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# Evaluation of Household Water Quality in Richmond and Westmoreland Counties, Virginia



1999

Household Water Quality Series 36  
Department of Biological Systems Engineering  
Virginia Polytechnic Institute and State University  
Blacksburg, Virginia 24061-0303

**Virginia Cooperative Extension**



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# **EVALUATION OF HOUSEHOLD WATER QUALITY IN RICHMOND AND WESTMORELAND COUNTIES, VIRGINIA**

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# Evaluation of Household Water Quality in Richmond and Westmoreland Counties, Virginia

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## ABSTRACT

During Spring 1998 in Richmond and Westmoreland Counties, Virginia, programs of household water quality education, which included water sampling, testing, and diagnosis, were conducted. Participation in the water quality programs was made available to any resident of these two counties who utilized a private, individual water supply. During the course of the projects, 135 households submitted water samples which were analyzed for iron, manganese, hardness, sulfate, chloride, fluoride, total dissolved solids, pH, saturation index, copper, sodium, nitrate, and total coliform and E. coli bacteria. These analyses identified the major household water quality problems in these two counties as iron/manganese, corrosivity, and bacteria. Additionally, a number of samples were determined to have concentrations of sodium and nitrate high enough to possibly lead to health complications for at-risk segments of the population.

After the completion of the general water testing program, water supplies from 7 households were resampled for the testing of 23 pesticides and other chemical compounds. None of the samples had a concentration of any of these contaminants exceeding EPA Health Advisory of Maximum Contaminant Levels. Furthermore, a total of only four detections were observed, all of which were trifluralin.

Following completion of the programs, a survey was mailed to the 135 participants. Forty participants returned survey forms on which they identified their reason(s) for participating in such a program; the primary reason was concern about safety of their water supply. Returned survey forms also provided insight into measures participants had already taken, or planned to take, to improve the quality of their water supply. More than one-half of the households who reported having at least one water quality problem had taken, or planned to take, at least one measure to improve the quality of their water supply. Ten percent or more of all participants had taken, or planned to take, one or more of the following actions: use bottled water for drinking/cooking and shock chlorinate the water system.

# ACKNOWLEDGMENTS

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Many thanks are due the residents of Richmond and Westmoreland Counties who participated in the educational program. Without their enthusiasm and cooperation, the program could not have succeeded. Special thanks are extended to all others who provided support in terms of publicity, encouragement, and interest, thus contributing to the success of the household water quality educational program. The public officials from the two counties, as well as Virginia Department of Health personnel, who spoke at the public meets are appreciated for their contributions.

The Boards of Supervisors of both counties are especially acknowledged for their financial support of the program. In addition, funding was provided by the Cat Point Creek Watershed Project. CSREES/USDA Water Quality Program Support 3-d funds were also made available for this program.

The Water Quality Laboratory of the Department of Biological Systems Engineering at Virginia Tech was responsible for the majority of the water quality analyses, as well as coordination among the various labs and for much of the data management. Carol Newell, Laboratory Supervisor, and her staff are especially acknowledged for their efforts. Assisting with the general water chemistry analysis was the Soils Testing Laboratory of the Department of Crop and Soil Environmental Sciences at Virginia Tech. The Pesticide Research Laboratory, of the Biochemistry and Anaerobic Microbiology Department of Virginia Tech, performed the pesticide analyses.

Additional support from Virginia Tech should also be noted. Judy Poff, of the Virginia Water Resources Research Center, was instrumental in providing educational publications for participants at the public meetings. Joe Gray, of the Virginia Cooperative Extension Distribution Center, is appreciated for his assistance in preparing and mailing the evaluation survey packets to participants. Appreciation is due Diane Mahaffey for her efforts in preparing project forms and in typing this manuscript. In addition, Bev Brinlee and Tim FisherPoff are acknowledged for their editorial and design contributions.

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# INTRODUCTION

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The water supply and wastewater disposal requirements of the vast majority of rural homes and farms throughout Virginia are met by individual water supply and wastewater disposal systems. In Richmond and Westmoreland Counties, for example, more than three-fifths of all housing units (61%) are served by individual water systems (Koebel et al., 1993). Virtually all of these homes depend on groundwater sources.

Throughout these two counties, most wells were drilled only for farm or domestic water supply. George and Gray (1988) have estimated that 80% of the drilled wells are inadequately constructed, while 90% all dug/bored wells are inadequate. Three percent of households were also estimated to have failing or inadequate waste disposal systems.

Richmond and Westmoreland Counties have a combined land area of 421 square miles. Both counties lie within the Coastal Plain physiographic province. Richmond and Westmoreland Counties comprise part of the Northern Neck of Virginia with the former bordered to the south and west by the Rappahannock River. Westmoreland County, located to the north of Richmond County, has a small portion of its border on the Rappahannock River, while it has much larger frontage on the Potomac River. Consequently, Westmoreland County drains into both river basins, while essentially all of Richmond County drains into the Rappahannock River only.

The population of the two-county area increased by more than 8% during the period 1980-90. Some new home sites are rural-based without public water and sewage services. As rural home sites encroach on agricultural land, the water supply becomes suspect to residents. Of equal importance is the potential failure of septic systems, since many home sites are on land less than ideal for a properly functioning septic system.

One such area of the two-county region experiencing water quality impacts is the Cat Point Creek Watershed. This watershed, which straddles part of the border of Richmond and Westmoreland Counties, drains 73 square miles of the two counties. It remains largely rural with most of its area consisting of agricultural land, woodland and tidal marsh. The watershed has a high potential for nonpoint source pollution considering the extent of agricultural production. A multi-year Federal Grant designed to improve Cat Point Creek Watershed surface water (and groundwater) quality provided funding for additional technical assistance and cost sharing for implementation of innovative soil and water conservation practices, as well as on-farm assessments under the pilot Virginia Farm\*A\*Syst Program.

In addressing similar concerns, Ross et al. (1991) initiated a pilot program of household water quality education in Warren County, Virginia, which included water sampling, testing, and diagnosis. Based on requests and support from local interests, subsequent programs have been conducted in 40 additional counties. During the course of these projects, more than 6,200 households submitted water samples through local Virginia Cooperative Extension Offices to be analyzed for the following: iron, manganese, hardness, sulfate, chloride, fluoride, total dissolved solids, pH, saturation index, copper, sodium, nitrate, and total coliform and fecal coliform/E. coli bacteria.

Major household water quality problems identified, as a result of these previous analyses, were determined to be iron/manganese, hardness, fluoride, and total dissolved solids, and because of their potential health significance, corrosivity, bacteria, and to a lesser extent, sodium and nitrate, although the occurrence and extent of these problems varied across counties. In most county programs, a limited number of additional samples from “high-risk” households were tested for over two dozen pesticides and other chemical compounds. Most of these compounds have been detected in measurable quantities in one or more samples, with several values exceeding a corresponding U.S. Environmental Protection Agency Health Advisory Level (HAL) or Maximum Contaminant Level (MCL). It was the need to assess the current state of rural household water supplies in Richmond and Westmoreland Counties, as well as the Cat Point Creek Watershed, in addressing the above water quality issues, that led to the implementation of the Household Water Quality Education Program in both counties.

## **OBJECTIVES**

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The primary goal of this project was to conduct educational programs on household water quality to include water testing/diagnosis in Richmond and Westmoreland Counties, Virginia while also assessing the status of those household water supplies in the Cat Point Creek Watershed. The general program objectives were to: (1) improve the quality of life of rural homeowners by increasing awareness and understanding of water quality problems, protection strategies, and treatment alternatives; and (2) create a groundwater quality data inventory to assist local governments in land use and groundwater management planning.

## **METHODS**

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Household water quality educational programs were offered through the local Virginia Cooperative Extension Offices in Richmond and Westmoreland Counties during Spring 1998. Any household resident of these counties who utilized a private, individual water supply was eligible to participate. The programs were patterned after the model developed under the pilot educational program completed in 1989 in Warren County (Ross et al., 1991). Local news media and agency newsletters publicized the program in each county, and program fact sheets were prepared (see Appendix).

The programs were launched through local meetings held in Warsaw and Montross in mid-March. Attendees of these initial meetings were presented with information on local hydrogeologic characteristics in relation to groundwater pollution, likely sources of, and activities contributing to, groundwater contamination, the nature of household water quality problems (both nuisance and health-related), and specifics of the water testing program to follow. At these meetings, individuals were invited to sign up to participate in the testing program at a basic cost of \$20 per household water sample submitted, which was further reduced to \$10 if the household was located within the boundaries of the Cat Point Creek Watershed.

Provisions were made to analyze up to 150 household water samples per county. Water sampling kits, for use by the participants themselves, were made available at the meetings and at the county Cooperative Extension offices after the meetings for late registrants. Two types of water sampling kits were distributed: (1) general water chemistry analysis for iron, manganese, hardness,

sulfate, chloride, fluoride, total dissolved solids, pH, saturation index (Langlier), copper, sodium, and nitrate; and (2) bacteriological analysis (total coliform and E. coli).

The sampling kits included a 250 ml plastic bottle for general water chemistry samples and a sample identification form (see Appendix). The form included sampling instructions and a questionnaire on which participants were asked to describe the characteristics of their water supply. Also included in the kits was a 125 ml sterilized plastic bottle for bacteriological samples. Instructions called for sampling from a drinking water tap and for flushing water systems prior to sampling to minimize contaminants contributed by the plumbing system. Persons who already had a water treatment device, such as a water softener, were requested to provide information about the type of equipment so that effective evaluation of their water quality and proper interpretation of results could be obtained, as further explained below.

Water samples were collected on March 17 and 31 at the Extension offices in Warsaw and Montross. At the close of each collection day, all samples were packed in ice and immediately delivered to Virginia Tech in Blacksburg for analysis.

The general water chemistry and bacteriological analysis was coordinated by the Department of Biological Systems Engineering Water Quality Laboratory at Virginia Tech. The Soils Testing Laboratory of the Department of Crop and Soil Environmental Sciences at Virginia Tech was subcontracted to analyze samples for several of the constituents. Water quality analyses were performed using standard analytical procedures (USEPA, 1979).

After the analysis had been completed for each county, participants were reminded by mail to attend subsequent meetings in either Warsaw or Montross to obtain and discuss the test results and management practices to reduce or prevent water contamination. Complete test results were ultimately mailed to those participants who could not attend any of the meetings. A sample report form and accompanying report interpretation are shown in the Appendix.

At the conclusion of the general water testing program described above, participating households were given the opportunity to have their water further tested, for the presence of pesticides and other chemical compounds, at a cost of \$75 per sample, except for households located within the Cat Point Creek Watershed for which this analysis was offered for \$50, as a result of available grant funding. The Pesticide Research Laboratory of the Biochemistry and Anaerobic Microbiology Department at Virginia Tech performed the analyses. Sample jars and forms (see Appendix) were provided, whereby local project personnel collected the samples from August 11–13, 1998.

At the conclusion of the programs, an evaluation survey was mailed to participants (see Appendix). The objectives of the survey were to determine (1) the reasons for participation in the educational programs and for having household water tested, and (2) the actions to correct water quality problems the participants had taken, or planned to take, as a result of participation in the programs. Limited socio-economic information was also requested to obtain a profile of the total audience reached by the programs.

In addressing overall project objective 2, local government and public officials were kept apprised of water quality test results, during the course of the programs and at their completion. While the project was designed to involve voluntary participation, and quality control in sampling was not assured, the information gathered was nevertheless deemed useful for water quality assessment and planning at county and regional levels.

# FINDINGS AND RESULTS

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During the course of the projects, 135 individual household water samples were returned for general water chemistry and bacteriological analysis from all areas of the two counties. Two surveys were distributed to all water testing participants: One, the questionnaire with the water sampling kit, to be completed and returned by all participants with the sample submitted for analysis; and the other, an evaluation of the completed programs (see Appendix). For the latter, of the 135 forms mailed, 40 were returned (a 30% response rate). Both surveys provided insight into the characteristics of the households and their water supplies.

## Profile of Participant Households

The average length of the respondents' residence in Richmond or Westmoreland Counties was 20 years. The length of residence reported ranged from 1 to 60 years. Twenty-three percent of those responding had lived in their present county for 5 years or less. The size of the respondents' households ranged from one to five members; average household size was 2.44. It can, therefore, be estimated that more than 325 residents of the two counties were directly impacted by the water analysis/diagnosis aspect of the programs.

More than two-fifths (43%) of the respondents were college graduates and 95% had at least a complete high school education (see Figure 1); facts that are not surprising, since it is likely that such individuals would have a greater awareness and understanding of water quality issues and be more likely to participate in such a program.

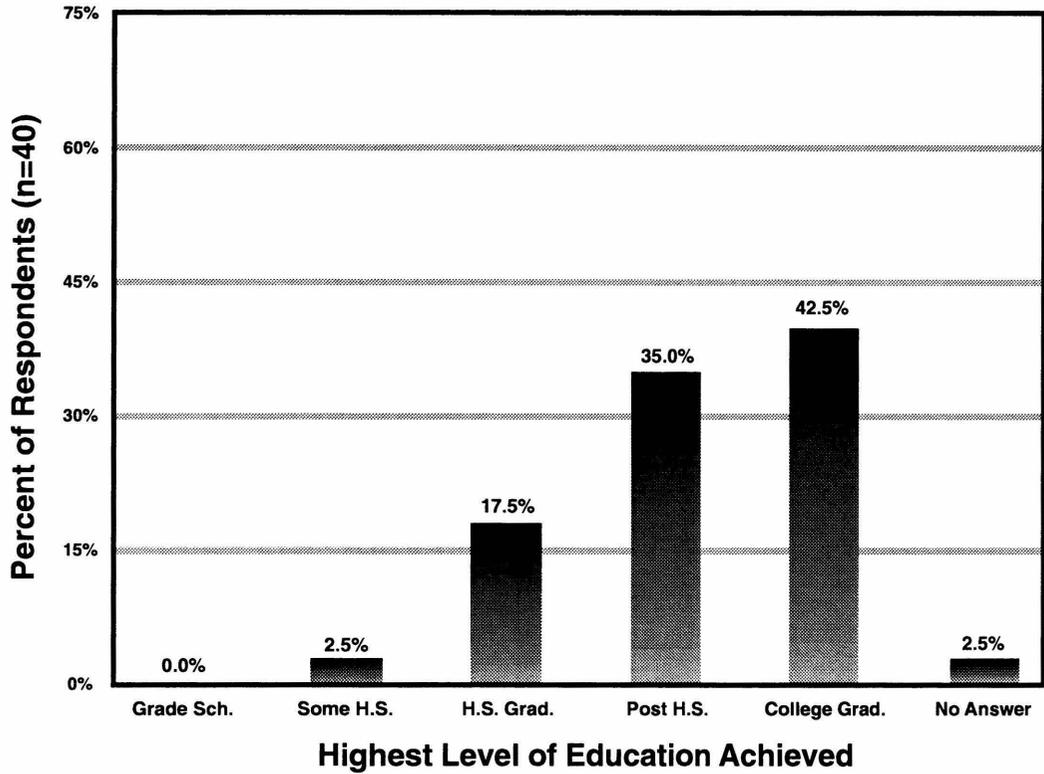
Participation in the program was on the high end of income distribution. Figure 2, which shows the family income (before taxes) of the respondents, indicates that a majority of the respondents exceeded the median family income (\$29,450 averaged for the two counties and according to the 1990 Census) (Koebel et al., 1993). Eighteen percent of respondents declined to indicate family income.

## Profile of Household Water Supplies

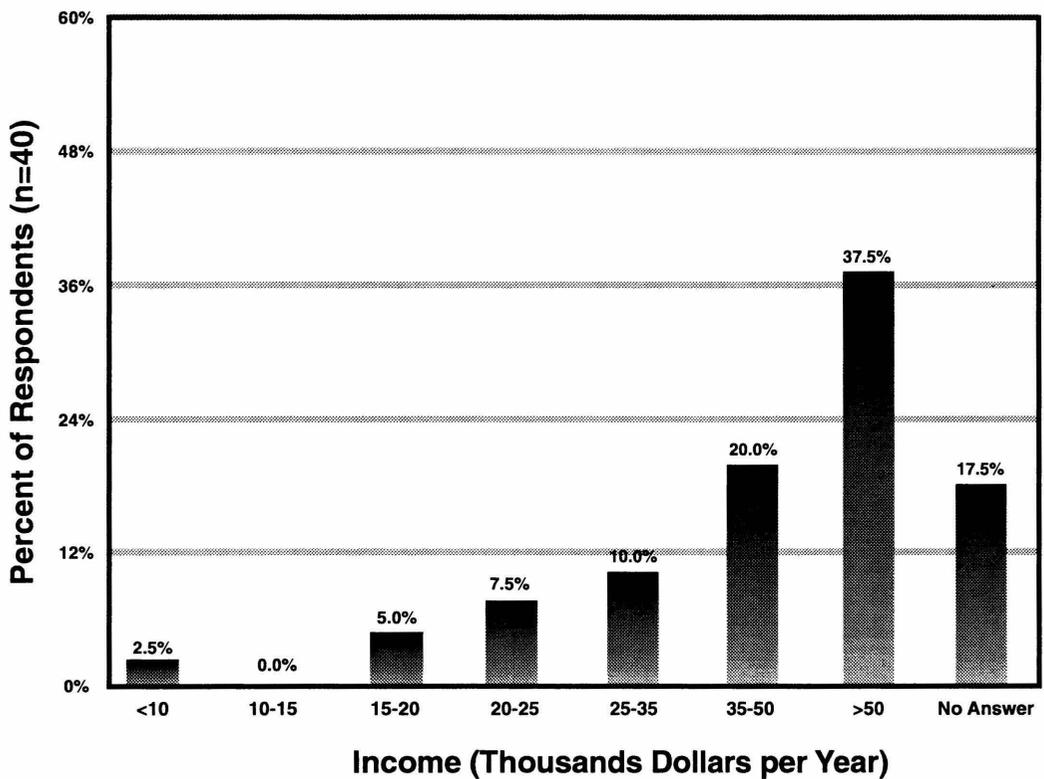
The initial survey answers, provided by all 135 participants in the water testing programs, helped to characterize their water supplies (see Appendix). One set of questions dealt with the proximity of the household water supply to potential sources of groundwater contamination. One such question sought to define housing density, which may have an impact primarily from the standpoint of contamination from septic systems and related water quality problems. Participants were asked to classify their household environs as one of the following four categories, ranging from low to high density: (1) on a farm, (2) on a remote, rural lot, (3) in a rural community, and (4) in a housing subdivision. As shown in Figure 3, farm and rural community were the most common at 40% and 37%, respectively, while subdivision (5%) was the least common.

Participants were also asked to identify potential contamination sources within 100 feet of their water supply. The major sources identified were septic system drainfields and home heating oil storage tanks, noted by 26% and 24% of all households. Indications of proximity (within one-half mile) to larger activities which could potentially contribute to groundwater pollution were also sought. Agricultural activities were the most commonly identified; 68% of the participants indicated that their water supply was located within one-half mile of field crop production and 16% within one-half mile of a major farm animal operations.

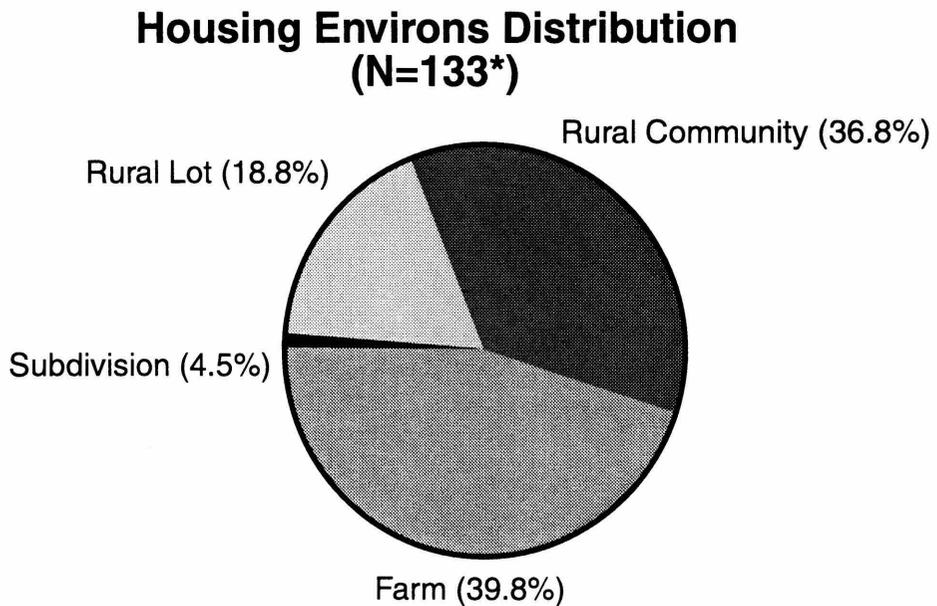
**Figure 1. Educational Level Achieved by Participants**



**Figure 2. Family Income of Participants**



**Figure 3. Housing Environs of Participants**



\* Two participants did not respond.

Information was also obtained regarding characteristics of the participants' water supply systems. Regarding the type of water source supplying the household, all of the participants reported that they rely on a well. Participants were asked to provide an estimate of the well depth, if known. Of those participants indicating well depths, 70% reported depths of more than 50 feet, while 30% reported less than or equal to 50 feet. The maximum well depth reported was 600 feet; the average well depth was 178 feet. Thirty-three percent of the wells were constructed in or prior to 1970. The earliest reported well construction date was 1810.

Household water systems were further identified with respect to the type of material used in the piping network for water distribution throughout the dwellings. The most widely used material was copper (52%), while plastic was reported by 36% of the participants. Three percent of participants reported, "Don't know."

To properly evaluate the quality of water supplies in relation to the point of sampling, participants were asked if their household water systems had water treatment devices currently installed, and if so, the type of device. The results of the inquiry are presented in Figure 4. Four percent of the participants reported at least one treatment device installed, with the most common type of treatment device in use being a sediment filter (50%). Seventeen percent of those with treatment device(s) indicated "other."

### **Participants' Perceptions of Household Water Quality**

Participants were also asked about problems they were experiencing in their household water systems (see Appendix). They were asked initially whether or not they experienced one or more of the following conditions: (1) corrosion of 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. With the exception of (1) above, with which 19% of the participants identified, participants were given several more specific descriptions from which to choose if answering positively.

Nineteen percent of the participants responded that their water had an unpleasant taste. For these participants, the identification of tastes is presented in Figure 5. "Sulfur" taste was the most common problem (32%), followed by "metallic", identified by 28% of those who reported taste problems. Twenty percent of these reported "other" tastes, such as swampy.

An objectionable odor was reported by 17% of the participants. Of these, the description of odors selected is shown in Figure 6. The most prevalent odor described was "rotten egg," or sulfur, identified by 74% of those reporting odor problems. Thirteen percent provided other odors, such as marshy.

Thirteen percent of the participants affirmed their water had an unnatural color or appearance. "Muddy" was identified by 47% of those who reported appearance problems (Figure 7), followed closely by 41% indicating "yellow." Twelve percent offered their own descriptions by selecting "other" to include cloudy.

A related question sought to identify the presence of solid particles in participants' water supplies. Eight percent described such a condition; more than one-half of these (55%) reported that they noticed "white flakes" in their water (Figure 8). Nine percent indicated "other."

Staining problems on plumbing fixtures, cooking appliances/utensils, and/or laundry were reported by 39% of the participants. As presented in Figure 9, the major problem was that of "blue-green" identified by 52% of those with staining problems, followed by "rusty" stains, reported by 37%.

## **Household Water Quality Analysis**

Ultimately, two sample groups resulted: the "tap water" and "raw water" samples. The "tap water" group consisted of the 135 individual household water supplies analyzed to represent the actual water quality at the drinking water tap (including treated water). The "raw water" group consisted of samples from untreated systems only - a total of 129 samples.

The raw water sample results presented below may not be entirely indicative of the status of raw groundwater quality in Richmond and Westmoreland Counties. This may be particularly true for many of the nuisance contaminants for which treatment systems have been installed, since many of the already treated supplies likely represented the worst cases for specific contaminants correctable by treatment devices. Therefore, the inclusion of actual raw water (before treatment) analyses, if they had been available from those households with treatment devices installed, would likely have tended to worsen the overall assessment of raw water quality in the two counties, however, due to the small number of treated systems, these overall impacts are likely to be minimal.

## **General Water Chemistry Analysis**

The tests included in the general water chemistry analysis are listed in Table 1, along with the detection limits, where appropriate, for each test as determined by laboratory equipment and testing procedure constraints. Also presented are the averages and ranges for each sample group defined for both counties combined. Table 2 provides, for both sample groups and each county, as well as both counties combined and the Cat Point Creek Watershed itself, the percentage of constituent

values exceeding a given water quality standard or guideline. The results and importance of each test for both of the sample groups are individually discussed below.

**Iron.** Iron in water does not usually present a health risk. It can, however, be very objectionable if present in amounts greater than 0.3 mg/L. Excessive iron can leave brown-orange stains on plumbing fixtures and laundry. It may give water and/or beverages a bitter metallic taste and may also discolor beverages.

Overall, 8% of samples in both the tap water raw water sample groups had iron concentrations exceeding the U.S. Environmental Protection Agency (EPA) Secondary Maximum Contaminant Level (SMCL) of 0.3 mg/L. It should be noted that the occurrence of excessive iron was only slightly higher for Westmoreland County as compared to Richmond County (Table 2). The presence of iron was not surprising in view of the generally accepted notion that excessive iron is prevalent in rural water supplies throughout much of Virginia. While none of the participants reported the installation of an iron removal filter, the results of the sample questionnaire (see Appendix) revealed that 37% of the 52 who reported staining problems, or 14% of all participants, classified the color of those stains as “rusty” (red/orange/brown). Stains of this color on plumbing fixtures, cooking appliances/utensils, and/or laundry are usually attributed to excessive iron concentrations.

It should be noted that the SMCL for iron is likely based more on taste considerations than long-term staining tendencies, particularly on plumbing fixtures. It has been suggested that concentrations below 0.1 mg/L are preferred, when stain prevention is of concern. When a value of 0.1 mg/L was used as the threshold concentration, an additional 16% and 17% of samples in the tap water and raw water sample groups, respectively, of both counties exceeded this limit.

**Manganese.** Manganese does not present a health risk. However, if present in amounts greater than 0.05 mg/L, it may give water a bitter taste and produce black stains on laundry, cooking utensils, and plumbing fixtures.

The results of these analyses indicated that the extent of manganese problems in the two counties was slightly less than that of iron, and that Westmoreland County had more samples with excessive concentrations of both (Table 2). While manganese stains are generally dark and 3% of all participants indicated “black” stains, 3% of the tap water and 2% of the raw water samples exceeded the SMCL for manganese of 0.05 mg/L. The “particles in water” description of “black specks,” reported by 2% of all participants, may also provide evidence of excessive manganese concentrations.

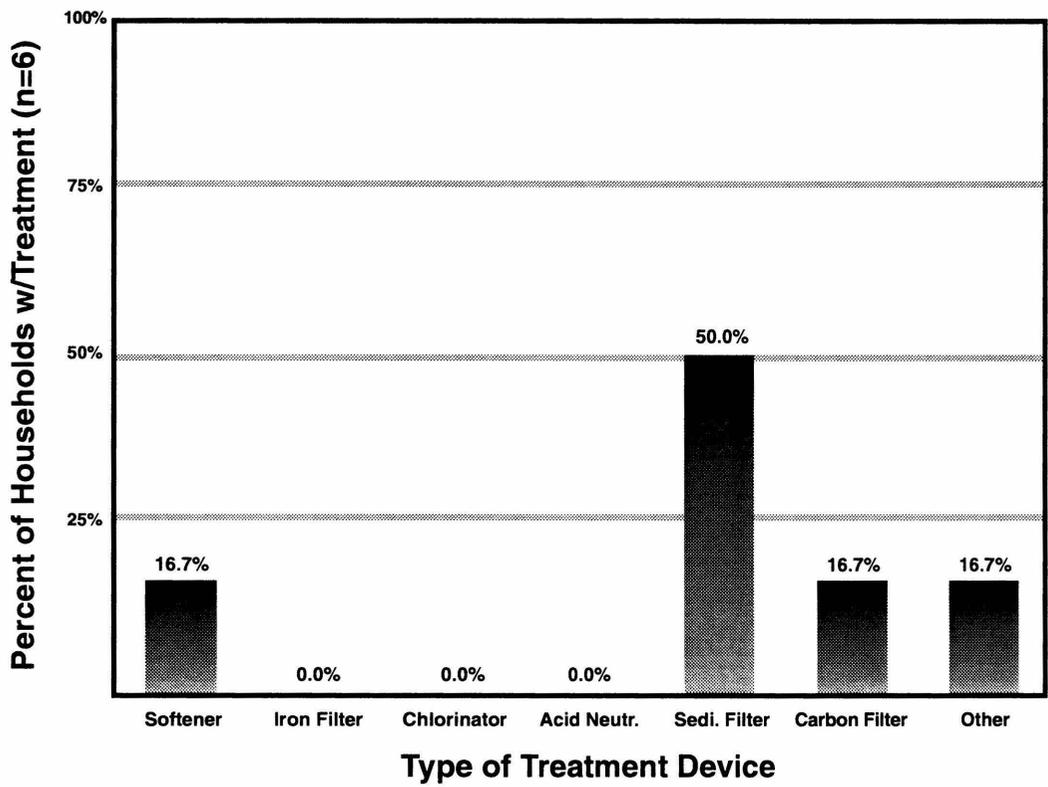
**Hardness.** Hardness is a measure of calcium and magnesium in water. Hard water does not present a health risk. However, it keeps soap from lathering, decreases the cleaning action of soaps and detergents, and leaves soap “scum” on plumbing fixtures, and scale deposits in water pipes and hot water heaters. Softening treatment is highly recommended for very hard water (above 180 mg/L). Water with a hardness of about 60 mg/L or less does not need softening.

Hardness is an additional “natural” parameter usually linked to karst terrain and limestone formations that are not prevalent in this region of Virginia. Extensive use of water softeners is not warranted, and only one participant had installed a water softener (Figure 4). Furthermore, only one sample (from Westmoreland County) in the tap water and raw water groups exceeded the maximum recommended hardness level of 180 mg/L.

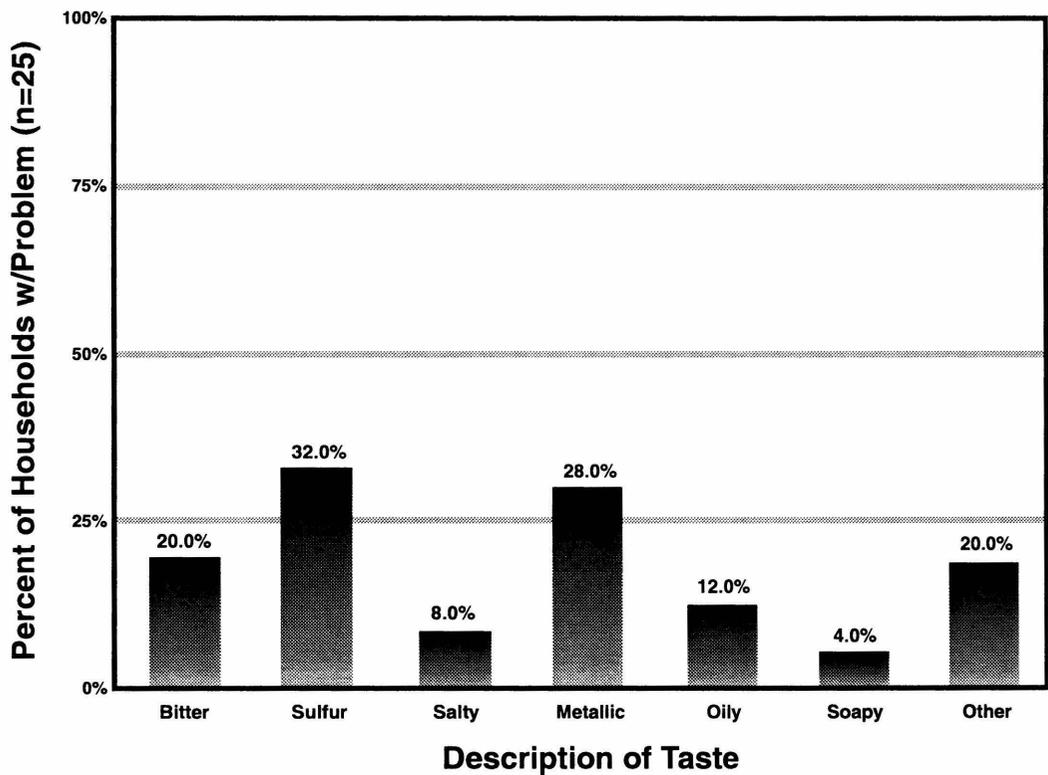
Hardness tolerance, like that of many nuisance contaminants, is somewhat relative to individual preferences. For example, water with total hardness between 60 mg/L and 180 mg/L



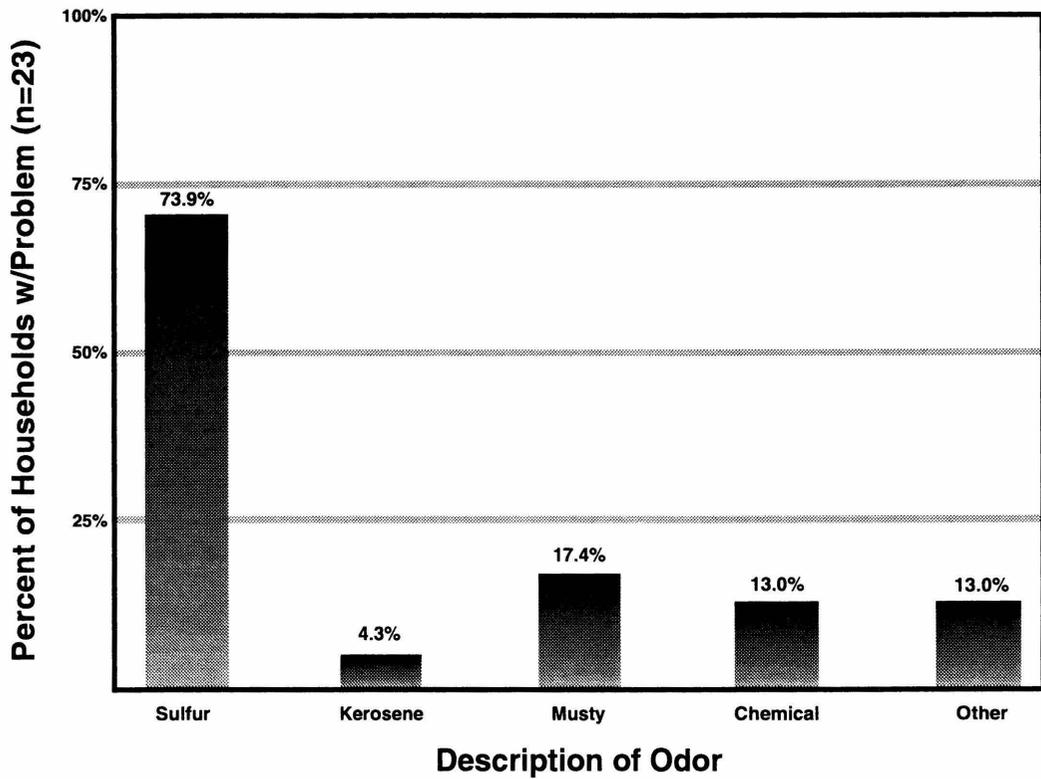
**Figure 4. Household Water Treatment Devices Installed**



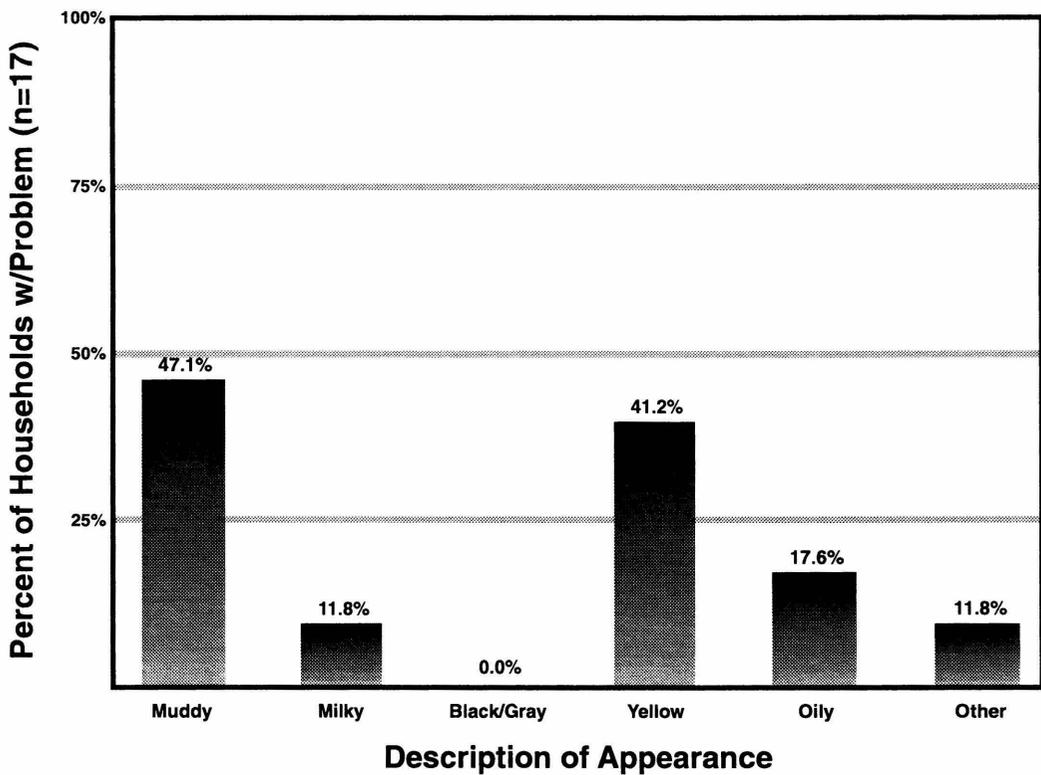
**Figure 5. Unpleasant Tastes Reported by Participants**



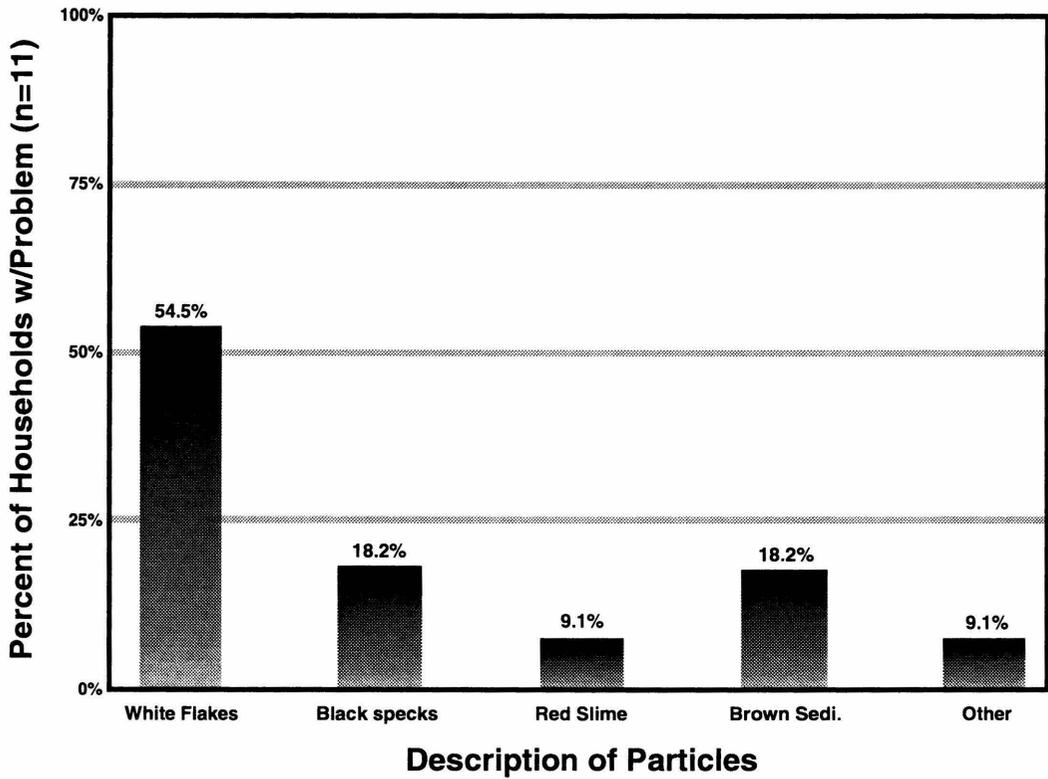
**Figure 6. Objectionable Odors Reported by Participants**



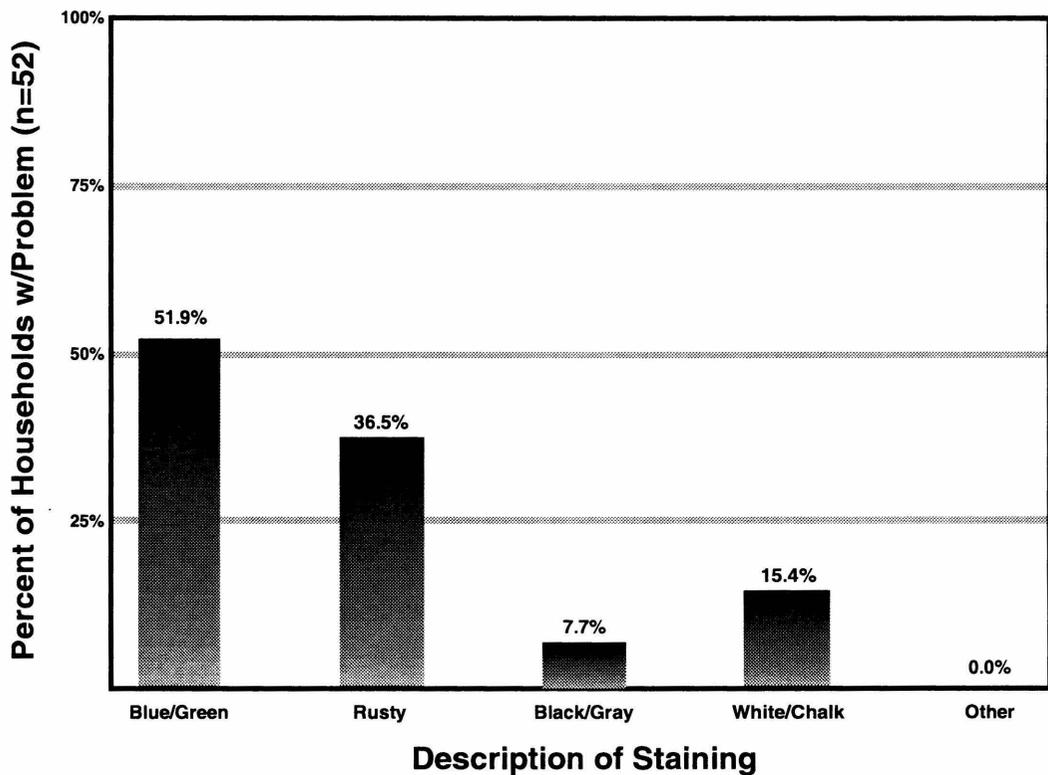
**Figure 7. Unnatural Appearance Reported by Participants**



**Figure 8. Particles in Water Reported by Participants**



**Figure 9. Staining Problems Reported by Participants**



may warrant the installation of a commercial water softener in the view of some household water users while others are satisfied with untreated water. Sixteen percent of both the tap water and raw water samples of both counties were in the range of 60 mg/L to 180 mg/L total hardness, indicating that nearly one-sixth of all samples could be classified as “moderately hard” or “harder.”

Sulfate. High sulfate concentrations may result in adverse taste or may cause a laxative effect. The SMCL for sulfate is 250 mg/L. Sulfates are generally naturally present in groundwater and may be associated with other sulfur-related problems, such as hydrogen sulfide gas. This gas may be caused by the action of sulfate-reducing bacteria, as well as by other types of bacteria (possibly disease-causing bacteria) on decaying organic matter. While it is difficult to test for the presence of this gas in water, it can be easily detected by its characteristic “rotten egg” odor, which may be more noticeable in hot water. Water containing this gas may also corrode iron and other metals in the water system and may stain plumbing fixtures and cooking utensils.

Sulfate concentrations were relatively low for both the raw water and tap water sample groups. None of the raw water or tap water samples exceeded 250 mg/L. The complaints of a “rotten egg/sulfur” odor by nearly three-fourths of those reporting odor problems indicate that hydrogen sulfide gas may be a somewhat widespread problem in household water systems in the two counties; a conclusion that can not be confirmed by the presence of sulfate.

Chloride. Chloride in drinking water is not a health risk. Natural levels of chloride are generally low, and high levels in drinking water usually indicate contamination from a septic system, road salts, fertilizers, industry, or animal wastes. High levels of chloride may speed corrosion rates of metal pipes and cause pitting and darkening of stainless steel. The EPA has set an SMCL for chloride of 250 mg/L. One of the tap water and raw water samples in Westmoreland County exceeded the SMCL for chloride.

Fluoride. Fluoride is of concern primarily from the standpoint of its effect on teeth and gums. Small concentrations of fluoride are considered to be beneficial in preventing tooth decay, whereas moderate amounts can cause brownish discoloration of teeth, and high fluoride concentrations can lead to tooth and bone damage. For these reasons, the EPA has set both a SMCL of 2 mg/L and a Maximum Contaminant Level (MCL) of 4 mg/L. Only one sample in the tap water and raw water groups of Westmoreland County exceeded the SMCL, however at 2.17 mg/L it was less than the MCL.

Total Dissolved Solids (TDS). High concentrations of dissolved solids may cause adverse taste effects and may also deteriorate household plumbing and appliances. The EPA SMCL is 500 mg/L total dissolved solids. Average TDS concentrations were 144 mg/L and 146 mg/L for the raw water and tap water sample groups, respectively. None of the samples in either sample group exceeded the standard. The maximum TDS concentration among the raw water samples was 356 mg/L and the tap water samples was 442 mg/L.

pH. The pH indicates whether water is acidic or alkaline. Acidic water can cause corrosion in pipes and may cause toxic metals from the plumbing system to be dissolved in drinking water. The life of plumbing systems may be shortened due to corrosion, requiring expensive repair and replacement of water pipes and plumbing fixtures. Treatment is generally recommended for water with a pH below 6.5. Alkaline water with a pH above 8.5 is seldom found naturally and may indicate contamination by alkaline industrial wastes. The EPA has set a suggested range of between 6.5 and 8.5 on the pH scale for drinking water.

The average pH reading was 7.0 for both the tap water and raw water sample groups. Three of the samples (all in Richmond County) in each sample group exceeded a pH of 8.5, with a maximum pH value in both groups of 8.7. For both the tap water and raw water sample

groups, 40% were less than 6.5 and incidence of excessive acidity was relatively consistent across both counties (Table 2). While the remaining samples had a pH above 6.5, slightly acidic water with a pH between 6.5 and 7.0 can lead to less immediate staining and corrosion problems. An additional 11% of the tap water and raw water samples of both counties fell into this category.

Saturation Index. The saturation index (Langlier) is used, in addition to pH, to evaluate the extent of potential corrosion of metal pipes, plumbing fixtures, etc. It is a calculated value based on the calcium concentration, total dissolved solids concentration, measured pH, and alkalinity. A saturation index greater than zero indicates that protective calcium carbonate deposits may readily form on pipe walls. A saturation index less than zero indicates that the water does not have scale-forming properties and pipes may be subject to corrosion. Saturation index values between -1 and +1 are considered acceptable for household water supplies.

No saturation index values were determined to be above +1 in either sample group. Values of less than -1, however, were determined for 52% of both the tap water and raw water samples. Average saturation index values were -2.09 for both the tap water and raw water sample groups with minimum values of -5.70 in both groups.

Copper. The EPA health standard for copper in public drinking water supplies is 1.3 mg/L, the maximum level recommended to protect people from acute gastrointestinal illness. Even lower levels of dissolved copper may give water a bitter or metallic taste and produce blue-green stains on plumbing fixtures. Consequently, EPA has established an SMCL for copper of 1.0 mg/L in household water.

Only one sample in both the tap and raw water groups exceeded the recommended health level of 1.3 mg/L and the SMCL of 1.0 mg/L. The maximum copper concentration measured was 2.6 mg/L. Since natural levels of copper in groundwater are low, and the primary contributor of copper in drinking water is corrosion of copper water pipes and fittings, low copper levels were expected, even in the case of tap water samples, assuming that water lines were flushed properly prior to sampling.

Sodium. Sodium may be a health hazard to people suffering from high blood pressure or cardiovascular or kidney diseases. For those on low-sodium diets, 20 mg/L is suggested as a maximum level for sodium in drinking water, although a physician should be consulted in individual cases. Average sodium concentrations were 44.5 mg/L and 43.7 mg/L for the tap water and raw water sample groups, respectively, while the maximum concentration was 200 mg/L in the former case and 153 mg/L in the latter case. For the tap water and raw water samples, respectively, 56% and 55% exceeded 20 mg/L with a considerable majority of these samples from Westmoreland County (Table 2).

It should be reemphasized, however, that the suggested threshold of 20 mg/L for sodium is relatively low and applicable only to individuals suffering from health problems, such as heart disease or high blood pressure. To evaluate the presence of high sodium levels in the context of an otherwise healthy individual, a threshold value of 100 mg/L sodium has been suggested. Of both the raw and tap water samples, only 13% exceeded this 100 mg/L threshold.

Nitrate. High levels of nitrate may cause methemoglobinemia or “blue-baby” disease in infants. Though the EPA has set a MCL for nitrate (as N) of 10 mg/L, it suggests that water with greater than 1 mg/L not be used for feeding infants. Levels of 3 mg/L or higher may indicate excessive contamination of the water supply by commercial fertilizers and/or organic wastes from septic systems or farm animal operations, which may be subject to seasonal and climatic influences.

**Table 1. Average and range of concentration of contaminants comprising general water chemistry analysis for Richmond and Westmoreland Counties.**

Test	Detection Limit	Measured Concentrations					
		Raw Water (n=129)			Tap Water (n=135)		
		Avg. <sup>1</sup>	Min.	Max.	Avg.	Min.	Max.
Iron (mg/L)	0.005	0.097	DL <sup>2</sup>	1.436	0.111	DL	2.384
Manganese (mg/L)	0.001	0.020	DL	1.015	0.021	DL	1.015
Hardness (mg/L)	0.3	38.2	2.1	191.3	38.3	DL	191.3
Sulfate (mg/L)	0.3	6.9	DL	29.1	6.9	DL	29.1
Chloride (mg/L)	40.0	45.0	DL	270.0	45.0	DL	270.0
Fluoride (mg/L)	0.5	0.54	DL	2.17	0.54	DL	2.17
TDS (mg/L)	1.0	144.0	20.0	356.0	146.0	20.0	442.0
pH	-	7.04	4.90	8.65	7.04	4.90	8.65
Saturation Index	-	-2.09	-5.70	-0.42	-2.09	-5.70	-0.42
Copper (mg/L)	0.002	0.093	DL	2.610	0.090	DL	2.610
Sodium (mg/L)	0.01	43.67	1.33	152.90	44.50	1.33	199.80
Nitrate (mg/L)	0.005	1.703	DL	14.930	1.715	DL	14.930

<sup>1</sup>Averages calculated on the basis of below detection limit (DL) values set equal to the DL.

<sup>2</sup>Sample concentration non-detectable, i.e., below the detection limit for the given contaminant.

**Table 2. Percent of concentrations exceeding established standards for contaminants comprising general water chemistry and bacteriological analysis for Richmond and Westmoreland Counties, as well as the Cat Point Creek Watershed.**

Test	Standard	Percent of Values Exceeding Standard							
		Raw Water				Tap Water			
		Total n=129	Rich. n=67	West. n=62	WS n=49	Total n=135	Rich. n=71	West. n=64	WS n=51
Iron (mg/L)	0.3	7.8	6.0	9.7	10.2	8.1	7.0	9.4	9.8
Manganese (mg/L)	0.05	2.4	1.5	3.2	4.0	2.9	2.8	3.2	4.0
Hardness (mg/L)	180.0	0.8	0	1.6	0	0.7	0	1.6	0
Sulfate (mg/L)	250.0	0	0	0	0	0	0	0	0
Chloride (mg/L)	250.0	0.8	0	1.6	2.0	0.7	0	1.6	2.0
Fluoride (mg/L)	$\frac{2}{4}$	$\frac{0.8}{0}$	$\frac{0}{0}$	$\frac{1.6}{0}$	$\frac{0}{0}$	$\frac{0.7}{0}$	$\frac{0}{0}$	$\frac{1.6}{0}$	$\frac{0}{0}$
TDS (mg/L)	500.0	0	0	0	0	0	0	0	0
pH - Low	6.5	40.3	41.8	38.7	53.1	40.0	40.8	39.1	52.9
pH - High	8.5	2.3	4.5	0	2.0	2.2	4.2	0	2.0
Saturation Index - Low	-1.0	51.9	50.7	53.2	67.3	51.9	50.7	53.1	66.7
Saturation Index - High	+1.0	0	0	0	0	0	0	0	0
Copper (mg/L)	$\frac{1.0}{1.3}$	$\frac{0.8}{0.8}$	$\frac{0}{0}$	$\frac{1.6}{1.6}$	$\frac{2.0}{2.0}$	$\frac{0.7}{0.7}$	$\frac{0}{0}$	$\frac{1.6}{1.6}$	$\frac{2.0}{2.0}$
Sodium (mg/L)	20.0	55.1	44.8	66.1	40.8	55.5	46.4	65.7	41.1
Nitrate (mg/L)	10.0	3.1	6.0	0	6.1	3.0	5.6	0	5.9
Total Coliform	ABSENT	32.6	40.3	24.2	42.9	32.6	39.4	25.0	43.1
E. coli	ABSENT	7.0	6.0	8.1	12.2	7.4	7.0	7.8	13.7

The maximum concentration of nitrate obtained was 14.9 mg/L for both the tap water and raw water sample groups. Only three percent of the samples (all from Richmond County) in both sample groups exceeded the MCL of 10 mg/L. Thus, serious nitrate contamination does not appear to be a widespread problem in either county. When a 1 mg/L threshold value was selected, however, a much higher occurrence of nitrate was determined. In this case, about one-third of the samples, 32% of both the tap water and raw water samples, exceeded the level of potential concern to infant health. Furthermore, 22% of both the tap water samples and 21% of the raw water samples had nitrate concentrations exceeding 3 mg/L, indicating that health-impacting levels would likely be approached in a number of cases in both counties. In both of the non-standard threshold cases, similar occurrences of excessive nitrate were noted for both counties.

## **Bacteriological Analysis**

A common hazard of private household water supplies is contamination by 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. Of the non-gastrointestinal disorders, one particularly important disease transmissible through drinking water is Viral Hepatitis A. Other diseases include salmonella infections, dysentery, typhoid fever, and cholera.

Coliform bacterial detection is simply an indication of the possible presence of pathogenic, or disease-causing organisms. Detection of coliform bacteria is confirmed by a total coliform analysis result above zero. Coliforms are always present in the digestive systems of all warm-blooded animals and can be found in their wastes. Coliforms are also present in the soil and in plant material. While a water sample with total coliform bacteria present may have been inadvertently contaminated during sampling, other possibilities include surface water contamination due to poor well construction, contamination of the household plumbing system, or water table contamination. To determine whether or not the bacteria were from human and/or animal waste, positive total coliform tests were followed up by an analysis for *E. coli* bacteria.

Of the 135 household water samples from the two counties analyzed for total coliform bacteria, 44 (33%) tested positive (present). Subsequent *E. coli* analysis for these total coliform positive samples resulted in 10, or 23%, positive results, or 7% of all household water samples undergoing bacteriological analysis. The percentages of positive total coliform and *E. coli* results for the raw water sample group were also 33 and 7, respectively. It is interesting to note that the incidence of total coliform was considerably greater in Richmond County water samples as compared to those from Westmoreland County, while the latter had slightly more positive *E. coli* results than the former county.

The susceptibility of household water supplies to bacteriological contamination has often been associated with the type of water source. For example, it is generally accepted that the likelihood of bacteriological contamination of springs is greater than that of well water supplies, which usually offer better protection from surface, or near surface, contaminants. Similarly, deep drilled wells are better protected than shallow dug and bored wells. This contention is clearly borne out by the results of this program, which indicated that the incidence of total coliform and *E. coli* contamination of dug/bored wells was 58% and 15%, respectively, while for drilled wells, positive total coliform and *E. coli* results were obtained for only 15% and 4% of the samples.

While fecal bacteria in household water supplies may have originated from animal waste generation in some cases, it is likely that, considering the wide geographic distribution of positive results and the proximity of water supplies to specific pollution sources, many fecal coliforms present in water were due to human waste from septic systems. Although, positive



**Table 3. Pesticides and other chemical compounds analyzed in 7 household water supplies (Richmond and Westmoreland Counties).**

Common Name	Trade name	Maximum Desired Concentration <sup>1</sup> (ppb) <sup>2</sup>	Maximum Measured Concentration (ppb)	Frequency of Sample Detection
Alachlor	Lasso	2.0	ND <sup>3</sup>	0
Atrazine	Aatrex	3.0	ND	0
Butylate	Sutan	350.0	ND	0
Chlordane		2.0	ND	0
Chlorpyrifos	Dursban	20.0	ND	0
Cyanazine	Bladex	1.0	ND	0
DCPA	Dacthal	400.0	ND	0
DDTs		–	ND	0
Diazinon	Spectracide	0.6	ND	0
Dicamba	Banvel	200.0	ND	0
Dieldrin		–	ND	0
Disulfoton	Disyston	0.3	ND	0
Lindane		0.2	ND	0
Linuron		–	ND	0
Malathion	Cythion	200.0	ND	0
Methoxychlor	Marlate	40.0	ND	0
Metolachlor	Dual	70.0	ND	0
Prometon		100.0	ND	0
Simazine	Princep	4.0	ND	0
Trifluralin	Treflan	5.0	0.005	4
2, 4-D		70.0	ND	0
2, 4, 5-T		70.0	ND	0
2, 4, 5-TP	Silvex	50.0	ND	0

<sup>1</sup> U.S. EPA MCL or HAL, if available

<sup>2</sup> ppb - parts per billion, equivalent to micrograms per liter in water

<sup>3</sup> ND - Non-detectable (below laboratory detection limit of 0.01 ppb)

**Table 4. Measures taken or planned by respondents, since water quality analysis, to improve water supply (Richmond and Westmoreland Counties)**

Measure	Percent of All Respondents (n=40)	Percent of Respondents who Reported the Following Problems			
		Health Only (n=20)	Nuisance Only (n=2)	Health & Nuisance (n=5)	None (n=13)
Contact an Agency, such as the Health Department	7.5	5.0	0	40.0	0
Seek Additional Water Testing from Another Lab	5.0	10.0	0	0	0
Sign Up For Farm*A*Syst Assessment	7.5	5.0	0	40.0	0
Pump Out Septic System	5.0	0	0	40.0	0
Improve Physical Condition of Water Source	5.0	0	0	40.0	0
Shock-Chlorinate Water System	10.0	15.0	0	20.0	0
Obtain New Water Source	0	0	0	0	0
Use Bottled Water for Drinking/Cooking	20.0	30.0	0	40.0	0
Temporary Disinfection, such as Boiling Water	5.0	5.0	0	20.0	0
Purchase or Rent Water Treatment Equipment	5.0	5.0	0	0	7.7
Improve Existing Water Treatment Equipment	0	0	0	0	0
Take Other Measures to Eliminate/Reduce Contaminant(s)	7.5	10.0	0	0	7.7
Have Not Done Anything	57.5	50.0	100.0	0	84.6

results should be viewed with concern, they are not a cause for panic. Individuals have probably been drinking this water for some time with no ill effects and could possibly continue to do so. Nevertheless, such problems should be further investigated and remedied, if possible. Program participants whose water tested positive were given information regarding emergency disinfection, well improvements, septic system maintenance and other steps to correct the source of contamination. After taking initial corrective measures, they were advised to have the water retested for total coliform, followed by E. coli tests, if warranted.

## **Pesticide Analysis**

As mentioned earlier, several of the original participating households opted to pay for additional testing of pesticides and other chemical compounds. Ultimately, 7 household water supplies, of the original total of 135, were resampled. The 23 constituents analyzed were considered to be the most likely to be found in groundwater partly because they are currently, or were recently, in common use in the two-county area. These pesticides and other compounds are listed in Table 3.

Analysis of these constituents revealed little evidence of excessive contamination in terms of human health implications. Out of a total of 161 test results, 157 or 97.5%, resulted in concentrations below the laboratory detection limit (considered to be approximately 0.01 parts per billion, or ppb). Four water samples had a compound present in a detectable concentration. As shown in Table 3, four detections of trifluralin resulted, all of which were well below the EPA Health Advisory Level (HAL) of 5.0 ppb.

## **Post-Program Survey**

Following the completion of the basic educational program, a survey form (see Appendix) was mailed to the 135 households whose water supply had been tested. The objectives of the survey were to determine: 1) reasons for program participation and for having water tested, and 2) what the respondents had done to correct water quality problems as a result of participation in the educational program. Forty (30%) had returned the survey forms by the deadline.

## **Household Water Testing History**

Participants were asked to indicate their previous experience with water testing and, specifically, if and when they had last had a laboratory analysis of their present household water supply. Thirty-eight percent of the respondents indicated that they had previously obtained water test results. Of those reporting a prior testing date, 40% had done so within the past five years and 13% within the past two years.

## **Reasons for Program Participation**

People participated in the water quality program for one or more reasons. Seventy-eight percent of the respondents were prompted to participate by concern about the safety of their water supply. Thirty percent of the respondents were prompted by nuisance problems, such as staining, objectionable taste and odor, etc. Eight percent wanted to follow up on previous tests of their household water. Twenty-eight percent cited other reasons, such as general curiosity and low-cost opportunity.

## Follow-up Activities Taken or Planned

Participants were asked to indicate the measures they planned to take, or had already taken, to improve the quality of their water supply, since receiving the results of their water quality analysis. Table 4 presents the results of this inquiry, with the greatest number of households indicating that they had already, or planned to, use bottled water for drinking/cooking.

Participants were asked if the water analysis showed that their water was unsatisfactory for one or more of the following: bacteria, nitrate, sodium, iron, manganese, hardness, and pH. Responses were grouped in four categories: 1) households with potential health problems (positive bacteria test results and/or unsatisfactory levels of nitrate or sodium in their water samples), 2) households with unsatisfactory levels of nuisance contaminants (one or more of the following: iron, manganese, hardness, and pH), 3) households with potential health problems and unsatisfactory levels of nuisance contaminants, and 4) households with neither potential health problems nor unsatisfactory levels of nuisance contaminants.

The measures planned or already taken to improve household water as follow-up to the water quality analysis were generally in agreement with the water quality problems identified by the testing. Of the households with potential health problems only, and those with health problems in combination with unsatisfactory levels of nuisance contaminants, 60% had taken, or planned to take, at least one measure to improve their water supply. The measures taken by the greatest number of households in these two categories were: use bottled water for drinking/cooking and shock chlorinate the water system.

Respondents were similarly likely to address health-related problems as nuisance problems. Of the households with unsatisfactory levels of one or more nuisance contaminants only and those with nuisance problems in combination with potential health problems, 71% had taken, or planned to take, at least one measure to improve their water supply. Only 15% the households with neither potential health problems nor unsatisfactory levels of nuisance contaminants reported taking follow-up measures.

## CONCLUSIONS

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The Household Water Quality Educational Programs conducted in Richmond and Westmoreland Counties were considered to be successful. The opportunity to participate in the programs was well-received by those residents who chose to do so. Individuals participated in the programs primarily because of concern about the safety of their water supply. Despite being voluntary programs, a geographically distributed sample representing diverse household and water supply characteristics was obtained. While the project was designed for voluntary participation and quality control in sampling was not assured, the type of information gathered and summarized was, nevertheless, deemed useful for water quality assessment at county and regional levels.

Water quality analysis, for many nuisance constituents, generally supported the participants' descriptions of their water supplies regarding such problems as staining, taste and odor, and appearance. While a substantial number of households reported nuisance symptoms, only 4% of all households participating had one or more water treatment devices installed.

Considering the results for both the raw and tap water sample groups, and the influence of the few water treatment devices in use, the major remaining household water quality problems

in the few Richmond and Westmoreland Counties, existing from a nuisance standpoint, were iron/manganese and corrosivity. The major health-related concerns were corrosivity (because of the potential to raise dissolved copper and lead levels in household water) and bacteria. Furthermore, elevated nitrate and sodium concentrations may present a health risk to children and some adults, respectively, in a number of cases. Thirty-three percent of the samples tested positive for total coliform and 7% were positive for E. coli bacteria. In these positive cases, participants were advised of ways to improve water supply conditions and were encouraged to pursue retesting for coliform bacteria.

The limited analysis for pesticides and other chemical compounds revealed few problems with such contamination. In all but four cases, concentrations were nondetectable at levels below 0.01 ppb. None of the 7 tested samples had a concentration of any of the 23 pesticides and other chemical compounds analyzed present in a quantity exceeding the corresponding EPA MCL or HAL.

Fifty-six percent of the households that reported having at least one water quality problem had taken, or planned to take, at least one measure to improve the quality of their water supply. Ten percent or more of all respondents had taken, or planned to take, one or more of the following actions: use bottled water for drinking/cooking and shock chlorinate the water system.

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## APPENDIX \*

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- (1) Program Fact Sheet
- (2) Sample Identification and Questionnaire Form
- (3) Sample Water Quality Analysis Report
- (4) Report Interpretation
- (5) Pesticide Analysis Sample Form
- (6) Post-Program Survey

*\* The following examples represent forms, reports, etc. used in either both counties or the Richmond County Program only. Paperwork for Westmoreland County only was similar, except for the information that was county-specific.*

## HOUSEHOLD WATER TESTING PROGRAM FACT SHEET

**Purpose:** To increase the awareness and understanding of private water system users of household water quality problems, protection and treatment alternatives

**Who is Eligible:**

Household residents of Richmond and Westmoreland counties on **private** water systems which includes wells, cisterns or springs. Public water supply users are not eligible because their water is regularly tested and maintained for health standards. Lab analysis at Virginia Tech. can accommodate a maximum of 300 tests per county.

**Confidentiality:**

All results will be confidential and information gathered will bear no names or sufficient data to determine a particular water supply. Participants should also know that no State or Federal agency has jurisdiction over private wells once they are installed and operating.

**What will be tested:**

Hardness	Iron	Nitrate	Total Coliform Bacteria
pH	Sodium	Chloride	E. Coli Bacteria
Corrosion Index	Copper	Fluoride	
Total Dissolved Solids	Manganese	Sulfate	

**Cost:**

The cost for water tests normally ranges between \$100-200.00. This program will offer the following water test rates;

\$20.00 Richmond & Westmoreland County residents  
\$10.00 Cat Point Creek watershed residents

Participants may pay by cash or check, payable to the **Virginia Cooperative Extension** to receive a water sample kit at one of the informational meetings.

**Information Exchange and Sign-up Meetings:**

Participants must attend **one** of the information meetings to register, make payment and receive a water sample kit. The meeting will include instructions on how to collect a water sample.

**March 9:** Richmond County Courthouse, Warsaw, 7:30 p.m.

**March 10:** American Legion Hall, Montross, 7:30 p.m.

## Program Fact Sheet (cont.)

### **Water Sample Collection Days:**

Water samples must be delivered to either the Richmond or Westmoreland County Extension Office on the following dates;

**March 17** - 8 a.m. to 12:30

**March 31** - 8 a.m. to 12:30

### **Test Results and Explanation:**

Your water analysis results will be given to you at a follow-up meeting scheduled on the dates below. Specialists will be available to explain results and any necessary treatment and protection strategies.

**Attend one of the following meetings;**

**April 20** American Legion Hall, Montross, 7:30 p.m.

**April 21** Richmond County Courthouse, Warsaw, 7:30 p.m.

### **Funding:**

Funding for a Household Water Testing program is provided by;

USDA Extension Water Quality Initiative

Virginia Tech. Department of Biological Systems Engineering

Virginia Cooperative Extension

Richmond and Westmoreland County Boards of Supervisors

Cat Point Creek Watershed Project (EPA 319 grant program)



(2) Sample Identification and Questionnaire Form

**RICHMOND COUNTY HOUSEHOLD WATER QUALITY PROGRAM**

Richmond County Cooperative Extension  
P.O. Box 152  
Warsaw, VA 22572  
(804) 333-3420

**SAMPLE IDENTIFICATION** (Please **print** clearly and provide complete information on both sides of form.)

Sample No.: \_\_\_\_\_ Date collected: \_\_\_\_\_

Sample submitted by:

Name: \_\_\_\_\_

Mailing address: \_\_\_\_\_

\_\_\_\_\_

Telephone: \_\_\_\_\_

<p style="text-align: center;"><b>FOR OFFICE USE ONLY</b></p> <p>Map Grid No. _____</p> <p>Lab Sample No. _____</p>
---

Household water supply source **drawn for sample** (check one):

well     spring     cistern     other (Specify: \_\_\_\_\_)

If **well** is checked above: (a) is it a  dug or bored well,  drilled well,  don't know;

(b) what is its approximate depth, if known? \_\_\_\_\_ feet

(c) what year was well constructed, if known? \_\_\_\_\_

Do other households share the same water supply?  yes  no    If yes, approximately how many? \_\_\_\_\_

Water treatment devices currently installed and affecting **cold water only** drawn at faucet for sample (check **all** that apply):

<input type="checkbox"/> none	<input type="checkbox"/> acid water neutralizer
<input type="checkbox"/> water softener (conditioner)	<input type="checkbox"/> sediment filter (screen or sand type)
<input type="checkbox"/> iron removal filter	<input type="checkbox"/> activated carbon (charcoal) filter
<input type="checkbox"/> automatic chlorinator	<input type="checkbox"/> other (specify: _____)

**SAMPLING INSTRUCTIONS:** You must take your water samples only on the collection day you have been assigned. For the general water analysis sample, use the larger plastic bottle as described below. A separate, smaller bottle is provided for bacteriological samples which should be taken last. If you have any questions about sampling procedures, call the Extension Office at 333-3420.

1. Do not remove caps from sample bottles until you are ready to take each sample. Do not touch inside of cap or mouth of either bottle.
2. Turn on the cold water faucet in the kitchen or bathroom (select a stationary, non-swivel faucet, if possible) and allow the water to run until it becomes as cold as it will get; then let it run for one more minute.
3. Slowly and carefully fill the larger bottle to avoid splashing or overflowing. Pour out this rinse water and then refill bottle completely. Tighten cap on bottle securely.
4. Let the water run for an additional two or three minutes. Reduce flow to prevent splashing and carefully fill the smaller bottle only once to the shoulder (just below the threaded top). **DO NOT RINSE BOTTLE.** Replace cap tightly.
5. Do not write anything on the bottle labels. If samples are not to be delivered immediately, store in refrigerator or on ice until ready to deliver later that day.
6. Fill out this Sample Identification Form and Questionnaire (on reverse side) completely and bring it, along with both water sample bottles, to the designated collection site on your assigned collection day.

## Sample Identification and Questionnaire Form (cont.)

**QUESTIONNAIRE** (Please answer the following questions as completely as possible, considering how you view the **present** condition of the water sampled, including improvements due to any treatment devices identified on other side of form.)

1. Describe the location of your home. (Check **one**)  
 on a farm     on a remote, rural lot     in a rural community     in a housing subdivision
2. What pipe material is primarily used throughout your house for water distribution? (Check **one**)  
 copper     lead     galvanized steel     plastic (PVC, PE, etc.)     other (specify: \_\_\_\_\_)     don't know
3. Do you have problems with corrosion or pitting of pipes or plumbing fixtures?  yes     no
4. Does your water have an unpleasant taste?  yes     no
5. If yes, how would you describe the taste? (Check **all** that apply)  
 bitter     sulfur     salty     metallic     oily     soapy     other (specify: \_\_\_\_\_)
6. Does your water have an objectionable odor?  yes     no
7. If yes, how would you describe the odor? (Check **all** that apply)  
 "rotten egg" or sulfur     kerosene     musty     chemical     other (specify: \_\_\_\_\_)
8. Does your water have an unnatural color or appearance?  yes     no
9. If yes, how would you describe the color or appearance? (Check **all** that apply)  
 muddy     milky     black/gray tint     yellow tint     oily film     other (specify: \_\_\_\_\_)
10. Do you have problems with staining of plumbing fixtures, cooking appliances/utensils, or laundry?  yes     no
11. If yes, how would you describe the color of stains? (Check **all** that apply)  
 blue-green     rusty (red/orange/brown)     black or gray     white or chalk     other (specify: \_\_\_\_\_)
12. In a standing glass of water, do you notice floating, suspended, or settled particles?  yes     no
13. If yes, how would you describe this material? (Check **all** that apply)  
 white flakes     black specks     reddish-orange slime     brown sediment     other (specify: \_\_\_\_\_)
14. If your water supply is located **100 feet or less** from any of the following, please indicate. (Check **all** that apply)  
 septic system drain field     home heating oil storage tank (above or below ground)  
 pit privy or outhouse     pond or fresh water stream  
 cemetery     tidal shoreline or marsh
15. If your water supply is located **½ mile or closer** to any of the following, please indicate. (Check **all** that apply)  
 landfill     marina  
 illegal dump     field crop/plant production  
 active quarry/sand pit     farm animal operation  
 abandoned quarry, industry, etc.     manufacturing/processing operation (specify: \_\_\_\_\_)  
 commercial underground storage tank or supply lines (gasoline service station, heating oil supplier, etc.)

This material is based upon work supported by the U.S. Department of Agriculture, Extension Service.

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Extension is a joint program of Virginia Tech, Virginia State University, the U.S. Department of Agriculture, and state and local governments.

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(3) Sample Water Quality Analysis Report

**RICHMOND COUNTY  
HOUSEHOLD WATER QUALITY PROGRAM**

Richmond County Cooperative Extension  
P.O. Box 152  
Warsaw, VA 22572  
(804)333-3420

Sample No. R-

Warsaw, Va 22572

804 -333-

Source: drilled well 566 ft deep

Treatment: none

**Water Quality Results  
Date of sample: 03/31/98**

Test	Household Water Sample	Maximum Recommended Level or Range
Iron (mg/l)	0.3446 **	0.3
Manganese (mg/l)	< 0.001	0.05
Hardness (mg/l)	13	180
Sulfate (mg/l)	10.585	250
Chloride (mg/l)	< 40	250
Fluoride (mg/l)	< 0.5	2
TDS (mg/l)	315	500
pH	8.0	6.5 to 8.5
Saturation Index	-0.89	-1 to 1
Copper (mg/l)	< 0.002	1.0
Sodium (mg/l)	132.5 **	20
Nitrate-N (mg/l)	< 0.005	10
Total Coliform Bacteria	PRESENT**	ABSENT
E. Coli Bacteria	ABSENT	ABSENT

\*\* Measured value exceeds recommendation for household water.

Analysis coordinated by Water Quality Laboratory, Department of Biological Systems Engineering, Virginia Tech, Blacksburg, VA.  
The information provided is for the exclusive use of the homeowner and should not be used as official documentation of water quality. The material is based upon work supported by the U. S. Department of Agriculture, Extension Service.

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Lorenza W. Lyons, Administrator, 1890 Extension Program, Virginia State, Petersburg.

## (4) Report Interpretation

### Richmond County Household Water Quality Program

#### INTERPRETING YOUR HOUSEHOLD WATER QUALITY ANALYSIS REPORT

##### IRON

Iron in water does not usually present a health risk. It can, however, be very objectional if present in amounts greater than 0.3 mg/l. Excessive iron can leave red-orange-brown stains on plumbing fixtures and laundry. It may give water and/or beverages a bitter, metallic taste and discolor beverages.

##### MANGANESE

Manganese does not present a health risk. However, if present in amounts greater than 0.05 mg/l it may give water a bitter taste and produce black stains on laundry, cooking utensils, and plumbing fixtures.

##### HARDNESS

Hardness is a measure of calcium and magnesium in water. Hard water does not present a health risk. However, it keeps soap from lathering, decreases cleaning action of soaps and detergents, leaves soap "scum" on plumbing fixtures, and leaves scale deposits on water pipes and hot water heaters. Softening treatment is highly recommended for very hard water (above 180 mg/l). Water with a hardness of about 50 mg/l or less does not need softening. Water hardness may also be reported in units of grains per gallon, or gpg (1 gpg = 17.1 mg/l hardness). In all but extremely hard water situations, it may be desirable to soften only the hot water.

##### SULFATE

High sulfate concentrations may result in adverse taste as well as cause a laxative effect. The Secondary Maximum Contaminant Level for sulfate is 250 mg/l. Sulfates are generally naturally present in groundwater and be linked to other sulfur-related problems, such as hydrogen sulfide gas. This gas may be caused by the action of sulfate reducing bacteria as well as other types of bacteria on decaying organic matter. While it is difficult to test for the presence of hydrogen sulfide gas in water, it can be easily detected by its characteristic "rotten egg" odor which may be more noticeable in hot water. Water containing this gas may also corrode iron and other metals in the water system as well as stain plumbing fixtures and cooking utensils.

##### CHLORIDE

Chloride in drinking water is not a health risk. Natural levels of chlorides are low; high levels in drinking water usually indicate contamination from a septic system, road salts, fertilizers, industry, or animal wastes. High levels of chloride may speed corrosion rates of metal pipes, and causing pitting and darkening of stainless steel. The EPA has set a Secondary Maximum Contaminant Level for chloride of 250 mg/l.

##### FLUORIDE

Fluoride is of concern primarily from the standpoint of its effect on teeth and gums. Small concentrations of fluoride are considered to be beneficial in preventing tooth decay while moderate amounts can cause brownish discoloration of teeth and high fluoride concentrations can lead to tooth and bone damage. For these reasons, the EPA has set both a Secondary Maximum Contaminant Level and a Maximum Contaminant Level of 2 and 4 mg/l, respectively.

##### TOTAL DISSOLVED SOLIDS (TDS)

High concentrations of dissolved solids may cause adverse taste effects and may also lead to increased deterioration of household plumbing and appliances. The EPA Secondary Maximum Contaminant Level is 500 mg/l total dissolved solids.

##### pH

The pH of water indicates whether it is acidic (below 7.0) or alkaline (above 7.0). Acidic water can cause corrosion in pipes, and may cause toxic metals from plumbing systems, such as copper and lead, to be dissolved in drinking water. Dissolved copper may give water a bitter or metallic taste, and produce blue-green stains on plumbing fixtures. The life of plumbing systems may be shortened due to corrosion requiring expensive repair and replacement of water pipes and plumbing fixtures. The use of plastic pipes throughout the water distribution system should lessen these concerns. Water with a pH below 6.5 is considered to be acidic enough to require treatment. Alkaline water with a pH above 8.5 is seldom found naturally, and may indicate contamination by alkaline industrial wastes. The EPA has set a suggested range of between 6.5 and 8.5 on the pH scale for drinking water.

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## Report Interpretation (cont.)

### SATURATION INDEX

The saturation (Langlier) index, in addition to pH, is used to evaluate the extent of potential corrosion of metal pipes, plumbing fixtures, etc. It is a calculated value based on the calcium concentration, total dissolved solids concentration, measured pH, and alkalinity, and is a measure of the scale formation potential of the water. A saturation index greater than zero indicates that protective calcium carbonate deposits may readily form on pipe walls. A saturation index less than zero indicates that the water does not have scale-forming properties and pipes may be subject to corrosion. Saturation index values between -1 and +1 are considered acceptable for household water supplies. **NOTE: Values of less than -1 need not be of concern if the water is not acidic (indicated by a pH of 7.0 or above).** Water softener owners may note a saturation index reading lower than desired. While these treatment devices correct hardness, they may enhance the corrosion potential of the water. Concerns about resulting drinking water quality may be lessened by softening only the hot water or bypassing drinking water lines.

### COPPER

The EPA drinking water standard for copper is 1.3 mg/l, based on concerns about acute gastrointestinal illness. Since dissolved copper also leaves blue-green stains on plumbing fixtures, a Secondary Maximum Contaminant Level of 1.0 mg/l is also provided for copper. While copper in household water most often comes from the corrosion of brass and copper plumbing materials, this type of contamination is not likely to be detected under the sampling procedure followed in this program which called for flushing the water lines. Therefore, any excessive amounts of copper from the water source itself may indicate contamination from industrial wastes or dumps/landfills.

### SODIUM

Excessive sodium has been linked to problems with high blood pressure, and heart and kidney diseases. Moderate quantities of sodium in drinking water are not considered harmful since an individual normally receives most (over 90%) of his/her sodium intake from food. For those on low-sodium diets, both the American Heart Association and EPA suggest 20 mg/l as a maximum level for sodium in drinking water; a physician should be consulted in individual cases. Water softening by ion-exchange will increase sodium levels in water. To reduce sodium in drinking water requiring such treatment, soften only the hot water or bypass drinking water lines.

### NITRATE

High levels of nitrate may cause methemoglobinemia or "blue-baby" disease in infants. Though the EPA has set a Maximum Contaminant Level for nitrate-nitrogen of 10 mg/l, they suggest that water with greater than 1 mg/l be used with caution for feeding infants. Levels of higher than 3 mg/l may indicate excessive contamination of water supply by commercial fertilizers as well as organic wastes from septic systems or farm animal operations.

### TOTAL COLIFORM BACTERIA

Microbiological contamination of drinking water can cause short term gastrointestinal disorders, resulting in cramps and diarrhea that may be mild to very severe. Other diseases of concern are Viral Hepatitis A, salmonella infections, dysentery, typhoid fever, and cholera. While coliform bacteria do not cause disease, they serve as indicators of the possible presence of disease bacteria. Coliform bacteria are always present in the digestive systems of humans and animals and could also come from natural sources such as soil or decaying vegetation. Analysis for total coliform bacteria is the EPA standard test for microbiological contamination of a water supply. A positive test result reported as "present" indicates the presence of coliform bacteria and is followed by a test for fecal coliform bacteria.

### FECAL COLIFORM BACTERIA

A test for fecal coliform bacteria is necessary to determine whether or not any coliform bacteria present are from human and/or animal waste. A positive test result reported as "present" indicates that waste from a septic system or nearby animals is likely contaminating the water supply.

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### Glossary

**EPA** - U. S. Environmental Protection Agency

**mg/l** - Concentration unit of milligrams per liter in water, equivalent to one part per million (ppm).

**Maximum Contaminant Level (MCL)** - Legally enforceable national standard set by the EPA to protect the public from exposure to water hazards. Standards only apply to public drinking water systems, but, they also serve as a guide for individual water supplies.

**Secondary Maximum Contaminant Level (SMCL)** - Concentration limits for nuisance contaminants and physical problems. These standards are not enforced by governments. However, they are useful guidelines for individual water supplies.

Compiled by Blake Ross, Extension Agricultural Engineer, and Kathy Parrott, Extension Specialist, Housing, Virginia Tech, Blacksburg, VA

April 1998

This material is based upon work supported by the U. S. Department of Agriculture-Extension Service.

(5) Pesticide Analysis Sample Form

**RICHMOND/WESTMORELAND COUNTIES  
HOUSEHOLD WATER QUALITY PROGRAM  
CHEMICAL ANALYSIS**

Department of Biological Systems Engineering  
Virginia Polytechnic Institute and State University  
Blacksburg, Virginia 24061-0303

SAMPLE NUMBER: \_\_\_\_\_ DATE COLLECTED: \_\_\_\_\_

PESTICIDE ANALYSIS: \_\_\_\_\_ YES \_\_\_\_\_ NO      PETROLEUM ANALYSIS \_\_\_\_\_ YES \_\_\_\_\_ NO

SAMPLE SUBMITTED BY:  
NAME: \_\_\_\_\_

MAILING ADDRESS: \_\_\_\_\_

TELEPHONE: \_\_\_\_\_

WAS THE WATER TREATED BEFORE SAMPLING? \_\_\_\_\_ YES \_\_\_\_\_ NO (IF AT ALL POSSIBLE, SAMPLE WATER **BEFORE** TREATMENT)

IF YES, WHAT TREATMENT DEVICE(S) DID THE WATER PASS THROUGH PRIOR TO SAMPLING?

\_\_\_\_\_

COMMENTS REGARDING LIKELIHOOD OF PESTICIDE CONTAMINATION (SPILLS, NEARBY USE, STORAGE, ETC.):

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**SAMPLING INSTRUCTIONS:**

1. Do not remove cap from Sample Jar until you are ready to take sample. Do not touch inside of cap or mouth of the jar.
2. Take the sample as close to the water source (well or spring) as possible. If there are no water treatment devices in use, the sample may be taken from a kitchen or bathroom tap. If there is a treatment device in the house, the sample should be taken from a spigot not affected by a treatment device.
3. Turn on the Cold Water and allow it to run until it is as cold as it will get. Then allow it to run one minute more.
4. Slowly and carefully fill the jar to avoid splashing and overflowing. Pour out this water and refill the jar completely.
5. Place the Aluminum Foil Sheet over the mouth of the jar with the Dull Side down. Tighten cap on the jar securely.
6. If sample is not to be delivered immediately, store on ice until ready to deliver.

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(6) Post-Program Survey

**Richmond County**

HOUSEHOLD WATER QUALITY PROGRAM EVALUATION SURVEY

Please answer each question below as instructed in reference to your **household** water supply only. **Your answers are completely confidential and cannot be identified with any individual participant.**

1. Have you had a laboratory test of your water supply before this Household Water Quality Education Program?  
Yes \_\_\_\_\_ No \_\_\_\_\_

If Yes, about what year was your last test? \_\_\_\_\_

2. What prompted you to participate in this program? (Check **all** that apply.)

- \_\_\_\_\_ Concern about safety of my water supply
- \_\_\_\_\_ Nuisance problems such as staining, objectionable taste or odor, corrosion, etc.
- \_\_\_\_\_ Follow-up to previous test of my water supply
- \_\_\_\_\_ Other (explain) \_\_\_\_\_

3. Did your household water analysis in this program show that your water was unsatisfactory for **any** of the following tests? (Check **one** response for each test.)

Nitrate	Yes _____	No _____
Sodium	Yes _____	No _____
Iron	Yes _____	No _____
Manganese	Yes _____	No _____
Hardness	Yes _____	No _____
pH	Yes _____	No _____

4. What were the results of the tests for the following? (Check **one** response for each test.)

<b>Total</b> coliform bacteria	Present _____	Absent _____
<b>E. coli</b> bacteria	Present _____	Absent _____

5. Since receiving the results of your water quality analysis, which of the following measures do you plan to take, or have already taken, to improve the quality of your water supply? (Check **all** that apply.)

- \_\_\_\_\_ Contact a state agency such as the Health Dept., Dept. of Environmental Quality, etc. for assistance or additional information
- \_\_\_\_\_ Seek additional water testing from a laboratory
- \_\_\_\_\_ Sign up for Farm\*A\*Syst assessment
- \_\_\_\_\_ Pump out septic system
- \_\_\_\_\_ Improve physical condition of water source (well, spring, or cistern)
- \_\_\_\_\_ Shock chlorinate water system
- \_\_\_\_\_ Obtain new water source
- \_\_\_\_\_ Use bottled water for drinking/cooking
- \_\_\_\_\_ Temporary disinfection, such as boiling water
- \_\_\_\_\_ Purchase or rent water treatment equipment
- \_\_\_\_\_ Improve functioning of existing water treatment equipment
- \_\_\_\_\_ Take other measures to eliminate or reduce contaminant(s) in your water (explain)

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ Haven't done anything because \_\_\_\_\_

\_\_\_\_\_

## Post-Program Survey (cont.)

The following questions are designed to provide us with a profile of the total audience we've reached with this program. **Be assured that answers cannot be identified with individual participants.**

6. How many years have you lived at your present location? \_\_\_\_\_
- 6a. Is your home located within the Cat Point Creek Watershed? \_\_\_\_\_ Yes \_\_\_\_\_ No
7. Number of persons in your household. \_\_\_\_\_
8. What is the highest grade in school you've completed? (Check **one**.)
- \_\_\_\_\_ Grade school
  - \_\_\_\_\_ Some high school
  - \_\_\_\_\_ High school graduate
  - \_\_\_\_\_ Some education after high school
  - \_\_\_\_\_ College graduate
9. What is your **family** income before taxes? (Check **one**.)
- \_\_\_\_\_ Less than \$10,000
  - \_\_\_\_\_ \$10,000 to \$14,999
  - \_\_\_\_\_ \$15,000 to \$19,999
  - \_\_\_\_\_ \$20,000 to \$24,999
  - \_\_\_\_\_ \$25,000 to \$34,999
  - \_\_\_\_\_ \$35,000 to \$49,000
  - \_\_\_\_\_ \$50,000 or more
10. Other comments about the Household Water Quality Education Program:
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
11. Are there other educational programs that you would like to see offered by the Richmond County Extension Office?
- \_\_\_\_\_
- \_\_\_\_\_
12. How did you hear about this Household Water Quality Education Program? (Check **all** that apply.)
- \_\_\_\_\_ Newspaper
  - \_\_\_\_\_ Radio
  - \_\_\_\_\_ Television
  - \_\_\_\_\_ Extension Newsletter
  - \_\_\_\_\_ Direct Mailing
  - \_\_\_\_\_ Friend or Neighbor
  - \_\_\_\_\_ Other (explain)
- \_\_\_\_\_

Thank you for your participation. Please return this survey form by **July 6, 1998**. A postage-paid envelope has been provided for your use in returning this form to:

Kelly Liddington, Richmond County  
Virginia Cooperative Extension  
Extension Distribution Center  
112 Landsdowne Street  
Blacksburg, VA 24060-9984









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