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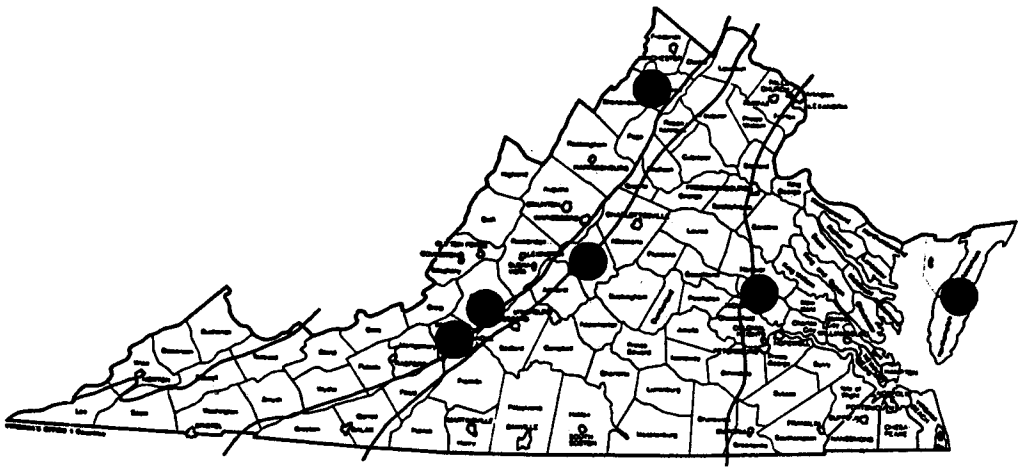
# WELLHEAD PROTECTION:

# CASE STUDIES OF SIX LOCAL GOVERNMENTS IN VIRGINIA



**Fall 1993**

**Virginia Ground Water Protection Steering Committee**

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## ACKNOWLEDGEMENTS

Preparation of this set of case studies would not have been possible without the assistance of many people. Over a period of several months, staff from the Institute for Environmental Negotiation contacted local representatives requesting copies of reports and arranging site visits and interviews. Follow-up telephone calls for additional information were common. Drafts of the chapters were also checked with local representatives. In every case, the local representatives were helpful, responded in a timely manner, and were supportive of this project's goals.

The following individuals are acknowledged and thanked for their assistance in this endeavor.

Tom Brokenbrough
Timothy Castillo
Michael Collins
Ruby Dodd
James Eichelberger
Nick Evans
C. D. Fleming, Jr.
Mike Gray
Terry Herrington
Cromer Hedrick
John Humphrey
Jim McGowan
Terry Pettit
Janet Scheid
Randy Silber
Jeffrey Slack
Chuck Supan
Wayne Weikel
Haywood Wigglesworth

If errors of fact or of understanding are found in this report, they are the responsibility of the authors and not the persons listed above.

# TABLE OF CONTENTS


| | | Page |
|---|---|---|
| I. | Overview | 1 |
| | Basic Concepts | 1 |
| | The Wellhead Protection Process | 1 |
| | Examples of Wellhead Protection: Case Studies of Six Local Governments in Virginia | 2 |
| | Summary of Findings | 3 |
| II. | Roanoke County | 7 |
| | Water Supply in Roanoke County | 7 |
| | The Area's Hydrogeology | 8 |
| | The Wellhead Protection Process | 10 |
| | Data Inventory | 11 |
| | Protection Area Delineation | 13 |
| | The Proposed WHP Overlay District | 13 |
| | Public Participation | 14 |
| III. | Botetourt County and the Town of Fincastle | 17 |
| | Water Supply Issues in Fincastle/Botetourt | 18 |
| | Project History | 19 |
| | The Area's Hydrogeology | 20 |
| | The Wellhead Protection Study | 21 |
| | Protection Area Delineation | 23 |
| | Study Recommendations & Conclusions | 23 |
| IV. | Lord Fairfax Planning District Commission | 27 |
| | The Area's Hydrogeology | 28 |
| | The Four Town Wellhead Protection Projects | 29 |
| | Mount Jackson | 31 |
| | New Market | 32 |
| | Stephens City | 33 |
| | Stanley | 35 |
| | Recommendations to the Four Towns | 37 |
| V. | Nelson County Service Authority | 41 |
| | The Nelson County Service Authority | 42 |
| | The Project | 43 |
| | Progress to Date | 46 |
| VI. | Henrico County | 49 |
| | Public Water Supply Wells in Henrico County | 50 |
| | The Project | 51 |
| | The Area's Hydrogeology | 52 |
| | Data Collection and Analysis | 54 |

Field Inspection 55
Wellhead Protection Area Delineation 55
Uses of the Wellhead Studies 57
Public Education 58

VII. The Eastern Shore (Accomack and Northampton Counties) 63
Ground Water Use on the Eastern Shore 64
The Area's Hydrogeology 65
Identification of Wells Needing Protection 67
Delineation Methods 67
Implementing the Study Recommendations 69

VIII. Appendix 74

A) Public Water Supply Systems in Virginia Using Ground Water 75
B) Field Office Contacts for the Virginia Department of Health 79

## List of Figures

Figure 1 - Participating Localities 3
Figure 2 - Roanoke County 6
Figure 3 - Photo of Residential Subdivision 7
Figure 4 - News Article About Well Contamination 9
Figure 5 - Example of Wellhead Protection Area 12
Figure 6 - Botetourt County 16
Figure 7 - Photo of Well #2 Vicinity 17
Figure 8 - Photo of New Well House 19
Figure 9 - Wellhead Protection and Recharge Areas 22
Figure 10 - Lord Fairfax Planning District Commission 26
Figure 11 - Photo of Horse Farm 27
Figure 12 - Mount Jackson Area Survey Boundaries 30
Figure 13 - New Market Area Survey Boundaries 32
Figure 14 - Stephens City Area Survey Boundaries 34
Figure 15 - Stanley Area Survey Boundaries 36
Figure 16 - Nelson County 40
Figure 17 - Photo of Lovingston Main Street 41
Figure 18 - Photo of Lovingston Ridge Apartments 42
Figure 19 - Henrico County 48
Figure 20 - Photo of Henrico County Government Center 49
Figure 21 - Photo of Computers Assisting in Delineation Studies 52
Figure 22 - Types of Wells and Protection Areas 53
Figure 23 - Public Information Brochure 60, 61
Figure 24 - The Eastern Shore 62
Figure 25 - Photo of Assateague Lighthouse 63
Figure 26 - Photo of Tomatoes 65

Figure 27 - Eastern Shore Ground Water Diagram 66
Figure 28 - Wellhead Protection Areas 69

# I. OVERVIEW

## Basic Concepts

**Wellhead protection** is the term applied by EPA and others to describe a process for assessing potential threats to ground water, for managing land uses and activities in the area near public water supply wells, and for planning to prevent problems before they arise.

A **wellhead protection area** consists of land in the vicinity of a public water supply well chosen for special protection to prevent pollution of the ground water from nearby surface and sub-surface activities.

The **size and shape** of the protection area is a function of factors such as the hydrogeology in the vicinity of the well, its daily withdrawal rate, land use activities existing or likely in the area, and assessment of replacement or other options if the well were to become polluted. The area could range from a few acres to several square miles or more.

The special **protection measures** which could be applied to a wellhead protection area include zoning limitations on the types of land uses allowed, performance standards to contain and manage potential pollutants, contingency plans for accidents, and coordination among local, state, and federal governments and private property owners.

**Public water supply wells*** include community wells - both those owned by governments and those owned privately - serving residential customers as well as a variety of wells serving the public in locations such as restaurants, schools and industry. (A list of public well systems found in each Virginia county and city is contained in Appendix A.)

**Local governments** are essential participants in wellhead protection because of their authority over land use and because of their frequent role as a public utility supplying drinking water to community residents and businesses.

## The Wellhead Protection Process

In 1992, the state Ground Water Protection Steering Committee** found that:

- **There is a need for wellhead protection in Virginia.** Many public water supplies in Virginia depend wholly or in significant part

* A full explanation of the different types of public water supply wells can be found in Chapter 6.

** This Committee consists of representatives from nine state agencies who meet regularly to discuss ways to improve ground water protection in Virginia.

on ground water wells. Replacement supplies or treatment would in most cases prove very expensive or impractical.

- **Local governments in Virginia have the land use authority needed for wellhead protection.** The state code was specifically modified in 1988 and in 1990 to give localities clear authority to use their planning and zoning powers to protect ground water and public water supplies. Since wellhead protection is based on land use management, it is essential that local governments be involved.

In order to assist counties, towns, cities, and service authorities in Virginia with wellhead protection, **Wellhead Protection: A Handbook for Local Governments in Virginia** was prepared and distributed to local government officials across the Commonwealth.

That **Wellhead Protection Handbook** sets out a series of twelve steps aimed specifically at jurisdictions in Virginia to help these localities get started with wellhead protection. It outlines a range of options that allow decision makers to tailor specific wellhead protection programs to their particular situation and to reflect local land use patterns, hydrogeology, staff skills and the availability of alternative water supplies.

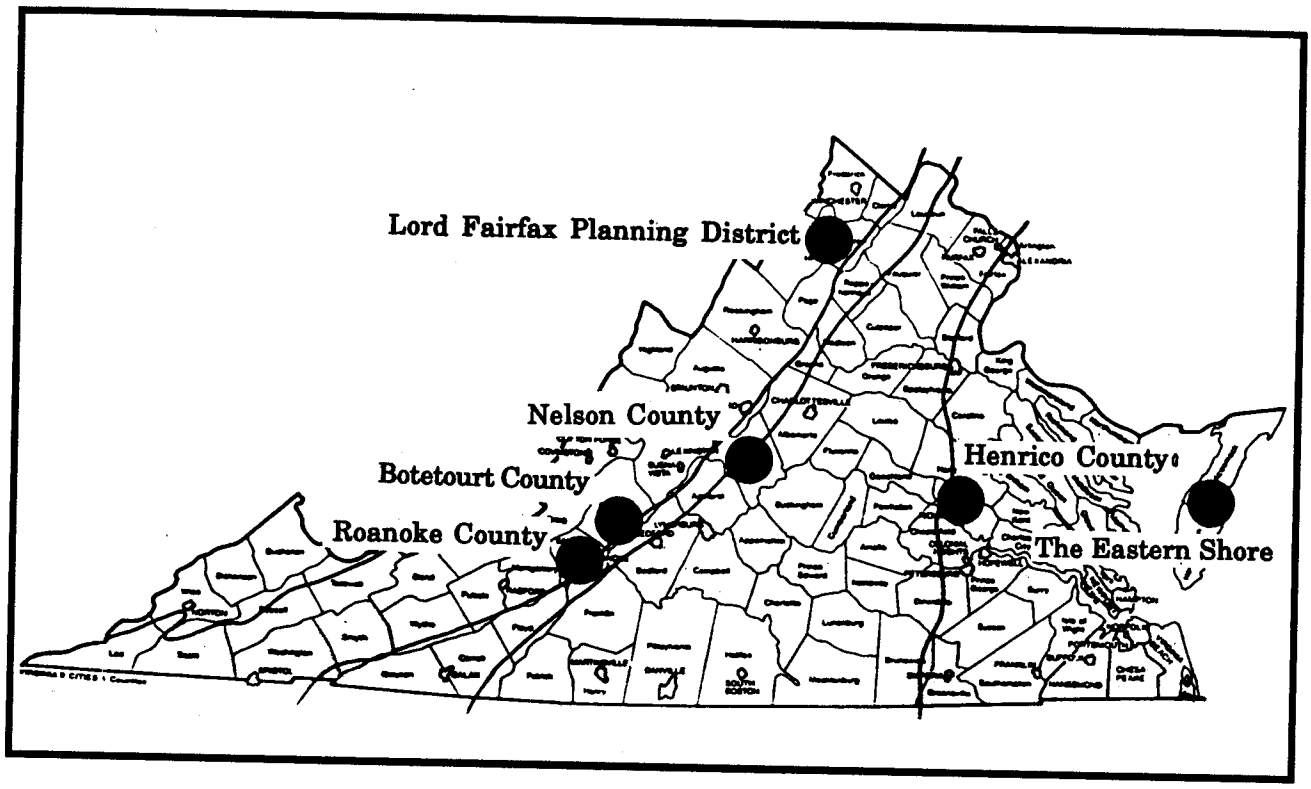
## Examples of Wellhead Protection: Case Studies of Six Local Governments in Virginia

It is one thing to "tell" someone how to do something in a handbook, and it is another to "show" them by example how it is actually being done by someone much like themselves. That is the reason for this report: **Wellhead Protection: Case Studies of Six Virginia Local Governments.**

- What has been the experience so far in Virginia?
- What has been learned?
- How can other local governments benefit from this experience?

Six localities in Virginia have recently initiated studies which have or are expected to lead to wellhead protection in their jurisdictions.

Figure 1 - Participating Localities




These localities are found, as shown on the above map, in several different parts of the state - a significant factor in Virginia where ground water and geologic conditions vary dramatically across the state. Two localities (Henrico County and Roanoke County) received grants through the State of Virginia while the other four (Botetourt County, Lord Fairfax Planning District Commission, Nelson County, and the Eastern Shore) received support directly from the EPA Wellhead Protection Demonstration Grant Program.

**Summary of Findings**

In comparing the experiences of these six localities, one thing that is consistently found is that, in each case, they tailored both the study process and the options considered to fit their own local need and circumstance.

Some relied only on their own staff, some worked through the PDC, and some hired consultants. With the **Wellhead Protection Handbook** and other materials and technical assistance that are available, it is not always necessary to hire a consultant.

Some appointed a committee of community members to guide the study from the outset. Others completed the basic studies at the staff level and then presented the results to the Planning Commission, Board of Supervisors, and the

Some appointed a committee of community members to guide the study from the outset. Others completed the basic studies at the staff level and then presented the results to the Planning Commission, Board of Supervisors, and the public. Both processes can work but community involvement can contribute much to a successful project.

Some used a fixed radius method for delineating potential protection areas. A distance of 500 yards was the most frequently used distance. Others used computer models to generate protection areas more reflective of actual conditions believed to influence each well. Others had geologic studies conducted to examine often complex hydrogeologic conditions before mapping out wellhead protection areas. Many different degrees of sophistication and refinement are possible. "First cut" fixed radius approaches can be refined later if better data becomes available.

The motivation to conduct wellhead studies in some cases, stemmed from past experience where wells had been lost due to contamination. The goal was to prevent a reoccurrence of the past problems. In other cases, a more preventive approach was taken in order to avoid having to learn from experience. In two instances, future well sites were studied and given as much attention as current wells. No localities treated lightly the possibility of losing a valuable public water supply source.

Mostly, the case study localities addressed only the water supply wells that they themselves owned, but in one jurisdiction investor owned wells that supply drinking water to residents and businesses were also included in the study. These, too, are public water supply wells. The number of wells addressed in these cases ranged from as few as two, to as many as nearly sixty. In three cases, town wells were located beyond town limits in the surrounding county. This is not uncommon and places considerable emphasis on interlocal cooperation.

For most of these localities, studies are just now or will soon be completed and so implementation experience is limited. Some are looking at overlay zoning and have developed draft text. Others intend to implement wellhead protection through case by case plan review. Others intend to incorporate wellhead protection into their comprehensive plans. No one implementation approach is right for all jurisdictions.

Expenditure of time and money varies significantly among the cases and none of the jurisdictions offered an estimate of how much their own staff time cost. Grants to support these projects ranged from $10,000 to $95,000. The higher costs included more sophisticated research. Some localities were able to build on work already being done in connection with comprehensive plan updates, preparation of a DRASTIC map, or geologic studies recently completed or underway under other auspices.

Several constants also emerged from the experience of the six Virginia localities.

All found the need to consolidate a wide variety of data sources and maps but when this was done, it was surprising how much was already known.

All would have liked to have more data and so they have kept the door open to revise their program if better information becomes available.

All had concerns about land owner attitudes but contacts during field studies suggested that citizens are glad that someone is looking after their water supply. While none of the localities has yet adopted wellhead protection overlay zoning, the hope among staff members is that reasonable measures will be responded to reasonably.

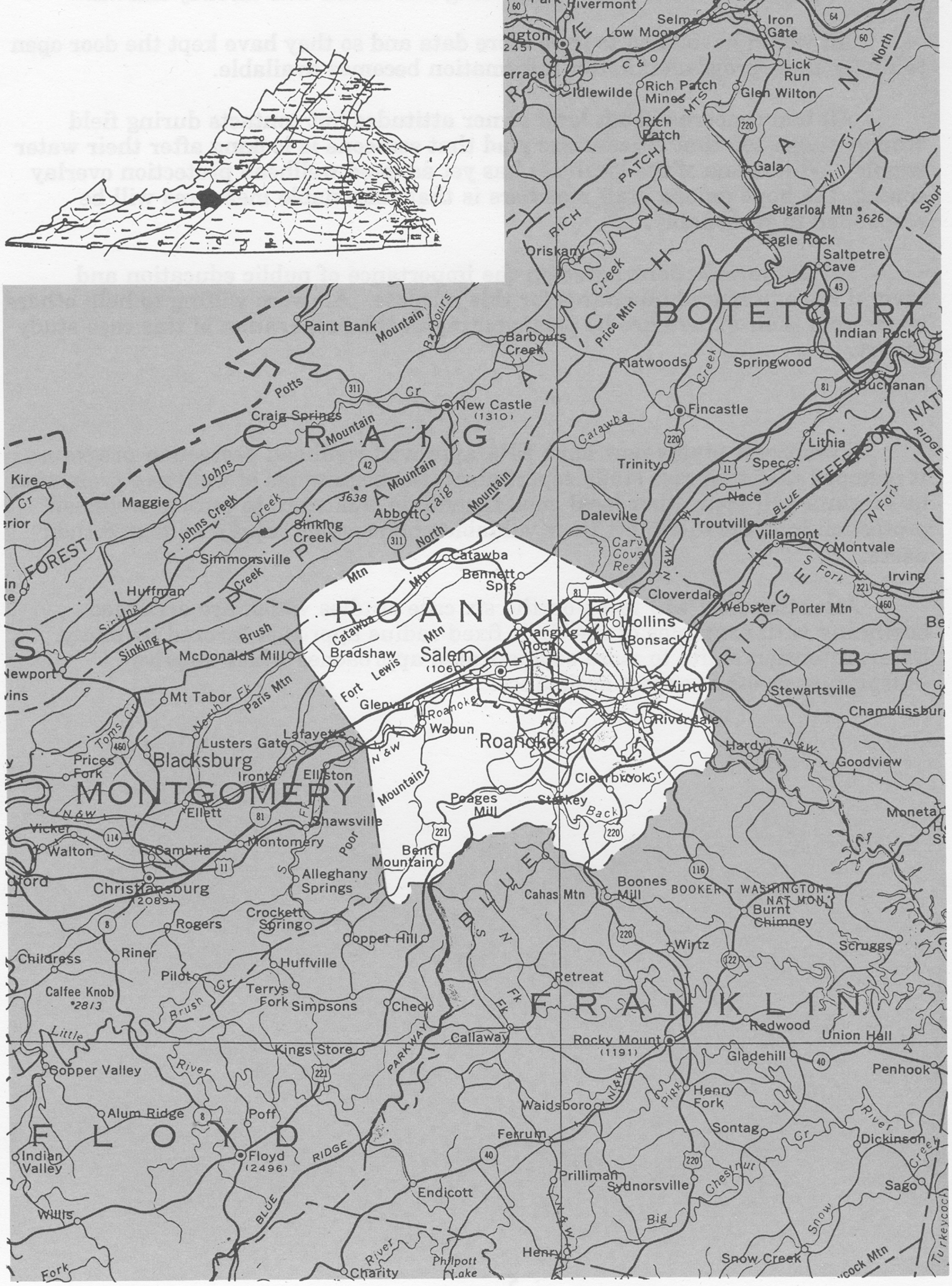
All the jurisdictions agree on the importance of public education and several have prepared brochures for this purpose. All were willing to help others learn from their experience by participating in the preparation of this case study report.

• • •

Twenty-six states now have EPA approved wellhead protection programs. It is hoped that this case study report about the beginnings of wellhead protection in Virginia will spur other local governments in this state to pursue wellhead protection in order to protect their valuable public water supply wells and their users.

Attention now will focus on the six case studies which are arranged beginning with examples of the basic fixed radius approach favored by many. Later, attention shifts to more sophisticated approaches which require consultants or other expert assistance.

## Figure 2 - Roanoke County



# II. ROANOKE COUNTY

Roanoke County has more ground water supplied public water systems (77) than any other county in Virginia. It is a relatively compact county of 251 square miles located in Southwest Virginia and is home to nearly 80,000 residents. Although the Spring Hollow Reservoir project is expected to be on-line in the near future and will provide the County with its own source of surface water, ground water is expected to continue to play an essential role for a long period of time. Given the large number and the diverse nature of the ground water based public water supply systems in the County, a decision was made to start small with wellhead protection. Three wells were given highest priority by the Department of Utilities and a Planning Department staff member devoted six months to assessing and planning for the wellhead protection situation of these three wells. At this point, the study has been completed and a proposal for a zoning text amendment to establish a wellhead protection overlay zoning district has been developed. It is slated for consideration by the Planning Commission in the near future.

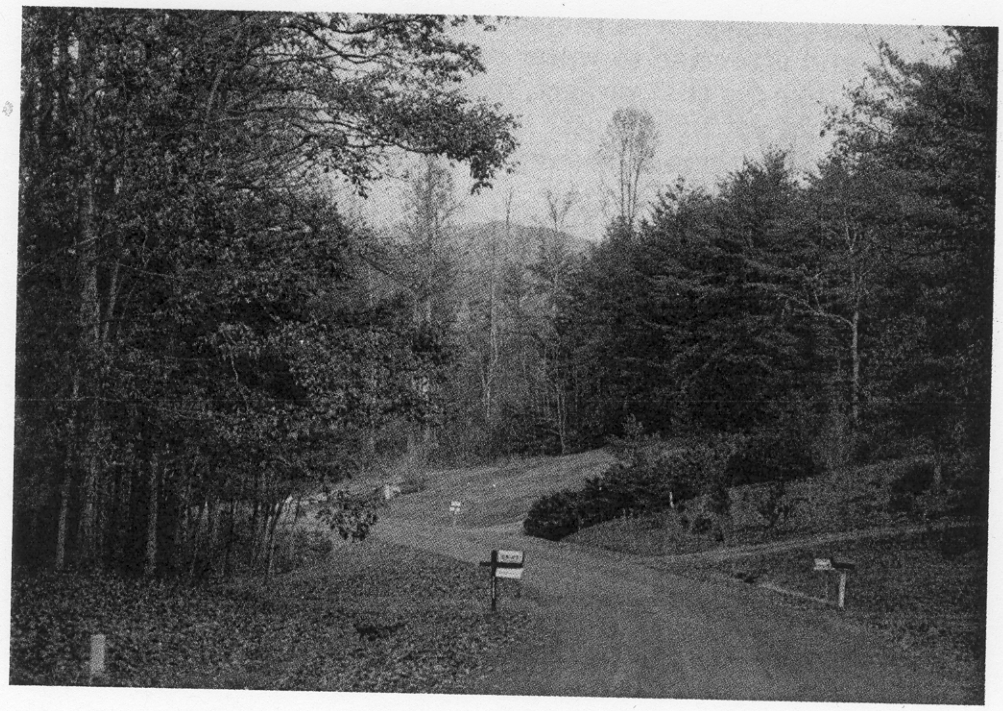


Figure 3 - Roanoke County has more ground water supplied public water systems than any other county in Virginia. These systems serve a variety of users including residential subdivisions, elementary, junior high, and high schools.

## Water Supply in Roanoke County

Close to 75% of Roanoke County residents are served by the 77 wells which make up the public water supply in the County. Over the years, County owned and operated wells, 41 of the 77, have been developed in response to the increased residential and commercial growth taking place, or in other cases, the County has taken over privately owned public water supply systems which have either failed or have been unable to meet state standards. Because the County's water

demands cannot be met with the ground water system alone, water is also purchased from the City of Roanoke, City of Salem, and the Town of Vinton. The County's long term strategy to address the bulk of its increasing water demands is the construction of the Spring Hollow Reservoir. Construction of the dam for the reservoir is now completed, water lines are being installed and operation is expected to begin in December of 1994.

Well contamination and failure problems, as well as controversy for several years surrounding the Spring Hollow Reservoir project, brought ground water and wellhead protection into the public arena. One of the most publicized contamination problems experienced in the County was one which left residents of a County trailer park without water. To meet the water needs of these 30 or so mobile homes, the County was able to extend water lines to replace the contaminated well where TCE (trichloroethylene) was found at 400 times acceptable levels. (See Figure 4.)

The Spring Hollow Reservoir controversy also spotlighted the County's need for water and the extent to which it was relying on ground water to serve many areas in the County. The project was controversial and sparked almost five years of debate and attention to water resource issues. With such a large amount of money at stake for that project, many residents began to wonder where their children would get their water. The debate made people appreciate what they already have in terms of ground water supplied systems.

Roanoke County illustrates a very important point about wellhead protection that warrants repeating. The fact that surface water meets a part of a jurisdiction's need or the fact that a new reservoir is going in, does not mean that ground water will not still need protection. This was made clear in Roanoke County's assessment of its own situation.

> Plans provide for the proposed Spring Hollow Reservoir to meet the long-term water needs of the County. Although currently under development, the reservoir is a long-term solution to a decreased reliance on ground water. Initial transmission facilities from the accompanying new water treatment plan will only serve a small portion of the County. Thus, the County will continue to rely on ground water supplies to serve major areas of the County well into the 21st Century.

## The Area's Hydrogeology

Roanoke County lies within two physiographic provinces: the Valley and Ridge, and the Blue Ridge. As described in their wellhead study, the region is characterized by sharply differing geologic conditions depending on the part of the County being considered. All of the study wells are located in Blue Ridge Fault Zone and Cambrian-Ordovician (CO/OC) Aquifer System. This system is a karst aquifer and forms the major valley area of the County. Recharge is dependent upon topography, soil characteristics, permeability of the aquifer, and the degree of development of vertical fractures in the rock.

# Suspected carcinogen found in trailer park well

By GEORGE KEGLEY
STAFF WRITER

The state Health Department is investigating a suspected carcinogen found in a Hollins area trailer court well.

Trichloroethylene (TCE), the chemical, was discovered in December in a routine inspection of a well supplying Tinkerview Trailer Court, off Plantation Road, according to Jesse Mayhew, district engineer for the Health Department in Lexington. A second sample was taken for confirmation.

The well was taken off line Wednesday and the 22 to 25 residents of the trailer court are receiving water from Roanoke County, he said.

No complaints were received from the residents, Mayhew said. The chemical, new on the Environmental Protection Agency standards list, is a colorless liquid and it probably has no taste, he said.

TCE, a compound used in degreasing, like a solvent in cleaning or a lubricant in cutting, has been tested only with animals "as far as we know," Mayhew said. He called it a possible threat to humans, "not a major problem."

Dr. Molly Hagan, Alleghany Region health director, is looking into the effects of the chemical on humans, according to Mayhew. Hagan was out of her Vinton office Thursday.

Mayhew said he does not know the source of the chemical. The nearby ITT Electro-Optical Products plant said it is assisting in the investigation.

Kip Foster of the state Water Control Board regional office said his office "may possibly take enforcement action against the responsible party," he said.

The EPA has known about TCE for years "but just now set standards" for its use, Mayhew said. His samples exceeded the EPA standards.

This was the first trace of TCE found in the Roanoke area, he said. Mayhew said he plans to meet with other Health Department and Water Control Board representatives Monday "to plan what to do next and to find out whether the chemical has spread to other wells."

# Search for source of chemical begins

By GEORGE KEGLEY
and MARK LAYMAN
STAFF WRITERS

State Health Department engineers Friday began a search for the source of a chemical that may have contaminated wells in the Hollins-Plantation Road area of Roanoke County.

Seventeen samples were taken from wells in the search for trichloroethylene (TCE), according to Dr. Molly Hagan, Alleghany Region health director. The samples will be sent to Richmond for laboratory tests that may take a week, she said.

An estimated 50 homes within a mile of the trailer court have private wells that could contain the chemical, Hagan said.

The samples were taken within a quarter-mile of the Tinkerview Trailer Court, where a well was found to be contaminated with a high level of TCE. According to Roanoke County Utilities Director Cliff Craig, the safe level for TCE is .005 milligrams per liter. A sample from the trailer court well contained 1 milligram per liter, he said.

Roanoke County is supplying water to the 34-lot trailer court and to two nearby houses and a small apartment complex, all managed by HCMF Real Estate and Housing Management of Blacksburg.

County Supervisor Bob Johnson is president of HCMF. But County Administrator Elmer Hodge said Friday, "We're not treating them any differently than we would any other. . . . Our purpose was to get safe drinking water to them as fast as we could."

HCMF will owe the county about $25,000 in connection fees for the water hookup. Because the hookup was needed to provide safe drinking water to the trailer court, Craig said he would recommend to the Board of Supervisors on Tuesday that HCMF be given until July 1 to pay the connection fees.

Ideally, the party responsible for the contamination will be located and will pay the connection fees, he said.

Hagan said she doubts that the TCE came from the nearby ITT plant, but she does not know the source. Other smaller industries are located nearby.

"There are four or five potential places this could come from," Craig said.

If she lived in that area, Hagan said, she would drink bottled water, but she considers the well water safe for showers. Concerned residents might use a carbon filter to remove the chemical as a short-term solution, she said.

TCE is a non-flammable, colorless liquid with a sweet odor, Hagan said. The chemical came under regulation by the Environmental Protection Agency only last year.

TCE is used in anesthesia, she said, and "any acute effect is nonexistent." No evidence has been found to associate cancer with TCE in humans, the doctor said.

Positive samples of TCE were found in two other wells within a half-mile radius of the trailer court, Hagan said.

Hagan is working with the state Water Control Board on the problem. She planned to study ground water maps with the board and ITT representatives "to try to anticipate where other contamination may be."

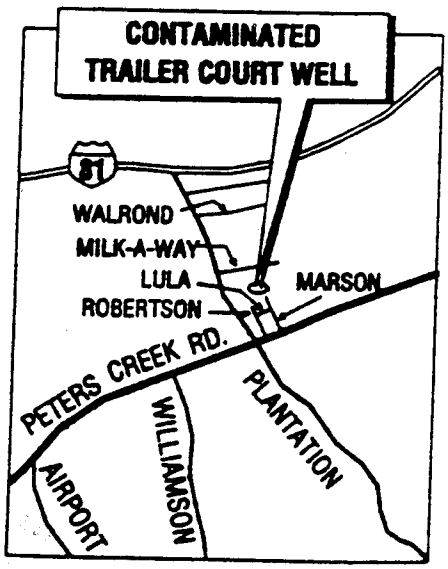



Figure 4 -

Articles from the Roanoke Times & World News, Feb. 21 and 22, 1992.
Graphic from the Roanoke Times & World News, February 26, 1992

The Starkey 1A well, one of the three studied by the County, is located in the Shady Dolomite formation south of the city of Roanoke. This formation is comprised of coarse-grained dolomite interbedded with shale and clay. Thick soil cover reduces the number of outcrops in the area which helps minimize contamination potential from runoff. The availability of ground water in this formation is excellent and high yields are frequently encountered. The remaining two study wells, Hidden Valley 6 and Bonsack, tap into the Rome Formation which, according to the study, underlies a large portion of the Valley along the western portion of the Blue Ridge. The formation is characterized by a high carbonate content with excellent water-bearing properties. This formation has experienced considerable faulting and folding that increases the possibility of contamination.

**The Wellhead Protection Process**

County Planning Director, Terry Harrington, who formerly served on the Ad Hoc Wellhead Protection Advisory Committee*, was a key actor in identifying the need in Roanoke County for a Wellhead Protection Pilot Study as a way of addressing the ground water protection objectives stated in the County's Comprehensive Plan and shown on its Resource Protection map since 1985. Money for the study came through a $10,000 grant from the State Department of Environmental Quality** through their federal 106 Ground Water Protection Grant. The application for funds was endorsed by the County Board of Supervisors. The money was used to fund a staff person to work full time on the project for a period of six months. County Planner Janet Scheid, estimated that without prioritizing the time of the person doing the study, it could have taken two to three years of part-time attention as this project would have to be fit in along with other staff demands. "Staffing is critical" to perform such a study, according to Ms. Scheid.

The goal of the Roanoke County study was to determine a wellhead protection area which would protect against several types of threats: direct introduction of contaminants to the area immediately contiguous to the well, microbial contaminants, and chemical contaminants. The county felt that three wellheads was a manageable number for the initial study and requested the Department of Utility to recommend the specific sites. The sites were selected based on the fact that they (1) had been historically free of contamination; (2) were heavily used; (3) were good producers; (4) were wells about which the Department of Utility wanted to get more information; and (5) were located in different parts of the County.

---

* A Committee made up of representatives from a number of local governments as well as several state agencies in Virginia which came to the conclusion that wellhead protection was both possible and needed in Virginia.

** formerly the State Water Control Board

The Roanoke study coordinator divided the wellhead study into several general steps: (1) data inventory; (2) delineation of the protection area; (3) development of the proposed wellhead protection overlay district; and (4) public participation and education.

*Data Inventory*

The wells selected for the study were the three recommended by the Department of Utility after reviewing basic data on all of the County's public water supply wells. The data inventory process for these three priority wells sought to be as comprehensive as possible. It began by locating the wells on base maps. In this case, this was not difficult but for some jurisdictions, especially when investor owned wells are being included, locating the wells on a map can be surprisingly time consuming and difficult.

Field studies, generally following the guidelines described in the **Wellhead Protection Handbook,** were then performed on the recommended wells. The survey was conducted by a two person team. The first was a land use survey of the general features and current practices in the immediate area of each wellhead. A core study area was established as a 100 yard radius from each of the wellheads. A secondary survey was also conducted to note possible sources of contamination in an expanded study area of a 500 yard radius around the three wellheads. The survey contained information on zoning designation, current and future land use, drainage area, water source, sewer system, soil class, and aquifer system. A list was also compiled of the registered underground storage tanks in the County and a map of the UST sites was created from the listed information. According to the study, there was an awareness that some unregistered tanks probably existed in the area as well.

An assessment was then made based on this data of the risk of contamination from the observed sources. As noted in the **Wellhead Protection Handbook,** the assessment of vulnerability is a crucial early step in wellhead protection and involves balancing and reconciling a number of different factors.

In speaking with the planners in the County, it was interesting to learn that landowners encountered during these surveys were cooperative and expressed that they were pleased that the County was taking an interest in wellhead protection.

Back in the office, other pertinent data were collected on the wellheads, and the geography and hydrology of the area. This information included well yields, storage capacity, depth, and historical data. The data collection process was described as a somewhat arduous task due to the disparate locations of many of the information sources. Information was obtained from the local utilities, the Department of Environmental Quality, the Health Department, Environmental Protection Agency (EPA) documents, and the Virginia Water Resources Research Center located at Virginia Tech.

## Figure 5 - Example of WHP Area

Hidden Valley 6 Wellhead Protection (WHP) Overlay District

*Protection Area Delineation*

The second phase of the pilot process was delineation of the protection area, discussed as Step 11 and in Chapter 5 in the **Wellhead Protection Handbook**. The fixed radius method was selected for three reasons: (1) it does not require advanced technical expertise; (2) only a moderate amount of data is required, (3) it involves modest costs; and (4) speed. The complications associated with the karst aquifer system, along with a lack of data, also made the fixed radius a workable choice for a first cut approach. A radius of 500 yards - 1,500 feet - was chosen for each of the three wells being addressed.

*The Proposed WHP Overlay District*

Development of a proposed Wellhead Protection Overlay District, described in the Wellhead Protection Tools section of the **Wellhead Protection Handbook** was the third element of Roanoke County's pilot study process. The overlay zoning district would apply to the areas within the fixed radius protection areas for each well. The zones would be superimposed on one or more existing zoning districts and add requirements and/ or restrictions to those already in place. An overlay district, according to project staff, was seen as an appropriate protection method because it permits a "precise, sensitive, and consistent response to environmental features, regardless of pre-existing zoning." Flexibility can be achieved by making uses conditional in the overlay district. While such zoning may restrict some aspects of development, it does not prohibit development, according to the study. This is important to property owners whose cooperation and support are necessary if wellhead protection is to succeed.

The uses proposed to be permitted in the Wellhead Protection Overlay District would be the same as those in the underlying district except for the following prohibited uses:

(1) storage, production or disposal of hazardous waste
(2) disposal of solid wastes other than brush and stumps
(3) storage of petroleum or other refined petroleum product except within or attached to buildings which it will heat
(4) land application of industrial wastes
(5) industrial uses which discharge process wastewater on-site
(6) disposal of liquid or leachable wastes, except residential waste disposal systems
(7) commercial feedlots
(8) storage of uncovered manure
(9) storage of road salt or other deicing chemicals
(10) automotive service and repair shops, junk and salvage yards.

The plan is to initiate the overlay district in the near future but at this stage it has not yet been formally addressed by the Planning Commission or Board of Supervisors. The overlay districts are on the Planning Commission's calendar

for late 1993 - early 1994. If all proceeds as anticipated, the overlay districts should be in place sometime mid-1994. Planning Director Harrington explains that the delay in bringing the proposed ordinance forward for these three areas does not have to do with opposition but rather with other items such as the recent controversy over development near the Blue Ridge Parkway, which have crowded the agenda of local officials.

*Public Participation*

"Public participation is a critical component of wellhead protection," according to Janet Scheid. An overlay district in and of itself will not be sufficient to protect wellhead areas. The County does not have the staff or the resources to constantly police the wellheads and must, therefore, rely on the cooperation of the public. Awareness and understanding of the consequences of potentially damaging activities will help people to act more environmentally responsible.

To inform and involve the public, the County intends to conduct community meetings in areas that would be covered by the proposed overlay district. At these public workshops pertinent information will be made available from the state, the county, and the EPA about "do's and don'ts" of wellhead protection. A free information brochure has also been developed and will be available from the County. Janet Scheid said that the County is considering sending the brochure as part of tax mailings. This is preferred over sending the brochure with water utility bills since 30% of County residents are on private well systems and don't receive a utility bill. The only drawback to this, according to Ms. Scheid, is that "people aren't usually in a great mood when they receive their tax bills and may not be as receptive to the information as they would otherwise be."

• • • • •

Roanoke County will be an interesting case to follow as the Planning Commission and Board of Supervisors consider the proposed overlay zoning district. The **Wellhead Protection Handbook** offers the following conclusion on this topic:

> **Overlay zoning is one of a number of tools available in Virginia's local governments for wellhead protection.** This technique is already in use for a variety of purposes such as protecting surface water supplies in the Commonwealth. Overlay zoning does not change the basic underlying zoning upon which property owners have relied and adds protective provisions only in those areas where needed. The technique is flexible and can be tailored to the desired degree and type of protection sought by a locality.
>
> The Virginia Ground Water Protection Steering Committee finds that the need for wellhead protection exists, that the means for localities to protect wellhead areas exist, and now has prepared this **Wellhead Protection Handbook** to encourage local governments to take the next step.

Roanoke County is a jurisdiction that is on its way to doing just that.

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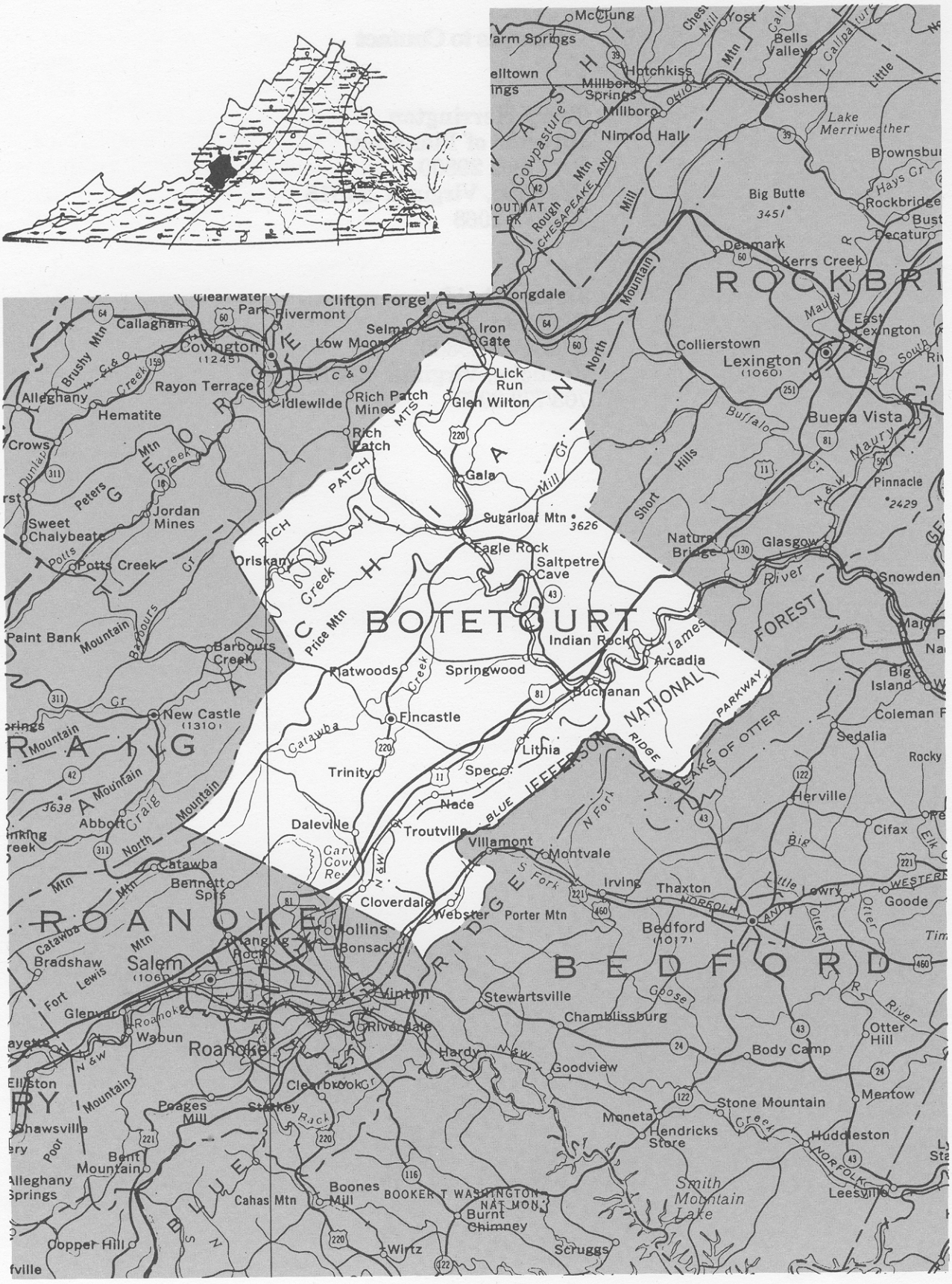
## Figure 6 - Botetourt County



## III. BOTETOURT COUNTY AND THE TOWN OF FINCASTLE

Botetourt County is a predominantly rural area of some 25,000 residents located in Southwestern Virginia just north of Roanoke. The Town of Fincastle, its historic County seat, owns and operates a small public water supply system which serves a mixture of users in the Town as well as in its environs. The County and Town recently completed a wellhead protection study of the Town's wells. What is especially interesting here is the degree to which cooperation has become necessary between the Town and the County.

Back in the mid-1970s, problems with ground water contamination led the Town to establish a public water supply system. To reach aquifers which had not been contaminated and which would yield good potable water, the Town installed two wells outside its own corporate limits in surrounding Botetourt County. Since the Town does not have the land use authority to protect wellheads outside its jurisdiction, a high degree of County/Town cooperation became necessary. A similar need exists in a number of other towns in Virginia.

Looked at narrowly, one can imagine that a County might be reluctant to take the steps necessary to protect another jurisdiction's water supply and this was the case initially in Botetourt. But, after a period of public education, the interdependence of the Town and County became clear. Not only were a number of County residents, businesses and the County offices served by the Town water system but growth would bring additional County and Town residents who would also need good water. Thus a partnership eventually emerged to protect this joint water supply resource which has the County now taking a key role.

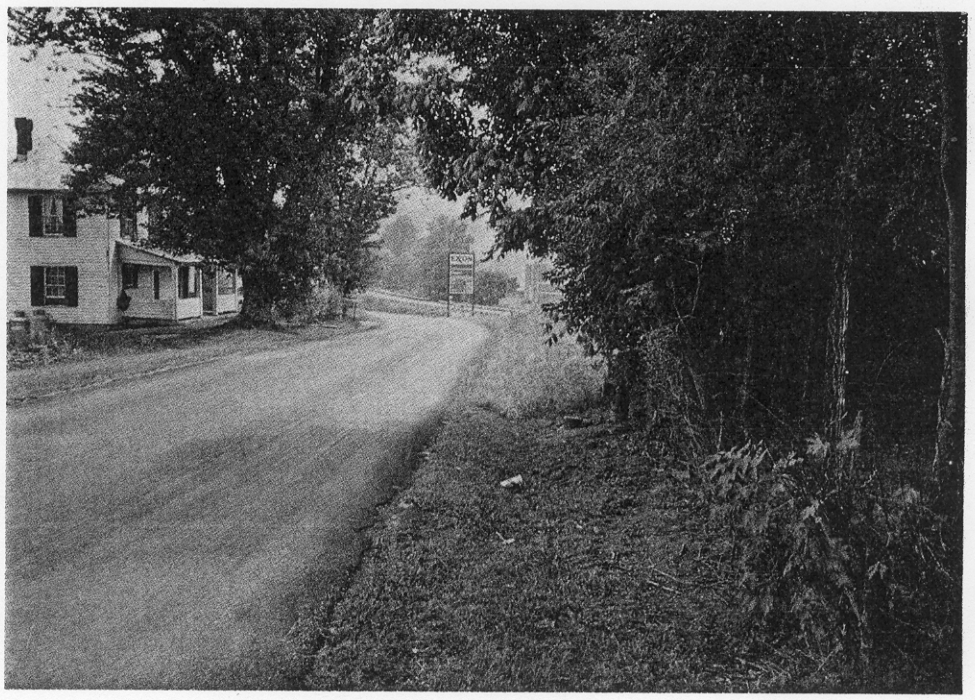


Figure 7 -

This tree lined road leads from the Town of Fincastle to Route 220 in the distance. Well #2 is located to the right, a short distance away.

**Water Supply Issues in Fincastle/Botetourt**

The Fincastle Water System, which is operated by the Town, consists of two public water supply wells located in Botetourt County. The system currently serves 975 people - about half of whom are located in the County. The service area includes residences, a number of churches and businesses, a nursing home, three schools, and all of the Botetourt County offices.

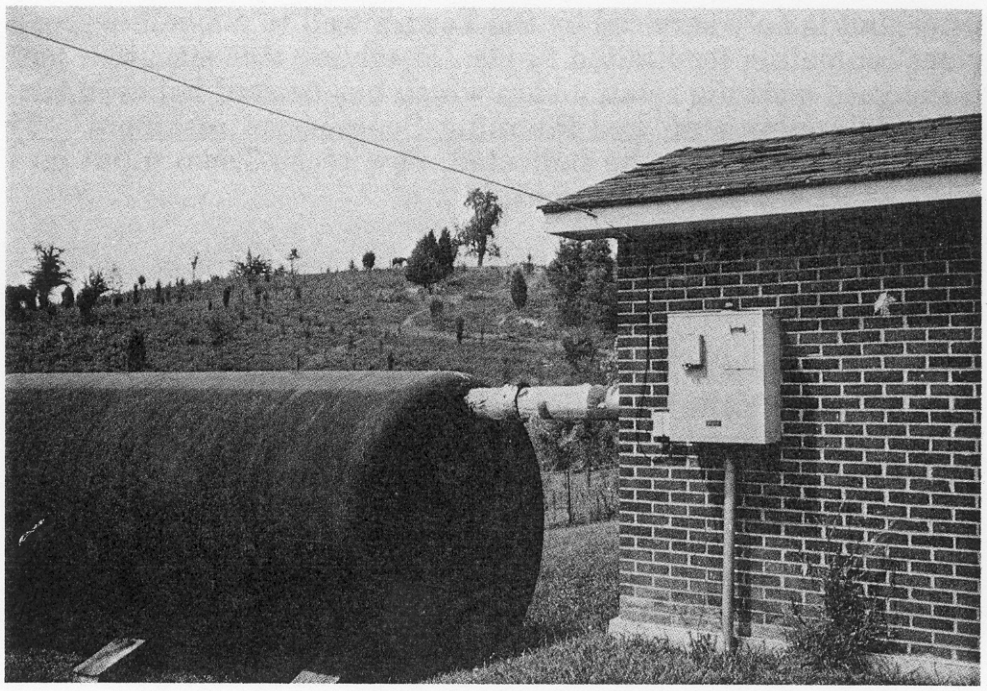
Ground water concerns in Fincastle came to the forefront in the mid-1970s as a result of experiencing well contamination problems in about 25% of the private wells located in the Town. At that time there was no public water or sanitary sewer system. The source of the problem was a hydrocarbon contamination - the cause of which was thought to be the washing of a large quantity of hydrocarbons into a low lying area while bringing a fire under control, as well as waste motor oil which was carelessly disposed. Also during this time bacteriological contamination from failed septic systems in the Town was relatively common. As a result, people in the town who had been relying on that aquifer could no longer drink their well water. As a consequence of this experience, the Town sought and received Environmental Protection Agency (EPA) funding for public works projects to provide sewers, a treatment plant, and a public water supply system. A condition of this money was that all private wells in the the Town be abandoned and all town residents be on the new public water system. As supporter of wellhead protection and former mayor Cromer Hedrick put it, "that fire and the other problems we had with ground water were the big reasons that brought town water in. People couldn't just drill new wells on their same property. Small towns need something like wellhead protection when they put in public wells."

The new public water system consists of two wells, located South and West of the Town, which tap a different aquifer than those contaminated by the hydrocarbons and bacteria. The Town owns each of these small well sites, as well as holding easements to provide access their property, but they do not control the surrounding land.

Speaking about the Town's desire to protect and prevent problems with these new wells, Wayne Weikel, former water system manager from the Town, explained, "The Town is concerned that its sole supply of drinking water could be jeopardized by encroaching development if wellhead protection measures are not taken into consideration in both Town and County land use planning. We feel that an important aspect of wellhead protection is to have the mechanisms in place to protect ground water - well ahead of the additional risks posed by future development. If the means of prevention are in place before pollution occurs, we can avoid disputes and lawsuits to ascertain responsibility."

Figure 8 -

The two new wells, like the one shown here, were installed by the Town of Fincastle outside Town limits in Botetourt County.



**Project History**

The Town of Fincastle originally applied to the U.S. Environmental Protection Agency (EPA) for funding of a wellhead protection study for the two wells. The basis for the application was the fact that both residents and businesses in the Town and its environs are totally dependent on the ground water and concern that previous contamination problems could reoccur. The objectives of the proposed study were: 1) to delineate wellhead protection areas for the two existing wells; 2) to inventory existing land uses and assess potential risks they pose to the water supply system; and 3) to propose land use controls which could minimize the risk of resource degradation from future development.

EPA grant monies, it was then learned, would only be available if the County were the primary applicant. The County Planning Commission, it turned out, was supportive of the project and gave the required go-ahead approval. As a result, the County joined with Fincastle in requesting EPA money. An engineering consulting firm was subsequently hired to add technical expertise. Even with the EPA grant of $10,000, however, the biggest issue associated with doing the wellhead study, according to County Planner and Zoning Administrator Chuck Supan, was cost. The small staff of the County and the Town had to take responsibility for the study in addition to their regular workload.

According to Chuck Supan, the wellhead study reflects the necessity that there be a joint effort to protect the Town's public water system. He describes the delicate balance in the two jurisdiction's cooperative efforts this way. "The Town is concerned about land use practices that may affect the wellhead, but has no jurisdiction over County land and has no Town tax to help fund protection. The County, on the other hand, is also concerned about wellhead contamination issues, but is only serviced by the Town's well to a small degree and has other

issues, but is only serviced by the Town's well to a small degree and has other issues competing for limited funds. Resolving this situation has been dependent on the good working relationship which has existed between the Town and the County planning staff and Planning Commission members." The County Planning Commission, he indicated, now seeks Town input on issues which might affect the wellhead areas.

**The Area's Hydrogeology**

The Town of Fincastle and the adjacent areas of Botetourt County are situated in the Valley and Ridge Physiographic Province. The geologic structure of this area is complex, with folding, thrust faulting, strike-slip faulting, and normal faulting identified in the immediate area. A thrust fault encircles the Town of Fincastle on the north, east and south. This folding and faulting complicates ground water flow. According to the consultant's wellhead study, they produce displacements and "breaks" in the earth's crust which may result in one of three conditions: (1) a conduit promoting the movement of waters; or (2) the production of clay or "gouge" which may prevent the movement of waters and result in an accumulation of waters on the "upstream" side of the fault; or (3) the displacement of a water bearing bed which then becomes "isolated" at a higher or lower elevation, or has only limited permeability permitting reduced or intermittent access to other water bearing zones at other elevations. Without detailed study it is not possible to know which conditions prevail and influence the Town's two wells.

The Town's #1 well is drilled 400 feet into and possibly through the dolomite and limestone rock of a thrust sheet. The #2 well bore penetrates limestone and dolomite strata underlying the thrust sheet to a depth of 475 feet. Both wells intersect open, waterbearing fractures and solution cavities described as follows in the consultant's study.

> The Driller's Log indicates two (2) caves or openings with muddy water were encountered from a depth of 125 feet to 130 feet and from 190 feet to 195 feet, and both of these openings were cased-off. The material from a depth of 195 feet to 470 feet was described simply as limestone with 'broken limestone' zones from 405 feet to 407 feet and from 428 feet to 431 feet. Another cave opening was reported at the bottom of the well, from 470 feet to 475 feet.

The intensely fractured limestones and dolomites in the Fincastle area assure good ground water potential but these same conditions also increase the potential for pollution. The good news is that to date both wells have performed as expected with no significant problems.

Like other areas with karst topography, the aquifer system in the Fincastle area is recharged largely through infiltration into the ground, which is controlled by topography. Streams flowing across the aquifer system also discharge water into the aquifer. Thus concern must focus on uses of the land surface.

A ground water pollution potential map of the land surface of Botetourt County was developed in 1988 based on the DRASTIC* rating system. The system indicated that the Fincastle area and the area to the southwest where the two wells were located in the mid-70s does have a very high potential for ground water contamination. Areas east and northeast of the town have a moderate potential for ground water contamination.

**The Wellhead Protection Study**

After obtaining the EPA grant, the study followed many of the twelve steps found in the **Wellhead Protection Handbook**. The wells were first located on available topographic maps and a study area of approximately 9 square miles was established. The area was set to cover at least one mile beyond the two existing water wells and the limits of the Town of Fincastle. The study team next reviewed available data on the physical setting, geology, and hydrogeology of the study area. Available data on the existing water system were examined. This included information on well construction (depth, diameter, driller's log), pump tests, and well yields.

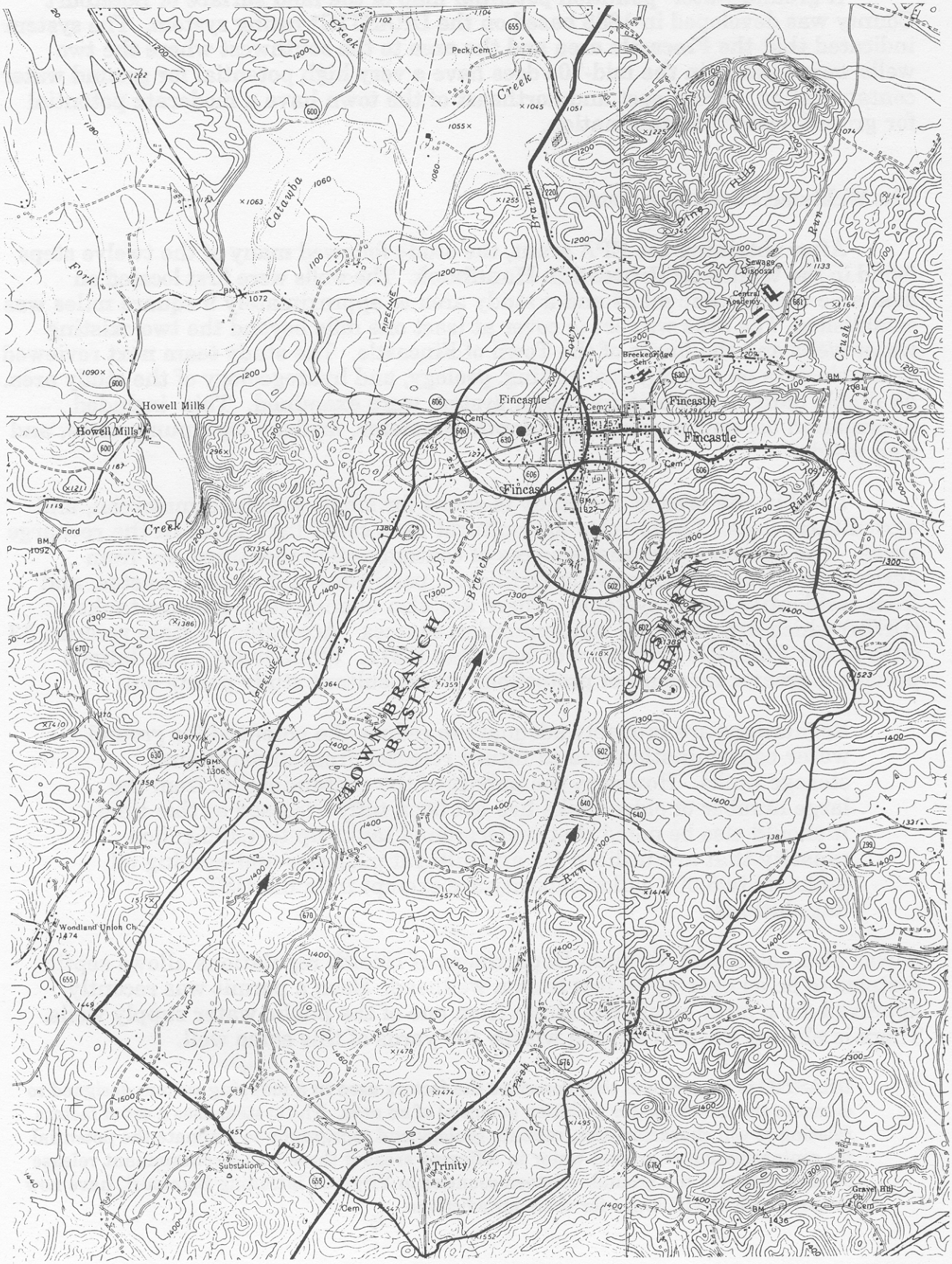
Land in the area of the study is zoned for single family, commercial, and agricultural uses. Large-scale agricultural uses could take place in the recharge areas. The primary potential sources of contamination identified are from agricultural land uses involving fertilizers, pesticides and animal wastes, and from residential septic systems. There are also underground storage tanks (USTs) which are potential contamination sources. According to state records, 13 sites in the Fincastle area have or have had USTs. While today's regulations provide a greater measure of protection, the consultant study points out:

> Regulations are probably adequate to reduce the potential for ground water contamination due to future releases from underground storage tanks. However, the impact of the contamination from the large number of older tanks has not been fully assessed at this time. It should also be noted that underground tanks up to 1,100 gallon capacity that are utilized for agricultural purposes and heating oil tanks up to 5,000 gallon capacity are exempt from the UST Regulations.

It was also noted that Virginia Department of Health regulations allows septic systems to be as near as 75 feet from a wellhead. Such a permit was recently approved for a farm across the street from one of the public water supply wells. There is also an EXXON station within 100 yards of this same well.

* DRASTIC is an acronym that describes the factors used in a mapping system designed to evaluate the ground water pollution potential of an area. The system uses a set of factors relating to soil characteristics, rainfall, geology and topography to estimate the potential for contamination of ground water in different areas if there was a contaminant release on the surface of the ground. Sixteen counties in Virginia, including Botetourt, have now prepared DRASTIC maps for their jurisdictions.

## Figure 9 - Wellhead Protection & Recharge Areas



The other general category of potential contamination sources cited in the report is State Route 220 which bisects both protection areas. Some people feel that the question will be what to do *when* a spill happens, not *if*. The nearest hazardous waste team, for example, is in Roanoke which would take somewhere between 25 and 45 minutes to respond to the spill and contamination would most likely have occurred by that time. In these situations a contingency plan should be available.

**Protection Area Delineation**

Due to the complex geology and hydrogeology of the area and the absence of a more detailed geologic study, a fixed radius approach was selected as the most appropriate. This and other means of delineation are discussed as part of Step 11 and in Chapter 5 in the **Wellhead Protection Handbook.**

County staff and the consultant considered pumping data, method of well construction, and area geology to estimate a radius of 500 yards for the protection area for each of the two Town wells. That distance was felt to be satisfactory because it encompassed known elements of concern based on what had been observed. Since protection of the areas in the immediate vicinity of wells in carbonate terrains may not be adequate, however, additional vulnerability mapping was also conducted. This mapping identified that areas upqradient of the two wells in the drainage areas of Town Branch and Crush Run are likely sources of recharge to the wells and their immediate protection areas. Protection was also recommended for this recharge area.

**Study Recommendations & Conclusions**

The wellhead study provided broad-based findings and recommendations regarding future land use in the area of the two wellheads. Foremost is that wellhead protection areas should be designated for the area within 500 yards of each of the Town of Fincastle's water wells. The County staff and consultant also recommended that future industrial and heavy commercial land rezonings within the 500 yard protection area be carefully scrutinized. Future land rezonings in the Town Branch and Crush Run drainage basins should also be carefully reviewed given the potential impact of these areas on ground water .

It was also noted that the existing public water system is operating at less than 50% of its rated capacity. Extension of the town water distribution system would be feasible which would minimize the number of individual water wells drilled. This would limit the number of opportunities for contamination from poorly constructed or grouted private wells.

In addition, the report recommended that every effort should be made to educate and assist developers, the agricultural community and the public about the potential for ground water contamination and identify specific actions to

minimize the potential for contamination. Best Management Practices (BMPs) to protect ground water quality should be encouraged both for agricultural activities and homeowners.

As additional funding and data becomes available, consideration should be given to further revisions and updates to the report. Currently, however, there is no money budgeted in the five year plan for a more detailed wellhead study.

A term which Chuck Supan uses to describe how the County will use the wellhead study and the approach it will take to the delineated areas is "consultative." The staff, the Planning Commission and Board will use the knowledge and information provided by the study as a factor in reviewing zoning, subdivision, Capital Improvement Program, site plan, and other decisions. The Comprehensive Plan for the area now refers to the wellhead study and Planning Commission members have copies. The County feels that this approach will be effective and is preferred to a more regulatory approach such as would be involved with overlay zoning. Perhaps because of this approach and attitude, the County has encountered no property owner opposition and citizens encountered in the field during the conduct of the study were receptive. Perhaps also this attitude is an extension of the voluntary and cooperative climate throughout the study process characterizing town/county relations.

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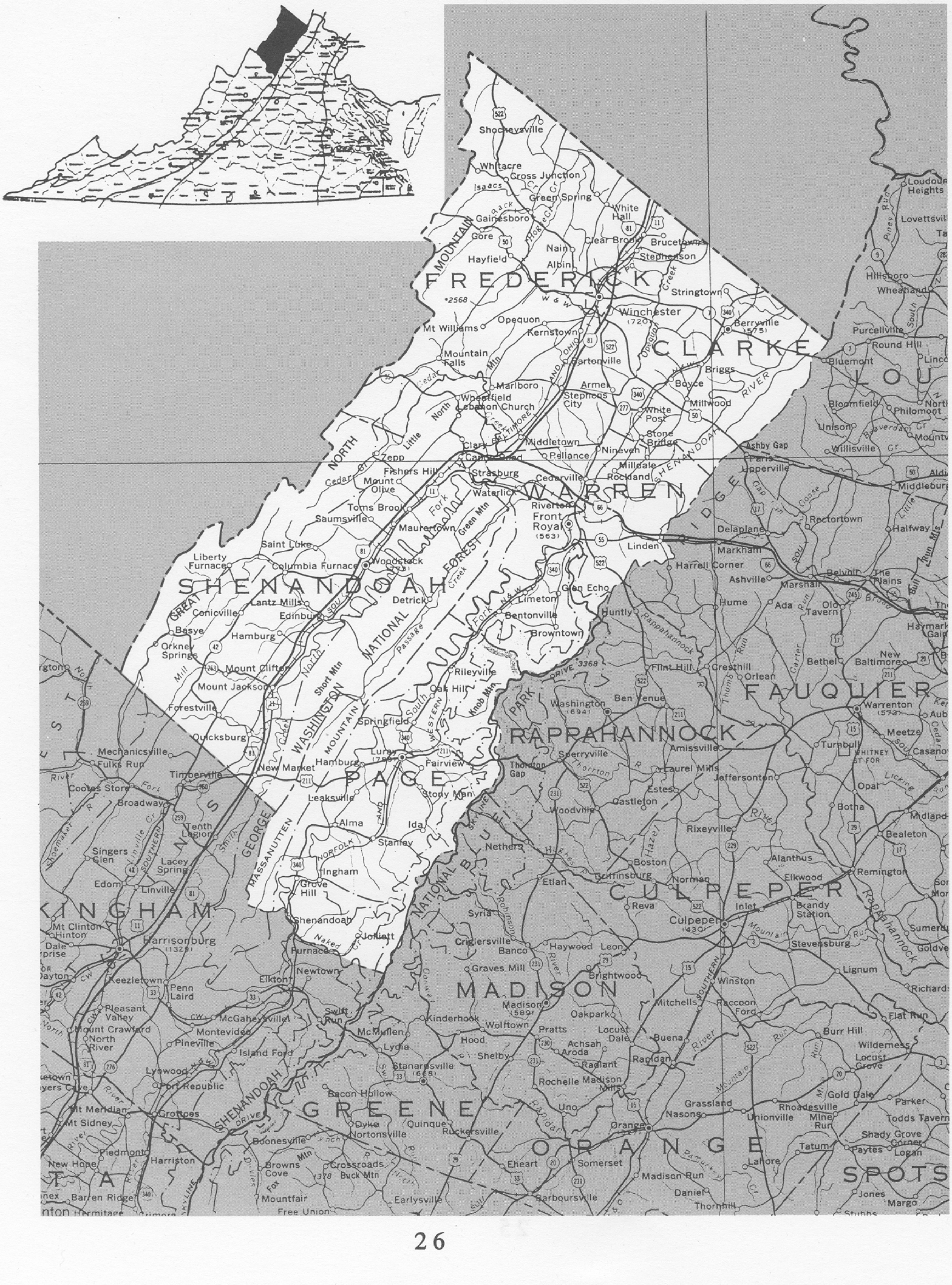
## Figure 10 - Lord Fairfax Planning District Commission



# IV. LORD FAIRFAX PLANNING DISTRICT COMMISSION

The Lord Fairfax Planning District Commission (LFPDC) and its member localities have for several years been leaders in wellhead protection in Virginia. This Planning District is located in the northern Shenandoah Valley and includes five counties: Clarke, Frederick, Page, Shenandoah, and Warren. In this region, protection of public wellheads is extremely important to the local governments and citizens because of the large numbers of people who rely on ground water for their water supplies. According to local officials, small communities that depend on wells as a source of public water frequently cannot afford the expensive and time consuming problems brought about by contamination of their water supplies. The studies described below illustrate that many everyday land uses are found in the vicinity of public water supply wells which can pose potential risks. The first step in wellhead protection is to identify those risks. The studies described here also illustrate how Planning District Commissions can supply wellhead protection technical assistance and staff capability to localities who lack the knowledge or resources to do wellhead protection all on their own.

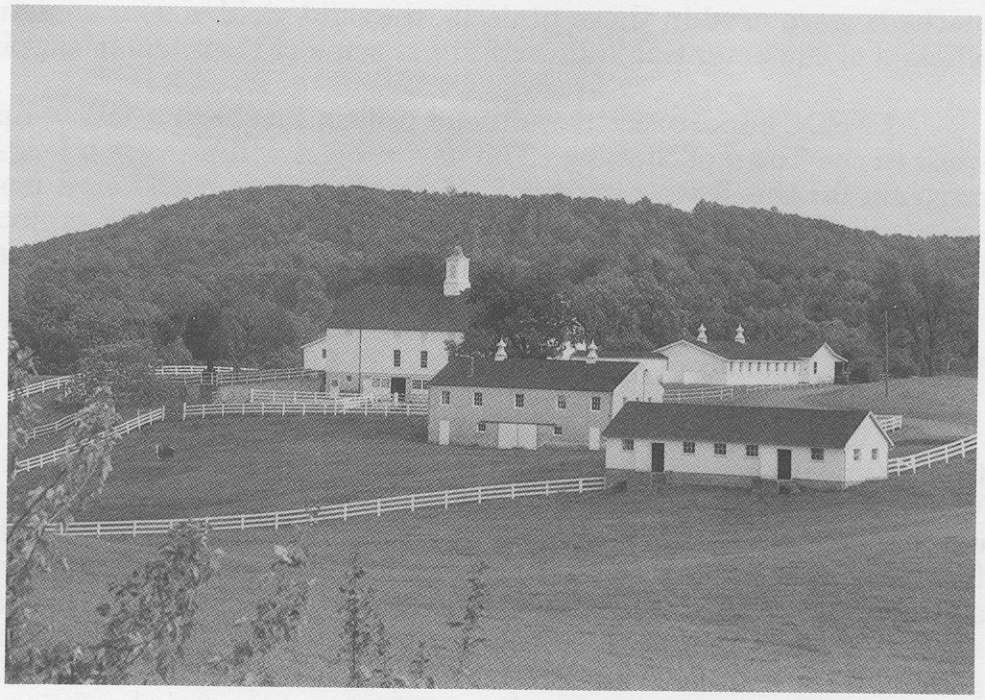


Figure 11 - The LFPDC contains a great variety of activity ranging from horse farms to orchards, from historic towns to new shopping centers, from forests to agriculture. Each can raise its own type of wellhead protection issues.

Concern for public water supply wells has a history in the LFPDC area. In 1981, the Town of Berryville in Clarke County lost the use of its public water supply wells due to contamination from nearby activities. Excessive levels of nitrates in the water were believed to have come from surrounding agricultural operations. This cost the town $1.3 million to construct a new water treatment facility on the Shenandoah River.

A few years later in 1983, concern arose that future growth and development in Clarke County might pose a contamination threat to the Prospect Hill Spring, a major source of drinking water for the communities of Boyce and Milwood. The county hired a consultant to perform a hydrogeologic and engineering study of the spring and, as a result, a Natural Resource Conservation Overlay District was adopted by the county to protect the recharge area surrounding the spring. This is believed to be the first overlay zoning ordinance implemented in Virginia for the purpose of ground water protection. Clarke County is also the first locality in Virginia to be granted a sole source aquifer designation by EPA.

Recently, four additional localities became involved in wellhead protection projects undertaken by LFPDC. During 1991 and 1992, the PDC conducted wellhead protection studies for the Towns of Mount Jackson and New Market in Shenandoah County, the Town of Stephens City in Frederick County, and the Town of Stanley in Page County. These studies were funded through a $22,500 grant from the State Department of Environmental Quality* through their federal Section 205(j) grant. This grant paid 75% of the project costs. The local share - $7,500 - was offset by a charge of $400 per well to the towns. While fairly simple methods were used in these projects, they did yield a clearer picture for local officials of the potential vulnerability of some of their water supplies.

LFPDC's most recent wellhead project has been a follow-up to the earlier work in the Town of Stanley. The new project will provide a long-term protection program for the Town's main water supply source based on a more detailed scientific delineation of the wellhead protection area. This project is funded directly through an EPA Wellhead Protection Demonstration Grant.

## The Area's Hydrogeology

The geology of the Lord Fairfax Planning District Commission, located in the northern-most part of the Valley and Ridge Physiographic Province in Virginia is varied, but generally is characteristic of limestone karst areas. This contributes to the risk of ground water contamination. In karst topography, the flow of water in the ground is through conduits or caves and along bedding planes and fractures. Very high flow rates can occur under rapid recharge conditions such as storms, thereby facilitating the transport of surface contaminants to the ground water system. Surface runoff can also enter sinkholes. It is because of these conditions in the region that LFPDC and the four localities felt it necessary to investigate and develop ground water protection programs for their communities that depend on ground water for their public water supplies.

This geologic setting is also significant because it makes delineation of the zones of contribution around each well extremely difficult due to varied flow and recharge patterns that can occur in karst terrain.

* Formerly the State Water Control Board

## The Four Town Wellhead Protection Projects

The primary goal of the four recent projects was to initiate a simple wellhead protection planning process designed to provide baseline information and recommendations which could offer some degree of protection from existing and future sources of well contamination. In total, 13 wells were studied: 4 in Mount Jackson; 3 in New Market; 5 in Stanley; 1 in Stephens City.

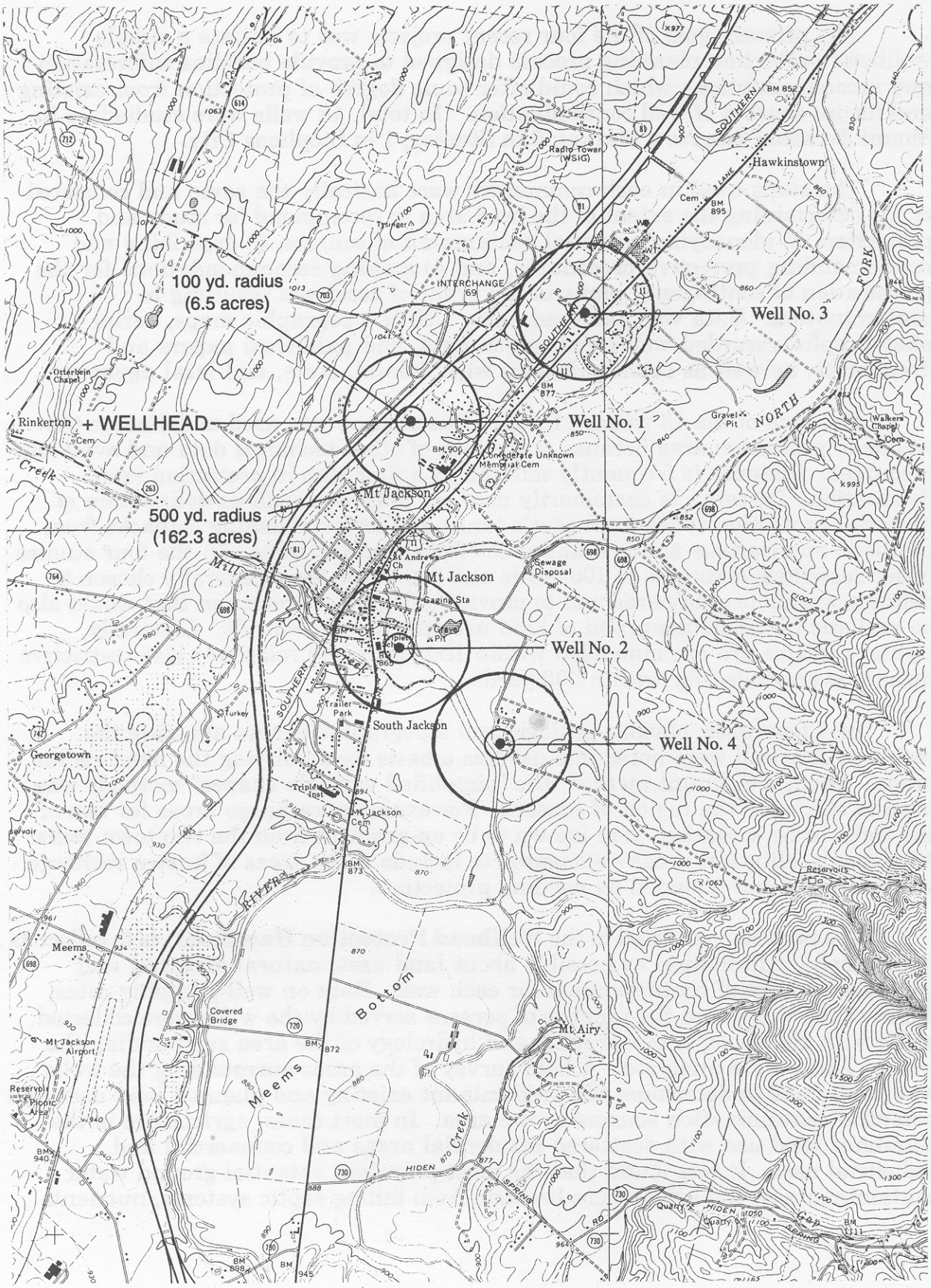
The steps used in each community were basically the same and consisted of: 1) determining the extent of the land area to recommend for study and protection, 2) identifying potential contamination sources, 3) describing and recommending protective procedures, and 4) making recommendations for the preparation of contingency plans in the event of accidents resulting in contamination. Data was gathered using USGS topographic maps, aerial photographs, recorded well construction data, and published papers and documents, as well as communication with federal, state, and local agencies.

For each of the 13 wells, a fixed radius method was used to delineate the wellhead protection area because of the lack of other technical data and available resources. Distance is frequently selected as a first step in protection area delineation. Distance is customarily used for purposes such as delineation of bacterial protection zones from septic tanks and for establishing setbacks from pesticide applications and is familiar to officials and citizens. In the four studies being described, distances of 100 yards and 500 yards were generally chosen to define a workable study area and to provide a degree of protection that would also be realistic for implementation of land use and zoning controls. Generally, tighter controls are recommended within 100 yards and relatively less restrictive measures are called for within 500 yards.

In a few cases, obvious geologic and topographic factors affecting the recharge of a well were noted and used as a basis for modifying the fixed radius areas. Then, a different method, the "simplified variable shapes" methods was used to delineate the region of concern. For example, recharge areas for two of the wells in New Market were known to be up-gradient from the two town wells. As a result, elliptical areas - elongated to include these areas of known recharge - were mapped and included as needing protection.

The next step, as noted in the **Wellhead Protection Handbook**, is to collect as much useful information as possible about land uses, natural features, and potential sources of contamination for each well. Data on well pumping rates, depth of the wells, and the number of persons served by the wells were collected, along with the geology, topography, and hydrology of the area surrounding the wells. These were analyzed. A field survey of the areas surrounding the wells was performed to determine the predominant existing and planned land uses and potential contamination sources in the area. In most cases, agriculture is the dominant land use with scattered residential areas and commercial and industrial uses. It was found that the most prevalent potential ground water contaminants in the LFPD were bacteria from failing septic systems, nutrients

## Figure 12 - Mount Jackson Area Survey Boundaries



from agricultural operations and pesticides from animal, crop, and fruit production.

Jeffrey Slack, a planner from the Lord Fairfax Planning District Commission working on the project, believes that the lack of more precise delineation data need not be an obstacle since the simple inexpensive method used here provides a significant improvement over no delineation at all and can be used to protect against the most common threats in the area. It also offers a starting point when considering more complex protective measures in the future as has been the case in the Town of Stanley.

*Mount Jackson*

The Town of Mount Jackson is located in southern Shenandoah County about 25 miles north of Harrisonburg. Its 1990 population is reported as 1,583 - up approximately 150 from 1980. Currently, all water in the town is obtained from four wells, three of which are within town limits. Quantity is expected to be no problem through the year 2030.

The well which supplies the majority of the town's water (#3) is located in a mixed residential/commercial area between Route 11 and the Norfolk and Southern Railroad Track. One of the remaining two wells in the town (#2) is behind a school near a residential area and the other (#1) is behind the Valley Chemical and Fertilizer Company. Mount Jackson's fourth public supply well (#4) is located in an agricultural area about 1/2 mile east of town.

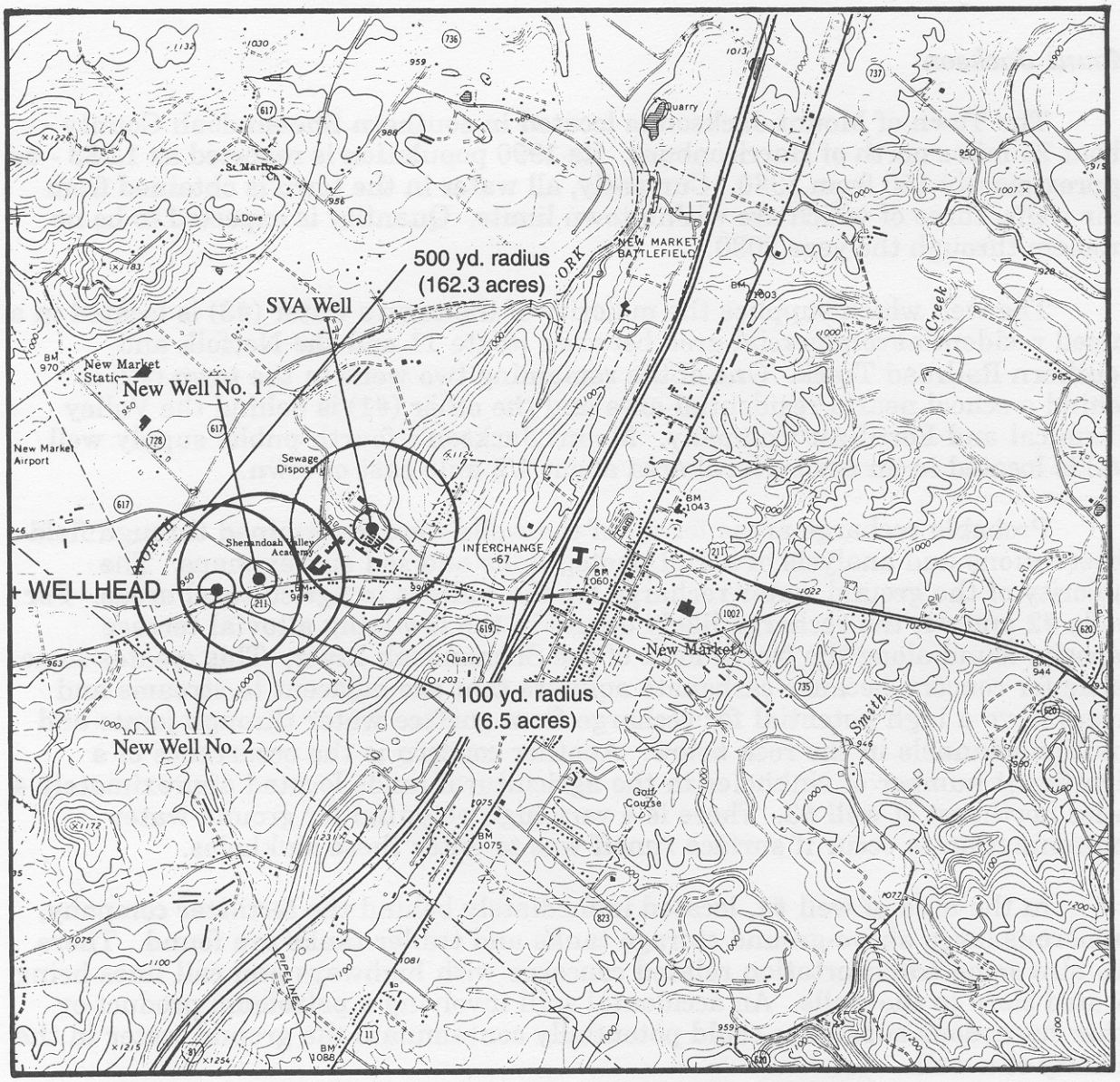
Probable recharge areas for all of the wells were determined through field observations and analysis of aerial photographs and soil survey maps. The majority of the ground water recharge for the wells is in agricultural areas. For wells #2 and #4, the recharge likely occurs in the low-lying alluvial terrace deposits found along the North Fork of the Shenandoah River. This creates some cause for concern because carbonate aquifers that are adjacent to streams and rivers have a high potential for recharge from surface water through joints and solution channels in the rock below. Another concern is the occurrence of a significant number of sinkholes in the agricultural lands located approximately 4 miles northeast of well #3. There is a very high potential for ground water contamination to occur if surface runoff was to enter these sinkholes.

In the area of well #1, located immediately behind the fertilizer company, numerous large above-ground storage tanks and trailer tanks are found. There are also some transportation related concerns with highways and rail lines being located close to the wells. An accidental spill involving a petroleum product or other hazardous substance could potentially contaminate the ground water in the vicinity of a well.

*New Market*

**The Town of New Market, with its 1990 population of 1,435, grew significantly over the previous decade. Like Mount Jackson, it is also located in Shenandoah County. It supplies water from a variety of ground and surface water sources. The Town recognizes the need for wellhead protection and states in the Environmental Goals and Policies section of its 1990 Comprehensive Plan that "New Market will investigate methods of protecting its wells which form the major source of its public water supply."**

**Figure 13 - New Market Area Survey Boundaries**




**New Market has three public supply wells located approximately one mile west of the center of town. The well which supplies the majority of the town's water is located in a relatively low-lying area behind dormitory-style housing on**

the Shenandoah Valley Academy (SVA) campus. Approximately 150 feet from this well is a machine shop which services and maintains the trucks and other equipment used in the operation of the school. Petroleum products such as used motor oil, gasoline, and various lubricating products stored and used at the shop are potential sources of contamination.

The Town's two remaining wells are located on an alluvial terrace near the North Fork of the Shenandoah River. Once again, this proximity to the river poses a potential threat. The land surrounding these wells is in cultivated agricultural use and comprises a large majority of the recharge area for the aquifer that produces the water for the two wells. The construction of Route 260 west of New Market divided a once continuous tract of agricultural land, resulting in agricultural runoff now being concentrated in the low-lying swale areas at the base of the highway. A great deal of recharge is expected to occur in these low-lying areas.

Due to the land use and probable recharge patterns here, two elliptical areas were delineated extending northeast of the 100 and 500 yard protection areas on the SVA well and southeast of the other two wells. These elliptical areas represent areas of known recharge and are proposed for consideration for protection due to the geology and topography of the surrounding area.

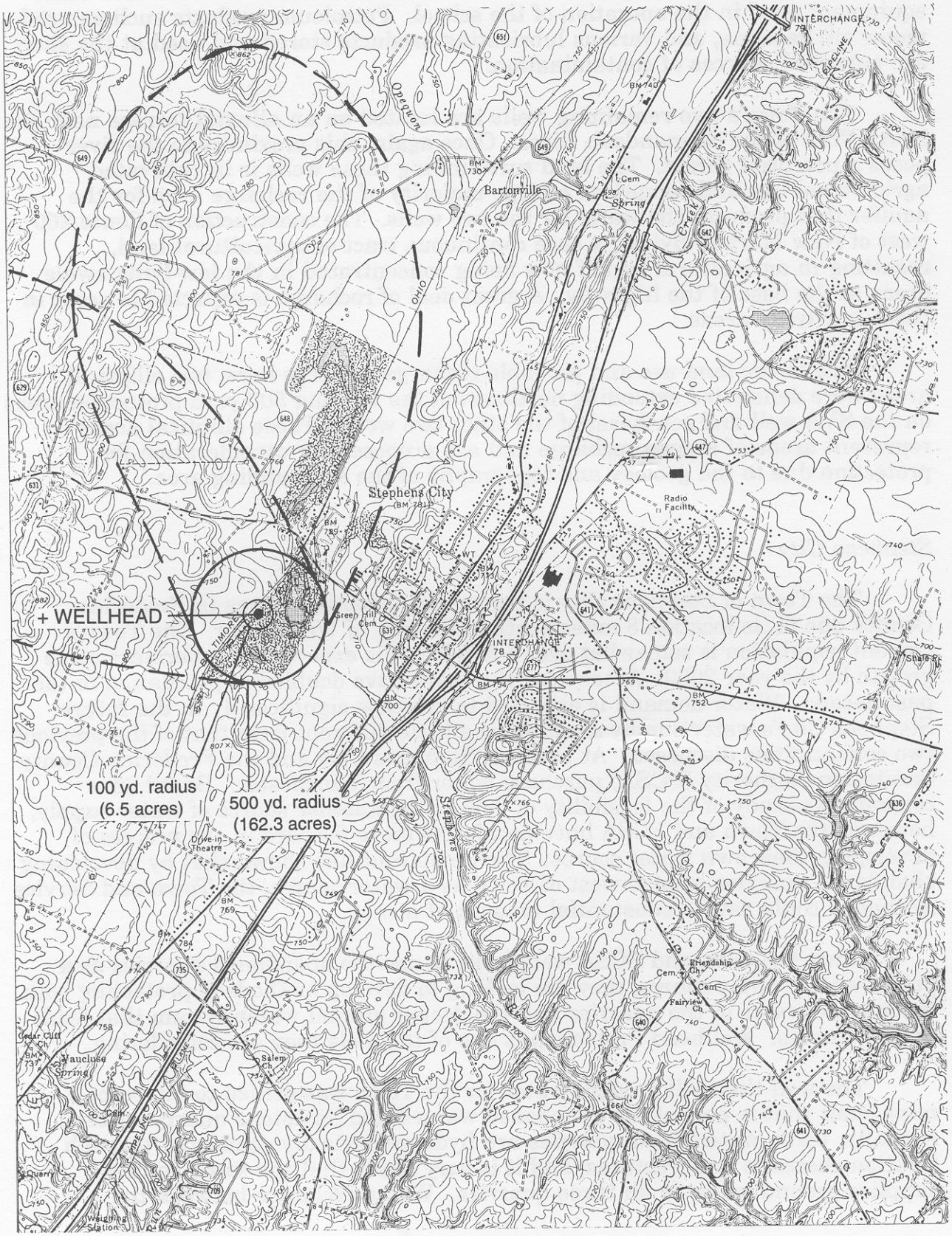
*Stephens City*

The Town of Stephens City is part of the urbanizing area in Frederick County due to its location 8 miles south of the city of Winchester. The Town's current population is somewhat over 1,000 but it is expected to experience some growth by the year 2000. Areas near the Town have doubled in population in the past decade. Water demand is expected to increase significantly in the future. Stephens City's water supply situation is a little different from that of the previous two communities discussed. At present, Stephens City and the Frederick County Sanitation Authority (FCSA) purchase water from Winchester. Based on a consultant's study of the feasibility of developing another source of water supply, however, the Town and FCSA have decided to move forward in the process of developing their own water source. The consultant has shown that by developing abandoned quarries located west of Town as a water source, the Town and Service Authority could save a substantial amount of money.

Since the town and FCSA would like to use the abandoned quarries as a public water supply source, they are looking to develop methods of protecting both the surface water in the quarries and the deeper ground water system that feeds these quarries. Wellhead Protection is one of the tools they are considering.

The well that will produce water for the Town was drilled to intercept a mine shaft that is part of the abandoned water-filled limestone quarry system. Actually, three water-filled quarries are hydrogeologically connected through solution channels and fractures, and it is very likely that the same aquifer supplies ground water to all three quarries. Water exchange between the

## Figure 14 - Stephens City Area Survey Boundaries



quarries via the aquifer is a strong possibility. In terms of water supply, it is beneficial that the quarries are interconnected because their combined storage capacity is enormous.

The disadvantage of using the quarries as a water supply is the extensive land area around them that will require protection. Since the three fairly large quarries, their source aquifer and its recharge area, occupy a large land area, attention needs to be given to a sizeable area. Simple delineation of a protection area within the immediate radius of the well will not likely offer sufficient protection of the water supply. The predominant land uses in the area surrounding the well and its supply quarry are agricultural uses including pasture land for livestock and hay production. Industrial uses include a concrete plant and a lime plant.

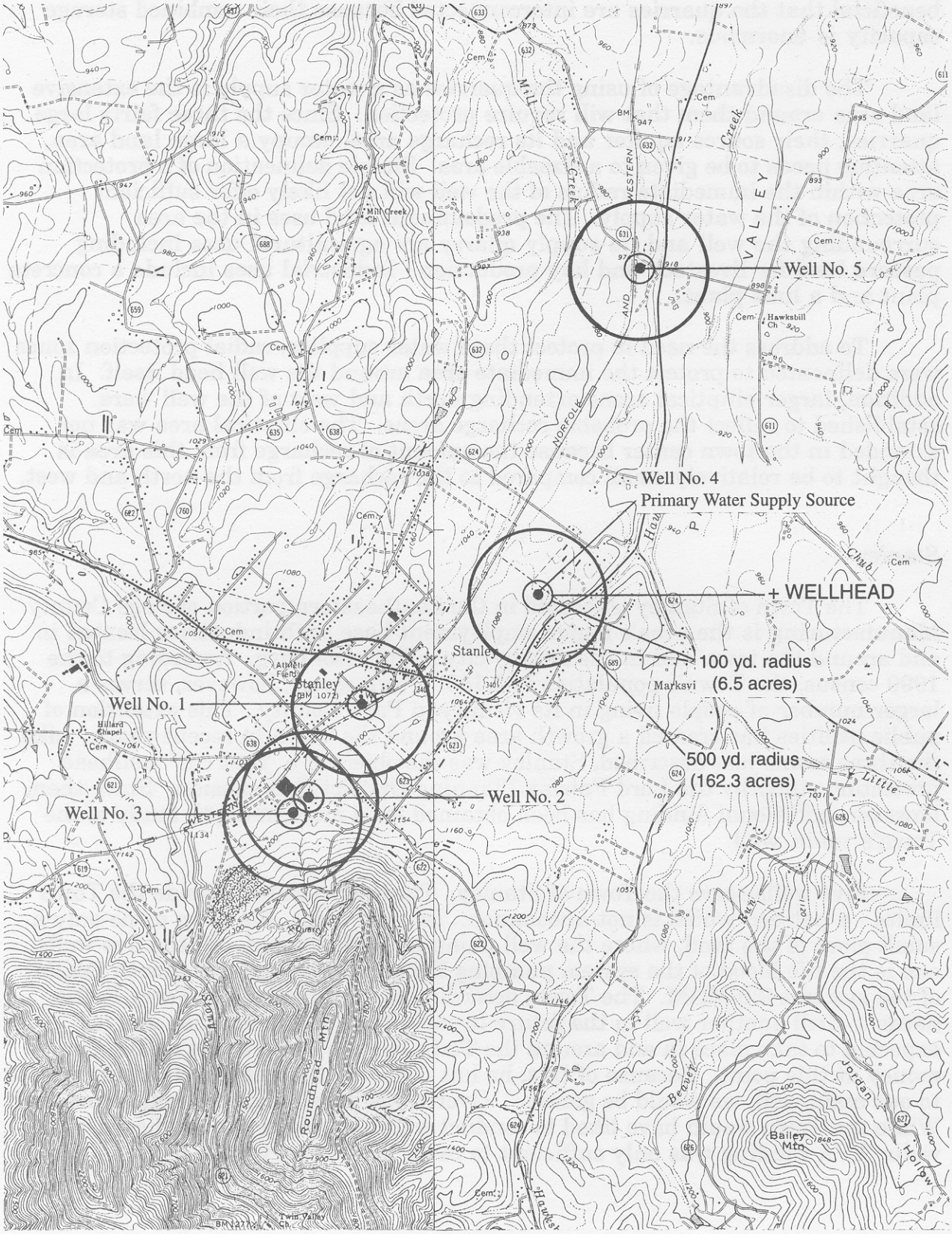
To address the need to protect these water supplies, radial protection zones were delineated to protect the immediate area around the well head itself. In addition, larger elliptical areas extending north and west of the well were established to reflect the probable recharge areas. The elliptical area was not extended in the town center because the amount of recharge from this area is thought to be relatively small compared to the recharge from the north and west.

*Stanley*

The Town of Stanley is located in the Southeastern portion of Page County. Manufacturing is the area's major employment base with industries located in and around the town and in the nearby city of Harrisonburg. According to the 1990 census, the Town's population is 1,186. Town water, however, serves a larger number of people living in its vicinity in Page County. This extension of public utilities has created a growth area around the Town in recent years. Like the three towns just described, Stanley was the object of a "first cut" wellhead protection study by the Lord Fairfax Planning District Commission. Since then, however, additional funding has been obtained for a more in-depth study of the Town's main well.

Five wells serve the Town of Stanley. Three are located outside the Town limits - a pattern which is not uncommon. In most cases, the town owns only a small piece of the land, where the well pump-house is located. Of the five wells, one is the life blood of the system pumping 7.5 million gallons per month (MGM) of the systems 9.0 MGM. The Town, according to Superintendent Terry Pettit, needs to drill another well in the future to serve the growth that has and is expected to take place in and around the Town but the Town doesn't have the money at this point. Because of this, he has observed that "if something happened to our main well, we would be goners." Over 4,000 people depend on this one well. While the Town would have liked to conduct wellhead protection studies of all its wells, EPA funding was only sufficient to cover the primary well.

## Figure 15 - Stanley Area Survey Boundaries



The basic problem for the Town is that the ground water flow and recharge pattern around this all important well is an unknown. Poultry litter is spread nearby. Garages used to dump oil on the land before current regulations were in force. A fertilizer plant is two miles away. The area's landfill is three miles south. The Shenandoah River is 2 1/2-3 miles to the west. What, if any, threat these activities might pose for the Town well is what the wellhead protection study is intended to address. Pettit explains that "years ago towns would look for a location where they thought they could find water and sink a well there. That pattern has to be changed. It is something that is very simple but we used to overlook what uses could go on the land. In Stanley, we hope to learn from the bad experience in some other towns without having to experience the problem of well contamination ourselves if we can prevent it." That is what led to the more in-depth study that is expected to be completed in the next several months. An EPA Wellhead Protection Demonstration Grant of $34,625 plus Town costs of $2,875 made it possible to retain a consultant to do the necessary computer modelling, to draw water from observation wells and to better estimate the recharge and flow patterns impacting the Town's well.

Following the completion of the technical studies, the Planning District Commission will work with Town and County leaders on a series of policy recommendations. Pettit emphasizes that since much of the recharge area most likely lies in the County, it will be important to work closely with the Page County Planning Commission.

**Recommendations to the Four Towns**

No specific formula for protection of delineated areas was laid out in the reports for the localities in the initial wellhead protection projects. Rather, general recommendations were made for the implementation of programs which would address existing and potential contamination threats. It was recommended that localities use the authority given them to "plan and regulate zoning activities that require protection to help insure a clean and abundant supply of ground water for future use." Local decision making bodies were referred to the **Wellhead Protection Handbook** for further information on methods which would best suit their situation. In several cases, counties are the units of local government which have jurisdiction over the land area surrounding the towns' wells. In such cases, cooperation between the towns and their county governments, it was noted, is critical to developing and implementing measures that will be suitable to both and offer the best possible protection.

LFPDC has suggested an overall strategy for gradually introducing wellhead protection measures. It believes it would be most feasible to initially implement land use controls in the form of Best Management Practices (BMPs) within delineated areas. Once the initial BMPs were in place, a gradual phasing process could be developed to include the larger recharge areas and other uses beyond those initially addressed. This would allow for public education to be

incorporated into the process, making the reasoning behind such practices easier to understand.

A public education program was recommended to provide information on the water supply systems for the localities, focusing on the sources of water, how and why it is treated, and why programs should be developed to protect recharge areas.

Specific recommendations were also made in each report concerning identified threats which could include existing uses, such as machine shops and underground storage tanks as well as other uses which could occur in the future. The suggested protection measures range from relocating certain industrial or commercial uses if this were feasible, strictly regulating these activities, and/or monitoring the ground water in the surrounding area. The land use tools to be used in each locality will be determined in the comprehensive plans and ordinances developed by the individual towns and counties. While localities do have authority to make land use determinations generally, it should be noted that in 1992 the General Assembly approved a measure reserving to the state the ability to regulate pesticide use.

At this time, comprehensive plan amendments calling for the establishment of a County Water Resources Steering Committees and development of a ground water protection strategy have been adopted in Page and Shenandoah Counties. The Town of New Market is considering a wellhead protection ordinance and when the study in the Town of Stanley is completed, it is expected that a number of specific policy recommendations will be made including a draft wellhead protection ordinance.

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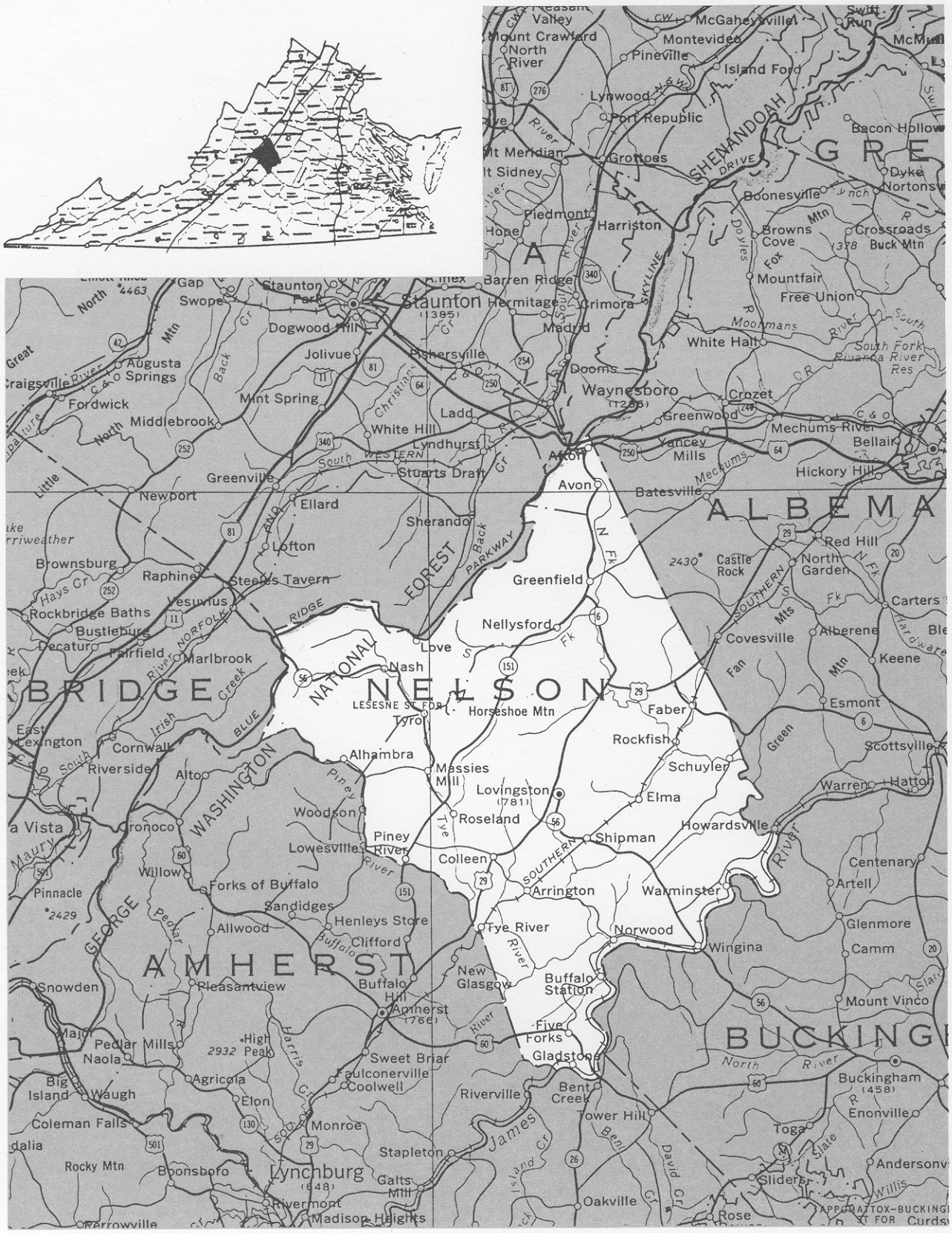
## Figure 16 - Nelson County



# V. NELSON COUNTY SERVICE AUTHORITY

The Nelson County Service Authority (NCSA) is representative of many public water supply authorities in Virginia. It is relatively small, serves customers in a few concentrated locations and relies heavily or exclusively on ground water. It has limited financial and staff resources and can't afford to take chances with its water supply wells. Wellhead protection offers NCSA both a way to protect what it has now and a way to assure that it will be able to continue in the future to serve the customers who depend upon it.

Figure 17 - Lovingston (shown here) and Shipman are 100% dependent on ground water to supply their public systems.

The NCSA Wellhead Protection Project and studies are being undertaken with funding from an EPA Demonstration Grant and with staffing and organization from the Thomas Jefferson Planning District Commission which brought the grant possibility to the service authority's attention. The project involves studying eight wells serving the Lovingston and Shipman areas plus an area east of Shipman which could be the location for future well fields. A variety of resources and expertise are being drawn upon - a Wellhead Protection Committee, a consultant, NCSA Board members and staff, the Virginia Division of Mineral Resources and the Planning District Commission staff. At this stage, the studies are nearing completion and attention will shift to a plan for implementation. The long term possibility is that the current wells - which are, in many cases, in the midst of the established community and barely adequate to handle current demand - might be replaced with new wells located in areas relatively free from potential contamination sources. These new wells, if they prove feasible, would have wellhead protection measures put in place from the outset.

**The Nelson County Service Authority**

Nelson County, with its nearly 13,000 permanent residents, is located in Central Virginia. It is divided between the Piedmont Physiographic Province and the Blue Ridge Physiographic Province. Most experts agree that the water supply potential is low in both regions with ground water existing mainly in cracks and crevices in the bedrock. This factor of limited yield plays a crucial role in the Nelson County Service Authority's decision to go forward with its wellhead protection project.

The Nelson County Service Authority supplies water to customers in five communities: Lovingston, Shipman, Schuyler, Gladstone, and Wintergreen. Lovingston and Shipman are the two communities where the wellhead protection project is being undertaken.

In these two communities, eight wells supply 100% of the drinking water for residents, businesses and other needs. Recently the two systems were linked so that water not needed in Shipman can be made available in Lovingston where demand periodically exceeds supply and draws down reserves stored in tanks. Each year the balance of supply and demand in the Lovingston area has gotten a little tighter. This spring, a Farmer's Home Administration complex - Lovingston Ridge Apartments - was begun across Route 29. When it opens in January, 1994, an additional 64 apartment units are slated to go on line. Also, a new assembly/ manufacturing business has recently gone in that will bring modest additional water supply demand. The Industrial Development Authority is hoping for more expansion of the area's job and tax base.

Figure 18 - Lovingston Ridge Apartments, located across Route 29, will add 64 units to the Nelson County Service Authority system.

The problem facing NCSA is described this way in the application which the NCSA and the TJPDC submitted to EPA for Demonstration Grant funds in 1992.

> The Towns of Lovingston and Shipman depend solely on ground water available from shallow surficial aquifers and deeper bedrock fractures. The Nelson County Service Authority is the publicly owned water supply purveyor for the county which pumps the ground water from these aquifers to residents of the towns. The Service Authority is facing a growing water quality and quantity crisis. The Service Authority's wells are found within the two towns and are thus in the midst of gasoline stations with underground storage tanks, houses with septic systems, banks and parking lots with non-point runoff, farms with pesticides and fertilizer, and chemicals from a dry cleaning facility. Of these contamination sources, the underground storage tanks represent the most immediate threat. The four primary water supply wells serving Lovingston are located within 1000 feet of underground petroleum tanks which do not meet Environmental Protection Agency standards.
>
> In addition to these water quality concerns, the Service Authority is barely able to serve year round demand. The four wells in Lovingston, for example, are pumped at capacity on a 24 hour clock. The pumps are turned on as the reservoir is depleted, and turned off again when storage has returned. In 1991, during August, September and October, public water supply wells pumping at full capacity were unable to meet demand. Consequently, 25% of the available capacity of the emergency storage tank was diverted into public water supply lines.
>
> Water supply for the towns of Lovingston and Shipman have reached a critical point. Contamination of any of their wells would render them unable to meet demand. Moreover, the Service Authority is unable to afford the construction of a new water supply impoundment. Consequently, the Service Authority must wisely manage the ground water resources they now draw upon and protect those which they may need in the future.

It is important to note in this description that for NCSA there is no distinction between a water quality and a water quantity problem. If they were to lose a well due to contamination, their quantity problem would become seriously compounded.

## The Project

A grant of $40,000 was received from EPA Region III as part of a national competition for funding. The goal of the project is to provide information to NCSA so that they can wisely manage the ground water drawn from their existing wells and protect the quality and quantity of ground water resources in areas which may be desirable for future water supply. Ruby Dodd, Service Authority Board chair describes the authority's wellhead protection project this way. "You can't expect people to buy into an idea unless you have the facts to back it up and a plan to carry it out. That is what we are doing now in our Wellhead Protection Project."

To get the project started, a Wellhead Protection Committee was established consisting of two Board members from NCSA, two citizens from the Lovingston and Shipman areas, and staff from the NCSA and the TJPDC. While this Committee proved useful in getting the project started, the NCSA Board as a whole is now also taking a growing interest and more active involvement in the wellhead protection project.

**Step 12 - Plan for the Future**

Wellhead protection should extend beyond currently operating wells in include planning for the future. Just as localities consider future surface water impoundment sites and take steps to protect these in anticipation of need, so should similar steps be taken to protect future well sites and wellhead protection areas.

Wellhead Protection Handbook (p. 25)

Overall, interest in ground water resource issues has increased as a result of several recent factors. A Student Training for Environmental Progress (STEP) study the previous summer tested water throughout the county and found a correlation between small lots and fecal coliform contamination. County residents, in addition, have formed a subdivision ordinance committee which will be addressing ground water protection as one of its concerns. Another committee is in the process of being formed to disseminate information about a DRASTIC* map of the county being prepared by TJPDC. Other concurrent activities include updating of the County Comprehensive Plan which will look at all the County's resources - historic, natural, economic, etc. The wellhead protection project, therefore, comes along at a good time - one when the County is actively assessing its strategic situation and planning for its future. Other counties might also find that wellhead protection could advantageously be coordinated with comprehensive plan updates, as well as zoning, subdivision ordinance, or CIP reviews.

A consulting firm was hired to provide technical support in the project. Their work includes providing high and low altitude aerial photography of the study areas, working with the Virginia Division of Mineral Resources to evaluate the area's bedrock geology, and to identify bedrock fractures.

The technical study process involves examining air photos to identify the length, orientation and density of bedrock fractures or lineaments and to analyze these using a technique called "photo lineament fracture analysis." The result is a sort of contour map which is then compared with what is actually observable on the ground. From this comes an understanding of preferred orientation of ground water movement. This type of knowledge will then allow the consultant to conduct a vulnerability analysis to see whether there are geologic pathways which could link potentially polluting land uses on the surface of the land with wells

* DRASTIC is an acronym that describes the factors used in a mapping system designed to evaluate the ground water pollution potential of an area. The system uses a set of factors relating to soil characteristics, rainfall, geology and topography to estimate the potential for contamination of ground water in different areas if there was a contaminant release on the surface of the ground. Sixteen counties in Virginia, including Nelson, have now prepared DRASTIC maps for their jurisdictions.

which are pumping water from beneath the ground in the nearby areas. Using this and other information being compiled by the Thomas Jefferson Planning District Commission, the consultant will then delineate wellhead protection areas around each of the eight existing wells. The resulting wellhead protection areas would likely take on an elliptical shape with the long axis of the ellipse oriented to parallel the fracture pattern in the bedrock. Areas would be elongated up-gradient as well to reflect the direction of ground water movement.

These lineament and other analyses would also be used to identify areas where future wells might be located. In the potential future well site areas, with property owner cooperation, the Service Authority will install three six inch monitoring wells in order to explore the ground water potential and quality. These wells will be tested and the resulting more accurate information will form the basis for establishing wellhead protection areas if these sites turn out to have useable water supply yields. These wells will be drilled, cased and grouted in accordance with government specifications and in a manner that they could later be converted to public water supply production wells at minimal expense.

The TJPDC's role is to coordinate and staff the overall project as well as to perform certain specific tasks. These include collecting water samples from the eight existing wells, providing maps of bedrock geology and soils plus climatic data, local hydrologic reports, domestic well records, existing zoning and land use, and similar information. Much of this has been established as part of the PDC's Geographic Information System known as TJSPARE. Investment in that computerized system is paying off in its utility for projects like this. The PDC will also work with the consultant on a contaminant threats analysis to identify potential sources of contamination which might threaten the quality of ground water resources relied upon by NCSA. Part of the work is to identify not only current threats but those which might have ceased operation some years ago. TJPDC Planner Michael Collins talks of an experience when he was conducting reconnaissance work in the field accompanied by a long-term resident of Shipman who told him about a particular ravine that was used years ago as an informal dump by town residents. That ravine is upgradient of the potential site for new production wells. This showed that it would be important to draw on citizens or others who had a long history with the community to help identify old dumps, abandoned wells, abandoned storage tanks, etc., that might not be immediately observable.

A fortunate factor that has helped in carrying out the geologic studies in Nelson County is that the Virginia Division of Mineral Resources, located nearby in Charlottesville, has recently completed a new geologic map of the County. Nick Evans, who developed the map, has been very helpful in assisting the TJPDC staff and the consultant by providing information and participating in the field checking of results.

In conducting the Wellhead Protection Study, part of the task, according to Mike Collins, has been bringing together a lot of people, studies and maps into a common focus and scale. The benefits are that more may already be known than is realized. He also discovered that many people are willing to make contributions

when they can see how they can help solve a community problem. NCSA Board and Wellhead Protection Committee member, Mike Gray, noted that a lot was found out when basic data began to be compiled - not the least of which was that it became apparent right away where not to look for water. "Down the road this kind of information could save tons of dollars," he explained.

**Progress to Date**

As of this writing, all the component parts of this project are moving forward with the major studies to be completed during the Fall of 1993.

It would be premature to judge what the outcome of the studies might be in any specific sense but certain general outlines are already evident. Protections will be needed for the eight existing wells for as long as they are still needed as part of the community system. Because the current supplies are not really adequate to meet expanding demand, new wells are also desperately needed. As one resident put it, "We are praying that the area over by Shipman pans out." If that is the case, a preventive approach can be taken as part of planning for the area's future. As long as the current wells prove a source of safe water, they can be continued or used as back-up in case of emergency. The new wells, with wellhead protection, could then become the heart of the system.

Other communities would do well to take a lesson from Nelson County and begin today to look into protecting their ground water supplies both for current customers and for the future.

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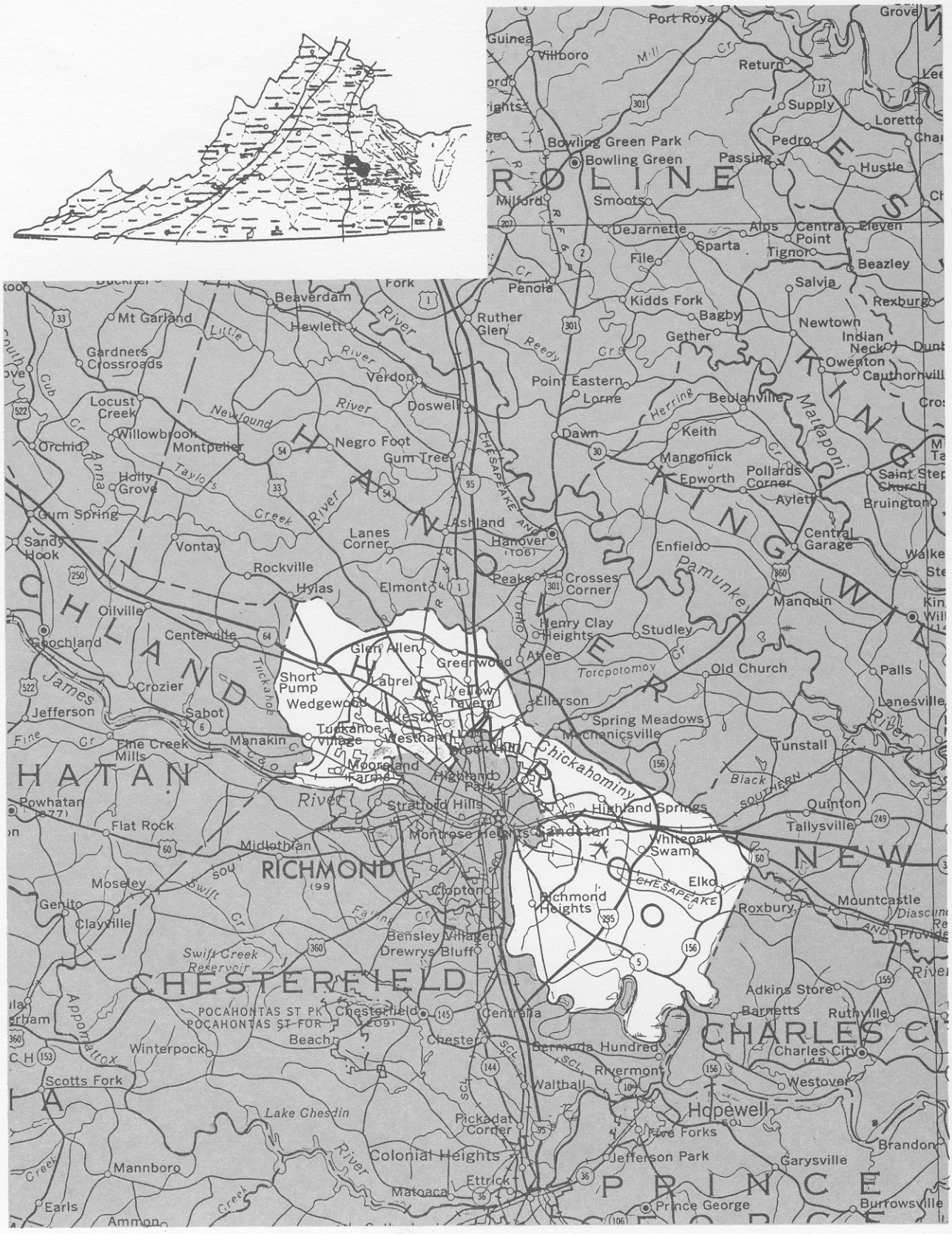
## Figure 17 - Henrico County



# VI. HENRICO COUNTY

Henrico County meets the public water supply needs of its 227,000 residents, plus numerous businesses and public buildings by a combination of water purchased outside the County and wells located within the County's territory. In its Wellhead Protection Pilot Study, 57 public water supply wells were studied. The County was able to work without the assistance of a consultant because it has a geologist/ground water specialist on the staff of its Department of Public Utilities. In assessing these wells - some of which are County owned but most of which are privately owned - the County found that they had to use different methods depending on, among other factors, where the well is located and the quality of the data available. Half the County is in the Piedmont Physiographic Province where wells are in granite; the other half of the County is located in the Coastal Plain Physiographic Province with most wells tapping into a deep confined aquifer. The study highlights the unknown but potentially significant threat from improperly abandoned wells which may exist in the County. The delineation studies allow the County's Planning Department to use this information in site plan review or in other planning activities. Public education is seen as a key factor in the County's efforts to protect its public water supply wells. The availability of a brochure about wellhead protection was announced through billings to all the Utility Department's customers as well as placed in public locations around the County.

Figure 20 -

Many different types of public wells are found in Henrico County - some are privately owned, the federal and state governments own others. The County actually owns only about a quarter of the "public" wells located in the County.

**Public Water Supply Wells in Henrico County**

Public water supply wells come in many varieties as is made clear by the following description from **Wellhead Protection: A Handbook for Local Governments in Virginia** (p. 17).

Step 1 - Obtain a List of Public Water Supply Wells

There are many more types of "public" wells than most people are aware. Typically the term "public well" brings to mind a municipally owned and operated well that serves a nearby community area. It is important to remember that there are also privately owned public water supply wells. Both can be called "community waterworks" in official parlance. Public water supply wells also, however, serve freestanding schools, industry and various transient facilities such as roadside rest areas. The following public well definitions are used by the Virginia Department of Health and by the federal government.

Community Waterworks - means one that has 15 or more service connections or that serves 25 or more year-round residents. Examples would be municipalities, subdivisions, mobile home parks, or institutions such as nursing homes and correctional facilities.

Transient (or Non-community) Waterworks - means one that serves a transient population of at least 25 people for at least 60 days each year. Examples include campgrounds, motels, restaurants, and highway rest areas with their own water supplies.

Other (Non-transient Non-community) Waterworks - means one that serves a fairly consistent non-residential population of at least 25 of the same people for at least 6 months per year. Examples here would include schools and factories with their own water supply.

Across the State of Virginia, community waterworks are the most numerous category making up over half of the systems coming under the authority of the Virginia Department of Health. It is important to note again that waterworks that are considered "public" wells or "community" wells may not be publicly owned. In Virginia, in fact, nearly 3 times as many community systems are owned by "investors" as local governments. Virtually all of the investor systems are small (serving fewer than 3,300 people) while publicly owned systems range all the way from the very small to the very large serving more than 10,000 customers.

Because of the diversity of wells falling into one category or other of "public," it is advisable that a listing be obtained from the Virginia Department of Health.

***Note:** A list of Virginia Department of Health field offices and phone numbers is provided in the Appendix to this report . Also provided is a listing of the number of public water supply systems using ground water in each of the state's counties and cities.*

Fifty seven public water supply wells of various types provide water to Henrico's citizens, businesses, and public facilities. In addition, two springs in the eastern portion of the County provide bottled commercial water. To illustrate the diversity of well types, it can be noted that most of the County owned wells belong to the Department of Public Utilities, the County's water supply entity, but some others are owned by other agencies such as the County's Division of Recreation and Parks. These serve public facilities such as the Deep Bottom Boat Ramp, Dorey Park, and Gravel Hill Community Center. County-owned wells also serve a number of residential areas, such as Hechler Village and White Oak Hills, but many wells serving subdivisions are privately owned. For example, Sydnor Hydrodynamics, a private waterworks company, owns and operates over fifteen subdivision well systems in Henrico County. Other wells are owned by and serve businesses - for instance, AT&T, Bubba's Restaurant, and C&P Telephone. A variety of state (e.g., VDOT) and federal agencies (e.g., National Park Service) also own public water supply wells located in Henrico County. Because all of these wells - despite their diversity - provide water to the public, they were all included in Henrico County Pilot Study.

Before describing the County's Study, it is also important to note that while much of Henrico County is served by public water lines distributing purchased surface water, there are still a relatively large number of freestanding public water supply wells in use. Many subdivisions and other users supplied by such privately owned wells are near or adjacent to Department of Public Utility water lines, but if a well were to become contaminated, the cost to hook up to County water could still be significant. Most wells, fortunately, are within a mile of existing water lines. The fact that Henrico County has options of this sort does not mean that they have no need to consider protection for their public water supply wells. That is why the Pilot Study was undertaken.

**The Project**

Wellhead protection in Henrico County was studied in a pilot project funded by a $10,000 grant from the Virginia Department of Environmental Quality (DEQ) as part of their section 106 Ground Water Protection grant program. The object of this project was to study the status of wellheads in the County by examining the County's 57 public water supply wells and calculating wellhead protection areas for each using the best method given the data available. Haywood Wigglesworth, a geologist and ground water specialist with the county's Department of Public Utilities (DPU), headed up the project. One of the things he learned in conducting this project was that gathering well-specific data was very difficult. However, by coupling available data with assumed values based on geologic conditions in the area, a basis for delineating protection areas can be provided. Most localities

considering wellhead protection are likely to have a similar experience and should not be deterred.

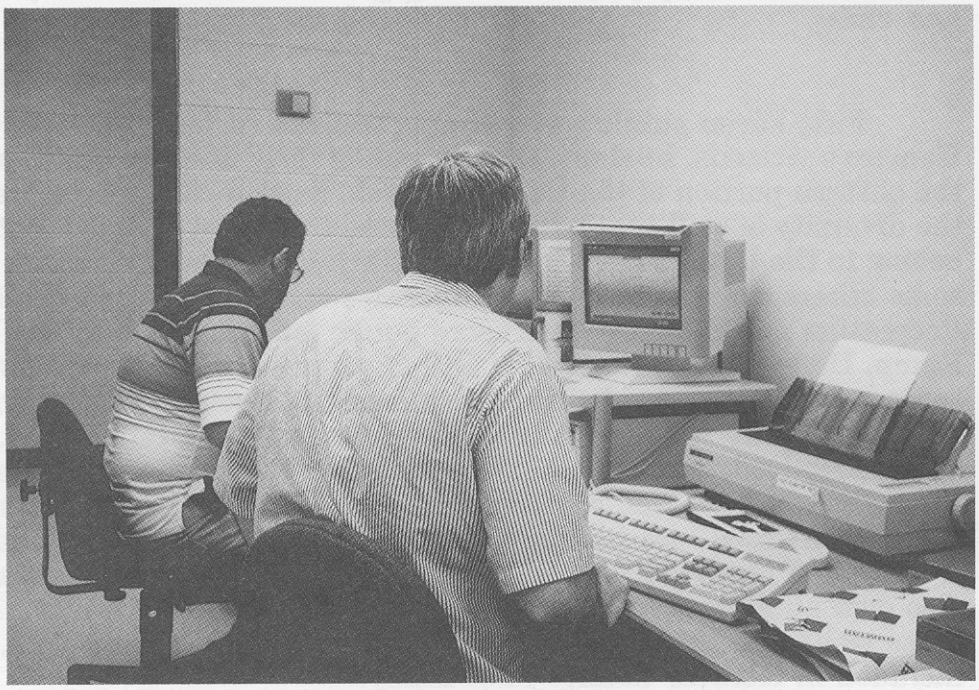


Figure 21 - Computers assisted Department of Public Utility staff in studying the large number of public wells located in Henrico County.

While the well data used in the assessment was not ideal, Wigglesworth stresses the value of using the available information to delineate wellhead protection areas. "If and when better data becomes available, calculations can be further refined using more sophisticated delineation methods. In the meantime a 'first cut' serves to educate the community and public officials about the need for wellhead protection and about the process involved." He and others believe that the resulting map of delineated areas, the study of existing land use and zoning around these wells and identification of possible options for protecting the wells from potentially contaminating land uses, will be important resources to Henrico County as they formulate their future land use plans.

## The Area's Hydrogeology

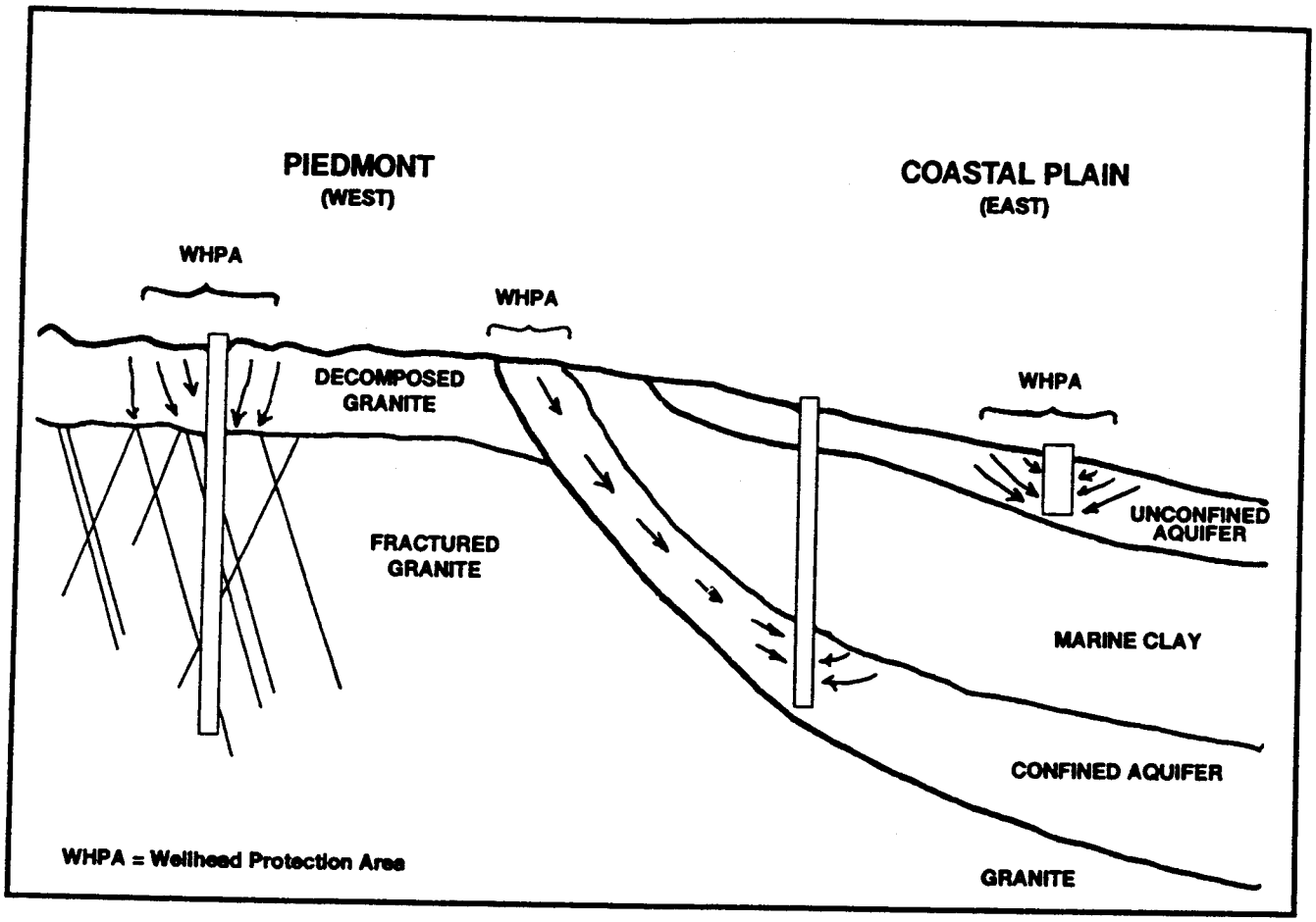
Located north of the James River in East-Central Virginia, Henrico County wraps around the north side of the City of Richmond. The County straddles the "fall line" which separates two physiographic provinces, the Coastal Plain to the east and the Piedmont to the west. These two hydrogeologic settings form distinct ground water regions with different aquifer types. When delineating protection areas, different methods were used depending on the hydrogeologic setting of the particular well.

Aquifers in the Coastal Plain portion of the County are made up of unconsolidated sand, gravel, silt, and clay layers which dip and thicken to the east. Many private household wells and some shallow public water supply wells

draw water from the upper unconfined or water-table aquifers in this hydrogeologic region. These wells are especially vulnerable to contamination from pollutants from the land around them because they do not lie beneath a protective clay layer.

Beneath this surface aquifer in the Coastal Plain are thick layers of marine clay through which ground water moves very slowly. Beneath the layers of clay are confined, or artesian, aquifers, which in Henrico County include the middle Potomac and lower Potomac aquifers. Most of the public ground water supplies in the eastern part of the County take water from one or both of these confined aquifers. The water recharging confined aquifers enters by two different routes. A portion of it leaks very slowly through the overlying clay layers. The rest is believed to enter the aquifer at the points near the James River where the aquifer is exposed at the land surface.

Figure 22 - Types of Wells and Protection Areas




In the western portion of the County, ground water resources in the Piedmont province are derived primarily from igneous and metamorphic rocks covered by variable thicknesses of saprolite, or weathered bedrock. The primary

ground water flow occurs in pore spaces in the saprolite and fractures and joints in the granite bedrock below. Unconfined ground water accumulates in the weathered material overlying the parent rock and serves as a recharge source for these aquifers. These aquifers are vulnerable to contamination from pollutants introduced at the land's surface.

Although the saprolite is an easily developed ground water source, low yields and seasonal fluctuations typically limit use of this resource. In Henrico County, all of the public water supply wells in the Piedmont province are drilled, therefore, into the granite below.

**Data Collection and Analysis**

Work on the project began with a computer printout of a list of wells classified as public water supplies, or waterworks, by the Virginia Department of Health (VDH) as described in the **Wellhead Protection Handbook**. As noted above, these waterworks need not be publicly-owned. Many systems which serve subdivisions, private schools, industry, and transient facilities are in fact privately owned. In Henrico's case, about a quarter of their public water supply wells are publicly-owned.

Using the information provided by Virginia Department of Health (VDH) and from records at Virginia Department of Environmental Quality (DEQ) and the firm of Sydnor Hydrodynamics which owns a number of the wells being studied, the approximate location of each of the 57 wells was determined. The wells were then plotted on a set of Henrico County Zoning Maps. This constitutes the second step described in the **Wellhead Protection Handbook**.

Although over 70 wells were initially considered, priority was assigned to 57 after a number were found to be inactive. This reduced the size of the task and saved time and resources. These wells are out of service because of a drop in production levels, a replacement water supply, or a reduction in demand for the well. In other cases, these inactive wells are being used only for purposes of observation and monitoring by the County. For wellhead protection purposes, a decision was made to concentrate efforts on only the active wells.

For the remaining 57 wells, the next step was to gather as much information as possible. Information sources included well logs in County files, records available from VDH and DEQ, and well reports from private well owners and well drillers records. This research was intended to assemble all available well-specific information, including precise location, age, depth, use, capacity, and pumping rate. It turned out that much of this information was not available for many of the wells. Though unfortunate, this experience does underscore the value for all concerned of good record keeping in the future.

## Field Inspection

Once the office research had been completed, the next step was to do a site inspection of all active granite wells in the western portion of Henrico County and of all the wells in the eastern portion of the County which would be vulnerable to surface contamination. Notes were made during these inspections on the geology, depth to ground water, presence of surface water, gradient, and potential contamination sources in the surrounding area. A site inspection form was used to record the observations made in the field.

In general, it was found that only a few wells are adjacent to areas where the current land use or zoning poses serious threats to the well. In most cases, the most likely potential hazard is leaking underground storage tanks (LUSTs). Service stations, office complexes, hospitals, and even residences may have fuel tanks. Pollution complaints related to LUSTs have increased dramatically across the state in recent years. Fortunately, in the past few years these tanks have also come under stricter regulation.

Another potential threat which was identified was improperly abandoned wells. Numerous wells in the County date back many years and are no longer in use. They may never have been properly abandoned. In many cases, new property owners do not even realize these wells are on their land. There is probably a large and possibly growing number of wells which need to be properly abandoned in order to insure that they will not someday become a conduit for contaminants to move into the aquifer. For this reason, the final report concluded that improperly abandoned wells in Henrico County could pose a serious contamination threat to ground water and need further attention. Since then the County has been examining old records and maps to locate abandoned wells now or formerly owned by the County as well as those in private ownership.

This completed what is described as steps 6-9 in the **Wellhead Protection Handbook**.

## Wellhead Protection Area Delineation

Because Henrico County falls into two distinct physiographic provinces, two different approaches to delineation (See Step 7 in the **Wellhead Protection Handbook**) were used.

Twenty-nine active wells tap into the confined aquifers of the eastern portion of the County. These wells were drilled through a thick, impermeable layer of marine clay which protects the Middle and Lower Potomac aquifers from surface contamination. To a considerable degree, protecting the area immediately surrounding the wellhead would add only a limited amount of protection for the quality of the water deep in the confined aquifers below. In order to protect these aquifers from contamination, it makes more sense, according to Haywood Wigglesworth, that the recharge area for the whole well field be protected. Rather than delineate wellhead protection areas around each of

these wells, attention shifted to identifying the aquifer recharge area near the fall line as the protection zone.

This recharge area for the middle Potomac and lower Potomac aquifers was delineated using information and maps from the Virginia Division of Mineral Resources (DMR) and the U.S. Geological Survey (USGS), and from a report written in 1985 for the County entitled Ground Water Resource Evaluation and Management: Henrico County, Virginia.

The recharge area represents a region where the marine clay confining beds are either thin or missing. It was located based on the estimated height of the Potomac aquifer and surface elevations. Areas where the aquifer appears to rise to be within fifty feet of the surface were targeted for protection. In the western part of the Coastal Plain, the boundary of this recharge area generally follows the hundred foot contour line. Based on well log information, it is estimated that the recharge boundary to the east runs with the fifty foot contour since the aquifer is significantly lower there. It is interesting to note that land use in this recharge is largely agricultural, however significant portions of the area are zoned for manufacturing and there is one area with railroad yards, chemical storage facilities, and a vehicle maintenance shop.

For the 6 shallow wells not deep enough to be protected by the confining clay layers in the Coastal Plain portion of the County, a wellhead delineation program developed by the EPA was used. This program - known as "RESSQC" - is one of four mathematical models in a delineation package known as the "WHPA Code*." RESSQC is a semi-analytical computer model recommended in situations where you have "homogeneous, isotropic aquifers in which there is a steady-state flow." Delineation is based on variables including hydraulic conductivity, hydraulic gradient, static water level, porosity, and pump rate. With the exception of the pumping rate, values for these variables had to be assumed using estimates from the literature. Pumping rates for specific wells were estimated from the number of users.

In the Piedmont portion of the County, aquifers cannot be assumed to be uniform because flow is through joints and fractures, and the transmissivity of the zones within the granite can vary dramatically. According to Haywood Wigglesworth, "finding a good method to compute protection areas for the Piedmont section of the County proved to be a most difficult part of this project. I found that there was very little information on most of these wells and virtually no usable aquifer tests for any of them." This required some inventiveness.

After much research, a model was found which was appropriate for bedrock wells without good aquifer tests and where it was possible to use estimates based on uneven information. The model, known as the "leakage model," was taken from the *Vermont Aquifer Protection Area Reference*

* For details about the WHPA code, consult: *WHPA: A Modular Semi-Analytical Model for the Delineation of Wellhead Protection Areas*; T. Neil Blandford, Peter S. Huyak, Hydrogeologic, Inc., Herndon, VA; Report prepared for U.S. EPA Office of Ground Water Protection, September 1990.

*Document*. This model outputs a calculated radius based on pump rates and hydraulic conductivity and gradient. Radii for the 19 granite wells in the Piedmont ranged from slightly under 200 feet to almost 2000 feet. For technical details about delineation in Henrico County, the final report of the Pilot Project should be consulted or contact Haywood Wigglesworth whose address and phone number are given at the end of this chapter.

Recognizing that a number of assumed values were used in estimating wellhead protection areas, the final report on the Henrico County pilot project concludes this way.

> All of these wellhead protection and aquifer recharge areas had to be delineated without the benefit of complete site-specific aquifer information. As a result they represent a best guess rather than unassailable fact. At some later time an adjacent property owner may wish to challenge these delineations and he or she should be allowed to do so.

The report suggests what sort of site-specific information would be necessary for a revision of these wellhead protection areas.

**Uses of the Wellhead Studies**

Henrico County wellhead studies are expected to serve as a useful resource for future County land use planning. Henrico County's Comprehensive Plan is scheduled for review and revision beginning in the fall of 1993. The County has a good record for environmental concerns in their comprehensive planning and currently has a sizeable amount of acreage designated as Environmental Protection Areas. These areas were designated as such primarily to protect the Chesapeake Bay from polluted runoff. However, some of this land coincides with the areas pointed out as wellhead and aquifer protection areas.

Wellhead areas which are not yet designated as Environmental Protection Areas will be studied further by the planning staff, the Planning Commission, and the Board of Supervisors to determine the best means for handling their protection. The County may use the comprehensive planning process as a means of offering protection to those sensitive areas. Community involvement and the Comprehensive Plan revision process will determine exactly what direction the County takes in wellhead protection.

In the meantime, Randy Silber, a principal planner for the County, said the County could begin by using the wellhead maps in a manner similar to the use of

Henrico County's DRASTIC* maps. The DRASTIC map for Henrico County, developed earlier as part of another pilot project, is kept on file in the Planning Office and is used to evaluate proposals which require County approval, such as subdivision plans, rezonings, site plans and special use permits.

**Public Education**

Educating the citizens of Henrico County about the need for wellhead protection was another aim of this pilot study project. Initially, a notice was included with all public utility bills briefly informing residents about the study and indicating the availability of an informational brochure entitled **Wellhead Protection in Henrico County**. Residents, businesses and facilities interested in further information about wellhead protection were instructed to call the Department of Public Utilities to receive a free copy of the brochure. Copies were also made available in libraries and other County buildings and through the Virginia Cooperative Extension.

A copy of the notice and brochure are attached.

**Persons to Contact**

Haywood Wigglesworth
Department of Public Utilities
1040 Woodman Road
Glen Allen, Virginia 23060
804/261-8715

Randy Silber/Audrey Anderson
Department of Planning
P. O. Box 27032
Richmond, Virginia 23273
804/672-4464

* DRASTIC is an acronym that describes the factors used in a mapping system designed to evaluate the ground water pollution potential of an area. The system uses a set of factors relating to soil characteristics, rainfall, geology and topography to estimate the potential for contamination of ground water in different areas if there was a contaminant release on the surface of the ground. Sixteen counties in Virginia, including Henrico, have now prepared DRASTIC maps for their jurisdictions.

**Public Notice**
**and**
**Brochure**

Figure 23 - Public Information Notice and Brochure

## Notice to Customers Interested in Well Water

Henrico County's ground water geologist recently completed a study of areas that supply water for wells operated by the Department of Public Utilities and several privately-owned wells. The geologist and other employees investigated potential causes of contamination. The project was funded by a grant from the U.S. Environmental Protection Agency (EPA) and administered by the Virginia Department of Environmental Quality.

If you own a well, anticipate drilling one or use well water supplied by the County government, you may be interested in a free brochure entitled *Wellhead Protection in Henrico County.* It describes the project, explains results and lists some steps that you can take to help preserve the high quality of well water in Henrico County.

If you have questions or wish to request a copy of the brochure, please call **261-8715.**

**Department of Public Utilities**
County of Henrico

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## Wellhead Protection in Henrico County

*The Henrico County ground water geologist and other employees recently conducted a wellhead protection pilot project funded by a grant from the United States Environmental Protection Agency (EPA) and administered by the Virginia Department of Environmental Quality. The goal of this project was to investigate the potential for contamination of public water supply wells in the County and to begin to devise a plan for their protection. The purposes of this brochure are to provide you with a brief summary of the project and to inform you of its importance to you.*

# Figure 23 (continued) - Inside and Back Panels

## Wellhead Protection

"Wellhead Protection" is the name given to the process of protecting the land area around a water well through which precipitation or surface water that replenishes the well is drawn. It is important to realize that precipitation is the source of drinking water withdrawn from the ground. Water wells are drilled into the ground to points where they can withdraw water from areas within the earth or bedrock where good water is found in sufficient quantity. These areas or layers are known as "aquifers." They differ from other layers or areas in the ground because they have more inter-connected open spaces through which water will flow.

Water falling on the earth will be drawn into aquifers in one of two ways. If the aquifer is exposed at the land surface, water will flow into it either from a body of surface water or from precipitation seeping downward through the overlying layers in the earth. If the aquifer is not exposed on the surface or beneath a body of water, that portion of precipitation that does not run off or is not evaporated from the earth will gradually seep downward to the aquifer through the overlying layers in the earth. Contaminants on the surface of the earth, in these overlying layers or in surface water, can be carried into the aquifer along with the water that is recharging the aquifer. For this reason it is necessary to protect areas through which the recharging water moves in order to maintain the quality of the water supplied from a well.

## Wellhead Protection Areas

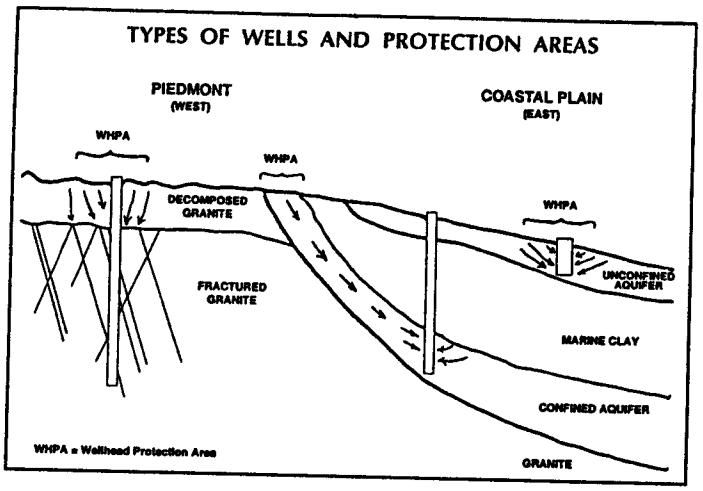
Before an area can be protected, it must be defined. If the exact nature of the aquifer and the surrounding material are known, along with the properties of the well, defining the protection area can be done accurately. Since complete information on these factors is seldom available, an educated guess is often the best that can be expected. The area calculated or estimated is known as a "Wellhead Protection Area" or "WHPA." The project completed in Henrico County consisted of obtaining the available data for public water supply wells, making estimates or calculations to delineate wellhead protection areas and providing the County Planning Office with information for planning purposes which could prove useful in minimizing ground water pollution. It was not our desire to place additional burdens on County residents, but rather to provide them with some protection against possible threats to their drinking water.

## What We Have Done

In late 1992 and early 1993, we gathered all of the available information on Henrico's public water supply wells and visited them. We then made an estimate of the areas around each individual well that should be protected. After estimating these areas, we looked at maps in the Henrico County Planning Office to see if existing zoning allowed potential sources of contamination to be constructed in these areas. Information that was developed will be provided to the Planning Office for review as part of the update of the County's Comprehensive Plan.

## What You Can Do

1. Try to use less water.
2. When using pesticides or fertilizers, follow the manufacturers' instructions so that you will not use too much of the chemicals.
3. Do not dump motor oil, paint, solvents or other waste in ditches or storm sewers or on the ground. For information on the proper disposal of motor oil, call 1-800-552-3831. For information on the proper disposal of other wastes, call the Department of Environmental Quality Waste Program at 527-5000.
4. If you have a septic system, make sure that it is kept in good repair and cleaned out periodically. Do not discharge chemical wastes to your septic system.
5. Find out if there were any potential sources of contamination on your property, such as buried fuel tanks, fuel oil spills, waste disposal areas or home businesses.
6. Be on the lookout for water wells which are out of service. If they are not going to be used again, they need to be abandoned properly. If they are out of service temporarily, they need to be sealed. This is not just common sense; it is State law. For information on well abandonment in Henrico County, call the Health Department at 672-4530.
7. Report illegal dumping of any sort of wastes by others by calling the Department of Environmental Quality Pollution Response Program at 527-5200.
8. Avoid excessive use of snow-melting chemicals.




## Aquifers in Our County

Ground water in Henrico County is found in two different types of aquifers: consolidated rock and unconsolidated sediments. The illustration is a generalized profile of these aquifers. The aquifer in the western portion of the County consists of the fractures and joints in the granite bedrock and the decomposed granite above the bedrock. This aquifer is particularly vulnerable to contamination from any pollutants introduced at the land's surface.

Aquifers in the eastern portion of the County are made up of unconsolidated sand, gravel, silt and clay. One of these aquifers, known as the "water table aquifer," is located near the surface of the earth. Many private wells are now withdrawing water from this aquifer, but it appears that only three public water supply wells are. This is fortunate, because these wells are especially vulnerable to contamination from pollutants on the land around them. The more water that is withdrawn from these wells, the greater the area around them that requires protection. Beneath the surface aquifer are thick layers of clay through which the water moves very slowly. Beneath the layers of clay are other aquifers known as "confined" or "artesian" aquifers. Most of the public water supply wells in the eastern portion of Henrico County withdraw water from these aquifers.

The water recharging confined aquifers enters by two different routes. A portion of it leaks very slowly through the overlying clay layers. The rest is believed to enter the aquifer at the points near the James River where the aquifer is exposed at the land surface. The latter areas must be protected from uses which may leave contaminants on the land surface. In addition, it is important to eliminate any conduits from the surface to the lower aquifers, such as improperly abandoned wells.

## Why Bother?

There are numerous instances of individual domestic wells being contaminated by fuel leaks and spills in the Central Virginia area. Once contaminated, ground water is difficult, and sometimes impossible, to clean. Remediation of these problems is a long, expensive process. Often much time is lost simply investigating a problem. Since cleaning the aquifer itself is time-consuming, other sources of water must be obtained, either by hauling or by connection with the municipal water system. For people used to well water, this is often an unwelcome change.

We are fortunate in this county not to have had contamination of a public water supply. However, other areas of Virginia have not been so lucky. The towns of Berryville and Fincastle have had public water supply wells contaminated and have had to find other sources. The best solution to such problems is to do everything possible to prevent them from happening. The Department of Public Utilities will do its best to preserve the quality of Henrico County's water — a valuable and irreplaceable resource. We hope you will help us.

For more information, please call

**261-8715**

**Department of Public Utilities**

***Proud of our progress;***
***Excited about our future.***

*The County of Henrico does not discriminate on the basis of race, color, religion, sex, national origin, age or disability.*

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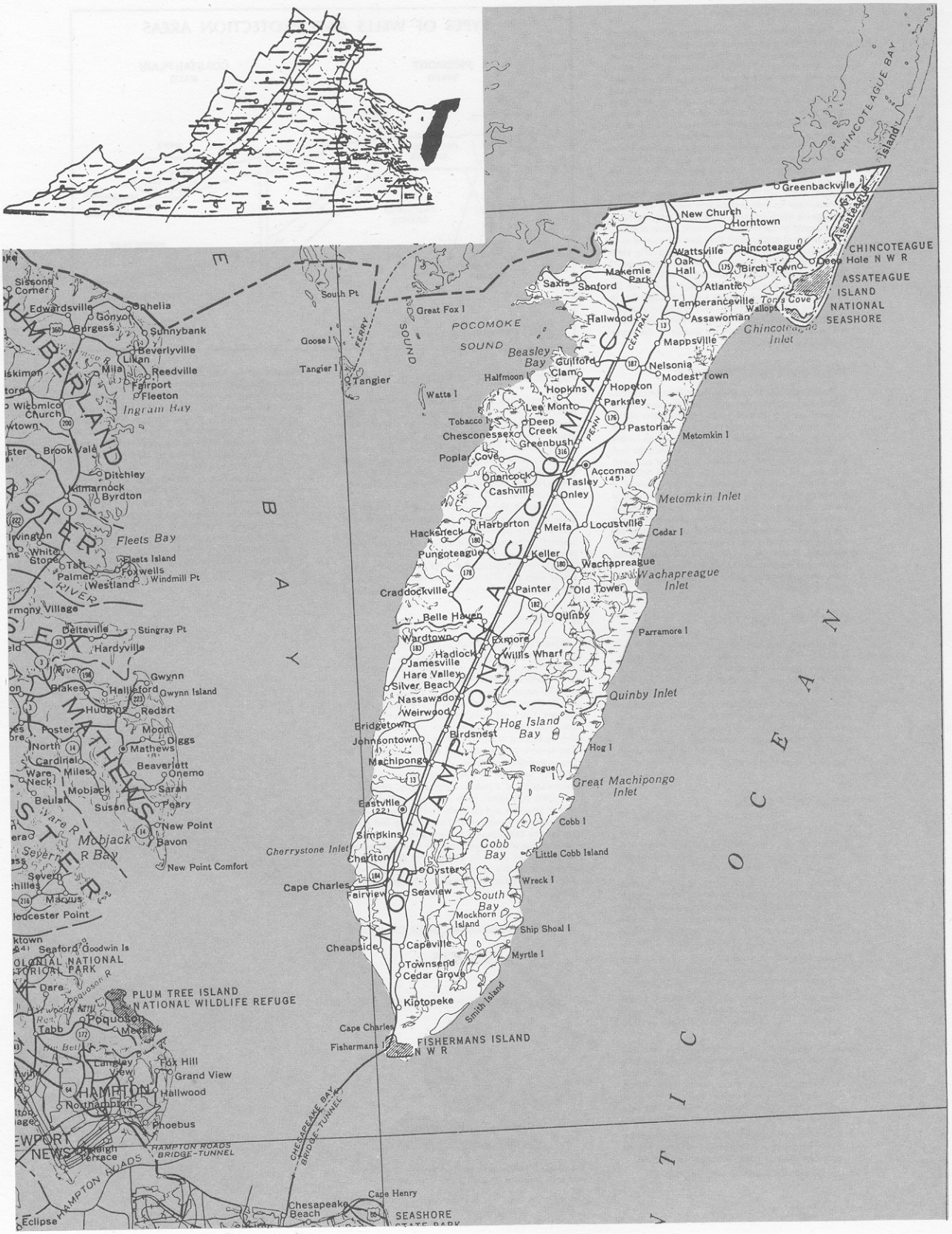
## Figure 24 - The Eastern Shore



# VII. THE EASTERN SHORE

Ground water is the only source of water supply for domestic, industrial, and agricultural uses in Accomack and Northampton Counties and the nineteen towns which make up the Eastern Shore of Virginia. Protection of this resource has been a concern there for some time - going back to the first aquifer resource study conducted in 1954. The most recent study, Ground Water Supply Protection and Management Plan for the Eastern Shore of Virginia, was initiated in 1990 at the request of the two counties. A bi-county Ground Water Study Committee was formed to oversee the development of the plan which was prepared by consultants in water resources and land planning. This Study Committee consists of two members from each county's Board of Supervisors, one citizen appointee by each Board, the County Administrator from each county, and the Executive Director of the Accomack-Northampton Planning District Commission (ANPDC). The Committee is chaired by C. D. Fleming, Jr. who is also a member of the Board of Supervisors from Accomack County. The project's $95,000 cost was funded through ANPDC by monies from the Virginia's Coastal Resources Management

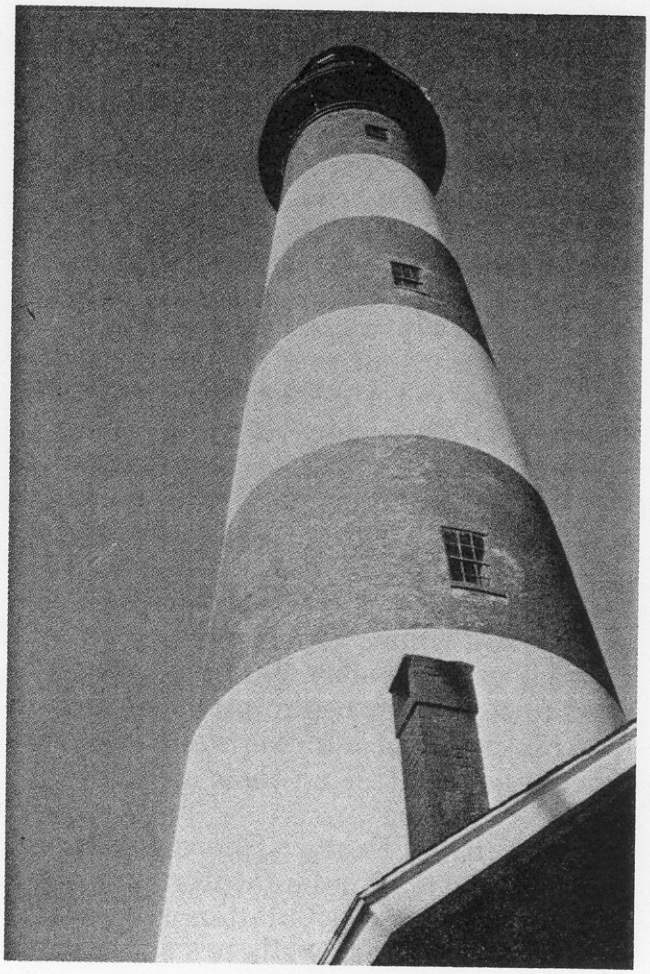


Figure 25 - The Assateague Lighthouse is a landmark to local residents as well as to visitors to the Eastern Shore where ground water is the only source of public drinking water.

Program and by other state and local sources. More recently, ANPDC received a $20,000 EPA Wellhead Protection Demonstration Grant to help with implementing their studies and plans.

The Plan, which was adopted in 1992, summarizes information on ground water hydrology, water withdrawals, land use threats, and current control mechanisms on the Eastern Shore and is intended to assist local governments and residents in understanding and safeguarding their ground water resource. Recommendations were proposed to develop a comprehensive ground water protection and supply management strategy which will maintain an adequate supply of high quality water for the future needs of the region. Five ground water supply management areas were delineated on the Eastern Shore, each consisting of three distinct zones: a protective zone immediately surrounding the well, an aquifer recharge area located along the central spine of the peninsula and a larger wellhead protection area.

Not all localities will be able to be as thorough as the Eastern Shore, nor will they necessarily need to do so in order to begin a basic wellhead protection program. The more background information available, however, the better the ensuing plan and the more the practices can be tailored to the local situation. Accomack and Northampton Counties stand out in the state as the areas which have for a number of years attempted to understand and to protect their valuable ground water resources.

**Ground Water Use on the Eastern Shore**

Ground water is considered an essential water resource on the Eastern Shore since it is the only source of drinking water. Virtually no streams or rivers exist on the peninsula, nor are there surface lakes or reservoirs of appreciable size. As a result of this dependence, protection of the resource, both in terms of water quantity and quality, takes on added importance.

In 1976, Virginia designated the Eastern Shore as a "Ground Water Management Area" based on findings of ground water level declines, well interference, and localized salt water intrusion. This designation means that major users of ground water, withdrawals of over 300,000 gallons per month, must be granted a permit before pumping. Therefore, a degree of management is being exercised to control over-pumping and well interference. A Ground Water Management Area does not address wellhead protection measures, however, and so the counties undertook this on their own.

Seven towns on the Eastern Shore have municipal water supply systems, and approximately 25 small public water supplies serve subdivisions and mobile home parks. The remaining population derives its water supply from private domestic wells. Some of these wells are shallow and withdraw water from only several feet below the water table which is the most highly vulnerable ground water in the area.

Agriculture and industry are the most water-intensive land uses on the Eastern Shore. Water withdrawal for crop irrigation is significant, with the Eastern Shore accounting for 62 percent of the reported statewide total for irrigation water use. Major industrial users include two poultry plants which account for 42 percent of the total permitted amount for industry on the peninsula. Since water quality is critical to the operations of agriculture and industry it is an important economic development issue. These sectors provide major employment opportunities and substantial tax revenues for the communities of the Eastern Shore. James Eichelberger, Water and Waste Water Manager for Perdue Farms Incorporated in the Town of Accomac, says that "without access to the large supply of ground water on the Eastern Shore, the company would never have been able to establish this facility, invest in the community, or provide jobs and producer contracts in the Accomac area."

Figure 26 -

In 1991, Virginia ranked third in the nation in the production of fresh market tomatoes. In 1987, Accomack Co. had 1,276 acres in tomatoes and Northampton Co. had 326. Together, this is 57% of the state's total.

## The Area's Hydrogeology

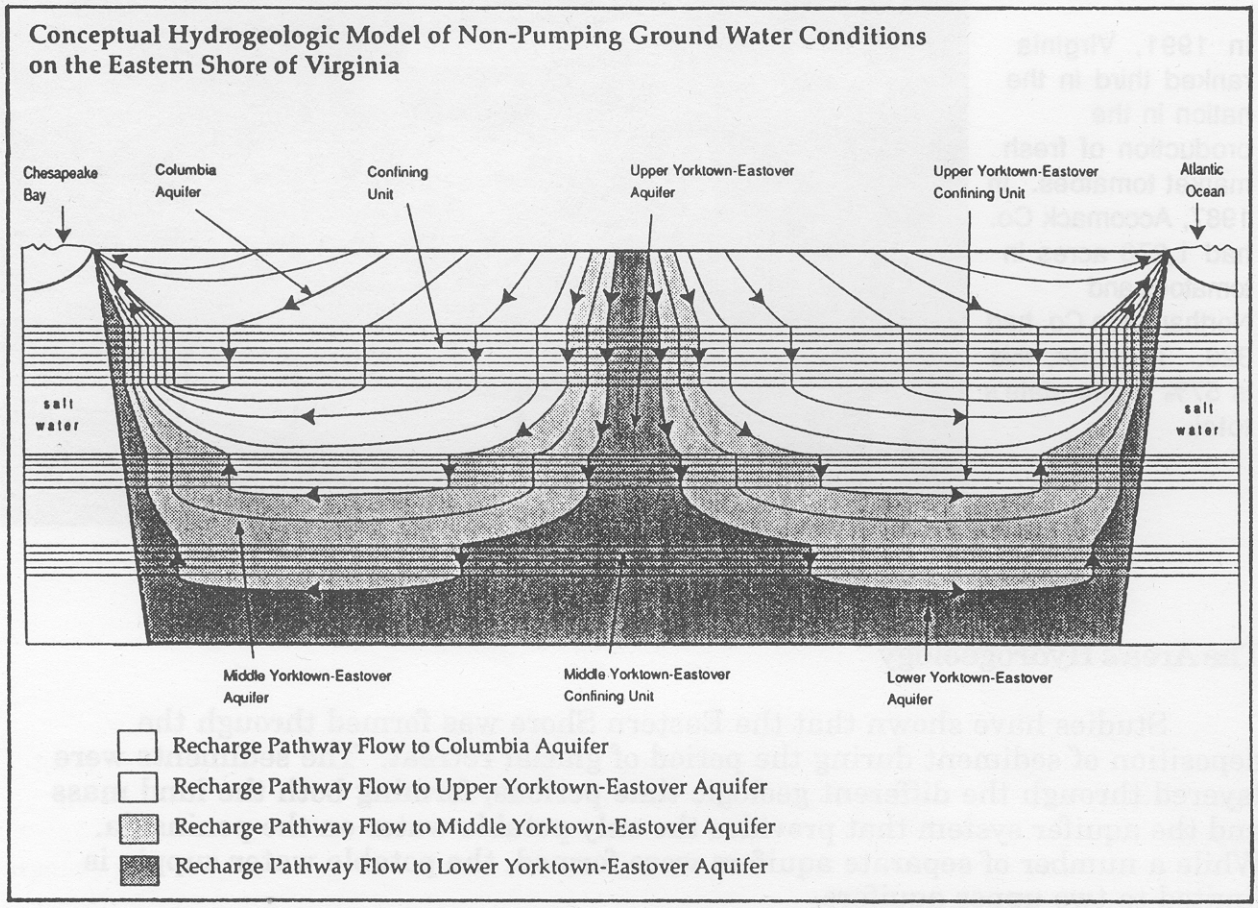
Studies have shown that the Eastern Shore was formed through the deposition of sediment during the period of glacial retreat. The sediments were layered through the different geologic time periods, forming both the land mass and the aquifer system that provides the only potable water on the peninsula. While a number of separate aquifers were formed, the potable water supply is limited to two upper aquifers.

The aquifers on the Eastern Shore are strongly influenced by the physical character of the geologic formations in the area. The upper aquifer, called the Columbia aquifer, is unconfined and between 80 and 100 feet thick. It is used

primarily for private on-site domestic wells and agricultural irrigation. Water quality in the Columbia aquifer is threatened by the many land uses that discharge, leach, or dispose of contaminants to the ground water, including septic systems, agricultural fertilizers, manure storage and animal waste disposal, septage lagoons, and landfills.

The next water bearing zone is the Yorktown-Eastover formation, a confined aquifer ranging primarily from 80 to 350 feet thick, although it is much deeper in the northern portion of Accomack County. The aquifer consists of coarse shelly sands found in three layers separated by clay confining units. These confining units serve to protect the aquifer from many water quality threats, but they also act to impede the amount and rate of recharge to the aquifer. Industrial withdrawals and public water supply wells are drawn from the Yorktown-Eastover aquifer. Problems of well interference and potential salt water intrusion, already observed near the largest industrial water users, will be greatly enhanced if the amount of withdrawal increases substantially as some forecasts would suggest.

Figure 27 - Eastern Shore Ground Water




Ground water found in aquifers below these has proven to be brackish in quality and is thus not utilized. Most of the potable water supply for the Eastern

Shore is found at depths that do not exceed 300 feet. However, in some portions of southern Northampton County the potable water supply is limited to 60 to 100 feet.

The only source of fresh water recharge to the aquifer system is from rainfall infiltrating the permeable Eastern Shore soil. Pressure from the fresh water lens provides a buffer or boundary which prevents the movement of saltwater from mixing with the fresh water. Fresh water, through recharge and other aquifer characteristics, is constantly moving through the aquifer to maintain this pressure.

Considering this complex hydrogeology, the Ground Water Plan recognizes the importance of understanding the water system as a whole in order to make future land use and development decisions designed to protect water supplies. An understanding of the flow patterns and locations of the recharge areas on the peninsula was seen as crucial so a conceptual model was developed which took a three-dimensional approach. The key element of the model with respect to protecting the long term quality and quantity of ground water on the Eastern Shore is the role played by the central spine of the peninsula. The center portion functions as the primary recharge source for the heavily used confined Yorktown-Eastover aquifer, and its protection is of utmost importance to the continued viability of the aquifer as a source of water.

**Identification of Wells Needing Protection**

Twenty-six public water supply wells, which account for most of the total ground water withdrawal permitted on the Eastern Shore, were located and mapped. The drawdown of these high capacity pumping wells was modeled analytically using a standard ground water flow model known as the Cooper-Jacob Method. The individual drawdowns were then added to simulate the interference effects from neighboring wells throughout the Eastern Shore. The area of the peninsula was divided into five regions based on the locational groupings of wells, the amount of permitted pumpage, and the contributing areas defined by contour mapping of the modelled drawdowns. The five well regions are: Chincoteague, Tyson Foods, Perdue, Exmore, and Cape Charles. The number of permitted wells in each region ranges from 9 to 17.

**Delineation Methods**

Once the five regions had been identified, it was necessary to evaluate potential methods of delineating protection areas. This was approached by first examining the geology and hydrology of the region and drawing upon existing technical literature. Various criteria for aquifer and wellhead protection were explored utilizing accepted EPA-approved criteria coupled with the hydrogeologic conditions of the Eastern shore. Assistance with this, as well as other technical aspects of the study and Plan, were provided by consultants to ANPDC.

Initially, a criterion of time of travel (TOT) was evaluated. With TOT, a distance is calculated from the well that corresponds to the distance a particle of water (or contaminant) would move to reach the supply source within a designated time period (10-year TOT, 25-year TOT, etc.). TOT is an extremely effective criteria in some hydrogeologic environments, particularly in unconfined aquifers in which the time it takes precipitation to recharge the saturated zone is quite short.

On the Eastern Shore, however, it is especially important to account for the vertical as well as the horizontal component, of ground water flow to the confined Yorktown-Eastover aquifer. This governed the choice of the protection area criteria. Studies indicated that the recharge area to the Yorktown-Eastover aquifer lies along the center of the peninsula. Accordingly, protection criteria were determined to address this particular setting. Ground Water Supply Management Areas consisting of three protection zones were defined around each wellhead area. The inner zone, Zone 1, was determined using a fixed radius of 200 feet. The outer two zones were delineated using hydrogeologic ground water flow boundaries and are known as "Zone 2 - Spine Recharge Area" and as "Zone 3 - Wellhead Protection Area."

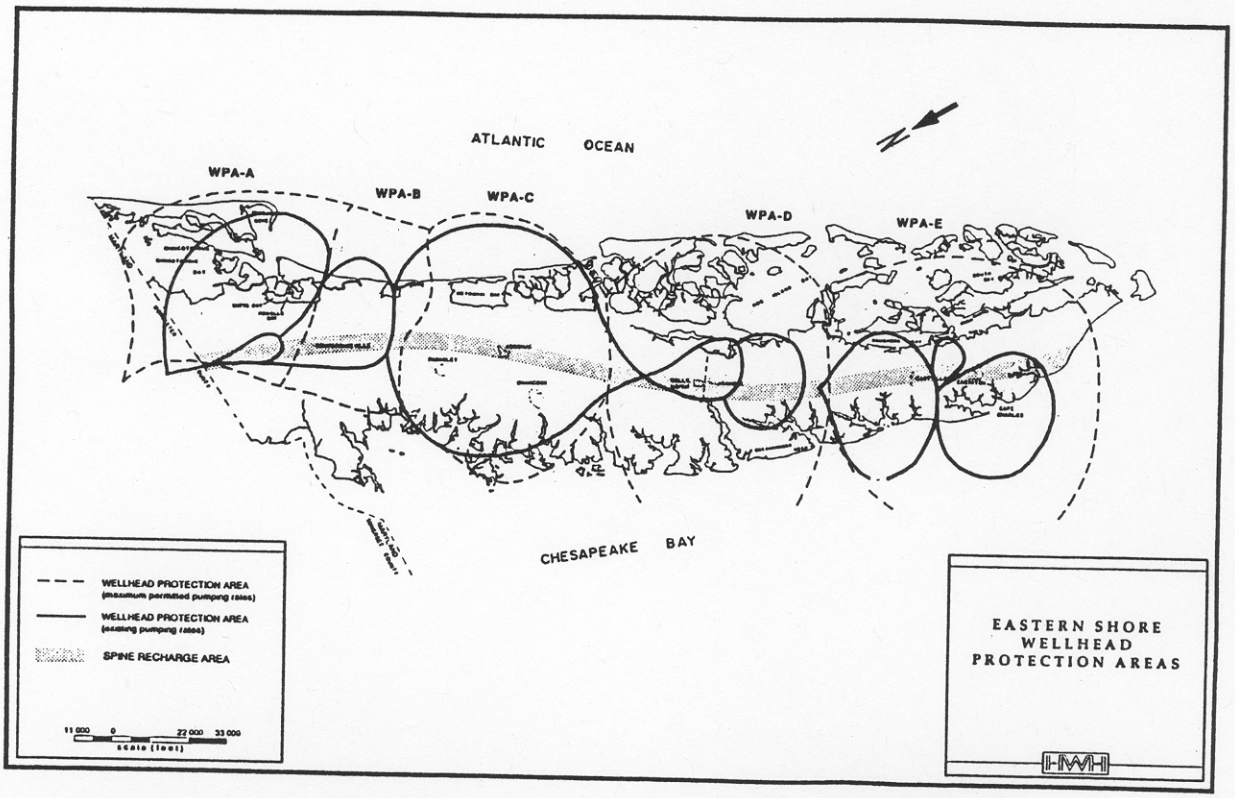
The Eastern Shore Ground Water Committee, working with the consultants, decided that there was a need for a highly protective zone immediately around a well for reasons more related to human error than to hydrogeologic conditions. They felt such a zone should be employed to maintain an area around the well to prevent potential contaminants from moving into the aquifer via a poorly constructed or faulty seal at the well. Wells that are poorly built or are old may lack the protective concrete or bentonite clay seal designed to prevent leakage from the surface down along the well casing into the aquifer. In addition, properly constructed seals may also break down over time and create a pathway for water and contaminants to flow into the well. Zone 1 areas were thus defined with a 200-foot radius around each well. It was recommended that virtually all potentially harmful activity be banned in this small zone.

Zone 2, the Spine Recharge Area, was delineated using hydrogeologic boundaries based on the recharge areas of the Yorktown-Eastover aquifer. The study of Eastern Shore hydrogeology had indicated that the primary recharge area is located along the center of the peninsula. Precipitation falling on the surface of the Eastern Shore penetrates vertically through the confining layer and recharges the aquifer below. Optimally, a full three-dimensional ground water flow model that accounts for the various differing permeabilities and thicknesses would be used to determine the exact recharge area but in this case the perfect model was not available so a simpler solution was derived.

A moderately conservative recharge rate of 9 inches per year was estimated for the unconfined Columbia aquifer. The recharge for the Yorktown-Eastover aquifer was assumed to be much slower due to the low permeability of the confining beds. The amount of area required to balance the volume of permitted pumping within a well region was calculated based on 9 inches per year. Since the recharge area was determined to be located along the center of the peninsula,

the length of the spine was measured in each zone of contribution, and the width of the protection zone determined by dividing the necessary recharge area by the length of the spine available. This width ranges from 1,530 feet to 4,660 feet but, to remain conservative, a larger 5,000-foot strip was plotted along the spine throughout the entire peninsula, 2500 feet on each side of the spine. Zone 2, this 5,000-foot strip, represents the surface area that contributes water to the wells in the Yorktown-Eastover aquifer.

Figure 28 - Wellhead Protection Areas




The third protection zone, known as the Wellhead Protection Area or Zone 3, reflects ground water divides and covers virtually the entire peninsula. This extensive wellhead protection area serves to establish formally how widespread the impact of ground water withdrawals has been on the hydrogeologic system of the Eastern Shore. Creating a zone of protection at the scale of Zone 3 re-emphasizes the dependence of the area on its ground water supply and how activities throughout the region, not simply along the central corridor, affect the quality and quantity of the area's ground water.

## Implementing the Study Recommendations

The recommendations made by the Ground Water Study Committee are large in scope and offer opportunities for extensive protection of the ground water resource on the Eastern Shore. However, additional work and funds were required to develop a means of implementing the strategies posed in the Plan. As

the Plan was being completed, the Accomack-Northampton Planning District Commission (ANPDC) applied for and received a $20,000 EPA Wellhead Protection Demonstration Grant in order to revise the comprehensive plans and develop ordinances for the two counties on the Eastern Shore. Jim McGowan, Director of Planning for ANPDC, provides staff support for the Ground Water Study Committee and is taking the lead on plan revisions and ordinance development.

Amendments to Northampton County's comprehensive plan incorporating revisions to the county's ground water objectives and policies were adopted in February 1993. Revisions to Accomack County's comprehensive plan are due to be completed in the fall of 1993. The areas' land use strategies reflect the need to collect and maintain accurate ground water data by supporting "the existing bi-county Ground Water Study Committee as an ongoing entity to gather quantitative and qualitative information." The changes also call for the revision of "all land use ordinances to include Ground Water Protection measures as recommended by the Ground Water Supply and Management Protection Plan."

While the comprehensive plan revisions passed with little conflict, Northampton County planner John Humphrey is more cautious when it comes to revising the County's zoning ordinance. Some property owners have questioned the technical accuracy of the report, stating that the study is a planning rather than a scientific document. Others respond that this is correct and that the intention of the Committee and the Study was to analyze the relationship between land use, planning, and ground water impacts. There is some uneasiness that the large amount of land delineated for protection could be challenged by land owners. Using a uniform measure of 2500 feet on either side of the spine as a means of determining who is in and who is out of the protection zone does treat everyone similarly but still may not sit well with some property owners. Holland Scott one of the two citizen members on the Ground Water Study Committee, sees that public education about wellhead protection is a key ingredient at this point. "People on the Shore have always assumed that they could pump water and that it would always be good water. Such attitudes have to be addressed and changed. Studies like those that have been done are important, but without a good public education program, they are not enough."

Mr. McGowan will be aiding the Committee as they develop the final ordinances for both Eastern Shore counties. The Committee has been busy recently with other issues, though, including Virginia's new ground water withdrawal regulations and several issues involving well failures and landfill sitings. They hope to be able to focus on developing the ordinances by the end of 1993 and have them adopted by the counties in the spring.

## Person to Contact

Jim McGowan
Director of Planning
Accomack-Northampton Planning District Commission
P. O. Box 4D
Accomac, Virginia 23301
804/787-2936

# APPENDIX

A) Public Water Supply Systems in Virginia Using Ground Water

B) Field Office Contacts for the Virginia Department of Health

## A) PUBLIC WATER SUPPLY SYSTEMS USING GROUND WATER

| County | CM | CM # gl | NT | NT # gl |
|---|---|---|---|---|
| Accomack | 20 | 525.63 | 25 | 1,257.23 |
| Albemarle | 27 | 92.03 | 11 | 5.74 |
| Alleghany | 16 | 32.39 | 4 | 0.00 |
| Amelia | 2 | 61.00 | 6 | 3.81 |
| Amherst | 9 | 16.96 | 6 | 0.83 |
| Appomatox | 6 | 75.02 | 5 | 5.87 |
| Arlington | 1 | 0.00 | 1 | 0.00 |
| Augusta | 23 | 406.34 | 8 | 8.55 |
| Bath | 11 | 545.80 | 1 | 1.62 |
| Bedford | 38 | 519.53 | 12 | 16.68 |
| Bland | 9 | 8.56 | 4 | 2.58 |
| Botetourt | 35 | 255.23 | 7 | 14.39 |
| Brunswick | 8 | 24.19 | 3 | 1.70 |
| Buchanan | 4 | 1.03 | 13 | 6.20 |
| Buckingham | 6 | 1.96 | 10 | 2.64 |
| Campbell | 31 | 69.72 | 10 | 65.98 |
| Caroline | 23 | 193.77 | 4 | 5.02 |
| Carroll | 25 | 80.63 | 14 | 7.17 |
| Charles City | 3 | 8.52 | 6 | 3.15 |
| Charlotte | 4 | 58.65 | 6 | 9.56 |
| Chesterfield | 6 | 4.78 | 4 | 11.00 |
| Clarke | 7 | 31.97 | 6 | 12.19 |
| Craig | 1 | 29.12 | 2 | 0.40 |
| Culpeper | 27 | 68.64 | 8 | 8.15 |
| Cumberland | 2 | 1.52 | 2 | 2.30 |
| Dickenson | 9 | 7.40 | 8 | 4.50 |
| Dinwiddie | 8 | 56.24 | 1 | 1.15 |
| Essex | 11 | 129.93 | 2 | 0.99 |
| Fairfax | 11 | 369.90 | 24 | 10.62 |
| Fauquier | 23 | 330.68 | 18 | 15.66 |
| Floyd | 2 | 31.46 | 3 | 1.62 |
| Fluvanna | 8 | 69.91 | 9 | 5.82 |
| Franklin | 48 | 165.52 | 15 | 5.20 |
| Frederick | 13 | 83.27 | 12 | 5.10 |

**KEY:** CM = Community System (Examples: Routier Subdivision, Rye Valley Water Authority, Jackson Creek Condominiums)
NT = Nontransient Noncommunity System (Examples: J.M. Bevins Elementary School, Roxbury Industrial Park, Boar's Head Provision Co.)
# gl = Million Gallons Per Year

**NOTE:** Does not include Nontransient Noncommunity Systems (e.g. restaurants and recreation areas)

| County | CM | CM # gl | NT | NT # gl |
|---|---|---|---|---|
| Giles | 19 | 386.10 | 4 | 309.40 |
| Gloucester | 12 | 287.84 | 17 | 6.07 |
| Goochland | 16 | 41.30 | 6 | 3.84 |
| Grayson | 7 | 65.92 | 11 | 7.33 |
| Greene | 6 | 19.22 | 1 | 2.29 |
| Greensville | 6 | 14.86 | 3 | 5.15 |
| Halifax | 7 | 26.87 | 12 | 3.40 |
| Hanover | 44 | 618.21 | 24 | 2,349.45 |
| Henrico | 23 | 991.60 | 7 | 252.10 |
| Henry | 39 | 111.53 | 20 | 13.73 |
| Highland | 2 | 25.27 | 0 | 0.00 |
| Isle of Wight | 42 | 978.39 | 8 | 12,284.93 |
| James City | 21 | 1,165.66 | 5 | 24.07 |
| King and Queen | 4 | 12.35 | 7 | 2.39 |
| King George | 25 | 334.69 | 3 | 19.30 |
| King William | 6 | 168.46 | 2 | 1.98 |
| Lancaster | 25 | 189.76 | 1 | 1.30 |
| Lee | 8 | 107.70 | 2 | 1.37 |
| Loudoun | 19 | 402.18 | 14 | 8.60 |
| Louisa | 8 | 52.97 | 5 | 28.30 |
| Lunenburg | 2 | 0.00 | 1 | 0.24 |
| Madison | 12 | 38.15 | 6 | 8.80 |
| Mathews | 6 | 7.11 | 5 | 4.21 |
| Mecklenburg | 10 | 155.57 | 12 | 10.23 |
| Middlesex | 14 | 594.80 | 3 | 0.75 |
| Montgomery | 41 | 247.02 | 2 | 0.34 |
| Nansemond | 0 | 0.00 | 0 | 0.00 |
| Nelson | 9 | 70.03 | 7 | 4.23 |
| New Kent | 20 | 104.66 | 6 | 7.03 |
| Northampton | 7 | 150.10 | 10 | 1.58 |
| Northumberland | 26 | 34.43 | 5 | 1.45 |
| Nottoway | 5 | 33.62 | 3 | 1.76 |
| Orange | 9 | 123.70 | 7 | 5.63 |
| Page | 11 | 471.82 | 6 | 3.60 |
| Patrick | 3 | 3.18 | 11 | 11.98 |
| Pittsylvania | 30 | 91.66 | 19 | 31.26 |
| Powhatan | 3 | 184.43 | 4 | 5.36 |
| Prince Edward | 3 | 38.79 | 2 | 2.25 |
| Prince George | 22 | 126.82 | 14 | 5.47 |

| County | CM | CM # gl | NT | NT # gl |
|---|---|---|---|---|
| Prince William | 26 | 744.52 | 21 | 7.44 |
| Pulaski | 20 | 24.31 | 3 | 0.55 |
| Rappahannock | 1 | 13.05 | 5 | 18.55 |
| Richmond | 5 | 56.62 | 1 | 0.62 |
| Roanoke | 52 | 2,954.47 | 14 | 29.28 |
| Rockbridge | 26 | 302.13 | 5 | 70.51 |
| Rockingham | 34 | 755.61 | 18 | 755.61 |
| Russell | 13 | 320.10 | 14 | 18.70 |
| Scott | 17 | 1,594.29 | 2 | 1.98 |
| Shenandoah | 25 | 331.33 | 14 | 298.94 |
| Southampton | 24 | 341.64 | 8 | 2,572.49 |
| Spotsylvania | 9 | 41.39 | 8 | 53.93 |
| Stafford | 6 | 6.89 | 4 | 2.17 |
| Surry | 11 | 67.58 | 3 | 29.04 |
| Sussex | 5 | 187.77 | 3 | 5.01 |
| Tazewell | 34 | 120.40 | 12 | 7.80 |
| Warren | 9 | 9.00 | 5 | 4.91 |
| Washington | 3 | 1,180.51 | 3 | 1.10 |
| Westmoreland | 22 | 386.34 | 7 | 7.63 |
| Wise | 16 | 17.66 | 6 | 5.31 |
| Wythe | 13 | 226.37 | 6 | 1.10 |
| York | 12 | 22.97 | 1 | 1.55 |

| City | CM | CM # gl | NT | NT # gl |
|---|---|---|---|---|
| Buena Vista | 1 | 312.46 | 0 | 0.00 |
| Franklin | 1 | 441.72 | 0 | 0.00 |
| Harrisonburg | 1 | 745.50 | 0 | 0.00 |
| Manassas Park | 1 | 183.00 | 0 | 0.00 |
| Petersburg | 1 | 0.00 | 1 | 1.75 |
| Staunton | 1 | 1,496.96 | 0 | 0.00 |
| Suffolk | 42 | 331.38 | 9 | 21.64 |
| Virginia Beach | 7 | 52.01 | 5 | 11.55 |
| Waynesboro | 1 | 1,040.22 | 0 | 0.00 |

June 23, 1993

VDH VIRGINIA DEPARTMENT OF HEALTH

*Protecting You and Your Environment*

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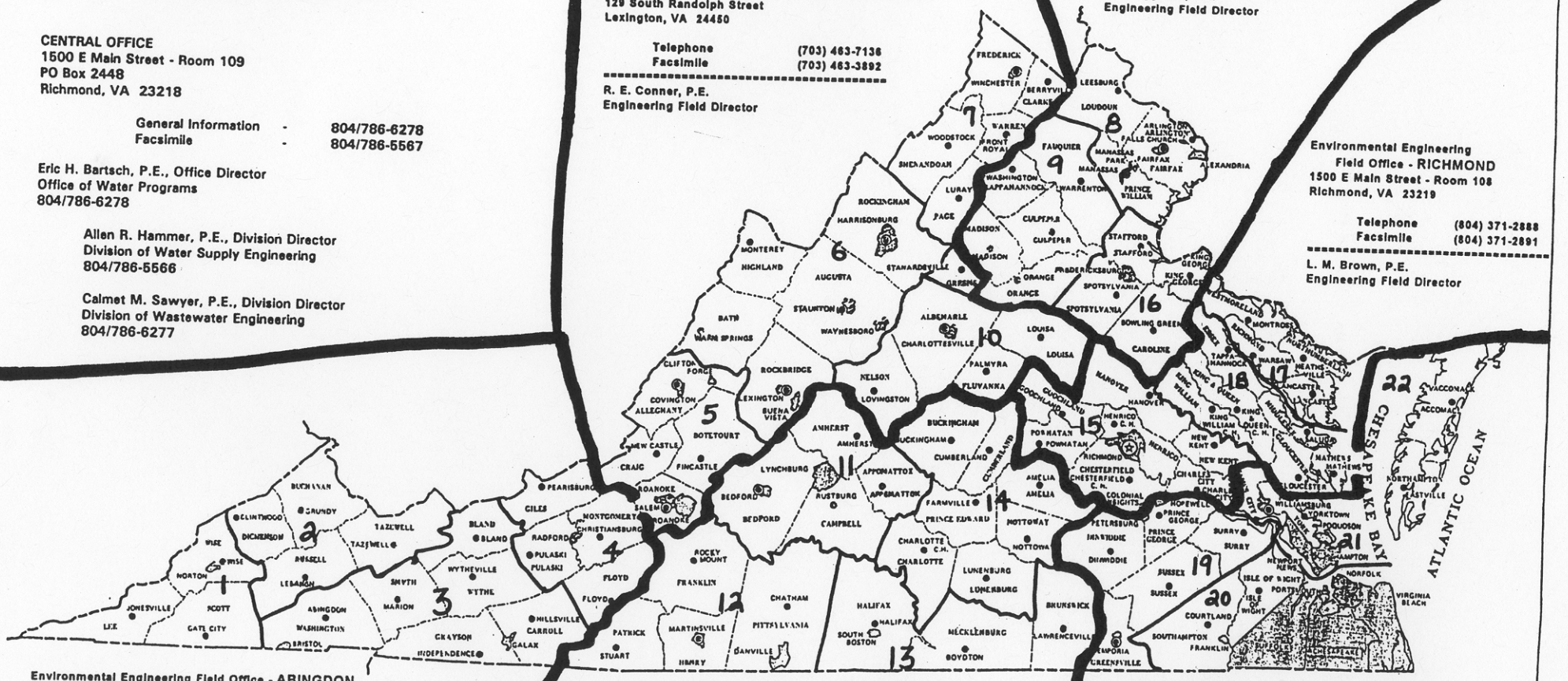


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END