Long-Range Water Supply System Study

for

Bedford County, Botetourt County, Franklin County, Roanoke County, City of Roanoke, City of Salem, and the Town of Vinton

Prepared for:

Roanoke Valley-Alleghany Regional Commission

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1.0 Introduction

The Roanoke Valley and surrounding communities have experienced steady and sustained growth over the last few decades. Although the Cities of Roanoke and Salem and the Town of Vinton contain limited land available for new development, growth of the region is expected to continue for the foreseeable future in the Counties of Bedford, Botetourt, Franklin, and Roanoke.

The principal purpose of this Long-Range Water System Supply Study was to analyze existing water supply system sources and facilities, considering future water needs, and to identify possible solutions to satisfy anticipated growth in the Roanoke Valley over the next 50 years. Unfortunately, several localities have experienced water shortages during recent droughts, and the long-term capacity of existing developed resources throughout the region is finite. Each of the participating localities has expressed commitment to its current and future citizens to provide an adequate supply of high quality water in the years to come.

Participants in the study included Bedford County, Botetourt County, Franklin County, the City of Roanoke, Roanoke County, the City of Salem, and the Town of Vinton. The Roanoke Valley-Alleghany Regional Commission provided oversight and technical support to the study. The study was additionally supported by the Fifth Planning District Regional Alliance to promote regional economic objectives.

A three-phased approach was used to conduct the study. The first phase involved information gathering, including interviews conducted with each entity to obtain information on existing water sharing agreements, an inventory of existing facilities and infrastructure, land use maps, and current and projected water use demands (if available). The second phase of the project approach consisted of analyzing the data and providing engineering assessment. This phase included a number of individual tasks including a review of existing agreements, inventory of existing resources, evaluation of population and land use, and analysis of potential need for additional supplies. Results of this work were presented to the study participants. The third phase of the project consisted of incorporating the results of the first two phases of the work and the responses to the comments received into this report.

This report represents the culmination of the Long-Range Water Supply System Study, and it includes extended discussion of the alternatives analysis, conclusions from that analysis, and recommended actions for the individual localities and the region.

2.0 Review of Previous Reports

A review of historical documents maintained by the Roanoke Valley-Alleghany Regional Commission reveals a pattern of regional consideration of water supply since the 1960s. The most recent comprehensive study, the *Upper Roanoke Valley Water Supply Study* (Moore, Gardner & Associates, 1980) was prepared for the US Army Corps of Engineers, and led to further evaluation, design, and construction of the Roanoke County Spring Hollow Reservoir and water treatment plant project.

A number of other water supply alternatives were considered in the 1980 comprehensive report, and the more promising alternatives were detailed in subsequent reports. Some detailed information is updated and used in this Long-Range Water Supply Study. A brief summary of the most relevant historical reports are presented here. Other work relevant to this study is cited at the end of this section.

- ***Upper Roanoke Valley Water Supply Study* (Moore, Gardner & Associates, Inc., January 1980)**

In 1980, the US Army Corps of Engineers conducted a comprehensive water resources plan for the upper Roanoke River entitled *Roanoke River Upper Basin Study*. However, in the interim, Moore, Gardner & Associates Inc. was hired to perform a complete water supply study to ensure that alternative water supply needs for the region were met through the year 2000. The study's purpose was to develop conceptual regional alternative plans that would ensure that public water demands would be satisfied for the period of 1980 through the year 2000. The study examined the water demands of the City of Roanoke, the City of Salem, the Town of Vinton, Roanoke County and a portion of Botetourt County.

The study investigated several alternatives as possible solutions to satisfy the projected year 2000 water supply deficits. Further screening of the alternatives reduced the number of recommended alternatives to eight. Conceptually, the recommended alternatives included:

1. Augmenting the Roanoke River raw water supply with additional reservoirs;
2. Augmenting the Roanoke River supply by an inter-basin transfer of raw water from the New River;
3. Construction of a new reservoir on Back Creek;
4. Construction of an intake and raw water pump station on Smith Mountain Lake;

5. Groundwater development; and
6. Water conservation.

- ***Roanoke River Carvins Cove Raw Water Interconnect*** **(Hayes, Seay, Mattern and Mattern, March 1983)**

The 1980 Moore-Gardner Study prompted the feasibility investigation of connecting the Roanoke River and Carvins Cove Reservoir. The Roanoke River has a relatively large annual flow, but lacks the storage capabilities to counteract the low river flows. Conversely, Carvins Cove has extensive storage capacity, but is limited by its recharge capabilities. Interconnecting these to sources could offset the limitations of each and increase the permitted capacity available to the region.

The study looked at existing water supply sources in addition to Carvins Cove and the Roanoke River. It also evaluated supply sources in Crystal Spring, Falling Creek, the Town of Vinton, and Roanoke County. The study determined the requirements of an interconnected system that would provide adequate supply of water to meet the demand needs of the Roanoke Valley in the years 2010 and 2040.

- ***Roanoke Basin Water Supply Plan*** **(Virginia State Water Control Board, March 1988)**

In 1988, the Virginia State Control Board published the Roanoke Basin Water Supply Plan. Seven of these reports were prepared for the major river basins in Virginia. The Roanoke Basin report was prepared to determine the projected water demand for the Roanoke basin of Virginia. The primary purpose of the plan was to identify potential supply problems and solution alternatives and to determine the ability of the region to meet the demands through the year 2030.

The study concluded that eight service areas would have difficulty fulfilling the water demand before 2030. The study states that both the Shawsville Water System and Roanoke County/Vinton would have a source deficit by the year 2000. It reported a source deficit for Boones Mill by 2022. The study detailed a source deficit for the future area of the Bedford County Lake District.

The following alternatives were considered to alleviate water needs in the region to the year 2030:

1. An intake and raw water transmission system from the New River to augment low flows in the Roanoke River;
2. A pumped-storage reservoir in the western portion of Roanoke County to augment Roanoke River flows during low flow periods;
3. A pumped-over raw water transmission system from the Roanoke River to Carvins Cove Reservoir;
4. A intake and raw water transmission system from Smith Mountain Lake; and
5. A reservoir located on Back Creek.

- ***Preliminary Assessment of Smith Mountain Lake as a Water Source for Roanoke County* (Hayes, Seay, Mattern and Mattern, May 1988)**

In 1983, the Roanoke Valley Water Supply Committee established four alternatives for increasing the County's water supply: Spring Hollow Reservoir; Smith Mountain Lake raw water intake; Roanoke River/Carvins Cove Reservoir interconnect; and Back Creek Reservoir. This report evaluated the possibility of using Smith Mountain Lake as a raw water source for the County of Roanoke.

The report evaluates the basic design concept presented in Moore-Gardner's report, Upper Roanoke Valley Water Supply Study (1980). The design consisted of a 7.7 mgd intake structure located near Hardy Ford Bridge that would pump water to a treatment plant located near the Gravel Hill Church on S.R. 634. The treated water would then be pumped to the eastern portion of the Roanoke Valley.

The Smith Mountain Lake alternative as presented in the Hayes, Seay, Mattern and Mattern report would provide 23 mgd of raw water. The report discusses the general consideration of Smith Mountain Lake as a raw water source and largely the disadvantages compared to the Spring Hollow Reservoir alternative.

- ***The following reports were reviewed and in many cases provided additional information for the analysis:***

1998 Community Plan, County of Roanoke, Virginia; Roanoke County Department of Community Development.

2000 Update to the 1994 Comprehensive Water & Wastewater Study, Bedford County, Virginia; Anderson & Associates, Inc., December 2000.

Botetourt County Comprehensive Plan; Botetourt County Planning Department with assistance from the Fifth Planning District Commission, November 1998.

Comprehensive Plan for the City of Salem; City of Salem Planning Department with support from the Fifth Planning District Commission, December 1993.

Inventing Franklin County's Future: 1995 Comprehensive Plan; Franklin County Board of Supervisors, April 1995.

Preliminary Engineering Report for the Franklin County/Smith Mountain Lake Water System Development Project; Thompson + Litton, November 2001.

Preliminary Engineering Report, Ferrum Water System, Franklin County, Virginia; Anderson & Associates, Inc., July 2002.

Water System Study, Salem, Virginia; Finkbeiner, Pettis and Strout, Inc., October 1995.

3.0 Existing Water Resources and Water Systems

3.1 Bedford County

3.1.1 Existing Water Demands

Based on data provided by the Bedford County Public Service Authority (BCPSA), Bedford County's water demand in 2001 averaged 1.37 mgd with a peak day demand of 1.92 mgd. Primary demand centers served by the County include the Forest area to the northeast, Smith Mountain Lake to the southwest, and Stewartsville to the west along Route 24.

3.1.2 Existing Sources of Supply

The BCPSA receives raw water from two sources, Smith Mountain Lake and wells. BCPSA is currently allowed by DEQ to withdrawal up to 0.5 mgd from Smith Mountain Lake; however, American Electric Power (AEP) possesses the primary water rights from Smith Mountain Lake, and they will allow BCPSA a withdrawal up to 0.999 mgd. Anything over 0.999 mgd requires additional regulatory approval, which would entail executing an agreement between BCPSA and AEP that establishes the cost of water as it relates to the loss of power generation capacity. A joint permit would have to be issued by the U.S. Army Corp of Engineers, but only after review and approval has been provided by the Federal Energy Regulatory Commission. In addition to withdrawing water from Smith Mountain Lake, BCPSA operates twelve well systems with an estimated combined permitted capacity of 0.6 mgd. Table 3.1 shows a summary of the water supply sources for Bedford County. In addition to these sources of raw water, BCPSA purchases finished water from the City of Lynchburg for the Forest Service Area and from the City of Roanoke for the Stewartsville Service Area.

Table 3.1
Bedford County Water Supply Sources

Source	Type	Permitted Capacity (mgd)
Smith Mountain Lake	Surface	0.5
Well Systems (12)	Ground	0.6

3.1.3 Treatment Capacities

BCPSA owns and operates a water treatment plant called, High Point WTP, which is located in the Smith Mountain Lake area. The treatment plant is a microfiltration plant with a current permitted treatment capacity of 0.06 mgd. The plant, however, can be expanded to an ultimate treatment capacity of 1.0 mgd. The High Point WTP receives raw water supply from Smith Mountain Lake. Table 3.2 shows a summary of the treatment capacity for Bedford County.

Table 3.2
Bedford County Treatment Capacity

Water Treatment Plant	Rated Capacity (mgd)
High Point WTP	0.06

3.1.4 Distribution/Transmission System

BCPSA owns and operates water distribution systems which serve the Forest, Smith Mountain Lake, and Stewartsville areas. In the Forest area, finished water is received via 8- to 16-inch diameter mains from the City of Lynchburg. The water supply system for this area contains an existing 1.2 million gallon storage tank, and in the near future, it will also contain another 1.0 million gallon storage tank. In the Smith Mountain Lake area, small waterlines serve individual subdivisions; however, 12- and 16-inch diameter waterlines, as well as an elevated storage tank, are being constructed, which will transport water along Routes 655 and 122 to Franklin County. In the Stewartsville area along Route 24, finished water is received via a 12-inch diameter main from the City of Roanoke, which serves this general area.

3.2 Botetourt County

3.2.1 Existing Water Demands

Based on data provided in the 2002 Countywide Water and Wastewater Analysis for Botetourt County, which was prepared by Draper Aden, the County's water demand in 2001 averaged 3.10 mgd with a peak day demand of 4.64 mgd. Primary demand centers served by the County include major highway corridors US 460, US 220, US 220-Alternate, and Interstate 81/US 1.

3.2.2 Existing Sources of Supply

Botetourt County has a number of County owned, municipal owned and privately owned water supply systems within its borders. There are currently more than sixty private water companies that serve various residential subdivisions within the County. Botetourt County owns and operates four water supply systems which are the Cloverdale, Glen Wilton, Greenfield/Wetherwood, and East Park systems. Each of these systems, with the exception of the East Park system, receives raw water from wells. The East Park system is supplied with water from Roanoke County. The Cloverdale system consists of one well with a source capacity of 0.094 mgd which currently serves approximately 120 customers in the Cloverdale and Vista Corporate Park areas. The Glen Wilton system consists of two wells with a combined source capacity of 0.132 mgd which currently serves approximately 62 customers. The Greenfield/Wetherwood system consists of four wells with a combined source capacity of 1.981 mgd that currently serves approximately 124 customers. Table 3.3 shows a summary of the County owned water supply sources for Botetourt County.

Table 3.3
Botetourt County Water Supply Sources

Source	Type	Permitted Capacity (mgd)
Cloverdale (1) Well	Ground	0.094
Glen Wilton – (2) Wells	Ground	0.132
Greenfield/Wetherwood – (4) Wells	Ground	1.981

3.2.3 Treatment Capacities

Botetourt County owns and operates a water treatment facility associated with the Cloverdale system, which consists of a Memcor Model 6M10C filtration unit. The design rate of the filtration unit is 52 gpm (0.075 mgd). The filtration unit receives raw water supply from the Cloverdale system's well. Some of the County's other groundwater supplies are treated for iron, manganese, and corrosion inhibitors. The capacities of those treatment systems are assumed equal to the well's permitted capacities. Table 3.4 shows a summary of the treatment capacity for Botetourt County.

Table 3.4
Botetourt County Treatment Capacity

Water Treatment Plant	Rated Capacity (mgd)
Cloverdale Filtration Unit	0.075

3.2.4 Distribution/Transmission System

Botetourt County owns and operates the Cloverdale, Glen Wilton, Greenfield/Wetherwood, and East Park water distribution systems, which serve the southern part of the County. The Cloverdale system consists of a 500,000-gallon storage tank (Hardee's Tank) located at Exit 150 off of I-81, a 465,000-gallon storage tank (Hollins Tank) located near I-81 north of the Vista Corporate Park, and 2-, 6-, 8- and 12-inch diameter distribution lines, which route along US 11 corridor and I-81 and connect to the Town of Troutville's water supply system. The Glen Wilton system consists of a 64,000-gallon storage tank (former Wetherwood Tank) and 2- and 6-inch diameter distribution lines that serve the Glen Wilton area, which is in the northern part of the County. The Greenfield/Wetherwood system consists of a 1.0 million gallon storage tank and 4- to 16-inch diameter distribution lines that serve an area west of I-81, along the US 220 corridor from the Wetherwood development southerly to the area near Exit 150 of I-81. The East Park system is located near Coyner Springs and serves the area along US 220-Alternate corridor from the County line to the East Park Commerce Center. The system is fed by a 12–inch diameter water main from the Roanoke County system.

3.3 Franklin County

Franklin County currently operates a water system at the Commerce Center Industrial Park. Recent studies have been conducted to evaluate County water needs and to determine alternatives for a water system to meet these needs. In particular, a study entitled "Preliminary Engineering Report for the Franklin County/Smith Mountain Lake Water System Development Project", dated November 2001 and revised July 2002, and prepared by Thompson & Litton addresses existing and future County water needs. That study mainly concentrates on the service areas along the following corridors: US Route 220 north and south of Rocky Mount, SR 40 east of Rocky Mount, SR 122, SR 834, and SR 616 (Smith Mountain Lake Area). The study indicates that present and future (20-year projected) average water demands for the study area are approximately 1.6 mgd and 2.55 mgd respectively, including residential, commercial, and industrial water demands. The Thompson & Litton study evaluated alternatives for providing the needed water supply as follows: (1) service from the BCPSA; (2) new Franklin County water treatment plant with intake on Smith Mountain Lake; (3) service from upgraded Town of Rocky Mount water treatment plant with new County-owned raw water intake on Smith Mountain Lake; (4) combination of 1 and 2 or combination of 1 and 3 above.

The Franklin County water system at the Commerce Center Industrial Park is a groundwater system. It was permitted in April 2000 to supply water to tenants in the industrial park, at a design capacity of 0.045 mgd. Table 3.5 shows a summary of the water supply sources for Franklin County.

Table 3.5
Franklin County Water Supply Sources

Source	Type	Permitted Capacity (mgd)
Well (1)	Ground	0.045

There are approximately 40 existing privately-owned community water systems, serving small residential developments and mobile home parks throughout Franklin County, mainly in the Smith Mountain Lake area. There are also three publicly-owned water systems including the Town of Boones Mill, Ferrum Water and Sewer Authority (FWSA), and the Town of Rocky Mount. These three publicly-owned systems are described in detail in the following sections.

3.3.1 Town of Boones Mill

3.3.1.1 Existing Water Demands. The Town of Boones Mill has an estimated population of 260 and is located in the northwest portion of Franklin County along US 220. Based on data retrieved from the Virginia Department of Health (VDH), the Town's water demand in 2001 averaged 0.079 mgd with a peak day demand of 0.095 mgd.

***3.3.1.2 Existing* Sources *of Supply*.** The Town of Boones Mill receives raw water from one spring and one well. The combined source capacity of the spring and supply well is 0.082 mgd. Table 3.6 shows a summary of the water supply sources for the Town of Boones Mill.

Table 3.6
Boones Mill Water Supply Sources

Source	Type	Permitted Capacity (mgd)
Spring (1) and Drilled Well (1)	Ground	0.082

3.3.1.3 Treatment Capacities. Boones Mill's waterworks system consists of one spring, one drilled well, disinfection treatment facilities, a hydropneumatic tank, two booster pumping stations, and distribution lines. Treatment consists only of the addition of calcium hypochlorite to the combined spring and well discharge for disinfection.

3.3.1.4 Distribution/Transmission System. Boones Mill's water distribution system consists of a 12,900-gallon spring reservoir, a 246,000-gallon storage tank, two booster pumping stations, and 2- to 12-inch diameter water distribution lines. The Town's water system provides service to the corporate limits of the Town of Boones Mill.

3.3.2 Village of Ferrum

3.3.2.1 Existing Water Demand. The village of Ferrum has an estimated population of 1,800 and is located in the southwest portion of Franklin County along Route 40. Based on data retrieved from the VDH, Ferrum's water demand in 2001 averaged 0.102 mgd with a peak day demand of 0.166 mgd. According to the Preliminary Engineering Report for Ferrum Water System, prepared by Anderson & Associates, Inc. (July 2002), there are currently 100 residential customers and 23 non-residential customers served by the water system. The largest customer is Ferrum College, which has an average daily demand of approximately 0.070 mgd.

3.3.2.2 Existing Sources of Supply. Water and Sewer services for the village and Ferrum College are provided by FWSA. FWSA presently receives raw water from three wells: Well #1, Well #4, and Well #5. A fourth well (Well #6) is also included in FWSA's water supply system; however, Well #6 went dry in the fall of 2000. FWSA recently performed a drawdown test on Well #1 while monitoring Wells #4 and #5, and determined that Wells #1 and #4 draw from the same aquifer while Well #5 draws from a separate aquifer. As a result, Wells #1 and #4 operate in tandem, and Well #5 operates independently. Table 3.7 shows a summary of the water supply sources for Ferrum.

Table 3.7
Ferrum Water Supply Sources

Source	Type	Permitted Capacity (mgd)
Well #1	Ground	0.077
Well #4	Ground	0.072
Well #5	Ground	0.216

3.3.2.3 Treatment Capacities. FWSA's water treatment facility consists of a package pressure filtration system. The system contains two pressure filters for iron and manganese removal, as well as reaction vessels for oxidation of iron and manganese by chlorination. Each filter is rated for 200 gpm. Disinfection is provided by chlorination. Table 3.8 shows the rated capacity of the treatment facility for Ferrum.

Table 3.8
Ferrum Treatment Capacity

Water Treatment Plant	Rated Capacity (mgd)
Ferrum WTP	0.32

3.3.2.4 Distribution/Transmission System. FWSA's water distribution system consists of three storage tanks, a booster pump station, and 2- to 8-inch diameter waterlines. The three storage tanks capacities are 50,000 gallons, 100,000 gallons, and 300,000 gallons, and they are all located on a single site above Ferrum College. The FWSA's water system serves Ferrum College and the Ferrum community.

3.3.3 Town of Rocky Mount

3.3.3.1 Existing Water Demands. The Town of Rocky Mount has an estimated population of 5,100 and is located in the central section of Franklin County along US 220 and Route 40/122. Based on data retrieved from the VDH, the Town's water demand in 2001 averaged 0.792 mgd with a peak day demand of 1.11 mgd. According to Town personnel, the Town just completed an annexation and system expansion that is going to add 150-170 connections for a total of approximately 2,400 customers being served by the water system. During the last five years, several large industries have closed, including: Lane Furniture, Virginia Apparel, J.P. Converter, and Pluma; as a result, only one large industrial customer remains.

3.3.3.2 Existing Sources of Supply. The Town of Rocky Mount presently receives raw water from the Blackwater River, which has a drainage area of approximately 86 square miles. A check dam is provided from which raw water flows by gravity to the Town's WTP. The Town is permitted to withdraw up to 2 mgd from the Blackwater River. Table 3.9 shows a summary of the water supply source for the Town of Rocky Mount.

Table 3.9 Rocky Mount Water Supply Sources		
Source	Type	Permitted Capacity (mgd)
Blackwater River	Surface	2.0

3.3.3.3 Treatment Capacities. Rocky Mount's water treatment system has a design capacity of 2.0 mgd and provides aeration, coagulation, flocculation, sedimentation, filtration, disinfection, and fluoridation treatment processes. Table 3.10 shows the rated capacity of the treatment facility for the Town of Rocky Mount.

Table 3.10 Rocky Mount Treatment Capacity	
Water Treatment Plant	Rated Capacity (mgd)
Town of Rocky Mount WTP	2.0

3.3.3.4 Distribution/Transmission System. Rocky Mount's water distribution system primarily consists of water mains ranging in size from 2- to 18-inches in diameter, seven storage tanks with a combined volume of 2.4 million gallons, and a 250 gpm water booster pump station. The storage tanks within the system include: one 0.2 million gallon ground level tank (US 220 North Tank) located on the east side of US 220 north of Town, one 0.2 million gallon ground level tank (Grassy Hill Tank) located on the north side of Town near Route 919, one 1.0 million gallon ground level tank (Morningside Tank) located at the west side of US 220 south of Town, one 0.3 million gallon ground level tank (Bald Knob Tank) located at Bald Knob Avenue in the eastern section of Town, one 0.3 million gallon standpipe (Pendleton Street Tank) located at Pendleton Street in the north-central section of Town, one 0.1 million gallon elevated tank (Pendleton Street Tank No. 2), which is operated in conjunction with the adjacent standpipe through an altitude valve arrangement, and one 0.3 million gallon elevated tank (Scuffling Hill Road Tank) located west of Town and north of Route 40. Additionally, the Town is currently installing a 500,000-gallon ground tank that will allow them to serve the north US 220 corridor. The Town's water system provides service along the US 220 north corridor to the water treatment plant on the Blackwater River; east to where Routes 40 and 122 split; south along US 220 to Route 674; and west along Route 40 to the Pigg River.

3.4 City of Roanoke

3.4.1 Existing Water Demands

Based on data provided by the City, water demand in 2001 averaged 14.77 mgd, with a peak day demand in that year of 22.16 mgd. The City of Roanoke is very developed and water demand is spread throughout the City. The largest water demands are in the center or downtown area of the City.

3.4.2 Existing Sources of Supply

The City of Roanoke receives raw water from three sources: Carvins Cove Reservoir, Falling Creek Reservoir, and Crystal Spring.

Carvins Cove Reservoir has a total storage capacity of 6.47 billion gallons, with 5.65 billion gallons of usable storage. The dam consists of a 315-feet wide concrete ogee spillway that is tied to rock at both ends. The top of the spillway crest stands at an elevation of 1,170 feet above mean sea level (msl). Carvins Cove Reservoir receives raw water from its drainage basin and from two out-of-basin creeks, Catawba and Tinker, through diversion tunnels at each creek. Using a mass-balance model, a constant withdrawal rate of 14.1 mgd was calculated for the reservoir.

Falling Creek Reservoir receives raw water from its drainage area and Beaver Dam Reservoir. Falling Creek Reservoir has a total storage of 85 million gallons, while Beaver Dam Reservoir has a total storage of 435 million gallons. The two reservoirs operate as a single source, since they are connected by a 12" diameter pipeline. Based on the City's data, the combined yield of the reservoirs is approximately 1.45 mgd.

Crystal Spring is a live spring at the base of Mill Mountain. The City has built a covered 3 mgd reservoir under tennis courts that stores the captured water from the spring. The approximate available withdrawal rate of Crystal Spring is 3.5 mgd. Table 3.11 shows a summary of the water supply sources for the City of Roanoke.

Table 3.11 City of Roanoke Water Supply Sources		
Source	Type	Available Constant Withdrawal Rate (mgd)
Carvins Cove Reservoir	Surface	14.10
Falling Creek Reservoir	Surface	1.45
Crystal Spring	Ground	3.50

3.4.3 Treatment Capacity

The City of Roanoke owns and operates three drinking water treatment plants, one located at each source. The Carvins Cove plant has a rated treatment capacity of 28 mgd. The Falling Creek plant has a rated treatment capacity of 1.45 mgd. The membrane filtration plant at Crystal Spring has a rated treatment capacity of 3.5 mgd. Table 3.12 provides a summary of the treatment capacity for the City of Roanoke.

Table 3.12 City of Roanoke Treatment Capacity	
Water Treatment Plant	Rated Capacity (mgd)
Carvins Cove	28.0
Falling Creek	1.45
Crystal Spring	3.5

3.4.4 Distribution/Transmission System

The City owns and operates a water system that supplies finished water to the City of Roanoke and parts of the City of Salem, Town of Vinton, Bedford County and Roanoke County. The City's distribution system is connected through 17 interconnections to the distribution systems of Roanoke County, City of Salem, Bedford County and Town of Vinton. Some of these connections are used on a regular basis, but many are identified for the purpose of emergency supplies.

3.5 Roanoke County

3.5.1 Existing Water Demands

Roanoke County contains a considerable amount of open land zoned for development, and the County is promoting specific areas for current development. A

petition process exists by which a privately-served subdivision can connect to the County water system, if at least 50 percent of the residents are in favor of the change. New developments within 300 feet of the existing system are required to connect.

Based on production and billing data provided by the County, water demand in 2001 averaged 5.63 mgd, with a peak day demand in that year of 8.45 mgd. Demand centers or subdivisions served include: Hampden Hills, Martin Creek, Longridge, Delaney Court, East County, Campbell Hills, Spring Hollow, and Read Mountain. Current average consumption is estimated at 85 gallons per capita per day (gpcd).

The County's water supply withdrawal permit requires a conservation program. The County has developed a conservation policy that will be implemented according to the terms of the permit.

3.5.2 Existing Sources of Supply

The County of Roanoke receives raw water from two sources, Spring Hollow Reservoir and groundwater wells. Spring Hollow Reservoir is a 3.2 billion gallon offline storage reservoir that is maintained by pumping water from the Roanoke River, when available, based on a withdrawal permit issued by the DEQ. The reservoir was designed to retain the probable maximum flood (PMF) without overtopping the dam. The top of dam is at elevation 1,420 feet above msl, and normal pool elevation is at 1,412.6 feet above msl. The state and federal permits associated with construction of the reservoir acknowledge a combined permitted capacity of 23 mgd from the County system, considering surface water, groundwater, and conservation use restrictions.

For consistency of analysis in this regional study, the supply offset by conservation was not separately quantified. Using a computer model, the reservoir was shown to withstand a constant withdrawal rate of 15.0 mgd during the drought of record, and that value is used for planning purposes

In addition to the reservoir, a yield of 3 mgd is attributed to the County's three wells. A summary of water supply availability by source is shown in Table 3.13

Table 3.13 Roanoke County Water Supply Sources		
Source	Type	Available Constant Withdrawal Rate (mgd)
Spring Hollow Reservoir	Surface	15.0
Wells (3)	Ground	3.0

3.5.3 Treatment Capacity

The County operates a water treatment plant located adjacent to Spring Hollow Reservoir. Raw water from Spring Hollow Reservoir is transferred to the treatment plant through a pipeline. The treatment plant has a rated treatment capacity of 15.0 mgd, designed for expansion to 30 mgd. The County is currently exploring operational changes and regulatory approval to operate the plant at 18.0 mgd. Table 3.14 shows a summary of treatment capacity for Roanoke County.

Table 3.14 Roanoke County Treatment Capacity	
Water Treatment Plant	Rated Capacity (mgd)
Spring Hollow	15.0

3.5.4 Distribution/Transmission System

The County owns and operates a water system that supplies finished water to the County and parts of the City of Salem, City of Roanoke, Town of Vinton, and Botetourt County. The main lines of its distribution system consist of 12- to 30-inch diameter pipelines. The County's distribution system is connected through 18 major interconnections to the distribution systems of Botetourt County, City of Roanoke, City of Salem, and Town of Vinton.

3.6 City of Salem

3.6.1 Existing Water Demands

Water consumption data provided by the City showed water demand in 2000 averaged 4.50 mgd, with a peak day demand in that year of 6.75 mgd. Year 2000 is identified as a representative baseline demand year. The City of Salem is nearly built-out

with some open land and lots available and with re-development opportunities along Main Street.

3.6.2 Existing Sources of Supply

The City of Salem is currently completing an expansion and upgrade of its water supply and treatment system. Historically, the City used the Roanoke River to supply its two drinking water treatment plants. As part of the system upgrade, groundwater supplies are being added to the system. Two wells, providing 2 mgd of supply, will be located on the site of the new water treatment plant. A new 8 mgd intake is being constructed at the new site to withdraw water from the Roanoke River. So, the total available supply will be expanded to 10 mgd. One of the two existing river intakes will be refurbished and maintained to provide a total of 5 mgd additional withdrawal capability for emergency purposes.

It is planned that as projected demands develop in the future, additional wells will be constructed to augment the Roanoke River and groundwater withdrawals. A summary of the existing water supply sources for the City of Salem is provided in Table 3.15.

Table 3.15
City of Salem Water Supply Sources

Source	Type	Permitted Capacity (mgd)
Roanoke River	Surface	8.0
Wells (2)	Ground	2.0

3.6.3 Treatment Capacity

The City of Salem has operated two treatment plants since the 1970s. Water Treatment Plant No. 1 is located in the downtown area and draws raw water from the Roanoke River through an intake structure located on Tidewater Street. The plant has a rated treatment capacity of 5 mgd. Treatment plant No. 2 is located in the Glenvar area and receives raw water from the Roanoke River through an intake structure located north of the Koppers Woodyard. The plant has a rated treatment capacity of 3 mgd. Both of these plants use conventional flocculation, clarification, and filtration processes. When the new 10 mgd water treatment plant is placed into service in 2003, the two older plants will be decommissioned. When future demands are realized, it is planned that the new

plant could be expanded to 12 mgd. Table 3.16 shows a summary of the treatment capacity for the City of Salem.

Table 3.16
City of Salem Treatment Capacity

Water Treatment Plant	Rated Capacity (mgd)
WTP No. 1 (Downtown, 4th Street) [1]	5.0
WTP No. 2 (Glenvar) [1]	3.0
New WTP	10.0

[1] To be decommissioned when New WTP placed into service.

3.6.4 Distribution/Transmission System

The City of Salem owns and operates a water system that supplies finished water to the City and parts of the City of Roanoke and Roanoke County. Salem's distribution system is connected through six large interconnections to the distribution systems of Roanoke County and the City of Roanoke. During the recent drought, Salem was providing up to 2.5 mgd to the City of Roanoke. Salem's water distribution system is divided into seven pressure zones with pipes ranging in size from 2- to 24-inch in diameter.

3.7 Town of Vinton

3.7.1 Existing Water Demands

Based on data provided by the Town of Vinton, water demand in 2000 averaged 1.4 mgd, with a peak day demand in that year of 2.1 mgd. The population in the Town of Vinton is dispersed and water demand is spread throughout the Town, but the largest water demands are in the downtown area on the west side of Town, where it abuts Roanoke County's system.

3.7.2 Existing Sources of Supply

The Town of Vinton receives its source water from groundwater wells. The Town operates 14 wells located in two water systems, Vinton and Falling Creek. In addition, a fifteenth well has been drilled, tested and capped. The well may be placed into service in

2003. The combined yield of all 15 wells is estimated at approximately 4.35 mgd, as shown in Table 3.17.

Table 3.17
Town of Vinton Water Supply Sources

Source	Type	Withdrawal Rate (mgd)
Wells (15)	Ground	4.35

3.7.3 Treatment Capacity

The Town of Vinton does not have treatment plants. The Town depends exclusively on groundwater from their wells and purchased finished water from the City of Roanoke and Roanoke County for its water needs. At this time, there has been no indication of surface influence on any of their wells, and no need to provide treatment.

3.7.4 Distribution/Transmission System

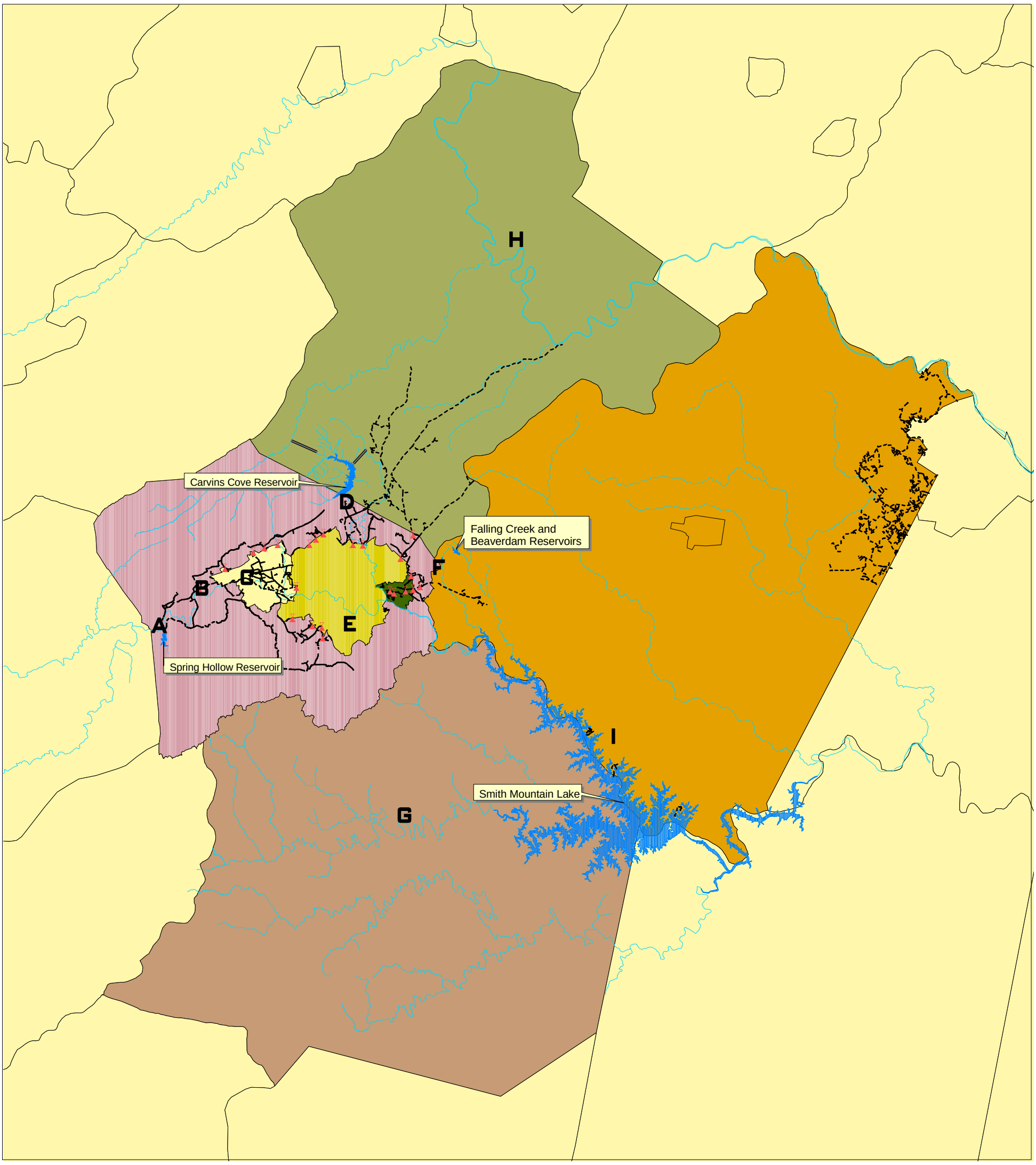
The Town owns and operates a water system that supplies stored groundwater from their wells and finished water from the City of Roanoke and Roanoke County. The Town's distribution system is connected through 7 interconnections to the distribution systems of Roanoke County and City of Roanoke. The distribution system is divided into six pressure zones and two well water systems: the Vinton and Falling Creek water systems. The water distribution system consists of pipes ranging in size from 1- to 16-inch diameter.

3.8 Existing Regional Water Resources and Water Systems Summary

This section is intended as a summary of the existing demands, sources of supply, and treatment capacities for each community in the region. For further details about the existing water resources and systems, see previous sections of the report. Tables 3.18 and 3.19 summarize the existing water resources, water systems and water supply interconnects for the region. Figure 3.1 shows the geographic location of the existing water resources and water systems in the region.

Table 3.18
Summary of Existing Water Resources and Water Systems

Locality	Demand Avg. / Peak (mgd)	Water Sources	Withdrawal Rate (mgd)	Treatment Plants	Treatment Capacity (mgd)
Bedford County	1.37 / 1.92	Smith Mountain Lake	0.5	High Point WTP	0.06
		Wells	0.6	N/A	N/A
		Lynchburg WTP	3.0		
Botetourt County	3.10 / 4.64	Wells (1) (Cloverdale)	0.09	N/A	N/A
		Wells (2) (Glen Wilton)	0.13		
		Wells (2 each) (Greenfield/ Wetherwood)	1.98		
Franklin County	2.46 / 4.43	Rocky Mount – Blackwater River	2.0	Rocky Mount WTP	2.00
		Franklin County – Well	0.045	N/A	N/A
		Boones Mill – Spring	0.01		
		Boones Mill – Well	0.07		
		Ferrum – Wells (3)	0.37		
City of Roanoke	14.77 / 22.16	Carvins Cove Reservoir	14.1	Carvins Cove WTP	28.00
		Falling Creek Reservoir	1.45	Falling Creek WTP	1.45
		Crystal Spring	3.5	Crystal Spring WTP	3.50
Roanoke County	5.63 / 8.45	Spring Hollow Reservoir	15.0	Spring Hollow WTP	15.00
		Wells (3)	3.0	N/A	N/A
City of Salem	4.50 / 6.75	Roanoke River	8.0	New WTP	10.00
		Wells (2)	2.0		
Town of Vinton	1.40 / 2.10	Wells (12) Vinton System	4.21	N/A	N/A
		Wells (3) Falling Creek System	0.14		



Regional WTP

- A SPRING HOLLOW WTP
- B GLENVAR WTP
- C SALEM WTP
- D CARVINS COVE WTP
- E CRYSTAL SPRING WTP
- F FALLING CREEK WTP
- G ROCKY MOUNT WTP
- H EAGLE ROCK WATER CO
- I HIGH POINT WTP

Water Supply Interconnects

Main Waterlines

N

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Existing Regional Water Resources & Water Systems

Figure 3.1

Table 3.19
Summary of Water Systems Interconnects

ID No.	Name	Participating Communities	Connection Type
1	Florist	City of Roanoke, Roanoke County	2 Way (+- meter)
2	Plantation/Hollins	City of Roanoke, Roanoke County	2 Way (+- meter)
3	Orange	City of Roanoke, Roanoke County, Vinton	2 Way (+- meter)
4	Brambleton	City of Roanoke, Roanoke County	2 Way (+- meter)
5	Colonial	City of Roanoke, Roanoke County	2 Way (+- meter)
6	Roanoke Blvd	City of Roanoke, Salem City	2 Way (+- meter)
7	North Lakes	City of Roanoke Roanoke County	2 Way (+- meter)
8	Ogden	City of Roanoke, Roanoke County	2 Way (+- meter)
9	Route 311	Roanoke County, Salem City	2 Way (+- meter)
10	Red Lane	Roanoke County, Salem City	2 Way (+- meter)
11	Rt. 11 across from Glenvar Plant	Roanoke County, Salem City	2 Way (+- meter)
12	Valley Point	City of Roanoke, Roanoke County	1 Way (reversible)
13	Thirlane	City of Roanoke, Roanoke County	1 Way (reversible)
14	Grandin Road	City of Roanoke, Roanoke County	1 Way (reversible)
15	Wildwood Road	Salem City, Roanoke County	1 Way (reversible)
16	Kessler Mill	Salem City, Roanoke County	1 Way (reversible)
17	Melissa Drive	Vinton, City of Roanoke, Roanoke County	1 Way (reversible)
18	Swan Drive	City of Roanoke, Vinton	1 Way (reversible)
19	Washington/ Lynn Haven	City of Roanoke, Vinton	1 Way (reversible)
20	Fairmont Drive	City of Roanoke, Vinton	1 Way (reversible)
21	Virginia/ Chestnut	City of Roanoke, Vinton	1 Way (reversible)
22	Virginia/ Pollard	City of Roanoke,Vinton	1 Way (reversible)
23	US 220	Botetourt County, Roanoke County	Bulk Purchase

3.9 Water Supply Agreements

Several entities in the region utilize water supply agreements to meet their water demands. This section summarizes the agreements that are shared among various Roanoke Valley water suppliers. Figure 3.2, located at the end of this section, details these agreements.

3.9.1 Bedford County

3.9.1.1 Bedford County and Franklin County. A contract was established between these parties on October 18, 2002, which established an allowable maximum daily quantity of water to be purchased by Franklin County from Bedford County. For the term of the contract, Bedford County has agreed to sell up to 400,000 gpd of water to Franklin County. The contract stipulates that Bedford County shall sell water to Franklin County at a rate that recovers all costs associated with withdrawing and treating the water, pumping the water to storage and to the point of entry into Franklin County's system. The charge also provides for the replacement, maintenance and capital recovery of the facilities that are used for this specific purpose. This contract remains in effect for twelve years from October 18, 2002 through October 31, 2014. At the end of the ninth year, either party shall have the right to terminate or renew the contract for an additional ten year period.

3.9.1.2 Bedford County and the City of Lynchburg. A contract was established between these parties on July 1, 1994, which specified that Bedford County would purchase all of its water needs for its Forest service area from the City of Lynchburg. The County agreed to purchase water from the City at a rate of:

$/HCF = UAC + Rate of Return x UAC; where, HCF = Hundred Cubic Feet

$$UAC = \frac{\text{City's Annual Water Utility Operating Costs}}{\text{Annual System Wide Water Consumption}}$$

Rate of Return:	Annual Use in HCF	Return Percentage
	Less than 300,000 HCF	24%
	300,000 to 350,000	23%
	350,001 to 400,000	22%
	400,000 to 450,000	21%
	450,000 to 500,000	20%
	500,001 to 550,001	19%
	550,001 to 600,001	18%

The contract initially expires on June 30, 2004; however, provisions were included for it to automatically renew in five-year increments provided the parties give notice of their intention to renew two years prior to the end of each contract term.

3.9.1.3 Bedford County and the City of Roanoke. A contract was established between these parties on February 1, 1999, which established a minimum average daily quantity of water to be purchased by Bedford County from City of Roanoke. The minimal annual average daily quantity that must be purchased by the County is equal to 80% of the preceding Fiscal Year's annual average daily quantity that was purchased. The maximum annual average daily quantity that can be purchased is established at 120% of the previous Fiscal Year's annual average daily quantity once a 100,000 gpd average is met; however, this amount can never exceed 1.0 mgd. Up to 2010, the County purchases water from the City at a rate of:

$$\$/HCF = 1.25 \times \frac{\text{Total Dollars Charged All City Customers for Water Service During the Previous Fiscal Year}}{\text{Total HCF of Water Billed to All City Customers During Previous Fiscal Year}}$$

After 2010, the multiplier (1.25) is reduced to 1.20 for consumption greater than 0.5 mgd, but less than 1.0 mgd. This contract expires on June 30, 2004 and contains no provisions for automatic renewal.

3.9.2 Botetourt County

3.9.2.1 ***Botetourt County and Roanoke County.*** A contract was established between these parties on October 1, 1999, which specifies that Roanoke County will provide and guarantee a maximum volume of 0.250 mgd of water from its public water system delivered through an existing 12-inch waterline metered at the Botetourt County line, along route 604. Water is purchased by Botetourt County from Roanoke County at the bulk water rate of $3.40/1,000 gallons. The initial term of this agreement expires on July 1, 2004; however, provisions were included to allow the contract to renew for additional five-year terms, if desired by Roanoke County and Botetourt County.

3.9.3 Franklin County

3.9.3.1 Franklin County and Bedford County. Details noted in Section 3.9.1.1.

3.9.4 City of Roanoke

3.9.4.1 ***The City of Roanoke and Bedford County.*** Details noted in Section 3.9.1.3.

3.9.4.2 ***The City of Roanoke and Roanoke County.*** A contract was established between these parties on September 30, 1999, which allows the County to sell up to 4 mgd, as well as any additional surplus, of water to the City whenever requested to do so; and it requires the City to sell any surplus water to the County whenever requested to do so. Water sold by either the City or County to the other is sold at the bulk rate of $2.75/1,000 gallons and is adjusted each year proportionate to the Consumer Price Index. The contract also contains provisions for the City and County to transport up to 3 mgd of water through the other's distribution system at no cost or expense to the party causing or desiring the water to be transported. This contract expires on June 30, 2020 and contains no provisions for automatic renewal.

3.9.4.3 ***The City of Roanoke and the City of Salem.*** A contract was established between these parties on January 1, 1985, which allows water to be transferred at certain interconnect points between these two parties' water systems. The contract states that Roanoke will pay the City of Salem for water purchased through these interconnect points at the rate of:

$$\$/1{,}000\ \text{gal} = 1.1 \times \frac{\text{O\&M + Debt Service + Interest + Capital Outlay}}{\text{Water Delivered in 1,000 gallons}}$$

O&M = Actual cost of operating and maintaining the Salem's entire water system.

Interest = Annual interest cost to Salem for outstanding debt on Salem's water system.

Debt Service = Annual cost to Salem for debt retirement of the water system less any federal and state grants.

Capital Outlay = Actual expenditures in any fiscal year for capital outlay from that current fiscal year's earnings or any previous fiscal year's retained earnings.

Additionally, the contract states that Salem will pay Roanoke for water purchased through these interconnect points at the rate established in the 1979 contract between City of Roanoke and Roanoke County except that the factor of 1.1 will be used in lieu of the factor of 1.25. However, the current contract between the City of Roanoke and Roanoke County, which was established on September 30, 1999, states that "this Agreement supersedes all prior negotiations, representations or agreements, either written or oral. Except as otherwise provided in this Agreement, the 1979 Contract is terminated hereby." The 1999 contract between City of Roanoke and Roanoke County states that water sold by either the City of Roanoke or Roanoke County to the other shall be sold at the bulk rate of $2.75 per thousand gallons.

The initial term of the contract between the City of Roanoke and the City of Salem expired on January 1, 1995; but, provisions were included to allow the contract to renew automatically on a yearly basis until notice of termination is provided in writing by one of the parties. The Contract has since been renewed and remains in effect today.

3.9.4.4 *The City of Roanoke and the Town of Vinton*. A contract was established between these parties on April 26, 1996, which established a minimum average daily quantity of water to be purchased by the Town of Vinton from the City of Roanoke. The contract states that a minimal monthly amount of 500,000 gallons per month must be purchased by the Town, as long as PFG, Inc. remains a viable business operation within the Town. If less than 6,000,000 gallons is purchased by the Town during the Fiscal Year, the Town shall pay for the difference at the Town Rate. For water up to 1,500,000 gallons per month, the Town Rate shall be the City Rate times a multiplier of 1.25. For water volume in excess of 1,500,000 gallons per month, the Town Rate shall be the City Rate times a multiplier of 1.50. The City Rate is established at the same rate as the City sells water to Roanoke County, pursuant to their agreement, dated January 27, 1995. The initial term of the contract was for five years until April 26, 2002; but, the contract contains provisions to renew upon mutual agreement of the City and Town.

3.9.5 Roanoke County

3.9.5.1 *Roanoke County and Botetourt County*. Details noted in Section 3.9.2.1.

3.9.5.2 *Roanoke County and the City of Roanoke*. Details noted in Section 3.9.4.2.

3.9.5.3 Roanoke County and the City of Salem. The City of Salem entered into a thirty year contract with the County of Roanoke on May 6, 1981 and the contract became effective July 1, 1981.

The contract consists of five major sections: 1. Ownership of Sewer and Water Lines, 2. Bulk Water, and 3. Terms of Contract, Renewal, and Termination, 4. Metering of Sewage and Water Flow, and 5. Miscellaneous Provisions.

1. Ownership of Sewer and Water Lines

This section identifies which transmission lines belong to the City and which belong to the County. "Exhibit 1" and "Exhibit 2" of the contract list transmission lines that fall outside of the general jurisdictional boundary property divisions. This section of the contract also identifies the customers of both the City of Salem and Roanoke County.

2. Bulk Water

According to the Bulk Water section of the contract, the City of Salem agrees to sell and the County of Roanoke agrees to buy surplus water at bulk rates. The bulk rates are determined by an equation set out in the contract that had been mutually agreed upon by both parties. Any costs incurred due to future installments of waterlines will not affect the bulk rate unless the lines benefit the County or customers of the County.

The determination of "Surplus Water" is determined solely by the City. If the City determines that surplus is available, the contract establishes minimum and maximum quantities for FY 1981-82 at an annual average daily quantity of 150 thousand gallons per day and 300 thousand gallons per day, respectively. The County may request an increase in water any fiscal year with a ceiling set at 110% of the then existing minimum quantity. However, the maximum annual average daily quantity shall always be at least 150% of the minimum annual average daily quantity.

3. Terms of Contract, Renewal, and Termination

According to the contract, the contract shall, upon the expiration of term of thirty years, be automatically renewed for successive terms of ten years unless notice of termination is given in writing by either party to the other party at least twenty-four months prior to the end of the original term of contract or any ten year term of renewal.

4. Metering of Sewage and Water Flow.

This section of the contract identifies the legal rights belonging to both the City of Salem and Roanoke County in regards to metering, meters, and the discontinuance of service to particular service areas. This section also identifies the point at which purchased water is metered for the determination of fees.

5. Miscellaneous Provisions

Additionally, the agreement allows the City to sell surplus water to neighboring political subdivisions at the following rate:

$$\$/1{,}000\ \text{gal} = 1.25 \times \frac{\text{O\&M + Debt Service + Interest + Capital Outlay}}{\text{Water Delivered in 1,000 gallons}}$$

O&M = Actual cost of operating and maintaining the City's entire water system.

Interest = Annual interest cost to the City for outstanding debt on the City's water system.

Debt Service = Annual cost to the City for debt retirement of the water system less any federal and state grants.

Capital Outlay = Actual expenditures in any fiscal year for capital outlay from that current fiscal year's earnings or any previous fiscal year's retained earnings.

The initial term of the contract expires on May 6, 2011; however, the contract will automatically renew for successive 10-year terms unless notice of termination is given in writing by either of the parties.

3.9.5.4 Roanoke County and the Town of Vinton. A contract was established between these parties on May 25, 1979, which stipulates that a 2 mgd water system would be constructed in order to reduce the reliance on the City of Roanoke's water system and equalize the water rates of Town and County customers. The agreement indicates that the Town must pay the County the rental sum of One Dollar ($1.00) per year. The agreement also specifies that all excess revenues received by the Town must go into a sinking fund for future capital and maintenance needs. This agreement expires on May 25, 2029 and contains no provisions for automatic renewal.

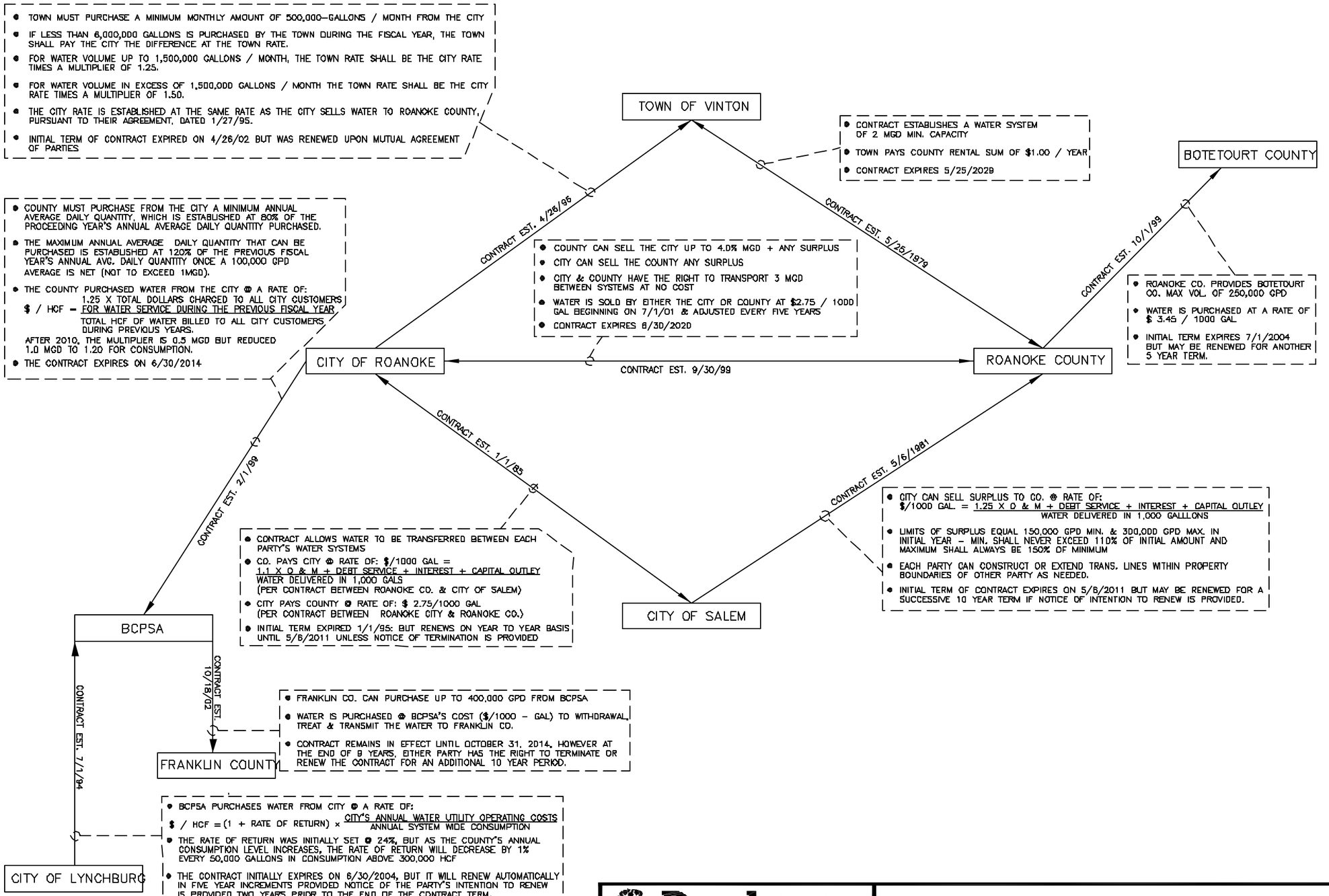
3.9.6 City of Salem

3.9.6.1 ***The City of Salem and the City of Roanoke.*** Details noted in Section 3.9.4.3.

3.9.6.2 The City of Salem and Roanoke County. Details noted in Section 3.9.5.3.

3.9.7 Town of Vinton

3.9.7.1 The Town of Vinton and Roanoke County. Details noted in Section 3.9.5.4.



Dewberry
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SUMMARY OF WATER AGREEMENTS

FIGURE 3.2

4.0 Population and Water Demand Projections

This section summarizes the procedures and assumptions used to develop future demand projections for the region and provides the sources for the data used in these analyses.

4.1 Land Use

Black & Veatch consolidated the locally prepared zoning maps into a single future land use map, see Figure 4.1. Each jurisdiction provided land use data in various formats, electronic and paper, and divided into different categories. The data was categorized into eight different land use categories to standardize it for presentation in this study. The land use categories used include: Agriculture, Commercial, Forest/Parks, Industry, Institutional, Rural Village Center, Residential, and Vacant/Other. The data was grouped together based on land use patterns including zoning classifications, land use categories, and estimated built densities. Appendix A contains classification details for each locality.

4.2 Population Projections

Population projection data for cities and counties was obtained from the Roanoke Valley-Alleghany Regional Commission, as provided to them by the Virginia Employment Commission (VEC). VEC develops these projections for use by state agencies and the General Assembly, as well as local governments, businesses, and the general public. The information presented in Table 4-1 is based on 1999 data.

The main purpose of providing population projections is to establish benchmarks against which future land use decisions regarding the type, mix, character and quantity of future development products may be compared. Population forecasting is at best an "educated guess." For this reason, population forecasts should be used only in the context of establishing a generalized analytical framework for the allocation of future land uses.

Regional Land Use

- Agriculture
- Commercial
- Residential
- Industry
- Forest, Parks, and Government
- Institutional
- Vacant/Other
- Rural Village Center

N

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Regional Future Land Use

Figure 4.1

Table 4.1
Regional Population Projections

Locality	Population					
	2000	2010	2020	2030	2040	2050
Bedford County	58,900	71,601	84,302	97,003	109,704	122,405
Botetourt County	29,799	34,302	38,805	43,308	47,811	52,314
Franklin County	46,802	53,797	60,792	67,787	74,782	81,777
Roanoke County	84,710	89,800	94,890	99,980	105,070	110,160
City of Roanoke	95,596	94,500	94,500	94,500	94,500	94,500
City of Salem	24,792	25,897	27,002	28,107	29,212	30,317
Total	340,599	369,897	400,291	430,685	461,079	491,473

4.3 Water Demand Projections

Generally, when water demand projections were provided by individual localities, they were used as a basis for the projections presented below. Several of the localities provided data indicating daily peaking factors. However, given the extended planning period, and the goal of providing an equal comparison across systems, a uniform peaking factor of 1.5 was used for all systems.

4.3.1 Bedford County Projections

Bedford County provided the *2000 Update to the 1994 Comprehensive Water and Wastewater Study* (Anderson and Associates, 2000). The report estimated demands for a potential future service area, which is significantly larger than the existing BCPSA service area. Using the estimated demand for the potential service area shown in the report for the year 2000, projections were made for 2020 and 2050 using a growth rate equal to that of the VEC population projections. The future average demands projected for years 2020 and 2050 are 5.4 mgd and 7.9 mgd, respectively.

4.3.2 Botetourt County Projections

Botetourt County provided information from the draft of the Countywide Water and Wastewater Analysis, prepared by Draper Aden Associates. Draper Aden reported a current average demand of 3.1 mgd and projected a 2020 average demand of 4.3 mgd for Botetourt County. Using this information, the 2050 average demand is projected to be 5.8 mgd, based on extrapolation of the assumed constant 1% population growth per year.

4.3.3 Franklin County Projections

The County's future service area was identified in the 2001 Thompson and Litton Report provided by the County. It included the eastern portion of the County near Smith Mountain Lake, the U.S. 220 corridor, and the towns of Rocky Mount and Boones Mill. Also included in the total County projections was the village of Ferrum. Future demand projections were determined by applying the population growth rates to current demands for each entity. Based on the Thompson Litton (2001) study, a growth rate of 1% was applied to the current demand of 1.5 mgd to project demands of 1.8 mgd and 2.4 mgd for the years 2020 and 2050, respectively. Based on the 1995 Franklin County Comprehensive Plan, growth rates of 1%, 0.5%, and 0.75%, were applied to the current demands of the towns of Rocky Mount and Boones Mill and the village of Ferrum, respectively. Future average demands are projected to be 1.0 mgd, 0.09 mgd, and 0.12 mgd in 2020 and 1.3 mgd, 0.1 mgd and 0.15 mgd in 2050. Future total average demands for Franklin County, including the towns, are projected to be 3.0 mgd in 2020 and 3.9 mgd in 2050.

4.3.4 City of Roanoke Projections

The City of Roanoke provided annual water production data for 1992 through 2001. The data for 1998 was selected as the best representation of demand under normal conditions. The years 1999 through 2002 were influenced by the record drought and implementation of mandatory conservation measures. The total production for 1998 was 7,281,010,000 gallons. Distributing this across 365 days gives an average total demand of 20.0 mgd. Current production is approximately 16 mgd. The VEC projects limited future population growth for the City of Roanoke, and water demand is not expected to grow. The demand equal to that of 1998 is used for the future planning period, and is assumed to include all system losses.

4.3.5 Roanoke County Projections

The projections for Roanoke County combine available population and future land use information. Population growth rates were applied to the existing demand to project requirements for the residential portion of Roanoke County's future 2020 and 2050 demands. To account for future industrial, institutional and commercial growth, demand was estimated for each land use type based on build out in 2070 and a typical use rate per acre. Combining the future residential demand with the institutional, industrial and commercial demands shows a total average demand of 10.2 mgd and 17.0 mgd for 2020 and 2050, respectively.

4.3.6 City of Salem Projections

The City of Salem provided demand projections of 6.7 mgd for 2025 and 8.0 mgd for 2050. This projection included both plant and distribution system losses at 10% and 15%, respectively. The 2025 projection, 6.7 mgd, was used for the 2020 average demand.

4.3.7 Town of Vinton Projections

The Town of Vinton reported an average daily production of 1.4 mgd for 2001-2002. The Town is nearly built-out, so future growth is expected to be limited. The Town expects an additional 0.4 mgd will be needed to meet their daily needs through the planning period. Water demand projections for 2020 and 2050 are 1.8 mgd.

4.3.8 Summary of Projected Water Demands

Projected water demands for each community are listed in Table 4.2. An additional 10% was added to each demand to account for uncertainty in the projects and for anticipated treatment losses. Most of the projections described above were based either on current plant/well production records, or on conservative consumption estimates (gallon per capita per day, of gallon per developed acre per day). In each case, the future distribution system losses are assumed to be included. However, since this study is primarily focused on raw water resources, it was important to factor in the losses associated with the various treatment processes. Though well systems, not identified as being under the influence of surface waters, do not currently require treatment, it was considered prudent to include treatment losses even for those communities completely dependent on wells. Over the length of the planning period, there is a possibility that these communities will need to add treatment, either because wells are found at some future date to be surface influenced, or due to changes in regulations.

In the case of the Cities of Salem and Roanoke, the projections provided by the Cities expressly included treatment losses. Therefore, an additional 10% to account for losses was not added to Salem's or Roanoke's projections.

Table 4.2
Projected Demands

Locality	2020		2050	
	Average Day	Peak Day	Average Day	Peak Day
Bedford County	5.9	8.9	8.7	13.1
Botetourt County	4.7	7.0	6.4	9.6
Franklin County	3.3	4.8	4.3	6.5
City of Roanoke	20.0	30.0	20.0	30.0
Roanoke County	11.2	16.8	18.7	28.1
City of Salem	6.7	10.0	8.0	12.0
Town of Vinton	2.0	3.0	2.0	3.0

5.0 Water Supply and Demand Analysis

The discussion below addresses the projected future surpluses, or deficits, for each locality with regard to raw water supply, treatment capacity and distribution, with an emphasis on the available raw water supply. For localities that have a reservoir as a source of raw water, it was assumed that the raw water supply would need to meet the average daily demand only. Even during drought conditions, water can be taken from reservoirs at an instantaneous rate greater than their safe withdrawal capacity, as long as the long-term average remains below the safe withdrawal capacity. This will allow localities to meet peak day demands, even though the calculated capacity of their raw resources is less than the peak day demand. For localities that depend on groundwater and run-of-river raw water sources, the deficit was calculated using the peak day demand. Wells cannot be safely pumped beyond their permitted capacity without risking damage to the system. Run-of-river intakes, similarly, are rated based on the minimum flow expected in the river during drought conditions (typically the one-day low flow rate expected during a 30-year return period). In either case, the system must be rated to meet the peak day demand, since there is no storage that will allow for long-term averaging. Details on supply and treatment capacities are described in Chapter 3, and future demand projections are presented in Chapter 4, Table 4.2.

5.1 Bedford County

Bedford County has experienced significant growth in recent years, especially in the area immediately adjacent to Smith Mountain Lake and in the Forest region of the County. As is indicated by flow projections presented in Chapter 4, that growth is expected to continue. Current water demands in Bedford County are met from several different sources. Water for the Forest area is purchased by the BCPSA from the City of Lynchburg. The area around Smith Mountain Lake is served by BCPSA's High Point Water Treatment Plant, as well as various well systems. The area around the City of Bedford receives water from the City. The Stewartsville area is provided water purchased from the City of Roanoke. Other areas in the County are served by groundwater systems.

5.1.1 Raw Water Supply

For the purposes of this study, the demands throughout the County for raw water were treated equally and an aggregate deficit for the County was developed. As shown in

Table 5.1 the anticipated raw water deficit in the year 2050 is expected to be 4.6 mgd. This is based on 3 mgd available to BCPSA from the City of Lynchburg and 0.5 mgd at the High Point WTP, and the existing well yields. (Though the High Point WTP is currently rated at only 60,000 gpd, the current withdrawal permit is for 0.5 mgd.)

Table 5.1
Bedford County Projections (mgd)

	2020	2050
Average Daily Demand	5.9	8.7
Peak Day Demand	8.9	13.1
Available Raw Water Supply	4.1	4.1
Raw Water Surplus/Deficit	-1.8	-4.6
Potable Water Supply	3.7	3.7
Treatment Surplus/Deficit	-5.2	-9.5

5.1.2 Treatment Capacity

The 3 mgd available from the City of Lynchburg is treated water, and therefore is equivalent to 3 mgd of treatment capacity. There are various public wells with a combined capacity of 0.6 mgd. The High Point WTP currently has a rated capacity of 60,000 gpd. In total, there is currently 3.7 mgd (3 + 0.6 + 0.06 = 3.7) of potable water available to BCPSA for distribution. This will result in a projected deficit of 9.5 mgd in 2050 based on a peak day demand.

5.1.3 Distribution

In order to realize the benefit of existing water sources, and potential future sources (especially an expanded withdrawal from Smith Mountain Lake), the BCPSA will need to develop a distribution system that will allow for the transfer of relatively large quantities of water between the various demand centers. BCPSA has a large interconnection with the City of Lynchburg (which is outside the study region), and purchases water from the City of Roanoke to serve its Stewartsville region. However, in order to benefit from the interconnections, Bedford County will need to interconnect its separate service areas within the County.

5.2 Botetourt County

As outlined in previous sections, Botetourt County is primarily dependent on wells to provide water to its customers, with the exception of the East Park system which receives water from Roanoke County. At this time, the County has limited its customer base to commercial and institutional customers, with the exception of the Glen Wilton system in the north end of the County. Residential customers are serviced, primarily, by private well systems, or by one of the Town systems (Troutville, Buchanan and Fincastle), which also depend on well water.

5.2.1 Raw Water Supply

The County anticipates that groundwater resources will continue to meet the demand for some time in the future. There is potential for drilling additional wells, and using existing surface influenced wells by installing treatment systems. Although deficits in water supply are identified when comparing existing supplies to future demands, the planned phased development of groundwater wells, as called for in the Draper Aden study, would reduce or potentially eliminate the projected supply deficits noted in this long-range study. Based on the existing groundwater supply systems and anticipated demands detailed in previous sections of this report, Botetourt County faces a projected raw water deficit of 7.4 mgd by 2050 (see Table 5.2, below). This deficit is based on the peak daily demand. As noted above, this is due to the requirement of wells to have a permitted capacity equal to the peak day demand.

Table 5.2
Botetourt County Projections (mgd)

	2020	2050
Average Daily Demand	4.7	6.4
Peak Day Demand	7.0	9.6
Available Raw Water Supply	2.2	2.2
Raw Water Surplus/Deficit	-4.8	-7.4
Potable Water Supply	2.2	2.2
Treatment Surplus/Deficit	-4.8	-7.4

5.2.2 Treatment Capacity

The amount of potable water available to Botetourt County is limited by the available well capacity. The only treatment system currently operated by the County is

the membrane system used to treat surface influenced groundwater at the County's Vista Park system. In the case of well systems, the amount of potable water available equals the permitted capacity of the wells. Therefore, the potable water deficit projected for 2050 also equals 7.4 mgd.

5.2.3 Distribution

The County's distribution system is built around four distinct commercial/institutional systems (Greenfield, Glen Wilton, East Park and Cloverdale). These are generally located in the southwestern end of the County with the exception of Glen Wilton. In addition, there are systems owned by the three towns (Troutville, Buchanon and Fincastle). Though there are some interconnections, they are generally distinct systems that function independently. The County has plans to connect the four commercial/industrial systems and has designed those systems with that eventuality in mind.

Certain scenarios would provide improved system reliability and performance, and might be advantageous as the County experiences continued growth. These include:

- Interconnection of the County's four systems, Troutville and Buchanan along the U.S. 11 Corridor.
- Interconnection between the U.S. 11 corridor and the U.S. 220 corridor to Fincastle.
- Interconnection to the City of Roanoke's system to allow for an emergency water supply.

5.3 Franklin County

Franklin County does not currently provide water supply to communities. The County operates a well at the Commerce Center Industrial Park. All public water supplies in the County are provided currently by one of the towns (Rocky Mount, Boones Mill and FWSA), or by private well systems.

5.3.1 Raw Water Supply

The existing raw water resources in Franklin County include the Town of Rocky Mount's Blackwater River intake (run-of-river intake), groundwater supplies in Franklin County, Boones Mill (well and spring) and Ferrum, and various private well systems. As

stated previously, groundwater resources and run-of-river intakes are compared to maximum day demands when assessing deficits, since these systems do not have raw water storage. The 2050 deficit projected for Franklin County is 4.0 mgd (see Table 5.3, below). This deficit does not consider future capacity to be purchased from the BCPSA based on a recently signed agreement

Table 5.3
Franklin County Projections (mgd)

	2020	2050
Average Daily Demand	3.3	4.3
Peak Day Demand	4.8	6.5
Existing Raw Water Supply	2.5	2.5
Raw Water Surplus/Deficit	-2.3	-4.0
Potable Water Supply	2.5	2.5
Treatment Surplus/Deficit	-2.3	-4.0

5.3.2 Treatment Capacity

The only existing treatment plant in Franklin County is the 2 mgd plant owned and operated by the Town of Rocky Mount. In addition, there are public and privately operated wells which can produce potable water at a rate equal to their permitted capacity. It is projected that by the year 2050, Franklin County will face a deficit of treated/potable water of 4.0 mgd. As stated previously, this does not include the future purchase of water from BCPSA, or future plans by the County to construct a treatment plant on Smith Mountain Lake. Only existing facilities are included in this analysis.

5.3.3 Distribution

Currently, Franklin County does not own any distribution system. The Towns of Rocky Mount and Boones Mill distribute water within their corporate boundaries, and to a limited extent to neighboring areas of the County. In order to serve the planning area identified by the County in its recent water supply planning areas, a distribution system will need to be developed between the northeastern (lake) area of the County, the Town of Rocky Mount and the U.S. 220 corridor.

5.4 City of Roanoke

The City of Roanoke is the oldest water provider in the region and has the most stable anticipated future demand. As noted in previous sections of this report, the City of Roanoke demand is not anticipated to increase significantly over the planning period.

5.4.1 Raw Water Supply

As noted in Section 3 of this report, the City of Roanoke currently takes water from three separate raw water sources (Carvins Cove Reservoir, Falling Creek Reservoir and Crystal Spring). The total raw water capacity is 19.1 mgd. Since the City's major raw water source is an impoundment that allows for significant storage of raw water, the calculated deficit is based upon projected average daily demands. The projected deficits for 2020 and 2050 are shown in Table 5.4.

Table 5.4
City of Roanoke Projections (mgd)

	2020	2050
Average Daily Demand	20.0	20.0
Peak Day Demand	30.0	30.0
Available Raw Water Supply	19.1	19.1
Raw Water Surplus/Deficit	-0.9	-0.9
Treatment Capacity	33.0	33.0
Treatment Surplus/Deficit	+3.0	+3.0

5.4.2 Treatment Capacity

The City operates three treatment facilities, one at each source. The capacity for each is the same as the raw water capacity for that source, with the exception of Carvins Cove. The water treatment plant at Carvins Cove has a rated capacity of 28 mgd. For the purposes of the summary table above, the full treatment capacity of the Carvins Cove plant was included, to demonstrate the difference between raw water and treatment capacity. It should be noted, however, that the Carvins Cove plant could not be operated above the capacity of the reservoir for an extended period of time, unless additional raw water was delivered to the Carvins Cove reservoir or plant, or the capacity of Carvins Cove Reservoir was increased.

5.4.3 Distribution

The City of Roanoke is fully developed, and will not require significant additions to its distribution system to provide service within its corporate limits. It also has multiple connections which allow it to serve contiguous areas of neighboring localities and to allow for some emergency water supply. Distribution system additions would be required to interconnect with Botetourt or Bedford Counties, or to provide significant interchange of water with Roanoke County.

5.5 Roanoke County

Though Roanoke County has experienced significant development over the past decades, and is significantly more developed than Bedford, Botetourt or Franklin, it still has large areas of open space and is expected to continue to grow for the foreseeable future.

5.5.1 Raw Water Supply

As noted in Section 3, Roanoke County draws the majority of its raw water from the Spring Hollow Reservoir which is fed from the Roanoke River. An additional 3 mgd is available from wells. The total capacity of raw water supplies available to Roanoke County is 18 mgd. As with the City of Roanoke, the County's primary source of raw water is a large impoundment. Therefore, the deficit was calculated using anticipated average daily demands, see Table 5.5.

Table 5.5
Roanoke County Projections (mgd)

	2020	2050
Average Daily Demand	11.2	18.7
Peak Day Demand	16.8	28.1
Available Raw Water Supply	18.0	18.0
Raw Water Surplus/Deficit	6.8	-0.7
Treatment Capacity	18.0	18.0
Treatment Surplus/Deficit	1.2	-10.1

5.5.2 Treatment Capacity

The County's existing treatment plant has a rated capacity of 15 mgd. However, this is limited by the filter loading rate approved by the VDH. The approved rates are conservative, and lower than are often approved for similar plants. The County has made improvements to the plant, and is working with the VDH to increase the permitted filter loading rate. This will allow the County to operate their plant at 18 mgd. Because it is likely that the new rate will be approved, the above table is based on the approved plant capacity. This was done to maintain a consistent process for analysis of facilities in this study.

5.5.3 Distribution

Though much of the County is currently served by the County's water supply, there are still extensive areas which either have no water distribution systems, or are served by small private systems. Through the planning period, it is anticipated that extensive additions to the distribution system will be made. The County currently has multiple connections with neighboring localities. Additional distribution interconnections will be required if significant future transfer of water to or from neighboring localities is anticipated.

5.6 City of Salem

The City of Salem is a relatively urbanized community, though there are some areas within the City that are not currently served by the City with potable water. The existing raw water supplies include wells and run-of-river intakes on the Roanoke River. Because there is no raw water storage in the City's system, the future deficit/surplus is based on the peak day demand, see Table 5.6.

5.6.1 Raw Water Supply

The City of Salem currently has 10 mgd of available raw water supply. This includes 8 mgd available from the Roanoke River and 2 mgd available from groundwater.

Table 5.6 City of Salem Projections (mgd)		
	2020	2050
Average Daily Demand	6.7	8.0
Peak Day Demand	10.0	12.0
Available Raw Water Supply	10.0	10.0
Raw Water Surplus/Deficit	0.0	-2.0
Treatment Capacity	10.0	10.0
Treatment Surplus/Deficit	0.0	-2.0

5.6.2 Treatment Capacity

A new 10 mgd treatment plant is currently under construction. When the new 10 mgd water treatment plant is placed into service in 2003, the two older plants will be decommissioned. When future demands are realized, it is planned that the new plant could be expanded to 12 mgd.

5.6.3 Distribution

The City of Salem is fairly well developed. There are some isolated communities that are not served by the City, but generally this is due to the relative elevation of these areas as opposed to there distance from the existing distribution system. Service to these areas will require the development of separate pressure zones. The City has numerous interconnections with the City of Roanoke and Roanoke County, and serves areas of both Roanoke County and City. No major extension of the City's service area is anticipated.

5.7 Town of Vinton

The Town of Vinton borders the City of Roanoke and is located within Roanoke County. It owns and operates its own water supply system. The Town is nearly built out. There is a relatively small tract of undeveloped land in the section of Roanoke County currently served by the Town of Vinton. However, even with the build-out of this property, the total water demand to the Town's system is not anticipated to experience significant growth.

5.7.1 Raw Water Supply

The Town of Vinton depends on wells for its supply of drinking water. Several of the wells have extremely high yields. There has been no indication of surface influence

in any of the wells. The Town plans to continue to depend on these wells for the foreseeable future. Since there is no raw water storage in the Town's system, the future surplus estimates are based on the peak day demand, see Table 5.7.

Table 5.7
Town of Vinton Projections (mgd)

	2020	2050
Average Daily Demand	2.0	2.0
Peak Day Demand	3.0	3.0
Available Raw Water Supply	4.4	4.4
Raw Water Surplus/Deficit	1.4	1.4
Potable Water Capacity	4.4	4.4
Potable Water Surplus/Deficit	1.4	1.4

5.7.2 Treatment Capacity

Since the Town relies on groundwater as its principal supply, they do not operate any treatment plants. The availability of potable water, as well as the anticipated surpluses are equivalent to that for raw water.

5.7.3 Distribution

As stated above, the Town is built-out, and no additional service area is anticipated. The Town has interconnections with the City of Roanoke and Roanoke County.

5.8 Regional Summary

The study area is a mix of rural and suburban areas experiencing and anticipating growth, and established urban communities with limited future growth potential. Summarizing the total projected deficit for the region, shown in Table 5.8, is helpful in assessing the overall need for development of additional resources. It should be noted, however, that the summary data does not indicate the particular needs of individual communities and does not address the location of surpluses and deficits relative to potential raw water sources. Specific alternatives to address anticipated deficits are described in the following section of this report. Figure 5.1 shows projected 2050 raw and finished water surplus/deficits per community.

5.8.1 Raw Water Supply

The raw water sources described above are run-of-river intakes, raw water impoundments and groundwater resources (both wells and springs). The surpluses and deficits listed below are a summary of the individual locality surpluses/deficits. As indicated above, the calculations were based on average daily demand for those communities that had raw water storage, and maximum day demand for those communities using wells or run-of-river intakes. The cumulative numbers reflect these different assumptions. If the region were interconnected into a truly integrated system, such that each locality would have access to raw water storage, the overall surplus/demand estimates could be based on the sum of average daily demands. However, since the systems are not currently interconnected to allow for this sharing of daily peak flows, they were treated as separate systems for this analysis. Any benefits realized by future interconnections are reflected in the analysis presented in the next section of this report.

Table 5.8
Projections (mgd) for Study Communities

	2020	2050
Average Daily Demand	55.8	70.1
Peak Day Demand	83.5	105.3
Available Raw Water Supply	60.2	60.2
Raw Water Surplus/Deficit	-2.7	-19.3
Potable Water Capacity	73.7	73.7
Potable Water Surplus/Deficit	-9.9	-31.7

Using the accepted procedures for water supply planning, the existing supply and treatment capacities are compared to estimated future needs to calculate a projected water supply shortfall, or deficit. It should be noted that projects that are planned, but not yet implemented are evaluated in the alternatives section, unless construction is currently underway. The growing counties of Bedford, Botetourt, and Franklin are notable in that they continue to develop plans and pursue solutions for their future needs that are identified as deficits in this report.

5.8.2 Treatment Capacity

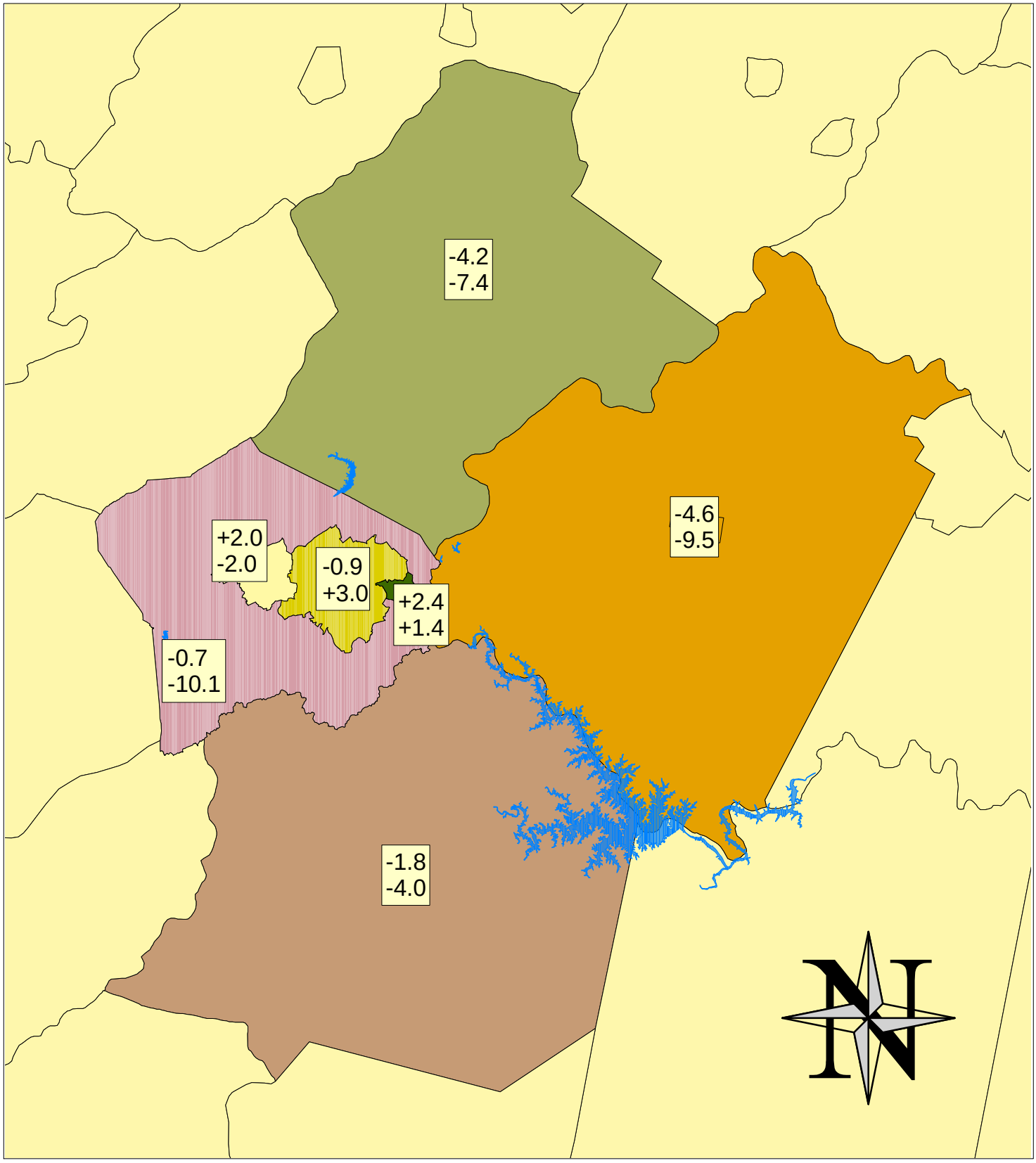
As noted above, the cumulative projections listed in Table 5.8 do not reflect the location of facilities relative to the anticipated demand. Additionally, the treatment capacity is based on the rated capacity of treatment facilities whether or not raw water is available to realize those capacities. It should also be noted that operating wells are included in the total treatment capacity whether or not the water is treated, because they add to the available potable water.

5.8.3 Distribution

The potential for additional distribution systems are noted for each locality. Generally, the more rural counties (Bedford, Botetourt and Franklin) have the greatest need for additional distribution in order to provide water to their anticipated service areas. Though Roanoke County already has a significant distribution system, there are still large areas of the County that will require infrastructure in the future. The more urbanized communities (the City of Roanoke, the City of Salem and the Town of Vinton), have limited need for further distribution within their service areas.

The City of Roanoke, Roanoke County, the City of Salem and the Town of Vinton already have extensive interconnections and have the capability to provide water to each other on an emergency basis, and can exchange a limited amount of capacity on an on-going basis. However, in order to exchange enough flow to operate as a regional system, additional interconnection capacity would need to be developed, especially between Roanoke County and the City of Roanoke.

The other communities (Bedford County, Botetourt County and Franklin County) are fairly isolated in relation to the other communities in the study. Small service areas in Bedford and Botetourt County are served with water purchased from City of Roanoke and County, respectively. Franklin County has plans to build a line connecting areas of the County with BCPSA. Each of these communities will require significant investment in infrastructure to establish connected systems, both internal to each county and to share resources across jurisdictional boundaries.



2050 Raw Water Surplus (+) / Deficit (-)
2050 Finished Water Surplus (+) / Deficit (-)

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Regional 2050 Surplus/Deficit

Figure 5.1

6.0 Alternative Sources of Supply

6.1 Introduction

A detailed analysis of projected water deficits for each locality and the region as a whole are presented in Chapter 5. A summary of the projected surpluses and deficits for year 2050 is presented in Table 6.1. Generally, the required treatment capacity for each alternative is based on the projected peak day demand for the utilities served by that alternative. The required raw water capacity was also based on the projected peak day demand, except that for raw water storage facilities (reservoirs), the available capacity in meeting the peak day demand was assumed to be 1.5 times the long-term constant withdrawal capacity of that facility. The available capacity of well and run-of-river intakes was compared to the peak day demand, with no peaking. The finished water surplus or deficit shown is based on the system component that limits peak day supply capabilities. In some localities, treatment capacity is the limiting factor, and in others, sources of supply are the limiting factors. The alternatives are structured to provide facilities to satisfy the combination of raw water, treatment, and finished water deficits or surpluses for the different combinations of users considered.

Table 6.1
Estimated 2050 Surplus/Deficit by Locality

	Raw Water Surplus/Deficit Based on Average Daily Demand (mgd)	Raw Water Surplus/Deficit Based on Peak Day Demand (mgd)	Finished Water Surplus/Deficit (mgd)
Bedford County	-4.6	-9.0	-9.5
Botetourt County	-4.2	-7.4	-7.4
Franklin County	-1.8	-4.0	-4.0
Roanoke County	-0.7	-2.6	-10.1
City of Roanoke	-0.9	-3.2	+3.0
City of Salem	+2.0	-2.0	-2.0
Town of Vinton	+2.4	+1.4	+1.4

6.1.1 Alternatives Considered

In order to address the estimated future deficits, several alternatives were considered. The primary alternatives considered for this report include the following:

1. Augmentation of the Spring Hollow System
2. Augmentation of the Carvins Cove Reservoir System.
3. Expansion of the existing BCPSA Water Plant or construction of a new regional water treatment plant on Smith Mountain Lake.

Each of these sets of alternatives was considered for serving the future needs of individual localities and for serving the needs of neighboring and regional municipalities. In addition to these major regional alternatives, several other sources of water supply were considered, which include the following:

1. New reservoir sites throughout the region.
2. Groundwater supply.
3. Conservation and demand management.
4. Water reuse.

6.1.2 Cost Assumptions

All costs presented in this section are planning level costs are presented primarily for the purpose of comparison between alternatives. A more detailed engineering analysis will be required to provide budget costs for a chosen alternative. As noted in the previous chapter, losses due to distribution and treatment losses are accounted for in the projected demands. For delivery of raw water to a raw water storage system average daily demands were used. In the case of finished water delivery, the peak day demand was used for sizing system components.

The installed unit costs used for estimating the project costs are as follows:

Pipeline

Size, inches	Unit Cost $/ft
14	84
16	96
18	108
20	120

24	140
30	175
36	210

New Pumping Station

Size, mgd	Unit Cost $/mgd
5	126,000
10	101,000
20	78,000

Expansion of Existing Pumping Station

Use one-half cost of new pumping station.

Water Treatment Plant

$2.0/gal for new water treatment plant.

$1.5/gal for expansion of existing water treatment plant.

Contingency

20% Contingency

10% Engineering

10% Land, legal, administration.

For the purposes of calculating annual operating cosots and present worth costs for the various alternatives, the following parameters were used:

Annual Inflation Rate = 3%
Interest Rate = 6%
Electricity Cost = $0.04/KWHr
Project Life Cycle = 20 Years

6.2 Augmentation of Spring Hollow System

There are several alternatives for augmenting the finished water available in the Roanoke County system. These include providing additional raw water supplies to the Spring Hollow Reservoir, increasing storage volume in the Spring Hollow Reservoir, and delivering additional finished water supplies to the Roanoke County system from the Blacksburg Christiansburg VPI (BCVPI) system. The first two will require expansion of

Roanoke County's existing water treatment plant. The third will require expansion of the BCVPI water treatment plant.

Additional raw water supplies in the Roanoke County system can be dedicated solely to meeting the County's long-term deficit (0.7 mgd), or meeting the combined Roanoke County deficit and the City of Roanoke deficit (0.7 mgd + 0.9 mgd = 1.6 mgd), or meeting these deficits plus one-half of Botetourt County's deficiency (0.7 mgd + 0.9 mgd + 2.1 mgd = 3.7 mgd). So, three options sized for 0.7 mgd, 1.6 mgd, and 3.7 mgd are evaluated.

6.2.1 New River Supply Option

The New River, which is located to the southwest of the Roanoke Valley, has a significantly larger watershed and a much larger base flow than does the Roanoke River. The New River has an average flow at Radford of over 3,800 cfs (2,500 mgd) as compared to 240 cfs (160 mgd) for the Roanoke River near the Roanoke County intake. For its size, there are relatively few large intakes on the New River. Based on this, the New River could be a source for supplemental water resources.

There are several advantages to the use of New River Valley water in the long-term water supply planning for the Roanoke Valley. In addition to being a larger and somewhat more drought-resistant resource, the New River drains a much larger area and so may not be affected to the extent the Roanoke Valley is by any given drought event. Additionally, there are no other large metropolitan water providers located on the New River; therefore, there may not be as much competition in the long-term for the river's resources as there might be on the James River.

A disadvantage of this alternative is that the use of New River water would represent an inter-basin transfer. Potential exists for this becoming a regulatory and political hurdle, especially if a new water intake permit is required.

Three alternatives for withdrawal from the New River were considered. These include the use of the BCVPI intakes at Pepper's Ferry, the construction (and permitting) of a new intake in the Pepper's Ferry area, or the use of an existing intake or source on the Radford Army Arsenal reservation. Each of these alternatives is discussed below.

In addition to the intake alternatives, there are two basic alternatives for delivering water from the New River to the Spring Hollow Reservoir. The first is to pump the water over the eastern continental divide into the Roanoke watershed, such that it augments Roanoke River flow. The second alternative is to pump the water all of the way from the New River intake to Spring Hollow Reservoir. Each of these alternatives is considered separately below.

6.2.1.1 Intake Alternatives. Three intake alternatives are described below. Each has advantages and disadvantages with respect to costs, regulatory, and institutional issues.

6.2.1.1.1 Blacksburg-Christiansburg-VPI Water Authority Intake. The BCVPI currently owns and operates two intakes on the New River at Pepper's Ferry just downstream of the City of Radford. Preliminary discussions with BCVPI indicate a willingness to consider allowing additional water to be taken at their intake for transmission to the Roanoke Valley. This alternative has several benefits. First and foremost, this is an existing withdrawal. Depending on the capacity of the additional withdrawal and type of modifications needed, limited permitting would be required. Also, cooperative operation of the facility with BCVPI would benefit both parties by allowing them to share operation and maintenance costs. In addition, the BCVPI intake is located adjacent to State Route (SR) 114. A pipeline along SR 114 would provide the most direct route from the New River to the Roanoke Valley.

A potential disadvantage with this alternative is the long-term contractual relationship that would be required between Roanoke County and the BCVPI Water Authority. This alternative will require initial and continued negotiations regarding operations, maintenance and permitting issues.

6.2.1.1.2 Construction of a New Intake on the New River. Under this alternative, a new intake would be permitted and constructed by a utility from the Roanoke Valley. Property would be purchased in the area of Pepper's Ferry for the construction of both the intake and a pumping station. Once again, a pipeline alignment along SR 114 would be the most direct route.

The advantage to this alternative is that the owning utility from the Roanoke Valley would control the intake and pumping facilities. No contractual relationships with other utilities would be required for the construction or operation of the intake.

A significant disadvantage is the requirement to permit a new water intake. A withdrawal request will trigger a series of state and federal regulations. It may also face significant local opposition, due to perceived impacts from transfer of water outside of the New River Basin.

6.2.1.1.3 Radford Arsenal Supply. The Radford Arsenal operates several intakes on the New River, downstream of BCVPI. In addition, the Arsenal has several discharges returned to the New River. The largest single discharge is water of very high quality used for cooling. It is a continuous 12 mgd supply that could be intercepted and transported to the Roanoke River Valley. Similar to existing relationships with other municipalities, the Arsenal personnel would likely construct, operate and maintain the needed facilities for a fee.

This alternative has several disadvantages. First, the Radford Arsenal source is farther from the proposed alignment of a transmission pipeline (along SR 114). This will result in additional construction and pumping costs. Second, the long-term future of the intake/source ownership is somewhat less clear than with BCVPI. BCVPI has a long-term interest and investment in the maintenance of their intake as a local utility. The U.S. Army may or may not see the advantage of maintaining their intake (and their permit) or their industrial processes over the long-term. The future of the raw water source, as part of the Arsenal facility, is subject to policy decisions made at the federal level, based on federal budget and defense priorities. The interest of maintaining local water supply facilities and permits may not always be the top priority.

6.2.1.2 Water Delivery Alternatives

6.2.1.2.1 Roanoke River Augmentation. The least expensive way to transport water from the New River to the Roanoke River is to pump the water along SR 114 across U.S. 460 and across the drainage divide between the New and Roanoke River Basins. The water would then flow by gravity into a Roanoke River tributary (Wilson Creek). The additional flow in the Roanoke River could then be taken back out of the River at Roanoke County's intake and pumped into the Spring Hollow Reservoir. The obvious benefit of this approach is its relatively low cost. The length of pipeline required is only 9.6 miles to discharge into Wilson Creek, as opposed to 26.5 miles to pump all the way to Spring Hollow Reservoir.

There are, however, significant disadvantages to this approach. It is unlikely that adding water to the upper Roanoke River watershed will relieve the County's regulatory

requirements regarding minimum in-stream flows in the Roanoke River. Currently, as long as the river flow is above the required minimum flow limits defined in the County's permits, the amount of water that can be pumped to the Spring Hollow Reservoir is limited only by the pumping capacity at the river intake pumping station. If the flow at the intake drops below the permitted minimum, the pumping must cease, regardless of whether the flow is being augmented upstream. Therefore, augmenting the flow in the Roanoke River would benefit the Spring Hollow operations if the additional water causes the flow at the intake to exceed the minimum flow-by requirements.

Another significant disadvantage of this alternative is the uncertainty of transmission along the Roanoke River. Since the County's permit is keyed to flow at the intake, additional flow in the river will impact water availability only to the extent that it reaches the intake. Natural river flow is subject to groundwater infiltration and exfiltration depending on hydrologic conditions, as well as evaporation. There may also be agricultural and other third-party withdrawals along the upper Roanoke River. During low flow or drought conditions when the additional water will be needed, a significant amount of water will likely be lost along the greater than 20 river miles between the New River pipeline discharge and the Roanoke County intake. In order to compensate for this loss, the pumping station and the pipeline will need to be oversized with regard to the additional water actually delivered at the intake. Estimating the amount of loss for design purposes will be extremely difficult and will likely result in additional engineering and construction costs. For the purpose of estimating construction costs for this alternative, it is assumed that twice the pumping capacity would be provided to pump New River water to Wilson Creek. The actual design capacity will require additional study.

There are other possible regulatory concerns regarding the discharge of water from one river basin into another river basin and concerns regarding the impact of large continuous flows on relatively small tributaries.

6.2.1.2.2 Piping of Water from the New River Intake to the Spring Hollow Reservoir. A much more technically dependable solution would be to pipe the water all the way from the intake on the New River to the Spring Hollow Reservoir. This has the advantage that each gallon delivered to the Spring Hollow Reservoir would be immediately and dependably available for treatment. One significant disadvantage to this alternative would be the cost of over 26 miles of pipeline. Also, much of the alignment would be along the Roanoke River itself, with associated environmental and regulatory impacts.

6.2.1.3 Estimated Project Costs. The estimated project costs for delivering raw water from New River to Spring Hollow Reservoir are shown in Tables 6.2 through 6.4.

Table 6.2
Delivery of Raw Water from New River
to Spring Hollow Reservoir to Serve Roanoke County

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
BCVPI Intake to Wilson Creek	0.7	10.1 mgd Treatment Capacity at Roanoke County Pumping Station (4 mgd) Pipeline (50,500 lf, 16”)	$29 M
BCVPI Intake to Spring Hollow Reservoir	0.7	10.1 mgd Treatment Capacity at Roanoke County Pumping Station (2 mgd) Pipeline (140,000 lf, 12”)	$36 M

Table 6.3
Delivery of Raw Water from New River to
Spring Hollow Reservoir to Serve Roanoke County and The City of Roanoke

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
BCVPI Intake to Wilson Creek	1.6	13.3 mgd Treatment Capacity at Roanoke County Pumping Station (8 mgd) Pipeline (50,500 lf, 24”)	$39 M
BCVPI Intake to Spring Hollow Reservoir	1.6	13.3 mgd Treatment Capacity Pumping Station (4 mgd) Pipeline (140,000 lf, 16”)	$47 M

Table 6.4
Delivery of Raw Water from New River to Spring Hollow Reservoir to Serve Roanoke County, City of Roanoke and 1/2 Botetourt County Demand

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
BCVPI Intake to Wilson Creek	3.7	17.0 mgd Treatment Capacity at Roanoke County Pumping Station (14 mgd) Pipeline (50,500 lf, 30") Connection Between The City of Roanoke and Botetourt County	$55 M
BCVPI Intake to Spring Hollow Reservoir	3.7	17.0 mgd Treatment Capacity at Roanoke County Pumping Station (7 mgd) Pipeline (140,000 lf, 20") Connection Between The City of Roanoke and Botetourt County	$65 M

6.2.2 *Expand Spring Hollow Reservoir*

The most practical alternative for expanding the storage volume of the Spring Hollow Reservoir would be to increase the operating depth of the reservoir. Spring Hollow reservoir is an offline storage reservoir that pumps raw water from the Roanoke River when available, based on a withdrawal permit issued by the DEQ. The reservoir was designed to withstand the PMF without overtopping the dam; the top of dam is at elevation 1,420 feet above msl. Design calculations of the dam performed at the time of permitting determined that the reservoir would need to be maintained at a maximum stage of 1,412.6 feet above msl (3,200 mg), leaving 7.4 feet of freeboard to hold the PMF without overtopping the dam. One of the alternatives to augment raw water supply for the region is to increase the normal pool elevation at Spring Hollow reservoir. Using a mass-balance model for the reservoir and a full pool elevation of 1,412.6 feet, a constant withdrawal rate of 15.0 mgd was computed. Augmenting the reservoir volume, by allowing the reservoir normal pool elevation to increase by three feet to 1,415.6 feet, yields a constant withdrawal rate of 15.6 mgd.

The advantage with this alternative is that there are minimal capital costs associated with it since the top of the dam stands at elevation 1,420 ft above msl. The disadvantages are that this alternative may not be feasible since, under the dam's permit, the dam needs to withstand the PMF without dam overtopping. Detailed analysis of the PMF event and the effects on Spring Hollow reservoir's stage will need to be re-evaluated to determine if raising the normal pool elevation by 3 feet could cause the dam to be overtopped. Consultation with and the approval of Virginia Dam Safety officials will be required. Overall, the potential complications and uncertainties appear to outweigh the benefit of an increase of 0.6 mgd.

6.2.3 Finished Water Connection to BCVPI System

BCVPI currently operates a 12.5 mgd water treatment plant, treating water from the New River. BCVPI's existing distribution system extends east beyond Christiansburg on U.S. 11. One alternative for providing additional water supplies to the Roanoke Valley would be to purchase water from BCVPI at a point on the eastern end of their distribution system and pipe it to Roanoke County's system near their water treatment plant. At that point, the water could be fed into the County's North Loop system which serves both the northern portion of the County and can feed into the City of Roanoke's system.

BCVPI's water treatment plant does not have the capacity to provide for the Roanoke Valley's long-term deficit. At some point in the medium-term, a plant expansion would be required. In terms of estimated project costs, it was assumed that the municipalities receiving finished water would be responsible for the capital costs associated with the additional capacity, either directly as a capital expenditure, as an annual share of debt service, or through wholesale water fees. This is summarized in Table 6.5.

Table 6.5
Purchase of BCVPI Finished Water

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
Roanoke County and City of Roanoke Deficits	1.6	Additional 13.3 mgd Treatment Capacity at BCVPI Pipeline (85,000 lf, 30”)	$49 M
Roanoke County, City of Roanoke, and 1/2 Botetourt County Deficits	3.7	Additional 17.0 mgd Treatment Capacity at BCVPI Pipeline (85,000 lf, 36”) Connection Between The City of Roanoke and Botetourt County	$66 M

6.3 Augmentation of the Carvins Cove System

As with Spring Hollow, there are several alternatives for augmenting flow to the City of Roanoke’s Carvins Cove System. These include providing additional raw water to Carvins Cove and increasing the size of the Carvins Cove Reservoir. In terms of the beneficiaries for the additional capacity, four scenarios were considered.

1. The first scenario would be to meet the City of Roanoke’s long-term needs only. This is estimated to be approximately 0.9 mgd additional capacity.

2. The second scenario would be to meet the future needs of both Roanoke County and the City of Roanoke (0.7 mgd + 0.9 mgd = 1.6 mgd).

3. The third scenario would be to provide enough capacity for demands from the City of Roanoke, Roanoke County and one-half Botetourt County (0.7 mgd + 0.9 mgd + 2.1 mgd = 3.7 mgd).

4. A fourth scenario would be to expand the capacity of the City of Roanoke system to meet the needs of all municipalities in the study (12.2 mgd).

6.3.1 Pipeline from Spring Hollow Reservoir/Roanoke River

The Carvins Cove reservoir is a relatively large reservoir, but has a relatively small drainage area. That drainage area is augmented by flow from Tinkers Creek and Catawba Creek, but flow from these creeks is limited by minimum in-stream flow agreements with Botetourt County. Due to this lack of inflow as compared to available storage volume, during much of the year the storage potential of Carvins Cove is under utilized.

In contrast, the regulation governing the operation of Spring Hollow reservoir allows a relatively large amount of water to be pumped from the Roanoke River into Spring Hollow as long as minimum in-stream flow conditions are maintained on the Roanoke River. However, the amount of water that can be pumped from the Roanoke River is often limited by the amount of storage available in the Spring Hollow Reservoir.

The objective of this alternative is to optimize each reservoir's potential by taking advantage of each reservoir's strengths. Connecting the two reservoirs to take advantage of the large inflows at Spring Hollow reservoir and storing them at Carvins Cove reservoir increases Carvins Cove constant withdrawal rate from 14.1 mgd to 15.8 mgd, while keeping Spring Hollow's withdrawal rate at 15.0 mgd.

6.3.1.1 Pumping from the Roanoke River to Carvins Cove. One alternative to maximize the utilization of both of these resources is to build a pipeline from the Roanoke River/Spring Hollow system to the Carvins Cove Reservoir. During times when Spring Hollow is full and the flow in the Roanoke River exceeds the minimum in-stream flow, water can be pumped from the river and stored in Carvins Cove. This could allow Carvins Cove to stay full, or more full later into the dry portion of the year, and will help it to sustain the Roanoke County/City of Roanoke system through drought years. Increased pumping capacity is needed to capture the river flows during the brief periods when it is available, and a large pipeline is needed to carry that flow to Carvins Cove. A summary of this alternative is presented in Table 6.6.

Table 6.6
Pumping from Roanoke River to Carvins Cove

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
Pumping from Roanoke River Intake to Carvins Cove	1.7	40 mgd Pumping Capacity to Carvins Cove Pipeline (67,000 lf, 48”)	$28 M
Pumping from Roanoke River Intake to Carvins Cove with 3 ft Additional Depth at Carvins Cove	3.0	40 mgd Pumping Capacity to Carvins Cove Pipeline (67,000 lf, 48”) Rubber Dam	$30 M

6.3.1.2 Pumping from Spring Hollow Reservoir to Carvins Cove. A modification of the previous option involves pumping from the Roanoke River, when flow is available, and storing it in Spring Hollow Reservoir for gradual transfer by pumping to Carvins Cove Reservoir. Economic benefits may be realized from the modified transfer scenario because continuous pumping to Carvins Cove at a lower rate will allow a smaller diameter pipeline to be used. The modified transfer pumping scenario may require the normal operating pool of Spring Hollow Reservoir to be exceeded for periods when high river flows are available for capture and storage in Spring Hollow. The disadvantage of this is that the 7.4 feet of freeboard between the normal operating pool (El. 1,412.6 ft) and the elevation needed to contain the PMF may be reduced during the period that water is being transferred to Carvins Cove. Operating in this manner would require consultation with and the approval of Virginia Dam Safety officials. The Operating Certificate for Spring Hollow Dam may need to be modified. A summary of this alternative is presented in Table 6.7.

Table 6.7 Pumping from Spring Hollow to Carvins Cove (Modified Spring Hollow operation)			
Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
Pumping from Spring Hollow Reservoir to Carvins Cove	1.7	40 mgd Pumping Capacity to Spring Hollow 1.7 mgd Pumping Capacity to Carvins Cove Pipeline (88,500 lf, 12”)	$9 M
Pumping from Spring Hollow Reservoir to Carvins Cove with 3 ft Additional Depth at Carvins Cove	3.0	40 mgd Pumping Capacity to Spring Hollow 1.7 mgd Pumping Capacity to Carvins Cove Pipeline (88,500 lf, 12”) Rubber Dam	$11 M

6.3.2 New River Supply Alternatives

Alternatives for providing New River water to augment flow to the Carvins Cove Reservoir are similar to those presented above for augmenting flow to the Spring Hollow Reservoir. The intake alternatives would be the same as presented above: use of BCVPI intake, construction of a new intake, or use of an intake on the Radford Arsenal facility. As with the Spring Hollow alternatives, the pipeline would be routed along SR 114 over U.S. 460, over the drainage divide, and into the Roanoke valley. The relative merits of each intake alternative were discussed previously. As with the Spring Hollow analysis, the BCVPI intake alternative was considered for cost estimating. Once over the drainage divide, the water would be piped either to the upper reaches of the Catawba Creek or directly to Carvins Cove Reservoir.

Discharge into Catawba Creek would require 26 miles of pipeline and would have similar disadvantages to those described previously for discharge into the upper reaches of the Roanoke River. The additional flow would not be beneficial once the augmented flow dropped below the minimum in-stream flow required in Catawba Creek. Also, the additional flow would be subject to losses due to evaporation, exfiltration and other uses

between the New River pipeline discharge and the Carvins Cove diversion. There is, however, a difference in the way water is taken from Catawba Creek into Carvins Cove as compared to the Roanoke County intake on the Roanoke River. The Catawba Creek diversion is provided by a fixed weir which allows gravity flow into Carvins Cove. Therefore, even at high base flows, additional flow in Catawba Creek will result in additional flows to Carvins Cove. The magnitude of this additional flow is dependent on the particular stream and weir geometry. Additional study would be required to quantify the potential effects. Piping the water directly to Carvins Cove Reservoir would be more straight-forward from a technical and regulatory stand-point; but would require over 43 miles of pipeline.

Due to the relatively high cost associated with this alternative, it was assumed that it would not be feasible for providing additional water to the City of Roanoke only, or to the City and County of Roanoke combined. Both of these deficits can be met by less costly projects. Therefore, costs were developed for two options: serving Roanoke County, the City of Roanoke and one-half Botetourt County (3.7 mgd), and for serving all of the deficits in the region (12.2 mgd). The facilities required for technical details regarding these alternatives and these projected costs are presented in Tables 6.8 and 6.9.

Table 6.8
Delivery of Raw Water from New River to Carvins Cove Reservoir to Serve City of Roanoke, Roanoke County and ½ of Botetourt County's Demand

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
BCVPI Intake to Catawba Creek	3.7	Additional 10.8 mgd Treatment Capacity at Carvins Cove WTP Pumping Station (24 mgd) Pipeline (139,000 lf, 42") Connection Between The City of Roanoke and Botetourt Systems	$78 M
BCVPI Intake to Carvins Cove Reservoir	3.7	Additional 10.8 mgd Treatment Capacity at Carvins Cove WTP Pumping Station (12 mgd,) Pipeline (227,500 lf, 30") Connection Between The City of Roanoke and Botetourt Systems	$85 M

Table 6.9
Delivery of Raw Water from New River to Carvins Cove Reservoir to Serve Entire Regional Deficit

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
BCVPI Intake to Catawba Creek	12.2	Additional 28.1 mgd Treatment Capacity at Carvins Cove WTP Pumping Station (46 mgd) Pipeline (139,000 lf, 54") Connection Between City of Roanoke and Botetourt Systems Connection Between City of Roanoke and Bedford County Connection Between Roanoke County and Franklin County	$151 M
BCVPI Intake to Carvins Cove Reservoir	12.2	Additional 28.1 mgd Treatment Capacity at Carvins Cove WTP Pumping Station (23 mgd) Pipeline (227,500 lf, 36") Connection Between City of Roanoke and Botetourt Systems Connection Between City of Roanoke and Bedford County Connection Between Roanoke County and Franklin County	$154 M

6.3.3 Expand Carvins Cove Reservoir

Carvins Cove Reservoir has a relatively large storage volume, but limited inflow. The dam consists of a 315-feet wide concrete ogee spillway that is tied to rock at both ends. The top of the spillway crest stands at an elevation of 1,170 feet above msl.

Increasing the reservoir volume by installing an inflatable rubber bladder of 3 to 5 feet in diameter would increase the storage capacity by 1.4 to 1.9 mgd, while capital costs would be relatively low, see Table 6.10.

Using a mass-balance model, the reservoir's operations were simulated for approximately the last 100 years. Setting the full-pool elevation of the reservoir at 1,170 feet, the model calculated that the reservoir would yield a constant withdrawal rate of 14.1 mgd, under critical drought conditions occurring in 2002. Setting the full-pool elevation of the reservoir at 1,173 feet (3 feet higher than normal pool), the model calculated that the reservoir would yield a constant withdrawal rate of 15.5 mgd. Setting the full-pool elevation of the reservoir at 1,175 feet (5 feet higher than normal pool), the model calculated that the reservoir would yield a constant withdrawal rate of 16.0 mgd.

Table 6.10
Expansion of Carvins Cove Reservoir

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
Installation of 3' Rubber Dam	1.4	Rubber Dam and Air System	$2 M

6.3.4 James River Raw Water Supply

Several pipeline alignments are possible for pumping water from the James to Carvins Cove. The 1980 Moore, Gardner & Associates Report considered a pipeline from the north, bringing water into Carvins Cove over Tinker Mountain. However, it was concluded that the pumping costs for that route would be prohibitive. A second possible alignment would be to follow the alignment, roughly, of U.S. 11 and Interstate 81, and to access Carvins Cove by following Carvins Creek past the dam. This would reduce the elevation difference and pumping head. The technical details for this alternative are presented in Table 6.11.

An advantage to this alternative is that it allows access to a water resource that is outside the Roanoke Valley, and, therefore, may not be as affected by localized drought. The James River also has control structures upstream and a relatively large lake (Lake Moomaw). This may allow for somewhat less susceptibility to drought, as compared to the Roanoke River.

From a regulatory and political standpoint, the fact that the Roanoke Valley would be tapping a separate watershed could be problematic. The issue of inter-basin transfer

could prove to be an impediment to permitting of an intake on the James River. Particularly due to the recent drought events, there may also be resistance from other large municipalities with downstream intakes, who depend on the James River as a municipal water source.

Table 6.11
Delivery of Raw Water from James River to Carvins Cove Reservoir

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
New James River Intake to Carvins Cove	12.2	Additional 28.1 mgd Treatment Capacity at Carvins Cove WTP Pumping Station (23 mgd) Pipeline (99,500 lf, 36") Connection Between The City of Roanoke and Botetourt Systems Connection Between The City of Roanoke and Bedford County Connection Between Roanoke County and Franklin County	$116 M

It is quite reasonable, from a local perspective, that an intake on the James River could be constructed to provide water supply to Botetourt County only. Since part of Botetourt County is located in the James River basin, and a smaller withdrawal would be needed than for the regional option, this option would not be as subject to opposition from downstream users of the James River.

6.3.5 Smith Mountain Lake Raw Water Supply to Carvins Cove

Another alternative for providing additional water to Carvins Cove Reservoir is to pump raw water from Smith Mountain Lake. This has the advantage of a very large source of raw water that is relatively drought resistant. Additionally, due to the City's wastewater discharge upstream of the lake, and the operation of the lake as part of a pump-storage electrical generation system, it is probable that an intake can be obtained

with minimal pumping restrictions. This alternative also has the advantage of staying within the Roanoke River watershed. There is no inter-basin transfer issues associated with this alternative. Though the impacts to the lake from a withdrawal will be minimal, there may be political resistance from area landowners regarding a new withdrawal permit.

Detailed technical information and cost estimates for this alternative are presented in Table 6.12.

Table 6.12
Delivery of Raw Water from Smith Mountain Lake to Carvins Cove Reservoir

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
Smith Mountain Lake Intake to Carvins Cove to Serve Roanoke County and The City of Roanoke	1.6	Additional 7.1 mgd Treatment Capacity at The Carvins Cove WTP Pumping Station (9 mgd) Pipeline (80,000 lf, 24”)	$32 M
Smith Mountain Lake Intake to Carvins Cove to Serve Roanoke County and The City of Roanoke and 1/2 Botetourt County	3.7	Additional 10.8 mgd Treatment Capacity at The Carvins Cove WTP Pumping Station (12 mgd) Pipeline (80,000 lf, 30”)	$49 M
Smith Mountain Lake Intake to Carvins Cove to Serve Entire Regional Deficit	12.2	Additional 28.1 mgd Treatment Capacity at The Carvins Cove WTP Pumping Station (23 mgd) Pipeline (80,000 lf, 36”) Connection Between The City of Roanoke and Botetourt Systems Connection Between The City of Roanoke and Bedford County Connection Between Roanoke County and Franklin County	$110 M

6.4 Regional Water Treatment Plant on Smith Mountain Lake

The BCPSA currently owns and operates a 0.06 mgd membrane filtration plant on Smith Mountain Lake. BCPSA has a permit for withdrawal of 0.5 mgd, but is considering expansion. Based on the size of the lake and its use along with Leesville Lake as part of a pump-back electrical power generation/storage facility, a relatively large amount of water could be withdrawn for water supply before there is significant impact to downstream flows.

For evaluation of a regional plant, it was assumed the existing BCPSA plant would be expanded. Ownership of the plant could either be by BCPSA or by a regional authority. Though this will impact the direct oversight and financing of the plant, it should not have a significant impact on the long-term costs to either the region as a whole or to any individual municipal wholesale customer. Capital cost will be distributed either through debt service or water use fees. Either way, the impact to individual municipalities should be similar depending on reserved capacity and actual water use.

Within the scope of this study, the most likely consumers of finished water produced at Smith Mountain Lake plant would be Bedford and Franklin Counties. Both have been identified as having future water needs that exceed their current supply capabilities. In the case of Bedford County, the areas around the lake and the western portion of the County are the most likely to be serviced from Smith Mountain lake in the near future. The eastern portions of the County are currently serviced by water purchased from the City of Lynchburg, which is understood to have available capacity. However, in the long-term, BCPSA may determine that it is preferred to eventually service larger portions of the County from Smith Mountain Lake. Also, if the County were to develop additional customers in the east that required piping of water in that direction, it might prove to be cost effective to provide service to the eastern portion of the County from Smith Mountain Lake at that time.

The most likely areas of Franklin to be serviced immediately are the lake front communities currently serviced by a series of private well systems. In the short-term, the rest of the County would appear to have sufficient capacity. The Town of Rocky Mount has extra capacity, and Boones Mill is generally keeping up with demand. However, in order to foster long-term development and possibly to support water dependent industries, a connection between Smith Mountain lake and U.S. 220 corridor may be

required. For the purposes of this study, it was assumed that a pipeline would be constructed from the treatment plant across Hales Ford Bridge and along S.R. 122 to U.S. 220 near Rocky Mount.

Beyond Bedford and Franklin Counties, the other entities' deficit could be met by building additional capacity in the Smith Mountain Lake plant and piping finished water to either the City of Roanoke or Roanoke County distribution systems. For the purposes of this study, it was assumed that a pipeline would be constructed between the plant site and Roanoke County along S.R . 24.

These three alternatives are detailed below and in Table 6.13:

1. The first alternative is a new plant sized to serve Bedford and Franklin Counties' long-term needs and piping to transmit water to Franklin County (4.6 mgd + 1.8 mgd = 6.4 mgd).

2. The second alternative is a new plant sized to serve Bedford, Franklin and Roanoke Counties and the City of Roanoke (4.6 mgd + 1.8 mgd + 0.7 mgd + 0.9 mgd = 8.0 mgd), a pipeline to provide water to Franklin County, and a pipeline to provide water to the City of Roanoke and Roanoke County.

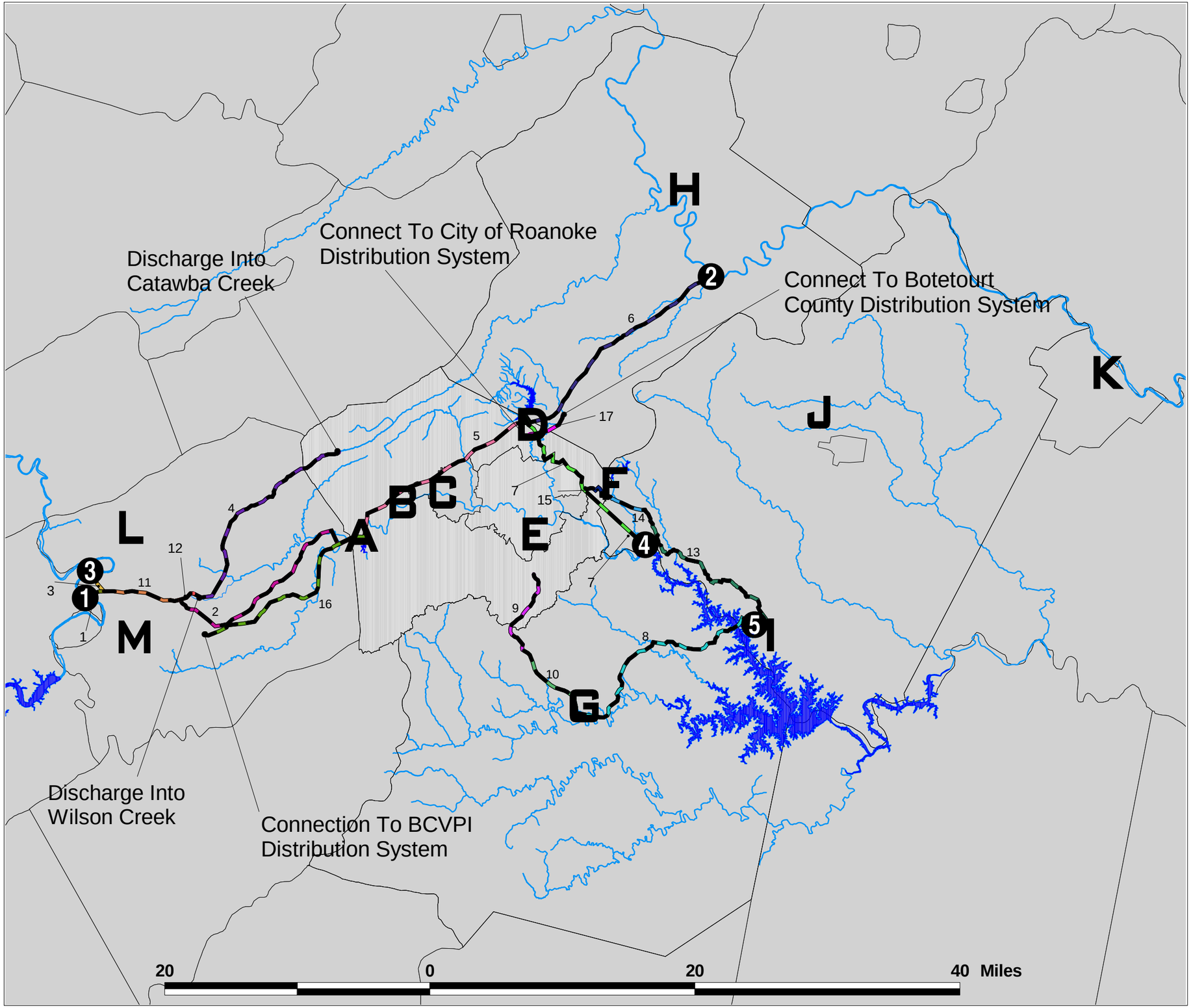
3. The third alternative is to construct a new plant sized to serve all of the above localities plus Botetourt County's demand (4.6 mgd + 1.8 mgd + 0.7 mgd + 0.9 mgd + 4.2 mgd = 12.2 mgd).

Table 6.13
Smith Mountain Lake Regional Treatment Plant

Description	Average Daily Demand Capacity (mgd)	Required Infrastructure	Estimated Project Costs
Service for Bedford and Franklin Counties	6.4	13.6 mgd Treatment Capacity Franklin Pumping Station (4 mgd) Pipeline (110,000 lf, 16”)	$54 M
Service for Bedford, Franklin and Roanoke Counties, and the City of Roanoke	8.0	26.9 mgd Treatment Capacity Franklin Pumping Station (4 mgd) Franklin Pipeline (110,000 lf, 16”) Roanoke Pumping Station (14 mgd) Roanoke Pipeline (116,500 lf, 30”)	$121 M
Service for Bedford, Franklin and Roanoke Counties, the City of Roanoke and Botetourt County Demand	12.2	34.3 mgd Treatment Capacity Franklin Pumping Station (4 mgd) Franklin Pipeline (110,000 lf, 16”) Roanoke Pumping Station (21 mgd) Roanoke Pipeline (116,500 lf, 36”) Connection Between The City of Roanoke and Botetourt Systems	$ 156 M

6.5 Cost Summary

A summary of estimated project costs and present worth costs are presented in Table 6.14. The present worth cost estimates include project capital costs and pumping costs for a period of 20 years.



Water Treatment Plants

- A SPRING HOLLOW WTP
- B GLENVAR WTP
- C SALEM WTP
- D CARVINS COVE WTP
- E CRYSTAL SPRING WTP
- F FALLING CREEK WTP
- G ROCKY MOUNT WTP
- H EAGLE ROCK WATER CO
- I HIGH POINT WTP
- J CITY OF BEDFORD WTP
- K LYNCHBURG WTP
- L BCVPI WTP
- M RADFORD ARSENAL

Raw Water Intakes

1. BCVPI Water Authority
2. James River Intake
3. Radford Arsenal
4. Smith Mountain Lake at Hardy Bridge
5. Smith Mountain Lake Intake

Figure 6.1

Summary of Regional Source Water Alternatives

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Table 6.14
Summary of Cost Estimates for Alternatives to Meet 2050 Demands

Description	Communities Served							Estimated Project Cost (Millions)	Present Worth[1] (Millions)	Pipeline Required[2]
	Bedford County	Botetourt County	Franklin County	Roanoke County	City of Roanoke	City of Salem	Town of Vinton			
Augmentation of Spring Hollow System										
BCVPI Intake to Wilson Creek				X		X	X	$29 M	$30 M	1, 11, 12
BCVPI Intake to Spring Hollow Reservoir				X		X	X	$36 M	$37 M	1, 2, 11
BCVPI Intake to Wilson Creek				X	X	X	X	$39 M	$42 M	1, 11, 12
BCVPI Intake to Spring Hollow Reservoir				X	X	X	X	$47 M	$49 M	1, 2, 11
BCVPI Intake to Wilson Creek		X		X	X	X	X	$55 M	$60 M	1, 11, 12, 17
BCVPI Intake to Spring Hollow Reservoir		X		X	X	X	X	$65 M	$69 M	1, 2, 11, 17
Purchase of Finished Water from BCVPI				X	X	X	X	$49 M	$49 M	16
Purchase of Finished Water from BCVPI		X		X	X	X	X	$66 M	$66 M	16, 17
Augmentation of Carvins Cove System										
Pumping from Roanoke River Intake to Carvins Cove				X	X	X	X	$28 M	$34 M	5
Pumping from Roanoke River Intake to Carvins Cove and adding 3' depth at Carvins Cove Reservoir				X	X	X	X	$30 M	$36 M	5
Pumping from Spring Hollow Reservoir to Carvins Cove				X	X	X	X	$9 M	$10 M	5
Pumping from Spring Hollow Reservoir to Carvins Cove and adding 3' depth at Carvins Cove Reservoir				X	X	X	X	$11 M	$12 M	5
BCVPI Intake to Catawba Creek		X		X	X	X	X	$78 M	$90 M	1, 4, 11, 12, 17
BCVPI Intake to Carvins Cove Reservoir		X		X	X	X	X	$85 M	$92 M	1, 2, 5, 11, 17
BCVPI Intake to Catawba Creek	X	X	X	X	X	X	X	$151 M	$171 M	1, 4, 9, 10, 11, 12, 15, 17
BCVPI Intake to Carvins Cove Reservoir	X	X	X	X	X	X	X	$154 M	$168 M	1, 2, 5, 9, 10, 11, 15, 17
Expansion of Carvins Cove Reservoir (3' Rubber Dam)					X			$2 M	$2 M	-----
James River Intake to Carvins Cove	X	X	X	X	X	X	X	$116 M	$125 M	6, 9, 10, 15, 17
Smith Mountain Lake Intake to Carvins Cove				X	X	X	X	$32 M	$35 M	7
Smith Mountain Lake Intake to Carvins Cove		X		X	X	X	X	$49 M	$53 M	7, 17
Smith Mountain Lake Intake to Carvins Cove	X	X	X	X	X	X	X	$110 M	$121 M	7, 9, 10, 15, 17
Smith Mountain Lake Regional Water Treatment Plant										
Smith Mountain Lake Regional WTP	X		X					$54 M	$55 M	8
Smith Mountain Lake Regional WTP	X		X	X	X	X	X	$121 M	$126 M	8, 13, 14, 15
Smith Mountain Lake Regional WTP	X	X	X	X	X	X	X	$156 M	$163 M	8, 13, 14, 15, 17

[1] Including 20 Years Pumping Costs
[2] Numbers Correspond to Pipelines Shown in Figure 6.1

6.6 Groundwater

Groundwater has historically been a significant resource for municipalities in the region. Currently, all of the localities depend on groundwater to provide all or part of their demand. The Town of Vinton and the City of Roanoke in particular have been fortunate to find and develop relatively high yielding groundwater sources. Botetourt County is currently completely reliant on groundwater wells; Roanoke County, City of Salem, Franklin County and Bedford County each depend on wells to provide a portion of their water, either through municipal or private systems. It is likely that groundwater sources, both wells and springs, will continue to be an important part of the regional water system future. Existing groundwater sources are included in estimates of future production.

Unfortunately, predicting the extent and yield of groundwater sources not currently developed is problematic. The hydraulics of surface water systems are well understood, and potential future surface water sources can be modeled using historic stream gauge and rainfall data. Therefore, the supply capabilities of existing rivers, lakes and proposed impoundments can be predicted with a relatively high level of certainty. In addition, the location of surface resources is fixed. Groundwater sources do not lend themselves to the same level of prediction or certainty. The hydrologic mechanisms that produce such high yielding sources as Town of Vinton's wells or City of Roanoke's Crystal Spring are not well-understood. It would be difficult to predict where or if similar resources could be located. Additionally, without operating experience with a particular well or spring, it is difficult to predict how that resource might respond to a given drought event.

For these reasons, currently undeveloped groundwater resources have not been included in the evaluation of potential regional water sources. The conclusion is that individual localities will continue to use existing resources and may choose to explore for and develop additional groundwater sources. This may well prove to be a successful local strategy; however, given the uncertainty of such development, it has not been considered in this long-range regional plan.

6.7 New Reservoir Construction

In the *Upper Roanoke Valley Water Supply Study* (1980), Moore, Gardner & Associates (MGA) examined several conceptual alternatives for developing additional water supplies in the Upper Roanoke River Basin. These alternatives primarily focused

on integrating existing supplies with new water sources shown to be feasible based on cost allocation among the region's water utilities.

6.7.1 Proposed New Reservoirs

Of the alternatives considered in detail, four included construction of a new water supply reservoir. A brief summary of the information presented in the MGA report follows.

6.7.1.1 New Ellett Reservoir. This alternative represented an effort to augment flow in the Roanoke River. The alternative proposed constructing a 2.5 billion gallon reservoir on the North Fork of the Roanoke River at New Ellett in Montgomery County with a projected yield of 12.7 mgd.

6.7.1.2 Bradshaw Creek Reservoir. Similar to the New Ellett Reservoir, this alternative considered Roanoke River flow augmentation. The alternative proposed constructing a 2.7 billion gallon reservoir on Bradshaw Creek near the Montgomery County-Roanoke County line with a projected yield of 12.7 mgd.

6.7.1.3 Back Creek Reservoir. The MGA report evaluated several new reservoir sources that included direct withdrawal from the impoundment, including the Back Creek Reservoir. This alternative proposed constructing a 1.1 billion gallon reservoir on Back Creek at Windy Gap with a projected yield of 5.5 mgd.

6.7.1.4 Dry Branch Reservoir. Focusing on utilization of excess flow in the Roanoke River, this alternative consisted of pumping excess river flow into a side stream reservoir for release during drought. The proposed reservoir would be located on Dry Branch in western Roanoke County and provide a projected yield of 12.7 mgd. This alternative was modified and implemented as the construction of the Spring Hollow reservoir.

6.7.2 Projected Capital Costs

The MGA report presented estimated capital costs of construction for each proposed new reservoir. These costs represented projected 1990 costs and ranged from approximately \$26 to \$31 million. Using the Engineering News Record Construction Cost Index, these costs were trended to present values, which ranged from approximately \$37 to \$44 million (refer to Table 6.15).

Table 6.15
Estimated Current Costs for Reservoir Construction

Reservoir	1990 Capital Cost	2003 Capital Cost[1]
New Ellett Reservoir	$27,272,000	$38,618,000
Bradshaw Creek Reservoir	$26,211,000	$37,115,000
Back Creek Reservoir	$30,561,000	$43,275,000

[1]Based on ENR Construction Cost Index (JAN 1990 ENR CCI = 4680; MAR 2003 ENR CCI = 6627; Percent Increase = 42)

Permitting of a new reservoir will take a significant amount of time, resulting in capital cost significantly higher than indicated.

Regulatory constraints coupled with a general lack of public acceptance often render the construction of new reservoirs exceptionally difficult. Additionally, the costs associated with environmental, legal and regulatory challenges often significantly increase project costs.

6.8 Water Reuse

Use of reclaimed water is another water resources conservation strategy. It serves to reduce demand on the potable water system, if some uses can be satisfied with water treated for nonpotable uses. Virginia's proposed Regulation for Wastewater Reclamation and Reuse (9 VAC ac 25-740) was open for public comment through April 24, 2003. The proposed regulation establishes requirements for the reclamation and reuse of wastewater that are protective of state waters and public health. The regulation establishes standards and water quality requirements for several categories of reuse.

Two levels of reclaimed water quality are proposed for the following reuse categories: irrigation for agricultural, forest and landscape uses, industrial processes (cooling, boiler feed, stack scrubbing, and process water); and non-potable urban use (street washing, vehicle washing, and fire protection).

The required level of treatment is linked to the potential for public contact, depending on its intended use. For example, most non-potable urban uses of reclaimed water have potential for contact with the public. That water will be required to meet a higher standard of treatment and disinfection.

The proposed regulation does not cover indirect potable reuse, the concept of utilizing highly treated reclaimed water to augment or recharge surface and groundwater sources of drinking water. The principal concern is that conventional processes for treatment of drinking water do not remove compounds that may have long-term effects on public health. Much research is underway examining endocrine disruptors, hormonally active agents, and other similar organic compounds to better quantify the public health uncertainties.

It is important to appreciate the value of the highly treated effluent from the Roanoke Regional Wastewater Treatment Plant as a future water source. A number of communities, across the United States have evaluated the merits and risks of proposed water supply augmentation and recharge projects. In Virginia, the development of regulations to cover uses other than indirect potable reuse should serve to encourage the use of reclaimed water for a variety of other uses. As the use of reclaimed water becomes a more widely accepted practice and as the health effects are better defined, it is expected that the use of highly treated wastewater for augmenting raw water sources will become an acceptable practice.

However, due to the uncertainty with current permitting and implementation, cost estimates have not been prepared for this option.

6.9 Conservation and Demand Management

In recent years, water utilities facing the challenges of diminishing untapped water resources have implemented demand management programs as an alternative to developing new water supplies. Water resource management during historic drought events, such as the drought affecting much of Virginia over the past several years, has prompted serious consideration of various conservation options. Many successful demand management programs have initiated the integrated resource planning (IRP) approach endorsed by the American Water Works Association (AWWA). The IRP process broadens the scope of conventional water planning to include both supply and demand management. Along those lines, many regulatory procedures, such as application for new withdrawals under the Virginia Water Protection Permits, may require documentation of a proposed demand management or conservation program.

EPA published guidelines for water conservation plan development in response to the 1996 amendments to the Safe Drinking Water Act. These guidelines designate a

three-tiered approach by scaling the scope of the procedure based on the size of the water system. In *Handbook of Water Use and Conservation* (Amy Vickers & Associates, Inc., 2001), a ten-step planning procedure is presented. Table 6.16 lists a summary of Vickers' procedure.

Table 6.16
Ten-Step Water Conservation Program Development

1. Identify Conservation Goals
Establish water use reduction goals and determine the time frame
2. Develop a Water-Use Profile
Evaluate existing water sources and future demand forecasts
3. Evaluate Planned Facilities
Develop cost estimates based on total forecasted system capacity
4. Identify and Evaluate Conservation Measures
Evaluate specific conservation measure applicable to the water system
5. Identify and Assess Conservation Incentives
Propose conservation incentives based on customer usage characteristics
6. Analyze Benefits and Costs
Estimate water savings, associated costs, and compare to supply development alternatives
7. Select Conservation Measures and Incentives
Select conservation measures based on quantitative and qualitative criteria
8. Prepare and Implement the Conservation Plan
Develop the plan and solicit public involvement
9. Integrate Conservation and Supply Plans, Modify Forecasts
Modify proposed plans for facilities based on revised projected future demand
10. Monitor, Evaluate, and Revise Program as Needed
Monitor each conservation measure's effectiveness and adjust the conservation program accordingly

Demand management can be classified into two categories: structural and behavioral. Structural conservation measures achieve water use reduction by implementing large-scale system changes, such as water saving fixture programs. Behavioral conservation focuses on realizing demand reduction by identifying inefficient water usage and suggesting more efficient operations like irrigation scheduling based on precipitation rather than fixed application rates. Effective implementation of either type of program has been shown to initially reduce demand by as much as 30 percent.

6.9.1 Structural Conservation Measures

Structural measures are generally more reliable in achieving long-term water savings because they typically need to be installed only once and require no on-going effort to maintain water savings. In most regions of North America, water is used inside the home primarily for two functions: cleaning and sanitation. Indoor residential use typically ranges from 60 to 80 gpcd in households with older (pre-1980) high-volume plumbing fixtures and appliances. Over the next 20 to 25 years, U.S. water utilities are expected to see reductions in water demand by plumbing fixtures as a result of national water-efficiency requirements established by the U.S. Energy Policy Act of 1992 (EPAct). This legislation set maximum water-use levels for toilets (1.6 gallons per flush), urinals (1.0 gallon per flush), and showerheads (2.5 gallons per minute). The efficiency standards apply to plumbing fixtures in new and renovated residential and nonresidential facilities. The EPAct standards will have a cumulative, long-term impact on indoor water use, as existing high-volume fixtures are gradually replaced, particularly in the residential sector. The water savings that EPAct is expected to produce among U.S. residential and nonresidential customers have been projected to occur by 2020, by which time most existing fixtures will have been replaced with ones that comply with EPAct. Studies of 16 U.S. localities show that the EPAct standards will reduce water demand enough to save local water utilities millions of dollars as a result of deferred or avoided investments to expand drinking water treatment or storage capacity.

It is important to note that successful development of water conservation programs require participation from all involved stakeholders. This situation re-emphasizes the need for an IRP approach to water management.

6.9.2 Behavioral Conservation Practices

Rate structures can play a significant role in implementing a demand management program. However, demand management can impose detrimental revenue losses depending on the rate structure in place. Therefore, it is imperative for a utility to examine their rate structure to determine its suitability for use as a demand management tool. The following discussion summarizes the sensitivity of selected rate structures as presented by Bishop and Weber in *Impacts of Demand Reduction on Water Utilities* (AWWARF, 1996).

Fixed rate structures, or flat rates, maintain the same periodic charge irrespective of a customer's usage. This structure shows no sensitivity to demand reduction since the rates are not a function of consumption volume.

Declining block rate charges are set indirectly proportional to consumption. Consequently, large volume usage carries a reduced rate. This structure was generally considered the most common structure in the past. Under this scenario, reduced consumption by higher volume users would have less negative impact on revenue collection compared to the losses expected from an equal demand reduction on behalf of the lower volume users.

Conversely, inclining rate structures, or inverted block rates, apply higher rates to large volume users. Obviously, this rate structure promotes conservation by targeting high volume water users. The rates may also be based on peak demands, and, consequently, are sensitive to demand reductions. Excess use rates resemble inclining block rates because their block rates are set using a base consumption volume often developed from historical consumption patterns specific to the customer.

Uniform rates apply a single block rate to all customers. Demand reductions, therefore, affect revenue equally regardless of consumption. This rate structure allows a predictable response in revenue collections under a demand management program. Seasonal rates are similar to the uniform structure except a higher rate is charged during the peak demand season, which is typically the summer months. Marginal cost rates tend to be the most sensitive to demand reduction. Their rates are set using economic projections of the cost of providing water.

Uniform rates, inclined block rates, seasonal rates, and marginal cost rates are typically considered to be conservation-focused rate structures. Clearly, the impact of demand management programs on revenue collections is a direct function of the rate structure in place and the distribution of the reduction among the customer base. However, it is important to note that water utilities have been able to implement effective conservation rate structures and still meet required revenue goals.

6.9.3 Drought Management Measures

Comprehensive water supply management programs include a drought contingency plan that represents a proactive approach to mitigating the severe effects of climatological

water shortages. Drought contingency plans not only consider seasonal water supply and demand patterns, but they also establish a response strategy targeting prompt and clear communication to the public. Additionally, the plan outlines procedures for continuous, systematic assessment of drought conditions in conjunction with specific risk management measures that minimize water shortage impacts.

Water use restrictions are an integral component of a drought contingency plan. Obviously, these restrictions must become progressively more stringent as drought conditions become more severe. Staged drought indicators (triggers) can identify the onset of deteriorating drought conditions and provide a warning for adequate drought response. Initial triggers prompt early response actions such as voluntary conservation. Subsequent triggers indicate an eminent water shortage, and strict water rationing may eventually be necessary.

In 2002, the City of Roanoke developed a drought plan incorporating the features discussed above. The City monitors drought severity using identified critical water levels in the Carvins Cove Reservoir, which is the City's primary water source, to establish five "drought stages." The City imposes water restrictions corresponding to each drought stage. The plan includes penalties for violating mandatory water restrictions and a water surcharge applied when full mandatory restrictions are in place. Additionally, the plan outlines procedures for utilizing inter-connections with Roanoke County and the City of Salem during severe drought events where water storage in the reservoir reaches critically low levels. The City's drought management approach can serve as an effective model for other regional water utilities.

6.9.4 Conservation Program Implementation

As noted above, a water conservation program needs to begin with a primary goal for demand reduction. This reduction in volume may be achieved by implementing a variety of techniques such as water fixture replacement programs (structural conservation) or rate-based conservation incentives (behavioral conservation). However, a cursory review of the literature provides little documented "industry-accepted" expectations for demand reductions resulting from these programs. A water utility must develop initial projections based on effective programs implemented by similar utilities and common rules of practice. For example, many water engineers consider a program reducing demand by as much as 30 percent largely successful. More specifically, fixture replacement programs often result in enormous reductions, while rate incentives typically provide modest, non-

linear reductions (e.g., doubling water rates may only yield a 20 percent reduction in consumption). Another rule of practice states that residential water use above 100 gpcd may provide opportunities for conservation, while residential usage below 100 gpcd may not. In sum, conservation goals need to be developed from representative information for specific water utilities.

7.0 Conclusions and Recommendations

7.1 Regional Considerations

The basic objective of the long-range study is to determine the anticipated future needs of the participating communities, and to examine a range of options to satisfy projected individual and regional treated water supply needs. A range of options are considered, and the following general conclusions are reached:

- Drought-resistant solutions require tapping large volumes of water that are not as easily affected by drought as the existing large reservoir supplies. This involves consideration of the New River, the James River, and the downstream impounded Roanoke River for additional water supply.

- Permitting of alternatives involving raw or finished water sources outside of the Roanoke River Basin will be more challenging and will likely require more time and resources to complete, than for sources within the Roanoke River Basin.

- Permitting requirements for new raw water reservoirs are significant with much uncertainty as to the time and resources needed to complete the process successfully. Recent experiences of other Virginia communities attempting to permit new reservoir supplies has taken 10 to 15 years.

- Groundwater has proven to be a good complement to larger surface water sources in Roanoke County, Salem, Bedford County, and the City of Roanoke. Botetourt and Franklin Counties, and the Town of Vinton are completely or nearly dependent on groundwater supplies. The magnitude of future regional treated water deficiencies across the region is such that groundwater is considered as a local water supply option.

- Virginia has proposed regulations for Wastewater Reclamation and Reuse for limited types of use. As the use of reclaimed water becomes a more widely accepted practice, it is expected that the permissible uses will expand in scope, to possibly include indirect augmentation of sources of drinking water. Reclaimed water should continue to be evaluated as part of the future water supply of the Roanoke region.

- Conservation and demand management programs are needed to sustain the existing water supplies in time of drought, as well as to defer the need for additional supplies. Initial implementation of these programs has been shown to result in significant benefits in some systems; however, the magnitude of expected benefits is unique to each water system. In light of the recent extended drought, it is prudent for each water supplier to develop a drought contingency plan for their sources.

The evaluation of alternative sources of supply in Chapter 6 results in conclusions and recommendations for the region, as well as the application of these conclusions to each participating municipality:

- To serve the projected potable water supply deficits for all of the participating jurisdictions, augmentation of Carvins Cove with raw water from Smith Mountain Lake is the least expensive option, followed by James River augmentation of Carvins Cove. Due to anticipated inter-basin transfer discussions and other potential concerns of existing water suppliers using the James River as a source, the Smith Mountain Lake option appears the most easily implemented at the least cost.

- The least costly option for Bedford and Franklin Counties is to construct a water treatment plant on Smith Mountain Lake to satisfy their combined needs. However, if regional treatment redundancy is a desired objective of the participating jurisdictions, consideration should be given to constructing some additional capacity in the new plant, as well as constructing a pipeline to connect to Roanoke County's finished water transmission system.

- Among the alternatives that would serve the interconnected communities of Vinton, Salem, Roanoke County, Roanoke, and half of Botetourt, the augmentation of Carvins Cove using raw water from Smith Mountain Lake is the least costly option. This is closely followed by augmentation of Spring Hollow Reservoir with water from the New River, if discharged to Wilson Creek. The range of possible permitting issues associated with the option, including modifying withdrawal and discharge permits make it less attractive. It is notable that purchasing treated water from BCVPI Water Authority is not a great deal more costly. The benefits of regional treatment redundancy could justify the difference in cost.

- Installation of a rubber bladder on the Carvins Cove dam to increase its operating depth and volume is a low capital cost to gain an additional 1.4 mgd of water supply. In concert with a small pipeline from Spring Hollow Reservoir, the project could provide more capacity, still for low cost. Further investigation is needed to address dam safety issues and other potential impacts associated with these two options. A range of capacities and operating strategies should be investigated to determine the optimum sizing for short-term as well as long-term operational benefits.

7.2 Bedford County

Though Bedford County can expect to experience significant growth over the foreseeable future, it is uniquely situated with regard to potential water supply alternatives. The BCPSA currently purchases water from its two large municipal neighbors: the City of Roanoke and the City of Lynchburg, and has plans in the near term to supply water to Franklin County. It also has begun to produce its own water from Smith Mountain Lake. Given the County's location between Smith Mountain Lake and the James River, and between the City of Lynchburg and the City of Roanoke, the BCPSA has numerous alternatives for providing water to its customers and participating in inter-municipal and regional water supply systems.

Over the medium term, the most practical scenario for the BCPSA will be to continue to develop its source on Smith Mountain Lake, to meet Bedford County's growing need for water. Based on this study, it does not seem likely that the communities in the Roanoke Valley will have the need for significant water from Bedford County within the planning period, and the City of Lynchburg appears to have excess capacity for the foreseeable future. Franklin County has agreed to purchase water from the BCPSA to meet its medium-term needs in the northeastern portion of Franklin County. From a regional perspective, there are advantages to servicing the two Counties from a single lake intake and treatment plant. Other communities to the south and east of Bedford County (e.g.: Campbell County and Appomattox County) do not have the water resources available to them that Bedford has available. From a long-term regional perspective, BCPSA may benefit from exploring the possibility of providing finished water to these localities.

Bedford County is not likely to be needed as a major supplier to the developed cities of Lynchburg or Roanoke, but it may have an important future role as a link between water systems. In recent years, the focus on redundancy and reliability of water supply systems is increasing. As Bedford County continues to develop, and a greater area of the County is serviced by public water, the opportunity exists for providing regional interconnections.

7.3 Botetourt County

Botetourt County is located on the northern edge of the Roanoke metropolitan area. It has experienced significant growth in the recent past and more growth can be expected. To date, the County has focused its utility development towards encouraging industrial and commercial growth. The County serves its commercial and industrial customers from a series of well systems and the purchase of water from Roanoke County. The County plans to interconnect these systems and to serve all of its customers from its wells.

For the medium term, it appears that the County can obtain adequate groundwater supplies to serve industrial and commercial costumers. To date the County has not focused on providing water service to residential customers. With the exception of the Glen Wilton system in the north end of the County, residential customers in Botetourt County are served by one of the Towns, or by privately developed and operated water systems. Water demand projections over the planning period indicate that the water demand in Botetourt County will exceed the existing developed groundwater resources.

The County has several alternatives for addressing these future needs. One alternative is to continue to allow private development and operation of residential water supply systems. Development, in this case, will be dependent on the ability of private developers to locate adequate groundwater resources. The long-term dependability and quality of the County's residential water supply will depend on the operation of a large number of small systems operated by private entities. This may not provide the level of dependability desired by residential customers and may result in political pressure for the County to take responsibility for operation of residential water systems in the future.

Another alternative would be for the County to develop a centralized water supply system to serve both residential and industrial/commercial customers. In the short to medium term, the County may continue to depend on groundwater resources to provide

this service. This will likely include the use of some wells which have been assessed to be under the influence of surface water. These wells will require additional treatment systems.

In the long-term, however, the County will probably look to some surface water source to meet some of its growing water demand. This could mean the purchase of finished water from the Roanoke County or City of Roanoke systems, or the development of a new intake and treatment plant on the James River. Of these alternatives, the purchase of water may be cost effective given the location of the City of Roanoke water treatment plant, and the location of planned development in Botetourt County in the southwestern portion of the County.

Alternatively, Botetourt County is in a good position to develop an intake and new WTP on the James River. Since part of Botetourt County is located in the James River basin, resistance from existing downstream users would likely not be as political, as is anticipated if the Roanoke River Basin communities pursued this option.

Whether or not the County determines that purchase of water from Roanoke County or the City of Roanoke is in its best interest, there are advantages to developing alternative sources of supply, such as the James River or distribution system interconnections for emergency back-up. It is recommended that the County evaluate the long-term use of its Roanoke County interconnection to provide emergency water service to its existing and future water distribution systems. It should also evaluate the potential for interconnecting with the City of Roanoke system along the U.S. 11 corridor. On the northern end of the County especially, the James River withdrawal option should be considered to address long-term water supply needs.

7.4 Franklin County

Franklin County currently owns or operates a well at the Commerce Center Industrial Park. Community water is currently provided either by one of the incorporated Towns, private water systems or in the case of the Ferrum area, by the FWSA. However, the County has performed some planning studies to determine the feasibility of providing water services to areas not currently serve by the public systems. Recently the County has entered into an agreement with the BCPSA to purchase finished water.

In the short term, Franklin County plans to use the supply from Bedford County to provide water service to the northeastern portion of the County, in the vicinity of Smith

Mountain Lake. In the long term, the County plans to develop its own water treatment plant on Smith Mountain Lake and to provide water service, in cooperation with towns, to the developing areas in the eastern portion of the County and along the major transportation corridors.

Given the availability of Smith Mountain Lake, Franklin County should have ample raw water resources to meet its needs for the 50-year planning period. Consideration should be given to the most cost-effective means for obtaining that water, at various points in the development process, whether it involves construction of a separate Franklin County intake and treatment plant or participation with BCPSA in a regional plant.

There is not a projected need in the communities west of the Blue Ridge that would justify pumping significant amounts of water from Franklin County to Roanoke County or City. However, over the long-term, additional emergency connections with Bedford County and Roanoke County should be considered.

7.5 City of Roanoke

The City of Roanoke's system is well-developed with an established system of supply, treatment, distribution, and interconnections to its neighboring water suppliers. Significant growth in water demands is not expected for the future, and the objective of developing new supplies and interconnecting systems is linked to an interest in deriving greater efficiency and reliability from the existing facilities. The City likely experienced a new drought of record for their Carvins Cove system, due to the last several years of drought. This has resulted in a focus on system redundancy and options to reduce the City's susceptibility during drought. The City implemented a conservation policy and conservation rates, and are looking to augment their surface water supplies through groundwater exploration, as well as participation in this regional study. The decision to form a joint water and wastewater authority with Roanoke County will likely lead to further opportunities for cooperation and mutual benefit.

Options to be examined in the short term include cooperative operations of the two major surface water sources – Carvins Cove Reservoir and Spring Hollow Reservoir. Benefits that may be attributed to raising the operating pool of Carvins Cove should be considered in the context of benefits to coordinated operations, and further research into potential dam stability issues and land-based impacts is advised. Virginia Dam Safety officials will need to be consulted and must grant approval to implement any modification to the dam at Carvins Cove.

In the long term, it may be to the City and Botetourt County's mutual benefit to provide a stronger connection to supply Botetourt's developing areas in the southern portion of the County, closest to the Carvins Cove facilities. A stronger capability to provide emergency water supply from the City of Roanoke would provide benefits to Botetourt in the near term.

7.6 Roanoke County

The Roanoke County water system extends around the Cities of Roanoke and Salem. With the County's major supply and treatment infrastructure located in the western part of the County, some areas of the system are more efficiently served by the City of Roanoke's Carvins Cove and Salem's supplies. The County has existing water supply agreements with Botetourt County, the City of Roanoke, the City of Salem, and the Town of Vinton.

Through year 2020, the County should have surplus treated water supply available from the Spring Hollow facilities. Re-rating the water treatment plant filters to allow additional treatment capacity would provide even more supply without major capital investment.

Over the long term, to satisfy the development projected by the County's future land use plan, water demand in the commercial/industrial sector is expected to increase. It is projected that by year 2050, the County would be nearly built-out and will need some additional raw water supply capacity. The water treatment facilities at Spring Hollow would also require expansion.

The recent decision to form a joint water and wastewater authority with the City of Roanoke is expected to provide even greater opportunities for cooperation and sharing of resources. The potential benefits to the County due to more coordinated operation with the City of Roanoke are not evaluated in detail in this study. However, the analysis of the Spring Hollow and Carvins Cove reservoirs reveals that opportunities exist to operate the two facilities in a manner that will provide greater reliability to both systems.

7.7 City of Salem

The City of Salem's system is well-developed with an established system of supply, treatment, distribution, and interconnections to its neighboring water suppliers, the City and County of Roanoke. Modest growth in water demands is expected for the future, and the City is implementing its master water plan to satisfy needs through the planning horizon of this regional study.

In 1995, the City performed an evaluation of the major components of the water system, and developed a plan for expansion and rehabilitation to meet the system needs over a 30-year planning horizon. The City of Salem decided to design the plant at the downtown location for an ultimate capacity of 12 mgd, to satisfy future peak demands. The initial phase of the water treatment plant project will increase plant capacity to 10 mgd, matched with 10 mgd in raw water sources from ground and surface supplies. The City plans to expand the plant by 2 mgd and supplement these sources with 2 mgd of additional groundwater around year 2020, to achieve the ultimate planned capacity.

Through year 2020, Salem is projected to have at least 2 mgd of supply exceeding their peak day needs, and this supply would likely be available to its neighboring systems, the City and County of Roanoke, if Salem determines it to be surplus water, under the terms of their existing agreements. In the short term, the City of Roanoke could benefit from the availability of surplus water, as it seeks to strengthen its own sources of supply. For purposes of this study, due to existing interconnections, Salem should benefit from improvements to reliability and redundancy in the Roanoke County and City systems.

7.8 Town of Vinton

The Town of Vinton's system is dispersed, with the largest demands in the downtown area. Wells are located in two distinct systems. The Town continues to develop groundwater supplies to supplement its current system, and does not treat the water at this time. The Town has limited properties available for new development, and limited growth in water demands is predicted. The existing groundwater well supplies are expected to exceed the Town's future water demands. The Town has water supply agreements with the City of Roanoke and with Roanoke County, and is connected to those systems through seven interconnections. The Town has agreed to provide Roanoke County with surplus water, since the Town's system was developed jointly with the

County. Recently, the Town was able to provide water to the City of Roanoke during the drought while the City's Crystal Spring was offline.

The Town appears well-positioned for the long term with respect to supply. For purposes of this study, the Town should benefit from improvements to reliability and redundancy in the Roanoke County and City systems.

Appendix A

Land Use Key

Bedford County Land Use Key

City Zoning Category	Black and Veatch Broad Category
Industrial	Industrial
Residential	Residential
Commercial	Commercial
Industrial	Industrial
Agricultural	Agricultural
City of Bedford	City of Bedford

Botetourt County Landuse Key

County Category	Black and Veatch Broad Category
Industrial	Industrial
Residential	Residential
Commercial	Commercial
Industrial	Industrial
Agricultural	Agricultural

Franklin County Land Use Key

County Category	Black and Veatch Broad Category
Conservation	Agriculture
Residential	Residential
Rural Village Center	Commercial
Agriculture	Agriculture
Commercial	Commercial

	City of Roanoke Category	City of Roanoke Classification	Black & Veatch Broad Category
100	RES I DENT IAL	Single Family Residence	Residential
101	Stacked Townhouse Condominiums	Multi-Family Residence	Residential
110	Converted Single-family - 2 units	Multi-Family Residence	Residential
111	Single-family detached	Single Family Residence	Residential
112	Converted Single-family -3 or more units	Multi-Family Residence	Residential
113	Single-family attached row	Multi-Family Residence	Residential
114	Duplex	Multi-Family Residence	Residential
115	Two-family, semi-detached	Multi-Family Residence	Residential

116	Garden Apartments - 1-4 stories	Multi-Family Residence	Residential
117	Medium-rise Apartments; 5-8 stories	Multi-Family Residence	Residential
118	High-rise Apartment - More than 8 stories	Multi-Family Residence	Residential
119	Single family, Town house	Multi-Family Residence	Residential
120	Group Quarters	Multi-Family Residence	Residential
121	Group Quarters - Rooming & Boarding House	Multi-Family Residence	Residential
125	Group Quarters - Religious Quarters, Rectory, etc.	Institutional/Government	Residential
127	Group Quarters - Convalescent, Nursing or Rest Home	Institutional/Government	Residential
130	Residential Hotels	Multi-Family Residence	Residential
150	Transient Lodgings	Commercial	Commercial
151	Hotel/Motel, no pool or restaurant	Commercial	Commercial
152	Tourist Court	Commercial	Commercial
153	Tourist Home	Commercial	Commercial
154	Hotel/Motel, with restaurnt	Commercial	Commercial
155	Hotel/Motel, with pool	Commercial	Commercial
156	Hotel/Motel, with pool and restaurant	Commercial	Commercial
159	Hotel/Motel, Site Plan	Commercial	Commercial
190	Other Residential, NEC	Multi-Family Residence	Commercial
200	MANUFACTURING	Industrial	Industry
210	Food and Kindred Products	Industrial	Industry
212	Dairy Products - Manufacturing	Industrial	Industry
213	Canning & Preserving of Fruits, Vegetables and Seafood	Industrial	Industry
215	Bakery Products - Manufacturing	Industrial	Industry
217	Confectionery & Related Products - Manufacturing	Industrial	Industry
218	Beverage - Manufacturing	Industrial	Industry

219	Other Food Preparations & Kindred Products Manufacturing - NEC	Industrial	Industry
220	Textile Mill Products - Manufacturing	Industrial	Industry
229	Textile Goods Manufacturing, Includes Knit Goods, Dyeing - NEC	Industrial	Industry
230	Apparel & Other Finished Products made from Fabrics, Leather & Similar Materials - Manufacturing	Industrial	Industry
238	Miscellaneous Apparel & Accessories - Manufacturing	Industrial	Industry
239	Other Fabricated Textile Products - Manufacturing NEC	Industrial	Industry
240	Lumber & Wood Products (Except Furniture) - Manufacturing	Industrial	Industry
243	Millwork, Prefab Structural Wood - Manufacturing	Industrial	Industry
244	Wooden Containers - Manufacturing	Industrial	Industry
249	Other Lumber & Wood Products (Except Furniture) - Manufacturing, NEC	Industrial	Industry
250	Furniture & Fixtures - Manufacturing	Industrial	Industry
251	Household Furniture - manufacturing	Industrial	Industry
252	Office Furniture - Manufacturing	Industrial	Industry
255	Venetian Blinds & Shades - Manufacturing	Industrial	Industry
259	Other Furniture & Fixtures - Manufacturing,	Industrial	Industry
260	Paper & Allied Products - Manufacturing	Industrial	Industry
263	Paperboard -	Industrial	Industry

	Manufacturing		
265	Paperboard Containers & Boxes - Manufacturing	Industrial	Industry
269	Other Paper & Allied Products - Manufacturing, NEC	Industrial	Industry
270	Printing, Publishing & Allied Industries	Industrial	Industry
271	Newspapers: Publishing, Publishing & Printing	Industrial	Industry
279	Other Printing & Publishing, NEC	Industrial	Industry
280	Chemicals & Allied Products - Manufacturing	Industrial	Industry
281	Industrial Organix & Inorganix Chemicals - Manufacturing	Industrial	Industry
283	Drug - Manufacturing	Industrial	Industry
289	Other Chemicals & Allied Products - Manufacturing, NEC	Industrial	Industry
290	Petroleum Refining & Related Industries	Industrial	Industry
292	Paving & Roofing Materials - Manufacturing	Industrial	Industry
299	Other Petroleum Refining & Related Industries, NEC	Industrial	Industry
300	MANUFACTURING	Industrial	Industry
310	Rubber & Miscellaneous Plastic Products — Manufacturing	Industrial	Industry
312	Rubber Footwear - Manufacturing	Industrial	Industry
313	Reclaiming Rubber	Industrial	Industry
314	Miscellaneous Plastic Products	Industrial	Industry
319	Other Fabricated Rubber Products - Manufacturing, NEC	Industrial	Industry
320	Stone, Clay & Glass Products - Manufacturing	Industrial	Industry

323	Concrete, Gypsum & Plaster Products - Manufacturing	Industrial	Industry
324	Structural Clay Products - Manufacturing	Industrial	Industry
325	Cut Stone & Stone Products - Manufacturing	Industrial	Industry
327	Pottery & Related Products -Manufacturing	Industrial	Industry
329	Other Stone, Clay & Glass Products - Manufacturing, NEC	Industrial	Industry
330	Primary Metal Industries	Industrial	Industry
339	Primary Metal Industries, NEC	Industrial	Industry
340	Fabricated Metal Products - Manufacturing	Industrial	Industry
342	Machinery (except Electrical) - Manufacturing	Industrial	Industry
343	Electrical Machinery, Equipment & Supplies, - Manufacturing	Industrial	Industry
349	Other Fabricated Metal Products - Manufacturing, NEC	Industrial	Industry
350	Professional, Scientific & Controlling Instruments	Industrial	Industry
351	Engineering, Laboratory & Scientific & Research Instruments and Associated Equipment - Manufacturing	Industrial	Industry
352	Optical Instruments & Lenses - Manufacturinq	Industrial	Industry
357	Watches, Clocks, Clockwork Operated Devices & Parts - Manufacturing	Industrial	Industry
359	359 Other Professional, Scientific & Controlling Instruments - Manufacturing, NEC	Industrial	Industry
390	Miscellaneous	Industrial	Industry

	Manufacturing		
391	Jewelry, Silverware, & Plated Ware - Manufacturing	Industrial	Industry
392	Musical Instruments & Parts - Manufacturing	Industrial	Industry
398	Sign Shop	Industrial	Industry
399	Other Miscellaneous Manufacturing, NEC	Industrial	Industry
400	TRANSPORTATION, COMMUNICATIONS & UTILITIES	Industrial	Industry
410	Railroad, Rapid Rail Transit & Street Railway Transportation	Industrial	Industry
411	Railroad Transportation	Industrial	Industry
412	Railroad Right-of-Way	Industrial	Industry
413	METRO Rail Right of Way & Station	Industrial	Industry
419	Other Railroad, Rapid Rail Transit & Street RailwaysTransportation, NEC	Industrial	Industry
420	Bus Transportation	Industrial	Industry
421	Bus Terminals	Industrial	Industry
422	Bus Garaging — Includes maintenance or storage	Industrial	Industry
429	Other Bus Transportation, NEC	Industrial	Industry
430	Motor Freight Transportation	Industrial	Industry
431	Motor Freight Terminal	Industrial	Industry
432	Motor Freight Garaging & Equipment Maintenance	Industrial	Industry
439	Other Motor Freight Transportation, NEC	Industrial	Industry
440	Taxicab Transportation	Industrial	Industry
441	Taxi Company	Industrial	Industry
449	Other Taxi, NEC	Industrial	Industry
450	Aircraft Transportation	Industrial	Institutional/Government
451	Airports and Flying Fields	Industrial	Institutional/Government
452	Aircraft Guidance Signals	Industrial	Institutional/Government

459	Other Aircraft Transportation, NEC	Industrial	Institutional/Government
460	Automobile Parking	Industrial	Institutional/Government
462	Auto Parking - City	Industrial	Institutional/Government
463	Auto Parking - Ancillary to Commercial Use	Industrial	Institutional/Government
464	Auto Parking - Fee Paid Lot	Industrial	Institutional/Government
465	Auto Parking - Public Metered Lot	Industrial	Institutional/Government
470	High and Street Right-of-Way	Industrial	Institutional/Government
471	Freeways (200-300 foot right-of-ways)	Industrial	Institutional/Government
472	Arterial Highways (110-160 foot right-of-ways)	Industrial	Institutional/Government
476	Local Street and Road Right-of-way	Industrial	Institutional/Government
479	Other Highway and Street Right-of-way, NEC	Industrial	Institutional/Government
480	Communication	Industrial	Institutional/Government
481	Telephone Communication Facilities	Industrial	Institutional/Government
482	Telegraph Communication Facilities	Industrial	Institutional/Government
483	Radio Communication Facilities	Industrial	Institutional/Government
484	Television Communication Facilities	Industrial	Institutional/Government
485	Radio & Television (Combined) Communication Facilities	Industrial	Institutional/Government
489	Other Communications, NEC	Industrial	Institutional/Government
490	Utilities	Industrial	Institutional/Government
491	Electric Utility Facilities	Industrial	Institutional/Government
492	Gas Utility Facilities	Industrial	Institutional/Government
493	Water Utility Facilities	Industrial	Institutional/Government
494	Sewage Disposal Facilities	Industrial	Institutional/Government
495	Solid Waste Disposal Facilities	Industrial	Institutional/Government
496	Utilities Right-of-way	Industrial	Institutional/Government

499	Other Utilities, NEC	Industrial	Institutional/Government
500	TRADE	Commercial	Commercial
510	Wholesale Trade	Commercial	Commercial
511	Motor Vehicles & Automotive Equipment	Commercial	Commercial
512	Drugs, Chemicals, & Allied Products	Commercial	Commercial
514	Groceries & Related Products - Wholesale	Commercial	Commercial
516	Electrical Goods - Wholesale	Commercial	Commercial
517	Hardware, Plumbing, Heating Equipment & Supplies - Wholesale	Commercial	Commercial
518	Machinery, Equipment & Supplies - Wholesale 1/	Commercial	Commercial
519	Miscellaneous Wholesale Trade NEC 2/	Commercial	Commercial
520	Retail Trade - Building Materials, Hardware	Commercial	Commercial
521	Lumber, Brick, Other Building Material - Retail	Commercial	Commercial
522	Heating & Plumbing Equipment - Retail	Commercial	Commercial
523	Paint, Glass, Wallpaper - Retail	Commercial	Commercial
524	Electrical Supplies - Retail	Commercial	Commercial
525	Hardware - Retail	Commercial	Commercial
526	Awnings - Retail	Commercial	Commercial
527	Junkyard	Commercial	Commercial
529	Other Building Materials, Hardware, including Storage Facilities, NEC	Commercial	Commercial
530	Retail Trade - General Merchandise	Commercial	Commercial
531	Department Stores - Retail	Commercial	Commercial
532	Mail Order Houses - Retail	Commercial	Commercial
533	Limited Price (five and ten cent stores) Variety	Commercial	Commercial
534	Neighborhood Shopping Center (Primarily for the	Commercial	Commercial

	sale of convenience goods and personal services. A single parcel may contain up to 10 stores.)		
535	Community Shopping Center (Provides services in addition to those of neighborhood center such as apparel, appliance, hardware. The significant difference is that a community center contains more than 10 stores.)	Commercial	Commercial
536	Mixed Commercial Office Building - 7 or more stories. (Includes Buildings which house two or more distinct trade, service, or manufacturing business offices. Excludes buildings having primarily residential uses.)	Commercial	Commercial
537	Mixed Commercial Office Building - - Less than 7 stories. (Includes buildings which house two or more distinct trade,service or manufacturing business offices. Excludesbuildings having primarily residential use.)	Commercial	Commercial
539	Other Retail Trade - General Merchandise, NEC	Commercial	Commercial
540	Retail Trade - Food	Commercial	Commercial
541	Supermarket	Commercial	Commercial
542	Meat or- Fish Store - Retail	Commercial	Commercial
543	Imported Food Store - Retail	Commercial	Commercial
544	Candy, Nut, and Confectionery - Retail	Commercial	Commercial
545	Dairy Products - Retail	Commercial	Commercial
546	Bakeries - Retail	Commercial	Commercial
547	7-11 and High's or other Convenience Store	Commercial	Commercial

548	Liquor Store - ABC	Commercial	Commercial
549	Other Retail Trade - Food, NEC	Commercial	Commercial
550	Retail Trade - Automotive, Marine Craft, Aircraft and Accessories	Commercial	Commercial
551	Motor Vehicles - Retail	Commercial	Commercial
552	Tires, Batteries, Auto Parts - Retail	Commercial	Commercial
553	Gas Station	Commercial	Commercial
554	Marine Sales	Commercial	Commercial
555	Used Cars Only - Retail	Commercial	Commercial
558	Outside Storage Facilities for Automotive, Marine craft, Aircraft, and Accessories	Commercial	Commercial
559	Other Retail Trade - Automotive, Marine Craft, Aircraft, and Accessories, NEC	Commercial	Commercial
560	Retail Trade- Apparel & Accessories	Commercial	Commercial
561	Men's and Boy's Clothing and Furnishing - Retail	Commercial	Commercial
562	Women's; Ready-to-Wear - Retail	Commercial	Commercial
563	Women's Accessories and Specialities - Retail	Commercial	Commercial
564	Children's and Infant's Wear - Retail	Commercial	Commercial
566	Shoes - Retail	Commercial	Commercial
567	Custom Tailoring	Commercial	Commercial
569	Other Retail Trade - Apparel and Accessories, NEC	Commercial	Commercial
570	Retail Trade - Furniture, Home Furnishings & Equipment	Commercial	Commercial
571	China, Glassware, Metalware - Retail	Commercial	Commercial
572	Household Appliances - Retail	Commercial	Commercial

573	Radios, Televisions, Stereos - Retail	Commercial	Commercial
574	Office Supplies	Commercial	Commercial
575	Floor Coverings, Rugs - Retail	Commercial	Commercial
576	Beds and Mattresses	Commercial	Commercial
577	Draperies, Curtains, Venetian Blinds and Upholstery - Retail	Commercial	Commercial
578	Furniture & Home Furnishings - Retail	Commercial	Commercial
579	Other Furniture, Homefurnishings and Equipment - Retail, NEC	Commercial	Commercial
580	Retail Trade - Eating Places	Commercial	Commercial
582	Eating Place - Inside Facilities with Alcohol	Commercial	Commercial
583	Eating Place - Inside Facilities without Alcohol	Commercial	Commercial
585	Eating Place - Carry-out Only	Commercial	Commercial
589	Other EatingPlace or Facility, NEC	Commercial	Commercial
590	Miscellaneous Retail Trade	Commercial	Commercial
591	Drug Store	Commercial	Commercial
592	Cameras and Photographic Supplies - Retail	Commercial	Commercial
593	Antique & Second-hand Store - Retail	Commercial	Commercial
594	Books, Stationery, Magazines, Newspapers - Retail	Commercial	Commercial
595	Sporting Goods and Bicycles - Retail	Commercial	Commercial
596	Garden Supplies and Florists - Retail	Commercial	Commercial
597	Jewelry - Retail	Commercial	Commercial
598	Fuel and Ice - Retail	Commercial	Commercial
599	Miscellaneous Retail Trade- NEC (Includes health studios, massage	Commercial	Commercial

	parlors, palmist, etc.)		
600	SERVICES	Commercial	Commercial
610	Finance, Insurance and Real Estate Services	Commercial	Commercial
611	Bank	Commercial	Commercial
612	Savings and Loan, Loan and Mortgage Company	Commercial	Commercial
613	Security and Commodity Brokers, Dealers, Exchanges	Commercial	Commercial
614	Insurance	Commercial	Commercial
615	Real Estate and Related Services 6/	Commercial	Commercial
616	Holding and Investment Services	Commercial	Commercial
619	Other Finance, Insurance and Real Estate Services, NEC	Commercial	Commercial
620	Personal Services	Commercial	Commercial
621	Laundry, Drycleaning and Dyeing Services 7/	Commercial	Commercial
622	Photo Services	Commercial	Commercial
623	Beauty Salon, Barber Shop	Commercial	Commercial
624	Funeral and Crematory	Commercial	Commercial
625	Shoe and Garment Repair Services	Commercial	Commercial
626	Private Cemetery	Commercial	Commercial
627	Self-Service Laundromat	Commercial	Commercial
628	Pet grooming	Commercial	Commercial
629	Other Personal Services, NEC	Commercial	Commercial
630	Business Services	Commercial	Commercial
631	Advertising Services 8/	Commercial	Commercial
632	Consumer and Mercantile Credit Reporting Services; Adjustment and Collection	Commercial	Commercial
633	Duplicating, Mailing, Litho, and Stenographic Services	Commercial	Commercial
634	Dwelling and Building Services 9/	Commercial	Commercial
635	Equipment Rental & Leasing Services including	Commercial	Commercial

	Truck and Automobile		
636	Employment Services	Commercial	Commercial
637	Warehousing and Storage Services 10/	Commercial	Commercial
638	Research, Development and Testing Services	Commercial	Commercial
639	Other Business Services, NEC	Commercial	Commercial
640	Repair Services	Commercial	Commercial
641	Automobile Repair and Service	Commercial	Commercial
642	Car Wash	Commercial	Commercial
643	Radio-TV Repair	Commercial	Commercial
644	Watch and Clock Repair	Commercial	Commercial
645	Reupholstery and Furniture Repair	Commercial	Commercial
646	Air Conditioner, Heating Repair	Commercial	Commercial
647	Repair or Electrical Equipment	Commercial	Commercial
648	Plating or Replating	Commercial	Commercial
649	Other Repair Services, NEC	Commercial	Commercial
650	Professional Services	Commercial	Commercial
651	Physicians Services, M.D.	Commercial	Commercial
652	Legal Services	Commercial	Commercial
653	Medical and Dental (Combined) Services	Commercial	Commercial
654	Dental Services	Commercial	Commercial
655	Architect-Engineering Services	Commercial	Commercial
656	Non-profit Clinic, Health Center	Commercial	Commercial
657	Travel Agencies	Commercial	Commercial
658	Accounting, Auditing and Bookkeeping Services	Commercial	Commercial
659	Other Professional Services, NEC	Commercial	Commercial
660	Contract Construction Services	Commercial	Commercial
661	General Contract Construction Service	Commercial	Commercial

662	Plumbing, Heating and Airconditioning Service	Commercial	Commercial
663	Painting, Paper Hanging, and Decorating Service	Commercial	Commercial
664	Electrical Contractor Services	Commercial	Commercial
665	Masonry, Stonework, Tile, Plastering & Insulating	Commercial	Commercial
666	General Carpentry and Acoustics	Commercial	Commercial
667	Roofing and Sheet Metal Services	Commercial	Commercial
668	Concrete Services	Commercial	Commercial
669	Other Contract Construction Services, NEC	Commercial	Commercial
670	Government Services	Institutional/Government	Institutional/Government
671	Government Offices md uding School Administration	Institutional/Government	Institutional/Government
672	Protective functions, Fire, Police, Civil Defense	Institutional/Government	Institutional/Government
673	Postal Services	Institutional/Government	Institutional/Government
674	Correctional Facilities	Institutional/Government	Institutional/Government
675	Military Bases & Reservations	Institutional/Government	Institutional/Government
676	Government Motor Pools and Garages	Institutional/Government	Institutional/Government
678	Government Warehouse and Storage	Institutional/Government	Institutional/Government
679	Other Government,	Institutional/Government	Institutional/Government
680	Educational Services	Institutional/Government	Institutional/Government
681	Nursery Schools	Institutional/Government	Institutional/Government
682	Elementary Schools	Institutional/Government	Institutional/Government
683	Vocational Workshops and Schools for the Handicapped	Institutional/Government	Institutional/Government
684	Colleges	Institutional/Government	Institutional/Government
686	Intermediate Schools	Institutional/Government	Institutional/Government
687	High Schools	Institutional/Government	Institutional/Government
688	Vocational & Trade Schools	Institutional/Government	Institutional/Government

689	Other Educational Services,	Institutional/Government	Institutional/Government
690	Miscellaneous Services	Institutional/Government	Institutional/Government
691	Religious Structures, Churches, Temples	Institutional/Government	Institutional/Government
692	Welfare & Charitable Services	Institutional/Government	Institutional/Government
693	Trade & Professional Associations, Unions	Institutional/Government	Institutional/Government
694	Civic, Social and Fraternal Associations	Institutional/Government	Institutional/Government
699	Other Miscellaneous Services, NEC	Institutional/Government	Institutional/Government
700	CULTURAL, ENTERTAINMENT AND RECREATIONAL	Institutional/Government	Institutional/Government
710	Cultural Activities and Nature Exhibitions	Institutional/Government	Institutional/Government
711	Libraries, Museums, Art Galleries	Institutional/Government	Institutional/Government
712	Nature Exhibitions	Institutional/Government	Institutional/Government
715	Community Centers	Institutional/Government	Institutional/Government
717	Historic Sites	Institutional/Government	Institutional/Government
719	Other Cultural Activities, NEC	Institutional/Government	Institutional/Government
720	Public Assembly	Institutional/Government	Institutional/Government
721	Theatres, Fixed Seating Auditoria	Commercial	Institutional/Government
722	Sports Stadia, Field Houses	Institutional/Government	Institutional/Government
723	Gymnasiums, Non-fixed Seating Auditoria	Institutional/Government	Institutional/Government
729	Other Public Assembly, NEC	Institutional/Government	Institutional/Government
730	Amusements	Commercial	Institutional/Government
731	Amusement Areas, Miniature Golf	Commercial	Institutional/Government
732	Bowling	Commercial	Institutional/Government
733	Penny Arcades	Commercial	Institutional/Government
734	Golf Driving Ranges	Commercial	Institutional/Government
735	Ice Skating Rink	Commercial	Institutional/Government

739	Other Amusements, NEC	Commercial	Institutional/Government
740	Recreational Activities	Institutional/Government	Parks/Forrests
741	Golf Courses	Institutional/Government	Parks/Forrests
742	Playgrounds & Parks, Private	Institutional/Government	Parks/Forrests
743	Swimming Facilities	Institutional/Government	Parks/Forrests
745	Camping and Picnicking	Institutional/Government	Parks/Forrests
746	Playfields, Athletic	Institutional/Government	Parks/Forrests
747	Recreational Centers	Institutional/Government	Parks/Forrests
748	Playgrounds, Public	Parks	Parks/Forrests
749	Other Recreation Activity, NEC	Parks	Parks/Forrests
750	Parks	Parks	Parks/Forrests
751	Regional Park	Parks	Parks/Forrests
752	City Park	Parks	Parks/Forrests
753	Street Islands & Mini Parks	Parks	Parks/Forrests
779	Other Parks, NEC	Parks	Parks/Forrests
800	RESOURCES PRODUCTION AND EXTRACTION	Parks	Agriculture
810	Agriculture	Parks	Agriculture
820	Agriculture Related Activities	Parks	Agriculture
822	Animal Hospital , Veterinarian	Parks	Agriculture
829	Other Agriculture Related Activities, NEC	Parks	Agriculture
900	UNDEVELOPED AREAS	Parks	Vacant/Not available
910	Undeveloped and Unused Land Area	Parks	Vacant/Not available
911	Vacant Land - Buildable (Vacant land undeveloped and unused but potentially buildable within zoning constraints.)	Parks	Vacant/Not available
912	Vacant Land - Unbuildable (Vacant land undeveloped and unused because size, width, frontage, etc. of parcel do not satisfy zoning constraints.)	Parks	Vacant/Not available

913	Vacant Land - Encumbered (Vacant land encumbered by peripheral uses, usually used as open space- to satisfy peripheral densities.)	Parks	Vacant/Not available
919	Other Vacant Land, NEC	Parks	Vacant/Not available
920	Water Areas	Parks	Vacant/Not available
921	Rivers, Streams, Creeks, Lakes, Ponds	Parks	Vacant/Not available
922	Lakes, Ponds	Parks	Vacant/Not available
929	Other Water Areas, NEC	Parks	Vacant/Not available
930	Vacant Floor Area	Parks	Vacant/Not available
939	Vacant Floor Area, NEC	Parks	Vacant/Not available
940	Under Construction	Parks	Vacant/Not available
941	Under Construction, Single Family, Residential	Parks	Vacant/Not available
942	Under Construction, Non-Residential	Parks	Vacant/Not available
943	Under Construction - Residential, multi-family - Motel/hotel, Condominium	Parks	Vacant/Not available
949	Other Under Construction, NEC	Parks	Vacant/Not available

Roanoke County/Town of Vinton Land Use Key

	Specific Categories			Black and Veatch Broad Categories
0100	Single Family Residence	Single Family Residence	01	Residential
0101	Single Family Residence	Single Family Residence	01	Residential
0111	Single Family Residence	Single Family Residence	01	Residential
0120	Agriculture	Rural Acreage	01	Residential
0121	Single Family Residence	Single Family Residence	01	Residential
0123	Single Family Residence	Single Family Residence	01	Residential
0150	Single Family Residence	Patio Home	01	Residential
0151	Single Family Residence	Patio Home	01	Residential

0200	Single Family Residence	Manufactured Home - Vacant	02	Residential
0201	Single Family Residence	Mobile Homesite	02	Residential
0202	Single Family Residence	Manufactured Home	02	Residential
0210	Single Family Residence	Mobile Home Park	02	Residential
0220	Single Family Residence	Manufactured Home	02	Residential
0300	Single Family Residence	Mobile Home - Vacant	03	Residential
0302	Single Family Residence	Mobile Home	03	Residential
0309	Single Family Residence	Town House	03	Residential
0311	Single Family Residence	Condominium	03	Residential
0371	Single Family Residence	Town House	03	Residential
0400	Townhouse/Condo	Condominum - Vacant	04	Residential
0403	Townhouse/Condo	Condominium	04	Residential
0500	Townhouse/Condo	Patio Home - Vacant	05	Residential
0501	Townhouse/Condo	Patio Home	05	Residential
0512	Townhouse/Condo	Multi Family	05	Residential
0562	Townhouse/Condo	Duplex/Triplex	05	Residential
0600	Townhouse/Condo	Industrial	06	Residential
0603	Townhouse/Condo	Condo High	06	Residential
0700	Single Family Residence	Commercial	07	Residential
0734	Single Family Residence	Bowling Alley, Skating Rinks, Arenas	07	Residential
0736	Single Family Residence	Tower/Transmitter	07	Residential
0900	Townhouse/Condo	Townhouse - Vacant	09	Residential
0903	Townhouse/Condo	Townhouse	09	Residential
0906	Townhouse/Condo	Prefab Warehouse	09	Residential
1000	Commercial	Commercial - Vacant	10	Commercial
1001	Commercial	Commercial- Single Family Residence	10	Commercial
1007	Commercial	Commercial	10	Commercial
1107	Commercial	Convenience Store	11	Commercial
1206	Commercial	Carwash	12	Commercial
1307	Commercial	Department Store	13	Commercial
1407	Commercial	Super Market	14	Commercial
1507	Commercial	Shop- Mall	15	Commercial

1600	Commercial	Shop- Strip- Vacant	16	Commercial
1607	Commercial	Shop- Strip	16	Commercial
1700	Commercial	Office Vacant	17	Commercial
1701	Commercial	Office - Single Family Residence	17	Commercial
1704	Commercial	Office	17	Commercial
1804	Commercial	Office - 4 story	18	Commercial
1901	Commercial	Medical - Single Family Residence	19	Commercial
1904	Commercial	Medical	19	Commercial
2004	Commercial	Medical Condo	20	Commercial
2107	Commercial	Restaurants	21	Commercial
2207	Commercial	Fast Foods	22	Commercial
2304	Commercial	Banks	23	Commercial
2404	Commercial	Office Condo	24	Commercial
2507	Commercial	Community Service	25	Commercial
2600	Commercial	Service Station - Vacant	26	Commercial
2607	Commercial	Service Station	26	Commercial
2700	Commercial	Auto Sale - Vacant	27	Commercial
2706	Commercial	Auto Sale	27	Commercial
2806	Commercial	Parking Garage	28	Commercial
2906	Commercial	Mini-Warehouse	29	Commercial
3004	Commercial	Lab/Research	30	Commercial
3104	Commercial	Day Care Center	31	Commercial
3207	Commercial	Theaters	32	Commercial
3307	Commercial	Lounge/Nightclub	33	Commercial
3407	Commercial	Bowling Alley / Arena	34	Commercial
3500	Commercial	Commercial Condos - Vacant	35	Commercial
3507	Commercial	Commercial Condos	35	Commercial
3705	Commercial	Hotel/ Motel higher than 3 stories	37	Commercial
3807	Commercial	Furniture Showroom	38	Commercial
3905	Commercial	Hotel/ Motel fewer than 3 stories	39	Commercial
4000	Industrial	Industrial - Vacant	40	Industrial
4006	Industrial	Industrial	40	Industrial
4100	Industrial	Light Manufacturing - Vacant	41	Industrial
4106	Industrial	Light Manufacturing	41	Industrial
4200	Industrial	Heavy Manufacturing - Vacant	42	Industrial
4206	Industrial	Heavy Manufacturing	42	Industrial
4306	Industrial	Lumber Yard	43	Industrial
4406	Industrial	Packing Plant/ Food	44	Industrial
4606	Industrial	Bottler/Brewery	46	Industrial
4706	Industrial	Warehouse Condo	47	Industrial
4800	Industrial	Warehouse- Vacant	48	Industrial
4806	Industrial	Warehouse	48	Industrial

5000	Agriculture	Rural Homesite - Vacant	50	Agriculture
5001	Agriculture	Rural Homesite	50	Agriculture
5020	Agriculture	Rural Homesite	50	Agriculture
5106	Industrial	Cold Storage/ Freezer	51	Industrial
5206	Industrial	Truck Terminal	52	Industrial
5300	Industrial	Service Garage- Vacant	53	Industrial
5306	Industrial	Service Garage	53	Industrial
5400	Industrial	Office- Warehouse- Vacant	54	Industrial
5406	Industrial	Office- Warehouse	54	Industrial
6000	Mulit-Family Residence	Garden Apartment - Vacant	60	Residential
6001	Mulit-Family Residence	Multi-Single Family Residence	60	Residential
6005	Mulit-Family Residence	Garden Apartment	60	Residential
6105	Mulit-Family Residence	Townhouse Apartment	61	Residential
6200	Mulit-Family Residence	Duplex-Triplex- Vacant	62	Residential
6201	Mulit-Family Residence	Duplex-Triplex	62	Residential
6205	Mulit-Family Residence	Duplex-Triplex	62	Residential
6305	Mulit-Family Residence	High Rise Apartment	63	Residential
7000	Institutional /Government	Institutional- Vacant	70	Institution /Government
7001	Institutional /Government	Institutional - Single Family Residen	70	Institution /Government
7004	Institutional /Government	Institutional	70	Institution /Government
7100	Institutional /Government	Churches - Vacant	71	Institution /Government
7101	Institutional /Government	Churches - Single Family Residence	71	Institution /Government
7104	Institutional /Government	Churches	71	Institution /Government
7200	Institutional /Government	School/College - Vacant	72	Institution /Government
7201	Institutional /Government	School/College - Single Family Reside	72	Institution /Government
7204	Institutional /Government	School/College	72	Institution /Government
7304	Institutional /Government	Hospital/Private	73	Institution /Government
7400	Institutional	Homes Aged- Vacant	74	Institution /Government

	/Government			
7401	Institutional /Government	Homes Aged - Single Family Residence	74	Institution /Government
7405	Institutional /Government	Homes Aged	74	Institution /Government
7405	Institutional /Government	Homes Aged	74	Institution /Government
7504	Institutional /Government	Orphanages	75	Institution /Government
7600	Institutional /Government	Mortuary/Cemetary - Vacant	76	Institution /Government
7604	Institutional /Government	Mortuary/Cemetary	76	Institution /Government
7700	Institutional /Government	Clubs/Lodges- Vacant	77	Institution /Government
7701	Institutional /Government	Clubs/Lodges - Single Family Residenc	77	Institution /Government
7707	Institutional /Government	Clubs/Lodges	77	Institution /Government
7800	Institutional /Government	Country Clubs	78	Institution /Government
7803	Institutional /Government	Public Golf Courses	78	Institution /Government
7804	Institutional /Government	Country Clubs	78	Institution /Government
7900	Institutional /Government	Airport	79	Institution /Government
7904	Institutional /Government	Airport	79	Institution /Government
8200	Institutional /Government	Land Trust	82	Forest/ Parks
8300	School	Public School - Vacant	83	Institution /Government
8304	School	Public School	83	Institution /Government
8404	School	Public College	84	Institution /Government
8504	Institutional /Government	Public Hospital	85	Institution /Government
8600	Institutional /Government	Other County - Vacant	86	Institution /Government
8601	Institutional /Government	Other County - Single Family Residenc	86	Institution /Government
8604	Institutional /Government	Other County	86	Institution /Government
8700	Institutional /Government	Other State- Vacant	87	Institution /Government
8701	Institutional /Government	Other State- Single Family Residence	87	Institution /Government

8704	Institutional /Government	Other State	87	Institution /Government	
8800	Institutional /Government	Other Federal- Vacant	88	Institution /Government	
8801	Institutional /Government	Other Federal- Single Family Residenc	88	Institution /Government	
8804	Institutional /Government	Other Federal	88	Institution /Government	
8900	Institutional /Government	Other Municipal- Vacant	89	Institution /Government	
8901	Institutional /Government	Other Municipal- Single Family Reside	89	Institution /Government	
8902	Institutional /Government	Municipal Airport	89	Institution /Government	
8904	Institutional /Government	Other Municipal	89	Institution /Government	
9000	Institutional /Government	Leasehold	90	Institution /Government	
9010	Institutional /Government	Leasehold	90	Institution /Government	
9100	Commercial	Utilities -Vacant	91	Industrial	
9104	Commercial	Utilities	91	Industrial	
9200	Industrial	Mining - Vacant	92	Industrial	
9204	Industrial	Mining	92	Industrial	
9300	Industrial	Petroleum and Gas	93	Industrial	
9304	Industrial	Petroleum and Gas	93	Industrial	
9400	Institutional /Government	Right of Way	94	Institutional /Government	
9600	N/A	N/A	96		0
9700	N/A	N/A	97		0
9710	N/A	N/A	97		0
9800	N/A	N/A	98		0
9900	Tax Exempt Residential	Split - no subdividision	99		0

City of Salem Land Use Key

City Zoning Category		Classification	Black and Veatch Broad Category
A1	AGRICULTURE	SINGLE FAMILY RESIDEN	Agriculture
A1	AGRICULTURE	COMMERCIAL	Agriculture
A1	AGRICULTURE	INSTITUTIONAL/GOVERNM	Agriculture
A1	AGRICULTURE	COMMERCIAL	Agriculture
B1	LIGHT BUSINESS	COMMERCIAL	Commercial
B1	LIGHT BUSINESS	INSTITUTIONAL/GOVERNM	Commercial

B1 LIGHT BUSINESS	SINGLE FAMILY RESIDEN	Commercial
B1 LIGHT BUSINESS	#N/A	Commercial
B1 LIGHT BUSINESS	INDUSTRIAL	Commercial
B2 BUSINESS	COMMERCIAL	Commercial
B2 BUSINESS	SINGLE FAMILY RESIDEN	Commercial
B2 BUSINESS	COMMERCIAL	Commercial
B2 BUSINESS	INSTITUTIONAL/GOVERNM	Commercial
B2 BUSINESS	#N/A	Commercial
B3 HEAVY BUSINESS	COMMERCIAL	Commercial
B3 HEAVY BUSINESS	SINGLE FAMILY RESIDEN	Commercial
B3 HEAVY BUSINESS	#N/A	Commercial
B3 HEAVY BUSINESS	INSTITUTIONAL/GOVERNM	Commercial
B3 HEAVY BUSINESS	MULTI-FAMILY RESIDENT	Commercial
BC COMMERCE	COMMERCIAL	Commercial
BC COMMERCE	INDUSTRIAL	Commercial
BC COMMERCE	SINGLE FAMILY RESIDEN	Commercial
BC COMMERCE	INSTITUTIONAL/GOVERNM	Commercial
BC COMMERCE	INSTITUTIONAL/GOVERNM	Commercial
BCR2 COMMERCE/RESIDENT	INSTITUTIONAL/GOVERNM	Commercial
M1 LIGHT INDUSTRIAL	COMMERCIAL	Industrial
M1 LIGHT INDUSTRIAL	INDUSTRIAL	Industrial
M1 LIGHT INDUSTRIAL	SINGLE FAMILY RESIDEN	Industrial
M1 LIGHT INDUSTRIAL	#N/A	Industrial
M1 LIGHT INDUSTRIAL	INSTITUTIONAL/GOVERNM	Industrial
M2 HEAVY INDUSTRIAL	INSTITUTIONAL/GOVERNM	Industrial
M2 HEAVY INDUSTRIAL	COMMERCIAL	Industrial
M2 HEAVY INDUSTRIAL	#N/A	Industrial
M2 HEAVY INDUSTRIAL	SINGLE FAMILY RESIDEN	Industrial
M2 HEAVY INDUSTRIAL	INSTITUTIONAL/GOVERNM	Industrial
M2 HEAVY INDUSTRIAL	INDUSTRIAL	Industrial
R1 SINGLE FAMILY	COMMERCIAL	Residential
R1 SINGLE FAMILY	SINGLE FAMILY RESIDEN	Residential
R1 SINGLE FAMILY	INSTITUTIONAL/GOVERNM	Residential
R1 SINGLE FAMILY	#N/A	Residential
R1 SINGLE FAMILY	MULTI-FAMILY RESIDENT	Residential
R2 SINGLE/DUPLEX	SINGLE FAMILY RESIDEN	Residential
R2 SINGLE/DUPLEX	COMMERCIAL	Residential
R2 SINGLE/DUPLEX	INSTITUTIONAL/GOVERNM	Residential
R2 SINGLE/DUPLEX	MULTI-FAMILY RESIDENT	Residential

R2B2 COMBINATION ZONIN	COMMERCIAL	Residential
R2B2 COMBINATION ZONIN	INSTITUTIONAL/GOVERNM	Residential
R2B2 COMBINATION ZONIN	SINGLE FAMILY RESIDEN	Residential
R2M2 RESIDENTIAL/INDUS	#N/A	Residential
R2M2 RESIDENTIAL/INDUS	COMMERCIAL	Residential
R2M2 RESIDENTIAL/INDUS	INSTITUTIONAL/GOVERNM	Residential
R2M2 RESIDENTIAL/INDUS	SINGLE FAMILY RESIDEN	Residential
R3 MULTI-FAMILY	#N/A	Residential
R3 MULTI-FAMILY	COMMERCIAL	Residential
R3 MULTI-FAMILY	INSTITUTIONAL/GOVERNM	Residential
R3 MULTI-FAMILY	MULTI-FAMILY RESIDENT	Residential
R3 MULTI-FAMILY	INSTITUTIONAL/GOVERNM	Residential
R3 MULTI-FAMILY	MULTI-FAMILY RESIDENT	Residential
R4 MULTI-FAMILY	#N/A	Residential
R4 MULTI-FAMILY	COMMERCIAL	Residential
R4 MULTI-FAMILY	INSTITUTIONAL/GOVERNM	Residential
R4 MULTI-FAMILY	MULTI-FAMILY RESIDENT	Residential
R4 MULTI-FAMILY	SINGLE FAMILY RESIDEN	Residential
RB RESIDENTIAL/BUSIN	#N/A	Commercial
RB RESIDENTIAL/BUSIN	COMMERCIAL	Commercial
RB RESIDENTIAL/BUSIN	INSTITUTIONAL/GOVERNM	Commercial
RB RESIDENTIAL/BUSIN	SINGLE FAMILY RESIDEN	Commercial
RM MOBILE HOME PARK	SINGLE FAMILY RESIDEN	Residential