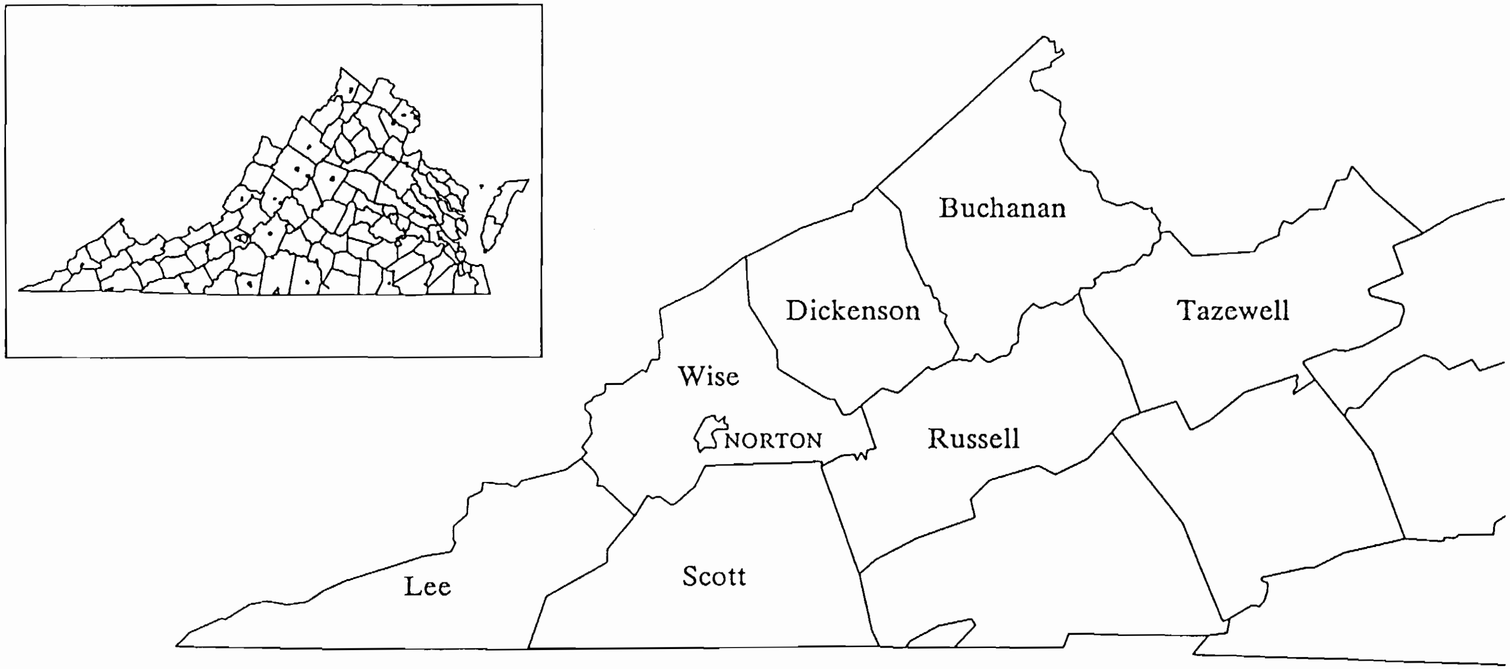

Figure 2.1: The Virginia Coalfield Counties

While the economy of the coalfields is dominated by coal production, other industries impact population and employment. These industries include: apparel; lumber and wood products; furniture and fixtures; paper and allied products; other petroleum products; fabricated metal; machinery; transportation equipment; and stone, clay, and glass products.

II. B. Water Issues on the Coalfields

Major drinking water problems in the coalfields are associated with water availability and quality. Water availability problems are related to the general geology of the region, the percentage of connections to public water systems, and the number of housing units lacking adequate plumbing facilities. Water quality problems consist of natural water characteristics of the region, source contamination, and impacts of mining activities.

Water Availability Problems

The coalfield region experiences severe water quantity problems during drought periods. Some municipal groundwater sources and many individual wells have dried out during drought periods. Even during dry summer months, some water utilities reported unacceptable, low yields. Water quantity limitation is characteristic of sandstone and shale formations. Sandstones in the coalfields tend to be "well cemented and generally poor water sources" (Roth, et. al., 1990: 10). This type of geology is characteristic of the Cumberland Plateau, in which most of the region is located. Even in the Valley and Ridge Plateau, where a higher conductor of water (limestone) dominates, sand and shale typically underlay the ridges and upland areas of the Valley and Ridge Plateau. For these reasons, water sources in the coalfields, particularly individual systems, are unreliable. In a study of two coalfield counties, reliability problems were noted by 16% of those using private/public systems and 19% relying on individual water supplies (Ross et. al., 1995: 29).

Even when water quantity problems can be mitigated by public water, access to these sources is often not available. This water availability problem is illustrated by the low percentages of public water connections in the coalfield counties. In 1990, U.S. Census data indicate that only 2,746 out of 12,222 housing units in Buchanan County are connected to public water systems (Table 2.1). Having the lowest percentage of connected housing units in the coalfields, Buchanan County improved from 9.9 percent in 1970 to 22.5 percent in 1990. Appendix A, Figure 1 shows the percentage of housing units with public water connections for 1970, 1980, and 1990 in each county. From 1970 to 1990, census data indicate that Buchanan, Dickenson, Lee, and Wise counties experienced double digit increases in the percentage of housing units with public water hookups. Russell and Scott stayed in the thirty percentage range with Tazewell remaining in the fifties (Appendix A, Figure 1).

In addition to having the highest number and percentage housing units with public water hookups, 11,548 connections or 72.5% of the total number of housing units, Wise County has the lowest percentage of housing units with individual drilled (18.8%) and dug wells (2.2%) of all the counties in 1990. Dug and drilled wells are discussed in detail in Chapter III. Buchanan County had the highest percentage of housing units with individual drilled wells for 1970, 1980, and 1990 (Appendix A, Figure 2). While the percentage of housing units with individual drill wells decreased more than 10% for other counties, Lee, Scott, and Tazewell only changed by less than 6% (Table 2.1).

Appendix A, Figure 3 shows the percentage of housing units with individual dug wells for the 1980 and 1990 Census. Appendix A, Figure 4 presents data from the 1970, 1980, and 1990 Census for the percentage of housing units using other water sources. Examples of the latter are use of springs, hauled water, or cisterns. In 1970, Lee County had the highest percentage (40.7%) of housing units using other water sources (Appendix A, Figure 4). Although the percentage dropped to 22.8% in the 1990 Census, Lee County remained in the highest percentage range (20% to 30%), with Russell and Scott counties.

In addition to the increases in public water connections, the coalfields have experienced significant decreases in the percentage of housing units lacking plumbing, indicating significant improvement between 1970 and 1990. In 1970, Lee County had the highest percentage (54.1%) of housing units without plumbing (Appendix A, Figure 5).

Table 2.1: Drinking Water Systems in the Virginia Coalfields

		Public Water		Individual Drill Well		Individual Dug Well		Other Water	
County	Total Housing Units	Housing Units	Percent of Total	Housing Units	Percent of Total	Housing Units	Percent of Total	Housing Units	Percent of Total
Buchanan									
1970	8,973	892	9.9%	7,229	80.6%		N/A	852	9.5%
1980	12,764	1,011	7.9%	9,478	74.3%	1,032	8.1%	1,243	9.7%
1990	12,222	2,746	22.5%	7,553	61.8%	787	6.4%	1,136	9.3%
Dickenson									
1970	5,056	988	19.5%	2,888	57.1%		N/A	1,174	23.2%
1980	6,899	2,502	36.3%	2,802	40.6%	341	4.9%	1,254	18.2%
1990	7,112	3,152	44.3%	2,590	36.4%	232	3.3%	1,138	16.0%
Lee									
1970	7,289	2,087	28.6%	2,239	30.7%		N/A	2,963	40.7%
1980	9,652	3,943	40.9%	2,510	26.0%	360	3.7%	2,839	29.4%
1990	10,263	4,756	46.3%	2,739	26.7%	429	4.2%	2,339	22.8%
Russell									
1970	7,607	2,566	33.7%	2,190	28.8%		N/A	2,856	37.5%
1980	11,518	4,502	39.1%	3,906	33.9%	379	3.3%	2,731	23.7%
1990	11,558	4,342	37.6%	4,456	38.6%	331	2.9%	2,429	21.0%
Scott									
1970	8,124	2,689	33.1%	2,721	33.5%		N/A	2,705	33.3%
1980	9,741	3,482	35.7%	2,842	29.2%	531	5.5%	2,886	29.6%
1990	10,003	3,655	36.5%	3,409	34.1%	525	5.2%	2,414	24.1%
Tazewell									
1970	12,841	6,589	51.3%	3,368	26.2%		N/A	2,878	22.4%
1980	18,230	10,079	55.3%	4,997	27.4%	447	2.5%	2,707	14.8%
1990	18,901	10,467	55.4%	5,587	29.6%	450	2.4%	2,397	12.7%
Wise									
1970	11,512	6,349	55.2%	3,192	27.7%		N/A	1,963	17.1%
1980	15,645	9,853	63.0%	3,658	23.4%	450	2.9%	1,684	10.8%
1990	15,927	11,548	72.5%	2,999	18.8%	347	2.2%	1,033	6.5%
Norton City									
1970	1,436	1,386	96.5%		N/A		N/A	46	3.2%
1980	1,839	1,794	97.6%	19	1.0%	0	0.0%	26	1.4%
1990	1,845	1,828	99.1%	12	0.7%	5	0.3%		N/A
Coalfield Counties									
1970	62,838	23,546	37.5%	23,827	37.9%		N/A	15,437	24.6%
1980	86,288	37,166	43.1%	30,212	35.0%	3,540	4.1%	15,370	17.8%
1990	87,831	42,494	48.4%	29,345	33.4%	3,106	3.5%	12,886	14.7%

Source: U.S. Census: 1970, 1980, 1990

This percentage dropped to 9.2% in the 1990 Census. At 10.3%, Scott is the only county to still be in the 10% to 20% group. Although these improvements in indoor plumbing are dramatic, approximately 1,028 housing units in Scott County still did not have complete plumbing facilities as of the 1990 Census (Table 2.2). The findings indicate a substantial number of housing units requires not only public water access but also modern infrastructure to support public system water.

Natural Water Quality Problems in the Coalfields

In addition to water quantity problems, the physiography of the coalfields contributes to water quality problems. That is, groundwater in the Cumberland Plateau tends to be of poor quality, sulfurous and iron-rich, due to the sandstone, shale, and coal formations (Weigmann et. al., 1988: 5). At depths of greater than 300 feet, naturally saline waters occur in this region. Furthermore, the chemical composition of limestone formations contributes to the "hardness" of water in the Valley and Ridge Plateau. In limestone areas, sizable surface streams disappear into underground channels to become head waters for rivers, carrying contamination during the process (Weigmann et. al., 1988: 5).

Karst terrain is another natural formation that can contribute to water contamination. The karst terrain in the Ridge and Valley Plateau "is characterized by sinkholes and solution channels which may accelerate the movement of contaminants into deep wells" (Ross, et. al., 1995: 29). That is, while streams and surface runoff entering sinkholes to recharge the Ridge and Valley Plateau aquifers, they are also direct conduits of contaminants. Dumping in sinkholes also has tremendous adverse impact on groundwater. These conditions make the pollution potential in this province very high.

The coalfields are also characterized by thin top soil that allows relatively easy penetration by contaminants. Furthermore, shallow wells or springs not only have the tendency to dry up during summer months but are also easily contaminated by land use practices. All of these conditions contribute to natural water quality problems in the region.

Table 2.2: Sewage Disposal and Lack of Plumbing in the Virginia Coalfields

		Public Sewer		Septic Tank and Cesspool		Other Sewer Disposal Means		Lack of Plumbing	
County	Total Housing Units	Housing Units	Percent of Total	Housing Units	Percent of Total	Housing Units	Percent of Total	Housing Units	Percent of Total
Buchanan									
1970	8,973	676	7.5%	4,241	47.3%	4,056	45.2%	3,879	43.2%
1980	12,764	1,022	8.0%	9,896	77.5%	1,846	14.5%	1,785	14.0%
1990	12,222	1,297	10.6%	10,034	82.1%	891	7.3%	581	4.8%
Dickenson									
1970	5,056	480	9.5%	1,913	37.8%	2,657	52.6%	2,459	48.6%
1980	6,899	935	13.6%	4,567	66.2%	1,397	20.2%	951	13.8%
1990	7,112	1,058	14.9%	5,180	72.8%	874	12.3%	480	6.7%
Lee									
1970	7,289	930	12.8%	2,685	36.8%	3,674	50.4%	3,942	54.1%
1980	9,652	1,440	14.9%	6,226	64.5%	1,986	20.6%	1,755	18.2%
1990	10,263	1,700	16.6%	7,563	73.7%	1,000	9.7%	941	9.2%
Russell									
1970	7,607	1,272	16.7%	3,082	40.5%	3,258	42.8%	3,285	43.2%
1980	11,518	2,450	21.3%	7,315	63.5%	1,753	15.2%	1,508	13.1%
1990	11,558	2,417	20.9%	8,159	70.6%	982	8.5%	719	6.2%
Scott									
1970	8,124	848	10.4%	3,735	46.0%	3,532	43.5%	3,647	44.9%
1980	9,741	1,213	12.5%	6,467	66.4%	2,061	21.2%	2,161	22.3%
1990	10,003	1,806	18.1%	7,314	73.1%	883	8.8%	1,028	10.3%
Tazewell									
1970	12,841	5,163	40.2%	4,074	31.7%	3,598	28.0%	4,050	31.5%
1980	18,230	8,401	46.1%	8,210	45.0%	1,619	8.9%	1,423	7.8%
1990	18,901	9,391	49.7%	8,737	46.2%	773	4.1%	566	3.0%
Wise									
1970	11,512	4,089	35.5%	3,407	29.6%	4,008	34.8%	4,187	36.4%
1980	15,645	6,887	44.0%	7,298	46.6%	1,460	9.3%	1,331	8.5%
1990	15,927	7,284	45.7%	7,905	49.6%	738	4.6%	703	4.4%
Norton City									
1970	1,436	1,287	89.6%	23	1.6%	122	8.5%	294	20.5%
1980	1,839	1,706	92.8%	70	3.8%	63	3.4%	88	4.8%
1990	1,845	1,784	96.7%	61	3.3%		N/A	13	0.7%
Coalfield Counties									
1970	62,838	14,745	23.5%	23,160	36.9%	24,905	39.6%	25,743	41.0%
1980	86,288	24,054	27.9%	50,049	58.0%	12,185	14.1%	11,002	12.8%
1990	87,831	26,737	30.4%	54,953	62.6%	6,141	7.0%	5,031	5.7%

Source: U.S. Census: 1970, 1980, 1990

Potential Water Quality Problems from Source Contamination by Septic Systems

When combined with naturally occurring water contamination, land use practices magnify and intensify water quality problems. In particular, the use of septic systems can have dramatic impact on groundwater if not properly designed, sited, or maintained. They have a high potential to contaminate groundwater with nitrates, coliform bacteria, viruses, and a variety of organic and inorganic chemicals from household use. For this reason, the U.S. Environmental Protection Agency considers septic systems as the major source of the groundwater contamination process (Weigmann et. al., 1988: 11).

The problem intensifies when the working conditions of septic systems are also considered. That is, inappropriate siting and poor design, construction, and maintenance of these systems can contaminate groundwater. Since the design life of septic systems averages 10 to 15 years, many existing septic systems installed in the 1960s have exceeded their design life and may no longer be functioning properly (Weigmann et. al., 1988: 11). These problems are exacerbated in the coalfield area, which is characterized by shallow soils, steep slopes, and dense development in narrow valleys and hollows.

In the coalfield counties, a high percentage of housing units uses septic systems and cesspools for sewer disposal. Of all the counties, the highest percentage (49.7%) of housing units connected to public sewer systems is found in Tazewell County (Appendix A, Figure 6). This means that the percentage of housing units with access to public sewer disposal is still less than 50%. From the 1970 to the 1990 Census, percentage increases in housing units connected to public sewer have not exceeded more than 10 percent for any county in the coalfields (Appendix A, Figure 6).

The 1990 U.S. Census showed that four counties (Dickenson, Lee, Russell, and Scott) have more than 70 percent of housing units using septic tanks or cesspools for sewage disposal (Appendix A, Figure 7). Being in the lowest percentage range, between 40 and 50 percent, 49.6 percent of Wise County and 46.2 percent of Tazewell County use septic systems (Appendix A, Figure 7). Buchanan County had the highest percentage of 82.1 percent. Having the advantage of being an urban area, Norton City only had a 3.3 percent septic use as well as a high percentage of public water connections.

The trends of septic tank and other means of sewer disposal use, such as privies, are shown in Appendix A, Figure 7 and Figure 8. Although both trend are downward, a total of 54,953 housing units in the coalfields still use septic tank or cesspool to dispose sewage (Table 2.2). Furthermore, the total number of housing units using other sewer disposal means consists of 6,204. These numbers indicate that the potential for groundwater contamination from septic and other sewage disposal systems should be addressed.

Water Quality Problems and Mining

Although mining has provided a large percentage of the employment in the coalfields, it has yielded adverse impacts on water quantity and quality. For example, "the stripping on the surface and the tunneling below the surface contaminated and disrupted the groundwater supply" of some locations in Wise County (Weigmann et. al., 1988: 29). Both surface and deep coal mining in Virginia pose treats to groundwater.

Two major problems are created by mining. The first problem involves the loss of water in wells when aquifers are interrupted by nearby blasting or subsidence. The latter results from the honeycombing of mine shafts in mountains. Subsequently, land subsidence and cave-ins of overlying material disturb surface material. Subsidence can damage well shafts, drain acquifers, and contaminate well water. High extraction mining, the most prevalently used method in Virginia, causes subsidence by design.

The second problem created by mining consists of surface and groundwater contamination from coal extraction and production processes. Since coal is frequently found with iron pyrites and other sulfides, water contamination can occur from acid mine drainage, the washing of chemicals and minerals, and mine wastes. For example, dewatering causes these minerals to be exposed to oxygen, resulting in chemical reactions that render the minerals acidic. The reintroduction of these transformed minerals into water results in "very acidic groundwater with high levels of iron and sulfates" (Weigmann et. al., 1988: 29).

Even wells that tap water from coal seams are often characterized by high levels of inorganic constituents, especially iron, manganese, and sulfates (Ross, et. al., 1995:

29). Coal seams are "the only lithologic units capable of storing and transmitting significant qualities of water" (Roth, et. al., 1990: 12). Thus, water from these sources must be treated by appropriate treatment technologies for acceptable household use.

II. C. Water Supply Systems in the Virginia Coalfields

This section provided an inventory of existing water supply systems in the Virginia coalfields counties. Since the coalfields are located on two major river basins, this section is organized by the Big Sandy Planning Area and Tennessee Planning Area. Within the Tennessee Planning Area, two relevant subbasins consist of the Clinch and Powell subbasins. The two planning areas are also located in PDC 1 and PDC 2. The relationship between planning areas, subbasins, planning district commissions (PDCs), and counties are summarized in Table 2.3. Table 2.4 summarizes the service areas in terms of the number of connections in 1983 and 1995, the Virginia Department of Health (VDH) limit on the number of connections and water loss in 1983 and 1995.

Table 2.3: Water Basins in the Virginia Coalfields

Counties	Planning Areas	Subareas	PDC
Buchanan	Big Sandy		2
Dickenson	Big Sandy		2
Wise	Big Sandy & Tennessee	Powell & Clinch	1
Lee	Tennessee	Powell	1
Russell	Tennessee	Clinch	2
Tazewell	Tennessee	Clinch	2
Norton	Tennessee	Clinch	1

Big Sandy Planning Area

The Big Sandy River Basin occupies all of Buchanan County and portions of Dickenson, Tazewell, and Wise counties. It is largely located in the Appalachian Plateau Physiographic Province or the Cumberland Plateau. The Big Sandy Planning Area

Table 2.4

The Virginia Coalfields Water Supply Systems

			Connections			Water Loss		
Area	**County**	**Source**	**1983**	**1995**	**VDH Limit**	**1983**	**1995**	**Issues**
Big Sandy Planning Area								
John Flannagan Demand Center								
Town of Clintwood	Dickenson	Surface	970	1,580	1,620	20%	18%	Supplied by JFWA Limited pump capacity
Big Caney Water Corp.	Dickenson	Ground	n/a	1,780	3,300	n/a	50%	Inadequate treatment capacity
Town of Grundy	Buchanan	Ground	700		n/a	59%	n/a	Inadequate treatment
Buchanan County PSA	Buchanan	Surface	400	3,950	None	76%	21%	Includes Town of Grundy
Dickenson County PSA	Dickenson	Surface	n/a	291	None	n/a	5%	Buys from JFWA & Wise County
Pound Demand Center	Wise	Surface	576	795	n/a	n/a	n/a	Inadequate source
Amonate Demand Center	Tazewell	Ground	90	77	n/a	n/a	n/a	Supplied by TCPSA
Bishop Demand Center	Tazewell	Surface	103	104	103	n/a	n/a	Supplied by TCPSA
Tennessee Planning Area								
Clinch River Planning Subarea								
Clinchport Demand Center	Scott	Surface	45	n/a	75	n/a	n/a	Decreasing demand
Duffield Demand Center	Scott	Surface	275	321	None	n/a	11%	All water supplied by DDA
Lebanon Demand Center	Russell	S & G	1,400	1,655	n/a	17%	12%	May have shortage by 2010
Honaker Demand Center	Russell	S & G	740	900	None	24%	13%	Water loss is high
St. Paul Russell County Demand Center								
Town of Cleveland	Russell	S & G	120	121	168	64%	n/a	Old distribution system
Town of St. Paul	Russell	Surface	450	395	n/a	20%	n/a	A water surplus projected for 2030
RCWSA	Russell	S & G	1,510	1,669	1,440	50%	n/a	A water surplus projected for 2030
Wise-Norton Demand Center								
City of Norton	Norton	Surface	2,200	2,101	n/a	45%	n/a	High commercial water use & water loss
Town of Wise	Wise	Surface	2,281	2,246	3,750	27%	25%	
Town of Coeburn	Wise	Surface	1,300	1,413	None	33%	18%	Included in WCPSA
WCPSA	Wise	Surface	725	2,282	n/a	n/a	n/a	Expanded recently
Richlands-Tazewell Demand Center								
TCPSA	Tazewell	Surface						Average water loss is at 20%
Jewell Ridge Section			94	82	125	24%	n/a	Formally Cavitts Creek Project
Raven-Doran Section			737	751	n/a	11%	n/a	More expansions planned
Claypool Hill Section			457	839	n/a	n/a	n/a	
Town of Richlands	Tazewell	Surface	2,300	2,680	n/a	50%	20%	Upgraded recently
Town of Cedar Bluff	Tazewell	Surface	584	697	n/a	29%	n/a	Water loss requires reduction
Town of Tazewell	Tazewell	Surface	1,645	1,850	n/a	21%	n/a	Water loss requires reduction
Powell River Subarea								
Pennington Gap Demand Center								
Town of Pennington Gap	Lee	Surface	n/a	1,184	n/a	20%	n/a	System should expand to Jonesville
SCWSA	Lee	Surface	530	545	n/a	20%	n/a	Buys from Pennington Gap
Dryden Water Authority	Lee	Surface	338	443	n/a	20%	n/a	Buys from Pennington Gap
Town of Jonesville	Lee	Surface	517	593	n/a	36%	12%	Upgraded recently
Woodway Water Auth.	Lee	Surface	720	968	n/a	50%	n/a	High water loss
Big Stone Gap Demand Center								
Appalachia SA	Wise/Lee	Surface	1,605	1,469	None	52%	18%	Upgraded recently
BSGSA	Wise	Surface	3,063	3,493	n/a	42%	n/a	High water loss
Western Lee County Demand Center								
Lee County Water Auth.	Lee	Surface	575	709	n/a	n/a	20%	Buys from ASUD in Tennessee VDH approved a local spring
Rose Hill SA	Lee	Surface	217	n/a	217	n/a	n/a	Unmetered system, depends on gravity
Dunbar Demand Center	Wise	Ground	52	n/a	52	n/a	n/a	Maintained by Westmoreland Coal Co.

consists of four demand centers: 1) John Flannagan; 2) Pound; 3) Amonate; and 4) Bishop. The John Flannagan demand center is broken down into four service areas.

Service areas in the planning area are summarized, in terms of connection numbers and water source type, in Table 2.4. Individual systems are discussed in more detail in Appendix B. In 1995, Buchanan PSA has the highest number of connections in the Big Sandy Planning Area. It includes the Town of Grundy.

Public water withdrawals in the planning area are from reservoirs, ground water, and surface water. In 1980, approximately 16 percent of the Basin population was served by public water supply systems. Thus, a large portion of the Basin population, 84 percent, did not obtain water from public supply systems. The majority of these people relied on ground water wells while a small percentage used springs, surface water streams, and cisterns. It was expected that most of the region will connect to public water supplies whenever possible, because the ground water is typically of relatively poor quality due to increased levels of iron, manganese, sulfates, and, occasionally, chlorides. In 1990, many counties in this area, particularly Buchanan, have made significant improvements in service connection.

Tennessee Planning Area

The largest water basin planning area in the coalfields is the Tennessee Planning Area. It includes two subbasin areas: the Clinch River subbasin and the Powell River subbasin. These subbasins are discussed separately below.

The Clinch River Subbasin

The Clinch River subbasin includes portions of Scott, Russell, Wise, and Tazewell counties, as well as the City of Norton. It consists of six demand centers: 1) Duffield; 2) Lebanon; 3) Honaker; 4) St. Paul/Russell; 5) Wise/Norton; and 6) Richlands/Tazewell. The Clinch River Subbasin contains 15 service areas within 6 demand centers. These are summarized in Table 2.4. Individual water supply system are described in Appendix B.

Powell River Subarea

The Powell River Subarea is the westernmost of the three Tennessee River Subareas in Virginia. It includes Lee County, and the southwestern portion of Wise County. The total land area of the subbasin is 548 square miles. The Big Sandy River Basin borders the subarea on the north, the Clinch River Subbasin on the east, Tennessee on the south, and Kentucky on the west. There are 2 physiographic regions in the subbasin: *the Valley and Ridge Physiographic Province* (Lee County portion of the subbasin) and the *Appalachian Plateau Physiographic Province* (Wise County portion).

Ground water availability within the subbasin varies with the physiographic regions: it is typically scarce and of poor quality in the Appalachian Plateau region while more plentiful and of better quality in the Valley and Ridge region. Land use varies with physiographic provinces: coal mining is more prevalent in the Appalachian Plateau region, while farming is more common in the Valley and Ridge region.

There are four demand centers that encompass ten water service areas. *The Big Stone Gap Demand Center* includes the Appalachia Service Areas. *The Pennington Gap Demand Center* covers five service areas: the Town of Pennington Gap; St. Charles Water and Sewerage Authority; Dryden Water Authority; Woodway Water Authority; and the Town of Jonesville. The most southwestern demand center of *western Lee County* is composed of Lee County Water Authority (LCWA) and the Rose Hill Service Area. *The Dunbar Demand Center* is the smallest in the subarea, serving the communities of Dunbar and Roaring Fork. These service areas are summarized in Table 2.4. Individual system descriptions are in Appendix B.

Approximately 42% percent of the subarea is not being served by municipal water supplies. These areas rely on ground water wells and springs for domestic needs. A small percentage uses surface streams and cisterns. In 1980, there were approximately 17,012 people who obtained their water supplies independently for domestic use. It was estimated that 90% of this water was obtained from groundwater, 7% from surface water, and 3% from cisterns.

Of all water produced in the demand center, 31% is unaccounted or lost. Water loss is mostly caused by improperly installed or poorly maintained distribution systems in the subarea. Most industrial water use in the subarea is by coal producing operations, which obtain their water independently from ground water wells and surface water streams. Although 84 percent of the self-supplied industrial demand occurs within demand center boundaries, they have caused no threat to central water supplies to date, and no shortages are projected to be caused by these withdrawals.

Primary water sources for Big Stone Gap and Pennington Gap demand centers are surface water supplies. In fact, 78 percent of water used in the subarea's demand centers is surface water. Groundwater quality and quantity in the Appalachian Plateau region of the subarea is generally inadequate for large public waterworks systems. Furthermore, some of the smaller communities, such as Rose Hill and Dunbar, have low water pressure. Compounded by the fact that the cost of refurbishing these distributions systems is high, few service areas have capital available for improvements.

The largest withdrawal in the subarea is from the Big Cherry reservoir. The latter is the sole water source for the Town of Big Stone Gap. Two other water supply reservoirs in the subarea comprise the primary water supplies for the Town of Appalachia and Town of Big Stone Gap. Each reservoir is located to the east of its respective town. The Big Cherry Reservoir is actually two impoundments in series which act as a single source.

Summary of Water Systems in the Coalfields

Table 2.5 identifies water systems having unconventional sources, quantity and quality problems, and high water loss. These system would particularly benefit from information and analyses provided by this paper. The Town of Coeburn, in particular, can contribute to future case studies of innovative water system sources. It operates a well in an abandon mine shaft.

Quantity water problems listed below consist of wells and reservoir going dry during summer months. Service areas with this problem are looking for more reliable water sources. They are also very concerned about keeping water loss at a minimum to minimize water shortage. These service areas may be suitable candidates for water harvesting techniques described in the next chapter.

Quality water problems listed in Table 2.5 comprise of high iron, manganese, sodium, and chlorides. These problems complicate water treatment requirements and increase treatment costs. System maintenance costs also increases as contaminant can cause corrosion of equipment. Although only those service areas with stated, high water quality problems are identified, other systems may have similar contamination. Treatment technologies, suitable for these contaminants, are discussed in Chapter III.

In addition to water quantity and quality problems, many service areas in the coalfields experience high water loss. Although some systems have improved water loss since the 1980s, many are still operating over the recommended 20 percent water loss. Old, unmetered systems and theft contribute to high water unaccountability. Since water loss is costly to maintain and resolve, some systems have no choice but accept existing operating conditions. These service areas may especially benefit from the information and analysis provided in Chapter III and Chapter IV.

Table 2.5: Reported Water System Problems

Water Systems	Special Notes
Unconventional Water Sources	
Town of Coeburn	Supplement well in abandon mine shaft
Systems with Quantity Problems	
Town of Grundy (BCPSA)	Well #2 often goes dry
Russell County Water & Sewer Auth.	Groundwater sources goes dry during summer
City of Norton	Supplement wells unreliable during droughts
TCPSA: Jewell Ridge	Surface impoundment goes dry during summer
Systems with Quality Problems	
Town of Grundy (BCPSA)	Wells have iron, manganese, chlorides
Town of Coeburn	High iron, manganese, & sodium in supplement well
TCPSA: Jewell Ridge	Supplement well has high iron & manganese
Town of Appalachia	Emergency deep wells has high iron & manganese
Systems with High Water Loss	
Big Caney Water Corporation	50%
Town of Cleveland	60%*
Russell County Water & Sewer Auth.	50%*
City of Norton	45%*
Woodway Water Authority	50%*
Big Stone Gap Service Area	42%*
BCPSA	21%
Town of Wise	25%
Rose Hill Service Area	Entire system old, unmetered, gravity feed: needs repairs
	* 1983

Chapter III. Technical Options for Small Drinking Water Systems in the Coalfields

This chapter discusses technical options for constructing, upgrading, and extending small water systems. Technical options selected for review were those deemed applicable to the Virginia coalfields, based on their use in small water supply systems and their relatively low costs. Capital and operation and maintenance costs are provided where available. These cost estimates are used in the costing and rate-impact spreadsheet methodology described in Chapter IV.

Chapter III is organized into three major sections. Section A deals with retention systems for surface and groundwater. Section B describes supply/distribution systems and associated component costs. Section C provides an overall assessment of treatment technologies and associated costs.

As a raw material, water "circulates between the natural environment and the technological world through three processes: supply, industrial and domestic use, and treatment" (Brdys et. al., 1994: 1). In studying water supply systems, the first of these three steps serves as the main focus. That is, water systems are the means by which water is transferred from the environment to people. These systems generally are of two types: *water retention systems* and *water supply/distribution systems*.

III. A. Water Sources/Retention Systems

Often considered as part of the environment, water retention systems function "to ensure the continuity of water supplies, in spite of seasonal fluctuations in water availability, and to protect against [floods]" (Brdys et. al., 1994: 2). Retention systems are generally associated with both surface and underground water sources.

Groundwater Sources

Groundwater is found in the *zone of saturation*. This is the level, below the earth's surface, at which all of the openings or voids of the earth's materials are filled with water. This zone is replenished by infiltration of precipitation draining downward from the earth's surface. As a source of groundwater, a spring is an opening from which groundwater flows. In coal producing areas, such as the Virginia coalfields, groundwater can be found in coal seams. The latter consist of several individual coal beds separated by thin inorganic layers (Harlow et. al., 1991: 5). Wells are used to extract water from these unconventional groundwater reservoirs as well as conventional ones.

Extracting Groundwater

The development of groundwater falls into two categories: development by wells and development from springs. Two basic types of wells include nonartesian and artesian. The two general types of springs consist of gravity and artesian.

Nonartesian wells are those that penetrate formations in which groundwater is found under water-table conditions. Water is pumped from wells via artificially created pressures that lowers the water table in the vicinity of the well, creating a cone of depression. Alternatively, *artesian wells* penetrate aquifers in which the groundwater is found under hydrostatic pressure. Such a condition occurs in an aquifer that is confined beneath an impermeable layer of material at an elevation lower than that of the intake or recharge area of the aquifer. (EPA-570/9-82-004, 1982: 26).

Gravity springs occur where water percolating laterally through permeable material, overlying an impermeable layer, comes to the surface. They also occur where the water table intersects the land surface. Being sensitive to seasonal fluctuations and typically low-discharge sources, gravity springs can be suitable for individual water supply system when properly developed.

Artesian springs or flowing artesian wells discharge from artesian aquifers without a pump. They may occur where the confining formation over the artesian aquifer is ruptured by a fault or where the aquifer discharges to a lower topographic area. Although more dependable then gravity springs, they are sensitive to the pumping of wells in the same aquifer. Consequently, pumping can cause artesian springs to stop flowing.

Well Technologies

Dug wells are usually constructed by hand down to a shallow water table. They can be lined with brick, stone, or concrete. Because they are close to the surface, they are more difficult to protect from contamination; thus, they are only suitable for individual water systems in areas with low risk of water contamination. Because of their shallow penetration into the zone of saturation, dug wells are also more prone to failure in times of drought.

Bored wells are usually constructed with earth augers turned by hand or power equipment. They extend deeper than dug wells, but usually to depths of less than 100 feet into the water-bearing formation. Generally, they have the same basic characteristics of dug wells.

Driven wells, in contrast, are constructed by driving a drive-well point, fitted to the end of a series of pipe sections, into the ground. Drive points are usually 1.25 or 2 inches in diameter. The well is driven with the aid of a maul or a special drive weight. Deeper wells are constructed by driving well points into water-bearing strata from the bottom of a dug or bored well. Driven wells are the simplest and least expensive of all driven wells.

Jetted wells employ a rapid and efficient method of sinking well points. Also called washing-in, the jetting process requires a source of water and a pressure pump. The jetting loosens earth material as water is forced down under pressure. The well point and pipe are then lowered as material is loosened.

Drilled wells are constructed by the percussion and rotary hydraulic drilling. Percussion drilling employs a cable tool that raises and drops a heavy drill bit and stem. The impact of the bit crushes and dislodges pieces of earth formations. Rotary hydraulic drilling involves a derrick and hoist, a revolving table through which the drill pipe passes, a series of drill-pipe sections, a cutting bit at the lower end of the drill pipe, a pump for circulation drilling fluid, and a power source to drive the drill (EPA-570/9-82-004, 1982: 41).

Development of Springs

Two general requirements are necessary in the development of springs for domestic water use. First, the selected spring must have adequate capacity to provide the required quantity of water needed throughout the year. Second, the spring's water quality must be protected.

Water quality is a special concern since springs usually become contaminated when barnyards, sewers, septic tanks, cesspools, or other sources of pollution are located on higher adjacent land. Contaminated material in limestone formations also frequently enters the water-bearing channels through sink holes or other large openings. These contaminants may be carried with groundwater for long distances before reaching a spring.

In terms of construction, a spring encasement is used. A spring encasement is an open-bottom, watertight basin. It intercepts source water by an extension to bedrock or via a system of collection pipes and a storage tank. It has a cover that prevents surface drainage or debris from entering the storage tank. Provisions for overflow and the emptying of the tank contents are also required. The encasement is connected to the distribution system or auxiliary supply.

Surface Water Sources

Surface water originates from precipitation that does not enter the ground through infiltration nor return to the atmosphere by evaporation. Conventional surface water sources consist of rivers, streams, and natural reservoirs such as lakes and ponds. Since groundwater becomes surface water at springs, the latter is also a source of surface water. In fact, a spring can be characterized as surface or groundwater, depending on where it is tapped. Artificial reservoirs are also sources of surface water. Unconventional surface water sources include cisterns for hauled water and harvested rain water.

Surface Water Source Development

Conventional surface water, such as rivers, lakes, ponds, artificial reservoirs, employ relatively simple extraction technologies. The latter consist of pumps, pipes, valves and an intake point. The specification for these components varies depending on volume, elevation, climate of the region, and quality of the water. For example, the intake point of a lake may have thinner screening or initial filtering requirements than that of a river. In a pond, a flexible pipe may be needed to raise the intake point to a desired 12" to 18" below the water surface. In areas with slopes, gravity can also be a source of flow power.

Water Harvesting

Harvesting of rain water is an alternative and unconventional water supply source. It is the deliberate collection and storage of rainwater from a surface catchment to provide a supply of water. Water harvesting, however, is distinct from the process of controlling and storing natural runoff of water, into perennial rivers, in dams and reservoirs. The harvesting of rainwater and storm runoff helps mitigate the problem of water storage during dry seasons in areas where rainfall is heavy for some months of the year and light for the rest. Water harvested during wet months can be stored and used during dry months.

Rainwater harvesting was used extensively in ancient Europe. These techniques date back to prehistoric times. Sophisticated examples of rain harvesting have been found in the ruins of the palace of Knossos (1700 BC), the center of Minoan Crete (UNEP, 1983: 5). Water harvesting was a sufficient water source since the amount of drinking, cooking, and washing water consumption in ancient European civilizations was relatively low. As a result, areas for collecting water through rain harvesting were incorporated into house designs, for example, roofs and paved courts (UNEP, 1983: 3). Cisterns or basins were also constructed to store water. As community size increased, rain harvesting lost its importance because water demand was much higher than could be provided for by such a simple method. It is, however, still being used in smaller communities to supplement existing water sources (UNEP, 1983: 8). In fact, rain harvesting is used in areas where only highly mineralized groundwater is available for domestic use. Since the high salt content of the groundwater is undesirable for certain functions, collected rainwater is used for washing and cooking in these areas.

Furthermore, increased interest in water harvesting occurs in areas, such as the U.S. southwest or where rainfall is plentiful, where surface and groundwater are unreliable.

Techniques of Harvesting Water

Rain and stormwater can be harvested by contour terracing, silt traps, check dams, and canals. Commonly design on a large scale, these methods are typically used in tropical countries. Small earthen dams, called bunds, are also used in south India and Sri Lanka. Being a very old technique, water harvesting via bunds is the practice of putting small earthen dams across local streams to collect rainwater running off the neighboring region (UNEP, 1983: 149). Bunds are generally built with human and animal power. They can supply both domestic and agricultural water needs. Water can also be harvested by haffirs. The latter are essentially excavations made at the bottom of natural catchments. Commonly found in the Middle East and western India, haffir water is used mainly for livestock . In arid and semi-arid climates, water can be harvested from dew, mist, and snow. Of all techniques, water harvesting from roofs may be most applicable to the Virginia coalfields.

Water Harvesting from Roofs

The use of roofs for water collection is widely practiced in tropical areas (UNEP, 1983: 27). Rainwater harvesting from rooftops is currently widely used in Africa and Israel. Even in areas with low per capita surface water flow, for example in parts of Rajasthan in India, roof water harvesting is practiced.

Corrugated galvanized iron roofs have been used to harvest water in many humid and sub-humid regions. When employed with gutters, these roofs are relatively inexpensive and have low maintenance costs (UNEP, 1983: 27). Similarly, tile roofs are inexpensive and durable. They also make less noise during rain periods than iron sheets. Since tile roofs are heavier, they require stronger supporting frames.

After the collected water is filtered through sand and gravel, it can be stored above or underground. Underground cisterns are typically cooler, less expensive to construct, and spatially unobtrusive. Storage containers are covered to prevent contamination from dust, human and animals, algal growth, and breeding of mosquito larvae. In addition to health considerations, covered storage is recommended to prevent water loss through evaporation. Cisterns should also be located under shade to keep water cool and prevent evaporation.

Above and underground cisterns can be constructed with cement, brick cemented with a waterproof mortar, rocks, clay, or iron. The choice of material depends on the availability and costs of materials in a particular region. Reinforced cement is recommended for underground cisterns. This material provides durable and potentially large cisterns. In Australia, the most common size cistern of this type has a volume 100,000 liters. When equipped with sand filters, settling tanks, and hand or powered pumps, cement reinforced cisterns can be independent, long-term water storage facilities for individual water systems.

III. B. Water Source Protection

All water sources can be easily contaminated. While water treatment is necessary in most drinking water systems, water source protection can reduce treatment needs. Source protection consists of preventative strategies that protect surface and groundwater from pollution. It reduces threats to important water resources, thus, lowers future costs of removing pollutants. Table 3.1 lists source protection strategies applicable to the Virginia coalfields.

Table 3.1: Water Source Protection Strategies

Preserve Riparian Areas
Fence Stream Banks
Check septic system
Minimize Fertilizer and Pesticide Use
Dispose of Wastes Safely
Buffers and Setback in Zoning
Best Management Practices

Source: Derived from Weigmann et. al., 1993: 13-14 and Lower James River Association, 1991: 61-62, 69-70.

One method of ensuring good water quality is to *preserve riparian areas.* This is achieved by creating and protecting buffer zones along riparian areas. Not only do trees, grasses, and shrubs along riparian areas provide shade, cool temperature, and shelter for fish and wildlife, vegetation helps prevent pollutants from entering surface water. That is, roots of grasses, wildflowers, and shrubs bind the soil to banks, slow storm runoff, and prevent erosion and sedimentation. They also act as a natural filter for harmful nutrients, sediments, and pesticides before they enter the water.

Another method of protecting water quality is to *fence stream banks.* In addition to promoting better livestock management, fencing limits access by livestock to springs and streams (Weigmann et. al., 1993: 13). Fencing reduces erosion and other damage to surface water from livestock. By limiting livestock access to drinking water sources, waterborne diseases, common where livestock drink and defecate, can be minimized.

Proper maintenance of *septic systems* also reduces pollutants from entering drinking water sources. It is important for landowners to know that "the life of a septic drain field averages 10 to 20 years, after which the soil's capacity to filter and remove impurities is reduced (Weigmann et. al., 1993: 13). Furthermore, a septic tank should be pumped out every 3 to 5 years to remove solids and prevent overflows. Poisonous chemicals, such as pesticides and metal solvents, should not be poured into a septic system since they can kill the bacteria that help detoxify and decompose wastes (Weigmann et. al., 1993: 13). Finally, proper siting, design, and construction of septic systems can minimize adverse impacts on nearby drinking water sources. For example, "the appropriate distance between an on-site septic system and a spring is 200 feet if the septic system is upslope or above the spring, and 100 feet if the septic systems is below the spring" (Weigmann et. al., 1993: 13).

Reducing the amount of nitrogen and phosphorus fertilizers on farm land, gardens, and lawns can significantly reduce contamination of springs, streams, and groundwater. Initially, the soil can be tested to determine the appropriate amount and type of fertilizer needed, which saves money protects water quality. Of course safe and effective use of fertilizer also protect water quality. For example, fertilizer should not be applied near water sources, on steep slopes, during rainy weather, or when the ground is frozen. Furthermore, fertilizer storage should be sited away from water sources. Finally, water pollution can be minimized by using less toxic chemicals that are readily degradable and relying less on fertilizers. Example of alternatives to fertilizers include "the use of biological control (natural pest predators and competitors), culturing practices (types of planting and tillage), and genetic manipulation (pest-resistant crop varieties)" (Weigmann et. al., 1993: 14). The U.S. Fish and Wildlife Service sponsored a three-volume, pest management guide series that are available upon request.

The proper disposal of wastes can also protect water quality. Initially, the selection of common home and farm chemicals should be aimed at those with minimal harm to the environment. Examples of common chemicals that are harmful to water and fish include solvents, cleaning agents, drain openers, paints, motor oil, pesticides, fertilizers, and battery acids (Weigmann et. al., 1993: 14). These products require proper disposal. General waste disposal habits can also significantly affect water quality. Since sinkholes are directly connected to groundwater, past practice of waste disposal in sinkholes should be stopped. Overall reduction of waste production and adoption of recycling are best alternatives to waste disposal that protect the natural environment, hence, drinking water quality.

Buffers and setback requirements are commonly used zoning techniques to minimize adverse impacts on important resources. They separate land development activities from water resources and provide natural filtration for non-point source pollution. As mentioned, vegetated buffers can serve as a natural filter of pollutants from runoff before they enter the receiving stream. Buffers and setback requirements can be implemented by a municipality to protect a drinking water source, such as a stream or river. They can also be voluntarily adopted by property owners to protect individual drinking water source.

Best Management Practices (BMPs) "are voluntary efforts undertaken by individual landowners or developers to reduce water quality impacts of runoff from a particular site" (LJRA, 1991: 69). Properly installed and maintained BMPs can prevent pollutants, such as sediment, oil and grease, fertilizers, pesticides, and heavy metals, from entering drinking water sources. Commonly used BMPs consist of vegetated buffer strips along surface water sources, grassy drainage ways, porous pavement, and stormwater retention ponds.

III. C. Water Distribution Systems

Water supply/distribution systems move water from retention systems to users. Generally, water distribution systems take water from surface and underground sources such as rivers, retention reservoirs, and boreholes. The water is then purified by treatment involving physical and chemical processes. The treated water is usually stored in contact tanks until it is pumped into a network of pipes. Water can be transported by booster pumps or by gravity along pipes. In particular, the three main components of water supply/distribution systems are (Brdys et. al., 1994: 3):

1) treatment works
2) supply network of trunk mains and main reservoirs
3) distribution network of small-diameter pipes and local reservoirs.

At the treatment works, water is first screened to remove leaves and other debris. The raw water is continuously tested for hardness. It is then pumped to reaction tanks where the first major stage of treatment takes place. The water travels by gravity through subsequent stages before it appears as drinking water. In the last stage of the treatment process, for example, the treated water is screened for materials carried over from the reaction tanks through a rapid gravity filter. Treated water is usually stored in treated water reservoir or storing tanks until being pumped to customers. Treatment technologies and associated costs are presented in Section D of this chapter.

Customers receive treated water via pipes. In the supply part of the networks, pipes can be up to 2.5 meters, 98.4 inches, or 8.2 feet in diameter (Brdys et. al., 1994: 6). Distribution pipes are smaller and gradually decrease in size down to 0.05 meters or 1.97 inches in diameter at individual houses (Brdys et. al., 1994: 6).

Water under pressure is boosted by pumps or moves under gravity through pipes. As active elements of the network, pumps supply water at required elevation and covers energy losses in pipes and valves.

> Centrifugal pumps are the most widely used. They have a rotating element which imparts energy to the water. Energy is supplied externally by electrical motors, and changes into the mechanical energy of water. The latter can be expressed quantitatively as the product of head increase through pump, flow and gravity constants. . . . Considering two different flows, a larger flow can be provided under a smaller head increase. (Brdys et. al., 1994: 6).

Generally, two basic types of pumps exist: variable speed pumps (VSP) and fixed speed pumps (FSP). In VSP pumps, the speed of the electrical motor can be subjected to external control signals. FSP pumps have speed fixed at a constant value. FSPs are more widely used. In a pump station consisting of only FSP pumps, the pump configuration is the only control factor available to the system operator. On the other hand, stations with VSP pumps have two control factors: speed, which can change continuously; and pump configuration, which is a discrete variable (Brdys et. al., 1994: 6).

An additional essential component of the network consists of storage reservoirs. Reservoir storage has an important function of enhancing system flexibility by providing supplies for random fluctuation in demand. It can also reduce pumping costs by allowing shifts in periods of heavy pumping and high demands. Furthermore, tanks at elevation contribute pressure and gravity flow to the system. Another important function of a reservoir is to sustain pressure in a neighborhood network. In terms of maintenance, reservoirs are usually equipped with special valves to avoid sudden overflowing or emptying. (Brdys et. al., 1994: 7).

Costs of Water Supply/Distribution Systems

Table 3.2 lists estimated construction costs, material and labor, for components in water distribution systems. Costs are based on 1994 dollars. As a partial list, the purpose of the listing is to provide system managers with example data for preparing preliminary financial and costing analyses for system design, upgrade, and extension. These costs will be used in Chapter IV to conduct these analyses. Systems with more specific component needs should compile their own list.

Table 3.2: Construction Costs for Water Supply/Distribution Systems

System Component	Unit	Unit Cost
Water main: 6 inch	Linear Feet (L.F.)	$ 22
Water main: 8 inch	L.F.	$ 25
Water main: 10 inch	L.F.	$ 27
Gate valve & box: 6 inch	Set	$ 450
Gate valve & box: 8 inch	Set	$ 550
Gate valve & box: 10 inch	Set	$ 600
Water service connections	Each	$ 1,500
Pump station	Each	$ 100,000
Master meter	Each	$ 25,000
150,000 Gallon Tank	Each	$ 150,000
300,000 Gallon Tank	Each	$ 240,000
Fire hydrants	Each	$ 1,200
Road bore	Each	$ 5,000
Railroad bore	Each	$ 5,000

Source: Anderson & Associates, Inc., 1994: Appendix B.

III. D. Treatment in Drinking Water Systems

As an important component of water supply/distribution systems, drinking water treatment is the process by which solid matter, disease-causing microorganisms, and chemical contaminants, both natural and man-made, are reduced or removed from raw water. The major advantage of water treatment is reduction of health risks. Since the discovery of water transmitted diseases in the early nineteenth century, water "treatment to eliminate disease-causing microorganisms has dramatically reduced the incidence of waterborne diseases . . . such as typhoid, cholera, and hepatitis in the United States" (EPA/625/5-90/025, 1990: 3). Although water quality has been improved by water treatment, microorganisms carrying waterborne diseases have not been eliminated by treatment systems.

In most cases, microorganisms contaminate water through surface runoff carrying animal wastes, failures in septic or sewer systems, and sewage treatment plant effluents (EPA/625/5-90/025, 1990: 4). Microbiological contamination can also occur in groundwater, for example through improperly placed or sealed wells. After water leaves the treatment plant, contamination can also transpire via a cross connection between safe drinking water and a source of contamination, a backflow in a water supply line, or a regrowth of microorganisms in the distribution system.

Natural and synthetic chemical contaminants are frequently found in groundwater, used by approximately 85 percent of small systems. Common sources are listed in Table 3.3. Chemical contamination can lead to corrosion of materials, such as pipes, in the distribution systems. Other materials, such as lead, can be introduced into the drinking water as well.

The purpose of this section is to provide an assessment of treatment processes to achieve more informed decisions for system design and upgrade. First, filtration technologies for removing suspended solids from water will be discussed. Typically, several treatment processes, such as chemical feed and rapid mix, flocculation, and sedimentation, are involved in filtration. Second, the disinfection technologies will be briefly illustrated. Third, the discussion will turn to technologies for treating organic contaminants. Treatment processes to be included in this section consist of the granular activated carbon (GAC) and various aeration processes. The final section of the chapter will focus on existing and emerging technologies for controlling and removing inorganic contaminants. In particular, the coagulation/filtration, membranes, ion exchange, and activated alumina processes will be assessed. The final component of the section will summarize treatment technologies in terms of capital and operating costs.

Table 3.3: Common Sources of Natural and Synthetic Chemical Contaminants

Minerals dissolved from rocks that form the earth's crust
Pesticides and herbicides used in agriculture
Leaking underground storage tanks
Industrial effluents
Seepage from septic tanks
Sewage treatment plants
Landfills
Other improper disposal of chemicals in or on the ground

Source: EPA/625/5-90/025, 1990: 4.

In addition to reducing health risks from microorganic and chemical contamination, a water treatment system can improve the water's color, odor, or taste. Iron and manganese can be removed by some systems to prevent staining of laundry and plumbing fixtures. Such treatment capability would be beneficial in areas of the Virginia coalfields where iron is evident in water.

Water Treatment Processes

Table 3.4 illustrates common types of water treatment processes used by small water systems. The various processes are categorized into *preliminary* and *main* treatment processes. Preliminary treatment processes are typically used for treating surface water supplies. The purpose or goal is included for each process type. Those checked indicate processes identified as especially appropriate for water quality problems prevalent in Southwest Virginia.

Table 3.4: Water Treatment Processes Appropriate for Small Water Systems

PROCESS	PURPOSE
Preliminary Treatment Process	
Screening	Removes large debris (leaves, sticks, fish) to protect plant equipment
Chemical pretreatment	Conditions the water for removal of algae and other aquatic nuisances
Presedimentation	Removes gravel, sand, silt, and other gritty material
Microstraining	Removes algae, aquatic plants, and small debris
Main Treatment Processes	
Chemical feed and rapid mix	Adds chemicals (coagulants, pH adjusters, etc.) to water
Coagulation/flocculation	Converts nonsettleable to settleable particles
Sedimentation	Removes settleable particles
✔Softening	Removes hardness-causing chemicals from water
Filtration	Removes particles of solid matter which can include biological contamination and turbidity
Disinfection	Kills disease-causing microorganisms
Absorption using granular activated carbon (GAC)	Removes radon and many organic chemicals such as pesticides, solvents, and trihalomethanes.
✔Aeration	Removes volatile organic chemicals (VOCs), radon, H_2S, and other dissolved gases. Oxidizes iron and manganese
Corrosion control	Prevents scaling and corrosion
✔Reverse osmosis and electrodialysis (membranes)	Removes nearly all inorganic contaminants
✔Ion exchange	Removes some inorganic contaminants, including hardness-causing chemicals
Activated alumina	Removes some inorganic contaminants
✔Oxidation filtration	Removes some inorganic contaminants (iron, manganese, radium)

Source: American Water Works Association, Introduction to Water Treatment, Vol. 2, 1984, as adapted by EPA/625/5-90/025, 1990: 5.

✔ Treatment process particularly beneficial to the Virginia coalfields in treating for iron, manganese, hardness, corrosivity, sodium, and bacteria.

Description of Water Treatment Processes

Of the treatment processes listed in Table 3.4, public water systems in the Virginia coalfields are using mainly *preliminary,* but only a selected number of *main* treatment processes. The most commonly used main treatment processes include chemical feed and rapid mix, coagulation/flocculation, sedimentation, and filtration. In order to offer more alternatives for water treatment system design and upgrade, this section will provide descriptions of treatment processes.

Filtration Technologies

Filtration is the process of removing suspended solids from water. Particles are filtered as the water passes through a porous bed of materials. Typically, two types of filtration exists, one for groundwater and the other for surface water. In groundwater, *natural filtration* removes suspended matter as water passes through porous layers of soil into aquifers. Subjected to more diverse sources of contamination such as runoff, surface water must often be filtered by a constructed treatment system. (EPA/625/5-90/025, 1990: 29).

Filtration removes solids, such as soil and oxidized metals. Microorganisms, including some that are resistant to disinfection, can be filtered as well. The filtration process is important to a water treatment system since it can prevent suspended material, measured as turbidity, from interfering with subsequent treatment processes, including disinfection. In fact, a double barrier against waterborne disease-causing microorganisms is achieved when filtration and disinfection are combined.

The filter process typically operates with a combination of physical and chemical processes. *Mechanical straining* physically traps large particles between the grains of the filter medium, such as sand. In *adhesion* or absorption, a more active filtering process, particles stick to the surface of filter grains or previously deposited materials by a chemical adhesive. In addition to these physical and chemical processes, biological filters can also be used to trap organic matter. For example, slow sand filters can form "a filter skin containing microorganisms that trap and break down algae, bacteria, and other organic matter before the water reaches the filter medium itself" (EPA/625/5-90/025, 1990: 29).

Preceding these filtration processes, however, several pretreatment processes generally take place. In fact, some form of pretreatment is necessary even when filtering low turbidity water. Processes preceding filtration include: 1) chemical feed and rapid mix; 2) flocculation; and 3) sedimentation. Figure 3.1 illustrates the filtration treatment system, including pretreatment processes. The filtration process can include only one or all pretreatment processes.

Chemical feed and rapid mix is the process by which chemicals, such as pH adjusters and coagulants, are added to the water to improve successive treatment processes. "Coagulants are chemicals, such as alum, that neutralize positive or negative charges on small particles," allowing them to stick together to form larger and more easily removed particles (EPA/625/5-90/025, 1990: 29). These chemicals are mixed evenly in the water by devices, such as baffles, hydraulic jumps, static mixers, impellers, and in-line jet sprays.

Another process that can precede filtration is *flocculation*. Often following chemical feeding and rapid mixing, flocculation sends treated water into a basin where the suspended particles can collide and form heavier particles called *floc*. Gentle agitation and appropriate detention times of water in the basin support the forming of floc.

Following flocculation, a *sedimentation* phase may be used to isolate flocculated particles for removal. As the velocity of the water is decreased, particles settle to the bottom of the sedimentation basin. The settled particles form a sludge that is removed from the sedimentation basin via some sewer mechanism. The clarified or supernatant water then flows to a filtration process.

Several choices exist for filtration technology. The conventional filtration technology, that includes coagulation with the addition of chemicals, rapid mixing, flocculation and sedimentation, and granular media filtration, is the most adaptable and commonly available system. It is, however, usually not appropriate or economically feasible for very small water systems such as those found in the Virginia coalfields. For this reason, package plants are considered a cost-effective alternative. They simplify operation by employing automatic chemical feed control systems.

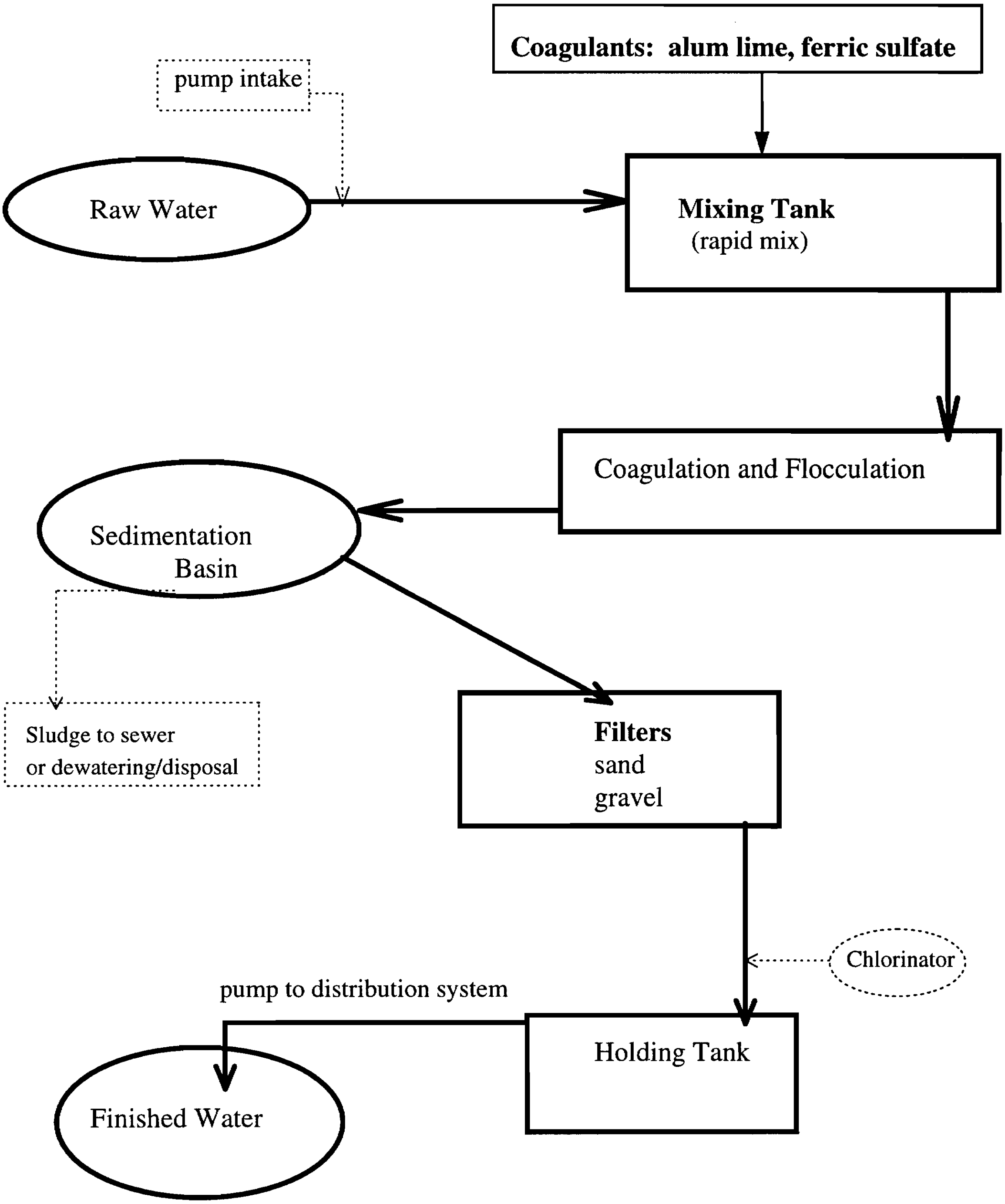

Figure 3.1: Pretreatment and Filtration
Source: derived from EPA/625/5-90/025, 1990: 30.

Assembled in a factory, *package plants* are treatment units shipped as component units. At the destination, component units are assembled to form the complete unit. Most widely used to treat surface water supplies, package plants can remove turbidity, color, and coliform organisms with filtration processes. Some can also remove inorganic and organic contaminants. These plants, however, can require a high level of operational skill and operator attention when the turbidity of the raw water varies greatly.

Three basic types of package plants are available. First, conventional package plants contain conventional processes of coagulation, flocculation, sedimentation, and filtration. Second, tube-type clarifier package plants use settlers to reduce settling detention time. Third, absorption clarifier package plants combine the flocculation and sedimentation basin steps by employing a contact bed with plastic bead media (an absorption clarifier). They also use a mixed media filter to complete the treatment. (EPA/625/5-90/025, 1990: 34).

Table 3.5 summarizes other filtration technologies that can be suitable for small water systems on the basis of advantages and disadvantages. The first of these, *slow sand filtration*, is the oldest type of municipal water filtration. It consists of a layer of fine sand supported by a layer of graded gravel.

Widely used for filtering swimming pool waters, *diatomaceous earth (DE) filtration* has also been used successfully to remove turbidity and Giardia cysts from drinking water. DE filters use a very thin layer of diatomaceous earth as a filter material. The diatomaceous earth is coated on a porous septum or a filter element. The porous septum operates in a pressure vessel or under a vacuum in an open vessel.

Also known as ultrafiltration, the third listed process, *membrane filtration,* uses hollow fiber membranes to remove solids from water. Traditional membrane filters feed water to the inside of the filter membrane, with the filtrate or filtered water emerging on the outside of the membrane. More innovative membrane filters, however, can pass influent to either the inside or the outside of the membrane. Contained in a pressure vessel or cartridge, the hollow fiber membranes collect contaminants on its end. The waste is then flushed out by a reversal of water flow.

Table 3.5: Advantages and Disadvantages of Filtration Technologies Suitable for Small Systems

Filtration Technology	Advantages	Disadvantages
Slow Sand	a. Simple and reliable operation b. Low Cost c. Ability to achieve greater than 99.9% Giardia cyst removal	a. Not suitable for water with high turbidity b. High maintenance needs of filter surfaces
Diatomaceous earth	a. Compact size b. Simple operation c. Excellent cyst & turbidity removal	a. Most suitable for raw water with low bacterial counts and low turbidity (< 10 NTU) b. Requires coagulant & filter aids for effective virus removal c. Can be difficult to maintain complete & uniform thickness of diatomaceous earth on filter septum
Membrane	a. Extremely compact b. Automated	a. Little available information to establish design criteria or operating parameters b. Most suitable for raw water with less than 1 NTU. Usually must be preceded by high levels of pretreatment c. Easily clogged with colloids and algae d. Short filter runs e. Concerns about membrane failure f. Complex repairs of automated controls e. High percentage of water lost in backflushing
Cartridge	a. Easy to operation and maintain	a. Little available information to establish design criteria or operating parameters b. Can be quickly clogged by algae and colloids c. Requires low turbidity influent d. Can require relatively large operating budget

Source: EPA/625/5-90/025, 1990: 31.

Instead of fibers, *cartridge filters* consist of ceramic or polypropylene filter elements. The latter are packed into pressurized housings. Cartridge filters employ a physical process for filtration that strains water through porous media. Ceramic filters may be used for repeated filter cycles after cleaning, while polypropylene cartridges tend to foul quickly and must be replaced with new units.

Another example of low-cost filtration technology, appropriate for some small systems, is the system developed by the 3M Company. It uses disposable filter bags made of polypropylene fibers that can remove Giardia cysts from drinking water. Combined with disinfection technology, these filters have been successful in several states for treating water from surface sources (EPA/625/5-90/025, 1990: 36).

Disinfection

Disinfection is a process required by the EPA's Surface Water Treatment Requirements, effective December 31, 1990 (EPA/625/5-90/025, 1990: 17). These requirements apply to public water systems using surface and groundwater sources under the direct influence of surface water. Their purpose is to control microbiological contaminants such as Giardia cysts and viruses.

Disinfection is the treatment process that destroys these disease-causing organisms. Primary disinfection is the treatment phase of the process that inactivates Giardia cysts, bacteria, and viruses in raw water. Secondary disinfection maintains a disinfectant residual that prevents the regrowth of microorganisms in distribution water.

The most common method of drinking water disinfection is *chlorination*. The latter is the addition of chlorine into raw water. Chlorination kills microorganisms through complex chemical reactions. The advantages and disadvantages of chlorination are illustrated in Table 3.6.

Table 3.6: Advantages and Disadvantages of Disinfectants Suitable for Small Water Systems

Disinfectant	Advantages	Disadvantages
Chlorine	a. Widely used; has a proven history of effectiveness against waterborne disease b. Has a variety of application points c. Can be easily tested throughout the water system d. Can be both primary and secondary disinfectant e. Inexpensive	a. Potential for harmful by-products under certain conditions
Ozone	a. Very effective b. Minimal harmful by-products identified to date	a. Relatively high cost b. More complex operations c. Requires a secondary disinfectant
Ultraviolet Radiation	a. Very effective for viruses and bacteria b. No known harmful residuals c. Simple O&M for high quality water d. Readily available	a. Inappropriate for surface water b. Requires secondary disinfectant

Source: EPA/625/5-90/025, 1990: 38.

Other disinfectants appropriate for small water systems include ozone and ultraviolet (UV) radiation. Their advantages and disadvantages are described in Table 3.6. In particular, *ozonation* is a disinfection process widely used in other countries. Ozone (O_3), however, is relatively new to the United States as a drinking water disinfectant (EPA/625/5-90/025, 1990: 41). As a powerful disinfectant, ozone requires shorter contact time than chlorine for disinfection. It is formed when air containing oxygen flows between two electrodes. Pure oxygen or ambient air can be used in ozone production. Packaged ozone generator systems using oxygen to produce ozone are available for small water systems.

Capital costs for ozonation systems can be relatively high. Operation and maintenance can be complex. Electricity is a major part of operating costs, representing 26 to 43 percent of total operating and maintenance costs for small plants (EPA/625/5-90/025, 1990: 42). Costs figures for this system, along with others, are illustrated towards the end of the chapter.

The third type of disinfection appropriate for small systems is *ultraviolet radiation (UV).* The latter is generated by a special lamp. Ultraviolet radiation kills organisms by penetrating cell walls and destroying their genetic material. Although UV effectively kills bacteria and viruses, it does not inactivate Giardia cysts. For this reason, UV is only recommended for groundwater not directly affected by surface water. Furthermore, it requires an additional secondary disinfectant to prevent regrowth of microorganisms in the distribution water.

Technologies for Treating Organic Contaminants in Drinking Water

Technologies most suitable for organic contaminant removal in small water systems consist of granular activated carbon (GAC) and aeration. The first method, *granular activated carbon*, removes radon and organic chemicals such as pesticides, solvents, and trihalomethanes. Activated carbon is a carbon that has been exposed to high temperature to create a vast network of internal pores. Using an absorption process, GAC removes contaminants by adhering dissolved contaminants to the porous surface of carbon particles. GAC is available in different grades of effectiveness. Even though low-cost carbon requires a lower initial capital outlay, it must be replaced more often, resulting in higher operating costs.

The second method, *aeration* or air stripping, mixes air with water to volatilize or turn contaminants into vapor. Volatilized contaminants can be released directly into the air or treated before release into the air. A small water system can use a simple aerator constructed from relatively common materials. Other aeration systems suitable for small systems include: packed column aeration; diffused aeration; multiple tray aeration; mechanical aeration; catenary grid; and Higee aeration. The last three systems are emerging technologies. These systems operate under varying processes, but under the same basic aeration principle described. Table 3.7 compares all technologies for removing organic contaminant based on level of operational skill, level of maintenance, and level of energy required. More detailed, technical descriptions are available from various EPA publications such as EPA/625/5-90/025. Their associated capital and operating costs are illustrated later on.

Table 3.7: Comparing Technologies for Removing Organic Contaminants Suitable for Small Systems

Technology	Level of Operational Skill Required	Level of Maintenance Required	Energy Requirements for Operation
Granular Activated Carbon (GAC)	Medium	Low	Low
Packed Column Aeration (PCAP	Low	Low	Varies
Diffused Aeration	Low	Low	Varies
Multiple Tray Aeration	Low	Low	Low
Mechanical Aeration	Low	Low	Low
Catenary Grid	Low	Low	High
Higee Aeration	Low	Medium	High

Source: EPA/625/5-90/025, 1990: 47.

Technologies for Removing Inorganic Contaminants

Two different strategies exist for removing inorganic contaminants. The first involves *preventing* contaminants in finished water. The second strategy consists of *removing* contaminants from raw water. The second strategy involves removal technologies that treat source water for metals or radioactive substances (such as radionuclides).

Preventing Inorganic Contaminants: Corrosion Control

The method for preventing inorganic contaminants in finished water is *corrosion control.* The latter prevents and minimizes the presence of lead, copper, cadmium, zinc, and iron at the consumer's tap. These inorganic contaminants are formed when a substance deteriorates by chemical reaction. Some inorganic contaminants, such as lead and cadmium, are harmful to human health. Corrosion also reduces the useful life of water distribution systems, thereby raising maintenance and replacement costs. It can promote microorganism growth, resulting in offensive tastes, odors, slimes, and further corrosion.

The techniques for controlling corrosion consist of modifying water quality and adding corrosion inhibitors to form protective coatings over metal. The method for modifying water quality is adjusting pH and alkalinity, where pH is a measure of hydrogen ions concentration in water and alkalinity is a measure of water's ability to neutralize acids (EPA/625/5-90/025, 1990: 55). Being simple and inexpensive, it is the most popular method for corrosion control. Commonly used chemicals for adjusting pH and alkalinity consist of lime, caustic soda, soda ash, and sodium bicarbonate. In terms of corrosion inhibitors, drinking water systems often use inorganic phosphates, sodium silicates, and mixtures of phosphates and silicates.

Removing Inorganic Contaminants

For removing inorganic contaminants, six processes are suitable for small water systems. Table 3.8 illustrates their advantages and disadvantages. The first listed process, coagulation/filtration was described in previous sections. To remove inorganic contaminants, coagulation uses aluminum or iron salts to remove most metal ions or colloidally dispersed compounds. The latter are finely divided substances that do not settle out of water for a prolonged period of time. Coagulation, as a method to remove inorganic contamination, is more expensive than coagulation to remove turbidity due to higher dosages of coagulant needed.

Reverse osmosis and *electrodialysis* are processes that use membranes for removing inorganics. Reverse osmosis employs a semipermeable membrane to isolate contaminants. The membrane permits only water to pass through its pores while trapping dissolved ions such as sodium and chloride. Subjected to high pressure, contaminated water passes through the membrane leaving contaminants behind in a brine solution.

Reverse osmosis systems are compact, simple to operate, have minimal labor requirements, and can attain 96 percent removal rates when properly employed. A major disadvantage is its high capital and operating costs. Operating costs can range from $3.00 to $6.00 per thousand gallons of treated water, for systems with less than one million gallons per day (mgd). Capital costs can range from $1.00 to $2.00 per gallon of capacity, depending on the level of pretreatment required acids (EPA/625/5-90/025, 1990: 58). System costs are listed at the end of the chapter.

Table 3.8: Advantages and Disadvantages of Inorganic Contaminant Removal Processes Suitable for Small Water Systems

Treatment Process	Advantages	Disadvantages
Coagulation/Filtration	a. Low cost for high volume b. Reliable process c. Suitable for automatic control	a. Not readily applied to small or intermittent flows b. High-water-content sludge disposal c. Very low contaminant levels may require two-stage precipitation d. Demands highly trained operator
Membranes - Reverse Osmosis and Electrodialysis	a. Removes nearly all contaminant ions and most dissolved non-ions b. Relatively insensitive to flow and total dissolved solids level c. Low effluent contamination possible d. Bacteria and particles are also removed in reverse osmosis e. Suitable for automation	a. High capital and operating costs b. High level of pretreatment may be required c. Membranes are prone to fouling. Electrodes require replacement
Ion Exchange	a. Relatively insensitive to flow variation b. Zero level of effluent contamination possible	a. Waste requires careful disposal b. May have unacceptable levels of contamination in effluent c. Not feasible at high levels of total dissolved solids d. Pretreatment require for most surface waters
Activated Alumina	a. Insensitive to flow and total dissolved solids background b. Low effluent contaminant level possible c. Highly suitable for fluoride and arsenic	a. Strong acid and base required for regeneration b. Medium tends to dissolve, producing fine particles c. Slow absorption d. Waste requires careful disposal

Note: effluent is partially or completely treated water flowing from a reservoir, basin, or treatment process.
Source: EPA/625/5-90/025, 1990: 57.

Electrodialysis, a process also using membranes, uses direct current to attract ions to one side of the treatment chamber. Electrodialysis systems include a source of pressurized water, a direct current power supply, and a pair of selective membranes. Electrodialysis is effective at removing fluoride and nitrate.

The third process for removing inorganics listed is *ion exchange.* Most often used to remove hardness and nitrate from groundwater, ion exchange units can also remove any ionic or charged substance from water. Since hardness is a prevalent problem in the Virginia coalfields, ion exchange can be an attractive treatment option for the area. It removes contaminants by absorbing them onto an exchange medium. The latter is usually a synthetic resin. On the surface of the medium, one ion is exchanged for another. Since ion exchange waste is highly concentrated, careful disposal is required.

As an ion exchange medium, *activated alumina* is primarily used to remove fluoride from groundwater. It is a commercially available system. A strong sodium hydroxide solution is used to regenerate the activated alumina medium in the exchange process. Sulfuric acid must also be added to the water after it leaves the exchange unit to lower the pH level of the water. Since activated alumina systems employ these strong acidic and basic solution, system waste can be hazardous to handle, resulting in increased waste management costs.

Costs Associated with Treatment Technologies Suitable for Small Water Systems

The treatment technologies described in previous sections come with capital and operation and maintenance (O&M) costs. Capital costs for water systems are fixed, one-time expenditures that are independent of the amount of water produced. They result in the acquisition of or addition of fixed assets. Capital costs have a useful life of more than one year. Capital costs for treatment technologies provided in Table 3.9 consist of manufactured equipment, concrete, steel, labor, pipes and valves, electrical equipment and instrumentation, housing, site evaluation, other site work, general contractor's overhead and profit, engineering costs, financial and administrative costs, and interest costs during construction (EPA/625/5-90/025, 1990: 27). They do not include land costs, legal fees, interface piping, roads, and certain other site work. Construction costs vary depending on site specific characteristics.

Operation and maintenance costs are ongoing, repetitive costs of operating a water system. As proprietary or enterprise fund expenses, they are directly related to the fund's primary service activities. O&M costs provided in Table 3.9 consist of annual energy, labor, and chemical costs. These costs are only approximates. They can vary greatly depending on variables such as raw water characteristics, flow rate, and chemical flow rates. More exact estimates can be made based on previous engineering reports on similar systems, knowledge and expertise of water system managers, and more comprehensive and customized cost analysis. Some spreadsheets provided in the next chapter may be helpful to make such an analysis.

The estimated costs provided in Table 3.9 are for a 100,000 gallons per day (GPD) plant. Such a plant would serve approximately 1,333 people in Virginia, based on a 75 GDP per capita use (USGS, 1995: Water-Use home page). Approximately 444 households would be served, if three persons are in each household.

In choosing the best options for a water system, managers should realize that tradeoffs exist between capital and O&M costs. That is, technologies with high capital outlay tend to have low operation and maintenance costs. Conversely, technologies with low capital costs often come with more maintenance requirements, thus, higher O&M cost obligations. If it is financially feasible to invest in a more expensive but superior technology, the benefits gained from longer product durability and lower O&M costs may exceed the costs of a higher initial investment in the long-run.

Table 3.9: Estimating Costs of Water Treatment Technologies for a 100,000 GPD Plant ($1989)

Treatment Technology	Capital Cost	Annual O&M	Total Cost Per 1,000 Gallons
Package Plant Filtration			
Coagulation/Filtration with tube settlers	$ 176,000	$ 11,000	$ 1.73
Pressure depth clarifier/Pressure filter	$ 206,000	$ 10,400	$ 1.90
Pressure depth clarifier/Pressure filter with GAC absorber	$ 246,000	$ 16,300	$ 2.47
Other Filtration			
Diatomaceous earth vacuum filter	$ 103,000	$ 11,100	$ 1.27
Diatomaceous earth pressure filter	$ 106,000	$ 10,600	$ 1.26
Slow sand filter: covered	$ 580,000	$ 7,700	$ 4.15
Slow sand filter: uncovered	$ 335,000	$ 7,100	$ 2.55
Disinfection			
Gas feed chlorination	$ 10,465	$ 3,520	$ 0.26
Hypochlorite solution	$ 4,080	$ 5,558	$ 0.33
Pellet feed chlorinators	$ 1,670	$ 4,010	$ 0.23
Ultraviolet light (57,600 GPD)	$ 25,990	$ 2,090	$ 0.49
Ozonation-high pressure	$ 39,270	$ 5,074	$ 0.53
Organic Contaminant Control			
GAC in pressure vessel	$ 175,000	$ 14,400 (6-mo carbon	$ 1.92 replacement)
		$ 9,800 (12-mo carbon	$ 1.67 replacement)
Packed tower aerator	$ 45,100	$ 2,900	$ 0.45
Inorganic Contaminant Control			
High pressure reverse osmosis	$ 275,000	$ 41,300	$ 4.03
Low pressure reverse osmosis	$ 275,000	$ 29,800	$ 3.40
Cation exchange	$ 151,000	$ 8,500	$ 1.44
Anion exchange	$ 115,000	$ 10,300	$ 1.46
Activated alumina	$ 104,000	$ 14,600	$ 1.47

Source: EPA/625/5-90/025, 1990: 26-27.

Chapter IV. Spreadsheet Model for Costing, Assessing Rate Impacts, and Rate-Setting for Small Water Systems Options

IV. A. Overview of the Spreadsheets

This chapter presents an interactive method of assessing costs, rate impacts, and other financial details associated with water supply system projects. A series of Microsoft Excel spreadsheets are provided for convenient financial analysis. The substance of the spreadsheets is based on the manual *Costing and Rate-Setting Workbook for Water and Sewer Utilities* by Paul Shinn and John Randolph.

Completed in 1989, the workbook was designed to assist municipal utilities to assess water and sewer projects and financing options, determine rate impacts, set rates, and in general, improve their financial performance. It consists of accepted techniques of water and sewer financial management. Combined with existing utility records and knowledge of the of the system's operations, utility managers can use the workbook to determine costs of service, assess capital investment needs, evaluate financing mechanisms, and set user rates.

The spreadsheets are based on the workbook procedure and are intended to be useful for communities and/or utilities that need to assess options for renovating, replacing, or extending their water supply systems when hiring an engineer or other consultants is not practical or affordable. Specifically, the spreadsheets will benefit small- to medium-sized utilities that need an affordable and manageable procedure to conduct a preliminary financial assessment of construction options. The spreadsheets, however, are not intended to replace outside consulting since facilities design and costing require specialized analysis. The spreadsheets are aimed at enhancing decision making in the early stages of water project planning.

IV. B. Organization of the Spreadsheets

The spreadsheets are organized similarly to the worksheets in the *Costing and Rate-Setting Workbook for Water and Sewer Utilities* for simple referencing. Basically, the spreadsheets are organized into four modules. The later are labeled numerically from

1 to 4. Each module contains one summary spreadsheet labeled numerically and one or more detailed spreadsheets with attached letter suffixes, for example, 3C. Calculations from a detailed spreadsheet serve as inputs for subsequent detailed spreadsheets. For example, spreadsheet 3F can contain inputs for spreadsheets 3E, 3C, or 3B. Generally, the spreadsheet "A" is the least detailed and depends on inputs from other spreadsheets. *Thus, the spreadsheet should be completed in reverse alphabetical order within each module. For example, spreadsheet 3F should completed before spreadsheets 3E, 3C, and 3B in Module 3. Finally, the summary spreadsheet or each module, for example Spreadsheet 3, depends on inputs from some or all detailed spreadsheets.*

Although the spreadsheets are designed to do a large number of calculations, users are required to enter numbers and make notes. In terms of design, input cells requiring manual data entry are distinguished by a light gray shading. Although most data entries are numeric, some spreadsheets, such as Spreadsheet 1, require text input. Cells requiring text entries are also shaded light gray. Calculations and most data transfers from other spreadsheets are automatically performed by the Microsoft Excel software. These cells, along with cells containing labels, are not shaded and requires no entry. The user of the spreadsheets is required, however, to do some calculations when a variation of inputs is presented. These calculations are accompanied by special instructions and are located in light-gray shaded cells.

IV. C. Overview of Module Contents

Table 4.1 illustrates the data flow of the modules. In particular, Module 1 helps users identify necessary or desirable capital projects for the water system and estimates their capital needs. Module 2 determines financing capital needs and helps develop financing resources for capital projects selected in Module 1. Module 3 identifies annual cost of service and total cost of operating the water system. Using some results from Module 3, Module 4 sets user charges.

Table 4.1: Data Flow of Modules

Module	Module Function	Spreadsheet Outputs	Source of Information
1	Estimates capital needs	a. Capital Program Requests and Funding (when combined with Module 2)	a. Land-Use Plans b. Facilities Inventory and records c. Capital Improvement Program d. Chapter III of this study
2	Financing Capital Needs	a. Capital Program Requests and Funding b. Financial Capability Measures	a. Capital Improvement Program b. Appendix C: Source of Funding and Financing in Virginia
3	Determining Annual Cost of Service	a. Carried to Module 4	a. Annual Report to State Auditor b. Annual Budget
4	Setting User Charges	a. User Charge Structure	a. Annual Report to State Auditor b. Annual Budget c. Billing and Customer Records

Source: Derived from Shinn and Randolph, 1989: Figure 1, page 2.

Module 1 and 2 are organized on a five-year planning horizon. A five-year period was randomly chosen and can be changed to meet the specific needs of a project. A full analysis, for example, would require a planning horizon of 20-25 years, depending on the life of the equipment and the project time frame. In effect, the user of the spreadsheet can select an appropriate planning horizon.

Numbers entered in these modules are in thousands of dollars to keep the spreadsheets readable. Actual numbers are used more often in Module 3 and 4. These modules, however, are organized to perform calculations for a one-year time frame. Some spreadsheets in Module 3 and 4 are also organized by project cost categories, as listed in Module 1.

IV. D. Discussion of Modules

Module 1: Estimating Capital Needs

Table 4.2 summarizes information inputs and outputs for Module 1. Consisting of two spreadsheets, 1 and 1A, this module helps identify capital projects needed or desired for a water system. Capital projects can consist of construction, rehabilitation of existing equipment, or purchase of equipment to improve or enhance system operation. Table 4.3 lists project components of Module 1 and their related project examples. Capital project costs are summarized for a selected planning horizon and adjusted for inflation (when appropriate) on spreadsheets 1 and 1A.

Capital projects do not include routine maintenance. Operating costs are recorded in Module 3. Changes in operation, maintenance, and repair (OM&R), however, are required in Module 1. These are estimated OM&R changes that result from the new system component or facility. OM&R entries are required on Spreadsheet 1A. They are summarized and adjusted for inflation in Spreadsheet 1.

Information requirements for Module 1 consist of a list of project needs and costs. Sources of information for Module 1 include previous engineering reports, earlier system needs assessments, capital improvement plans, or the utility manager's knowledge of the system. An inflationary rate can also be included for the planning period to bring future values back to today's dollars. A conservative estimate for the inflation rate, assuming a higher rate, is recommended to avoid under estimating future costs. Depending on the situation, an inflation rate may not be necessary.

Table 4.2

Information Needs and Output for Module 1

Spreadsheet #	Title	Information Needed, (Your Entry)	Output
1	Cost Summary: Total Costs of New Projects (for a five-year planning horizon)	a. Optional: Annual Operating Costs (if they vary from year to year)	a. Total construction costs: per year and for the planning horizon
		b. Inflationary rate for operating costs	b. Total operating costs (adjusted for inflation): per year and for the planning horizon
1A	Inventory of Costs by Project (for a five year planning horizon)	a. Type of project	a. Annual project cost adjusted for inflation
		b. Construction costs for each project in today's dollars	b. Total project cost (adjusted for inflation) for the planning horizon
		c. Estimated % of project cost spent annually	
		d. Annual Operating Cost	
		e. Inflation Rate for construction projects	

Source: Derived from Shinn & Randolph, 1989

Table 4.3: Water Capital Projects Examples

Capital Project Component	Examples of Projects
Source of Supply	A new reservoir and facilities to pump raw surface or ground water
Production and Treatment	A new or an additional treatment facility; rebuilding an old pump; raw water lines and pumps; treated water pumps/main
Distribution Storage	A new storage tank
Distribution & Transmission	New distribution or transmission mains
Meters and Service	New meters and customer service facilities
Source Protection	Source protection program
Fire Protection	Hydrants and standpipes
Administration	Office buildings; vehicles used by administration; office equipment; projects that do not fit in other categories
Billing	Vehicles for meter reading; computers and software for billing

Source: Derived from Shinn and Randolph, 1989: Figure 5, page 11.

Module 2: Financing Capital Needs

Table 4.4 summarizes information inputs and outputs for Module 2. Consisting of seven spreadsheets, 2 to 2F, Module 2 helps develop financing sources for projects identified in Module 1. The first spreadsheet (2F) was designed to evaluate different financing options for the same project. Outputs from Spreadsheet 2F include rate increase per 1,000 gallons, tax and rate impact on average residence, and total impact on assessed users. Although Spreadsheet 2F is optional, the outputs can help the user chose a desirable type of financing for the project. Once a financing alternative is selected, outputs for that selection can be entered into the subsequent spreadsheets in Module 2.

Included in Module 2 are two tables to make calculations. Appendix E is a debt service factor table. The latter is used to convert a construction cost, bond term, and bond interest rate into the annual debt service paid on the bonds that finance the project. This table can be used for all bonds: general obligation; revenue; or assessment. Appendix E

Table 4.4

Information Needs and Output for Module 2

Spreadsheet #	Title	Information Needed (Your Entry)	Output
2	**Impact of Capital Project on All Users, Taxes, and User Subgroups**	a. % revenue from household customers	a. Total additional revenue requirements
		b. Current average annual water bill	b. Estimated annual bill per HH
		c. Gallons consumed by all customers	c. Additional cost/1000 gal
		d. Number of customers paying assessments	d. Total cost increase (rates plus taxes) for all users
		e. Gallons consumed by assessed/surcharged users	e. Ave. annual unbonded or bonded assessment
		f. Assessed value of ave. residence	f. Total impact on bonded or unbonded assessed users
		g. Unbonded assessments/surcharges	g. Bonded or unbonded assessment cost/1000 gal
2F	**Project Financing Analysis: Looking at the Options** (4 options design, expandable to desired number)	a. Additional OM&R cost, 1st year of operation	a. Total financing
		b. Amount to be financed by rate-supported bonds	b. Rate-supported bond debt service
		c. Amount from revolving Loans	c. Revolving loan debt service
		d. Amount to be financed by tax supported bonds or loans	d. Annual reserve contributions
		e. Amt. to be financed by assessments/surcharges	e. Total annual increase in rates
		f. Amt. to be financed by capital fees	f. Rate increase per 1000 gal.
		g. Amt. to be financed by reserves	g. Rate impact on average annual household cost
		h. Amt. to be financed by current User Fees	h. Total tax and rate impact on average residence
		i. % revenue from households	i. Tax-supported debt service
		j. Number of household customers	j. Effect on tax rate per $1000
		k. Gallons consumed by all customers	k. Total impact on assessed users
		l. Total assessed value	l. Assessment/surcharge cost per 1000 gal.
		m. Assessed value of average home	
		n. Assessments for surcharges paid annually	
		o. # of customers paying assessment	
		p. Average annual assessment	
		q. Gallons consumed by assessed users	
		r. Sinking fund factor	
		s. Debt service factors for rate-supported bonds, revolving loans, tax-supported bonds, assessed-supported bonds	
2E	**Project Financing Details** (five year planning horizon)	a. Sources of financing in $1000s	a. Total financing for 5 years
		b. Name and cost of project	
2D	**Summary Sheet: Total of Projects Financing**	a. Totals from 2E	a. Total financing cost per year
			b. Total financing cost for 5 yrs
2C	**Calculating Contribution on Reserve Fund** (five year planning horizon)	a. Financing expected from reserves for Year 5	a. Total requirements from reserves
		b. Sinking fund factor	b. Total contribution for each year
			c. Total contribution to reserve
2B	**Calculating Bond/Loan Size and Cashflow** (five year planning horizon)	a. Bond/loan proceeds available for construction	a. Total bond/loan fund for each year
		b. Bond/loan fund carryover from previous year	b. Bond/loan fund residual for each year
		c. Annual cost of bond/loan financed projects	c. Bond/loan fund available for following year
		d. Interest rate on bond/loan fund residual	
2A	**Calculating Debt Issued and Annual Debt Service**	Revenue Bonds & General Obligation Bonds	
		a. Bond proceeds	a. Total bond issuing costs
		b. Bond issuance costs	b. Total new debt service
		c. Debt service factor	c. Total debt service
		d. Existing debt service	d. Total new issues
		e. Current bonds outstanding	e. Total of all bond issues
		f. New bond issues	f. Total G.O. debt
		g. Debt amount paid from charges	g. Net Debt
		h. Estimated population and % growth	h. Debt per capita
		i. Assessed Value and % growth	i. Debt as a % of Assess. Value
		Revolving Loans	
		a. Loan proceeds	a. Total loan issuing costs
		b. Loan issuance costs	b. Total new loan repayments
		c. Debt service factor	c. Total loan repayments
		d. Existing loan repayments	d. Total of all loans
		e. Current loan outstanding	e. Total outstanding water debt
			f. Annual water debt service

Source: Derived from Shinn & Randolph, 1989

is used specifically in spreadsheets 2F and 2A. Also included is a sinking fund service factor table (Appendix E). The latter is used to determine the annual contribution to a capital reserve fund, given the amount, year needed, and the interest rate earned in the reserve fund. Appendix E is used in spreadsheets 2F and 2C. (Shinn et. al., 1989: 13).

The completion of Module 2 yields a comprehensive financing structure for a capital project and annual estimates for their effect on rates and taxes. That is, Module 2 produces a five- or ten- year plan for capital improvements that includes the method of financing for the projects and their impacts on user charges, taxes, and assessments. These outputs can be used to develop a formal capital improvement program for the water division, to inform officials and the public of the financial direction of the water division, or to develop future budgets. Some of these data are also used to develop a full estimate of system costs for the first year of the capital program. (Shinn et. al., 1989: 21).

Module 3: Determining Annual Cost of Service

Table 4.5 summarizes inputs and outputs for Module 3. Consisting of seven spreadsheets, 3 to 3G, Module 3 determines the total operating cost of the water system. The purposes of this module are to provide information for setting rates in Module 4, to determine overhead costs in order to set interfund transfers or payments in lieu of taxes, and to establish the total cost of providing water service.

In contrast to Module 1 and 2, this module collects data for only one year in order to set rates for the next year. For this reason, the primary source of information for Module 3 is the coming year's budget. The module assumes that all costs of the water utility will be entered, including those not paid from user charges. This assumption ensures the development of a complete assessment of the "true" cost of operating the water system. At the end of the module, revenues sources not from user charges are subtracted to yield the amount that must be raised from user charges to begin Module 4. (Shinn et. al., 1989: 22).

In order to achieve the objective of determining the total operating costs of the water system in Module 3, it is imperative to accurately identify different costs. In Module 3, *total cost* is the sum of all costs, direct and indirect, associated with the

Table 4.5

Information Needs and Output for Module 3

Spreadsheet #	Title	Information Needed (Your Entry)	Output
3	**Cost of Service Summary by Project Cost Category**	a. Allocation of general overhead by project category	a. Total indirect costs
		b. Allocation of dept. overhead	b. Total O&M costs
		c. New O&M costs	c. Total system costs
		d. Taxes used for utility	d. Net charge to be recovered from charges
		e. Connection/hook-up fees	e. Total component allocation with administration costs
		f. Other revenue	
3G	**Determining Direct Benefits and Costs**	a. Benefits for the government or water dept. by category	a. Benefit percentage
3E	**Allocation of Department Overhead Cost to Water Systems**	a. Salaries: dept. budget, those allocated directly to water or other divisions	a. Total salaries
		b. Non-labor cost by category	b. Total labor
		c. Total budgets of all divisions in dept.	c. Total non-labor
		d. Budget of division	d. Total department overhead
			e. Total overhead allocation
3D	**Allocating Government-Wide Overhead Costs**	a. General government costs by category	a. Net overhead costs to allocate by category
		b. Total budget of government unit	b. Overhead to be allocated
		c. Major Capital Expenditures	c. Net government budget
		d. Internal transfer	d. Overhead allocation
			e. General govt. costs allocated directly to water division
			f. Total general overhead of water division
3C	**Determining and Allocating Capital Costs** (by project cost categories)	a. Existing debt service	a. Debt service totals by cost category
		b. New debt service (rate supported)	b. Total capital costs
		c. New debt service (tax supported	
		d. Capital costs from user charges	
		e. Capital reserve payment	
3B	**Allocating Salary Costs** (optional spreadsheet)	a. Salary & wages by project	a. Total salaries and wages
3A	**Allocating Direct Operation and Maintenance Cost by Project Category**	a. Salaries and wages	a. Benefit cost and total direct cost
		b. Material and supplies cost breakdown	b. Total material & supply
		c. Utilities cost breakdown	c. Total utilities
		d. Professional services paid directly from water project	d. Total professional service costs
		e. Payment in lieu of taxes	e. Total direct O&M costs

Source: Derived from Shinn & Randolph, 1989

provision of a service. *Direct costs* consist of direct operating and direct capital costs that can be charged directly as a part of the cost of a product or service, or of a department or operating unit. In contrast, *indirect costs* include general government and department overhead costs that are necessary for the functioning of the organization as a whole but which cannot be assigned to one service.

In particular, spreadsheets 3A, 3B, 3F, and 3G address *direct operating costs*. Spreadsheets 3A and 3C deal with direct capital costs. Indirect overhead costs are established by cost allocation in spreadsheets 3D and 3E. Cost allocation is the process of determining what part of departmental and general government overhead costs to attribute to each service provided by the government (Shinn et. al., 1989, 22). In particular, general governmental overhead costs are addressed in Spreadsheet 3D while department overhead costs are determined in Spreadsheet 3E.

The completion of Module 3 should yield an accurate estimate of the total cost of water service, including direct and overhead, operating and capital, user charge and tax-supported costs (Shinn et. al., 1989: 31). The data summarized in Module 3 can be used to evaluate the cost profile of the water utility, to keep a record of performance and cost indicators over time, and to form a cost data structure to support the establishment of a rate structure in Module 4.

Module 4: Setting User Charges

Table 4.6 summarizes the information inputs and outputs for the three spreadsheets in Module 4. In this module, spreadsheets 4A and 4B convert the cost data assembled in Module 3 into a set of user charge rates. Spreadsheet 4 tests rates, determined in spreadsheets 4A and 4B, to ensure that they will generate sufficient revenues.

Module 4 provides a choice of three different rate structures in Spreadsheet 4A. Based on methods recommended by the American Water Works Association (AWWA), the rate structures are intended for use in the simplest water utility settings. AWWA recommends that they be used for utilities serving fewer than 5,000 customers, with no industrial customers or commercial customers with unusual water use patterns, and with

Table 4.6

Information Needs and Output for Module 4

Spreadsheet #	Title	Information Needed (Your Entry)	Output
4	**Test of Revenues and Rates**	a. Outside & inside SA 5/8" meter equivalents	a. Outside & inside SA service charge revenue
		b. Billing periods per year	b. Outside & inside SA total revenue
		c. Outside & inside SA annual consumption in domestic or commercial blocks	c. Operating and total revenue as a percentage of expenditures
		d. Outside SA commercial block revenue	d. Total operating revenue
		e. Outside SA charge per HH equivalent per billing period	e. Net cost to be recovered from charges
			f. Total operating revenue
			g. Residential service charge for 5/8" meter equivalent per bill
			h. Domestic block volume rate
			i. Commercial block volume rate
			j. Flat charge per household equivalent
4B	**Units of Service, Rate Blocks, Inside-Outside Service Area (SA) Charges**	a. Total annual consumption in domestic and commercial blocks	a. Total meters and total 5/8" meter equivalent
		b. Number of bills issued per year	b. Total weighted water sales
		c. Estimated number of meters	c. Total annual consumption
		d. Surcharge for outside SA customers	d. Total adjusted flow
		e. Water consumption by metered customers	e. Adjusted un-metered HH equivalents in the system
		f. Average household consumption	f. Adjusted annual bills
4A	**Water Rate Structure**	a. Average # of bills per customers per year	a. Volume related costs
		b. Percentage water sold to metered customers	b. Service charge costs
			c. Outside & inside SA volume charge for domestic & commercial blocks
			d. Outside & inside service charge per 5/8" meter equivalent
			e. Costs charged to un-metered customers

Source: Derived from Shinn & Randolph, 1989

no extra charge for users outside the city or service area (Shinn et. al., 1989: 32). For these reasons, the spreadsheets are employable for utilities in the Virginia coalfields.

Of the three different options for setting rates for water utilities provided in Spreadsheet 4A, the most complex is the two-block commodity demand method. It should be used when all customers are metered and some variation in volume of water used by the customer exists (Shinn et. al., 1989: 32). Such volume variation, for example, can consist of water service provided to nonresidential customers that consume more water than residential customers. In Module 4,

> costs are divided into three causative factors, commodity, demand, and customer. Commodity costs are those that vary with total volume of water produced and are usually limited to chemical and pumping costs. Demand costs vary with the capacity of the system and the peaking nature of water use and include source of supply, storage, transmission, and distribution costs. Customer costs, such as meters and service and billing, vary with the number of customers. In this [spreadsheet], fire protection costs (costs of owning, maintaining, and supplying hydrants) are also classified as customer costs. The process for setting rates under this method is to identify two blocks of water use, determine use by customers in each block, estimate the peak demand of customers in each block, split costs into commodity and demand, and determine the rates in cents per thousand gallons for the blocks. Customer costs are charged on the basis of water meter size. (Shinn et. al., 1989: 32).

The second, more simple method is a single-block rate structure. This method yields a service charge and a volume rate (a cost per thousand gallons consumed). In this approach, the volume rate is determined by dividing all costs related to the water volume produced in the system by the total consumption of water. The service charge is calculated by dividing all other costs by the number of customers. Generally, this method is not intended for use by water systems that have high-volume customers. The latter are those using more water than the average customer.

Somewhat similar to the second method, the third method is a single-block rate structure that also yields a flat charge for unmetered customers. This method can be used to determine a flat rate when no metered customers exist. To complete this method, Part IV of Spreadsheet 4B must be completed.

A special note should be made, for Spreadsheet 4B, Part I, regarding the meter costs. The latter are based on the number of 5/8" equivalent meters in the system. The use of 5/8" equivalents is a way to standardize for differences in costs of installing and maintaining different size meters (Shinn et. al., 1989, 33). For this reason, ratios for 5/8" equivalents are provided for various meter sizes. The ratios are based on differences in purchase price, installation costs, and maintenance costs. If a ratio is not provide for a meter size, an estimate based on these criteria will be needed. In utilities where the basic meter size is not 5/8", a similar size may be used to enter all meter equivalents. For example, 3/4" equivalents is a suitable substitute.

IV. E. Spreadsheet Application

Examples of the spreadsheets are in Appendix D. They are presented in the spreadsheet form found on the Microsoft Excel screen. Formulas for calculations can be viewed when a cell is highlighted. Most calculations are also recorded in the "Calculations" column in each spreadsheet.

Description of Spreadsheet Example: Water Extension for the Town of Wise

The Town of Wise, located in Wise County, has been chosen as the example for the spreadsheet application for several reasons. Information availability was the most important factor. The Town filed annual reports of revenues and expenditures to the state auditor of public accounts and has been cooperative in sharing information for this paper. Furthermore, the Town of Wise have demonstrated a desire to expand service to unserved households. Table 4.7 shows existing water service for the Town. Description of the Town's water system is found in Appendix B.

Table 4.7: Existing Water System for the Town of Wise, Wise County

Number of connections	2,246
People Served	5,615
Storage Capacity	7 tanks
Water Source	Bear Creek Reservoir
Production Rate	0.70 mgd
Water Loss	27%

Source: The Town of Wise, 1995.

The example chosen for the spreadsheet application consists of a service extension to serve 327 new connections. The new connections require adding new lines to the Town's existing main lines. Two additional storage tanks will be needed to hold water for new customers. A pump station will also be added to pump water from the Town's line to new storage tanks and lines. Fire protection will also be provided for the 327 connections. These system component improvements may vary according to project and service area. Components of the service extension and associated costs are summarized in Table 4.8. The total cost of the extension is $3,221,400, of which construction costs totaled $2,872,400 (Table 4.8).

Estimating Capital Needs of the Water Extension Project

The costs for the project are entered into Spreadsheet 1A (Appendix D) to adjust for inflation over a 5-year planning horizon. The inflationary rate was estimated at three percent. Spreadsheet 1A breaks down spending for each of the five years. Changes in operation, maintenance, and repairs (OM&R) costs are estimated at two percent of construction costs. Actually (OM&R) costs can vary according to specific systems.

Spreadsheet 1 (Appendix D) summarized total construction and OM&R costs by year. Total construction cost, adjusted for inflation, for the five years was $3,425,000. OM&R costs, adjusted for inflation, increased between $63,000 to $71,000 per year.

Table 4.8: Hypothetical System Needs Service Extension

Component	Unit	Quantity	Unit Cost ($)	Total Cost ($)
Construction Cost				
10" Water Main	Linear Feet	24,800	$ 27	$ 669,600
8" Water Main	Linear Feet	33,400	25	835,000
6" Water Main	Linear Feet	7,500	22	165,000
10" Gate Valves & Boxes	Each	25	600	15,000
8" Gate Valves & Boxes	Each	33	550	18,150
6" Gate Valves & Boxes	Each	75	450	33,750
Water Service Connections	Each	327	1,500	490,500
150,000 Gallon Tank	Each	1	150,000	150,000
300,000 Gallon Tank	Each	1	240,000	240,000
Pump Station	Each	1	100,000	100,000
Master Meter	Each	3	25,000	75,000
Fire Hydrants	Each	67	1,200	80,400
Total Construction Costs				**2,872,400**
Related Costs				
Legal				24,000
Engineering				200,000
Administration				125,000
Total Related Costs				**349,000**
Total Costs				**3,221,400**

Source: Derived from Anderson & Associates, 1994.

Looking at Financing Options for the Project

The findings in Spreadsheets 1A and 1 are entered into Spreadsheet 2F to assess financing options for the water extension. The four options selected for this analysis are summarized in Table 4.9. These options vary by the amount of funding received from external sources, such as state and federal grants, and the percentage of financing from rate-supported means and assessments. The purpose of the analysis is to assess the impact of funding assistance and financing options on annual water rates, annual household costs from water rates, and water rates per 1,000 gallons of water.

Option 1, the base case example, assumed that the Town will pay for 100% of capital needs for the project through rate-supported revolving loans. No external financial assistance, such as grants, will be received. Option 2 assumed that the Town will pay for 70 percent of costs through rate-supported loans. The remaining 30 percent is financed with assessments from new customers. In Option 3, grants will pay for 50 percent of capital needs, with the remainder financed by rate-supported loans. In Option 4, the town will receive 50 percent of capital needs from grants, 35 percent from rate-supported loans, and 15 percent from new customer assessment. For all of these options, it is assumed that revolving loans are serviced at five percent over a twenty year term. The twenty year term was chosen as the repayment time based on an estimated useful life of the equipment. Thus, in twenty years, the loan for this service extension will be paid and the equipment could possibly be replaced.

Table 4.9: Financing Options for the Total Project Cost ($3.425 Million)

Financing Options	Amount Financed by Rate-Supported Loans	Amount Funded by Grants	Amount Funded by New Customer Assessment
Option 1, Base Case	$ 3,425,000 (100%)	None	None
Option 2	$ 2,398,000 (70%)	None	$ 1,028,000 (30%)
Option 3	$ 1,713,000 (50%)	$ 1,713,000 (50%)	None
Option 4	$ 1,199,000 (35%)	$ 1,713,000 (50%)	$ 514,000 (15%)

The impacts of these options on users are calculated in Spreadsheet 2F (Appendix D) and summarized in Table 4.10. Option 1 yielded the highest increases in total annual increase in rates ($345,000) for all users, rate increase on average annual household cost ($80.45), and rate increase per 1,000 gallons ($1.96). Option 4 yielded the lowest increases in total annual increase in rates ($167,000) for all users, rate increase on average annual household cost ($38.92), and rate increase per 1,000 gallons ($0.95).

Table 4.10: Impacts of Financing Options on Water Rates

Impacts	Option 1	Option 2	Option 3	Option 4
Total Annual Increase in Rates	$ 345,000	$ 263,000	$ 208,000	$ 167,000
Rate Increase on Average Annual HH Cost	$ 80.45	$ 61.28	$ 48.50	$ 38.92
Rate Increase per 1,000 Gallons	$ 1.96	$ 1.49	$ 1.18	$ 0.95

A comparison between Option 1 and Option 4 indicates that household customers in the Town of Wise would pay $41.53 more per year if they must rely on rate-supported financing for the water extension. Assuming the median household income in Wise County is approximately $21,854 (LENOWISCO PDC, 1994), a $80.45 increase in annual water rate (Option 1) is a 0.37 percent increase based on median household income. Consequently, a $38.92 increase in annual rates (Option 4) is only a 0.18 percent increase based on median household income. Thus, current household customers, connected to the Town of Wise water system, would only incur a 0.18 percent increase in their average annual household water cost.

Rate increases per 1,000 gallons also decrease as the percentage of rate-supported financing decreases. For example, Option 3 and 4 have lower rate increases per 1,000 gallons since the majority of the financial burden is placed on grants and assessments. In particular, Option 4 has the lowest increase of $0.95 per 1,000 gallons. Based on existing water rates for the Town of Wise (Table 4.11), a 0.95 increase would bring water rates to $3.70 (in-town) and $5.08 (out of town) per additional 1,000 gallons. Options 1 would increase in-town rates to $4.71 per additional 1,000 gallons.

Table 4.11: The Town of Wise Water Rates

In-Town Rates	Out of Town Rates
\$7.15 for 1st 1,000 gallons \$2.75 for additional 1,000 gallons	\$10.73 for the 1st 1,000 gallons \$ 4.13 for additional 1,000 gallons
\$500.00 per meter tap	\$750.00 per meter tap
\$100 meter deposit for renters	\$100 meter deposit for renters

Source: The Town of Wise, 1996.

Table 4.12 summarizes the potential impact of rate increases per 1,000 gallons, for each option, on existing in-town customers. The average water cost per month is based on water consumption of 5,625 gal/month for households consisting of 2.5 persons using 75 gallons per capita per day (USGS, 1995). The findings indicate that Options 4 would increase monthly rates by \$5.34 or 27%, from \$19.87 to \$25.21 per month, for existing in-town households. Option 1, financed solely by rate-supported loans, would increase monthly rates by \$11.02 or 55%. Based on the analyses, Option 4 would be most affordable for current in-town customers to extend water service to the new 327 customers.

Table 4.12: Rate Impact per 1,000 Gallons on Existing In-Town Customers

	Existing Rates	Option 1	Option 2	Option 3	Option 4
1st 1,000 gal	\$ 7.15	\$ 9.11	\$ 8.64	\$ 8.33	\$ 8.10
Add. 1,000 gal	\$ 2.75	\$ 4.71	\$ 4.24	\$ 3.93	\$ 3.70
Avg. \$/month	\$ 19.87	\$ 30.89	\$ 28.25	\$ 26.51	\$ 25.21

Potential Application of the Spreadsheets

The analyses performed in the previous section have two possible applications. One, municipality and water system officials, with knowledge of the system's physical operations and budget, can use the analysis to calculate project costs and determine appropriate funding strategies. The analysis can be performed prior to consultation with engineer consultants to indicate financial feasibility of the project early. The second possible application of the analysis is to provide officers of grant programs and endowments with an analysis tool for evaluating the impact of grant levels on existing system water rates.

Another application of the spreadsheets is to set water rates. This function is accomplished in the rest of Module 2 and Modules 3 and 4. It enables municipalities to set water rates that encompass new system modifications. Module 4 also tests these rates to determine if they meet expenditures.

However, this function was not performed for the paper due to data limitations. In order to perform the rest of the spreadsheets, data from budgets, capital improvement plans, and considerable knowledge of the water supply systems are required. These resources were not accessible for this study. However, the spreadsheets are included in Appendix D, with numbers for illustrative purposes, for review. Instructions and explanations for their usage were included in the beginning of this chapter.

In terms of the future use of the spreadsheets, it is recommended that the spreadsheets be refined into a more user-friendly format. This will involve modification of the existing format to include a user manual and initial screen in which the user can enter all require data by answering questions. In their current form, the spreadsheets must be performed by an individual with considerable knowledge of the water system's physical operations, budget, and spreadsheet application. A city manager, water system manager, or a financial manager can fill these requirements.

Chapter V. Summary and Conclusion

This major paper satisfies three main objectives. The first objective was to identify water supply characteristics and problems and to assess existing water supply in the coalfield counties. The findings from Chapter II indicate that the coalfield counties have inherent water quantity and quality problems typical for the region. It was further concluded that these issues require two major solutions: appropriate technologies and associated funding and financial assessment. The second objective addressed real options appropriate for the coalfields, while the third dealt with financial assessment.

While fulfilling the first objective in Chapter II, the findings indicated that water quantity limitation is characteristic of sandstone and shale formations. This type of geology is found of the Cumberland Plateau, in which most of the coalfield region is located. Even in the Valley and Ridge Plateau, where a higher conductor of water (limestone) dominates, sand and shale typically underlay the ridges and upland areas of the Valley and Ridge Plateau. For these reasons, water sources in the coalfields, particularly individual systems, are unreliable. For example, the coalfield region experiences severe water quantity problems during drought periods. Some municipal groundwater sources and many individual wells have dried out during drought periods. During dry summer months, some water utilities reported unacceptable, low yields.

Even when water quantity problems can be mitigated by public water, access to these sources is often not available. The water availability problem is illustrated by the low percentages of public water connections in the coalfield counties. In 1990, for example, U.S. Census data indicate that only 2,746 out of 12,222 housing units in Buchanan County are connected to public water systems. Although Buchanan County is one of the most aggressive water developer in the coalfield counties, it still has the lowest percentage (22.5 percent) of connected housing units to public water in 1990 for the region. Other counties have also increased their number of connections to public water, but many counties still rely heavily on individual wells and other water sources.

The findings also indicate a substantial number of housing units requires not only public water access but also modern infrastructure to support public system water. In 1990, a total of 5,031 housing units (5.7 percent of total housing units) in the coalfield counties did not have complete plumbing facilities. Although this was a significant improvement from the 25,743 units (41 percent) in 1970, over five thousand housing units still lack the appropriate facilities to sustain public system water.

In addition to water quantity problems, the physiography of the coalfields contributes to water quality problems. That is, groundwater in the Cumberland Plateau tends to be of poor quality, sulfurous and iron-rich, due to the sandstone, shale, and coal formations. At depths of greater than 300 feet, naturally saline waters occur in this region. Furthermore, the chemical composition of limestone formations contributes to the hardness of water in the Valley and Ridge Plateau.

Karst terrain is another natural formation that can contribute to water contamination. The karst terrain in the Ridge and Valley Plateau is characterized by sinkholes and solution channels which may accelerate the movement of contaminants into deep wells. That is, streams and surface runoff entering sinkholes to recharge aquifers are also direct conduits of contaminants. Dumping in sinkholes can adversely impact groundwater. Combined with the fact that the coalfields are characterized by thin top soil that allows relatively easy penetration by contaminants, these natural conditions and associated land use practices make the pollution potential in the region very high.

Another land use practice that may significantly contribute to water contamination is the increased use of septic system and cesspool in the coalfield region. In 1990, a total of 54,953 housing units (63% of all housing units) in the coalfield counties relied on septic tanks and cesspools for sewage disposal. Although septic systems do not generally lead to drinking water contamination, they can impact groundwater when not properly designed, sited, or maintained. In particular, they can contaminate groundwater with nitrates, coliform bacteria, viruses, and a variety of organic and inorganic chemicals from household use. The problem intensifies when the working conditions of septic systems are also considered. Since most septic systems were installed in the 1960s and 1970s, with the design life averaging 10 to 15 years, they can impose high risks in drinking water when not timely maintained or replaced.

Chapter II also characterized water quantity and quality problems arising from mining. Two major problems are created by mining. The first problem involves the loss of water in wells when aquifers are interrupted by nearby blasting or subsidence. High extraction mining, the most prevalently used method in Virginia, causes subsidence and cave-ins by design. Consequently, subsidence damages well shafts, drain acquifers, and contaminate well water.

The second problem created by mining consists of surface and groundwater contamination from coal extraction and production processes. Since coal is frequently found with iron pyrites and other sulfides, water contamination can occur from acid mine drainage, the washing of chemicals and minerals, and mine wastes. For example, the reintroduction of transformed minerals into water, by mining processes, results in very acidic groundwater with high levels of iron and sulfates. Thus, the water from affected sources must be treated by appropriate treatment technologies for acceptable household use.

In addition to typical quantity and quality problems, the coalfield counties also have operational constraints. For example, high water loss is a significant problem for some systems since system upgrade is not financially feasible for all communities due to resource limitation. Furthermore, some systems are in need of expansion to serve unserved populations and general repairs to modernize old systems. In addition to financial resources limitation, the region's steep slope terrain can significantly increase construction costs to render water projects unfeasible.

Chapter III explored the second objective of identifying technical options appropriate for small water systems for water supply source development and system design, upgrade, replacement, and extension. The chapter identified and discussed a variety of technological options and their associated costs. Water harvesting, for example, can help alleviate water quantity problems by supplementing existing supplies with collected rain water. Water source protection strategies, such as buffers and setback in zoning, stream bank fencing, and best management practices, were provided to guide land use practices that are more sensitive to water quality. Treatment technologies were identified as particularly responsive to water quality problems typical to the region, such as high levels of iron, manganese, sodium, and chlorides. Oxidation filtration, for example, removes iron, manganese, and radium. Aeration oxidizes iron and manganese. Ion exchange can remove inorganic contaminants, including hardness causing chemicals. The treatment technologies presented in Chapter III are all appropriate for small water systems.

Understanding that many municipalities in the coalfield counties have limited resources for water development, the third objective of the paper was to develop and demonstrate an interactive, manageable, and accessible spreadsheet method of assessing capital costs, financing options, and water rate impacts of development projects. The findings from Chapter IV indicate that the method can aid individuals and organizations in determining capital costs of water projects, evaluating funding and financing options, and calculating the impact of these options on existing water rates.

The application of the water extension example of 327 connections to the Town of Wise illustrated the capability of the spreadsheets to calculate capital and operation costs of water projects. Although only one example was generated, the water rate impact assessment conveyed that rate-supported financing, by itself, may render a water project unaffordable. For example, a project that is solely financed by rate-supported loans or bonds yields higher increases in water rates for current customers than one financed partly by new customer assessments and funded by grants. In effect, as the percentage of the total cost of the project funded by grants increases, the increase in current water rates seems to decrease. The findings indicated that water supply development, supported solely by rate-supported financing, may yield higher increases in current water rates. In effect, without the aid of other sources of financing and funding, such as grants, a water project can be financially infeasible, and thus, politically unpopular.

Overall, the three main components of the major paper serve as references for assessing and selecting appropriate options for water supply development in small water systems. Chapter II can be used to identify quantity, quality, and operational limitations of water service. Chapter III provides a basic foundation of technological options for addressing identified problems. Chapter IV enhances the assessment of financing feasibility of water development in terms of impacts on water rates. In effect, the findings from this research provide an assessment of water service and supply options that could enhance the opportunity for communities to achieve effective and efficient water service development.

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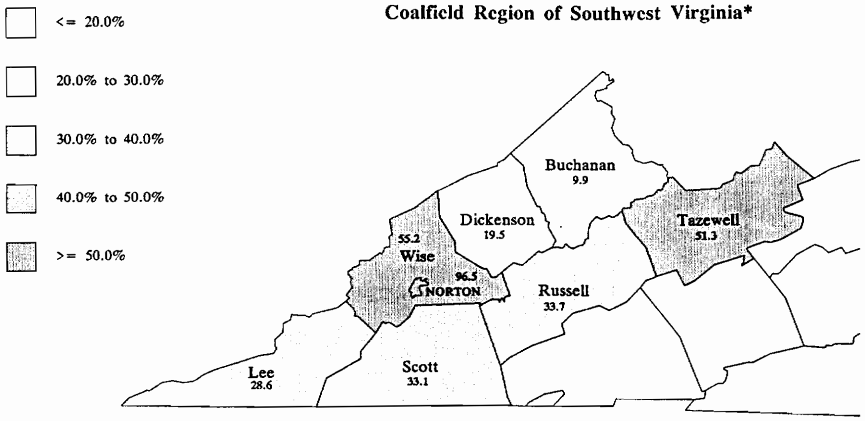
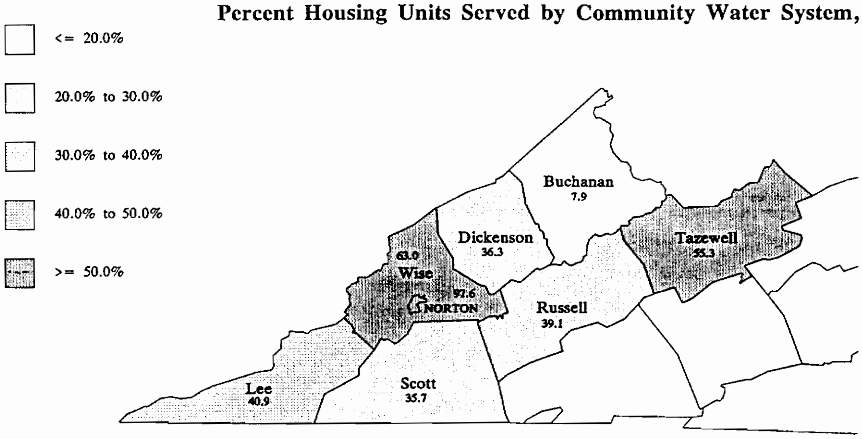
APPENDIX A

Percent Housing Units Served by Community Water System, 1970

Coalfield Region of Southwest Virginia*



Percent Housing Units Served by Community Water System, 1980



Percent Housing Units Served by Community Water System, 1990

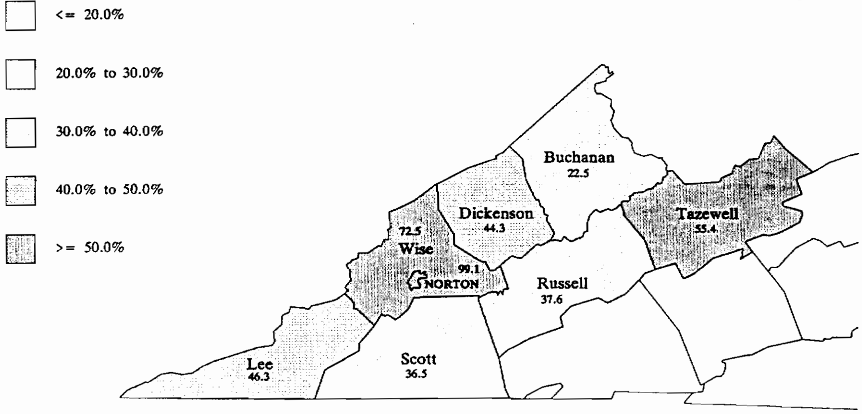
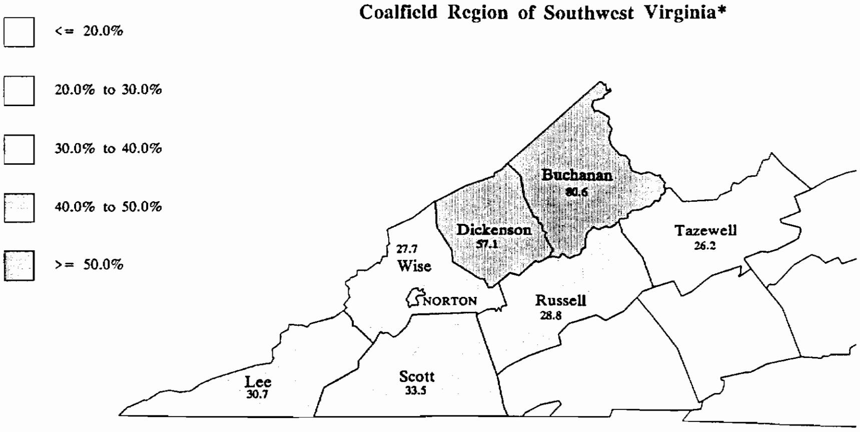


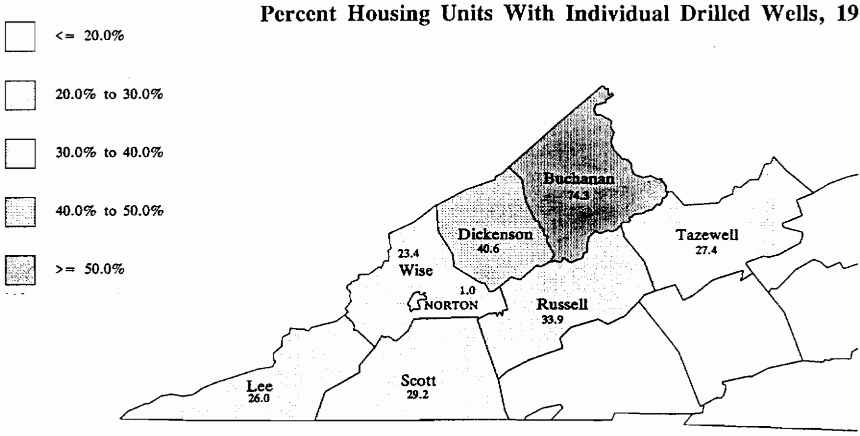
Figure A.1: Community Water System Service

Percent Housing Units With Individual Wells, 1970

Coalfield Region of Southwest Virginia*



Percent Housing Units With Individual Drilled Wells, 1980



Percent Housing Units With Individual Drilled Wells, 1990

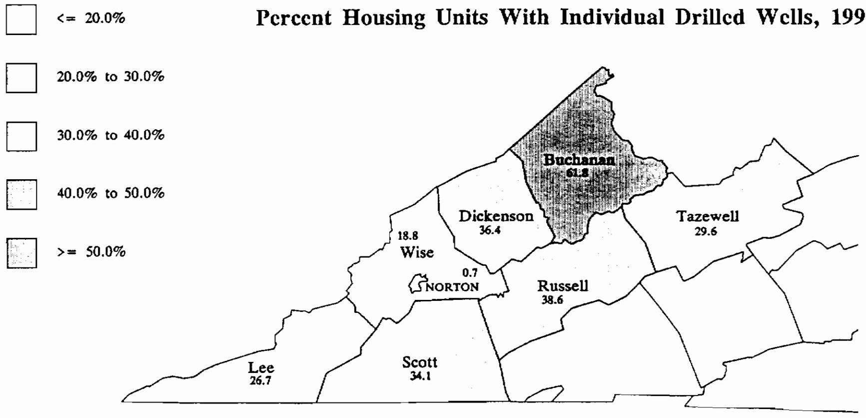
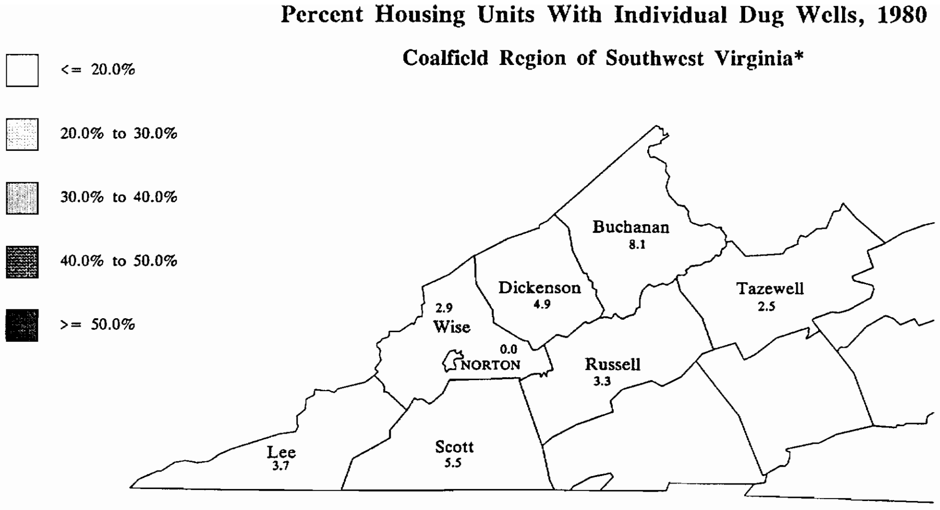
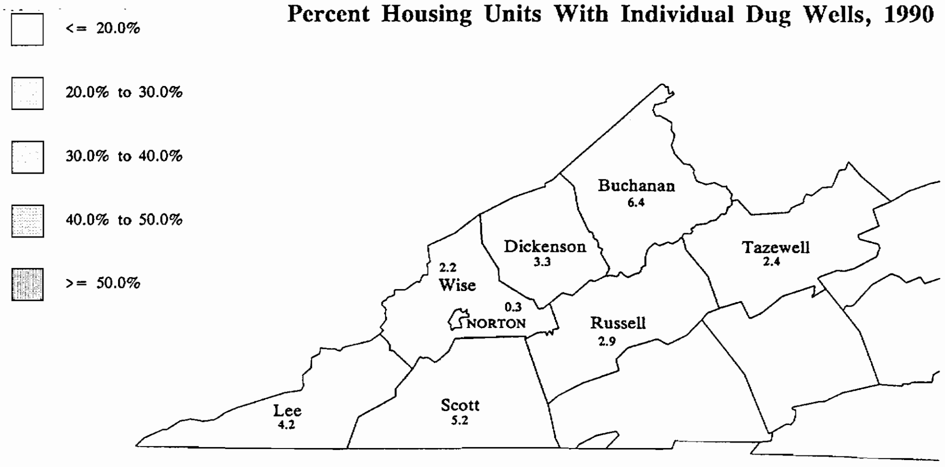


Figure A.2: Individual Drilled Well Usage



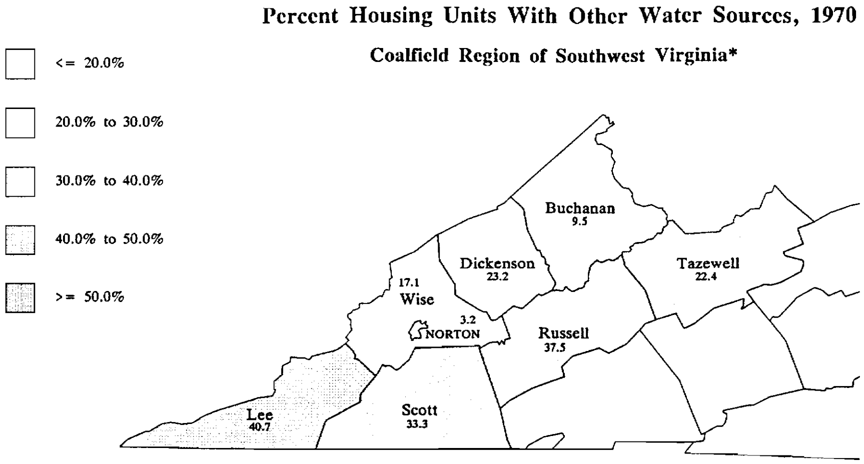
Percent Housing Units With Individual Dug Wells, 1980

Coalfield Region of Southwest Virginia*

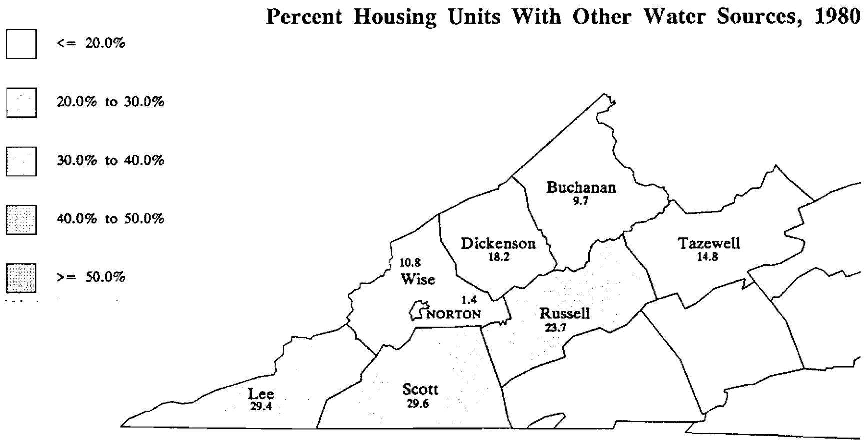


Percent Housing Units With Individual Dug Wells, 1990

Figure A.3: Individual Dug Well Usage


Percent Housing Units With Other Water Sources, 1970

Coalfield Region of Southwest Virginia*


Percent Housing Units With Other Water Sources, 1980

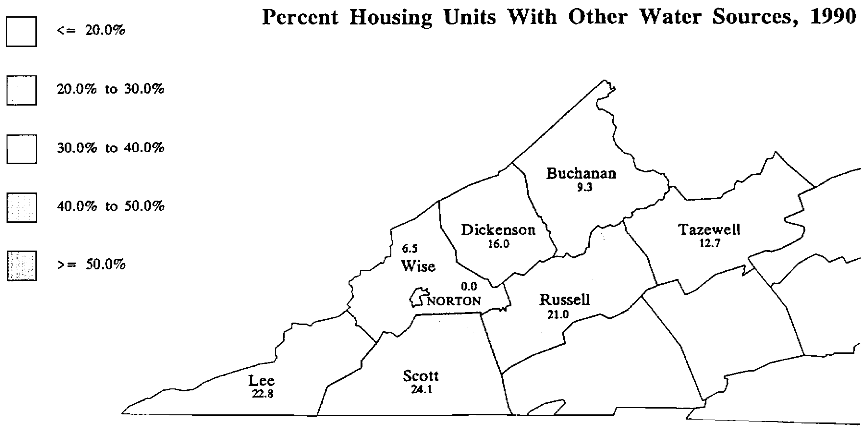
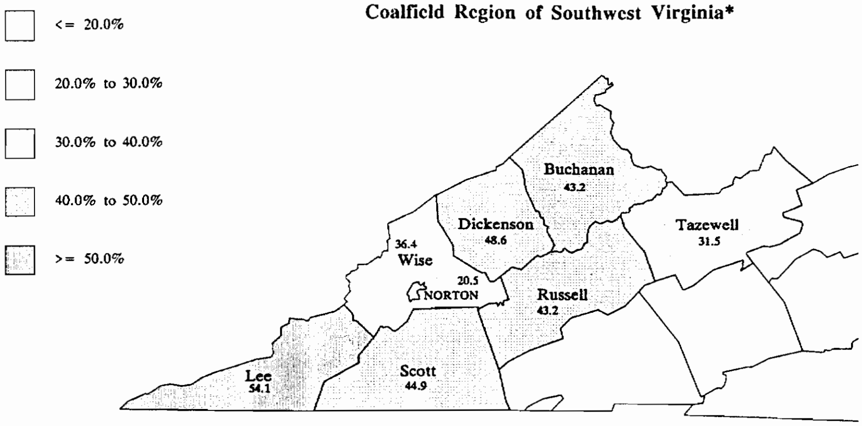

Percent Housing Units With Other Water Sources, 1990

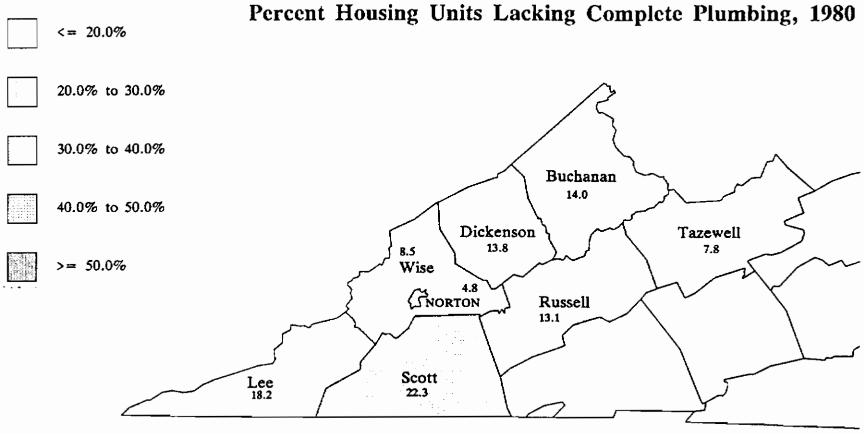
Figure A.4: Other Water Source Usage

Percent Housing Units Lacking Complete Plumbing, 1970

Coalfield Region of Southwest Virginia*



Percent Housing Units Lacking Complete Plumbing, 1980



Percent Housing Units Lacking Complete Plumbing, 1990

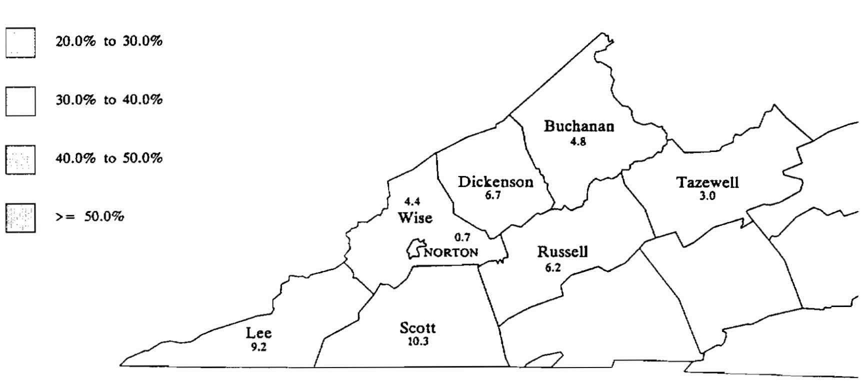
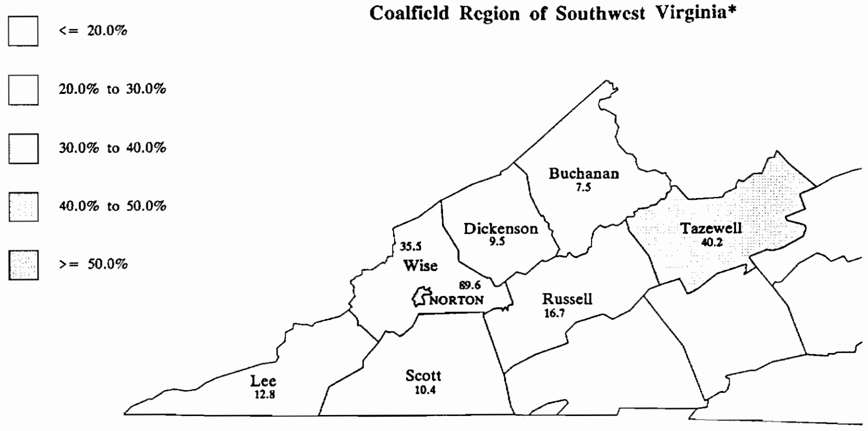


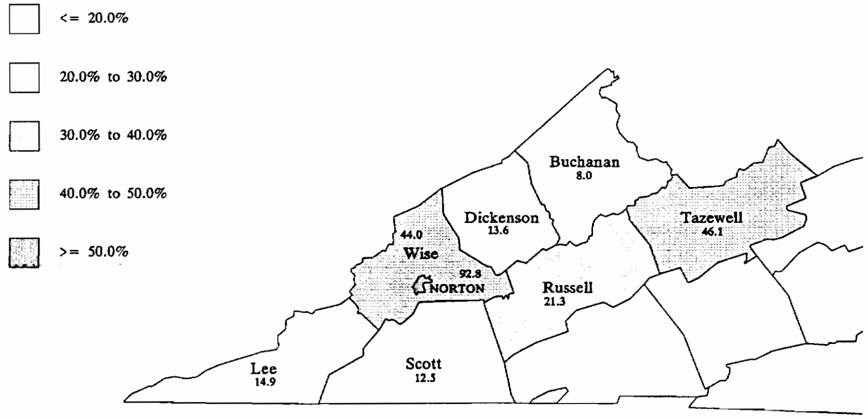
Figure A.5: Housing Units Lacking Complete Plumbing

Percent Housing Units Served By Public Sewers, 1970

Coalfield Region of Southwest Virginia*



Percent Housing Units Served By Public Sewers, 1980



Percent Housing Units Served By Public Sewers, 1990

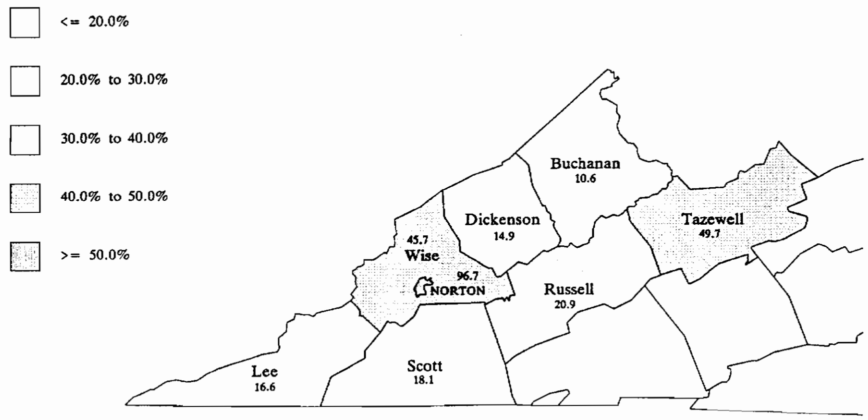
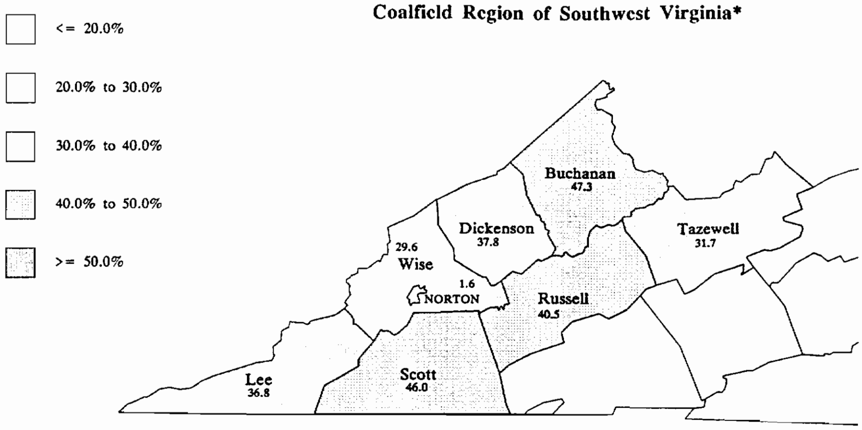


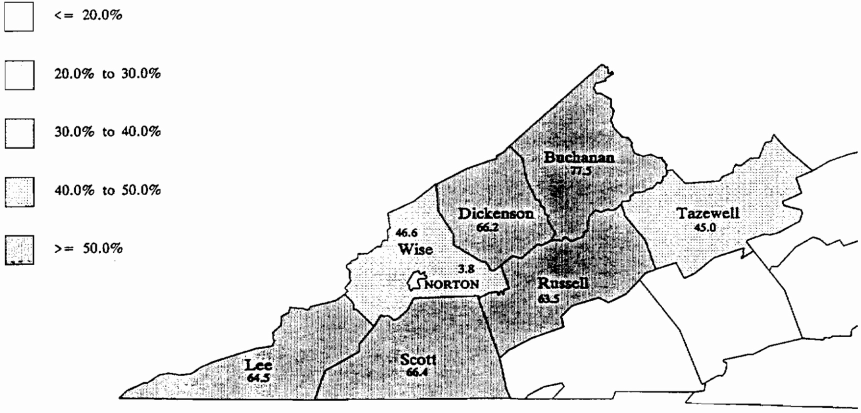
Figure A.6: Public Sewer Service

Percent Housing Units With Septic Tanks, 1970

Coalfield Region of Southwest Virginia*



Percent Housing Units With Septic Tanks, 1980



Percent Housing Units With Septic Tanks, 1990

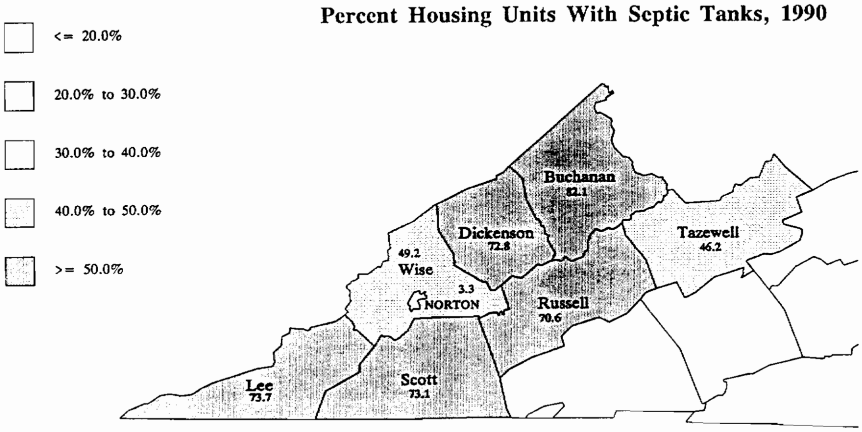
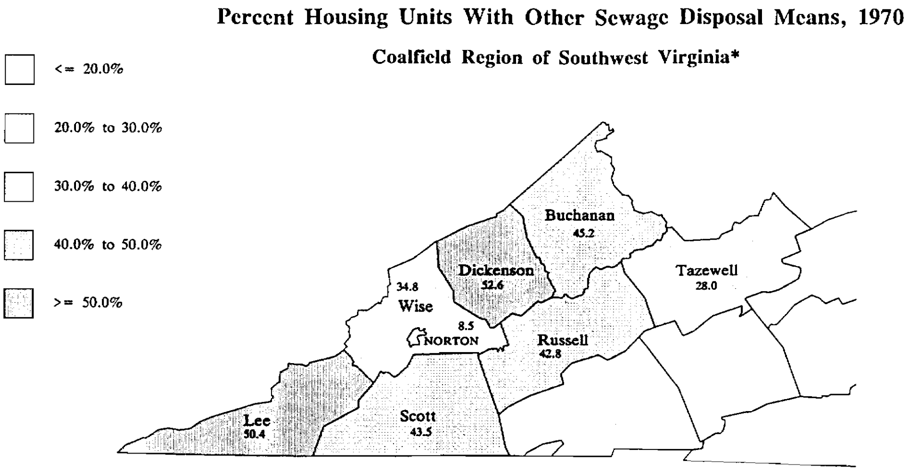
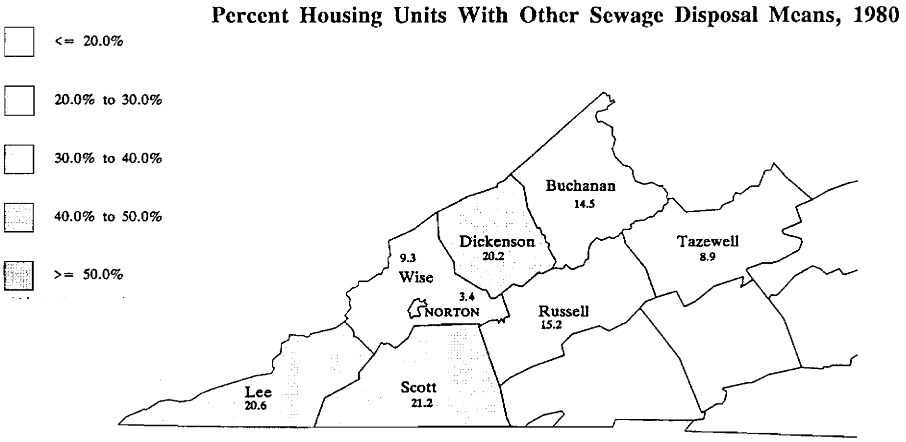


Figure A.7: Septic Tank Usage

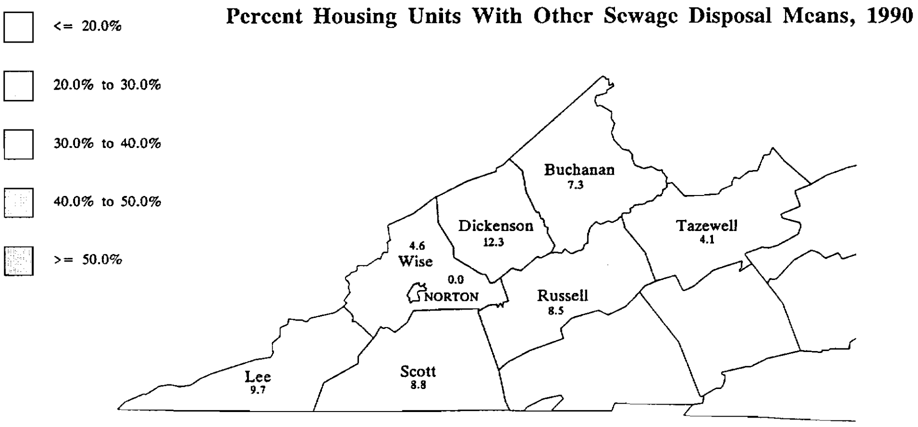


Percent Housing Units With Other Sewage Disposal Means, 1970

Coalfield Region of Southwest Virginia*



Percent Housing Units With Other Sewage Disposal Means, 1980



Percent Housing Units With Other Sewage Disposal Means, 1990

Figure A.8: Other Sewage Disposal Usage

Appendix B. Individual Water Systems in the Virginia Coalfields

A. Big Sandy Planning Area

a. John Flannagan Demand Center

One of the four demand centers in the Big Sandy Planning Area is the John Flannagan Demand Center. In this demand center, the John Flannagan Water Authority (JFWA) is the major water producer. It wholesales treated water to the *Town of Clintwood* and to the *Buchanan County Public Service Authority (BCPSA)*. BCPSA sells water to the *Big Caney Water Corporation (BCWC)*. *Dickenson County PSA* purchases water from both JFWA and Wise County.

In this demand center, self supplied industrial water withdrawals are made mostly by coal industries for coal cleaning processes. Approximately 84% of the water used by the coal industry is ground water. Only 16% is from surface water sources.

i. John Flannagan Water Authority (JFWA)

In the JFWA, water is obtained from the John Flannagan Reservoir (upstream of the dam). The reservoir is fed by the Pound River and the Cranesnest River. Maximum capacity of the JFWA is 47,248.4 million gallons. Water treatment scheme consists of chemical addition, flash mixing, flocculation, sedimentation, filtration, chlorination, fluoridation, and storage. In 1983, the treatment capacity was considered inadequate, and thus, required expansion.

ii. Buchanan County Public Service Authority (BCPSA)

The numbers indicate that the service area with the largest number of connections (3,950) is the *Buchanan County Public Service Authority* (Table 2.5). This PSA has made significant expansion and improvement in its system. For example, the Buchanan County PSA increased the number of connections from 400 in 1983 to the present 3,950. In 1995, this number of connections serves approximately 10,188 people. This increase in connections is partially due mergers with other service areas. For example, the Town of Grundy is currently a part of this PSA. The PSA still buys its water from JFWA.

Another notable change consists of the improvement in water loss. From 1983 to 1995, Buchanan County PSA has decreased its water loss from 76 percent to 21 percent. The high water loss in 1983 was due to faulty construction in the distribution system. This PSA is considered to be one of the most aggressive service area in terms of water supply system improvement and expansion.

iii. The Town of Grundy

Currently operated by Buchanan County PSA, The Town of Grundy had a history of quantity and quality in its two drilled wells (#2 and #5). A third well was available for use in emergency situations. The two drilled wells were the Town's primary water source. Due to water quality problems, treatment for the removal of iron and manganese was provided at each well. In particular, well #5 often had elevated levels of iron, manganese, and chlorides in the summer during periods of low rainfall. In terms of water quantity problems, Well #2 often went dry. For these reasons, these wells were regarded as not dependable sources in terms of quality and quantity.

iv. Big Caney Water Corporation (BCWC)

The service center with the second highest number of connections in the Big Sandy Planning Area is the *Big Caney Water Corporation (BCWC).* Located in Dickenson County, BCWC had 1,780 connections in 1995. Serving approximately 3,300 people, BCWC provides water to 75 percent of the population in the service area.

In 1995, the capacity of the system and its distribution lines is 0.225 mgd. The current withdraw of the system is 0.175 mgd. BCWC operates two inter-connected water systems in Dickenson County: the McClure and the Clincho systems. As a whole, however, the system is operating at full capacity. The VDH's limit on the maximum number of connections to the system is 3,300. On the Flannagan side, only 200 connections can be added. System officials indicate that the system need to be upgraded or renovated before service is extended. This is due to the fact that the percentage of water lost in the system is 50 %. Since the recommended limit for water loss for any water supply system is 20%, this number is currently unacceptable.

v. Town of Clintwood

In 1995, the service area with the third largest number of connections is the Town of Clintwood. The Town has 1,580 connections serving approximately 3,220 people (Table 2.5.). This number of connections serves 90% of the population in the service area. Overall, the system is not operating at full capacity even though there is a VDH limit of 1,620 residential connections. In fact, 152 connections can be added. Before extension can take place, however, the system requires upgrading. Water lost on the system is at 18%.

All water for the Town was supplied by JFWA. The town has 4 storage tanks. There are 36 miles of 8" and 6" diameter distribution line between the Town and the BCWC to transfer water between the systems. Current water projects in the service area consist of the Skeetrock, the Georges Fork, and the Honey Camp/Darwin water projects. Proposed projects include the Brush Creek and the Camp Creek water projects.

vi. Dickenson County PSA

The primary source of water for the service area is the John Flannagan Reservoir. This water is actually purchased from JFWA (BCPSA and BCWC) and Wise County (WCPSA). The SA also draw water from a private well located in the Walnut Grove section of Trammel, Virginia.

In 1995, the system has 291 connections. These connections include those on the Sandy Ridge, the Nealy Ridge, the Trammel, the Wolf Pen, the Doe Branch, and the Donnkenny water systems. They serve approximately 70% if the population in the service area, including connections to BCWC, Town of Clintwood, and BCPSA. Since the system is not operating at full capacity and is modern, connections can be added without upgrade to the system. Water lost is also low, below 5%, the lowest in the planning area.

Dickenson County PSA plans to expand to 1,200 connections. Current preliminary engineering reports are proposed for Ramsey Ridge/Dog Branch, Camp Creek, Smith Ridge, and Brush Creek. Preliminary engineering reports have been conducted for Brushy Ridge, Rakes Ridge, Tivis, and Hazel Mountain.

b. Pound Demand Center

The second demand center in the Big Sandy Planning Area, the Pound Demand Center, consists of the Town of Pound. The Town lies in the Roberson Magisterial District of Wise County. The main water source is the North Fork Pound River Lake. During winter months, the water level of the lake is dropped for flood control measures causing gravity flow of water into the plant to decrease. Thus, water supplies required supplementation from another source due to an inadequate raw water supply during the drawdown. In 1983, the Corps of Engineer encouraged the Town to either reduce its water demand or develop a supplemental or alternative raw water supply. In June 1995, the sole water source remains the North Fork Pound River Lake.

Water from the lake flows to the filter plant, below the dam, through an 8" diameter cast iron pipe. Water treatment equipment include: clarifiers, sand filters, dry chemical feeders, gas chlorinators, and fluoride feeder. In the 1990s, work was done on the plant and lines of the system. The Town indicated, in June 1995, that it has a new backwash pump. In June 1995, the system had 795 connections. All water produced were used for domestic purposes. There were no wet industries on this system.

c. Amonate Demand Center

The Amonate Demand Center consists of the community of Amonate, located along State Secondary Route 624 in the Jeffersonville Magisterial District of Tazewell County. The service area also crosses the Virginia State line into West Virginia. In 1983, water was supplied by Pocahontas Waterworks, Inc., headquartered in War, West Virginia. Currently, water is supplied by Tazewell County Public Service Authority. The water source for the Town was from a drilled artesian well. There was no supplemental water supply since the quantity and quality of water from the well have been consistently good.

Water delivery was through a 40,000 gallon covered steel standpipe and by a centrifugal pump. Water treatment is by a gas chlorinator. The well had continual excess flow. Pocahontas Waterworks had planned to install a valve to control the pump.

In 1983, no meters were on the 90 connections, but they were scheduled to be installed. In 1995, there were 77 connections serving 212 people. The VDH permit limited the system to 90 residential connections. All water was for domestic usage.

d. Bishop Demand Center

The Bishop Demand Center consists of the community of Bishop. The latter spans the Virginia-West Virginia state line along State Primary Route 16 in the Jeffersonville Magisterial District of Tazewell County. Once provided by Pocahontas Waterworks, Inc., water is presently supplied by Tazewell County Public Service Authority. The water source was designated to be from Crockett's Cave Spring. However, water for the filter plant was actually taken from a dam which contains water from the spring. Water from the spring has been abundant and of high quality. Thus, no supplemental nor emergency source for the filter plant exists.

Water from the Spring flows by gravity from the dam to the raw water well through an 8" diameter pipe. A centrifugal pump delivers water to a baffled mixing chamber where alum is added. Water treatment equipment consisted of sand filter and pulsating chlorinator. A turbine pump runs the distribution system. An open woodstave tank on a hillside stores the water.

With no wet industries in the service area, there were 104 connections serving 286 people in 1995. The VDH permitted the system for 103 residential connections. In this demand center, demand for water decreased with the installation and use of water meters. Furthermore, a system enlargement is not required as indicated by water demand.

B. Tennessee Planning Area

1. Clinch River Planning Area

a. Duffield Demand Center

Located in Scott County, the demand center comprises of two service areas: Duffield Development Authority (DDA) and Scott County Water and Sewer Authority (SCWSA). DDA service area includes the Thomas Village and Duffield Industrial Park area. SCWSA serves the remainder of the demand center, the Town of Duffield. All water is produced by the DDA. The latter wholesales water to SCWSA for further distribution. In 1995, the DDA and SCWSA have a combined 321 connections.

i. Duffield Development Authority (DDA)

Primary water sources for the DDA are Spurlock Branch and the North Fork of the Clinch River. In October 1994, DDA had a total of 83 connections on the Duffield Water Treatment system, serving approximately 95% of the population. Of these, 55 connections were residential and 28 were commercial.

Since the system is not operating at full capacity and there is no VDH limit on the number of connections. In fact, approximately 1,600 connections can be added without upgrade to the system. This is due to the fact that water lost is low, at 11%.

ii. Scott County Water and Sewer Authority (SCWSA)

All water in the service area is bought from DDA. SCWSA has no water source and owns no storage facilities. In October 1994, there were 220 connections on the Duffield/Pattonsville Water System. Water is predominantly used for domestic and commercial purposes.

b. Lebanon Demand Center

The demand center serves the Town of Lebanon, the largest urban area in Russell County. The primary source of water for the demand center is Big Cedar Creek. There are no supplement sources available. In 1995, the Lebanon Demand Center had 1,655 connections serving 3,950 people. Approximately 85% of the population in the service area is being served.

The current withdraw of the system is 0.5 mgd. It has a distribution capacity of 1.0 mgd. It is estimated that the system is operating at half capacity. Since water loss in the system is low, at 12 percent, 500 residential connections can be added without upgrade to the system.

c. Honaker Demand Center

Also located in Russell County, the demand center serves the Town of Honaker and the area along State Route 67 east of town to Gardner. Various areas, along major highways and streets, outside of the Town limits are also being served. In 1995, the system had 900 connections serving approximately 2,083 people. Approximately 95 percent of the population in the service area was served by these connection. Of these, 25 to 30 percent of connections are unmetered.

Water unaccountability was high, at 24% in 1983, due to old distribution lines dating back to 1967. Due to recent renovation, the current percentage of unaccountable water is between 10-15%. For this reason, the VDH has no limit on the number of connections to the system.

Water sources for the demand center consist of 4 wells: Town Hall well; Hillman Hollow well; Eaton Well; and Davis well (for drought emergencies). In 1995, the service area was in the process of digging a new well. Combined storage of 0.608 million gallons is provided by 4 tanks. Water treatment consists of chlorination units on each source. The system, as a whole, is currently operating at full capacity. Thus, utility officials indicated that the system needs to be upgraded before service is extended.

d. St. Paul-Russell County Demand Center (RCWSA)

Located in Russell County, this demand center includes 3 service areas: the Town of Cleveland; the Town of St. Paul; and Russell County Water and Sewerage Authority (RCWSA). RCWSA is divided into 3 smaller systems: Dante-Lick Creek, Castlewood, and South Clinchfield. The Town of St. Paul's water system and RCWSA are interconnected. St. Paul buys and sells water to RCWSA via the Castlewood system.

St. Paul and Cleveland service areas are basically defined by corporate limits, extending only slightly beyond their boundaries. RCWSA, however, serves the two more densely populated areas of Dante and Castlewood, and extends out into the county to reach smaller communities along Lick Creek and Gravel Lick Creek. It also extends west of Castlewood to Mew.

i. Town of Cleveland Service Area

In 1995, this service area had 121 connections, serving 264 people. Water sources for these connections consisted of Kiser Well and Elm Spring. Water from the two sources is stored in a 40,300 gallon concrete reservoir, the Count's Reservoir.

The system had many problems. First, water loss in the system has been high, at 64 percent. Primary water problems in the service area resulted from the distribution system, which is old and poorly maintained. Installed in the 1920s, the distribution system uses 1 & 2 inch lines. The water transmission system also had problems maintaining water pressures at high elevations. Water loss and low water pressure, in homes at higher elevations, were constant problems. It was also difficult to keep the 40,300 gallon Count's Reservoir full. Combined with the fact that the distribution system was unmetered, accurate water accountability was impossible. Furthermore, no adequate fire protection existed at facilities.

In spite of its high water loss, the service area was projected to have abundant water, a surplus of 35,000 gpd in 2030. It also had a $490,000 Community Development Block Grant to renovate the distribution system. If the system is properly repaired, it is expected to have even higher water surplus.

ii. Town of St. Paul Service Area

In 1995, the Town had 395 connections, serving 1,019 people. The Clinch River was the sole water source for the conventional treatment plant. The service area had three storage tanks with a total volume of 330,000 gallons. Water was estimated to be between 15-24%. This service areas was also projected to have a water surplus in 2030.

iii. Russell County Water and Sewer Authority (RCWSA)

RCWSA operates two independent water systems, the Dante-Lick Creek and the Castlewood, in Russell County. It also includes the South Clinchfield System. The primary water source for the Dante-Lick Creek system consisted of 2 abandoned deep mines owned by Clinchfield Coal Company. The Town of St. Paul acted as an emergency source. Primary water sources for the Castlewood system includes 3 springs and one well (collectively known as Crystal Springs), and a fourth spring called Seven Springs. These ground water sources, however, are less reliable during drought periods than surface water. Thus, it was recommended that a water plant on the Clinch River be developed to increase the reliability of the water source.

Water in the system was used for residential and commercial purposes. The Clinchfield Railroad also bought water. In 1995, the system had 1,669 connections, serving 4,840 people. The SA was projected to have a surplus of 261,000 gpd in 2030, even with a total water loss at approximately 50 percent. Most of the water loss in the system was thought to be stolen. The Castlewood section, however, only had approximately 20 percent water loss, a decrease from the previous 80 percent.

e. Wise-Norton Demand Center

The demand center consists of four different service areas: the City of Norton; the Town of Wise; the Town of Coeburn; and the Wise County Public Service Authority (WCPSA). All of the demand center is contained within Wise County.

The *Norton SA* includes almost all of the city limits and extends out from those limits to include Dorchester Junction, Josephine, and part of the area around Esserville. In October 1983, the City of Norton often bought water from the Town of Wise during dry seasons when the City reservoirs begin to run low (even though it produces its own water).

The *Town of Wise SA* includes the corporate limits of the Town and extends circumferentially to the north and east to serve Glamorgan. The Town of Wise sells to both the WCPSA and the City of Norton.

The *Town of Coeburn SA* contains all of the corporate limits and also stretches north along State Route 72 to include Cranesnest, east along County Route 652 to the community of Franco and the Coeburn Reservoir, and south along State Route 72 almost to Scott County border. The Town of Coeburn was recently connected to WCPSA.

Serving the remainder of the demand center, the WCPSA is broken up into several different sections. One section extends from the Dorchester-Needmore area west of Norton, north to the community of Stephens. Another section of this SA extends between Esserville and the Town of Wise SA. WCPSA also serves the population around Hurricane and counties south along County Route 644 to the are just north of Tacoma. WCPSA is the only SA that does not produce its own water. It purchases water from the City of Norton, the Town of Wise, and the Town of Coeburn.

The demand center used to contain a large unserved population. WCPSA system extensions currently serve this part of the DC. The extensions occurred in two phases. In phase one, distribution lines were connected from the existing lines on the south end of County Route 644 through Tacoma and east along US Route 58 to interconnect with the Coeburn system. In phase two, the lines were extended from Coeburn southeast along County Route 658 to the Clinch River at Carfax, where a new 1 mgd water treatment plant was constructed. The service areas were interconnected around 1986.

i. City of Norton Service Area

In October 1994, the Norton Water Treatment system had 2,101 connections. Of which, 351 were commercial and 1,750 were residential connections. Commercial water use was high in Norton. The City experiences high water losses of approximately 45 percent. For this reason, leak detection work has been ongoing in an attempt to reduce the unaccountability to 20%.

The City had several water sources. The primary sources included the lowermost of two reservoirs on Benges Branch and a reservoir on Robinette Branch just above the confluence with Benges Branch. The watershed for these reservoirs is about 700 acres of unmined National Forest land. Two deep wells at the mouth of the upper reservoir supplemented surface water supplies. The wells, however, were unreliable since they dry up during droughts. The City's supplies is also supplemented by the Town of Wise, when there was enough water to spare. The City's 1.44 mgd plant treats all water from the wells and reservoirs. Three tanks and a clearwell provide a total storage capacity of 2.338 million gallons.

ii. Town of Wise Service Area

In 1995, the Town of Wise had 2,246 connections. It also had an additional 166 commercial connections. In total, the system served approximately 99.9% of the service area's population. The current VDH's limit on the maximum number of connections is 3,750.

The 1.5 mgd capacity plant currently averages a production rate of approximately 0.70 mgd. The conventional 1.5 mgd water plant was constructed in 1963-64 and upgraded in 1974-75. The seven tanks in the distribution system provide a total storage capacity of 2.625 million gallons. At the present, the system is not operating at full capacity. In fact, 1,504 connections can be added. The system, however, needs to be upgraded or renovated before service is extended.

Of the water produced, 27 percent was unaccounted for. The unaccounted water in this service area included all the water used for operating the treatment plant, as well as all the water used by the Town. In effect, the amount of water actually lost in the distribution system is probably closer to 0.200 mgd or 20%.

A moratorium on the amount of water the Town sells to WCPSA was instituted after the 1980 drought. The purpose of the moratorium was to expedite WCPSA into developing its own water source. The enforcement of this water growth limit, however, has caused the County to lose contracts for industrial development.

The primary water source for the Town is the Bear Creek Reservoir. With a watershed of 818.2 acres, the reservoir is owned by various individuals and is slowly being encroached upon by strip mining operations. In addition, two wells under the courthouse have been authorized for use in emergency situations. It is doubtful, however, that they will ever be implemented because of their inaccessibility. They were initially abandoned because they were unreliable. Their estimated capacity was at 0.300 mgd. Currently, Bear Creek is the emergency source for the Town.

iii. Town of Coeburn Service Area

In 1995, the Town had 1,413 connections, serving 100% of the service area's population. Several of these connections were connected to institutional facilities, such as a penal institution, a Job Corps Center, three schools, and a large garment factory.

The primary water source for this SA is Tom's Creek Reservoir. The later was estimated, by engineering reports to have a capacity of 30 million gallons and a drainage area of 3.15 square miles. The supplemental water source is a well drilled to an underground cavern located adjacent to the reservoir. An engineering report determined the cavern to contain 448.1 million gallons of water.

Upon completion of the well, the Town, during a severe drought, pumped 720 gpm or 1.037 mgd through a meter from the well, 24 hours per day, for six consecutive weeks. Through daily monitoring, it was observed that this pumping did not reduced the daily yield at the site where the overflow exists, an abandoned mine shaft called Jenny Mine. Also note that water quality analyses from the well indicated high iron, manganese, and sodium concentrations.

The Town pumps its water from the well and combined with the water in the reservoir prior to treatment. The water is then treated at a refurbished filtering plant with a capacity to treat 1.15 mgd. The renovation was achieved by the installation of anthracite rapid rate filters. The entire plant was expanded and remains modern in 1995. The VDH limit of 0.750 mgd has been lifted after the Town verified its supplemental source. Thus, the service area is not operating at full capacity and is capable of accommodating more connections without renovation to the system.

Of the 0.450 mgd of water produced at the plant, approximately 18% is lost in the distribution system (including breaks that are immediately repaired). The Town was able to reduce the percentage of water lost by replacing and improving several old lines. In particular, approximately six miles of line was renovated and a new eight inch extension was made on Route 58A to the west toward Norton. Due to improvements in the system, the Town produced less water in 1995 than it did in 1983, even with a larger customer base. Furthermore, the Town of Coeburn and the Wise County Public Service Authority have mutual connection to each other's system in case of emergency.

In 1983, the Town applied for a $500,000 ARC grant, matched it with $187,522, and received a Farmer's Home Administration loan of $900,000. These funds allowed the Town to build a new million gallon storage tank. Combined with the three existing storage tanks of 0.100, 0.250, and 0.300 million gallons, the Town has a combined storage capacity of 1.650 million gallons.

iv. Wise County Public Service Authority (WCPSA)

This SA is divided into four different sections: the Norton section (serving the Dorchester, Needmore, and Stephens area); the Esserville section (serving customers

between the City of Norton and the Town of Wise); the Hurricane section (serving the area northeast of the Town of Wise through the Hurricane section and the area around the Town's reservoir). It also has been recently connected to the Town of Coeburn.
All four sections are interconnected with the distribution system of either the Town of Wise or City of Norton, or both.

In October 1994, WCPSA had a total of 2,282 connections. This figure included connections in the Town of Coeburn. All water is used for domestic and commercial purposes. Producing no water, WCPSA purchases water from the Town of Wise, the City of Norton, and the Town of Coeburn.

Billing records indicated that water loss is low, averaging 8%. Low water loss was due to a relatively new distribution system. The Norton and Wise sections of the distribution system were completed in 1973-74 and the Esserville and Hurricane sections in 1980-81.

In 1983, WCPSA was in the process of expanding its water system to include a water treatment plant on the Clinch River at Carfax. Distribution lines from Coeburn to Wise were constructed before the plant. After the completion of the lines, WCPSA purchased water from the Town of Coeburn to serve the new connections. WCPSA also provides supplementary/emergency water supply to Coeburn from a one mgd plant near Carfax. The project was funded by a $500,000 ARC grant, a $750,000 Block grant, and $3.35 million by local supporters. It was expected that $4.55 million will cover the cost of the plant and trunk lines. Money for service connections was obtained from Farmer's Home Administration loans.

f. Richlands-Tazewell Demand Center

The Richlands-Tazewell Demand Center is fully contained within Tazewell County. The demand center consists of 4 service areas: Tazewell County Public Service Authority (TCPSA); the Town of Richlands; the Town of Cedar Bluff; and the Town of Tazewell. The TCPSA Service Area is divided into 3 sections: Jewell Ridge, Raven-Doran, and Claypool Hill. This service area extends south along Big Creek to the communities of Doran and Raven, serving the population in the area between Richlands and the Russell County line. It continues southward along County Route 609 just beyond Midway and Piantlick. Where Route 609 crosses US Route 19, the service area goes east and west along the highway from the Russell County line encompassing the community of Claypool Hill. Jewell Ridge, Raven-Doran, and Claypool Hill have their own water sources. Only Claypool Hill wholesaled water to another community, the Town of Cedar Bluff.

The Town of Richlands Service Area includes most of the corporate limits and extends circumferentially south to one of its sources on Kent Ridge. It has its own water source and is connected to the Town of Cedar Bluff. The latter provides water for its community and extends approximately 1.5 miles east of Town up County Route 631 to a water source along Smith Ridge. The Town has its own ground water source. Its water distribution system also has connections to the Town of Richlands and the Town of Claypool Hill. The Town of Tazewell Service Area, however, is virtually restricted to the Town's corporate limits, extending beyond them only to reach the water source on the Clinch River.

i. Tazewell County Public Service Authority (TCPSA)

This SA is divided into 3 sections: Jewell Ridge (which includes the connections around the community of Jewell Ridge); Raven-Doran (which includes the SA population between Jewell Ridge and Claypool Hill); and Claypool Hill (which serves connections south of Richlands and between Raven-Doran and Cedar Bluff). Formerly Tazewell County Water and Sewerage Authority, TCPSA had plans to serve approximately 2,500 new connections in Baptist Valley, Johnson Hollow, Red Root Ridge, Smith and Chicken Ridges.

Jewell Ridge Distribution System

In 1995, the system had 82 connections, serving 226 people. The primary water source for the system is a small surface water impoundment on an unnamed tributary to Big Creek. This source has a history for unreliability. For example, in June 1983, the impoundment went dry. Between July and October 1983, water use had been restricted due to source shortages. This occurred shortly after the system was obtained from Jewell Ridge Coal Company in February 1983.

A deep well supplies supplemental water for the system. The well is used only during dry spells because of the high iron and manganese concentrations in the water. When both water sources are dry, water is hauled from Richlands by tank truck. Water from both sources is treated in a wood filter plant that has the storage capacity of 0.418 million gallons. Water loss in the distribution system is approximately 24 percent.

The Raven-Doran Section

In 1995, this section had 751 connections, serving 2,065 people. The sole water source was a 0.5 mgd treatment plant on the Clinch River. The plant was completed in 1968. The VDH permitted the plant to produce 0.5 mgd.

The Claypool Hill Section

In 1995, the Claypool Hill Section had 839 connections, serving 2,349 people. The sole water source for this system is the Little River. The VDH permit limited the production of the water plant, from the source, to 0.5 mgd. The plant, however, is expandable to 1.0 mgd with the addition of two new filters.

ii. Town of Richlands Service Area

In 1995, the Town had 2,680 connections, serving approximately 5,324 people. Roughly 98% of the population in the service area is served by these connections. The primary water source for the Town is the Clinch River. A limestone spring located about three miles southwest of Town acts as a supplementary source. It is estimated to provide 0.200 mgd during wet weather.

The Town currently withdraw 0.8 mgd from the Clinch River. The system is presently not operating at full capacity. In 1995, the system was undergoing new upgrade. Overall, the system's water lost of 20 percent is relatively low.

iii. Town of Cedar Bluff

In 1995, the service area had 697 connections serving 1,715 people. The majority of the water is purchased from the TCPSA Claypool Hill system. Barrett's Spring also supplies water for Cedar Bluff. The latter and Richlands are interconnected in order for Richlands to function as an emergency source.

iv. Town of Tazewell

In 1995, the Town of Tazewell had 1,850 connections, serving approximately 4,828 people. It operates a 1 mgd water treatment plant on Cox's Branch of the Clinch River. The raw water supply for the plant is taken from both a reservoir on Cox's Branch and a pump station on the Clinch River. Cox's Branch reservoir has a capacity of 50,000 gallons. The intake on the Clinch River is located just downstream of the confluence of the Lincolnshire Branch. There are 2 centrifugal pumps at the intake point on the Clinch River. One pump is used for water supplied from the Cox's Branch while the other is used when the Cox's Branch line is shut down for maintenance. Water loss in the system is at 21 percent.

There are two 175,000 gallon raw water storage reservoirs at the plant site where raw water from Cox's Branch reservoir flows by gravity. The filtration plant, constructed in 1965, is designed to produce two grades of water: complete treatment for domestic use and unchlorinated, unfluoridated water for industrial use.

2. Powell River Subarea

a. Pennington Gap Demand Center

Located in central Lee County, the demand center consists of five interconnected service areas: the Town of Pennington Gap; St. Charles Water and Sewerage Authority (SCWSA); Dryden Water Authority (DWA); Woodway Water Authority (WWA); and the Town of Jonesville. Pennington Gap was the sole supplier of drinking water to its own town, SCWSA, and DWA. The Town of Jonesville supplied its residents as well as WWA.

The Town of Pennington Gap provides water directly to residents in the Town of Pennington Gap, along alternate US Route 58 to Ben Hur, and within 1.5 mile radius of the southeast section of Town. The SCWSA system connects to the Pennington Gap system at the Pennington Gap corporate limits and continues along Stone Creek for about four miles. The lines also extend up Straight Branch through St. Charles to Monarch, along Gin Creek to Darbyville, along Bailey's Trace to Bonny Blue, and along Puckett Creek for about one mile.

The DWA system connects to Pennington Gap at the corporate limits northeast of Town. This system provides water to those residents along alternate US Route 58 through Dryden and beyond for a total of approximately 12 miles. Residents along several county roads off of Alternate 58 are also served.

The WWA service area stretches along US Route 421 toward the southeast through Woodway to US Route 58. From there, the water supply lines run along US Route 58 southwestward to the corporate limits of Jonesville. The distribution system for the Town of Jonesville is bound within the Corporate limits.

i. Town of Pennington Gap

In 1994, the Town had 1,184 connections to the water treatment system. The primary water source was a raw water intake on the Powell River approximately three miles southeast of Town near Highway 421. The drainage area for the Powell at the intake is 200 square miles. The Town's supplemental water supply, Upper Trurow Spring, was developed in 1924. It is located on the west end of Ben Hur. Cold Spring is the other supplemental water supply. It is located in a bend of the Powell River. The spring functions as an emergency water supply and is used only when the Town is experiencing water supply deficits.

A new 1 mgd conventional treatment plant was constructed in 1985. The plant replaced the old treatment plant. The new plant was designed to meet the projected water needs of all of the demand center. The Town of Jonesville is excluded and expected to supply its own water.

ii. St. Charles Water and Sewerage Authority (SCWSA)

In 1994, the St. Charles Water Treatment system had 545 connections. All water in this SA is purchased from the Town of Pennington Gap. SCWSA has no emergency or supplemental source or the desire to develop one. Water unaccountability was relatively low, at 20 percent.

iii. Dryden Water Authority (DWA)

In 1994, the Dryden Water System had 443 connections. DWA purchases all of its water from Pennington Gap. No supplemental or emergency sources exist for this system. Unaccountable water was at 20 percent. There is one 100,000 gallon covered steel standpipe available for storage. Another storage tank is desired because it would increase the design capacity of the system.

iv. Town of Jonesville

The sole water source for the system is Wynn Spring. No supplemental or emergency sources are available. The Town, however, has done some preliminary investigation into the possibility of increasing its water supply.

In July 1995, the Jonesville Water Treatment system had 593 connections to, serving 100% of the population of the service area. The Town also sells water to a wholesale customer, WWA. The remainder of the water is distributed through the other 592 connections within the service area. Since there is no VDH limit on the number of connections to the system and the Town is not operating at full capacity, several residential connections can be added without upgrade to the system. In fact, the Town followed recommendations and upgraded its system to reduce water lost from 36% to the current 12%. For this reason, the Jonesville water source should be adequate to supply the projected growth of the service area.

v. Woodway Water Authority (WWA)

In October 1994, there were 968 connections to the Woodway Water System. There were no commercial users on the system. The only non-domestic connections on the system were a school and a small rock crushing plant which used 3,000 gpd. Prompted by water shortages in the service area prior to October 1982, WWA signed a contract to buy a minimum of 0.045 mgd from Pennington Gap. One 200,000 gallon steel reservoir was available for water storage.

Water loss was at least 50% due to substandard lines installed in 1975. One maintenance man works with community volunteers to detect and repair the leaks in the 22-mile distribution system. It was estimated that the service area will have a water deficit in the 1990s if the leaky lines are not repaired. Furthermore, the community would lose half of water purchased, even with increased pumping and storage capacity.

b. Big Stone Gap Demand Center

The demand center is composed of two publicly owned, independently operated service areas, Appalachia and Big Stone Gap. The Appalachia Service Area (ASA) is widespread and serves many small communities in the northwestern part of the Richmond Magisterial District of Wise County, as well as one community in the northern end of Lee County. The ASA distribution network radiates from the Town of Appalachia up Callahan Creek past Stonega, up Mud Lick Creek to Roda, up Preacher Creek past Derby, up Looney Creek past Inman, along Pidgeon Creek to the Lee County line, and on to Keokee in Lee County.

The Big Stone Gap Service Area (BSGSA) includes most of the rest of Wise County population in the southwestern corner of the Richmond Magisterial District. BSGSA includes all of Big Stone Gap and East Stone Gap, as well as the Powell Valley northwestward to the Clinch-Powell River divide. It extends along two major roadways, Alternate US Route 58 and US Route 23, towards the southwest to the Lee County line. The section of BSGSA along US Route 23 south of Big Stone Gap is actually part of the Clinch River Subbasin, but is included in the Powell River Subbasin in this study.

i. Appalachia Service Area

In this service area, the water supply is obtained from the 316-acre Stone Mountain watershed one and one-half miles east of Appalachia. A masonry dam on Ben's Branch impounds approximately 146 million gallons of water for use in the ASA. Emergency water sources are available from two deep wells located in Osaka. The water quality of these wells suffers from high iron and manganese concentrations. Additional emergency wells are also available in Imboden and Keokee. These sources also contain high iron and manganese concentrations.

In 1995, the Town's withdrawal was at 0.550 mgd. Constructed in 1983, the treatment plant has a capacity of 0.750 mgd. The new plant actually has a capacity of 1 mgd plant, it is only permitted for 0.750 mgd by the VDH. The total storage capacity for the system is approximately 1.856 million gallons, which is provided by 13 tanks scattered throughout the distribution system.

In 1995, approximately 15-20 percent of the total water produced is lost in the lines or is unaccountable. This was a considerable improvement from the 52% in 1983. Wise County PSA is in the process of engineering a water line extension to the elementary school in the Town of Appalachia. The extension is for two miles, picking up 22 customers along the way. System officials indicated that the system had 1,469 connections in 1995. Approximately 101 of these connections were commercial.

ii. Big Stone Gap Service Area (BSGSA)

This service area obtains its water from the South Fork of the Powell River below the Big Cherry Reservoir Dam. The dam, built in 1935 by the WPA and owned by the Town of Big Stone Gap, was recently refurbished. It has a storage capacity of 410 million gallons. The SWCB's safe yield of 2.7 mgd is considered a limiting factor of the source. The Town can maintain the water flow from the dam to ensure it has adequate supplies. A new intake structure below the Big Cherry Reservoir dam allows for total catchment of the river. It would be preferable to obtain water directly from the lake but it was estimated that it would cost almost $6 million to build the necessary withdrawal structure, thus it is unlikely that this will be done. No emergency source exists on this system.

In October 1994, there were a total of 3,493 connections on the Big Stone Gap Water Treatment system. Completed in 1983, the treatment plant produced an average of 1.016 mgd. The Big Stone Gap Town Charter stated that water will neither be wholesaled nor sold outside of the County. The Town additionally would not consider selling water to Norton and Wise. However, the Town was willing to provide both service areas with water in emergencies.

Approximately 42% of the water produced is unaccounted for. The high percentage of water lost is due to hydraulic problems in the distribution system. High unaccountable figures are also caused by the Town providing free water to a number of local establishments and neighboring communities that experience water shortages.

Finished water storage is provided by 11 tanks with a combined volume of 3.337 million gallons. An additional 250,000 gallon tank is being proposed.

c. Western Lee County Demand Center

The demand center consists of two independent water systems located in the westernmost tip of Lee County. The publicly owned Lee County Water Authority (LCWA) service area stretches along US Route 58 from Station Creek at the Tennessee-Virginia line northwest to Rose Hill. The Stickley Waterworks service area, a privately owned system, encompasses only the community of Rose Hill.

i. Lee County Water Authority (LCWA)

All water for the SA is purchased from the Arthur Shawanee Utility District (ASUD) in Tennessee. The Authority has already obtained VDH approval to develop a local spring, Chance Spring. The development of this source would provide 40-50 percent of the service area's current demand, and thus help reduce current water rates. The spring water would be used as the primary source and ASUD would become the supplemental water supply. As of 1995, however, ASUD is still the primary source of water for LCWA.

In 1995, there were 709 connections on the Lee Water System, serving approximately 60 percent of the service area's population. Qualtex, a manufacturer of surgical sponges and bandages, was considering constructing a 500,000 gallon storage tank that will be supplied to LCWA.

Approximately 18 miles of main line and a 200,000 gallon storage tank were installed by ASUD in 1965 when LCWA first began to buy water. In 1995, four miles of the main distribution lines required replacement as soon as possible. These lines had a rated pressure of 160 psi while water is pumped at 165 psi. The pressure difference may cause leaks in the system and contribute to the high unaccountable water figure. In fact, between 0.033 and 0.083 million gallons of water were lost daily at a cost of $12,000 to $30,000 annually. These figures were expected to increase when the Qualtex storage tank is installed because it will increase the amount of water pumped through the faulty section of the line. In 1995, the water lost percentage dropped to 20%, suggesting some improvements since 1983. System officials, however, indicated that the system must be upgraded or renovated for future service extensions. They also stated that the system is currently operating at full capacity.

ii. Rose Hill Service Area

The water source of Rose Hill, Blue Spring, is owned by the Stickley Waterworks. No supplemental water supply existed for the community nor had there been a need for one. The master meter on the spring is the only meter on the entire distribution system. The VDH estimated the minimum flow from the spring to be 100 gpm or 0.144 mgd.

There were approximately 217 connections on the water supply system. This was also the maximum number of connections allowed by the system's VDH permit. It is estimated that 95% of the water produced is used for domestic purposes.

Water lost through the distribution lines cannot be calculated since no meters are on the system. Water pressure is less than 20 psi throughout the system due to the gravity-feed distribution scheme. In fact, connections at the end of the system are without water at times, even though the source produces an over abundance of water. Since the entire system is old, unmetered, and gravity-feed, a deficit is expected in the 1990s.

d. Dunbar Demand Center

The demand center is located on State Secondary Route 603 in the Gladeville-Roberson Magisterial District of Wise County. The demand center includes the communities of Dunbar and Roaring Fork. The Dunbar community was developed by the Westmoreland Coal Company over 50 years ago to encourage miners to settle in this remote area. The Westmoreland Coal Company still provides and maintains the gratis water service for the community.

Approximately 52 connections are in the demand center. Residences consisted of 49 connections. The other three connections included a church, a meeting house, and a bathhouse used by 100 coal company employees. VDH regulations restricted the number of connections to the current 52.

Water for Dunbar is obtained from a 250-foot drilled well with a dependable yield of 0.091 mgd. Total water production ranges from 0.016 to 0.023 mgd and averages about 0.020 mgd. The bathhouse used approximately 15 percent of water produced while Private residences used the remainder. Dunbar has not experienced problems with water quantity.

Appendix C. Sources of Financing and Funding Small Water Systems in Virginia

The purpose of this appendix is to list funding and financing options for water capital projects in Virginia. This information can be used in Module 2 of Chapter IV to identify financing alternatives. First, financing sources are illustrated in Table C.1. Second, funding sources available in Virginia are discussed.

For communities in the Virginia coalfields with inadequate income, some financing options listed in Table C.1 may not be financially feasible. For example, revenue bonds may be too costly to finance. As the result, these communities may require substantial grant amounts. Primary funding sources available in Virginia include (Anderson and Associates, 1994: 15-17):

1. Community Development Block Grants (CDBG)
2. Virginia Water Project
3. Virginia Revolving Loan Fund
4. Virginia Resource Authority (VRA)
5. Farmers Home Administration (FmHA)
6. Appalachian Regional Commission (ARC)

Funding Source Description

1. The U.S. Department of Housing and Community Development (HUD) sponsors a block grant program, through the Virginia Department of Housing and Community Development (VDHCD), that provides grants of up to $700,000 per year for some community facility water extension projects. If housing is included, grants of up to $1,000,000 are available. Furthermore, if the project contains three or more eligible activities, it can receive up to $1,250,000. Regional grants are also available at $700,000 per participating locality. The CDBG application is due in March of each year. Successful competitors for funds have been communities with low to moderate income families. Leveraging also increases the chance of receiving funds. Leveraging is the use of local and other funds that are committed to the project.

2. The Farmer's Home Administration (FmHA) sponsors a program to help the construction of rural water and wastewater systems. A community in Lee County or Scott County may receive up to 75% grant funds or approximately $4,000 per connection. The project must qualify as one in a needy community. FmHA also awards loans at or slightly below current market interest rates if a low interest loan cannot be obtained from a local source. The minimum rate of the bond is 5 percent with a pay back period of 40 years.

3. The Virginia Resources Authority (VRA) issues bonds in the national market. It loans the proceeds to political subdivisions of the State. Favorable rates are achieved by small borrowers on revenue bonds by using the moral obligation of the State. This source of funds is limited to water, sewer, and drainage projects. It may be backed by general obligation or revenue.

The VRA may issue up to $300 million in revenue bonds to localities for water and wastewater facilities improvements. The bonds may be short term or long term, fixed or variable rate. Financing is structured on current market conditions and based on investor preference. The VRA generally can obtain more attractive rates than most local governments due to State backing of bonds. Although there are no limits on the amount of money a locality can receive, the ability of the locality to repay the bonds must be demonstrated.

4. The Virginia Water Project (VWP) provides limited grants funds for the development of facilities for low income residents. In particular, the VWP can provide funds for the construction of a service line, from the meter to the main, for eligible residents.

5. The Appalachian Regional Commission (ARC) provides grant funds for a variety of development projects that emphasize on improvement of economic conditions and quality of life in a community. The program typically provides supplementary funds for matching funding from another lead agency. Application for funds are submitted each September.

Table C.1: Project Financing Sources

Financing Source	Time of Fund Provision	Repayment	Advantages	Disadvantages
Revenue Bonds (rate-supported bonds)	Immediately	By rate payers over 10-30 years	a. Funds available immediately b. Ties payment to benefits received	a. Increase rates b. High interest costs
Revolving Loans	Immediately	By rate payers over 10-20 years	a. Funds available immediately b. Ties payment to benefits received c. Lower interest cost	a. Increase rates b. Competition with local agencies for funds
General Obligation Bonds (tax-supported bonds)	Immediately	By taxpayers over 10-30 years	a. Funds available immediately b. Ties payment to benefits received c. Lower interest cost	a. Increase taxes b. Competition with local agencies for limited bond funds c. Payment separate from benefits
Assessment-supported Bonds	Immediately	By assessed customers over 10-30 years	a. Funds available immediately	a. Requires legislative approval b. Not practical for most projects
Assessment (Unbonded)	Immediately	By assessed customers at time of construction	a. Funds available immediately b. Ties payment to benefits received	a. Requires legislative approval b. May have serious impact on assessed customers
Capital Fees (hookups, taps, system development, or impact fees)	Immediately	By new customers immediately	a. Require new customers to pay for their impacts on the system	a. May be unpopular with new customers b. Ineffective where there is little growth
Reserves	In the future	By rate payers each year until reserve is adequate	a. Eliminate the need for borrowing b. Improves the financial stability of the system	a. Impractical for large projects b. Difficult to protect reserves for intended use
User Charges	Immediately	By rate payers immediately	a. Eliminate the need for borrowing or reserves	a. Impractical for large projects

Source: Shinn et. al., 1989: 16.

APPENDIX D. COSTING AND RATE-SETTING SPREADSHEETS

Worksheet 1A
Inventory of Costs by Project
Project Name: Town Hypothetical Extension
Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s.

								Breakdown of Spending By Year							**Annual**
			Construction												**OM&R**
			Cost	**Year 1**		**Year 2**		**Year 3**		**Year 4**		**Year 5**		**Total**	**Increase**
			(Today's $)	**%**	**Cost**	**%**	**Cost**	**%**	**Cost**	**%**	**Cost**	**%**	**Cost**	**Cost**	**Today's $**
		3%	Inflationary Factor		1.000		1.030		1.061		1.093		1.126		
	Source of Supply														
1					$ -		$ -		$ -		$ -		$ -	$ -	
2					$ -		$ -		$ -		$ -		$ -	$ -	
3					$ -		$ -		$ -		$ -		$ -	$ -	
4					$ -		$ -		$ -		$ -		$ -	$ -	
5	Total (sum lines 1-4)		$ -		$ -		$ -		$ -		$ -		$ -	$ -	$ -
		3%	Inflationary Factor		1.000		1.030		1.061		1.093		1.126		
	Production & Treatment														
6					$ -		$ -		$ -		$ -		$ -	$ -	
7					$ -		$ -		$ -		$ -		$ -	$ -	
8					$ -		$ -		$ -		$ -		$ -	$ -	
9					$ -		$ -		$ -		$ -		$ -	$ -	
10	Total (sum lines 6-9)		$ -		$ -		$ -		$ -		$ -		$ -	$ -	$ -
		3%	Inflationary Factor		1.000		1.030		1.061		1.093		1.126		
	Distribution Storage														
11	150,000 Gal Tank		$ 150	50%	$ 75	50%	$ 77	0%	$ -	0%	$ -	0%	$ -	$ 152	$ 3
12	300,000 Gal. Tank		$ 240		$ -		$ -	50%	$ 127	50%	$ 131		$ -	$ 258	$ 5
13					$ -		$ -		$ -		$ -		$ -	$ -	
14					$ -		$ -		$ -		$ -		$ -	$ -	
15	Total (sum lines 11-14)		$ 390		$ 75		$ 77		$ 127		$ 131		$ -	$ 411	$ 8

		3%	Inflationary Factor		1.000		1.030		1.061		1.093		1.126		
	Meters & Service														
26	Connection (92)		$ 138	20%	$ 28	20%	$ 28	20%	$ 29	20%	$ 30	20%	$ 31	$ 147	$ 3
27	Connection (235)		$ 353	0%	$ -	30%	$ 109	30%	$ 112	30%	$ 116	10%	$ 40	$ 376	$ 8
28	Master meters		$ 75	10%	$ 8	10%	$ 8	20%	$ 16	30%	$ 25	30%	$ 25	$ 81	$ 2
29					$ -		$ -		$ -		$ -		$ -	$ -	
30					$ -		$ -		$ -		$ -		$ -	$ -	
31					$ -		$ -		$ -		$ -		$ -	$ -	
32					$ -		$ -		$ -		$ -		$ -	$ -	
33	Total (sum lines 26-32)		$ 566		$ 35		$ 145		$ 157		$ 170		$ 96	$ 604	$ 12
		3%	Inflationary Factor		1.000		1.030		1.061		1.093		1.126		
	Source Protection														
34					$ -		$ -		$ -		$ -		$ -	$ -	
35					$ -		$ -		$ -		$ -		$ -	$ -	
36					$ -		$ -		$ -		$ -		$ -	$ -	
37					$ -		$ -		$ -		$ -		$ -	$ -	
38					$ -		$ -		$ -		$ -		$ -	$ -	
39					$ -		$ -		$ -		$ -		$ -	$ -	
40	Source Protection Total				$ -		$ -		$ -		$ -		$ -	$ -	$ -
		3%	Inflationary Factor		1.000		1.030		1.061		1.093		1.126		
	Fire Protection														
41	19 Fire hydrants		$ 23	30%	$ 7	30%	$ 7	20%	$ 5	10%	$ 2	10%	$ 3	$ 24	$ 0
42	48 Fire hydrants		$ 58		$ -		$ -	40%	$ 24	30%	$ 19	30%	$ 19	$ 63	$ 1
43					$ -		$ -		$ -		$ -		$ -	$ -	
44					$ -		$ -		$ -		$ -		$ -	$ -	
45	Fire Protection Total		$ 80		$ 7		$ 7		$ 29		$ 21		$ 22	$ 87	$ 2
		3%	Inflationary Factor		1.000		1.030		1.061		1.093		1.126		
	Administration														
46	Legal		$ 24	50%	$ 12	10%	$ 2	40%	$ 10		$ -		$ -	$ 25	
47	Engineering		$ 200	50%	$ 100	10%	$ 21	40%	$ 85		$ -		$ -	$ 206	
48	Administration		$ 125	50%	$ 63	10%	$ 13	40%	$ 53		$ -		$ -	$ 128	$ 1
49					$ -		$ -		$ -		$ -		$ -	$ -	
50	Administration Total		$ 349		$ 175		$ 36		$ 148		$ -		$ -	$ 359	$ 1
		3%	Inflationary Factor		1.000		1.030		1.061		1.093		1.126		
	Billing														
51					$ -		$ -		$ -		$ -		$ -	$ -	
52					$ -		$ -		$ -		$ -		$ -	$ -	
53					$ -		$ -		$ -		$ -		$ -	$ -	
54					$ -		$ -		$ -		$ -		$ -	$ -	
55					$ -		$ -		$ -		$ -		$ -	$ -	
56					$ -		$ -		$ -		$ -		$ -	$ -	
57					$ -		$ -		$ -		$ -		$ -	$ -	
58					$ -		$ -		$ -		$ -		$ -	$ -	
59	Billing Total		$ -		$ -		$ -		$ -		$ -		$ -	$ -	$ -

Worksheet 1							
Cost Summary: Total Costs of New Projects (in $000s)							
All Projects							
Construction Costs		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total Construction Costs**
1	Source of Supply	$ -	$ -	$ -	$ -	$ -	$ -
2	Production & Treatment	$ -	$ -	$ -	$ -	$ -	$ -
3	Distribution Storage	$ 75	$ 77	$ 127	$ 131	$ -	$ 411
4	Distribution & Transmission	$ 210	$ 248	$ 618	$ 487	$ 402	$ 1,965
5	Meters & Service	$ 35	$ 145	$ 157	$ 170	$ 96	$ 604
6	Source Protection	$ -	$ -	$ -	$ -	$ -	$ -
7	Fire Protection	$ 7	$ 7	$ 29	$ 21	$ 22	$ 87
8	Administration	$ 175	$ 36	$ 148	$ -	$ -	$ 359
9	Billing	$ -	$ -	$ -	$ -	$ -	$ -
10	Total Construction Costs/Year	$ 502	$ 513	$ 1,080	$ 810	$ 520	$ 3,425
Standard Calculated OM&R Costs, Inputs from Worksheet 1A							
3%	Inflationary Factor	1.000	1.030	1.061	1.093	1.126	
OM&R Costs		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	
11	Source of Supply	$ -	$ -	$ -	$ -	$ -	
12	Production & Treatment	$ -	$ -	$ -	$ -	$ -	
13	Distribution Storage	$ 8	$ 8	$ 9	$ 9	$ 9	
14	Distribution & Transmission	$ 39	$ 40	$ 42	$ 43	$ 44	
15	Meters & Service	$ 12	$ 12	$ 13	$ 13	$ 14	
16	Source Protection	$ -	$ -	$ -	$ -	$ -	
17	Fire Protection	$ 2	$ 2	$ 2	$ 2	$ 2	
18	Administration	$ 1	$ 1	$ 1	$ 1	$ 1	
19	Billing	$ -	$ -	$ -	$ -	$ -	
20	Total OM&R Costs/Year	$ 62	$ 64	$ 66	$ 68	$ 70	
Special Hand Calculated OM&R Costs for Varying Yearly OM&R Costs							
Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s.							
3%	Inflationary Factor	1.000	1.030	1.061	1.093	1.126	
OM&R Costs		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total OM&R Costs**
11	Source of Supply						$ -
12	Production & Treatment						$ -
13	Distribution Storage						$ -
14	Distribution & Transmission						$ -
15	Meters & Service						$ -
16	Source Protection						$ -
17	Fire Protection						$ -
18	Administration						$ -
19	Billing						$ -
20	Total OM&R Costs/Year	$ -	$ -	$ -	$ -	$ -	$ -
Note: Inputs for this page are provided by calculations from Worksheet 1A							

Work Sheet 2F						
Project Financing Analysis: Looking at the Options						
Project Name:		Town of Wise Water Service Extension				
Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s, unless instructed otherwise.						
Financing Options		**Calculations**	**Option 1**	**Option 2**	**Option 3**	**Option 4**
1	Additional OM&R Cost, 1st Year of Operation	Worksheet 1A	$ 71	$ 71	$ 71	$ 71
2	Amount to be Financed by Rate-Supported Bonds					
3	Amount from Revolving Loans		$ 3,425	$ 2,398	$ 1,713	$ 1,199
4	Amount to be Financed by Tax-Supported Bonds or Loans					
5	Amount to be Financed by Assessments/Surcharges			$ 1,028		$ 514
6	Amount to be Financed by Capital Fees					
7	Amount to be Financed by Reserves					
8	Amount to be Financed by Current User Fees					
8a	Grants		$ -	$ -	$ 1,713	$ 1,713
9	Total Financing	Sum Lines 2 to 8a	$ 3,425	$ 3,425	$ 1,713	$ 1,713
	Total Capital		$ 3,425	$ 3,425	$ 3,425	$ 3,425
Impact on All Users						
10	Debt Service Factor for Rate-Supported Bonds	Debt Service Factor Table				
	Enter Interest Rate (%) and Bond Term (Years) =					
11	Rate-Supported Bond Debt Service	Line 2 x Line 10	$ -	$ -	$ -	$ -
12	Debt Service Factor for Revolving Loan	Debt Service Factor Table	0.080	0.080	0.080	0.080
	Enter Interest Rate (%) and Loan Term (Years) =	5%, 10 years				
13	Revolving Loan Debt Service	Line 3 x Line 12	$ 274	$ 192	$ 137	$ 96
14	Reserve Sinking Fund Factor	Sinking Fund Factor Table				
	Enter Interest Rate (%) and Accumulate Term (Years) =					
15	Annual Reserve Contribution	Line 7 x Line 14	$ -	$ -	$ -	$ -
16	Total Annual Increase in Rates	Lines 1 + 8 + 11 + 13 + 15	$ 345	$ 263	$ 208	$ 167
17	% of Revenues from Households		60%	60%	60%	60%
18	Number of Household Connections		2,573	2,573	2,573	2,573
19	Rate Impact on Average Annual HH Cost	[(Line 16 x Line 17)/Line 18] x 1000	$ 80.45	$ 61.28	$ 48.50	$ 38.92
20	Gallons Consumed by All Customers (in Millions) Per Year		176	176	176	176
21	Rate Increase per 1,000 Gallons	Line 16 / Line 20	$ 1.96	$ 1.49	$ 1.18	$ 0.95
22	Debt Service Factor for Tax-Supported Bonds	Debt Service Factor Table				
	Enter Interest Rate (%) and Bond Term (Years) =					
23	Tax-Supported Debt Service	Line 4 x Line 22	$ -	$ -	$ -	$ -
24	Total Assessed Value (in Millions)		$ 0	$ 0	$ 0	$ 0
25	Effect on Tax Rate per $1,000	Line 23 / Line 24	$ -	$ -	$ -	$ -
26	Assessed Value of Average Home ($000s)					
27	Tax Impact on Average Household	Line 25 x Line 26	$ -	$ -	$ -	$ -
28	Total Tax and Rate Impact on Average Residence	Line 19 + Line 27	$ 80.45	$ 61.28	$ 48.50	$ 38.92
Impact on Assessed Users						
29	Debt Service Factor for Assessed-Supported Bonds	Debt Service Factor Table	0.080	0.080	0.080	0.080
	Enter Interest Rate (%) and Bond Term (Years) =					
30	Debt Service (if assessments are bonded)	Calculate: Line 5 x Line 29	$ -	$ 82	$ -	$ 41
31	Assessments for Surcharges Paid Annually	Enter amout from Line 5 if assessments are not bonded				
32	Number of Customers Paying Assessment	Enter amounts not in 000s	327	327	327	327
33	Average Annual Assessment	(Line 30 or 31 / Line 32) x 1000	$ -	$ 251	$ -	$ 126
34	Total Impact on Assessed Users	Line 28 + Line 33	$ 80.45	$ 312.66	$ 48.50	$ 164.61
35	Gallons Consumed by Assessed Users per Year	Enter amounts in Millions	22	22	22	22
36	Assessment/Surcharge Cost per 1000 gal.	Line 30 or 31 / Line 35	$ -	$ 3.67	$ -	$ 1.84

Note: Six worksheets 2E are provided for each project. Use as many as needed.

Totals must be calculated by hand to forward to Worksheet 2D.

Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s, unless instructed otherwise.

Worksheet 2E

Project Financing Details

Project Name: Source of Supply

Assumed Inflation Rate: 0.06%

Total Cost: $ 587

	Financing Sources	Year 1	Year 2	Year 3	Year 4	Year 5	Total	
1	Grants	$ 60	$ 60	$ 60	$ 60	$ 60	$ 300	
2	User Charges	$ 50	$ 50	$ 50	$ 50	$ 50	$ 250	
3	General Obligation Bonds						$ -	
4	Revenue Bonds						$ -	
5	Reserves						$ -	
6	Hook-up Fees	$ 1	$ 1	$ 1	$ 1	$ 1	$ 5	
7	Revolving Loans	$ 2	$ 2				$ 4	
8	Assessments/Surcharges	$ 20	$ 20	$ 20	$ 20	$ 20	$ 100	
		$ 133	$ 133	$ 131	$ 131	$ 131	$ 659	Grand Total

Worksheet 2E

Project Financing Details

Project Name: 150,000 Gal. Tank

Assumed Inflation Rate: 6%

Total Cost: $ 150

	Financing Sources	Year 1	Year 2	Year 3	Year 4	Year 5	Total	
1	Grants	$ 10	$ 10	$ 10	$ 10	$ 10	$ 50	
2	User Charges	$ 15	$ 15	$ 15	$ 15	$ 16	$ 76	
3	General Obligation Bonds						$ -	
4	Revenue Bonds						$ -	
5	Reserves						$ -	
6	Hook-up Fees						$ -	
7	Revolving Loans	$ 3	$ 5	$ 7	$ 9	$ 7	$ 31	
8	Assessments/Surcharges	$ 2	$ 2	$ 2	$ 3	$ 3	$ 12	
		$ 30	$ 32	$ 34	$ 37	$ 36	$ 169	Grand Total

	Worksheet 2E							
	Project Financing Details							
	Project Name:	Extend and purchase lines						
	Assumed Inflation Rate:	6%						
	Total Cost:	$ 2,650						
	Financing Sources		Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	Grants		$ 400	$ 400	$ 400	$ 400	$ 400	$ 2,000
2	User Charges		$ 70	$ 60	$ 50	$ 40	$ 30	$ 250
3	General Obligation Bonds		$ 150	$ 150	$ 150	$ 140	$ 140	$ 730
4	Revenue Bonds							$ -
5	Reserves							$ -
6	Hook-up Fees							$ -
7	Revolving Loans		$ 5	$ 5	$ 5	$ 5		$ 20
8	Assessments/Surcharges							$ -
			$ 625	$ 615	$ 605	$ 585	$ 570	$ 3,000
								Grand Total

	Worksheet 2E							
	Project Financing Details							
	Project Name:	Meter & Service						
	Assumed Inflation Rate:	6%						
	Total Cost:	$ 163						
	Financing Sources		Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	Grants		$ 25	$ 25	$ 25	$ 25	$ 25	$ 125
2	User Charges		$ 10	$ 10	$ 10	$ 10	$ 10	$ 50
3	General Obligation Bonds							$ -
4	Revenue Bonds							$ -
5	Reserves		$ 5	$ 5				$ 10
6	Hook-up Fees							$ -
7	Revolving Loans							$ -
8	Assessments/Surcharges							$ -
			$ 40	$ 40	$ 35	$ 35	$ 35	$ 185
								Grand Total

	Worksheet 2E							
	Project Financing Details							
	Project Name:	19 fire hydrants						
	Assumed Inflation Rate:	6%						
	Total Cost:	$ 23						
	Financing Sources		Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	Grants							$ -
2	User Charges							$ -
3	General Obligation Bonds							$ -
4	Revenue Bonds							$ -
5	Reserves		$ 4	$ 1	$ 1	$ 1	$ 1	$ 8
6	Hook-up Fees							$ -
7	Revolving Loans							$ -
8	Assessments/Surcharges		$ 5	$ 4	$ 3	$ 3	$ 2	$ 17
			$ 9	$ 5	$ 4	$ 4	$ 3	$ 25
								Grand Total

Worksheet 2D							
Summary Sheet: Total of Projects Financing							
All Projects							
Financing Sources in (000s)			Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	Grants	$ 495	$ 495	$ 495	$ 495	$ 495	$ 2,475
2	User Charges	$ 145	$ 135	$ 125	$ 115	$ 106	$ 626
3	General Obligation Bonds	$ 150	$ 150	$ 150	$ 140	$ 140	$ 730
4	Revenue Bonds						$ -
5	Reserves	$ 9	$ 6	$ 1	$ 1	$ 1	$ 18
6	Hook-up Fees	$ 1	$ 1	$ 1	$ 1	$ 1	$ 5
7	Revolving Loans	$ 10	$ 12	$ 12	$ 14	$ 7	$ 55
8	Assessments/Surcharges	$ 27	$ 26	$ 25	$ 26	$ 25	$ 129
9	Total Cost per Year	$ 837	$ 825	$ 809	$ 792	$ 775	$ 4,038
	(sum of lines 1-8)						
Note: figures on this worksheet are obtained from totals of 2E worksheets							
Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s.							

Worksheet 2C							
Calculating Contribution to Reserve Fund							
Project Name:							
Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s, unless instructed otherwise.							
		Calculations	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
1	Financing Expected from Reserves	Worksheet 2D, Line 5	$ 9	$ 6	$ 1	$ 1	$ 1
2	Desired Reserve Balance at End of Year 5						$ 10
3	Total Requirements form Reserves	Line 1 + Line 2	$ 9	$ 6	$ 1	$ 1	$ 11
4	Sinking Fund Factor	Sinking Fund Factor Table	1.000	0.462	0.308	0.231	0.185
	Enter Interest Rate=	Earning 4%					
Calculating Total Revenue Contribution							
5	Contribution to Year 1 Program	Line 3 x Line 4	$ 9				
6	Contribution to Year 2 Program		$ 3	$ 3			
7	Contribution to Year 3 Program		$ 0	$ 0	$ 0		
8	Contribution to Year 4 Program		$ 0	$ 0	$ 0	$ 0	
9	Contribution to Year 5 Program		$ 2	$ 2	$ 2	$ 2	$ 2
10	**Total Contribution to Reserve**	Sum Lines 5 to 9	$ 14	$ 5	$ 3	$ 2	$ 2

Worksheet 2B								
Calculating Bond/Loan Size and Cashflow								
Project Name:								
Type of Loan: General Obligation or Revolving Loan								
		Calculations		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
1	Bond/Loan Proceeds Available for Construction			$ 500	$ -	$ -	$ -	$ -
2	Bond/Loan Fund Carryover from Previous Year	Line 7 of Previous Year		$ 100	$ 466	$ 322	$ 169	$ 16
3	Total Bond/Loan Fund	Lines 1 + Line 2		$ 600	$ 466	$ 322	$ 169	$ 16
4	Annual Cost of Bond/Loan Financed Projects	Worksheet 2D: Line 3, 4, or 7		$ 160	$ 162	$ 162	$ 154	$ 147
5	Bond/Loan Fund Residual	Lines 3 - Line 4		$ 440	$ 304	$ 160	$ 15	$ (131)
6	Interest Rate on Bond/Loan Fund Residual			5.9%	5.9%	5.9%	5.9%	5.9%
7*	Bond/Loan Fund Available for Following Year	Line 5 (1 + Line 6)		$ 466	$ 322	$ 169	$ 16	$ (138)
Notes:								
7*	In the formula, Line 6 is in decimal form (7.5% is .075)							
Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s, unless instructed otherwise.								

Worksheet 2A (1 of 3)

Calculating Debt Issued and Annual Debt Service

Type of Debt: Revenue Bonds

Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s, unless instructed otherwise.

		Calculations		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1	Bond Proceeds (in $000s)	2B, Line1 or 2D Line 4		$ -					
Construction-Related Costs		Can be a % of Bond Proceeds	%						
2	Short-Term Interests								
3	Engineering & Legal								
4	Bond Issuance Costs		0%	$ -					
5	Capitalized Interest								
6	Total Bond Issuing Costs	Sum of Lines 1 to 5		$ -	$ -	$ -	$ -	$ -	
7	Debt Service Factor	Debt Service Factor Table		0.098					
	Enter Interest Rate (%) and Bond Term (Years) =	7.5%, 20 years							
Debt Service Summary									
8	Year 1 Issue	Year 1 (Line 6 x Line 7) x time in yrs		$ -	$ -	$ -	$ -	$ -	$ -
9	Year 2 Issue				$ -	$ -	$ -	$ -	$ -
10	Year 3 Issue					$ -	$ -	$ -	$ -
11	Year 4 Issue						$ -	$ -	$ -
12	Year 5 Issue							$ -	$ -
13	Total New Debt Service	Sum of Lines 8 to 12		$ -	$ -	$ -	$ -	$ -	$ -
14	Existing Debt Service			$ -	$ -	$ -	$ -	$ -	$ -
15	Total Debt Service	Line 13 + Line 14		$ -	$ -	$ -	$ -	$ -	$ -
Calculating Indebtedness									
16	Current Bonds Outstanding			$ -	$ -	$ -	$ -	$ -	$ -
17	Year 1 Issue	Line 6 (Year 1), estimate for future yrs		$ -	$ -	$ -	$ -	$ -	$ -
18	Year 2 Issue				$ -	$ -	$ -	$ -	$ -
19	Year 3 Issue					$ -	$ -	$ -	$ -
20	Year 4 Issue						$ -	$ -	$ -
21	Year 5 Issue							$ -	$ -
22	Total New Issues	Sum of Lines 17 to 21		$ -	$ -	$ -	$ -	$ -	$ -
23	Total of All Issues	Line 16 + Line 22		$ -	$ -	$ -	$ -	$ -	$ -

Worksheet 2A (2 of 3)

Calculating Debt Issued and Annual Debt Service

Type of Debt: General Obligation Bonds

Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s, unless instructed otherwise.

		Calculations		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
24	Bond Proceeds	2B, Line1 or 2D Line 3		$ 500					
Construction-Related Costs		Can be a % of Bond Proceeds	%						
25	Short-Term Interests								
26	Engineering & Legal								
27	Bond Issuance Costs		10%	$ 50					
28	Capitalized Interest								
29	Total Bond Issuing Costs	Sum of Lines 24 to 28		$ 550	$ -	$ -	$ -	$ -	
30	Debt Service Factor	Debt Service Factor Table		0.098					
	Enter Interest Rate (%) and Bond Term (Years) =	7.5%, 20 years							
Debt Service Summary									
31	Year 1 Issue	Line 29 x Line 30 x time in yrs		$ 54	$ 54	$ 54	$ 54	$ 54	$ 54
32	Year 2 Issue				$ -	$ -	$ -	$ -	$ -
33	Year 3 Issue					$ -	$ -	$ -	$ -
34	Year 4 Issue						$ -	$ -	$ -
35	Year 5 Issue							$ -	$ -
36	Total New Debt Service	Sum of Lines 31 to 35		$ 54	$ 54	$ 54	$ 54	$ 54	$ 54
37	Amount Paid from Taxes	Line 36		$ 54	$ 54	$ 54	$ 54	$ 54	$ 54
38	Amount Paid from Rates	Line 36 - Line 37		$ -	$ -	$ -	$ -	$ -	$ -
39	Existing Debt Service			$ 120	$ 100	$ 70	$ 50	$ 20	$ 10
40	Total Debt Service	Line 36 + Line 39		$ 174	$ 154	$ 124	$ 104	$ 74	$ 64
Calculating Indebtedness and Debt Ratios									
41	Current G.O. Bonds Outstanding for Water and Sewer			$ 200	$ 150	$ 120	$ 100	$ 90	$ 50
42	Year 1 Issue	Line 29 (Year 1), estimate for future yrs		$ 550	$ 550	$ 540	$ 530	$ 520	$ 500
43	Year 2 Issue				$ -				
44	Year 3 Issue					$ -			
45	Year 4 Issue						$ -		
46	Year 5 Issue							$ -	
47	Total New Issues	Sum of Lines 42 to 46		$ 550	$ 550	$ 540	$ 530	$ 520	$ 500
48	Total of All Debt Issued	Line 41 + Line 47		$ 750	$ 700	$ 660	$ 630	$ 610	$ 550
49	Other Outstanding GO Debt (excluding W&S)			$ 300	$ 270	$ 250	$ 230	$ 210	$ 200
50	Expected New Issues, other than Water & Sewer)			$ -	$ -	$ -	$ -	$ -	$ -
51	Total GO Debt	Sum of Lines 48 to 50		$ 1,050	$ 970	$ 910	$ 860	$ 820	$ 750
52	Debt Amount Paid from Water, Sewer, Electric, or other User Charges			0	0	0	0	0	0
53	Net Debt	Line 28 - Line 29		$ 1,050	$ 970	$ 910	$ 860	$ 820	$ 750
			% Growth						
54	Estimated Population in 000s	Enter 1st year pop. and growth %	1%	9.0	9.1	9.2	9.3	9.4	9.5
55	Debt Per Capita	Line 53/ Line 54		$ 117	$ 107	$ 99	$ 93	$ 88	$ 79
			% Growth						
56	Assessed Value in $000s	Enter 1st year pop. and growth %	1%	$ 180,000	$ 181,800	$ 183,618	$ 185,454	$ 187,309	$ 189,182
57	Debt as a % of Assessed Value	Line 53 / Line 56		0.58%	0.53%	0.50%	0.46%	0.44%	0.40%

Worksheet 2A (3 of 3)									
Calculating Debt Issued and Annual Debt Service									
Type of Debt: Revolving Loans									
Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s, unless instructed otherwise.									
		Calculations		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
58	Loan Proceeds (in $000s)	2B, Line 1 or 2D Line 7		$ 500					
Construction-Related Costs		Can be a % of Loan Proceeds	%						
59	Short-Term Interests								
60	Engineering & Legal								
61	Loan Issuance Costs		10%	$ 50					
62	Capitalized Interest								
63	Total Loan Issuing Costs	Sum of Lines 58 to 62		$ 550	$ -	$ -	$ -	$ -	
64	Debt Service Factor	Debt Service Factor Table		0.098					
	Enter Interest Rate (%) and Loan Term (Years) =	7.5%, 20 years							
Loan Repayment Summary									
65	Year 1 Loans	Year 1 (Line 63 x Line 64) x time in yrs		$ 54	$ 54	$ 54	$ 54	$ 54	$ 54
66	Year 2 Loans				$ -	$ -	$ -	$ -	$ -
67	Year 3 Loans					$ -	$ -	$ -	$ -
68	Year 4 Loans						$ -	$ -	$ -
69	Year 5 Loans							$ -	$ -
70	Total New Loan Repayments	Sum of Lines 65 to 69		$ 54	$ 54	$ 54	$ 54	$ 54	$ 54
71	Existing Loan Repayments			$ 30	$ 27	$ 25	$ 22	$ 20	$ 18
72	Total Loan Repayments	Line 70 + Line 71		$ 84	$ 81	$ 79	$ 76	$ 74	$ 72
Calculating Indebtedness									
73	Current Loans Outstanding			$ -					$ -
74	Year 1 Loans	Line 63 (Year 1), estimate for future yrs		$ 60	$ 55	$ 50	$ 45	$ 42	$ 39
75	Year 2 Loans				$ -				
76	Year 3 Loans					$ -			
77	Year 4 Loans						$ -		
78	Year 5 Loans							$ -	
79	Total New Loans	Sum of Lines 74 to 78		$ 60	$ 55	$ 50	$ 45	$ 42	$ 39
80	Total of All Loans	Line 73 + Line 79		$ 60	$ 55	$ 50	$ 45	$ 42	$ 39
81	Total Outstanding Water Debt	Line 23 + Line 48 + Line 80		$ 810	$ 755	$ 710	$ 675	$ 652	$ 589
82	Total Annual Water Debt Service	Line 15 + Line 40 + Line 72		$ 258	$ 235	$ 203	$ 180	$ 148	$ 136

Worksheet 2								
Impact of Capital Project on All Users, Taxes, and User Subgroups								
Instructions: Fill in the light gray shaded areas where needed; enter dollar amounts in $1000s, unless instructed otherwise.								
		Calculations		Year 1	Year 2	Year 3	Year 4	Year 5
Additions to Revenue Requirements								
1	GO Debt Service Paid from Rates	Worksheet 2A, Line 38						
2	Revenue Bond Debt Service	2A, Line 13						
3	Revolving Loan Payments	2A, Line 70		$ 54	$ 54	$ 54	$ 54	$ 54
4	Reserve Fund Contribution	2C, Line 10		$ 14	$ 5	$ 3	$ 2	$ 2
5	Capital Costs from Users Charges	2D, Line 2		$ -	$ 95	$ 95	$ 95	$ 95
6	O&M Increase	Worksheet 1, Line 18		$ -	$ 88	$ 100	$ 108	$ 113
7	Total Additional Revenue Requirements	(Sum of Lines 1 to 6)		$ 68	$ 242	$ 252	$ 259	$ 264
Estimating Impact on Customer Costs								
8	% of Revenues from Household Customers			32%	32%	32%	32%	32%
			% Growth					
9	Number of HH Customers	Enter 1st year pop. and growth %	1%	5,500	5,555	5,611	5,667	5,723
10	Impact on Typical Annual Cost Per HH Customer	([Line 7 x Line 8] / Line 9) 1000		$ 3.96	$ 13.94	$ 14.37	$ 14.63	$ 14.76
11	Monthly Impact	Line 10 / 12		$ 0.33	$ 1.16	$ 1.20	$ 1.22	$ 1.23
12	Current Average Annual Bill			$ 90.00	$ 90.00	$ 90.00	$ 90.00	$ 90.00
13	Estimated Annual Bill Per HH Cust.	Line 10 + Line 12		$ 93.96	$ 103.94	$ 104.37	$ 104.63	$ 104.76
14	% Increase Over Current Year	(Line 13 / Line 12) - 1		4%	15%	16%	16%	16%
15	% Increase Over Previous Year							
			% Growth					
16	Millions of Gallons Consumed by All Customers	Enter 1st year and growth %	1%	1,200	1,212	1,224	1,236	1,249
17	Additional Cost Per 1,000 Gallons	Line 7 / Line 16		$ 0.06	$ 0.20	$ 0.21	$ 0.21	$ 0.21
Estimating Impact on Property Taxes								
18	GO Debt Service Paid from Taxes	Worksheet 2A, Line 37		$ 54	$ 54	$ 54	$ 54	$ 54
19	Assessed Value (A.V.) in 000s	2A, Line 56	1%	180,000	181,800	183,618	185,454	187,309
20	Debt Service per $1,000 A.V.	(Line 18 / Line 19) 1000		$ 0.30	$ 0.30	$ 0.29	$ 0.29	$ 0.29
21	Assessed Value of Ave. Residence	Enter 1st year and growth %	1%	20.00	20.20	20.40	20.61	20.81
22	Tax Increase for Ave. Residence	Line 20 x Line 21		$ 5.99	$ 5.99	$ 5.99	$ 5.99	$ 5.99
23	**Total Cost Increase (Rates Plus Taxes) for all Users**	Line 10 + Line 22		$ 9.95	$ 19.93	$ 20.36	$ 20.61	$ 20.75
Impact of Water Project on User Subgroup								
24	Amount Financed by Assessments/Surcharges	Worksheet 2D, Line 8		$ 27.00	$ 26.00	$ 25.00	$ 26.00	$ 25.00
25	Debt Service Factor For Assessments Bonds			0	0	0	0	0
	Enter Interest Rate (%) and Bond Term (Years) =							
26	Debt Service	If assessments/surcharges are bonded, then Line 24 x Line 25; if not, skip to Line 27		0	0	0	0	0
27	Unbonded Assessments/Surcharges	Enter amounts from Line 24 if not bonded		$ 27	$ 26	$ 25	$ 26	$ 25
28	Actual Number of Customers Paying Assessments			350	350	350	350	350
29	Average Annual Bonded Assessment/Surcharge	(Line 26 / Line 28) x 1000		$ -	$ -	$ -	$ -	$ -
30	Average Annual Unbonded Assessment/Surcharge	(Line 27 / Line 28) x 1000		$ 77	$ 74	$ 71	$ 74	$ 71
Use figures from 31 or 32 accordingly								
31	Total Impact on Bonded Assessed/Surcharged Users	Line 23 + Line 29		$ 9.95	$ 19.93	$ 20.36	$ 20.61	$ 20.75
32	Total Impact on Unbonded Assessed/Surcharged Users	Line 23 + Line 30		$ 87.09	$ 94.22	$ 91.79	$ 94.90	$ 92.18
32	Gallons (Millions) Consumed by Assessed/Surcharged Users			110	110	110	110	110
33	Bonded Assessment/Surcharge Cost Per 1,000 Gallons	Line 26 / Line 32		$ -	$ -	$ -	$ -	$ -
34	Unbonded Assessment/Surcharge Cost Per 1,000 Gallons	Line 27 / Line 32		$ 0.25	$ 0.24	$ 0.23	$ 0.24	$ 0.23

Worksheet 3G			
Determining Direct Benefits and Costs			
Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts;			
	use only Part 1 or Part 2 to reach Summary		
For Benefits Budgeted Separately in the Water Department or to the Government as a Whole			
			Total for the Department or Government
		Calculations	
1	Regular Salaries		$ 700,000
2	Vacation, Sick, etc.		$ 60,000
3	Social Security		$ 57,780
4	Retirement		$ 100,000
5	Medical Insurance		$ 25,000
6	Other Insurance		$ 6,000
7	Worker's Compensation		$ 6,500
8	Unemployment		$ -
9	Total Benefits	Sum Line 2 to 9	$ 255,280
10	**Benefit %**	Line 9 / Line 1	**36.5%**

Worksheet 3E					
Allocation of Department Overhead Costs to Water Systems					
Name of Department:					
Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts					
					Budget Allocated
			Total Dept.	**Budget Allocated**	**Directly to Other**
		Calculations	**Budget**	**Directly to Water**	**Divisions**
Salaries					
1	Director		$ 50,000		
2	Clerical		$ 17,000	$ 6,000	$ 12,000
3	Other Administrative				
4	Engineering				
5	Meter Reading				
6	Inspection				
7	Physical Plant and Custodial				
8	Vehicle Maintenance				
9	Other labor				
10	**Total Salaries**	Sum Lines 1 to 9	$ 67,000	$ 6,000	$ 12,000
11	Benefits %	Worksheet 3G	36.5%		
12	Benefits in Dollars	Line 10 x Line 11	$ 24,434	$ 2,188	$ 4,376
13	Total Labor	Line 10 + Line 12	$ 91,434	$ 8,188	$ 16,376
Non-Labor Costs					
14	Office Supplies		$ 1,000		
15	Vehicle Operating Costs		$ 2,000		
16	Training and Travel		$ 450		
17	Office Space		$ -		
18	Consulting		$ -		
19	Engineering		$ -		
20	Insurance		$ -		
21	Other		$ 8,500		
22					
23					
24	Total Non-Labor	Sum Lines 14 to 23	$ 11,950	$ -	$ -
25	Total Department Overhead	Line 13 + Line 24	$ 103,384	$ 8,188	$ 16,376
Calculating Allocation of Dept. Overhead to Water System Division					
26	Net Water Dept. Overhead to Allocate	In Line 25: Dept. Total - Other Dept. Overhead		$ 78,820	
27	Total Budgets of All Divisions in Dept.			$ 2,500,000	
28	Less Overhead to be Allocated	Line 27 - Line 23 (Total Budget)		$ 2,396,616	
				Water Division	
29	Budget of Division			$ 400,000	
30	% Allocation to Division	Line 29 / Line 28		16.7%	
31	Overhead Allocation	Line 30 x Line 26		$ 13,155	
32	Direct Allocation	Line 25		$ 8,188	
33	**Total Overhead Allocation**	Line 31 + Line 32		**$ 21,343**	

Worksheet 3D

Allocating Government-Wide Overhead Costs

Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts

		Calculations	Total Budget	Budget Allocable Directly to Water	Allocable Directly to Other Dept.	Net Overhead to Allocate
Allocating General Government Costs			A	B	C	Col. A - (B+C)
1	Governing Body		$ 100,000			$ 100,000
2	Administrative Office		$ 150,000			$ 150,000
3	Clerk		$ -			$ -
4	Elections		$ 33,000			$ 33,000
5	Legal		$ 20,000			$ 20,000
6	Finance		$ 420,000			$ 420,000
7	Personnel		$ -			$ -
8	Purchasing		$ 55,000			$ 55,000
9	Data Processing		$ 60,000			$ 60,000
10	Insurance		$ 75,000			$ 75,000
11	Reserves and Contingencies		$ -			$ -
12	Physical Plant and Custodial		$ 150,000			$ 150,000
13	Other		$ 60,000			$ 60,000
14	**Total**	Sum Lines 1 to 13	$ 1,123,000	$ -	$ -	**$ 1,123,000**
Calculating Overhead Allocable to Water Services						
15	Total Budget of Govern. Unit			$ 30,000,000		
16	Major Capital Expenditures			$ 750,000		
17	Internal Transfer			$ 7,500,000		
18	Overhead to be Allocated	Line 14, Column D		$ 1,123,000		
19	Net Government Budget	Line 15 - (Lines 16 to 18)		$ 20,627,000		
				Water Division		
20	Budget of Divisions	Worksheet 3E, Line 29		$ 400,000		
21	% Allocation to Divisions	Line 20 / Line 19		1.94%		
22	Overhead Allocation	Line 21 x Line 18		$ 21,777		
23	General Govt. Costs Allocated Directly to Water	Line 14, Column B		$ -		
24	Total General Overhead of Water Division	Line 22 + Line 23		$ 21,777		

Worksheet 3A

Allocating Direct Operation and Maintenance (O&M) Costs by Category

Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts

		Calculations	Total	Supply Source	Production & Treatment	Distribution Storage	Distribution & Transmission	Meters & Service	Source Protection	Fire Protection	Administration	Billing
Direct Labor			A	B	C	D	E	F	G	H	I	J
1	Salaries and Wages	Entry, or Worksheet 3B	$ 161,000	$ 15,000	$ 10,000	$ 30,000	$ 55,000	$ 11,000	$ -	$ -	$ -	$ 40,000
2	Benefit %	Worksheet 3G, Line 10	36.5%									
3	Benefits Cost	Line 1 x Line 2	$ 58,714	$ 5,470	$ 3,647	$ 10,941	$ 20,058	$ 4,012	$ -	$ -	$ -	$ 14,587
4	**Total Direct Cost**	Line 1 + Line 3	$ 219,714	$ 20,470	$ 13,647	$ 40,941	$ 75,058	$ 15,012	$ -	$ -	$ -	$ 54,587
Material and Supplies												
5	Chemicals		$ 16,165	$ -	$ 16,000	$ 15	$ 140	$ 10				
6	Uniforms & Equipment		$ 21,400	$ 2,000	$ 500	$ 1,700	$ 14,000	$ 1,200				$ 2,000
7	Gasoline & Oil		$ -									
8	Parts		$ -									
9	Training and Travel		$ 95	$ 75	$ 20							
10	Purchased Water		$ -									
11	Misc. Materials & Supp.		$ 43,670	$ 4,500	$ 1,100	$ 4,100	$ 32,000	$ 1,900				$ 70
12	**Total Materials & Supp.**	Sum Lines 5 to 11	$ 81,330	$ 6,575	$ 17,620	$ 5,815	$ 46,140	$ 3,110	$ -	$ -	$ -	$ 2,070
Utilities												
13	Electricity		$ 85,250		$ 85,000	$ 25	$ 215	$ 10				
14	Fuel Oil		$ -									
15	Natural Gas		$ -									
16	**Total Utilities**	Sum Lines 13 to 15	$ 85,250	$ -	$ 85,000	$ 25	$ 215	$ 10	$ -	$ -	$ -	$ -
Professional Services: Include only if services are paid directly from water budget												
17	Legal		$ -									
18	Engineering		$ -									
19	Audit		$ -									
20	Other (Rent, Contacts)		$ 640			$ 60	$ 550	$ 30				
21	Insurance		$ 11,300	$ 9,000	$ 2,300							
22	**Total Professional Ser.**	Sum Lines 17 to 21	$ 11,940	$ 9,000	$ 2,300	$ 60	$ 550	$ 30	$ -	$ -	$ -	$ -
Total Costs												
23	Payments in Lieu of Taxes		$ -									
24	**Total Direct O&M**	Sum of Lines 4, 12, 16, 22, 23	$ 398,234	$ 36,045	$ 118,567	$ 46,841	$ 121,963	$ 18,162	$ -	$ -	$ -	$ 56,657

Worksheet 3B

Allocating Salary Costs

Optional Worksheet: Use if costs are not budgeted or accounted separately

Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts

		Calculations	Total Salaries	Supply Source	Production & Treatment	Distribution Storage	Distribution & Transmission	Meters & Service	Source Protection	Fire Protection	Administration	Billing
Salaries and Wages (In Actual Numbers)												
1	Source of Supply Division Salaries		$ -									
2	Trans. & Dist. Division Salaries		$ -									
3	Meter Reading Division Salaries		$ -									
4			$ -									
5			$ -									
6			$ -									
7			$ -									
8			$ -									
9			$ -									
10			$ -									
11			$ -									
12			$ -									
13			$ -									
14			$ -									
15			$ -									
16	**Total Salaries & Wages**	Sum Lines 1 to 15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Worksheets 3C, 3B, 3C

Worksheet 3C

Determining and Allocating Capital Costs

Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts

		Calculations	Total	Supply Source	Production & Treatment	Distribution Storage	Distribution & Transmission	Meters & Service	Source Protection	Fire Protection	Administration	Billing
1	Existing Debt Service		$ -									
2	New Debt Service (Rate Supported)*	Worksheet 2, Line 1 to 3 of Selected Year x 1000	$ 54,000	$ 54,000								
3	New Debt Service (Tax Supported)*	Worksheet 2A, Line 37 of Selected Year x 1000	$ 54,000	$ 54,000								
4	Debt Service Total	Sum Lines 1 to 3	$ 108,000	$ 108,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5	Capital Costs from User Charges*	Worksheet 2, Line 5 of Selected Year x 1000	$ 95,000	$ 95,000								
6	Capital Reserve Payment*	Worksheet 2, Line 4 of Selected Year x 1000	$ -	$ 5,000								
7	**Total Capital Costs**	Sum Lines 4 to 6	$ 203,000	$ 208,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Notes:

* **To set rates for 2nd year of capital plan, use Year 2 debt service from Worksheet 2.**

Worksheet 3

Cost of Service Summary by Category

Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts

			Total	Supply	Production	Distribution	Distribution &	Meters &	Source	Fire	Administration	Billing
		Calculations		Source	& Treatment	Storage	Transmission	Service	Protection	Protection		
			A	B	C	D	E	F	G	H	I	J
1	Direct O&M	Worksheet 3A, Line 24	$ 398,234	$ 36,045	$ 118,567	$ 46,841	$ 121,963	$ 18,162	$ -	$ -	$ -	$ 56,657
2	New O&M	Worksheet 1, Lines 11 to 20 of Year 2 (not in 000s)	$ 137,000	$ 69,000		$ 17,000	$ 31,000	$ 18,000		$ 2,000		
3	Total O&M	Line 1 + Line 2	$ 535,234	$ 105,045	$ 118,567	$ 63,841	$ 152,963	$ 36,162	$ -	$ 2,000	$ -	$ 56,657
Indirect Costs												
4	General Govt. Overhead	Worksheet 3D, Line 24	$ 21,777									
5	Allocation of Gen. Overhead			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 22,000	$ -
6	Department Overhead	Worksheet 3E, Line 33	$ 21,343									
7	Allocation of Dept. Overhead			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 13,000	$ 8,121
8	**Total Indirect Costs**	Gen. Govt. + Dept. Overhead	$ 43,121	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 35,000	$ 8,121
Capital costs												
9	**Capital Component**	Worksheet 3C, Line 7	$ 203,000	$ 208,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs												
10	**Total System Costs**	Line 3 + Line 8 + Line 9	$ 786,355	$ 313,045	$ 118,567	$ 63,841	$ 152,963	$ 36,162	$ -	$ 2,000	$ 35,000	$ 64,778
Reduction of Non-Operating Revenues												
11	Taxes Used for Utility		$ 114,000	$ 19,000			$ 95,000					
12	Connection/Hook-Up Fees		$ 30,000					$ 15,000				$ 15,000
13	Other Revenue		$ 15,000								$ 15,000	
14	Total Non-Oper. Revenues	Sum Line 11 to 13	$ 159,000	$ 19,000	$ -	$ -	$ 95,000	$ 15,000	$ -	$ -	$ 15,000	$ 15,000
15	**Net Charge to be Recovered From Charges**	Line 10 - Line 14	$ **627,355**	$ 294,045	$ 118,567	$ 63,841	$ 57,963	$ 21,162	$ -	$ 2,000	$ 20,000	$ 49,778
Reallocating Administrative Costs												
16	Total Cost less Administration	Line 15: Col. A - Col. I	$ 607,355									
17	Total Cost / Non-Administration Cost Ratio	Line 15 Col. A / Line 16	1.033									
18	Total Component Allocation with Administration	Line 15 x Line 17 Col. A		$ 303,728	$ 122,471	$ 65,943	$ 59,871	$ 21,858	$ -	$ 2,066		$ 51,418

Worksheet 4B										
Units of Service, Rate Blocks, Inside-Outside Service Area (SA) Charges										
Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts										
	Do Part I and II; Part III and IV are optional									
						Meter Size				
		Calculations	**5/8"**	**3/4"**	**1"**	**1 1/2"**	**2"**	**3"**	**4"**	**6"**
Part I Non-Volume Units of Service			**A**	**B**	**C**	**D**	**F**	**G**	**H**	**I**
1	Estimate # of Meters	Entry	6,200	-	70	121	52	13	5	4
2	Ratio for 5/8" Equivalent	Given	1.0	1.1	1.4	1.8	2.9	11.0	14.0	25.0
3	5/8" Equivalent	Line 1 x Line 2	6,200	-	98	218	151	143	70	100
4	Total Meters	Sum Columns A to I of Line 1	6,465							
5	Total 5/8" Equivalents	Sum Columns A to I of Line 2	6,980							
6	# of Bills Issued per Year	From Records & Estimates	37,636							
				Domestic	**Commercial**					
Part II Volume Units of Service			**Total**	**Block**	**Block**					
			A	**B**	**C**					
7	Consumption By Inside SA Consumers	Include 1% growth, state in 1,000 Gallons	989,686							
8	Consumption by Outside SA Customers	Include 1% growth, state in 1,000 Gallons	1,163							
9	Total Annual Consumption	Line 7 + Line 8	990,849							
10	Definition of Blocks: Monthly Consumption Per Customer Allowed in Each Block (in 1,000 gallons)	Enter values in 1,000 Gallons. Enter ceiling limit for domestic blocks and floor limit for commercial blocks		4.17	4.17					
11	Annual Consumption Allowed Per Customer in Each Block (in 1,000 gallons)	12 x Line 10		50	50					
12	Total Annual Consumption in Each Block (in 1,000 gal.)			310,000	500,000					
13	Demand Weighting Factor	Given		2	1					
14	Weighted Water Sales by Block	Line 12 x Line 13		620,000	500,000					
15	Total Weighted Sales	Line 14: Col. B + Col. C	1,120,000							
16	Percent of Weighted Sales in Each Block	Line 14 / Line 15	100%	55.4%	44.6%					
Part III Inside-Outside SA Charges										
17	Surcharge for Outside SA Customers		20%	enter a percentage						
18	Adjusted Outside SA Flow	Line 8 x (1 + Line 17)	1,396	in 1,000 Gallons						
19	Total Adjusted Flow	Line 7 + Line 18	991,082	in 1,000 Gallons						
20	Outside SA Adjust. Factor	Line 19 / Line 9	1.0002							
21	Adjusted Flow in Domestic Block	Line 12 Col. B x Line 20	310,073	in 1,000 Gallons						
22	Adjusted Flow in Commercial Block	Line 12 Col. C x Line 20	500,117	in 1,000 Gallons						
23	Adjusted 5/8" Equivalents	Line 5 x Line 20	6,981	meters						
24	Adjusted Annual Bills	Line 6 x Line 20	37,645	bills/year						
Part IV Inside-Outside SA Charges (If Some Customers are Un-Metered)										
25	Water Consumption by Metered Customers	Entry	860,000	in 1,000 gallons						
26	Adjusted Consumption by Metered Customers	Line 20 x Line 25	860,202	in 1,000 gallons						
27	Consumption by Un-Metered Customers	Line 9 - Line 25	130,849	in 1,000 gallons						
28	Average Annual Household Consumption	Entry	3,000	in 1,000 gallons						
29	Un-Metered Household Equivalents in System	Line 27 / Line 28	127,849							
30	Adjusted Un-Metered Household Equivalents	Line 20 x Line 29, only use line 20 if there are metered customers	127,879							

Worksheet 4A

Water Rate Structure

Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts

Use Either Part I or Part II

		Calculations	Total A	Supply Source B	Production & Treatment C	Distribution Storage D	Distribution & Transmission E	Source Protection F	Meters & Service G	Fire Protection H	Billing I
Part I	**Two Block Rate Design**										
1	Annual Costs to Distribute	Worksheet 3, Line 18	$ 627,355	$ 303,728	$ 122,471	$ 65,943	$ 59,871	$ -	$ 21,858	$ 2,066	$ 51,418
2	Pumping Power & Chemicals	3A: Sum Col. C (Lines 5 & 13)	$ 101,000								
3	Demand Costs	(Line 1 Col. B to F) - Line 2	$ 451,014								
4	Total Adjusted Flow (1000 gal.)	4B, Line 19	991,082	in 1000 gal.							
5	Commodity Unit Cost	Line 2 / Line 4	$ 0.10								
6	% of Weighted Sales (Domestic Block)	4B, Line 16 Col. B	55.4%								
7	Demand Costs for Dom. Block	Line 3 x Line 6	$ 249,668								
8	Adjusted Flow in Dom. Block	4B, Line 21	310,073	in 1000 gal.							
9	Demand Unit Cost (Dom. Block)	Line 7 / Line 8	$ 0.81	per 1000 gal.							
10	Demand Costs (Commercial Block)	Line 3 - Line 7	$ 201,345								
11	Adjusted Flow in Comm. Block	4B, Line 22	500,117	in 1000 gallons							
12	Demand Unit Cost (Comm. Block)	Line 10 / Line 11	$ 0.40	per 1000 gallons							
13	Service Charge Costs	Sum Col. G to I of Line 1	$ 75,342								
14	Adjusted 5/8" Equivalent Meters	4B, Line 23	6,981								
15	Inside SA Service Charge per 5/8" Equivalent	(Line 13 / Line 14) / Line 15a	$ 1.80	per bill							
15a	Ave. bills per customer per year	Entry	6	bills/customer/year							
16	Inside SA Volume Charge, Domestic Block	Line 5 + Line 9	$ 0.91	per 1000 gallons							
17	Inside SA Volume Charge, Commercial Block	Line 5 + Line 12	$ 0.50	per 1000 gallons							
18	Outside SA Surcharge	4B, Line 17	20%								
19	Outside SA Service Charge per 5/8" Equivalent	(1 + Line 18) x Line 15	$ 2.16	per bill							
20	Final Outside SA Vol. Charge, Domestic Block	(1 + Line 18) x Line 16	$ 1.09	per 1000 gallons							
21	Final Outside SA Vol. Charge, Comm. Block	(1 + Line 18) x Line 17	$ 0.61	per 1000 gallons							

Part II One Block Design (with optional flat rate for unmetered customers)

		Calculations	Total	Supply Source	Production & Treatment	Distribution Storage	Distribution & Transmission	Source Protection	Meters & Service	Fire Protection	Billing
			A	B	C	D	E	F	G	H	I
22	Annual Cost to Distribute	Worksheet 3, Line 18	$ 627,355	$ 303,728	$ 122,471	$ 65,943	$ 59,871	$ -	$ 21,858	$ 2,066	$ 51,418
23	% Water Sold to Metered Customers		100%								
24	Costs Charged to Metered Cust.	Line 22 x Line 23	$ 627,355	$ 303,728	$ 122,471	$ 65,943	$ 59,871	$ -	$ 21,858	$ 2,066	$ 51,418
25	Volume-Related Costs	Sum Col. B to F of Line 3	$ 552,014								
26	Adjusted Annual Consumption by Metered Customers	4B, Line 26	860,202	in 1000 gal.							
27	Service Charge Costs	Line 24 Col. A - Line 25	$ 75,342								
28	Adjusted 5/8" Equivalents of Metered Customers	4B, Line 23	6,981								
29	Inside SA Service Charge per 5/8" Equivalent	Line 27 / Line 28 / Line 29a	$ 1.80	per bill							
29a	Ave. bills per customer per year	Entry	6	bills/customer/year							
30	Inside SA Volume Charge	Line 25 / Line 26	$ 0.64	per 1000 gal.							
31	Outside SA Surcharge	4B, Line 17	20%								
32	Outside SA Service Charge per 5/8" Equivalent	(1 + Line 31) x Line 29	$ 2.16	per bill							
33	Outside City Volume Charge	(1 + Line 31) x Line 30	$ 0.77	per 1000 gal.							
34	Adjusted Household Equivalents	4B, Line 30	127,879								
35	Costs Charged to Un-Metered Customers	Col. A: Line 22 - Line 24	$ -								
36	Inside SA Charge per HH Equiv.	Line 35 / Line 34 / Line 29a	$ -	per bill							
37	Outside SA Charge per HH Equiv	(1 + Line 31) x Line 36	$ -	per bill							

Worksheet 4						
Test of Revenues and Rates						
Instructions: Fill in the light gray shaded areas where needed; enter actual dollar amounts						
Part I Inside SA: Fill Out the Column (A or B) That Matches the Rate Method Used in Worksheet 4A						
			Two-Block	**Single Block**		
		Calculations	**Method**	**Method**		
1	Inside SA 5/8" Equivalent	4B Line 5 or Entry	6,980	6,980		
2	Inside SA Service Charge per Billing Period	4A, Line 15 or Line 29	$ 1.80	$ 1.80		
3	Inside SA Service Charge Revenue	Line 1 x Line 2 x Line 3a	$ 75,328	$ 75,328		
3a	Billing Periods per Year	Entry	6	6		
4	Inside SA Consumption in Domestic Block (000 gal.)	4B Line 12 Col.A; 4B Line 7; or 4A Line 26	310,000	990,849	in 1000 gal.	
5	Inside SA Dom. Rate or Overall Rate	4A, Line 16 or Line 30	$ 0.91	$ 0.64	per 1000 gal.	
6	Inside SA Domestic Block Revenue	Line 4 x Line 5	$ 281,201	$ 635,853		
7	Inside SA Annual Consumption in Commercial Block (000 gal.)	4B, Line 12 Col. C	500,000			
8	Inside SA Commer. Rate Per 1000 gal.	4A, Line 17	$ 0.50			
9	Inside SA Commercial Block Revenue	Line 7 x Line 8	$ 252,253			
10	Inside SA Un-Metered Customers Household Equivalent	4B, Line 29		127,849		
11	Inside SA Charge per HH Equivalent per Billing Period	4A, Line 36		$ -		
12	Inside SA Annual Revenue From Non-Metered Customers	Line 10 x Line 11 x Line 3a		$ -		
13	Inside SA Total Revenue	Sum Lines 3, 6, 9, 12	$ 608,782	$ 711,182		
Part II Outside SA: Fill Out the One Column that Matches the Rate Method Used in Worksheet 4A						
			Two-Block	**Single Block**		
		Calculations	**Method**	**Method**		
14	Outside SA 5/8" Equivalent	4B Line 5 or Entry	60	60		
15	Outside SA Service Charge per Billing Period	4A, Line 19 or Line 32	$ 2.16	$ 2.16		
16	Outside SA Service Charge Revenue	Line 14 x Line 15 x Line 16a	$ 777	$ 777		
16	Billing Periods per Year		6	6		
17	Outside SA Consumption in Domestic Block (000 gal.)	4B Line 12 Col.A; 4B Line 8; or 4A Line 26	1,163	1,163	in 1000 gal.	
18	Outside SA Dom. Rate or Overall Rate	4A, Line 20 or Line 33	$ 1.09	$ 0.77	per 1000 gal.	
19	Outside SA Dom. Block Revenue	Line 17 x Line 18	$ 1,266	$ 896		
20	Outside SA Annual Consumption in Commercial Block (000 gal.)	Entry or 4B Line 12 Col. C	-			
21	Outside SA Comm. Rate Per 1000 gal.	Entry or 4A Line 21	$ -			
22	Outside SA Comm. Block Revenue	Line 20 x Line 21	$ -			
23	Outside SA Non-Metered Customers	Entry or 4B Line 29		-		
24	Outside SA Charge per Household Equivalent per Billing Period	Entry or 4A Line 36		0		
25	Outside SA Annual Revenue from Non-Metered Customers	Line 23 x Line 24 x Line 16a		$ -		
26	**Outside SA Total Revenue**	Sum Lines 16, 19, 22, 25	$ 2,043	$ 1,673		
			Two-Block	**Single Block**		
Part III Summarizing Revenues and Rates		**Calculations**	**Method**	**Method**		
27	Total Operating Revenues	Line 13 + Line 26	$ 610,825	$ 712,854		
28	% From Inside-SA Customers	Line 13 / Line 27	99.7%	99.8%		
29	% From Outside-SA Customers	Line 26 / Line 27	0.33%	0.23%		
30	Net Cost to be Recovered from Charges	Worksheet 3, Line 15 Col. A	$ 627,355	$ 627,355		
31	Oper. Revenues as a % of Expenditures	Line 27 / Line 30	97.4%	113.6%		
32	Non-Operating Revenues	3, Line 14 Col. A	$ 159,000	$ 159,000		
33	Total Revenues	Line 27 + Line 32	$ 769,825	$ 871,854		
34	Total Expenditures	3, Line 10 Col. A	$ 786,355	$ 786,355		
35	Total Revenue as a % of Expenditures	Line 33 / Line 34	97.9%	110.9%		
			Two-Block Method		**Single Block Method**	
			Inside SA	**Outside SA**	**Inside SA**	**Outside SA**
36	Residential Service Charge (5/8" Meter) per Bill	Inside SA: 4A Line 15 or 29. Outside SA: 4A Line 19 or 32	$ 1.80	$ 1.80	$ 2.16	$ 2.16
37	Domestic Block Volume Rate (for up to ____000 gallons per billing period)	Inside SA: 4A Line 16 or 30. Outside SA: 4A Line 20 or 33	$ 0.91	$ 0.64	$ 1.09	$ 0.77
38	Commercial Block Volume Rate (for up to 000 gal. per billing period)	Inside SA: 4A Line 17. Outside SA: 4A Line 21	$ 0.50	$ 0.61		
39	Flat Charge Per Household Equivalent	Inside SA: 4A Line 36. Outside SA: 4A Line 37			$ -	$ -

Appendix E. Debt Service Factor and Sinking Fund Factor Tables

Table E.1: Debt Service Factor Table

Inflation Rate	**Terms in Years**					
	5	**10**	**15**	**20**	**25**	**30**
0%	0.000	0.000	0.000	0.000	0.000	0.000
2%	0.212	0.111	0.078	0.061	0.051	0.045
4%	0.225	0.123	0.090	0.074	0.064	0.058
5%	0.231	0.130	0.096	0.080	0.071	0.065
6%	0.237	0.136	0.103	0.087	0.078	0.073
7%	0.244	0.142	0.110	0.094	0.086	0.081
8%	0.250	0.149	0.117	0.102	0.094	0.089
9%	0.257	0.156	0.124	0.110	0.102	0.097
10%	0.264	0.163	0.131	0.117	0.110	0.103
11%	0.271	0.170	0.139	0.126	0.119	0.115
12%	0.277	0.177	0.147	0.134	0.127	0.124

Source: Shinn et. al., 1989: 14.

Instructions:

1. Select an assumed interest rate and bond term (the number of years until final maturity)
2. Read across from the selected interest rate and down from the selected bond term to find the debt service factor. For example: debt service factor = 0.271, for interest rate of 11% and bond term of 5 years.
3. Enter the debt service factor into the appropriate spreadsheet cells

Notes: This table only applies to bond issue with fixed interest rates, serial maturities, and level debt service structures.

Table E.2: Sinking Fund Factor Table

Assumed Interest Earning Rates	Year 1	Year 2	Year 3	Year 4	Year 5
4%	1.000	0.462	0.308	0.231	0.185
6%	1.000	0.445	0.297	0.222	0.178
8%	1.000	0.429	0.286	0.214	0.171
10%	1.000	0.413	0.275	0.207	0.165
12%	1.000	0.399	0.266	0.199	0.159

Source: Shinn et. al., 1989: 15.

Instructions:

1. Select an assumed interest rate for earnings on the balance of the reserve fund and the number of the years from the establishment of the fund until the full construction amount is needed.
2. To locate the sinking fund factor, read across from the selected interest rate and down from the number of years.
3. Enter the sinking fund factor in appropriate spreadsheet cells.