Evaluation of Household Water Quality in Clarke and Frederick Counties, Virginia

MARCH 2011

VIRGINIA HOUSEHOLD WATER QUALITY PROGRAM

Background

More than 1.7 million Virginia households use private water supplies such as wells, springs, and cisterns. The Virginia Household Water Quality Program (VAHWQP) began in 1989 with the purpose of improving the water quality of Virginians reliant on private water supplies. Since then drinking water clinics have been conducted in 86 counties across Virginia and samples analyzed from more than 14,500 households. In 2007, the Virginia Master Well Owner Network (VAMWON) was formed to support the VAHWQP. Virginia Cooperative Extension agents and volunteers participate in a 1 day VAMWON training workshop that covers private water system maintenance and protection, routine water testing, and water treatment basics. They are then able to educate others about their private water supplies. More information about these programs may be found at our website: www.wellwater.bse.vt.edu.

Private water sources, such as wells and springs, are not regulated by the U.S. Environmental Protection Agency (EPA). Although private well construction regulations exist in Virginia, private water supply owners are responsible for maintaining their water systems, for monitoring water quality, and for taking appropriate steps to address problems should they arise. The EPA Safe Drinking Water Standards are good guidelines for assessing water quality. *Primary drinking water standards* apply to contaminants that can adversely affect health and are legally enforceable for public water systems. *Secondary drinking water standards* are non-regulatory guidelines for contaminants that may cause nuisance problems such as bad taste, foul odor, or staining. Testing water annually, and routinely inspecting and maintaining a water supply system will help keep water safe.

Geology

Frederick County and the majority of Clarke County lie within the ***Valley and Ridge*** physiographic province of Virginia. The Valley and Ridge Province is located to the west of the Blue Ridge Province and is underlain by sedimentary rocks deposited by ancient seas. In the low areas, such as the Shenandoah Valley, limestone and dolomite are common. These rock types have openings to yield water to wells and form the most productive aquifers in Virginia's consolidated rock formations. In contrast, the ridges and upland areas are often composed of sandstone and shale, which lack the cracks and pores to transmit or store water. Therefore, in ridges and upland areas, there is often only enough water for rural and domestic water supplies.

The connection between groundwater and surface water plays a major role in groundwater recharge in the Valley and Ridge. Streams often cross fault zones leading to recharge of aquifers and wells in the fault zone area. Recharge also occurs through surface runoff travelling into limestone sinkholes, bypassing filtration through the soil. This can cause serious water quality problems since polluted surface water may be introduced directly into the groundwater system. In addition, calcium and magnesium from carbonate formations contribute to high mineral content and can cause hard water (GWPSC, 2008).

The western side of Clarke County lies within the ***Blue Ridge*** physiographic province of Virginia. The Blue Ridge Province is a relatively narrow zone to the west of the Piedmont Province with some of the highest elevations in the state. Beneath a thin layer of soil and weathered rock lies bedrock, a relatively impervious zone containing water primarily in joints, fractures, and faults. On the eastern side of the Blue Ridge, igneous and metamorphic rocks are most common. Sedimentary rocks are most common on the western side. Steep terrain and a thin soil covering result in rapid surface runoff and low groundwater recharge.

There has been little residential or industrial development in the Blue Ridge itself, so groundwater use is mainly for domestic needs rather than for public wells. The lower slopes of the mountains are the most favorable areas for groundwater accumulation. Springs are common and are often used for private water supplies. Because the rocks in the Blue Ridge are relatively insoluble, the ground water is not severely mineralized, but iron content is high in some locations (GWPSC, 2008).

Overview

In March 2011, 51 residents from Clarke and Frederick Counties participated in a drinking water clinic sponsored by the local Virginia Cooperative Extension (VCE) offices and the Virginia Household Water Quality Program. Clinic participants received a confidential water sample analysis and attended educational meetings where they learned how to interpret their water test results and address potential issues. The most common household water quality issues identified as a result of the analyses for the participants were high levels of hardness, total dissolved solids, sodium, and the presence of total coliform bacteria. *Figure 1*, found at the end of this report, shows these common water quality issues along with basic information on standards, causes, and treatment options.

Drinking Water Clinic Process

Any Clarke or Frederick County resident relying on a well, spring, or cistern was welcome to participate in the clinic. Advertising began 8 weeks prior to the first meeting and utilized local media outlets, announcements at other VCE meetings, and word of mouth. Pre-registration was encouraged.

Kickoff meeting: Participants were given a brief presentation that addressed common water quality issues in the area, an introduction to parameters included in the analysis, and instructions for collecting their sample. Sample kits with sampling instructions and a short questionnaire were distributed. The questionnaire was designed to collect information about characteristics of the water supply (e.g. age, depth, and location), the home (e.g. age, plumbing materials, existing water treatment), and any existing perceived water quality issues. The purpose of the clinic was to build awareness among private water supply users about protection, maintenance, and routine testing of their water supply.

Participants were instructed to drop off their samples and completed questionnaires at a predetermined location on a specific date and time.

Sample collection: Following collection at a central location, all samples were iced in coolers and promptly transported to Virginia Tech for analysis.

Analysis: Samples were analyzed for the following water quality parameters: iron, manganese, nitrate, chloride, fluoride, sulfate, pH, total dissolved solids (TDS), hardness, sodium, copper, total coliform bacteria, and *E. coli*. General water chemistry and bacteriological analyses were performed by the Department of Biological Systems Engineering Water Quality Laboratory at Virginia Tech. The Virginia Tech Soils Testing Laboratory performed the elemental constituent analyses. All water quality analyses were performed using standard analytical procedures.

The Environmental Protection Agency (EPA) Safe Drinking Water Standards, which are enforced for public water systems in the U.S., were used as guidelines for this program. Water quality parameters not within range of these guidelines were identified on each test report. Test reports were prepared and sealed in envelopes for confidential distribution to clinic participants.

Interpretation meeting: At the interpretation meeting, participants received their confidential water test reports, and VCE personnel made a presentation providing a general explanation of what the numbers on the reports indicated. In addition, general tips for maintenance and care of private water supply systems, routine water quality testing recommendations, and possible options for correcting water problems were discussed. Participants were encouraged to ask questions and discuss findings either with the rest of the group or one-on-one with VCE personnel after the meeting.

Findings and Results

Profile of Household Water Supplies

The questionnaire responses, provided by all 51 participants at the clinic, helped to characterize the tested water supplies. All participants in the clinic indicated their water supply was a well.

Participants were asked to classify their housing location as one of four categories. The choices, ranging from low to high population density, are: (1) on a farm, (2) on a remote, rural lot, (3) in a rural community, and (4) in a housing subdivision.

For the Clarke/Frederick clinic, a farm was the most common household setting (29%), followed by a rural community (35%).

The major source of potential contamination near the home (within 100 feet of the well) was identified as an oil tank (14%). According to participants, larger, more significant potential pollutant sources were also proximate (within one-half mile) to water supplies. Sixty-one percent of respondents indicated that their water supply was located within one-half mile of a major farm animal operation while 33% indicated that their supply was within one half-mile of a field crop operation.

On the questionnaire, participants also described the type of material used for water distribution in each home. The two most common pipe materials were copper (63%) and plastic (33%).

To properly evaluate the quality of water supplies in relation to the sampling point, participants were asked if their water systems had water treatment devices currently installed, and if so, the type of device. Eighty-six percent of participants reported at least one treatment device installed. The most commonly reported treatment device was a water softener, installed by 75% of participants.

Participants' Perceptions of Household Water Quality

Participants were asked whether they perceived their water supply to have any of the following characteristics: (1) corrosive to pipes or plumbing fixtures; (2) unpleasant taste; (3) objectionable odor; (4) unnatural color or appearance; (5) floating, suspended, or settled particles in the water; and (6) staining of plumbing fixtures, cooking appliances/utensils, or laundry.

Staining problems were reported by 33% of clinic participants. Rusty (28%) was the most commonly reported stain. An objectionable odor was reported by 18% of clinic participants, mainly citing a rotten egg smell in their water (16%). Eight percent reported unpleasant tastes, indicating sulfur and metallic as the most common (each chosen by 4% of participants). Twelve percent reported having particles in their water, the most common being white flakes (6%). Finally, 6% reported an unnatural appearance in their water, observed as muddy or yellow (each 2% of the participants).

Bacteriological Analysis

Private water supply systems can become contaminated with potentially harmful bacteria and other microorganisms. Microbiological contamination of drinking water can cause short-term gastrointestinal disorders, such as cramps and diarrhea that may be mild to very severe. Other diseases that may be contracted from drinking contaminated water include viral hepatitis A, salmonella infections, dysentery, typhoid fever, and cholera.

Microbiological contamination of a water supply is typically detected with a test for total coliform bacteria. Coliform bacteria are present in the digestive systems of humans and animals and can be found in the soil and in decaying vegetation. While coliform bacteria do not cause disease, they are indicators of the possible presence of disease causing bacteria, so their presence in drinking water warrants additional testing.

Positive total coliform bacteria tests are often confirmed with a re-test. If coliform bacteria are present in a water supply, possible pathways or sources include: (1) improper well location or inadequate construction or maintenance (e.g. well too close to septic, well not fitted with sanitary cap); (2) contamination of the household plumbing system (e.g. contaminated faucet, water heater); and (3) contamination of the groundwater itself (perhaps due to surface water/groundwater interaction).

The presence of total coliform bacteria in a water sample triggers testing for the presence of *E. coli* bacteria. If *E. coli* are present, it indicates that human or animal waste is entering the water supply.

Of the 51 samples collected, 20% tested positive (present) for total coliform bacteria. Subsequent *E. coli* analyses for all of these samples showed that 2% of the samples tested positive for *E. coli* bacteria.

Program participants whose water tested positive (present) for total coliform bacteria were encouraged to retest their water to rule out possible cross contamination, and were given information regarding emergency disinfection, well improvements, and septic system maintenance. Any participant with a sample that tested positive for *E. coli*, was encouraged to take more immediate action, such as boiling water or using another source of water known to be safe until the source of contamination could be addressed and the water supply system disinfected. After taking initial corrective measures, participants were advised to have their water retested for total coliform, followed by testing for *E. coli*, if warranted. In addition, participants were provided with resources that discussed continuous disinfection treatment options.

Table 1, found at the end of this report, shows the general water chemistry and bacteriological analysis contaminant levels for the Clarke/Frederick drinking water clinic participants.

Chemical Analysis

As mentioned previously, all samples were tested for the following parameters: iron, manganese, nitrate, chloride, fluoride, sulfate, pH, total dissolved solids (TDS), hardness, sodium, and copper. Selected parameters of particular interest for the Clarke/Frederick drinking water clinic samples are discussed below.

Hardness

Hard water contains high levels of calcium and magnesium ions that dissolve into groundwater while the water is in contact with limestone and other minerals. Hard water is a nuisance and not a health risk.

Twenty-six of the clinic samples were considered “very hard” (exceeding 180mg/L of hardness). Hard water is indicated by scale build-up in pipes and on appliances, decreased cleaning action of soaps and detergents, and reduced efficiency and lifespan of water heaters. Ion exchange water softeners are typically used to remove water hardness.

Sodium

The EPA limit for sodium in drinking water (20 mg/L) is targeted for the most at-risk segment of the population, which are those with severe heart or high-blood pressure problems. The variation in sodium added to water by softeners is very large (ranging from around 50 mg/L to above 300 mg/L). Sodium in drinking water should be considered with respect to sodium intake in the diet. The average American adult consumes 2000 - 4000 mg of sodium per day. If concerned about sodium in water, intake should be discussed with a physician.

Of the 51 clinic samples, 71% exceeded the EPA standard of 20 mg/L. Some of this sodium could result from sodium naturally present in the geology (rocks, sediment) where well water originates, but the primary source of sodium is a water softener. There are several options for addressing sodium levels in softened water. Since only water used for washing needs to be softened, a water treatment specialist can bypass cold water lines around the softener, softening only the hot water and reducing the sodium in the cold drinking water. Another option is using potassium chloride instead of sodium chloride for the softener, although this option is more expensive.

Total Dissolved Solids (TDS)

As water moves underground or over land it dissolves a variety of compounds including minerals, salts, and organic compounds. The concentration of TDS in a water sample is a measure of all dissolved impurities in a water sample. This measure does not identify individual compounds or their sources. High concentrations of dissolved solids may cause adverse taste effects and may lead to increased deterioration of household plumbing and appliances. The EPA secondary maximum contaminant level (SMCL) is 500 mg/L for TDS. Thirty-seven percent Clarke/Frederick participants exceeded this level.

Conclusions

Participants were asked to complete a program evaluation survey following the interpretation meeting. Thirty-one percent of respondents said they would shock chlorinate, 31% said they would improve functioning of existing treatment, 23% said they would pump out their septic and 77% plan to discuss what they learned with others.

References

U.S. Environmental Protection Agency. Drinking Water Contaminants. http://www.epa.gov/safewater/contaminants/index.html. Accessed online 11/2011.

Virginia Cooperative Extension. Virginia PowerPoint Map. http://www.intra.ext.vt.edu/marketing/maps/powerpoint.html Accessed online 11/2011.

Virginia Department of Environmental Protection Groundwater Protection Steering Committee.

Virginia's Five Physiographic Provinces.
http://www.deq.virginia.gov/gwpsc/geol.html
Accessed online 11/2011.

Additional Resources

For more information about the water quality problems described in this document, please refer to our website. Here you will find resources for household water testing and interpretation, water quality problems, and solutions:
www.wellwater.bse.vt.edu/resources.php

Acknowledgements

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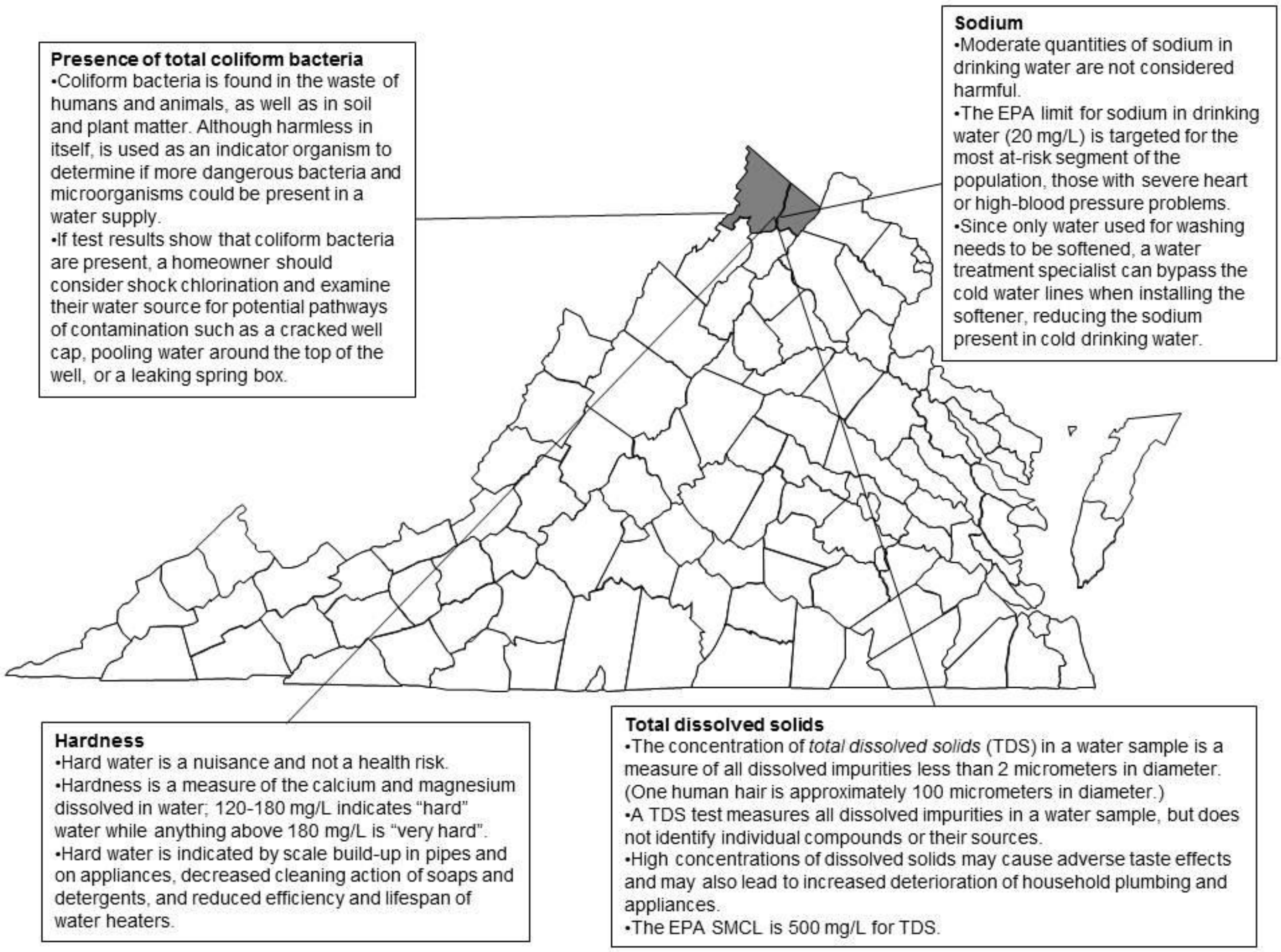

Figure 1. The most common household water quality issues found in the 51 Clarke/Frederick clinic participant samples were high levels of sodium, hardness, total dissolved solids, and the presence of total coliform bacteria.

2011 Clarke and Frederick County VAHWQP Drinking Water Clinic Results N = 51 samples				
Test	EPA Standard	Average	Maximum Value	% Exceeding Standard
Iron (mg/L)	0.3	0.043	0.550	2.0
Manganese (mg/L)	0.05	0.022	0.521	7.8
Hardness (mg/L)	180	120.3	597.7	25.5
Sulfate (mg/L)	250	34.9	332.3	2.0
Chloride (mg/L)	250	25	183	0
Fluoride (mg/L)	2.0/4.0	0.17	0.51	0
Total Dissolved Solids	500	452	992	37.3
pH	6.5 to 8.5	7.05	5.76 (min) 7.81 (max)	5.9 (<6.5) 0 (>8.5)
Copper (mg/L)	1.0/1.3	0.016	0.122	0
Sodium (mg/L)	20	96.51	290.40	70.6
Nitrate - N (mg/L)	10	2.539	10.810	2.0
Total Coliform Bacteria	ABSENT	--	--	19.6
E. coli Bacteria	ABSENT	--	--	2.0

Table 1. General water chemistry and bacteriological analysis contaminant levels for Clarke/Frederick drinking water clinic participants (N=51). This program uses the EPA primary and secondary standards of the Safe Drinking Water Act, which are enforced for public systems, as guidelines for private water supplies.