GROUNDWATER RESOURCES PLAN

Adopted

October 20, 1998

Clarke County
Comprehensive Plan
Implementing Component
Article 5a

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Executive Summary: Groundwater Resources Plan

The Groundwater Resources Plan is one of two sections of the Water Resources Plan, is an implementing component of the Clarke County Comprehensive Plan. This section specifically addresses issues relating to groundwater, including groundwater contamination from nonpoint sources, protecting the Prospect Hill Spring water supply, and increasing public understanding of the sensitive nature of limestone geology. The Groundwater Resources Plan is designed to accomplish Objective 3 in the Comprehensive Plan, which states: “Protect natural resources, including soil, water, air, scenery, and fragile ecosystems.”

The following actions are recommended to implement the Plan:

I. County Ordinances: Review and update County ordinances related to groundwater protection.

A. Septic Ordinance:

1. Phase out nonstandard waste disposal systems such as pit privies.
2. Implement regular maintenance, cleaning, and reporting of septic systems.
3. Identify acceptable alternatives to septic systems when failed or inadequate systems are identified. Installation and use of alternative systems should be accompanied by a maintenance schedule that is regulated by the Clarke County Sanitation Authority.

B. Sinkhole Ordinance: Amend the ordinance to require vegetative buffering of all Class1 sinkholes subject to contamination.

C. Underground Storage Tank (UST) Ordinance: Create a database of the locations of all USTs in the County, and develop a County ordinance that will serve to regulate USTs with less than 1,100 gallons capacity that are used for petroleum or chemical storage.

D. Storm Water Resources Ordinance: Revise the ordinance to better address runoff quantity and quality so as to protect surface and groundwater from contamination.

II. Natural Resources Overlay District: Consider enlarging the district to incorporate the entire groundwater recharge area for Prospect Hill Spring, as delineated by the available data.

III. Public awareness and education: Designate the Clarke County Natural Resource Planner as the County official responsible for public education concerning protection and conservation of groundwater resources.

IV. Nonpoint pollution: Cooperate with and encourage use of the programs administered by the Agricultural Extension Office and other agencies involved in developing Best Management Practices (BMPs).

V. Well testing: Establish a Countywide well-monitoring network to effectively monitor changes in water quality over time. Including routine testing of specific wells for coliform and water chemistry.

VI. Groundwater database development:

A. Develop a database of all existing well and septic permits on file in cooperation with the Health Department. Homes with systems not on file should be surveyed to determine the type and location of water source and sewage disposal.

B. Compile existing data from all previously conducted groundwater studies.

C. Use the GIS to identify and map areas sensitive to groundwater contamination, and utilize this information to prioritize areas in need of increased protection measures.

I. Introduction

The groundwater resources of Clarke County are particularly susceptible to contamination resulting from human activities because of the sensitive nature of the aquifers, found in carbonate rocks underling the Valley region of the County. Groundwater protection and management problems are generally greater in areas that are underlain by carbonate rocks, such as limestone and gypsum, than in areas underlain by most other rock types because of the presence of solution-enlarged sinkholes, conduits, and caves. These geologic features characterize what is called karst terrane. The generally high permeability of these rocks facilitates the infiltration and transport of contaminants from the land surface to the groundwater reservoir.

To minimize the effects of future growth and development, the Clarke County Planning Commission established a Water Study Committee in 1985. This committee directs plans and studies aimed at protecting the water resources of the County. Accomplishments of this committee include the creation of the Clarke County Groundwater Protection Plan (1987), which, in addition to describing the sensitivity of Clarke groundwater, proposed (1) an ordinance that limits land use around sinkholes, (2) septic system installation guidelines, and (3) water-well construction regulations. The Groundwater Protection Plan is a precursor to this Groundwater Resources Plan. These efforts were accompanied by a study sponsored by the American Farmland Trust to map the county's land and natural resources using a geographical information system (GIS) (Maizel and White, 1988). The committee also contracted with the U.S. Geological Survey (USGS) to conduct an in-depth study of the hydrology and quality of groundwater to assist in land use and planning decisions made in the County. This study produced the Water Resources Investigation Report 90-4134, entitled Ground-Water Hydrology and Quality in the Valley and Ridge and Blue Ridge Physiographic Provinces of Clarke County, Virginia (Wright 1990).

II. Purpose and Scope

Three-fourths of the people in Clarke County depend on groundwater as the source of their drinking water. Protecting the groundwater from contamination, therefore, has been of primary importance in the County for many years. The need to protect public health as well as the economic impact for doing so was highlighted in 1981, when the Town of Berryville had to abandon its public water supply wells as a result of contamination from an infiltration of nitrates, phenols, and herbicides, none of which could be traced to a single point source (Wright 1990). Because new wells might later become contaminated, and purification of existing wells was determined to be impossible, the Town decided to draw water from the Shenandoah River, a decision that necessitated construction of a $1.3 million plant to treat the water. This plan is intended to reduce the need for such significant public expenditures.

This plan is designed to address Objective 3 in the Comprehensive Plan, which states: “Protect natural resources, including soil, water, air, scenery, and fragile ecosystems.” Although integrally linked, groundwater is the focus for protection in the context of this plan. Protection and management of surface waters features, including the Shenandoah River, Opequon Creek, and the secondary stream network, are addressed in the Surface Water Resources Plan section of the Water Resources Plan.

When Clarke County began working on groundwater protection in 1983, there was very little available in terms of models. An important document published in November 1986 by the Virginia Water Resources Research Center: Protecting Virginia’s Groundwater: A Handbook for Local Government Officials (Hrezo and Nickinson 1986). It sets out clearly the role of local government in groundwater protection:

> Because human land use activities cause most groundwater pollution, local governments have a special role to play in protecting this resource. The foundation for this role rests on the responsibility of localities to protect the public health, safety and welfare; their delegated authority to manage land use practices; and their featured place in EPA's groundwater management strategy. Although groundwater protection is every citizen's responsibility, it is the role of local government to provide the leadership needed to assure the good quality of this vital and vulnerable resource, (p. 1).

The handbook states succinctly: Groundwater is a vulnerable resource whose quality is largely determined by how people use land, (p. 3).

III. Description of Resources

Clarke County's location at the junction of two distinct regions-the Valley and Ridge and the Blue Ridge physiographic provinces (figure 1)-creates two different hydrogeologic regions, underlain by characteristic bedrock types. Bedrock in the Valley region consists of carbonates (limestones and dolomites) and calcareous shales; in the Blue Ridge region, it consists of metamorphic basalt, sandstone, quartzite, slate and shale. The rocks of the Blue Ridge are more resistant to weathering and erosion, and this resistance is expressed in the more mountainous terrain, compared to the Valley region (Wright 1990).

Differences in resistance to weathering are also shown by the extent of bedrock openings where groundwater occurs and moves. In the Blue Ridge bedrock, water occurs in fractures in the rock, joints, faults, and bedding plane separations. In the Valley region, the carbonate bedrock is more easily dissolved by water, and many fractures can become enlarged into solution channels.

Enlargement of fractures by dissolution is one feature characteristic of karst topography, which is formed on limestone, gypsum, and other rocks by dissolution and is characterized by sinkholes, caves, and underground drainage (Wright 1990). Compared to other karst regions of the world, Clarke shows a relatively minor degree of karstification, in that the bedrock solution channels, sinkholes, and other features are not as extensive or well developed. The karst features do, nevertheless, greatly influence Clarke's groundwater resources. One important effect is that well developed aquifers, which are characterized by solutionally enlarged bedrock fractures, cause discharges from springs in the Valley region to be greater than those in the Blue Ridge region. Another important influence is the presence of springs and sinkholes, which provide direct connections between the land surface and groundwater (figure 2). Sinkholes, especially, offer an easy way for surface water contaminants to reach groundwater. In addition, new sinkholes can occur when the soil overburden collapses following groundwater pumping. Aquifers are recharged primarily by precipitation infiltrating the soil and reaching the water table. Some recharge also comes from irrigation and septic water. Springs, on the other hand, represent areas of groundwater discharge or the removal of water from an aquifer.
Discharge
Insert Figure 1 -- Physiographic provinces of Clarke County, Virginia.

Insert Figure 2 - Sinkhole & spring locations

also occurs due to water use by plants, input of groundwater to stream beds, and pumping from wells. Changes in the relative amounts of recharge and discharge appear as fluctuations in the level of the water table (Wright 1990).

Understanding groundwater flow patterns is critical for developing land use protection strategies, as the direction of water movement will dictate where areas highly susceptible to contamination are located. Water table hydrographs -graphs of the water table level over time- were made in 1987 as part of the USGS study. The hydrographs indicate that groundwater flow in most of the Valley region is a combination of diffuse and conduit like flow, with groundwater moving through many small, braided conduits and fissures. The bedrock fractures have been enlarged by dissolution, allowing groundwater to move more easily than it does in the Blue Ridge region, where movement occurs through smaller fractures in more-resistant metamorphic rock (Wright 1990). The specific direction of local groundwater flow is influenced by the fractures in the surrounding bedrock. As well as moving generally down gradient (i.e., perpendicular to contours of equal hydraulic potential), water moves toward areas of greater relative permeability, and fractures are more permeable to water than solid rock. Within the Blue Ridge region, another influence on groundwater flow is the steep terrain, which can cause infiltrating surface water to move quickly to springs or streams (Wright 1990).

Figure 3 shows the water table contours and groundwater divide (Wright 1990). Flow is generally down gradient (from high to low water table level) toward springs, streams, Opequon Creek, and the Shenandoah River. The divide in the western part of the County separates flows toward the Shenandoah from those toward Opequon Creek.

IV. Groundwater Quality and Contamination Concerns

Water quality refers to the chemical and biological constituents of water. Table 1 lists several of the most important groundwater quality parameters that are affected by both natural and human factors.

Natural groundwater quality depends primarily on bedrock composition. Groundwater in the Valley area has generally higher concentrations of total dissolved minerals, because the rocks of the Valley are more soluble than those of the Blue Ridge. Water from Valley wells and springs has relatively high calcium, low magnesium, and very low sodium and potassium. Water in the Blue Ridge has variable amounts of calcium, low magnesium, and variable (but often high)
sodium and potassium. Total hardness ranges from 89-422 milligrams per liter as calcium carbonate (mg/l) in the Valley, compared to 4-242 mg/1 in the Blue Ridge. Valley area groundwater is classified as very hard (Wright 1990). Unnatural groundwater quality or contaminated groundwater is caused primarily by human land uses. Principal land uses in Clarke County include agriculture, forestry, and residential, commercial, and industrial uses (table2).

INSERT FIGURE V.3

CONTOURS OF WATER-TABLE SURFACE IN CLARKE COUNTY, VA FOR JULY AND AUGUST, 1987

Table 1. Source and Significance of Selected Constituents of Groundwater in Clarke County, Virginia

CONSTITUENT OR PROPERTY	MAJOR SOURCES	EFFECT UPON USABILITY OF WATER
Calcium (Ca) and magnesium (Mg)	Dissolved from practically all soils and rocks but especially from limestone, dolomite, and gypsum	Cause most of the hardness and scale-forming properties of water; detergent consuming (see Hardness entry, below). A high concentration of magnesium may act as a laxative in humans.
Sodium (Na)	Dissolved from practically all rocks and soils; present in industrial wastes and sewage	In water containing calcium forms hard scale in steam boilers. Secondary maximum contaminant level is 200 mg/l.
Chloride (Cl)	Dissolved from rocks and soils; present in seawater, deep groundwater, sewage and industrial wastes, highway salts, and fertilizers	May impart salty taste above 100 mg/l and increases corrosiveness of water. Secondary maximum contaminant level is 250 mg/l.
Nitrate (NO_3)	Fertilizers and decay with organic matter, sewage, and animal waste	Encourages growth of algae and other organisms that produce undesirable taste and odors. Concentrations in excess of the suggested limit are suspected as a cause of methemoglobinemia (blue baby) in infants. Maximum contaminant level is 10 mg/l as nitrogen.
Hardness as calcium carbonate ($CaCO_3$)	Primarily calcium and magnesium	Consumes soap and synthetic detergents; produces scales in hot water heaters, pipes, and boilers
Fecal coliform and fecal streptococci	Wastes from human and animal intestines	Indicates contamination from human and/or animal waste. Maximum contaminant level is 4 colonies/100 ml.
Specific Conductance	Reflects dissolved mineral content of the water	Indicates the capacity of the water to conduct a current of electricity. Varies with the concentration of ions in solution

Source: Wright 1990.

Table 2. Clarke County Land Use, in Acres

	Rural County	B'ville	Boyce	Total County	Percentages
Single family residential- urban (in incorporated towns)	0	66.3	123.7	189.9	.2 %
Single family residential- suburban (not in incorporated towns, less than 20 acres in parcel)	15,557.5	0	0	15,557.5	14.0 %
Multifamily	5.5	3.8	0	9.3	<.1 %
Commercial/industrial	582.3	162.6	7.5	752.4	.7 %
Agricultural (20 - 99 acres in parcel)	28,091.4	166.6	20	28,278.8	25.5 %
Agricultural (more than 99 acres in parcel)	60,742.8	0	0	60,742.8	54.8 %
Exempt (government, churches, etc.)	4,567.6	506.7	161.2	5,235.5	4.7 %
Total Acreage	**109,547.1**	**906.0***	**312.4***	**110,812.6**	**100.0 %**

From the Clarke County Comprehensive Plan, 1994

Source: Clarke County Commissioner of Revenue, 1993

* Includes entire parcels of which only a majority may be within Town corporate limits

A. Contamination Sources

Table 3 describes the contamination sources associated with principal land uses.

Table 3. Contamination Threats to Groundwater Associated with Principal Land Uses in Clarke County, Virginia

LAND USE	LAND USE ACTIVITY	TYPE OF CONTAMINATION
Agriculture	Animal feed lots, manure spreading and pits, chemical application, and chemical storage areas	Coliform bacteria pesticides, fungicides fertilizers– nitrates
Residential	Septic systems Hazardous household products (paints, cleaning products) Lawn chemicals, fertilizers Underground storage tanks	Coliform bacteria chemicals chemicals, nitrates petroleum
Commercial And Industrial	Auto repair, construction areas, car washes, gas stations, paint shops, road deicing operations, storage tanks, storm water runoff	petroleum chemicals detergents salts
Other uses	Transportation railroad trucking	petroleum chemicals variety of contaminants

Source: U.S. Environmental Protection Agency 1989

B. Contamination Problems

General contamination of wells throughout the County has been documented in multiple groundwater studies. Health Department Records of water samples collected by the Clarke County office of the State Health Department (hereafter referred to as the Health Department) from 1980 to1998 indicate approximately 40% of wells sampled were contaminated by fecal coliform. This number was validated by a groundwater study completed in 1990 by the USGS that also identified 40% contamination rates, and again in 1991 a water testing program conducted by the Agricultural Extension Office showed that up to 40% of sampled wells were contaminated by coliform (figure 4). Since 1992, the Health Department has collected nitrate samples from all new wells installed in the County. Coliform samples are collected by the homeowner, and results are not reliable (figure 5). Additional data have been collected to determine the influence of agricultural chemicals and pesticides (LoCastro 1988). Pesticide data were also collected by the USGS in 1990 and during the Agricultural Extension Service 1991 water survey (Ross et. al. 1992).

Contamination levels prior to the 1960s are not known, but based on the available data it is reasonable to conclude that contamination levels are higher than would occur naturally. This elevated contamination is from an increase both in sources of contamination and in the number of wells located throughout the County. Wells, like sinkholes, are pathways for contaminants to enter the groundwater.

The major known contaminant problems have been caused by nitrates, bacteria, and petrochemicals. Figure 6 shows the location of these problems. Pollution of private wells was recognized as a problem in the 1960's in the Boyce-Millwood area and led to the creation of the Clarke County Sanitary Authority in 1968 (LFPDC 1987). By the mid-1970s, the authority began supplying water to more than 200 residences and businesses from the high-yielding Prospect Hill Spring. According to the 1987 Groundwater Protection Plan: The most costly case for the County citizens was the 1981 loss of the Berryville public water supply wells. The wells had been contaminated by a combination of nitrates, phenols, and herbicides, none of which could be tied to a single point source. Rather than drill new wells which could later become contaminated, the answer to Berryville’s water problem was a new $1.3 million water treatment plant using the Shenandoah River as the water supply (p. 1). In the early 1986, 10 wells in the village of Pine Grove were contaminated by petroleum believed to have leaked from underground storage tanks. The contamination of the groundwater supply for the community of White Post by petroleum products necessitated the expenditure of more than $2 million by the State Water Control Board to bring potable water from Prospect Hill Spring to White Post residents in 1992.

Faulty septic systems are one of the most common sources of groundwater pollution. Household waste water contains high levels of nutrients (primarily nitrogen and phosphorus), bacteria, viruses, and household chemicals (Weigmann et. al. 1992). In 1995 the Town of Boyce constructed a sewage treatment plant due to the high number of failing septic systems. An environmental survey performed by the Lord Fairfax Health District (a regional office of the State Health Department) in 1987 stated that 46% of the sewage disposal systems in Millwood did not meet the standards of the Health Department and that human health hazards exist as a result of these inadequacies. This situation not only causes a substandard life style for affected county residents but also presents a significant threat to the quality of groundwater. Efforts are ongoing to bring public sewer service to Millwood. In rural areas of the County, substandard septic systems such as cesspools and pit privies also represent a potential health and environmental hazard. Approximately 188 homes in the County do not have either a septic system or cesspool (Virginia 1990 Census of Population and Housing).

Figure 4. 1991 ag ext. Well survey

Fig 5. Health Dept. Well records

Fig 6. Past groundwater problems

New residential, commercial, and industrial development increases the potential of groundwater contamination from storm water runoff. Storm water management requirements are currently administered at the State level. Most management is directed towards maintaining predevelopment quantity of water leaving a property. Efforts are being initiated at the local government level to filter runoff to improve the quality of water leaving a site.

V. Past Groundwater Mitigation Efforts

Contaminants can move from surface to groundwater through a number of pathways. The most common avenues are wells, sinkholes, or infiltration into shallow overburden (unconsolidated material overlying bedrock, such as loose soil, silt, sand, and gravel) and movement through permeable overburden to fractures in the rock (Wright 1990). Preventing groundwater contamination can be accomplished by: (1) eliminating the contamination source, or (2) buffering or preventing access by contaminants to the groundwater.

Clarke County's past and ongoing efforts to prevent groundwater contamination are directed by the environmental objective described in the County's Comprehensive Plan. Policy 4 under this objective specifically addresses the management and protection of groundwater resources, focusing on two main areas:

1. protecting groundwater Countywide to prevent contamination of the private drinking water supply; and
2. protecting Prospect Hill Spring, which is the only public drinking water facility operated by the County.

A. Countywide Mitigation Efforts

Several State agencies are responsible for protecting Virginia's groundwater. These include the Department of Environmental Quality (DEQ), the Department of Conservation and Recreation (DCR), and the State Health Department. DEQ regulates underground storage tanks (greater than 1,100 gals. capacity), and groundwater withdrawals exceeding 300,000 gals/month within groundwater management areas. Additional regulations address surface waters and air quality. The Department of Conservation and Recreation (DCR) is responsible for administering the Cave Protection Act, which prohibits disposal of solid wastes in sinkholes. DCR also administers the storm water management regulations for the State. The State Health Department regulates sewage disposal and well installation. State regulations address the Statewide need for groundwater protection. Counties have been given the authority to enact regulations stricter than the State to prevent the pollution of water that is dangerous to the health or lives of persons residing in the county (15.2-1200, 32.1-34).

Due to the presence of karst terrane and the identified historic problems with groundwater contamination, Clarke County is more susceptible to contamination than counties in other regions in the state. Therefore, since 1983 Clarke County has adopted and amended ordinances to protect its groundwater resources. County septic, well, and sinkhole ordinances ensure that future growth does not introduce additional risk of groundwater contamination.

In the 1987 Groundwater Protection Plan the need for a County Septic Ordinance is described as follows:

> Approximately 4 million gallons of wastewater is discharged each day into the soils and groundwater of Clarke County from an estimated 3000 septic systems serving rural

> residences, businesses, and institutions. By comparison, the Town of Berryville discharges about .5 million gallons a day of treated wastewater into Dog Run, a tributary of the Shenandoah River. Therefore, septic systems collectively can be recognized as the largest point discharge of wastewater in the County. They present a continuous loading of bacteria and viruses, nitrates, metals, and organic compounds to groundwater. Given the problem caused by improperly installed or failing septic systems, or any other alternative system approved by the Virginia Department of Health, it is recommended that strong standards for the installation and maintenance of such systems be developed and implemented, (p. 11).

The Septic Ordinance was adopted December 15, 1987. As stated in the intent section, the purpose of the ordinance is "to minimize the potential for groundwater contamination resulting from improper siting and construction of subsurface septic systems in Clarke County." Amendments to this ordinance are summarized in Appendix A. County regulations are stricter than the State's primarily with regard to system siting and installation. A summary of the differences between State and County regulations is summarized in Appendix B.

The Groundwater Protection Plan also stated the need for a County Well Ordinance. The concern with wells and groundwater contamination is that improperly cased and grouted wells serve as conduits for surface pollutants to the groundwater. Considering the high number of positive tests for fecal coliform in wells, the immediate vicinity of the well could be the source of pollution; therefore increased setback requirements from contamination sources are included in the County ordinance. The County also wanted to protect groundwater from agricultural wells that are neither cased nor grouted but are located in areas of high concentrations of animal waste (LFPDC 1987). The County Well Ordinance was adopted March 20, 1990, and implemented May 1, 1991. A summary of the amendments to the ordinance is provided in Appendix A. County regulations are stricter than the State's primarily with regard to system siting and installation. A summary of the differences between State and County regulations is summarized in Appendix B.

Sinkholes are identified as points where contaminants can enter the groundwater system. The Clarke County Soil Survey data identify numerous sinkholes in the County (Edmonds and Steigler 1982). <u>The Model Ordinance for Groundwater Protection</u> developed by the Minnesota Project and published in July 1984 contained a sinkhole element that was modified to meet the needs of Clarke County by the County staff (LFPDC 1987). The Sinkhole Ordinance was adopted January 20, 1987. The State regulations prohibit dumping of solid waste into sinkholes. The County regulations go on to define Class 1 and Class 2 sinkholes as well as outlining remediation and penalties for violators.

The 1987 Groundwater Protection Plan drafted Underground Storage Tank Requirements to protect human health and the public welfare by establishing regulations for residential and agricultural underground storage tanks. However, the plan recognized that regulating underground storage tanks is a complex issue and the administration of such a program may be costly for a small local government. Therefore the recommendation of the Plan was to consider implementation should contamination from tanks increase significantly (LFPDC 1987).

<u>B. Prospect Hill Spring Mitigation Efforts</u>

Considerable effort has been and continues to be extended to protect Prospect Hill Spring, the public water supply for approximately 300 households in the Town of Boyce, the Villages of Millwood and White Post, and the Waterloo commercial district.

The spring was permitted by the State Health Department as a public water supply in 1977. Development pressures around the spring in the early 1980s prompted the County to contract two studies to determine the impact of new drainfields on the Spring. The Honkala report (1980) summarized the soils and geology of the area and listed several recommendations that might allow safe development of a limited number of homes. The second study, by Schnabel Engineering Associates (1983), was conducted "to develop general land use policies, guidelines, and recommended restrictions, which will protect the water quality of Prospect Hill Spring in a cost effective manner (p. 1)." This report led to development of the Natural Resource Conservation Overlay District (RC) in 1983 (figure 7). The Overlay District encompasses a 400 acre area within a 3,000 foot arc up gradient from the spring, which the report terms the "Local Recharge Area." A recharge area is defined as regions that are hydrogeologically connected to an aquifer and that contribute significant amounts of water to it (Virginia Groundwater Protection Steering Committee 1991). The intent of the Overlay District is to provide protection of the groundwater recharge area for Prospect Hill Spring; however, the boundary does not encompass what the study refers to as a "major recharge area that would include the surface water drainage basin of Page Brook." This area would encompass approximately 4,900 acres. Collaborating the Schnabel report's finding is the federal designation of the Page Brook's surface water drainage basin as an Environmental Protection Agency (EPA) sole-source aquifer in 1987. In the EPA's final determination, the agency found in part that "The Prospect Hill Spring is the sole or principal source of drinking water for that part of Clarke County, and that such aquifer, if contaminated, would create a significant hazard to public health (p. 21733)". In addition, such designation means that no federal assistance may be provided for any project in the area that the U.S. Environmental Protection Agency finds may contaminate the aquifer.

To continue to define the recharge area, dye tracing studies were conducted in 1987 by W. K. Jones. The tests indicated that groundwater in this area can move two miles or more from recharge points in as little as five months. Since the initial study two additional dye tests have been undertaken. In 1992, Jones was contracted by the County to continue his previous work. Dye was placed in three sinkholes but was never recovered. The lack of recovery was thought to be due to a drought that ensued shortly after the dyes were injected. In 1998, a study was conducted by EPA with dye placed in two sinkholes. The results of this test are not yet available.

Revisions to EPA's Surface Water Treatment Rule in 1989 required the County to go beyond previous protection efforts. The revised rule contains provisions that require disinfection and filtration for all public water systems that use surface water or a source that is groundwater under the direct influence of surface water. Previously springs were considered groundwater sources, requiring disinfection only. Only those systems that were able to demonstrate compliance with the stringent source water quality criteria could avoid the filtration requirement. In June 1994, the State Health Department issued a finding that Prospect Hill Spring is under the

Figure 7. Prospect Hill Spring

influence of surface waters as demonstrated by high bacteria levels (Eberly 1994). Based on this finding, the County is required to provide disinfection and filtration of the water. Concerned with the potential source of the bacteria, the County contacted W. K. Jones, a consulting hydrologist, and Dr. Charles Hagedorn, a professor of environment microbiology at V.P.I. These scientists independently concluded that cattle grazing in and around a sinkhole 500 feet up gradient of the spring were contributing to the contamination (Hagedorn 1994; Jones 1994). Responding to their conclusions, seven acres of land surrounding a sinkhole directly above the spring was purchased in 1997. The land was fenced to exclude cattle and in 1998 planted with approximately 400 hardwood seedlings so as to establish a permanent vegetated buffer.

VI. Plan Implementation

The County continues to experience residential growth at a rate of almost 2% annually in rural areas. Providing public water service outside of the designated growth areas is economically undesirable. Therefore protecting the quality of groundwater is essential to protect public health. Initial steps taken by County policy makers were focused on reducing groundwater pollution. Based on the anticipated growth, expanded efforts are necessary to address the continued threat to groundwater from existing and future contamination sources.

This plan presents a comprehensive approach to groundwater problems. The underlying assumptions are: (1) protection of natural resources and the environment is everyone's responsibility; (2) land use decisions should be in accord with a sound strategy for protecting the County's groundwater resources.

The County should take action in the following areas: (A) continue to review and update County ordinances related to groundwater protection; (B) reexamine and evaluate of the Natural Resources Conservation Overlay District protecting Prospect Hill Spring; (C) implement a public education program to encourage water conservation and protection by County citizens; (D) develop a response to nonpoint pollution; (E) establish and maintain a Countywide long- term groundwater monitoring network; and (F) develop a groundwater database.

A. Review and update County Ordinances related to groundwater protection.

Since initial publication of the Clarke County Groundwater Protection Plan in February 1987, the County has drafted or put in place ordinances related to groundwater protection in the following areas: (1) on-site waste-water treatment system resources; (2) sinkhole identification and education; (3) water-well construction and water testing; and (4) underground storage tank requirements. These regulations will help to ensure that new construction and development will be done only with necessary protection of the groundwater.

Additional regulations are needed to: (1) Phase out nonstandard waste disposal systems such as pit privies; (2) implement the ordinance requiring regular maintenance, cleaning, and reporting of septic systems; (3) develop an underground storage tank ordinance to regulate storage tanks less than 1,100 gals., which are not regulated by the Virginia Department of Environmental Quality; and (4) revise the Storm Water Resources Ordinance.

1. **Septic Ordinance**

   a. Phase out nonstandard waste disposal systems such as pit privies.
   Pit privies installed on poor soils and when used in conjunction with gray water systems represent a significant threat to public health and groundwater quality (Enferadi et. al. 1986). The 1990 census documented 188 households in the County using privies as their primary waste disposal system**.** Adoption of this ordinance must be accomplished in concert with a program for providing alternatives to those currently using these facilities. Whenever possible, the County should facilitate the work of community improvement organizations such as Help with Housing to provide indoor plumbing to residences in the County or to help upgrade substandard systems such as cesspools.

   b. Implement regular maintenance, cleaning, and reporting of septic systems.
   Septic systems fail if they are not properly maintained by pumping approximately every five years. Because of the soil qualities in Clarke County, a failed septic system presents a real danger to the quality of the County's groundwater. Many lots with building rights or existing houses within the county do not have an adequate reserve drainfield if a system fails. It is in the interest of homeowners and the county in general to ensure that all systems are adequately maintained. In June 1995 the Board of Supervisors approved a septic system maintenance section requiring pump-out of septic tanks, cesspools, and dry wells. For it to be implemented, a fee schedule needs to be developed and adopted by the Board. Prior to adopting a fee schedule, the administration of the pumpout schedule will need to be addressed. Haulers will be required to provide records of pumping to the Health Department. Consideration should be given to providing an incentive program should homeowners voluntarily pump their tank. Failure to meet this requirement should result in the County having the system pumped and charging the fee to the property owner.

   c. Identify acceptable alternatives to septic systems when failed or inadequate systems are identified. Installation and use of alternative systems should be accompanied by a maintenance schedule that is regulated by the Clarke County Sanitation Authority.
   Many existing properties within Clarke County are on lots of insufficient size to meet the County's current septic regulations. For example, Millwood has numerous residences on lots that will not support <u>any</u> septic system. Residents of these properties use privies and have no other means of wastewater disposal. Current County ordinances provide for relief from standards for failed systems but do not prescribe what alternative systems are acceptable or recommended.

2. **Sinkhole Ordinance: Amend the ordinance to require vegetative buffering of all Class 1 sinkholes subject to contamination.**
   As stated earlier, sinkholes are direct pathways for surface contaminants to enter the groundwater. Landowners with sinkholes on their properties should be sent educational information to increase their awareness of the potential threat to groundwater.

3. **Underground Storage Tank Ordinance: Create a database of the locations of all USTs in the County, and develop a County ordinance that will serve to regulate USTs with less than 1,100 gals. capacity that are used for petroleum or chemical storage**.

   Underground storage tanks (USTs) with greater than 1,100 gals. capacity for petroleum products and chemicals are strictly regulated by the Virginia Department of Environmental Quality (DEQ). Currently smaller tanks are not regulated. The potential for groundwater contamination of leaking tanks exists for all USTs.

4. **Storm water Resources Ordinance: Revise the ordinance to better address runoff quantity and quality so as to protect surface and groundwater from contamination.**

   Storm water management addresses the runoff from new development. Runoff impacts primarily surface waters and will be addressed more fully in the Surface Water Resources Plan. However, in karst areas impacts to groundwater can also occur.

B. Natural Resources Conservation Overlay District: Consider enlarging the district to incorporate the entire groundwater recharge area for the spring, as delineated by available data.

The Natural Resources Conservation Overlay District was established in 1983. Its intent was to provide greater protection to Prospect Hill Spring that serves as the only water source in the Boyce, Millwood, Waterloo, and White Post area. Since the establishment of the district, the federal government has designated a portion of the recharge area (the drainage basin of Page Brook) of Prospect Hill Spring as a "sole source aquifer." The area of the sole source aquifer encompasses a region significantly larger than the area designated within the Natural Resources Conservation Overlay District. Additional dye testing should conducted to further delineate the groundwater recharge area. To fully protect the springs water supply, the boundaries of the district should be expanded to incorporate the entire groundwater recharge area for the spring, as indicated by this testing.

C. Public awareness and education: Designate the Clarke County Natural Resource Planner as the County official responsible for public education concerning protection and conservation of groundwater resources.

Public education is an essential component of any attempt to protect and conserve groundwater resources. Scientific evidence demonstrates that human activities present the largest threat to Clarke County groundwater. Public education is needed in the following areas: (1) overview of the special nature of Clarke County groundwater dynamics and migration of contaminants; (2) groundwater contamination from inadequate and failing septic systems; (3) groundwater contamination from agricultural sources; (4) groundwater contamination from household toxins; (5) need for water conservation and use of conservation devices; and (6) education for property transfers - what are the existing water and sewage disposal systems, and how should they be maintained.

This plan recommends that appropriate materials concerning the above topics be developed and disseminated to the general public. Materials may be distributed at the time of property transfer, by Health and Building Department personnel when issuing permits, by public officials in interaction with citizen's groups, and by students in schools interested in natural resource issues.

D. **Nonpoint pollution: Cooperate with and encourage use of the programs administered by the Agricultural Extension Office and other agencies involved in developing Best Management Practices (BMPs).**
Nonpoint pollution is the single largest contributor to groundwater pollution in Clarke County. In Clarke County, it is characterized as pollution from agricultural and residential development practices that cause soil erosion as well as improper fertilizer and pesticide application.

Control measures for agricultural land use are currently supervised by the Natural Resource Conservation Service (NRCS), the Agricultural Stabilization and Conservation Service (ASCS), and the Agricultural Extension Office. These agencies work with farmers to develop Nutrient Resources Plans and implement Best Resources Practices (BMPs), which encourage farmers to avoid highly erodible lands when cropping and maintain minimal levels of fertilizer and pesticide applications. Residential landowners should be educated as to their responsibility for proper fertilizer and pesticide application on lawns and proper septic system maintenance.

E. Well testing: Establish a Countywide well monitoring network to effectively monitor changes in water quality over time. Including routine testing of specific wells for coliform and water chemistry.
Well monitoring is a fundamental means of tracking groundwater quality. To date, water testing has been conducted through independent studies where consistency in well monitoring was not required**.**

F. Groundwater database development:
1. Develop a database of all existing well and septic permits on file in cooperation with the Health Department. Homes with systems not on file should be surveyed to determine the type and location of water source and sewage disposal.
Identifying the types and locations of well and septic systems in the County is a critical piece of the puzzle with regards to groundwater contamination. Septic systems are a known contamination source. Failing systems or inadequate systems represent the most serious threat. Wells, in addition to being the source of drinking water, also represent pathways for contaminants to enter the groundwater. The Health Department maintains a filing system of all permits issued for well and septic systems in the County. In addition, all systems have been located on a set of County Tax Maps.

2. Compile existing data from all previously conducted groundwater studies.
The following agencies and studies have researched aspects of the County's groundwater quality.

a) Groundwater Hydrogeology and Quality in the Valley and Ridge and Blue Ridge Physiographic Provinces of Clarke County Virginia, by Winfield Wright, 1990. U. S. Geological Survey Water Investigations Report 90-4134.

b) The Influence of Geology and Agriculture on Groundwater Quality in Clarke and Frederick Counties, Virginia, by Richard Peter LoCastro. 1988. Masters Thesis, University of Virginia.
c) EPA STORET
d) Clarke County Health Department water testing: nitrate and coliform sampling
e) U. S. Geological Survey
f) Evaluation of Household Water Quality in Clarke County, Virginia, by Blake Ross et. al. 1992. Agricultural Extension Service 1991 Well Water Survey

Analyzing these data in total can provide the County with valuable insight into trends relating to groundwater contamination.

3. **Use the GIS to identify and map areas sensitive to groundwater contamination. Utilize this information to prioritize areas in need of increased protection measures.**
   The GIS is a tool that can best serve County officials by identifying and mapping areas sensitive to groundwater contamination. In addition, tabular data collected in well testing programs can be mapped and analyzed to attempt to identify patterns or correlate pollution problems with soils types or geologic features.

VII. Summary

The residents of Clarke County are proud of their community, its rural character, open space, and scenic beauty. Clean water is a reflection of the overall health of the County's natural environment, and therefore the ability to maintain and enhance the quality of our groundwater is integral to our quality of life. Three-fourths of the people in Clarke County depend on groundwater as the source of their drinking water. Protecting the groundwater from contamination, and thereby protecting public health, has been of primary importance in the County for many years. Human land use activities represent the most serious threat to our water resources.

Land use regulation is the primary means by which to control groundwater contamination. The recommendations detailed in this plan will serve to direct development to areas that are best equipped to assimilate it. Development will be avoided, or preventive measures taken, in areas where a high potential for groundwater contamination exists. These include areas near springs, wells, streams, and sinkholes.

The Groundwater Resources Plan section of the Clarke County Comprehensive Plan is designed to establish a land use planning strategy that will allow land use practices which enhance and protect groundwater quality in the County.

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APPENDIX A

Summary of the Amendments Adopted to Protect Groundwater Resources in Clarke County.

Septic Ordinance
Adopted December 15, 1987

Amendments

10/18/88 disallow use of alternative septic systems

11/22/88 provide variance procedure reviewed by the Board of Supervisors

12/20/88 add general intent, require soils to be evaluated by a certified soil scientist, add setbacks to springs, strengthen siting requirements

12/17/91 extend variance process to include parcels containing failed wastewater systems constructed after December 15, 1987 (TA-91-09)

02/18/92 establish severability clause and an administrative appeals process (TA-92-06)

03/17/92 allow off-site easements for drainfields for commercial uses (TA-92-01)

12/15/92 (1) establish a variance process; and (2) add the definition of a standard and alternative septic system (TA-92-18)

04/20/93 (1) move the section prohibiting septic systems in the floodway (10 year floodplain) from the Zoning Ordinance to the Septic Ordinance (TA-93-01); and (2) amend the variance section to allow alternative septic systems in limited circumstances and waive public hearing notice and fee requirements for failed systems requiring emergency repairs (TA-93-08)

07/20/93 add well variances to responsibilities of the Board of Septic and Well Appeals (TA-93-13)

12/21/93 amend variance criteria for historic properties to require application for historic overlay district (TA-93-15)

01/18/94 prohibit all new pit privies except portable for temporary activities, or vault privies outside the 10 year floodway, for primitive recreational areas with intermittent use and no plumbing facilities. (TA-93-15)

02/15/94 require removal of nonportable pit privies in the 10 year floodway of the Shenandoah River by May 1, 1995 (TA-93-15)

02/21/95 100% reserve area requirement, clarify and simplify ordinance, and strengthen system siting requirements. (TA-94-08a)

12/19/95 amend definition of standard subsurface septic system to include Perc-Rite drip disposal systems (TA-95-10)

06/20/95 add septic system maintenance section requiring pump-out of septic tanks, cesspools, and dry wells (TA-95-06)

04/21/98 establish procedure to consider a variance when a 100% reserve drainfield cannot be provided for an existing house (TA-98-02)

Well Ordinance
Adopted March 20, 1990
Implemented May 1, 1991

Amendments

11/17/92 eliminate water testing requirement at time of issuance of building permit and establish new sampling procedure prior to issuance of Health Department approval (TA-92-17)

07/20/93 add administrative appeals process and severability clause and establish criteria for well variances (TA-93-13)

12/21/93 add variance section requiring historic homes receiving variances to apply for historic overlay designation (TA-93-15)

10/18/94 clarify and simplify ordinance; add section prohibiting encroachment on an existing well in a manner that decreases conformance to setbacks from pollution sources (TA-94-08)

Sinkhole Ordinance
Adopted January 20, 1987

Zoning Ordinance
Natural Resource Conservation Overlay District
Adopted July 20, 1983

Amendments

03/20/90 enlarge maximum lot size from 2 to 4 acres (TA-90-03)

06/15/93 strengthen requirements for installation of on-site septic systems (TA-93-02)

01/20/98 prohibit construction within 400 feet of Prospect Hill Spring except for public utilities (TA-97-09)

Subdivision Ordinance
Amendments (as related to septic systems and wells)

05-18-93 delete requirement for siting septic drainfields on large tracts (41-100 acres) (TA-93-06)

12-19-95 require surveyed location of on-site septic systems on plats (TA-95-11)

02/17/98 require a reserve drainfield area for proposed parcels containing existing houses (TA-98-01)

APPENDIX B