A HOMEOWNER'S GUIDE TO THE DEVELOPMENT, MAINTENANCE, AND PROTECTION OF SPRINGS AS A DRINKING WATER SOURCE

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1999INTRODUCTION

There are locations throughout the United States and in Virginia where households do not have access to a public or community water system. For definition purposes, a public water system serves more than 25 people and has 15 or more service connections. A private or publicly-owned community water system, such as the kind of system that might provide water to a small housing development or mobile home park, serves less than 25 people and has less than 15 service connections. Water from a public or community water system is regulated by state and federal laws to ensure that the water supply is safe. If a public or community water system is not available, homeowners must rely on an alternative source for their drinking water, usually a well or spring. The homeowner is solely responsible for the safety of the drinking water and must take precautions to ensure that the water used in the household is not contaminated. The purpose of this publication is to provide information to the individual homeowner on the proper development, maintenance, and protection of springs when used as a source of drinking water. Homeowners currently using a spring as their primary drinking water source can use this publication to upgrade their individual drinking water system to ensure a safer and more reliable supply of water.

HISTORICAL BACKGROUND

From the early days of colonization, springs have been a valuable resource for the citizens of Virginia. In the early 1800s, whole communities and service industries were established around springs. Spas were located from Maine to Georgia along the spine of the Appalachian Mountains and were concentrated in the Blue Ridge and Allegheny Mountains of Virginia and West Virginia. Society's elite, such as the Vanderbilts, Astors, and duPonts, along with some of Virginia's more famous individuals, Thomas Jefferson and George Washington, were frequent visitors to the medicinal springs.

In addition to bathing, guests at these spas also consumed glasses of the spring water. It was believed that the water had medicinal value and could cure many illnesses. Spas attracted those afflicted with cholera, yellow fever, tuberculosis, pneumonia, dysentery, gout, rheumatism, and other diseases. Bottled mineral water was marketed widely as patent medicine and sold as a cure-all for a variety of diseases.

Many of the springs were named for their mineral or water characteristics, such as White, Red, Yellow, Salt, and Sulfur springs, or Warm, Hot, or Sweet springs. Elaborate hotels and bathhouses were erected, patterned after the early Roman and Greek bathhouses. While the primary allure of these great spring-centered resorts may have been the promise of relief from diseases and heat, they also afforded luxurious accommodations, excellent food, and extravagant and first-class entertainment. They provided an atmosphere conducive to negotiating major business agreements, and an opportunity to meet mates suitable for marriage from one's own social class. It was a grand era that would decline slowly after the Civil War. For more information about famous springs in Virginia, Marshall W. Fishwick's *Springlore in Virginia* provides insight into the historical and cultural atmosphere surrounding the spa springs.

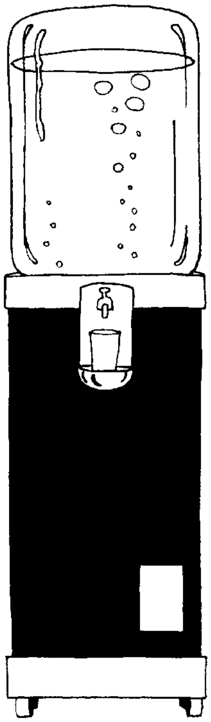
Not only were springs used for medicinal and social purposes, individuals, communities, and industries used springs as sources of drinking water. Commercial enterprises (breweries, distilleries, fish hatcheries), industrial operations (mining, manufacturing, electric power generation), and agricultural production (cropland irrigation, livestock watering) relied on springs to supply water for their needs. Today, springs are still being used as a source of water. When properly developed, maintained, and treated with an appropriate water treatment system, springs can be a reliable source of clean, low-cost, high-quality drinking water. They represent an increasingly valuable supply of water, particularly during droughts and in those areas where other sources of drinking water are not readily available. There are thousands of rural households in Virginia relying on springs for domestic use and for watering livestock. Virginia has 116 public water systems, mostly in the Blue Ridge and Valley and Ridge Provinces, using springs as the source for their water supply (Table 1).

Table 1. Virginia Public Water Systems Using Springs as a Source of Drinking Water

City/County	Number of Springs
Abingdon	26
Lexington	72
Danville	10
Culpeper	8
Total	116

Source: Virginia Health Department, Office of Water Programs.

Today, a new industry is emerging in Virginia. Bottled spring water has become a multi-billion dollar business and many citizens are starting companies to sell bottled spring water.



BOTTLED WATER

In 1997, according to the International Bottled Water Association, Americans consumed more than 2.9 billion gallons of bottled water. Even though the EPA regulates public water systems, these regulations do not apply to bottled water. Bottled water is regulated by the U.S. Food and Drug Administration (FDA) and is classified as a food. Bottled water must meet the FDA's Good Manufacturing Practice Regulations (21 C.F.R., Parts 110 and 129), and the Fair Packaging and Labeling requirements. However, on May 30, 1995, FDA regulations (21 C.F.R., Parts 129 and 184) went into effect requiring all bottled water suppliers to meet the same water quality standards the EPA requires of public and community water systems.

Bottled water must be tested yearly for chemical, physical, and radiological contaminants. Most states also have licensing requirements to sell bottled water. The Virginia Department of Agriculture and Consumer Services, (804)786-0412, can provide information to citizens about regulations concerning the manufacturing and licensing of bottled spring water for sale.

Another source of information about bottled water is the National Sanitation Foundation (NSF). NSF is a non-profit organization that sets standards to protect public health and certifies various products, such as water treatment systems and bottled water, to ensure that these standards are met. Bottled water produced by members of the International Bottled Water Association (IBWA) is screened regularly for 200 contaminants. Members of the IBWA agree to unannounced inspections by the NSF. Membership in the IBWA is noted on the bottle label or the NSF mark is displayed on the label. For more information about bottled water regulations, call the IBWA at 1-(800)928-3711, Monday-Friday, 9 a.m. to 5 p.m., EST.

Standard definitions of the types of bottled water were established to help eliminate confusion over terms used in labeling. Regulations require that water bottled from a public water system be labeled as such, unless the water is processed properly and can be labeled as distilled or purified water. Water labeled as sterile must meet the FDA's requirements for sterility, particularly bottled water marketed for infants. Bottled water sold as spring water must come from an underground source from which water flows naturally to the earth's surface. There must be a natural force causing the water to flow to the surface through a natural outlet. If a borehole is used to collect the water underground, it must be placed where the spring would have emerged.

WHAT IS A SPRING?

The word *spring* comes from the German word *springer,* which refers to "leaping from the ground." Springs are usually found in low-lying areas, at the base of slopes, or along hillsides. They may range from tiny seep holes, through which ground water oozes to form puddles or wet spots on the ground, to large fissures in rocks or openings in the ground. Springs are a naturally occurring output of ground water to the earth's surface, either from the force of gravity or hydrostatic pressure (water pressure pushes the water to the surface). If the rate of flow is rapid, a pool of clear water will form around the area of ground water discharge. The water running out of the pool creates an eroded channel and marks the beginning of a spring-fed stream.

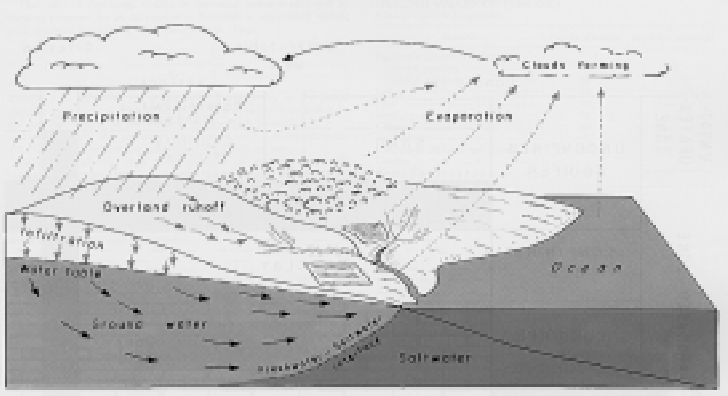
Pools of water form where the spring discharges ground water to the earth's surface.

The ground water discharge from the spring may be

constant or vary depending on the climate, time of the year, and ground water conditions. Springs are replenished by ground water via "recharge", the process by which water from rain, snowmelt, and other sources such as streams and rivers, enters the subsurface of the ground. The spring water flows through the soil or cracks in rock until it is forced to the surface by natural pressures.

WHAT IS GROUND WATER?

Except for polar icecaps and glaciers, 97 percent of the earth’s fresh water supply is stored underground and is referred to as ground water. Only 3 percent of the earth’s fresh water supply comes from surface water such as lakes, streams, and ponds. Surface water and ground water move through the hydrologic cycle, nature’s endless circulation of water. When precipitation falls to the earth’s surface in the form of rain, snow, or ice, some water evaporates and returns to the atmosphere, some flows to streams, rivers, and ponds, and some seeps into the soil and is absorbed by plant roots. According to the office of the State Climatologist in Charlottesville, Virginia, 72 billion gallons of water fell on Virginia in 1997. It is estimated that approximately 66 percent of that amount was returned to the atmosphere as evaporation and transpiration. Water that is not absorbed by plants or directly evaporated from the soil moves deeper into the ground, downward through cracks, empty spaces, or pores in the soil, sand, and rocks until the water reaches a layer of rock through which it cannot easily move. The water then fills these empty spaces above that layer. The top of the water in the soil, sand, or rocks is called the water table and the water that fills the empty spaces is called ground water.



A Cycle without Beginning or End…

Scientists call the constant movement of water from the atmosphere to earth to river to ocean the hydrologic cycle. How long it takes water that falls from the clouds to return to the atmosphere varies greatly. It may be only a matter of minutes before most of the rainfall has evaporated after a short summer shower. A drop of rain falling on the ocean may take as long as 37,000 years before it returns to the atmosphere, and some water has been in the ground for millions of years.

As the water moves laterally and downward through the soil layers, the rate of movement is determined by the soil type, land use, amount and duration of the precipitation, and the amount of vegetation covering the soil's surface. Water that is not absorbed by the soil flows over the surface of the land as runoff.

WHAT IS SURFACE WATER?

Water that is readily visible, such as streams, lakes, ponds, rivers, and oceans is considered surface water. Much of the surface water comes from precipitation that falls to the earth and from runoff. Ground water also feeds the surface water bodies in the form of seeps and springs and is an important supply source for surface water. The U.S. Geological Survey estimates that about 30 percent of the annual average flow of streams in Virginia is derived from ground water. This occurs when the water table near the stream is higher than the stream surface. A stream can be characterized as a gaining stream (receives ground water through the streambed), a losing stream (overflow from the stream moves downward), or a stream can be both, depending on the season.

Ground water becomes surface water when it exits at the spring site. Surface water can be easily contaminated as it flows over the land's surface. If water from the spring becomes muddy or is discolored shortly after a rainstorm, it is evidence that surface runoff is readily entering the spring. This may mean the spring is contaminated with pollutants from sources upslope from the spring's emergence.

SPRINGS IN VIRGINIA

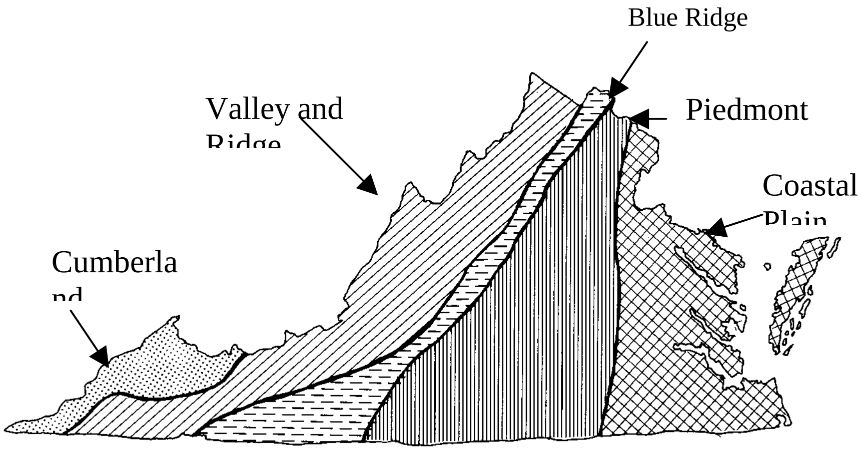
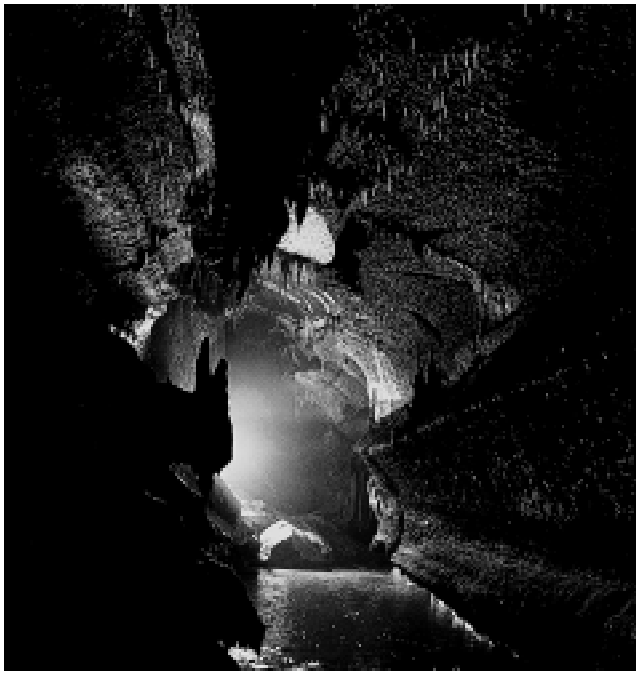


Figure 1. Virginia's Physiographic Provinces.

Geology and Springs

Five distinct physiographic provinces — each unique in geology, topography, soil types, climate, and aquatic resources — comprise the Virginia landscape (Figure 1). Natural springs occur throughout Virginia, but the greatest concentration and largest springs occur in the Valley and Ridge Province. Springs in this province are particularly common in karst areas, where fractures, cracks, and channels promote rapid ground water recharge, movement, and storage. Unfortunately, these springs have the greatest potential to become contaminated from surface water entering the underground caves, often through sinkholes.

Because of the interaction of surface and ground water, particularly in karst terrain containing underground drainage systems, the development of springs as a drinking water source requires more care than wells. The U.S. Geological Survey estimates that a spring with an average flow of about 10 cubic feet per second has an underground drainage basin of approximately 10 square miles. The average rate of movement of ground water is typically slow. Water flows through an aquifer composed of coarse sand at roughly 360 feet per year; similar movement through clay would be less than an inch per year. Only in certain circumstances, such as limestone formations with large openings, will water flow rates resemble those of streams. Contaminants can move rapidly through these underground channels, and entire underground basins are vulnerable to contamination from a single source.



Surface runoff and streams entering sinkholes or caves can travel rapidly through these underground tunnels carrying contaminants to wells and springs.

Springs are not abundant in the other four provinces of Virginia. The mountains of the Cumberland Plateau and Blue Ridge have small, shallow aquifers on thin soils in steep terrain underlain by hard, nonporous rock such as granite and marble, so springs are scarce. In the Piedmont and Coastal Plain provinces, springs are rare and small with flows under 20 gallons per minute (gpm) because of the flat terrain and sandy, porous soils.

County	Spring	Discharge(GPM)
A. Bath	Coursey	11,612
B. Rockbridge	Spring Creek	11,025
C. Pulaski	Woolwine	10,300
D. Alleghany	Falling	7,000
E. Page	Yeager	7,000
F. Buchanan	Carter Hall	6,000
G. Clarke	Green Mount	5,500
H. Rockingham	Baker	5,300
I. Augusta	Lacey	5,300
J. Highland	Mackey	5,200

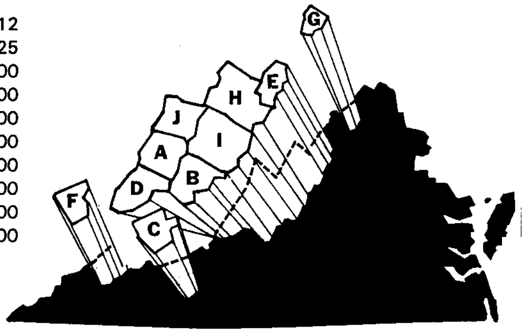


Figure 2. Large Springs in Virginia.

Locating Springs

In 1928, a team of geologists, led by W. D. Collins, explored Virginia’s fields and forests in search of springs. They located over 500 springs in the Valley and Ridge Province. Most of the springs were concentrated in the Shenandoah Valley and the counties of Augusta, Rockbridge, Rockingham, Shenandoah, Bath, and Highland. This is an area of karst topography, where water-soluble limestone is perforated by channels, caves, sinkholes, and underground caverns, and has an abundance of springs.

Researchers from the Department of Fisheries and Wildlife Sciences at Virginia Tech continued this survey some 50 years later. The research team located more than 1,600 additional springs. Most of the springs were on private lands west of the Blue Ridge.

Spring Size

A spring's size is classified according to its average discharge on a scale that runs from a magnitude of 1 (flows over 44,900 gallons per minute) to 8 (less than 1 liter per minute) (Table 2). Based on this classification, Virginia has no first magnitude springs, but does contain at least 10 springs of the second magnitude. The largest Virginia spring surveyed in 1928 was Woolwine Spring, located 4 miles east of Newbern, near the New River, with a recorded flow of 10,300 gpm. This spring was submerged by the construction of Claytor Lake Reservoir in 1938.

Spring flow varies in size depending on the geology, topography, and ground water available. A spring's flow rate and volume varies according to the ground water recharge and discharge elevations and on the size of the fractures and openings discharging the ground water to the surface.

Most Virginia springs are small, discharging at a rate less than 100 gpm. About half of the springs surveyed by the Virginia Tech researchers had flows less than 100 gpm. Flow rates of the larger springs in Virginia are relatively constant year-round. The flow rate for smaller springs may vary with weather patterns in areas characterized by sinkholes and fractured rock, where flood and rain water is funneled directly into the ground. Intermittent springs flow only during wet periods, when the water table rises to the land surface.

Table 2. Classification of Springs by Discharge Rate

Magnitude	Discharge
First	Greater than 44,900 gal/min
Second	4,490 to 44,900 gal/min
Third	449 to 4,490 gal/min
Fourth	100 to 449 gal/min

Fifth	10 to 100 gal/min
Sixth	1 to 10 gal/min
Seventh	1 liter/min to 1 gal/min
Eighth	Less than 1 liter/min (180 gal/day)

Types of Springs

Based on flow characteristics, springs are categorized as gravity springs or artesian springs.

Gravity Springs. Water comes to the surface as a gravity spring when water moving downward through subsurface permeable materials reaches an impermeable layer and is forced to the surface. Gravity springs also occur where the land intersects the water table, for example, on a hill slope. Gravity springs are particularly sensitive to seasonal fluctuations in the amount of ground water in storage and frequently dwindle or disappear during dry periods.

Artesian Springs. These springs discharge from a confined aquifer where the water is under pressure and rises through any cracks or openings in the confining layer. If the pressure is great enough, a fast, freeflowing artesian spring may result. Artesian springs are particularly sensitive to well development and the pumping of water from the same aquifer. Artesian springs may dry up as a consequence of these activities.
Springs may also be characterized by their origin as described below:

Seepage Springs. Water flows (or seeps) out of sand, gravel, or other loose materials. Larger springs can have extensive seepage areas with abundant vegetative growth. Decaying organic matter or iron may cause the water from smaller seepage springs to appear oily or colored. Generally, seepage springs are free from harmful bacteria, but they can be contaminated by surface runoff collecting in the valleys or depressions where the springs most commonly occur.

Non-seepage or concentrated and low-area springs include:

Tubular Springs. Some of the largest springs are found in limestone bedrock. Solution channels from limestone caverns, soluble rocks, or small channels that form in glacial drift produce tubular springs. Sinkhole springs rises to the surface where a cavern is connected to a shaft. Variations in runoff cause the water level to rise and fall in sinkhole springs. Limestone springs can be connected to sinkholes at higher elevations. These springs are called karst springs and the discharge generally corresponds with the water level in the sinkholes.

Fissure Springs. These occur along bedding, joint, cleavage, or fault planes and are identified when water passes along a break in the rocks. Many thermal springs are fissure springs. Water that is discharged from deep inside the earth is generally not contaminated. However, the discharged spring water may be contaminated by surface water close to the drainage area.

Natural Constituents of Spring Water

Spring waters unaffected by human activity reflect the quality of ground water and the chemical composition of local rock and soil. Spring waters can be mineral-rich (hard water) or mineral-poor (soft water) depending on the prevailing geology. Generally, springs in limestone rock have a high mineral content. Springs issuing from hard rock, like granite, have fewer minerals. Water hardness is due to calcium and magnesium, which are present in most rocks, especially limestone, dolomite, and gypsum. Thermal springs generally have a higher mineral content than cold springs.

The taste, color, and odor of spring water reflect a particular mix of minerals, dissolved gas, and organic constituents. Saline springs are rich in sodium, calcium, and magnesium, while sulfur springs have an abundance of hydrogen sulfide. Chalybeate springs contain iron, and alkaline springs have an abundance of calcium.

Spring waters not affected by surface activities are typically clear and sparkling as a result of the natural filtering ability of soil and rock materials. However, this does not mean that the water is contaminant-free or safe to drink. Only a water analysis can prove the safety of the water. Spring water that is dark brown or tea-colored may be the result of acids (tannic and humic) leaching from plants and organic matter. Cloudy, white-colored water may result from high concentrations of dissolved solids and calcium. Iron compounds in oxygenated water can impart a red or rust color.

Spring Water Temperature

Both cold-water and thermal (warm or hot water) springs are found in Virginia. The Virginia Tech researchers located more than 1,500 cold-water springs and 100 thermal springs. The water temperature of cold-water springs averages between 52 and 58°F, about the same as the mean annual air temperature. Thermal springs with waters heated deep within the earth flow at water temperatures of 100 to 600ºF year-round. Warm springs have a mean water temperature greater than the average air temperature, but less than 98°F; hot springs have mean water temperatures greater than 98°F.

Most spring waters have fairly uniform water temperatures that vary only a few degrees annually. However, water temperatures of small, shallow springs or those with high surface water contributions (recharge) can fluctuate considerably on a daily and seasonal basis. The water temperature of small, shallow springs is affected more by air temperature than the temperature of the earth's ground surface. Deep springs, influenced by the earth's internal heat, have more stable and higher water temperatures.

Calculating Spring Flow

Flow rate (discharge) is the volume of water coming out from the spring per unit of time. Determining the flow rate is necessary to estimate the available water supply and the amount of water storage needed to ensure an adequate water supply for the household. The flow rate should be measured during a low-flow period, usually in the early fall.

For small springs, the flow rate can be measured by damming the spring's flow, inserting a pipe to collect the water, and measuring the time it takes to fill a container of known volume (i.e., gallon jar). To meet a household's water needs, the flow rate should equal or exceed the peak use rate. Table 3 provides the recommended flow rate for household water use based on the number of bathrooms per house.

Table 3. Recommended flow rates for households

	Number of Bathrooms in House			
Number of Bedrooms	1	1 ½	2	3
Flow rate, gpm				
2	6	8	10	--
3	8	10	12	--
4	10	12	14	16
5	--	13	15	17
6	--	--	16	18

***Source: Private Water Systems Handbook, 1979. Midwest Plan Service, Iowa State University, Ames, Iowa.**

The average adult uses approximately 50-60 gallons of water per day (Table 4). An infant may require 100 gallons per day. About 70 percent of the water in a household is used for flushing the toilet, bathing, and laundry. Implementing water conservation practices can result in energy and water savings, and lead to a reduction in the amount of wastewater that must be treated. Installing low flush toilets and flow-restricting showerheads, and repairing leaks in faucets and toilet tanks are examples of water conservation techniques.

Table 4. Household Water Use Requirements

Use	Flow rate gal/min	Total use/gallons
Adult or child		50-100/day
baby		100/day

automatic washer	5	30-50/load
non-automatic washer, handtub	5	15-45/load
dishwasher	2	7-15/load
garbage disposal	3	4-6/day
kitchen sink[1]	3	2-4/use
shower or tub[1]	5	25/60/use
toilet flush[2]	3	4-7/use
bathroom lavatory	2	1-2/use
Water softener regeneration[3]	5	50-100/time
backwash filters[3]	10	100-200/backwashing
outside hose faucet	5	---
fire protection[4]	10	1200/2-hr period

*Source: Private Water Systems Handbook, 1979. Midwest Plan Service, Iowa State University, Ames, Iowa.

[1] Water flow restricting valves and showerheads can reduce flow and water use by up to 50 percent.
[2] Ordinary toilet; low flow toilets will reduce water usage by 40 - 90 percent.
[3] Water hardness, softener size, etc. can affect water use.
[4] For limited fire fighting; at least 20 gpm with a 1/4" nozzle at 30 psi for 2 hr/day. Preferred: 20 gpm at 60 psi - 2400 gal.

USING SPRINGS AS A SOURCE OF DRINKING WATER

Of the 116 spring sources used by Virginia waterworks, the majority are located west of the Blue Ridge, where the geology is karst with heavily fractured and channeled limestones and dolomites. The Virginia Department of Health (VDH) regulates the use of springs as a public or community water source. According to the VDH, springs may be used for a public or community water source only if it is impossible to develop an acceptable well or other source of water. Before a spring is approved for a public or community water system, an extensive sanitary survey must be performed. Private homeowners developing a spring as a private water source are not required to carry out a sanitary survey, however, it is recommended that the private homeowner use the following procedure in performing their own sanitary survey.

First, visually inspect the area around the spring site and surrounding area for possible sources of contamination. Consult county maps to locate housing developments, commercial areas, industrial and agricultural operations, underground storage tanks, and landfills that are near the spring's water supply source. Improperly operating on-site septic systems from housing developments can introduce nitrates, organic matter, and microbiological pathogens into the ground and surface water entering the spring. Wastes from commercial, industrial, and agricultural operations can add contaminants to the ground and surface water, such as heavy metals and other toxic materials, chemicals from fertilizers and pesticides, and fecal pathogens from animal wastes. Leachate from landfills and underground storage tanks containing petroleum-based products can be a source of contaminants for ground water.

Factors to be considered when performing the sanitary survey and before developing a spring as a drinking water source include:

1. The spring’s source should be an aquifer that is not susceptible to contamination, and the spring should not be subject to flooding.

2. The area surrounding the spring should be large enough to fence out animals and people to prevent contamination.

3. Surface water should be diverted away from the spring.

4. Setback distances from possible contaminant sources should be the same as for subsurface soil absorption systems. (A "subsurface soil absorption system" is the part of a sewage disposal system beginning at the flow splitting device and extending through the absorption area or areas.) (See Appendix A. Table 4.4 Minimum Separation Distances, 12VAC5-610-930: Gravity Distribution).

Springs developed by private homeowners as their drinking water source are not regulated by the VDH. However, just because water from a spring looks clear and clean does not mean that it is safe to drink.

Many disease-causing microorganisms, such as giardia or cryptosporidium, have no odor, color, or taste. Because of the possibility of contamination by surface water, springs are not recommended by the VDH for use as a drinking water source unless they are treated with an appropriate water treatment system.

When considering the development of a spring on your property as a private water supply, first discuss your plans with a representative of the local health department. Also, certain financial lending agencies will not provide loans to purchase homes with a spring as the drinking water source. Consult with your lending agency prior to signing purchase contracts.

Spring Development

In order to develop or upgrade an existing spring as a potentially safe, reliable drinking water source, there are two conditions. First, the flow must be sufficient to supply a household's daily needs throughout the year. Second, the spring must be adequately protected from possible contaminant sources. To properly develop a spring, the following components are necessary (Figure 3):

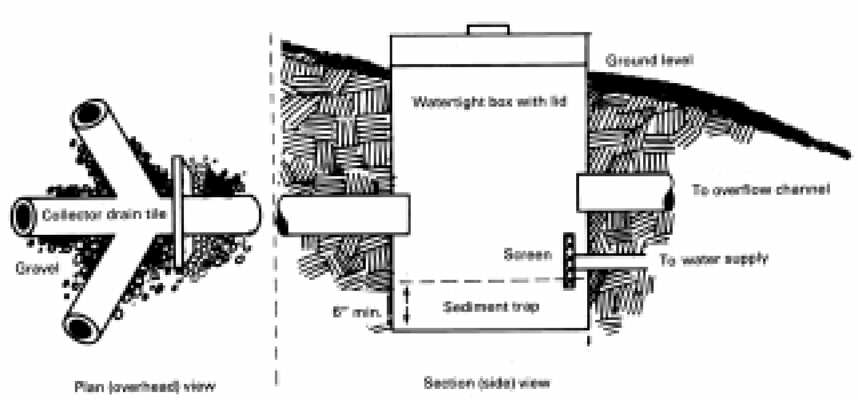


Figure 3. A Typical Collection Box

1. A collection system to channel the flow to the spring box or storage system.

2. A reinforced-concrete spring box with an overflow pipe.

3. A cover that will keep surface water and other contaminants out of the spring box.

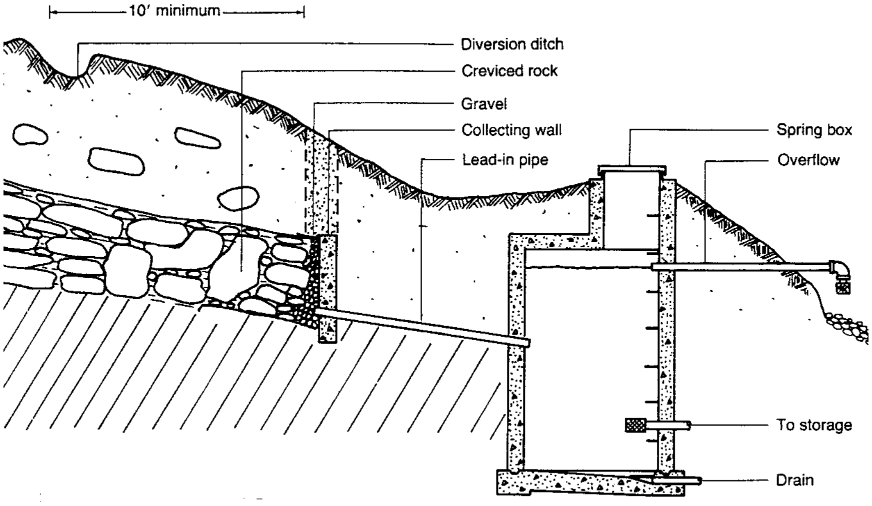
4. Easy access to clean and empty the spring box.
5. A connection to a backup supply if the flow rate ceases to provide an adequate water supply.

Both the geological conditions and the spring source must be taken into consideration when developing a spring. Water from springs formed in limestone formations may have direct input from surface water and may have been contaminated several miles away. It is very important to test and treat spring water before using it as a drinking water source.

Non-seepage springs, described as concentrated and low-area springs, are the most common springs used as a drinking water source. Concentrated springs are usually located at the base of mountain ranges or hillsides and can be easily developed. Surface water drains away from this type of spring making it easier to protect from contaminant sources. Low-area springs are found in valleys or lower level areas. The development of low-area springs requires more care because of the possible contamination from surface water. Seepage springs are the most difficult to develop. These springs are easily contaminated because the ground water is collected over a wide area from sources that may be very close to the surface. Microorganisms and other contaminants can easily infiltrate the spring. During periods of drought, seepage spring flows may diminish or disappear completely. Having an alternative source for drinking water or a storage box is advisable.

Concentrated and low-area spring development

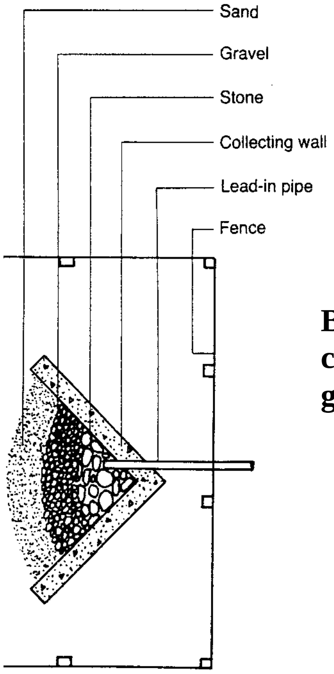
To develop a concentrated or low-area spring, locate the beginning of the spring flow. Dig a channel along the spring flow line at least 3 feet below the ground surface or until bedrock is encountered. The channel should be as wide as the spring box and extend approximately 10 feet. At this point, install a 4 to 6 inch cut-off wall. The cut-off wall may be constructed of concrete, plastic, or impermeable clay (Figure 4). Backfill the area from the channel to the cut-off wall with coarse rock and graded gravel (Figure 5). Cover the gravel with a plastic sheet and 1 to 2 inches of soil. This will help to hold the cut-off wall in place. However, avoid a large build up of water behind the cut-off wall. This could reduce the spring's output or change the location of its emergence. Install a 4-inch PVC (plastic) lead-in pipe in the cut-off wall connecting it to the spring box. Screen the lead-in pipe to prevent insects and debris from entering the spring box.



Source: Safeguarding Wells and Springs from Bacterial Contamination., Extension Circular 345, The Pennsylvania State University.

Figure 4. Diagram for the development of a concentrated spring.

The spring box must be watertight. A reinforced concrete box, similar to a septic tank, is used most frequently. Figure 6 shows a side-view of the installation of the spring box. The size of the spring box depends on the needed storage capacity. However, the spring box should be at least 4 feet high and 3 feet wide or round. A spring box of this size will hold approximately 135 gallons of water when the standing water level is 2 feet deep. If more water is needed, install an additional storage tank.



Backfill the area from the channel to the cut-off wall with graded sand, gravel, and stone.

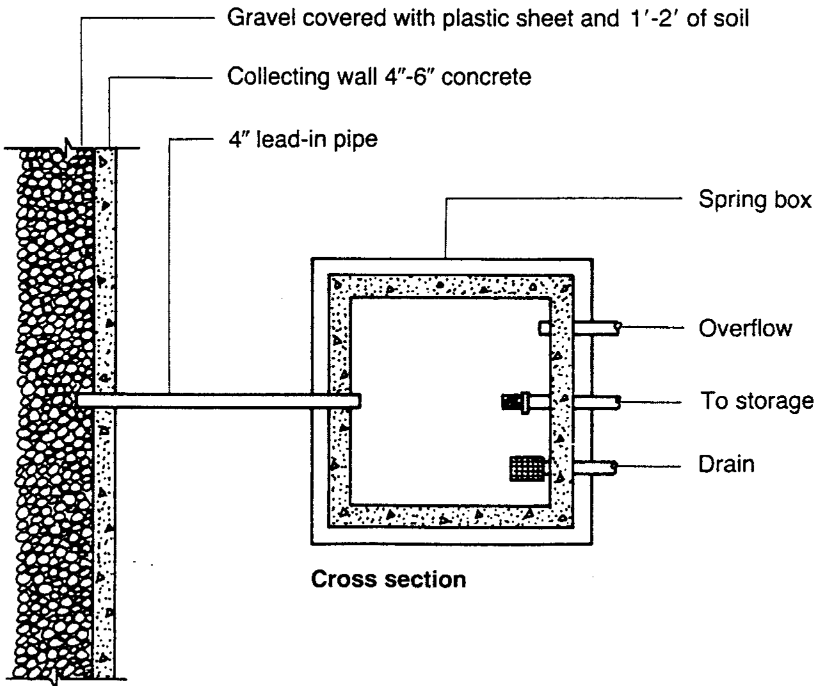
Source: Safeguarding Wells and Springs from Bacterial Contamination., Extension Circular 345, The Pennsylvania State University.

Figure 5. Side view showing backfill area.

Outlet, drain, and overflow pipes must be installed in

the spring box. A screened drain pipe, with an exterior valve and cut-off box that allows easy access for cleaning, should be placed horizontally near the bottom of the spring box and close to the wall. The drainage pipe should be approximately six inches above the normal ground level. Screen the outlet pipe and place it about six inches above the drainage pipe. Place a screened overflow pipe below the lead-in pipe

to prevent water build up behind the cut-off wall. Make sure the area around the pipes and installation sites is tightly sealed to prevent leakage.



Source: Safeguarding Wells and Springs from Bacterial Contamination. Extension Circular 345, The Pennsylvania State University.

Figure 6. Cross-section view of a spring box.

The spring box must be placed at least 3 feet below the ground surface and the top should extend 1 foot above the ground surface. A snug-fitting, watertight

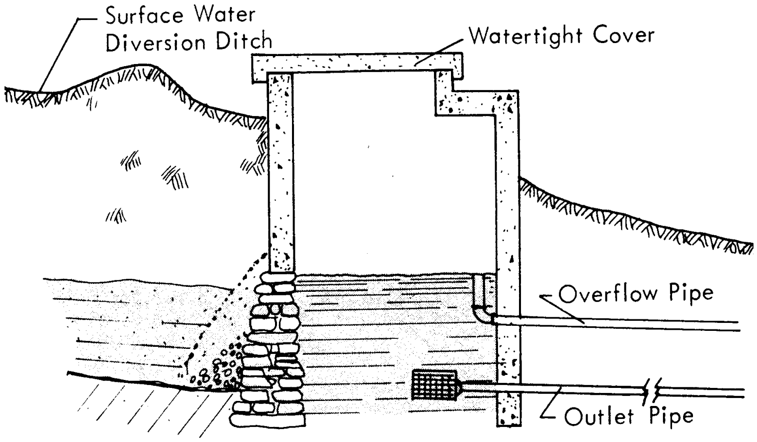
To complete the spring installation, cover the excavated site with soil taking care to maintain the surface water diversion ditch as shown in Figure 4. Do not cover the overflow pipe. As a final step, rock should be layered under the overflow

discharge site forming a "drain apron" to prevent soil erosion.

In the development of a low area spring, the spring box can collect the water and eliminate the need for pipe or tile (Figure 7).

Seepage spring development

The development of a seepage spring involves more effort than a concentrated or low-area spring because the possibility of con-tamination is greater. If the spring water becomes muddy or turbid after heavy rains, surface water is entering the spring.

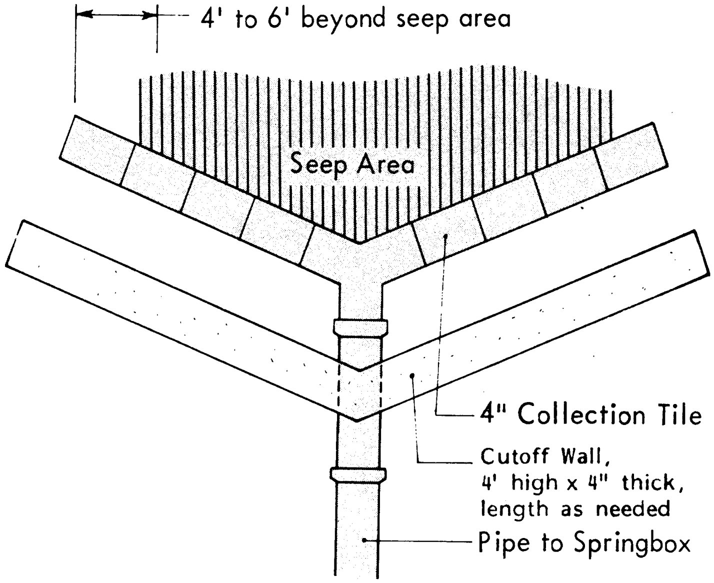


*Source: Private Water Systems Handbook, 1979. Midwest Plan Service, Iowa State University, Ames, Iowa.

Figure 7. Low-area spring box design.

To begin the development process, identify the seep site. Large seep areas are usually covered with dense plant growth. Smaller seep areas many have standing water that appears colored from iron content or has an oily

scum due to plant decomposition. Dig several 3-foot deep test holes uphill from the seep site. The purpose of digging test holes is to locate the impervious layer of rock. Water flows over this rock layer through the sand and gravel layer (water-bearing layer) into the seep area. At the site where the test holes indicate that the rock layer is at least 3 feet underground, dig an 18- to 24-inch trench across the slope. The trench should be dug to a depth of 6 inches below the water- bearing layer and may extend into the impervious layer but should not completely go through it (Figure 8). Extend the trench 4 to 6 feet beyond the seep spring on either side. Install a line of 4-inch drain tile and encircle it completely with 6 inches of gravel.

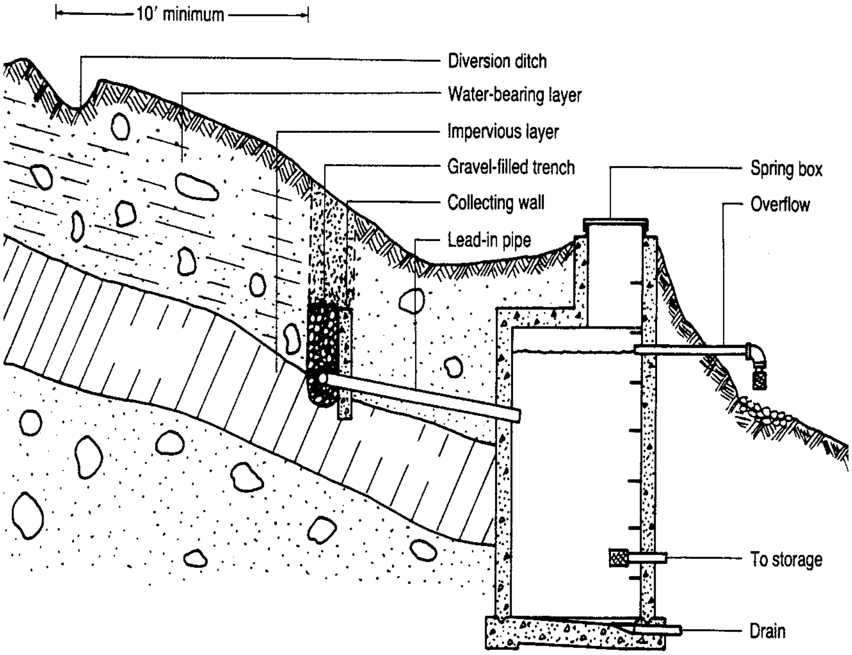


*Source: Private Water Systems Handbook, 1979. Midwest Plan Service, Iowa State University, Ames, Iowa.

Figure 8. Side view of the excavation of the seep area. The trench should be 18- to 24 inches wide, extend 6 inches into (but not through) the impervious layer, and reach 4 to 6 feet beyond the seep area on either side.

A cutoff wall similar to the wall used in a concentrated or low-area spring may be constructed if the soil is porous (Figure 9). The wall will keep the collector tile from overfilling. Connect the collector tile to a 4-inch pipe leading to the spring box. Make sure that the lead-in pipe is below the elevation of the collection tile. Complete the remainder of the spring

installation following the directions for a concentrated or low-area spring.



Source: Safeguarding Wells and Springs from Bacterial Contamination. Extension Circular 345, The Pennsylvania State University.

Figure 9. Diagram of the spring water collection system for a seepage spring.

Spring Disinfection

Because the spring may become contaminated during

the development and construction process or during maintenance and repair, always disinfect the water before use. Shock chlorination is an effective method to disinfect the spring and its water system components. Most pathogenic bacteria, viruses, and cyst organisms will be destroyed by chlorine if the contact time and level of chlorine is sufficient, approximately 200 ppm (parts per million). To obtain this level of concentration, add 3 pints of liquid chlorine

laundry bleach ("Clorox" is about 5 percent chlorine) for every 100 gallons of water, or 1 pint of swimming pool disinfectant or concentrated bleach (12 to 17 percent chlorine) per 100 gallons of water, or 4 ounces of calcium hypochlorite tables or power (must be at least 65 to 75 percent chlorine) to 100 gallons of water. It will be necessary to have an alternative drinking water source available during the chlorination treatment process and testing because the chlorine must remain in

the spring box and water system components for a minimum of 24 hours.

During the chlorination treatment process, it will be necessary to wear protective clothing and gloves to avoid accidental contact. Chlorine is a strong chemical and could cause serious injury. To begin the process:

1. Close off the lead-in pipe to stop the flow of water into the spring box.

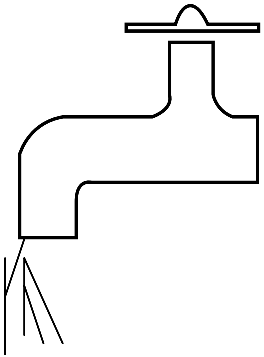
2. Remove all debris and sediment from the spring box and scrub the interior surface (down to the water level) with a chlorine solution of 1 gallon of liquid bleach per 10 gallons of water.

3. Disinfect the spring box. If the spring flow is small, close the outlet pipe and let the spring box fill with fresh water. Add enough chlorine to obtain the 200 ppm chlorine concentration. The chlorine solution must remain in the spring box for at least 12 hours. If the spring flow is large, then a continuous stream of

chlorine will be necessary to ensure a sufficient amount will be available over the 12- hour period.

4. After the 12-hour period, open all faucets until a strong chlorine odor is detected. Close the faucets and let the chlorine solution remain in the water distribution system for an additional 12- hour period. This will disinfect the water lines, storage and pressure tanks, valves, and faucets.

5. Open all valves and faucets and let the water flow until no strong chlorine odor or taste is detected.



Test the spring water for bacterial contamination 24 hours after the shock chlorination process. If the test indicates that bacteria is still present in the water, repeat the shock chlorination treatment process. Should bacteria still be present after a second chlorination treatment, then continuous chlorination will be necessary or an alternative water supply should be used.

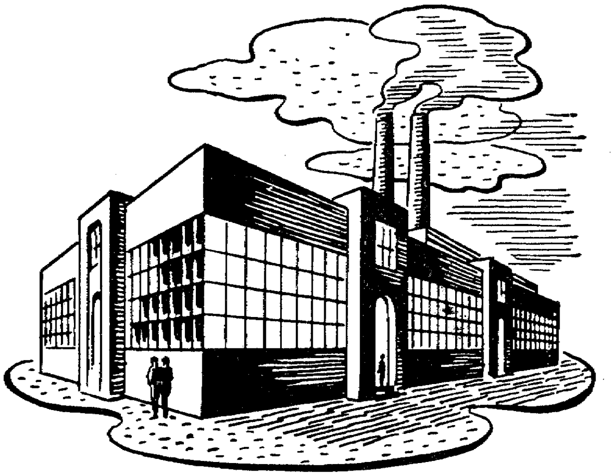
WATER TESTING

Before using the spring for the first time, on a yearly basis, and after heavy, extended periods of rainfall, the water should be tested for bacteria, pH, nitrate, turbidity, and conductivity to determine if there is surface water contamination. Testing is especially important if the water becomes cloudy or the flow changes after a rainstorm. This means that the spring is influenced by surface water. Water samples should be sent to a laboratory certified by the Virginia Department of Health and the U.S. Environmental Protection Agency. For a complete and up-to-date list of all VDH-approved laboratories and the specific tests for which they have been certified, contact your local health department, the Division of Consolidated Laboratory Services at (804) 786-1155, or visit the Virginia Water Resources Research Center's web site, www/vwrrc.vt.edu.

It is important to have your water tested before using the spring for the first time, on a yearly basis, and after heavy, extended periods of rainfall.

LOCATING A CONTAMINATION SOURCE

If the spring has contaminants that exceed the recommended maximum contaminant levels (the amount of the allowable contaminant in drinking water that the EPA has decided will not endanger human health over a lifetime of exposure), first try to locate the source of the contamination. This is not always easy with springs, because the source of the ground water pollution may be miles away or may have been caused many years ago.



Water contaminated by coliform bacteria or nitrate may be receiving surface runoff from a barnyard, animal feedlot, or a heavily fertilized field or yard. An on-site waste disposal system that has been improperly designed, constructed, sited,

or maintained can contaminate a homeowner’s individual water system. Inspect the spring to make sure it is properly encased and covered to prevent the entrance of surface drainage and debris.

Petroleum contamination of the spring may result from a spill of gasoline or diesel fuel from a fuel tank or of home heating oil from a leaking underground storage tank and lines. A gasoline station or industry with underground or aboveground storage tanks and lines could be responsible.

Herbicides and insecticides in the spring water could be caused by the use of these chemicals around the home or by commercial applications used to rid the home of termites, roaches, or ants. Surface runoff into an improperly sealed spring may be causing problems, especially if the spring is near agricultural fields and orchards or a chemical manufacturer and distributor. If industrial chemicals are found in the spring water and an industry is not nearby, check local newspapers for articles on ground-water contamination, improper waste disposal, or hazardous waste sites in the area or contact your local health department or Cooperative Extension office.

Pesticides sprayed around the home can contaminate ground and surface water.

Contamination of a spring should be reported to the nearest DEQ regional office or the Virginia Department of Agricultural and Consumer Services, Agricultural Stewardship Program (804-786-3538), or contact your local health department and the Cooperative Extension office for help in locating the pollution source.

THREATS TO WATER QUALITY

Spring water is ground water that has seeped or flowed to the surface. All of the activities that affect ground water quality, such as improper land disposal of liquid and solid wastes, faulty septic systems, spills and leaks of petroleum products, decaying plant and animal matter, inappropriate application of pesticides and fertilizers, abandoned wells, saltwater intrusion, mining, stockpiles and bulk storage, and spreading salt mixtures for highway de-icing, can degrade spring water. In addition to these potentially harmful activities, poor land-use practices that foster erosion and movement of soil and associated contaminants into a water source degrade spring-fed streams. The following is a partial list of the possible threats to Virginia's springs:

Pesticides

Pesticides (insecticides, herbicides, fungicides) are toxic chemicals widely used by farmers, foresters, utility operators, exterminators, and homeowners to kill harmful insects and weeds, to increase crop and timber harvests, to spray utility right-of-ways, and to prevent the spread of plant, animal, and human parasites and diseases. When improperly handled and applied, pesticides can contaminate ground and surface water. Their source of origin may be difficult to locate; since some pesticides can migrate considerable distances in water and air and is released in rainfall. Although targeted at pests, certain pesticides can indiscriminately harm humans and animals. Pesticides in water supplies (see Appendix B. National Drinking Water Standards) have been linked to cancer, birth defects, genetic mutations, and sterility in humans and wild and domestic animals.

Waste Oil

Gasoline, oil, and other petroleum products and their associated additives are common water pollutants. Each year, millions of gallons of motor and fuel oil are dumped in driveways, backyards, roadside ditches, and storm sewers, where they seep into ground water and contaminate springs and water wells. Leaking underground gasoline and fuel oil tanks add to the problem. Once in the water, these chemicals are difficult and costly to remove and render spring water unacceptable as drinking water. Trace amounts of petroleum products can be detected by taste or smell.

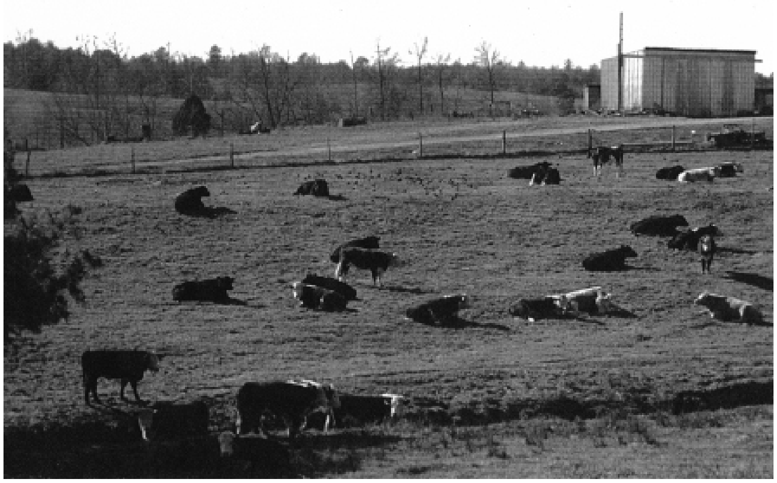
Improperly disposing of waste containers can contaminate ground water and surface water runoff.

Septic Systems

Faulty septic systems are one of the most common sources of ground water pollution. Household wastewater contains high levels of nutrients (primarily nitrogen and phosphorus), household chemicals, bacteria, and viruses.

Wastewater containing bacteria and viruses can cause dysentery, hepatitis, cholera, and other diseases that can threaten the health of humans, especially individuals with compromised immune systems, infants and young children, and the elderly. Water that contains nitrogen levels exceeding the national drinking water standard of 10 ppm (parts per million) should not be consumed by pregnant women and infants (See Appendix B. National Drinking Water Standards). In certain circumstances, high concentrations of nitrate in drinking water can cause methemoglobinemia (blue baby syndrome) in infants and very high concentrations may poison livestock, especially cattle. Also, excess nitrate in drinking water can increase algae and water plant growth and affect the spring's water quality.

Livestock Activities



Cattle allowed to stand in streams can contribute to ground and surface water contamination.

Livestock are attracted to springs and the surrounding (riparian areas) for drinking water, food (forage grasses), and shade. Livestock, especially cattle, trample and overgraze vegetation and increase erosion and silt build up. Unfenced spring pools and spring-fed pasture streams where livestock can enter unimpeded tend to be shallow, muddy, and silted-in and have bare banks, few pools and riffles, low oxygen concentrations, high water temperatures, and may be contaminated with animal wastes.

Animal Wastes

Livestock wastes, such as manure and urine from pastures, barnyards, and feed-lots, can contaminate spring waters with excess nutrients, poisonous methane, ammonia gases, disease-causing bacteria, viruses, and parasites. Waters polluted with animal waste acquire an unpleasant taste and a foul odor and are not suitable for drinking, swimming, or fishing. Disease-causing bacteria and viruses can infect humans and animals downstream. Place animal-waste storage tanks and manure piles well away from waterways.

Fertilizers

High amounts of ammonia and nitrogen fertilizers in spring water can cause health problems in humans, particularly infants and individuals with compromised immune systems. Also, organic and inorganic fertilizers can result in high nitrate levels and enrich aquatic systems with nutrients, stimulating the growth of algae and macrophytes (large plants with roots) that can choke spring streams and reduce stream flow, water clarity, and oxygen levels. Rotting algae and water plants can clog filters and intake pipes from spring-fed sources and create odor and taste problems in drinking water.

Soil Erosion

Millions of tons of topsoil are washed into Virginia's waters each year from freshly plowed fields, over-grazed pastures, logged forests, urban developments, and strip-mined lands. Topsoil regenerates slowly, and erosion removes the richest part of the soil where nutrients, organic matter, and beneficial soil microbes are found. On land, erosion can lower soil fertility and decrease plant production, and in the water, these fine soil particles can cover spring and spring-fed stream bottoms. Harmful chemicals may be associated with materials eroded from the land. Limiting land disturbance around springs and spring-fed streams and adopting best management practices when clearing land, plowing, burning, building structures, constructing roads, dumping, filling, mining, and dredging will help keep the soil on the land and out of the spring.

Controlling soil erosion helps keep topsoil from washing into streams and reducing the flow of water.

PROTECTING SPRINGS

For most of our actions that threaten springs, there is an alternative or preventative action to protect them. Prevention is always the best strategy for protecting springs and spring-fed streams. Some of the actions that can be taken to reduce the threats to springs include:

Preserve Riparian Areas

Protecting the critical buffer zone along the riparian areas of springs and spring-fed streams is the best way to ensure good water quality and minimize the impact of surface runoff on the stream. The thick roots of grasses and trees, wildflowers, and shrubs bind the soil to the banks, slow storm runoff, and prevent erosion and sedimentation. A lush filter strip of vegetation around the spring pool and along the spring-fed stream traps harmful nutrients, sediments, and pesticides on land before they can enter the water. Damaged, denuded riparian areas should be replanted with native vegetation.

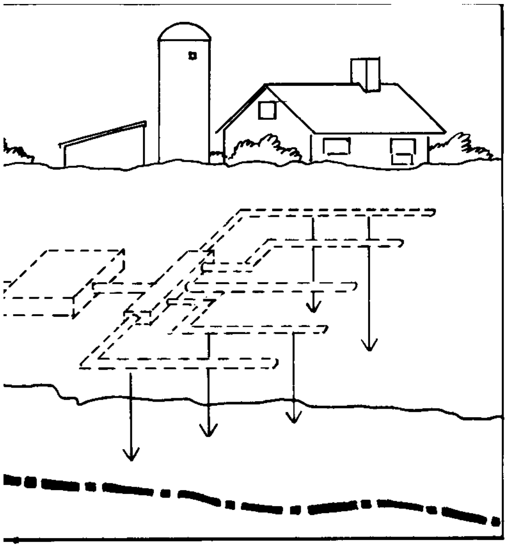
Fence Streambanks

Livestock should be fenced away from the spring’s collection area and spring box. Limiting the livestock's access to springs reduces erosion and improves water quality. Livestock needs can be met by providing watering tanks located off the spring site. Restricting watering and cattle crossings to areas where the banks and bottom of springs and spring-fed streams can be graveled to minimize erosion can protect the spring. If the water bearing area is heavy trafficked, the ground will compact and reduce the flow of water.

Check Your Septic System

The life of a septic drain field, when properly maintained averages 10 to 20 years, after which the soil's capacity to filter and remove a possible contaminant is reduced. A septic tank should be pumped out every 3 to 5 years to remove solids and prevent overflows. Improper siting, design, construction, and maintenance of septic systems can shorten their effective lifespan and endanger water supplies. Do not pour poisonous chemicals (pesticides, metals, and solvents) down household drains into a septic system. These can kill the bacteria that help detoxify and decompose wastes.

Figure 8. Wastewater enters the soil around



Residents who rely on septic systems to dispose of wastewater typically also use springs or wells for drinking water supplies. In general, the appropriate distance between an onsite septic system and a spring is 200 feet if the septic system is upslope or above the spring, and 100 feet

if the septic system is downslope or below the spring. However, before developing a spring as a drinking water source, contact your local health department. They are the best source of specific information concerning onsite septic systems and private water supplies. Before you buy or rent a home, check on the age and maintenance of the septic system and test the spring water, if you plan to continue to use the spring for your water supply (see Appendix

B. National Drinking Water Standards for information on microbiological contaminants in drinking water).

Minimize Fertilizer and Pesticide Use

Reducing the amount of nitrogen and phosphorus fertilizers applied on farmlands, gardens, and lawns can significantly reduce the contamination of springs, streams, and ground water. Testing the soil to determine the amount and type of fertilizer needed can save money and protect water quality. Avoid spreading manure or applying fertilizers near springs, streams, or on steep slopes, especially during rainy weather or when the ground is frozen.

Use less toxic chemicals and select pesticides that are readily degradable. Integrated pest management (IPM), an alternative to relying solely on pesticides, includes the use of biological control (natural pest predators and competitors),

cultural practices (types of plantings and tillage), genetic manipulation (pest-resistant crop varieties), and carefully planned use of chemicals to protect crops, forests, and livestock. Virginia Co-operative Extension outlines recommendations for the safe and effective use of pesticides as well as alternative controls for diseases, weeds, and insects in a three-volume, pest management guide series. ATTRA (Appropriate Technology Transfer for Rural Areas, sponsored by

the U.S. Fish and Wildlife Service, (800)346-9140, can provide information to farmers and land managers on sustainable agriculture and agricultural chemical reduction.

When using pesticides and fertilizers, follow directions and dispose of residues and

Handle and Dispose of Wastes Safely

Many common home and farm chemicals are hazardous to water quality. Try to select household products that do not harm the environment. Read the label and use common sense. Products such as solvents, cleaning agents, drain openers, paints, motor oil, pesticides, fertilizers, and battery acid can contaminate water if used improperly or the containers

In karst areas where springs are common, sinkholes have long been used as dumps for dead animals, garbage, and refuse. Do not use sinkholes as convenient dumpsites; these sinkholes are directly connected to the ground water. Reducing the amount of solid waste through recycling is a better alternative than discarding to a landfill.

WATER TREATMENT SYSTEMS

Before purchasing a water treatment system, have the water tested by a certified laboratory. Tests to assess the safety and quality of the water supply should include coliform bacteria, nitrate, lead, iron, hardness, pH, sulfate, total dissolved solids (TDS), and the corrosion index. If there are other possible sources of contaminants nearby, i.e., underground gasoline storage tanks, it may be necessary to test for these contaminants as well. If the test results indicate one or more contaminants are present in the water sample, try to locate the source of contamination and if at all possible, reduce or eliminate the contaminant source. Inspect the spring box and its components for defects and correct these problems. If the water tests positive for contaminants after the above steps have been taken, then a water treatment system will be necessary.

Talk to a water treatment specialist from the local health department or the Cooperative Extension office about the types of treatment systems available. The National Sanitation Foundation (NSF) tests water treatment systems and has a voluntary certification program for water treatment units. While the NSF cannot recommend a particular brand of water treatment, they can provide the homeowner with useful information about the various water treatment units and technologies. The NSF can be contacted by calling (800)NSF-MARK or through their homepage: **http://www.nsf.org/consumers/conguide2.html**. Another source for information is the Water Quality Association (WQA). The WQA is an independent trade association of manufacturers and distributions and can provide specific information on water treatment units. To contact the WQA, write to 4151 Naperville Road, Lisle, IL 60532, or call (708)505-0160. If there are concerns about health effects of particular contaminants, contact the Environmental Health Clearinghouse at 1-(800)643-4794.

The Virginia Water Resources Research Center has several publications that provide information on the different types of water treatment systems. Contact the Center at (540)231-5624 or email water@vt.edu for more information.

Information on a variety of water quality and quantity problems is available from Virginia Cooperative Extension at Virginia Tech and Virginia State or your local Cooperative Extension office. The Virginia Cooperative Extension web site is: http://www/ext/vt/edu.

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APPENDIX A. Virginia’s Administrative Code Pertaining to Springs and Ground Water

The following are sections from Virginia’s Administrative Code dealing with springs as a source of drinking water for public water systems. However, some of the information can be used when developing a spring as a private water source.

12VAC5-590-430. Determination of surface water influence of ground water sources.

All waterworks' ground water sources utilized by waterworks such as wells,

springs, and infiltration galleries shall be evaluated by the Division to determine surface water influence. The waterworks owner shall provide to the division all necessary information to make this determination in accordance with the following three-step procedure. The source shall be subjected to all criteria in a stepwise fashion. Once a determination with regard to surface water influence has been made it is not necessary to continue to the next step:

1. Step one - source history.
a. The source is not surface influenced if the division has previously determined that disinfection treatment is not required (see 12VAC5-590-380 H).
b. The source is surface influenced if it has been directly associated with a biological waterborne disease outbreak such a Giardiasis, or if it has been directly associated with chemical contamination from the surface.
c. For all sources consisting of a spring, infiltration gallery, wells located in Karstian geology, or not classified as either 12VAC5-590-430 A 1 or 2 the determination shall proceed to step two.

2. Step two - source physiology and geology.
a. The source is not surface influenced if it consists of a properly constructed Class I or Class II well in non-Karstain geologic provinces of the state, with no history of turbidity fluctuations, and that have been determined by the division to be adequately treated by disinfection alone (12VAC5-590-380 H).

b. The source is surface influenced if a sanitary survey reveals that surface water may directly enter the source either through structural defects or through

nearby surface water bodies, sinkholes, troughs, drainage ways, or other suspect geological features.

c. The determination for sources consisting of a spring, infiltration gallery, wells located in Karstian geology or otherwise not classified under 12VAC5-590-430 B 1 or 2 shall proceed to step three.

3. Step three - water quality.

a. The source is not surface influenced if the total coliform concentrations of the raw water as measured by the multiple-portion decimal-dilution (MPN) method is less than 100 organisms/100 mL based on a geometric mean of 20 or more samples over a period of six months with no more than 10% of these samples exceeding 100 organisms/100 mL; and having no record or confirmed fecal coliform contamination.

b. The source is surface influenced if:

(1) The source turbidity, temperature, pH, or conductivity fluctuate following climatic events or fluctuate relative to nearby surface bodies of water, or (2) The source exhibits the presence of diatoms, rotifers, coccidia, plant debris, insect parts, or Giardia cysts as identified by particulate analysis.

12VAC5-610-1160. Springs

A. Sanitary survey. Only springs which are found acceptable following a sanitary survey (12VAC5-610-1150 B) will be considered for use as a source of potable water. The following shall be considered when making the sanitary survey:

1. The spring's source should be an aquifer which is not subject to pollution;
2. The spring should not be subject to flooding;
3. Consideration should be given to fencing an adequate area completely around the spring to prevent contamination by people and/or animals;
4. Consideration should be given to diverting surface water away from the

spring; and 5. The distance from other sources of pollution shall be the same as for subsurface soil absorption systems contained in Table 4.4 and 12VAC5-610-810 A.

B. Construction of springs and/or reservoirs.
1. The spring shall be completely enclosed. The walls and cover shall be constructed of durable watertight material.
2. All springs and/or reservoirs shall be accessible for cleaning and maintenance. When access is through the top, the opening shall have a minimum dimension of 24 inches. The opening shall be fitted with a solid, watertight cover which overlaps the framed opening and extends vertically down around the frame at least two inches (shoe box).
3. The top of the cover frame shall be at least two 12 inches above the surrounding ground surface.
4.Overflows shall be screened to prevent entrance of undesirable materials (See 12VAC5-610-1170 C 9).

TABLE 4.4
Minimum Separation Distances

Structure or Topographic Features	Soil Texture Group	Minimum Distance (Feet) from Bottom or Sidewall of Subsurface Soil Absor-ption System Trench	
		Vertical	Horizontal
Property Lines	I,II,III,IV		5
Building Foundations	I,II,III,IV		10
Basements	I,II,III,IV		20
Drinking Water Wells			

Class I and II	I,II,III,IV		50
Class III	I,II,III,IV		100
Cisterns (bottom elevation lower than ground surface in area of subsurface soil absorption system)	I,II,III,IV		100
Shellfish Waters	I,II,III,IV		70
Natural lakes and impounded waters	I,II,III,IV		50
Streams	I,II,III,IV		50a
Development Springs (Up Slope)	I,II,III,IV		200e
Rock, outcropping, pans	I	1	1
Impervious Strata	II,III,IV	1	1
Drainage Ditches- Ditch Bottoms:			
Above seasonal water table	I,II,III,IV		10
Below seasonal water table And ditch normally contains Water	I		70a
	II		70a
	III		50a
	IV		50a
Water Table Depressor System	I	6b	70
	II	3b	70
	III	2b	50
	IV	2	50
Lateral Ground Water Movement Interceptor	I, II		70c,10d
	III,IV		50c,10d
Low Point of Sink Holes (when placed within the bowl of the sink hole	I,II,III,IV		100
Utility Lines	I,II,III,IV		10

Table 4.4 Continued

a) The set back distance may be reduced to 10 feet in Group III and IV soils and 20 feet in Group I and II soils if the subsurface soil absorption systems is designed to produce unsaturated flow conditions in the soil.
b) Vertical distance to the invert of the drain tile in the water table depressor system.

The following is a list of drinking water contaminants for which the U.S. Environmental Protection Agency is setting health-based standards (Maximum Contaminant Level Goals or MCLGs) and enforceable standards (Maximum Contaminant Levels or MCLs). Unless otherwise indicated, the levels presented are milligrams per liter (mg/l), which is approximately equivalent to parts per million (ppm). For some contaminants, there is

also a Secondary Maximum Contaminant Level (SMCL), a level set to prevent taste or odor problems. For some contaminants, the MCL is a prescribed treatment technique. See "Setting the standards for safe drinking water" for more information.

Contaminants	**MCLG (mg/L)**	**MCL (mg/ L)**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Fluoride	4.0	4.0	skeletal and dental fluorosis	natural deposits; fertilizer, aluminum industries, water additive
Volatile Organics				
Benzene	zero	0.005	cancer	some foods, gas, drugs, pesticide, paint, plastic industries
Carbon	zero	0.005	cancer	solvents and

Tetrachloride				their degradation products
p-Dichlorobenzene	0.075	0.075	cancer	room and water deodorants, and "mothballs"
1,2-Dichloroethan	zero	0.005	cancer	leaded gas, fumigants, paints
1,1-Dichloroethylene	0.007	0.007	cancer, liver, and kidney effects	plastics, dyes, perfumes, paints
Trichloroethylene	zero	0.005	cancer	textiles, adhes-ves and metal degreasers
1,1,1-Trichloroethane	0.2	0.2	liver, nervous system effects	adhesives, aerosols, textiles, paints, inks, metal degreasers
Vinyl Chloride	zero	0.002	cancer	may leach from PVC pipe; formed by sol-ent breakdown
Coliform and Surface Water Treatment				
Giardia lambia	zero	TT	Gastroenteric disease	human & animal fecal waste
Legionella	zero	TT	legionnaire's disease	indigenous to natural waters; can grow in water

				heating systems
Standard plant count	N/A	TT	indicates water quality, effectiveness of treatment	
Total coliform*	zero	<5% +	indicates gastroenteric pathogens	human and animal fecal waste
Turbidity*	N/A	TT	interferes with disinfection, filtration	soil runoff
Viruses	zero	TT	gastroenteric disease	human and animal fecal waste
Phase II- Inorganics				
Asbestos (>10um)	7MFL	7MFL	cancer	natural deposits; asbestos cement in water systems
Barium*	2	2	circulatory system effects	natural deposits; pigments, epoxy sealants, spent coal
Cadmium*	0.005	0.005	kidney effects	galvanized pipe corrosion; natural deposits; batteries, paints
Chromium* (total)	0.1	0.1	liver, kidney, circulatory disorders	natural deposits; mining,

				electroplating, pigments
Mercury* (inorganic)	0.002	0.002	kidney, nervous system disorders	crop runoff; natural deposits; batteries, electrical switches
Nitrate*	10	10	methemoglobulinemia	animal waste; fertilizer; natural deposits; septic tanks; sewage
Nitrite	1	1	methemoglobulinemia	same a nitrate; rapidly converted to nitrate
Selenium*	0.05	0.05	liver damage	natural deposits; mining, smelting, coal/oil combustion
Phase II - Organics				
Acrylamide	zero	TT	cancer, nervous system effects	polymers used in sewage/waste water treatment
Alachlor	zero	0.002	cancer	runoff from herbicide on corn, soybeans, other crops
Aldicarb*	0.001	0.003	nervous system	insecticide on

			effects	cotton, potatoes, others; widely restricted
Aldicarb sulfone*	0.001	0.002	nervous system effects	biodegradation of aldicarb
Aldicarb sulfoxide*	0.001	0.004	nervous system effects	biodegradation of aldicarb
Atrazine	0.003	0.003	mammary gland tumors	runoff from use as herbicide on corn and non-cropland
Carbofuran	0.04	0.04	nervous, reproductive system effects	soil fumigant on corn and cotton; restricted in some areas
Chlordane*	zero	0.002	cancer	leaching from soil treatment for termites
Chlorobenzene	0.1	0.1	nervous system and liver effects	waste solvent from metal degreasing processes
2,4-D*	0.07	0.07	liver and kidney damage	runoff from herbicide on wheat, corn, rangelands, lawns
o-Dichlorobenzene	0.6	0.6	liver, kidney, blood cell damage	paints, engine cleaning compounds, dyes, chemical wastes
cis,-1,2-	0.07	0.07	liver, kidney,	waste

Dichloroethylene			nervous, circulatory	industrial extraction solvents
trans, 1-2-Dichloroethylene	0.1	0.1	liver, kidney, nervous, circulatory	waste industrial extraction solvents
Dibromochloropropane	zero	0.0002	cancer	soil fumigant on soybeans, cotton, pineapple, orchards
1-2,-Dichloropropane	zero	0.005	liver, kidney effects; cancer	soil fumigant; waste industrial solvents
Epichlorohydrin	zero	TT	cancer	water treatment chemicals; waste epoxy resins; coatings
Ethylbenzene	0.7	0.7	liver, kidney, nervous system	gasoline; insecticides; chemical manu-facturing wastes
Ethylene dibromide	zero	0.00005	cancer	leaded gas addi-tives; leaching of soil fumigant
Heptachlor	zero	0.0004	cancer	leaching of insecticide for termites, very few crops
Heptachlor epoxide	zero	0.0002	cancer	biodegradation of

				heptachlor
Lindane	0.0002	0.0002	liver, kidney, nerve, immune, circulatory	insecticide on cattle, lumber, gardens; restricted 1983
Methoxychlor	0.04	0.04	growth, liver, kidney, nerve effects	insecticide for fruits, vegetables, alfalfa, livestock, pets
Pentachlorophenol	zero	0.001	cancer; liver and kidney effects	wood preservatives, herbicide, cooling tower wastes
PCBs	zero	0.0005	cancer	coolant oils from electrical trans-formers; plasticizers
Styrene	0.1	0.1	liver, nervous system damage	plastics, rubber, resin, drug industries; leachate from city landfills
Tetrachloroethylene	zero	0.005	cancer	improper disposal of dry cleaning and other solvents
Toluene	1	1	liver, kidney, nervous, circulatory	gasoline additive; manufacturing and sol-vent operations

Toxaphene	zero	0.003	cancer	insecticide on cattle, cotton, soybeans, cancelled 1982
2,4,5-TP	0.05	0.05	liver and kidney damage	herbicide on crops, right-of-ways, golf courses, cancelled 1983
Xylenes (total)	10	10	liver, kidney; nervous system	by-product of gasoline refining; paints, inks, detergents
Lead and Copper				
Lead*	zero	TT**	kidney, nervous system damage	natural/industrial deposits; plumbing, solder, brass alloy faucets
Copper	1.3	TT***	gastrointestinal irritation	natural/industrial deposits; wood pre-servatives, plumbing
Phase V - Inorganics				
Antimony	0.006	0.006	cancer	fire retardants, ceramics, electronics, fireworks, solder
Beryllium	0.004	0.004	bone, lung damage	electrical, aerospace, defense industries

Cyanide	0.2	0.2	Thyroid, nervous system damage	electroplating, steel, plastics, mining, fertilizer
Nickel	0.1	0.1	heart, liver damage	metal alloys, electroplating, batteries, chem-cal production
Thallium	0.0005	0.002	kidney, liver, brain, intestinal	electronics, drugs, alloys, glass
Organics				
Adipate, (di(2-ethylhexyl)	0.4	0.4	decreased body weight; liver and testes damage	synthetic rubber, food packaging, cosmetics
Dalapon	0.2	0.2	liver, kidney	herbicide on orchards, beans, coffee, lawns, road/railways
Dichloromethane	zero	0.005	cancer	paint stripper, metal degreaser, propellant, extraction
Dinoseb	0.007	0.007	thyroid, reproductive organ damage	Herbicide runoff from crop and non-crop applications
Diquat	0.02	0.02	liver, kidney, eye effects	herbicide runoff -land and aquatic weeds

Dioxin	zero	0.00000003	cancer	chemical production by-product; impurity in herbicides
Endothall	0.1	0.1	liver, kidney, gastrointestinal	herbicide on crops, land/aquatic weeds; rapidly degraded
endrin	0.002	0.002	liver, kidney, heart damage	pesticide on insects, rodents, birds; restricted since 1980
Glyphosate	0.7	0.7	liver, kidney damage	herbicide on grasses, weeds, brush
Hexachlorobenzene	zero	0.001	cancer	pesticide production waste by-product
Hexachloro-cyclopentadiene	0.05	0.05	kidney, stomach damage	pesticide production intermediate
Oxamyl (Vydate)	0.2	0.2	kidney damage	insecticide on apples, potatoes, tomatoes
PAHs (benzo(a)pyrene)	zero	0.0002	cancer	coal tar coatings; burning organic matter; volcanoes, fossil fuels
Phthalate, (di(2-	zero	0.006	cancer	PVC and

ethylhexyl)				other plastics
Picloram	0.5	0.5	kidney, liver damage	herbicide on broad-leaf and woody plants
Simazine	0.004	0.004	cancer	herbicide on grass sod, some crops, aquatic algae
1,2,4-Trichlorobenzene	0.07	0.07	liver, kidney damage	herbicide production; dye carrier
1,2,2-Trichloroethane	0.003	0.005	kidney, liver, nervous system	solvent in rubber, other organic products; chemical production wastes
Other Proposed (P) and Interim (I) Standards				
Beta/photon emitters (I) and (P)	zero	4	cancer	decay of radionuclides in natural and man-made deposits
Alpha emitters (I) and (P)	zero	15 pCi/L	cancer	decay of radionuclides in natural deposits
Combined Radium 226/228 (I)	zero	5 pCi/L	bone cancer	natural deposits
Radium 226*(P)	zero	20 pCi/L	bone cancer	natural deposits
Radium 228*(P)	zero	20 pCi/L	bone cancer	natural deposits
Radon (P)	zero	300	cancer	decay of

		pCi/L		radionuclides in natural deposits
Uranium (P)	zero	0.02	cancer	natural deposits
Sulfate (P)	400/500	400/500	diarrhea	natural deposits
Arsenic*(I)	0.05	0.05	skin, nervous system toxicity	natural deposits; smelters, glass, electronics wastes; orchards
Total Trihalomethanes (I)	zero	0.10	cancer	drinking water chlorination by-products

Source: National Primary Drinking Water Standards, U.S. Environmental Protection Agency, EPA 810-F-94-001A, February 1994.

Appendix C. Secondary Maximum Contaminant Levels

The following is a list of drinking water contaminants for which the U.S. Environmental Protection Agency has set or is setting aesthetic standards related to taste, odor, or color (Secondary Maximum Contaminant Levels or SMCLS). Unless otherwise indicated, the levels presented are concentrations expressed as milligrams per liter (mg/l), which is approximately equivalent to parts per million (ppm).

Contaminant	Synonym	Description	Contaminant Effects	SMCL
aluminum	Al	element	discoloration of water	0.05 to 0.2
chloride	Cl		taste; corrosion of pipes	250
color		property	aesthetic	15 color units
copper	Cu	element	taste; staining of porcelain	1.0
corrosivity		measure of ability of water to corrode	aesthetic; may leach pipe materials (e.g., lead) into water	non-corrosive
fluoride	F	element	dental fluorosis(discoloration of teeth)	2.0
foaming agents	MBAS		aesthetic	0.5
iron	Fe	element	taste; staining of laundry	0.3
manganese	Mn	element	taste; staining of laundry	0.05
odor		property	aesthetic	3 threshold odor number

pH		may affect corrosivity	6.5 to 8.5	

silver	Ag	element	argyria (skin discoloration)	0.1
sulfate	S0$_4$2		taste; laxative effects	250
total dissolved solids	TDS	measure of inorganic chemicals in water (hard water)	taste; indicator of corrosivity;can damage plumbing, limit effectiveness	500