WATER IN SHENANDOAH COUNTY

A PRIMER

INTRODUCTION

This paper was prepared by the Shenandoah County Water Resources Advisory Committee for the use of the elected and appointed officials of the county and the incorporated towns as well as all citizens of the county who wish to learn more about this most vital of natural resources -- our water. The information contained herein was compiled from a number of sources including: The Report of the Shenandoah County Commission on the Future, the United States Geological Survey (USGS), the Environmental Protection Agency (EPA), Virginia Department of Environmental Quality (DEQ), Virginia Department of Conservation and Recreation (DCR), Virginia Department of Health, Virginia Water Resources Research Center at Virginia Tech, and the Northern Shenandoah Valley Regional Commission.

GROUND WATER (GW)

1. This should perhaps more aptly be called "underground water" because that is where it is located.

2. Eighty percent of the residents of Shenandoah County (and of Virginia) rely on GW for their water supply.

3. Groundwater is a finite resource. Worldwide, for every 3 gallons of GW that is taken only 2 gallons replenishes it. The long term implications of this phenomenon are awesome. There is no reason to think that the Shenandoah Valley is exempt from the consequences of this.

4. By law (Clean Water Act and Safe Drinking Water Act), Virginia is committed to "antidegradation" of all state waters, including GW. Keys to ensuring quality of GW are educating citizens about the importance of GW protection and prevention of GW contamination.

5. Leading uses of GW in Virginia :

- Rural use (livestock & domestic) 39%
- Public supply 30%
- Industrial 29%
- Irrigation 2%
- Thermoelectric 1%

6. The water table is the upper boundary of the zone where all pores of the material are filled with water. Water in this zone is called GW. At the water table the hydraulic pressure is equal to atmospheric pressure. Below the water table, hydraulic pressure increases with increasing depth.

7. Both the quality and quantity of GW can be affected by the condition of the layer above the water table in a recharge area [example: septic drainfields]

8. Water bearing formations in the ground are commonly referred to as aquifers.

9. Granite, slate, and limestone are solid rock masses typical of the Shenandoah Valley. GW forms in pores, cracks, fissures, and solution channels (unique to limestone due to dissolving action.) Once solution channels have become developed they function more as pipes than sponges. The size, number, and extent of solution channel interconnections vary among deposits and from region to region. Some channels are so well connected that they resemble streams. The capacity of an aquifer to store and transmit water is governed by the size of cracks and solution channels and the number of their interconnections.

10. The orientation of cracks and fissures in nonporous rocks, e.g., limestone, can cause complex GW flow patterns that are quite different from surface flow patterns. That becomes important in locating septic systems relative to wells. The surface topography cannot be depended upon to accurately reflect the water table's topography. It requires more detailed study to ensure the facility is truly built "downhill."

11. The length of time water remains underground varies greatly. Some remains underground for only days or weeks. Other remains as much as 10,000 years.

12. Most of the recharge of GW aquifers occurs during the winter. More precipitation falls between April and September than between October

and March, but because of longer days and higher temperatures and the growth of vegetation during the summer months almost all of the rainfall is consumed through evaporation, evapotranspiration (through vegetation) and surface runoff. After mid-May the GW levels typically begin to decline and continue to do so throughout the growing season. Thus it is vital to GW recharge that adequate rainfall and snow occur during the winter months when evaporation and evapotranspiration are not a factor.

KARST

1. Landforms that are produced primarily by the dissolution of rocks, mainly limestone and dolomite (carbonates) are known as karst. In Shenandoah County much of the valley between the North Fork and the hills to the west is made of this karst landform. Karst characteristics include:

- numerous sinkholes
- an underground drainage network that consists of solution openings that range from enlarged cracks in the rocks to caves and large caverns.
- highly disrupted surface drainage systems which relate directly to the unique character of the underground drainage system

2. Ground water recharge is very efficient in karst terrain. Precipitation readily infiltrates through the rock openings in the land surface (but this is bad news for contamination).

3. Springs may be a combination of slow-moving water draining from pores in the bedrock and rapidly moving storm-derived water. The slow moving water reflects the chemistry of the aquifer materials; the rapidly moving water the chemical characteristics of precipitation and surface runoff.

4. Water movement in karst is especially unpredictable. In some cases true underground streams with high rates of flow equivalent to rates of flow in surface streams are found. It is not unusual for medium-sized streams to disappear into rock openings and reappear at the surface elsewhere. This is called ground water under the influence of surface water.

5. Seeps and springs are characteristic features. Large springs (having large GW recharge areas) often are the source of small to medium-sized streams and tributaries.

6. Because of the complex patterns of surface water and GW flow in karst terrain, the drainage divides of each do not coincide.

7. Portions of the Shenandoah Valley with karst consistently form the most productive aquifers in Virginia'a consolidated rock formations. Ridges and upland areas, however are often underlain by sandstone and shale which yield only enough water for rural and domestic supplies.

8. Rapid movement of GW in karst areas makes the pollution potential high. Contamination can spread over wide areas. Aquifers are often recharged directly by streams crossing fault zones.Wells in the fault zones generally have the greatest yields (and greatest potential for pollution).

9. As more scientific evidence becomes available about karst it is becoming increasingly apparent that its unpredictable GW supply and movement and its high potential for contamination call for a high level of awareness and diligence on the part of those who inhabit karst terrain (which is most of us who live in Shenandoah County).

SURFACE WATER (SW)

1. SW is found primarily in streams and rivers but is also in lakes, ponds, and reservoirs. Surface runoff is the prime source of water for these rivers and streams and impoundments, but GW is also an important contributor through the numerous springs in the county and through subsurface connections between GW and stream channels.

2. About 72% of annual precipitation returns to the atmosphere through evaporation from the surface or vegetation; the remaining 28% is divided about evenly between running off the land directly to become streamflow or infiltrating the soil to become GW.

3. The stream system in the county is part of the Shenandoah River Watershed which in turn flows into the Potomac River and ultimately the Chesapeake Bay and Atlantic Ocean. Eventually all surface water in the county flows into the North Fork, which averages 380 MGD (million gallons per day) although readings as low as 22 MGD and as high as 39,000 MGD have been recorded. The North Fork is supplied by some 10

major streams, including Mill Creek, Smith Creek, Holmans Creek, Stony Creek, and Cedar Creek.

4. The Virginia Department of Environmental Quality (DEQ) evaluates the surface water quality in Virginia as to its suitability for fishing and swimming. In its most recent report DEQ listed segments of the North Fork, Holmans Creek, Smith Creek, Mill Creek and Toms Brook as "impaired waters," meaning that they exceed the state's standards in one or more of the following types of pollution: fecal coliform bacteria, excessive nutrients (nitrogen and/or phosphorous), PCBs, or impaired aquatic organisms living on the stream bottom. For each of these streams the state will establish a Total Maximum Daily Load (TMDL) allowable of the offending pollutants, and DEQ has the responsibility to follow through to see that each stream's TMDL is achieved by a certain date in the future.

5. The towns of Woodstock and Strasburg draw their drinking water supplies from the North Fork and process it through treatment plants before providing it to the public. Drinking water for the towns of New Market, Mt. Jackson, Edinburg, the Stony Creek and Toms Brook/Maurertown Sanitary Districts and all other public water systems (defined as serving 25 or more people) comes from wells, i.e., GW sources.

6. The North Fork and some of its tributaries are also the source of water for numerous farms (irrigation) and industries along their courses. They also receive discharges from permitted wastewater treatment plants and impoundment lagoons.

7. Surface water streams are also used for recreation, scenic appeal, and as aquatic habitats.

8. The Northern Shenandoah Valley Regional Commission is currently conducting a Minimum Instream Flow (MIF) study for the North Fork. Due for completion in 2003, this study will define the minimum flow requirements of the river to support the expected functions such as water supply for the towns, recreation, and aquatic habitats. The MIF will provide a basis for reconciling conflicts between in-stream and off-stream uses of water in the North Fork watershed.

9. Surface water has its own vulnerabilities to contamination (ref. para. 4 above), primarily from runoff from the landmass containing excess amounts of nitrogen and phosphorous from fertilizers; chemicals from excessive use of pesticides; nitrates, bacteria and viruses from failing

septic systems; and nitrogen and phosphorous from improper management of animal wastes. Runoff containing the pollutants described above can come from either agricultural or urban/suburban sources and need to be managed by landowners responsible for applying fertilizers and chemicals on their property.

INTERACTION OF GW AND SW

Underground aquifers do not act solely as water receivers. They are not "dead ends" in the hydrologic cycle. Approximately 30% of the flow of surface streams is from GW sources. During periods of heavy rainfall or rapid snowmelt, surface runoff is the primary contributor to stream flow. When no surface runoff is occurring, GW in the form of springs is the only contributor to a stream's flow.

NUTRIENT MANAGEMENT

1. The quality of water for human consumption and for aquatic habitat can be seriously affected by high levels of nutrients (nitrogen and phosphorus). Excess nutrients coming from sources in the Shenandoah River basin have an impact on local water quality as well as on the living resources of the Potomac River and the Chesapeake Bay. Excessive nitrate in drinking water can cause human health impacts. High levels of nutrients also lead to increased algae which can cause taste and odor problems in drinking water. As algae increases it blocks light from reaching underwater grasses. As algae die and sink to the bottom their decay robs the water of dissolved oxygen which is essential for fish, shellfish and other aquatic animals to survive.

2. Virginia is a signatory to the Chesapeaake Bay Agreement of 1987, which calls for an overall 40% reduction of nitrogen and phosphorus controllable loads from 1985 levels throughout the Potomac and Shenandoah River basins. Shenandoah County, through its Nutrient Reduction Plan, has achieved the 40% reduction in phosphorus load and is approaching the 40% goal in nitrogen. (On an annual basis a 40% reduction in nitrogen is 318,000 pounds less nitrogen finding its way into the North Fork and tributaries; for phosphorus it is 54,000 pounds). Capping the nutrient levels, particularly in the face of a growing population, poses a continuing challenge for the county.

3. Agricultural best management practices (BMPs) have been found to be the most cost effective methods for reducing nutrient loads. Farmers are assisted in this regard by the Lord Fairfax Soil and Water Conservation

District, the Natural Resources Conservation Service, Virginia's Department of Conservation and Recreation, the Cooperative Extension Service, and others. Other measures include implementation of erosion and sediment control plans, education programs for homeowners to reduce over-use of fertilizers and promote home conservation techniques, adoption of stream buffers for new development, and pump-out of septic tanks at regular intervals.

WELLS

1. A well yield of at least 6 gallons per minute is needed for home use, although 10 is more desirable. Low yield wells (4 gallons or less) should have a storage tank four or five times larger than daily consumption (75 gals per person on average).

2. Wells are classified into 4 categories: Class I and II wells are public water supply wells. Class III are private wells used for drinking water. Class IV are private wells used for any other purpose. Outside the incorporated towns and the sanitary districts, most county citizens have Class III wells.

3. Grout to a depth of 20 feet or more is used to seal the space between the well casing and the bore hole. This is to prevent well contamination from surface sources around the wellhead. Also a tightly fitting cap should be installed to keep out dirt, rodents, and other foreign material. It is especially important that abandoned wells be capped inasmuch as the aquifer for each well is connected with other wells in the vicinity. Virginia's Private Wells Regulation, VR 355-34-100, Section 3.11 sets procedures for permanently abandoning a well. Check with the county health department for details.

4. To prevent contaminated runoff water or other materials from entering a well, it should be located on the highest suitable ground and far from potential pollution sources. Virginia state regulations (VR 355-34-100) govern minimum distances between a well and structure or topographic feature. Some examples for private wells (Class III):

Building foundation	10'
Building foundation (termite treated)	50'
House sewer line	50'
Septic tank	50'
Drainfield	100'
Underground storage tank	100'
Barnyard, hog lot, etc.	100'

5. Well water for drinking purposes should be tested for bacteria once per year and for harmful chemicals every three years. Testing should be done immediately if an unexplained gastrointestinal illness occurs or if water taste or color changes suddenly. There are over 100 public and private laboratories certified to test drinking water quality in Virginia. Check with the county health department for list of labs and the procedures involved in testing.

6. There are several methods available for disinfecting and conditioning drinking water. *Disinfecting* ensures that the water is free of harmful bacteria such as fecal coliform bacteria from human and animal waste (it is unacceptable for this to be present in any concentration). Chlorination is the most commonly used means of disinfection in both municipal and private water systems. *Conditioning* the home water supply makes the water more pleasing to the senses, that is, makes it feel softer, taste and smell better, etc. Water softening and filtering are the most common methods of conditioning well water. Check with the county health department for more information on water treatment.

WASTEWATER TREATMENT

1. Municipal wastewater treatment plants process sewage waste from the towns and sanitary districts they serve. Through a process of chemical treatment, filtering, and aeration the effluent is decomposed and cleansed of bacteria, viruses, and other harmful ingredients before being discharged into the North Fork or Stony Creek. The ensuing discharge water must meet standards set by the state.

2. The liquid wastes produced by processing and rendering plants, fertilizer production operations, and a wide variety of other commercial activities are often disposed of in surface impoundments where they are treated by aeration. Impoundments are permitted by the state through the Virginia Pollutant Discharge Elimination System (VPDES). The permit system allows for subsequent discharge into surface waters provided that standards on the quality of the discharge water are met.

CONTAMINANTS

1. Treating contaminated GW is difficult and expensive. The natural degradation of pollutants in GW occurs very slowly. Contamination may

go undetected for years and is almost always discovered by accident or after people become ill. Preventing contaminants from reaching GW is a better approach.

2. *Point Source (PS)* pollution originates from definable points such as industrial and municipal discharges. Point source pollution can be managed by treatment and monitoring at the specific discharge points through the state-run permit process. *Nonpoint Source (NPS)* pollution on the other hand presents a more difficult problem. NPS pollution comes from many different sources (agricultural runoff, road construction, residential development, storm sewers, and septic tanks, to name a few). NPS pollution comprising so many potential impacts and originating from so many potential sources presents a difficult management challenge.

3. Major sources of contamination:

- **Leaks and spills of petroleum products**

  - Oil and gasoline contain hydrocarbons that are soluble in water. Small concentrations (less than .005 mg/L) can be detected by taste or smell and make water unfit for human concumption.

  - Underground storage tanks (USTs), many buried since WWII. DEQ initiated a progrem in 1989 to register and regulate them. Funds are available to finance cleanup of leaking USTs.

  - Buried home furnace oil tanks. Generally thin-walled and easily corroded.

  - Used motor oil. Over 4 million gals. are disposed of improperly in Virginia each year.

- **Landfills**

  - The average household generates 4.5 pounds of trash per day.

  - Federal and state regulations govern the design, construction, and operation of all landfills (government or private). They require special monitoring wells to check for GW contamination, bi-annual analysis of GW samples, and remediation of GW contaminated by leachate liquids. All new sanitary landfills must have special clay and plastic liners.

- Leaching is the main problem in sanitary landfills. If leachate is not captured and treated it can contaminate GW. EPA estimates that 25% of the worst toxic waste sites are former landfills.

- **Hazardous Waste**

  - Superfund Sites administered by EPA and DEQ. Currently there are 18 private and 7 federal facilities in Va. None in Shenandoah County.

- **Septic Systems**

  - The most frequently reported sources of GW contamination in the U.S.

  - The design life of septic systems averages 10 to 15 years. Older systems, though still in use, have exceeded their design life and may no longer be functioning properly.

  - In addition, improperly sited septic systems may allow drainfield effluent to move too rapidly for adequate treatment by the soil (ref. amended Va. Dept. of Health regulations). In karst, where GW flow rates can be high, bacteria and viruses may be transported several miles and live below the water table for many days or even months.

  - Even properly functioning septic systems should be periodically inspected and maintained.

  - When many septic systems are concentrated in a small area, their combined wastewater flow may exceed the soil's treatment capacity. This can be a problem for densely spaced residential developments.

  - In soil conditions unsuitable for conventional septic systems so-called "alternative systems" may be approved. Such systems are more expensive and complex than conventional systems and require regular professional maintenance and inspections. The county health department can provide details on alternative systems and requirements.

  - Homeowners should not dispose of insecticides, herbicides or other chemicals in toilets and sinks. Septic systems are not designed to treat these materials. They can contaminate nearby

GW and destroy beneficial microorganisms in the septic tank and soil.

- In areas with inadequate soil or dense development, septic systems can cause noticeable increases of nitrate in GW. EPA standard is 10 parts per million (ppm) for drinking water. At this level water should not be consumed by infants or pregnant women. If nitrate-laden GW reaches surface water it can cause algae blooms.

- **Agricultural Activities**

  - Use of fertilizers and pesticides and storage or disposal of animal wastes all can cause degradation of GW quality. It depends on the rate of application, decomposition rates, level of water solubility, soil properties, and depth to GW.

  - Nitrogen in the form of nitrate is the fertilizer nutrient that most commonly contaminates GW beneath agricultural lands. Other sources of nitrate: human and animal wastes, atmospheric deposition, and leaching from holding areas for animal waste.

  - If wells are not properly grouted along the well bore above the screen, contaminated runoff can make its way into the aquifer that supplies water to the well.

  - Since WWII there has been a rapid development and use of pesticides (herbicides, insecticides, fungicides). Sources of pesticides getting into GW include applications to farm fields, orchards, in and around buildings, lawns and gardens, golf courses, parks and roadways. Disposal of surplus pesticides and containers can also be a problem.

- **Residential Activities**

  - Overapplication of fertilizers and pesticides on residential property can have the same effect on GW and SW contamination as on agricultural land.

  - See section above on Agricultural Activities. With the exception of livestock activities, much of this information applies to residential activities as well.

WHAT CITIZENS CAN DO

- **Chemicals and other toxic products**

  - Use fertilizers and pesticides with caution. Follow manufacturer's instructions.

  - Take unused pesticides and their containers to the reception point at the county landfill. There is no place on one's property where they can be safely disposed of.

  - Check spreader and spray equipment for proper calibration so that excessive amounts of fertilizer and pesticides are not applied.

  - Install devices to prevent back-siphoning on all faucets and hoses used to fill pesticide sprayers.

  - Certain wastes require special handling and disposal. For example: asbestos, wastes containing PCBs, tires, soils contaminated with petroleum products, lead and acid batteries, and flourescent light bulbs. Check with the county landfill office for instructions on how and where to dispose of these hazardous wastes.

- **Septic systems:**

  - Note: septic system wastewater carries disease-causing bacteria and viruses into the soil. A properly located drainfield with adequate soil depth and composition between the drainfield trench and bedrock is essential.

  - Have the tank pumped at regular intervals (recommended: every 5 years). This ensures that sludge and undissolved solids do not flow into the drainfield where they contaminate the soil and inhibit the functioning of the drainfield.

  - Do not pour or flush toxic substances such as paints, varnishes, photographic solutions, paint thinners, waste oils, pesticides, antifreeze and household cleaners that contain lye or petroleum distillates into the household plumbing system. These materials pass through the septic system without being treated.

and contaminate ground water. Moreover, they can destroy the beneficial bacterial action in the septic tank. Take these materials to the landfill reception point.

- If the kitchen has a garbage disposal use it sparingly. Kitchen wastes decompose slowly in the septic tank environment and can unnecessarily increase the buildup of sludge in the tank. A good rule of thumb: don't put anything into the septic system that could otherwise be put in the family garbage container.

- **Land use:**

  - Clean out sinkholes and fence them. Sinkholes provide a direct source of contamination to groundwater.

  - Locate livestock pens and barns as far downhill from the well as possible.

  - Utilize sound agricultural practices to reduce soil erosion and prevent surface runoff. Riparian landowners should maintain streambank vegetation and minimize disturbances in riparian areas. Landowners can apply to the USDA's Natural Resources Conservation Service to have riparian land placed in the Conservation Reserve Program (CRP).

  - To reduce the levels of unused nitrates, use slow-release fertilizers, apply nitrogen fertilizer in small amounts during the growing season as needed, and rotate crops with legumes. Using soil tests to determine the need for fertilizers in different soil types can save farmers and homeowners money as well as reduce the risk of GW and SW contamination.

- **Household Habits**

  - Routinely check for leaks in underground storage tanks used to store home heating oil or gasoline. Any smell or taste in drinking water, unexplained loss of fuel in tank, or oil slick should be investigated immediately.

  - Clean up any open dumps where household trash, construction materials, automobile tires and batteries, old appliances, and other waste items are discarded. Such open dumps endanger

GW, particularly in karst terrain as found in Shenandoah County, and are illegal in the state of Virginia.

- Collect used motor oil for recycling at oil collection centers (check local service stations for one that accepts used motor oil for recycling). A single quart of oil on the ground can contaminate 2 million gallons of drinking water!

- Recycle. Anywhere from 30 to 75 percent of the materials found in an authorized landfill could have been recycled for use in industry or agriculture. Recycling the maximum amount of waste possible helps to solve the waste disposal problem, offers an alternative to the use of new resources, and conserves energy.

- **Water conservation**

  - With the periodic droughts that occur in the Shenandoah Valley it is a waste of water and time to try to keep lawns green. Let them go and they will recover when natural rainfall resumes.

  - Use soaker hoses, the drip method, or hand-held hoses to water exterior flowers, shrubs, and trees.

  - Select more drought-tolerant vegetation and plant species for landscaping and use mulches to retain moisture.

  - Limit vehicle-washing activities. If you are washing, use a bucket, not a hose. Use commercial car washes that reuse their water.

  - Sweep sidewalks and driveways -- don't hose them down.

  - Cover pools and spas when they are unoccupied to reduce evaporation.

  - Inspect and repair all leaking faucets, pipes, hoses, and toilets.

  - Take short showers instead of baths. Consider bathing young children together.

  - Don't run water while shaving, brushing teeth, or washing dishes by hand.

- Retrofit existing showers and faucets with inexpensive flow restrictors.

- Install conservation equipment, such as a brick or a water-filled bottle in the toilet tank to reduce water used per flush. Half of all household water usage is in toilet flushes. Newer low-consumption toilets are on the market.

- Run dishwasher and washing machine only when filled to capacity. Use economy settings.

- When agricultural spray irrigation is practiced it should be limited to low evaporation periods. Evaporation rates are highest when the sun is out.

- **Well Management**

  - If the yield rate (in gallons per minute) is not known, the county health department or the well driller should be able to furnish it. This rate should be thought of as the absolute maximum, not the sustained rate. It is better to pump water at a sustained low rate than to pump the same volume of water at or near the rated yield.

  - If the water pressure drops or the water becomes cloudy, let the well rest overnight. This is a wake-up call that the well is being overtaxed. A cutback in daily water usage is highly advisable.

  - Test the well water for bacteria and harmful chemicals at periodic intervals (see earlier section on **Wells**).

  - Regularly inspect the wellhead and the area around it for condition of the cap, presence of pooled water around the casing, contaminants in the vicinity, etc.

- **Precaution for Home Buyers**

  - Have present owner provide written information about the well -- location, age, depth, rated yield, depth of case grouting, age of pump and piping if more recent than the age of the well. If there

is a septic system, obtain its location, age, and maintenance records.

- Have the water tested by a laboratory and the household plumbing and the wellhead checked by a plumber.

- Before buying undeveloped property, check with the county health department about perk tests and septic system construction regulations. If a well needs to be drilled, check with neighboring landowners, well drillers, the health department, and the county extension agent about well depths, well yields, and groundwater quality in the area. Keep in mind that local variations are such that water may not be found at the same depth and quantity as one's neighbor.

EVERY CITIZEN HAS A SIGNIFICANT DEGREE OF CONTROL OVER THE QUALITY AND QUANTITY OF THE WATER SUPPLY