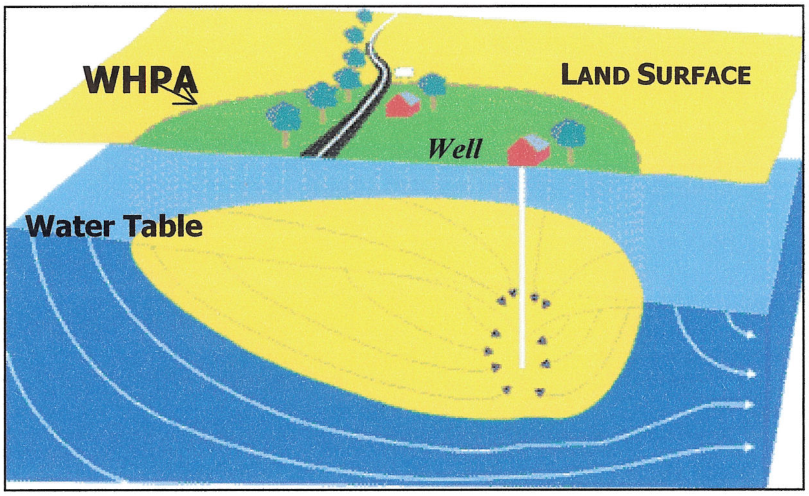
SOURCE WATER ASSESSMENT

for

CEDAR RIDGE CHILDREN'S HOME

Washington County, MD



Prepared By

WATER MANAGEMENT ADMINISTRATION

Water Supply Program

June, 2005

MDE

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SUMMARY

The Maryland Department of the Environment's Water Supply Program (WSP) has conducted a Source Water Assessment for the Cedar Ridge Children's Home water system. The required components of this report as described in Maryland's Source Water Assessment Program (SWAP) are 1) delineation of an area that contributes water to the source, 2) identification of potential sources of contamination, and 3) determination of the susceptibility of the water supply to contamination. Recommendations for protecting the drinking water supply conclude this report.

The source of Cedar Ridge's water supply is four wells in an unconfined fractured-rock carbonate aquifer, the Rockdale Run Formation. The Source Water Assessment area was delineated by the WSP using U.S. EPA approved methods specifically designed for this source type.

Point sources of contamination were investigated within the assessment area from field inspections, contaminant inventory databases, and previous studies. The Maryland Department of Planning's 2002 digital land use map for Washington County was used to identify non-point sources of contamination. Well information and water quality data were also reviewed. An aerial photograph and maps of potential contaminant sources and land use within the Source Water Assessment area are included in the report.

The susceptibility analysis is based on a review of the existing water quality data for the Cedar Ridge Children's Home water system, the presence of potential sources of contamination in the source water assessment area, well integrity, and the inherent vulnerability of the aquifer. It was determined that the Cedar Ridge Children's Home water supply is susceptible to nitrates and to protozoans like *Cryptosporidia* and *Giardia.* It is not to other inorganic compounds, volatile organic compounds, synthetic organic compounds, or radionuclides. It may be susceptible to synthetic organic compounds depending on the outcome of additional samples. The supply may also be susceptible to naturally occurring radon depending on the MCL adopted by EPA.

INTRODUCTION

The Water Supply Program has conducted a Source Water Assessment for the Cedar Ridge Children's Home water system in Washington County. The Cedar Ridge Children's Home is located approximately eight miles west of Hagerstown, just south of Interstate 70 in Washington County. The water system is owned and operated by Cedar Ridge Children's Home. The water system serves a population of 45 persons.

WELL INFORMATION

Well information was obtained from the Water Supply Program's database, site visits, well completion reports, sanitary survey inspection reports, and published reports. Cedar Ridge Children's Home presently obtains its water supply from four wells (Figure 1). A review of the well completion reports for the supply well indicates that Wells 1, 3 and 4 were drilled after 1973 when the State's well construction standards were implemented and should meet the standards. Well 2 was drilled in 1965 and may not meet current standards for grouting. A recent site inspection revealed that the wells were in good condition. Well information is shown in Table 1 below.

SOURCE NAME	PERMIT NUMBER	TOTAL DEPTH	CASING DEPTH	DATE DRILLED	AQUIFER NAME
WELL 1 (UPPER REAR)	WA730982	400	20	1975	ROCKDALE RUN FM
WELL 2 (UPPER FRONT)	WA650189	80	20	1965	ROCKDALE RUN FM
WELL 3 (SHOP WELL)	WA880299	585	55	1989	ROCKDALE RUN FM
WELL (NEW WELL)	WA880982	300	21	1991	ROCKDALE RUN FM

Table 1. Cedar Ridge Childern's Home Well Information.

Cedar Ridge Children's Home has an appropriation permit to pump water from the Rockdale Run Formation for an average annual use of 6,000 gallons per day (gpd) and a daily average of 8,000 gpd in the month of maximum use.

HYDROGEOLOGY

Cedar Ridge Children's Home lies within the Hagerstown Valley physiographic province, which is underlain by a sequence of metasedimentary limestones and shales that have eroded away to form the valley bound by South Mountain and the Bear Pond Mountains west of Clear Spring. In some areas the carbonate rock formations have developed into a karst-like aquifer. Duigon (2001) has identified sinkholes, wells that penetrate cavernous zones, and other karst features in the valley. Cedar Ridge's wells obtain water from the Rockdale Run Formation. The Rockdale Run Formation consists of gray, mottled cherty dolomite and dolomitic limestone in the upper third portion. The lower two-thirds of this formation consists of gray, cherty, argillaceous calcarenite and algal limestone with interbedded dolomite and oolitic limestone (Edwards, 1978). This is a heterogeneous formation and can be very karstic in some areas, and in others much more like a crystalline fractured-rock aquifer. Cedar Ridge Children's Home wells are located in an area where karstic features like sinkholes are present (Figure 2) and may be influenced by them. Ground water moves principally through secondary porosity, like solution enlarged fractures and sinkholes, and is recharged by precipitation percolating through soil and saprolite.

Source Water Assessment Area Delineation

For ground water systems, a Wellhead Protection Area (WHPA) is considered the source water assessment area for the system. The source water assessment area for public water systems with an average appropriation amount of less than 10,000 gpd and drawing from fractured-rock aquifers is a circle with a radius of 1,000 feet. This area is modified by geological boundaries, ground water divides and by annual average recharge needed to supply the well (MD SWAP, 1999). Cedar Ridge's Wells 1,2 and 3 were determined to be GWUDI based on the presence of fecal coliform bacteria in their raw water samples. For water supply sources that are determined to be GWUDI, the MDE's SWAP (1999) recommends locating and mapping sinkholes and conducting a dye trace study to define the contributing area (WHPA) for the well.

Duigon (2001) conducted a study of the karst hydrogeology of the Hagerstown Valley in which he located and mapped the sinkholes in the area. MDE completed a dye trace study to determine the source of bacterial contamination to the Cedar Ridge wells. (Evans and Holt, 2004). Fluorescent dyes were used to inoculate contamination sources: five onsite septic systems, Meadow Brook which a stream that forms the northern boundary of the Cedar Ridge Children's Home property, and two sinkholes north of Meadow Brook. Several sinkholes south of the wells were not evaluated in this study. The study concluded that there was no obvious connection between the aquifer used by Cedar Ridge's wells and onsite septic systems, surface water from Meadow Brook, or surface water from the sinkholes in the north. A copy of this study is included at the end of this report. The onsite septic systems, which may have been the source of bacterial contamination to the supply wells, were connected to a new wastewater treatment plant prior to the dye study. Sinkholes south of the wells were not used in the study, may also be sources of the bacterial contamination.

The wellhead protection area (WHPA) is the drainage area of the valley where the Cedar Ridge wells are located. It encompasses several of the sinkholes located south of the well, which may be contributing surface water to the aquifer of use. It is assumed that the ground water flow direction is northeast towards Meadow Brook. The area of the delineated WHPA is about 1147 acres (Figure 2).

POTENTIAL SOURCES OF CONTAMINATION

Potential sources of contamination are classified as either point or non-point sources. Examples of point sources of contamination are leaking underground storage tanks, landfills, discharge permits, large-scale feeding operations, and CERCLA sites. These sites are generally associated with commercial or industrial facilities that use chemical substances that may, if inappropriately handled, contaminate ground water via a discrete point location. In addition, in karst areas (areas underlain by limestone), sinkholes may be point sources of contamination to the aquifer by receiving contaminated runoff and delivering the contamination directly into the aquifer. Non-point sources of contamination are associated with certain types of land use practices such as use of pesticides, application of fertilizers or animal wastes, or septic systems that may lead to ground water contamination over a larger area.

Point Sources

Several sinkholes were identified in the WHPA (Duigon, 2001). Potential contaminant point sources located in or adjacent to the WHPA include the discharge of wastewater from Cedar Ridge Children's Home and one active onsite septic system northwest of Well 4. All the other onsite septic systems for the facility have been connected to the wastewater treatment plant.

Non-Point Sources

The Maryland Department of Planning's 2002 digital land use coverage of Washington County was used to determine the predominant types of land use in the WHPA (Figure 3). The land use summary is shown in Table 2. The majority of the WHPA (80%) is made up of agricultural land (cropland, pasture and feeding operations), with forested lands making up the next largest portion at only 16%.

LAND USE CATEGORIES	TOTAL AREA (acres)	PERCENTAGE OF WHPA
Low Density Residential	18.75	1.63
Commercial	22.15	1.93
Cropland	795.77	69.37
Pasture	104.47	9.11
Forest	184.17	16.06
Feeding Operations	21.82	1.90
Total	230.47	100

Table 2. Land Use Summary

Agricultural land is commonly associated with nitrate loading to ground water and also represents a potential source of SOCs depending on use of pesticides. Several dairy farms are located in the WHPA. In these areas where animals animal wastes are generated they become potential sources of microbial pathogens and nitrates to ground water. Residential areas without sewer service can be a source of nitrate from septic systems and microbial pathogens if systems are not constructed in accordance with regulations. Additionally, residential areas may be a source of nitrate and SOCs if fertilizers, pesticides, and herbicides are not used carefully in lawns and gardens.

A review of the Maryland Department of Planning's 2002 Sewer Map for Washington County indicates that there is no planned sewer service for 89% of the WHPA the remaining 11% of the WHPA is served by the existing Cedar Ridge Children's Home wastewater treatment plant (Figure 4) WHPA. Other properties in the WHPA have onsite septic systems.

WATER QUALITY DATA

Water Quality data was reviewed from the Water Supply Program's database for Safe Drinking Water Act (SDWA) contaminants. The State's SWAP defines a threshold for reporting water quality data as 50% of the Maximum Contaminant Level (MCL). If a monitoring result is greater than 50% of a MCL, this assessment will describe the sources of such a contaminant and if possible, locate the specific sources that are the cause of the elevated contaminant level. All data reported is from the finished (treated) water unless otherwise noted. The treatment that the Cedar Ridge Children's Home water system currently uses, include hypochlorination and ultraviolet radiation for disinfection, ion exchange for softening the water and cartridge filtration for treatment of surface water.

A review of the monitoring data since 1995 for Cedar Ridge Children's Home water supply indicates that it meets the current drinking water standards. The water quality sampling results are summarized in Table 3.

	Nitrate		SOCs		VOCs		IOCs (except nitrate)		Radionuclides	
PLANT NO	No. of Samples Collected	No. of samples > 50% MCL	No. of Samples Collected	No. of samples > 50% MCL	No. of Samples Collected	No. of samples > 50% MCL	No. of Samples Collected	No. of samples > 50% MCL	No. of Samples Collected	No. of samples > 50% MCL
1	14	1	5	2*	12	0	6	0	8	1**

Table 3. Summary of Water Quality Samples for Cedar Ridge Children's Home Water Supply.

* found in laboratory blank

**based on the lower proposed MCL for Radon-222

Inorganic Compounds (IOCs)

Nitrate was the only IOC detected above 50% of an MCL. It was detected in March 2002, at a concentration of 6.36 ppm. Nitrate has an MCL of 10 ppm. Nitrates have been routinely detected in the water supply since 1993. The nitrate levels in water supply have ranged from 0.2 to 6.36 ppm. The average on the nitrate concentrations is 3 ppm. Low levels of naturally occurring fluoride have been detected in the water supply. Sodium has been detected 194 (3/1998), 193 (7/2001) and 108.6 ppm (7/2004). The source of sodium is probably caused by the addition of sodium from ion exchange resin in exchange for the calcium removed by the resin. The concentration of sodium in the treated water is between 5 and 9 time higher than EPA's guidance of 20 mg/l for persons on a very restrictive sodium diet of 500 mg/day.

Radionuclides

No radionuclides above 50% of the MCL have been detected in the Cedar Ridge water supply. Gross alpha and gross beta, and radium have been detected at levels well below their MCLs several times in the water supply. Radon-222 was detected from a sample collected in May 1999 at 150 pCi/L. At present there is no MCL for radon-222, however EPA has proposed an MCL of 300 pCi/L and an alternate MCL of 4000 pCi/L for community water systems if the State has a program to address the more significant risk from radon in indoor air.

Volatile Organic Compounds (VOCs)

No VOCs above 50% of the MCL have been detected in Cedar Ridge's water supply. 1,1,1-Trichloroethane was detected one time in Cedar Ridge's water supply. The MCL for 1,1,1-Trichoroethane is 200 ppb and the one detection on January 29, 1991 was at 3 ppb. Trihalomethanes (THMs) which are disinfection byproducts were detected at 7.43 and 9.29 ppb in 2004 and 2003, respectively. THMs are the result of reaction between the chlorine used for disinfection and organic matter in the raw water. The MCL for the total of the THMs is 80 ppb.

Synthetic Organic Compounds (SOCs)

A review of the SOC data indicates that di(2-ethylhexyl)phthalate was the only SOC detected above 50% of the MCL. These detections are shown in table 4. Investigation of this data indicated that di(2-ethylhexyl)phthalate was also found on the same dates in the laboratory blanks, indicating that these results are not believed to represent the water quality at Cedar Ridge. As the results from the two most recent samples analyzed by the State laboratory were over the MCL for di(2-ethylhexl)phthalate it is recommended that the system obtain the services of a private laboratory and perform an analysis of the raw and treated water for di(2-ethylhexyl)phthalate. Earlier analysis performed in 1995 and 1998 had no detectable levels of di(2-ethylhexyl)phthalate in the treated water. Di(ethylhexyl)adipate was detected in one sample collected on September 27, 2001 at 1.2 ppb. Adipate has an MCl of 400 ppb and was also found in the laboratory blank. 3-Hydroxycarborfuran was detected one time in October 2004 at 5 ppb. This SOC does not have an MCL.

CONTAMINANT NAME	MCL (ppb)	SAMPLE DATE	RESULT (ppb)
DI(2-ETHYLHEXYL) PHTHALATE	6	21-OCT-04	9.3
DI(2-ETHYLHEXYL) PHTHALATE	6	27-SEP-01	13.6

Table 4. Synthetic Organic Chemicals detected above 50% of the MCL.

Microbiological Contaminants

Raw water bacteriological data is available from evaluation for ground water under the direct influence of surface water (GWUDI). A review of the data shows that total coliform and fecal coliform bacteria were detected in the raw water from Wells 1, 2 and 3. (Table 4). Negative numbers in the table indicate absence of coliform bacteria. No coliform was detected in the raw water for Well 4.

SOURCE NAME	RAIN DATE	RAIN AMOUNT (INCHES)	REMARK	SAMPLE DATE	TOTAL COLIFORM (MPN/100 ML	FECAL COLIFORM (MPN/100 ML)
WELL 1 (UPPER REAR)	12-MAY-98	.5	WET SET 1	12-MAY-98	8.1	8.1
WELL 1 (UPPER REAR)	12-MAY-98	.5	WET SET 1	13-MAY-98	8.1	8.1
WELL 1 (UPPER REAR)	12-MAY-98	.5	WET SET 1	14-MAY-98	8.1	8.1
WELL 1 (UPPER REAR)	12-MAY-98	.5	WET SET 1	15-MAY-98	8.1	4.6
WELL 1 (UPPER REAR)	19-MAY-98	0	DRY SAMPLE 1	19-MAY-98	8.1	4.6
WELL 1 (UPPER REAR)	24-JUN-98	.5	WET SET 2	24-JUN-98	8.1	8
WELL 1 (UPPER REAR)	24-JUN-98	.5	WET SET 2	25-JUN-98	-1.1	-1.1
WELL 1 (UPPER REAR)	24-JUN-98	.5	WET SET 2	26-JUN-98	8.1	8
WELL 1 (UPPER REAR)	24-JUN-98	.5	WET SET 2	27-JUN-98	4.6	2.6
WELL 1 (UPPER REAR)	07-JUL-98	0	DRY SAMPLE 2	07-JUL-98	8.1	2.6
WELL 3 (SHOP WELL)	12-MAY-98	.5	WET SET 1	12-MAY-98	8.1	8.1
WELL 3 (SHOP WELL)	12-MAY-98	.5	WET SET 1	13-MAY-98	46	11
WELL 3 (SHOP WELL)	12-MAY-98	.5	WET SET 1	14-MAY-98	8	-1.1
WELL 3 (SHOP WELL)	12-MAY-98	.5	WET SET 1	15-MAY-98	8	1.1
WELL 3 (SHOP WELL)	19-MAY-98	0	DRYSAMPLE 1	19-MAY-98	-1.1	-1.1
WELL 3 (SHOP WELL)	24-JUN-98	.5	WET SET 2	24-JUN-98	2.6	-1.1
WELL 3 (SHOP WELL)	24-JUN-98	.5	WET SET 2	25-JUN-98	8.1	8.1
WELL 3 (SHOP WELL)	24-JUN-98	.5	WET SET 2	26-JUN-98	-1.1	-1.1
WELL 3 (SHOP WELL)	24-JUN-98	.5	WET SET 2	27-JUN-98	-1.1	-1.1
WELL 3 (SHOP WELL)	07-JUL-98	0	DRYSAMPLE 2	07-JUL-98	1.1	-1.1
WELL 2 (UPPER FRONT)	12-MAY-98	.5	WET SET 1	12-MAY-98	8.1	8.1
WELL 2 (UPPER FRONT)	12-MAY-98	.5	WET SET 1	13-MAY-98	26	26
WELL 2 (UPPER FRONT)	12-MAY-98	.5	WET SET 1	14-MAY-98	8	4.6
WELL 2 (UPPER FRONT)	12-MAY-98	.5	WET SET 1	15-MAY-98	8.1	4.6
WELL 2 (UPPER FRONT)	19-MAY-98	0	DRY SAMPLE 1	19-MAY-98	8.1	-1.1
WELL 2 (UPPER FRONT)	24-JUN-98	.5	WET SET 2	24-JUN-98	8.1	1.1
WELL 2 (UPPER FRONT)	24-JUN-98	.5	WET SET 2	25-JUN-98	8.1	1.1
WELL 2 (UPPER FRONT)	24-JUN-98	.5	WET SET 2	26-JUN-98	8.1	2.6
WELL 2 (UPPER FRONT)	24-JUN-98	.5	WET SET 2	27-JUN-98	8.1	2.6
WELL 2 (UPPER FRONT)	07-JUL-98	0	DRY SAMPLE 2	07-JUL-98	8.1	-1.1
WELL 4 (NEW WELL)	12-MAY-98	.5	WET SET 1	12-MAY-98	-1.1	-1.1
WELL 4 (NEW WELL)	12-MAY-98	.5	WET SET 1	13-MAY-98	-1.1	-1.1
WELL 4 (NEW WELL)	12-MAY-98	.5	WET SET 1	14-MAY-98	-1.1	-1.1
WELL 4 (NEW WELL)	12-MAY-98	.5	WET SET 1	15-MAY-98	-1.1	-1.1
WELL 4 (NEW WELL)	19-MAY-98	0	DRY SAMPLE 1	19-MAY-98	-1.1	-1.1
WELL 4 (NEW WELL)	24-JUN-98	.5	WET SET 2	24-JUN-98	-1.1	-1.1
WELL 4 (NEW WELL)	24-JUN-98	.5	WET SET 2	25-JUN-98	-1.1	-1.1
WELL 4 (NEW WELL)	24-JUN-98	.5	WET SET 2	26-JUN-98	-1.1	-1.1
WELL 4 (NEW WELL)	24-JUN-98	.5	WET SET 2	27-JUN-98	-1.1	-1.1
WELL 4 (NEW WELL)	07-JUL-98	0	DRY SAMPLE 2	07-JUL-98	-1.1	-1.1

Table 5. Raw Water Bacteriological Sampling Data

SUSCEPTIBILITY ANALYSIS

The wells serving the Cedar Ridge Children's Home water supply pump water from an unconfined carbonate, fractured-rock aquifer. Wells in unconfined aquifers especially in carbonate rock, are generally vulnerable to any activity on the land surface that occurs within the wellhead protection area. Therefore, continued monitoring of contaminants is essential in assuring a safe drinking water supply. The *susceptibility* of the source to contamination is determined for each group of contaminants based on the following criteria: 1) the presence of potential contaminant sources within the WHPA, 2) water quality data, 3) well integrity, and 4) the aquifer conditions. Table 5 summarizes the susceptibility of Cedar Ridge's water supply to each of the groups of contaminants.

Inorganic Compounds

Nitrate was the only IOC detected above 50% of an MCL. Nitrates have been detected with levels ranging from 0.2 ppm to 6.36 ppm. Sources of nitrate can generally be traced to land use. Septic systems and the fertilization of cropland and residential properties are all sources of nitrate loading in ground water. Agricultural land and residential land comprise a large portion of the WHPA (table 2). Fertilization of agricultural fields and residential lawns, and onsite septic systems are all sources of nitrate loading in ground water. In addition, animal wastes generated by livestock also provide source of nitrates. The nitrate levels seem to have slightly increased from 3.3 ppm in June 2003 to 4.4 ppm in October 2004.

Based on the above analysis, Cedar Ridge's water supply **is** susceptible to nitrate but not to other inorganic compounds.

Radionuclides

No radionuclides above 50% of the MCL have been detected in Fahrney-Keedy's water supply. Radon-222 was detected above at levels above the lower proposed MCL of 300 pCi/L. Radionuclides are naturally occurring contaminant and is present due to the decay or uranium bearing minerals in the bedrock (Bolton, 1996).

Based on the above analysis, Fahrney-Keedy's water supply maybe susceptible to radon but **is not** susceptible to other radionuclides.

Volatile Organic Compounds

No VOCs above 50% of the MCL have been detected in Cedar Ridge's water supply. The water supply **is not** susceptible to volatile organic compounds, based on water quality data and the lack of potential contaminant sources within the WHPA.

Synthetic Organic Compounds

3- Hydroxycarbofuran which currently has no MCL or Health Advisory was detected on time at 5 ppb. This SOC is a breakdown product of carbofuran which is used as a fumigant on rice and alfafa. No point sources of SOCs were identified within the source water assessment area. Potential sources of SOCs within the WHPA may be pesticide or herbicide use in the agricultural or residential areas. The two most recent samples for SOCs (2001 and 2004) both reported levels of di(2-ethylhexyl)phthalate above the MCL, but also note its presence in laboratory blanks. Further investigation into the validity and potential source of di(2-ethylhexyl)phthalate in the treated water is needed. While the results maybe an artifact of laboratory contamination, the fact that two consecutive samples registered levels above the MCL warrants further investigation. Before we can determine the susceptibility of these sources to SOCs. However, because these contaminants have not been detected except for 3-Hydroxycarbofuran, it appears that any chemicals that may be used in the WHPA are degrading or being attenuated in the soil and are not reaching the wells.

Based on the above analysis, Cedar Ridge's water supply **maybe** susceptible to SOCs.

Microbiological Contaminants

Fecal coliform and total coliform bacteria were detected in Cedar Ridge's Wells 1, 2 and 3. and were determined to be GWUDI. Based on the raw water bacteriological data, aquifer type and potential contaminant sources, Cedar Ridge's water supply **is** susceptible to protozoans like *Giardia* and *Cryptosporidia*. The system is using filtration for removal of these protozoans.

CONTAMINANT TYPE	Are Contaminant Sources present in the WHPA?	Are Contaminants detected in WQ samples at 50% of the MCL	Is Well Integrity a Factor?	Is the Aquifer Vulnerable?	Is the System Susceptible to the Contaminant
Nitrate	YES	NO	NO	YES	YES
Inorganic Compounds (except nitrate)	NO	NO	NO	YES	NO
Volatile Organic Compounds	NO	NO	NO	YES	NO
Synthetic Organic Compounds	YES	YES***	NO	YES	MAYBE
Radionuclides	YES* (Radon-222)	YES**	NO	YES (Radon-222)	MAYBE (Radon-222)
Microbiological Contaminants	YES	YES	NO	YES	YES

Table 6. Susceptibility Summary for Cedar Ridge's water supply.

*Naturally occurring
**Proposed MCL for Radon-222
***Also detected in laboratory blanks

Management of the Source Water Assessment Area

Public Awareness and Outreach

- The Consumer Confidence Report should list that this report is available to the customers through their county library or by contacting the Water Supply Program.

Monitoring

- The system should continue to monitor for all Safe Drinking Water Act contaminants as required by MDE. As discussed above, additional sampling is recommended for di(2-ethylhexyl)phthalate to determine if this compound is truly present in the water supply or a result of laboratory artifact. Both treated and raw water samples are recommended.

Planning/ New Development

- Washington County Department of Planning is encouraged to adopt a wellhead protection ordinance that provides protection for all community water systems relying on ground water. MDE has a model ordinance that can be used as a starting point. Grant funding is available for wellhead protection projects.

Land Acquisition/Easements

- Loans are available for the purchase of property or easements for protection of the water supply. Eligible property must lie within the designated WHPA. Loans are currently offered at zero percent interest and zero points. Contact the Water Supply Program for more information.

Nutrient Management

- Agricultural producers within the wellhead protection area should be encouraged to apply for MDA Cost Share money for cover crop implementation. Cover crops have been shown to reduce nitrate levels in ground water.

Contaminant Source Inventory

- The system should conduct its own periodic surveys of the WHPA to ensure that there are no new or additional potential sources of contamination.
- Abandon any unused septic drainfield to prevent contamination of the aquifer.

Contingency Plan

- Cedar Ridge Children's Home should have a Contingency Plan for its water system. COMAR an 26.04.01.22 requires all community water systems to prepare and submit for approval a plan for providing a safe and adequate drinking water supply under emergency conditions.
- Develop a spill response plan in concert with the Fire Department and other emergency response personnel.

Changes in Use

- The Cedar Ridge Children's Home is required to notify MDE if new wells are to be put into service. Drilling a new well outside the current WHPA would modify the area; therefore the Water Supply Program should be notified if a new well is being proposed.

References

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Duigon, M.T., 2001, *Karst Hydrogeology of the Hagerstown Valley, Maryland*, MGS Report of Investigations 73, 128 pp.

Duigon, M.T., and J.R. Dine, 1991, *Water Resources of Washington County, Maryland*, MGS Bulletin 36, 109 pp.

Evans, W.N. and Holt, J.D., 2004, *Cedar Ridge Dye Study*, report submitted to Water Management Administration, Water Supply Program, 36 pp.

MDE, Water Supply Program, 1999, *Maryland's Source Water Assessment Plan*, 36 p.

U.S. Environmental Protection Agency, 1991, *Delineation of Wellhead Protection Areas in Fractured Rocks: Office of Ground Water and Drinking Water*, EPA/570/9-91-009, 144 pp.

Other Sources of Data

Water Appropriation and Use Permit WA1965G008
Public Water Supply Sanitary Survey Inspection Reports
MDE Water Supply Program Oracle® Database
MDE Waste Management Sites Database
Department of Natural Resources Digital Orthophoto Quarter Quadrangle for Mason-Dixon SW
USGS Topographic 7.5 Minute Quadrangles for Clearspring
Maryland Department of Planning 2002 Washington County Digital Land Use Map
Maryland Department of Planning 2002 Washington County Digital Sewer Map

FIGURES

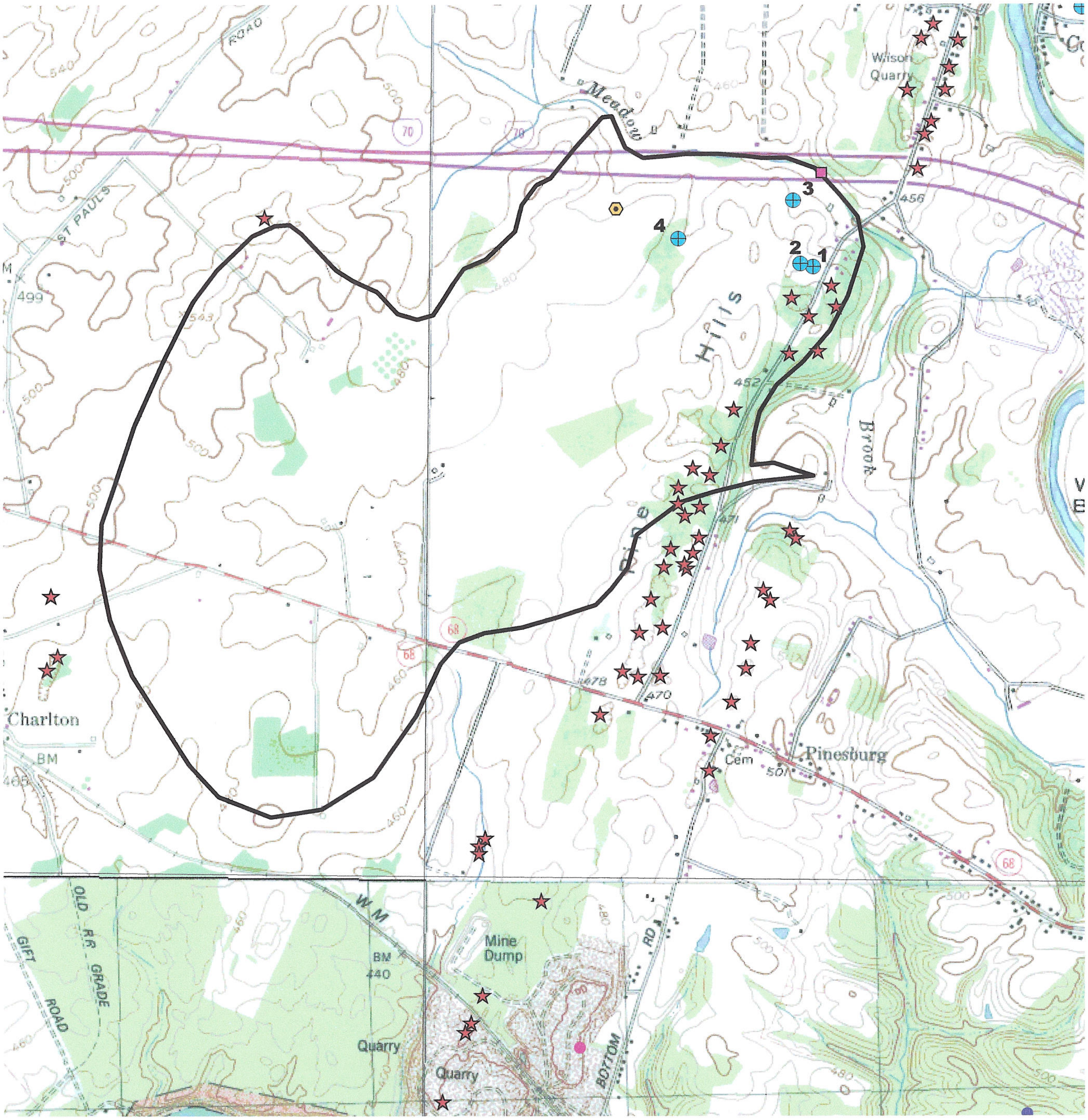
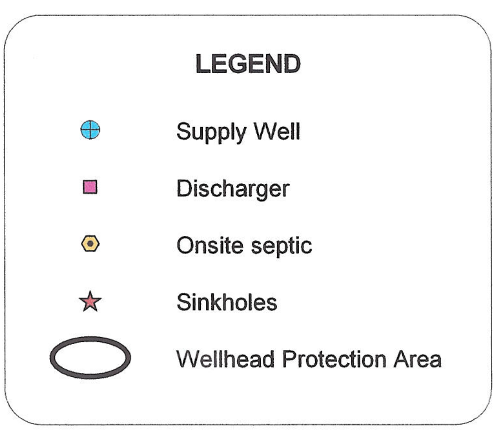
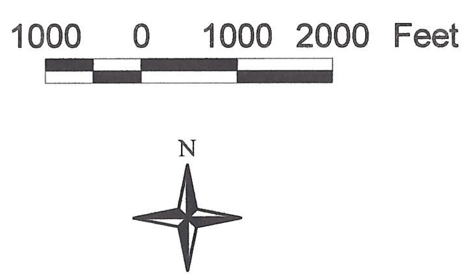


Figure 2. Cedar Ridge Children's Home Wellhead Protection Area with Potential Contaminant Sources





Base Map USGS Topographic 7.5 minute quadrangles- Clearspring

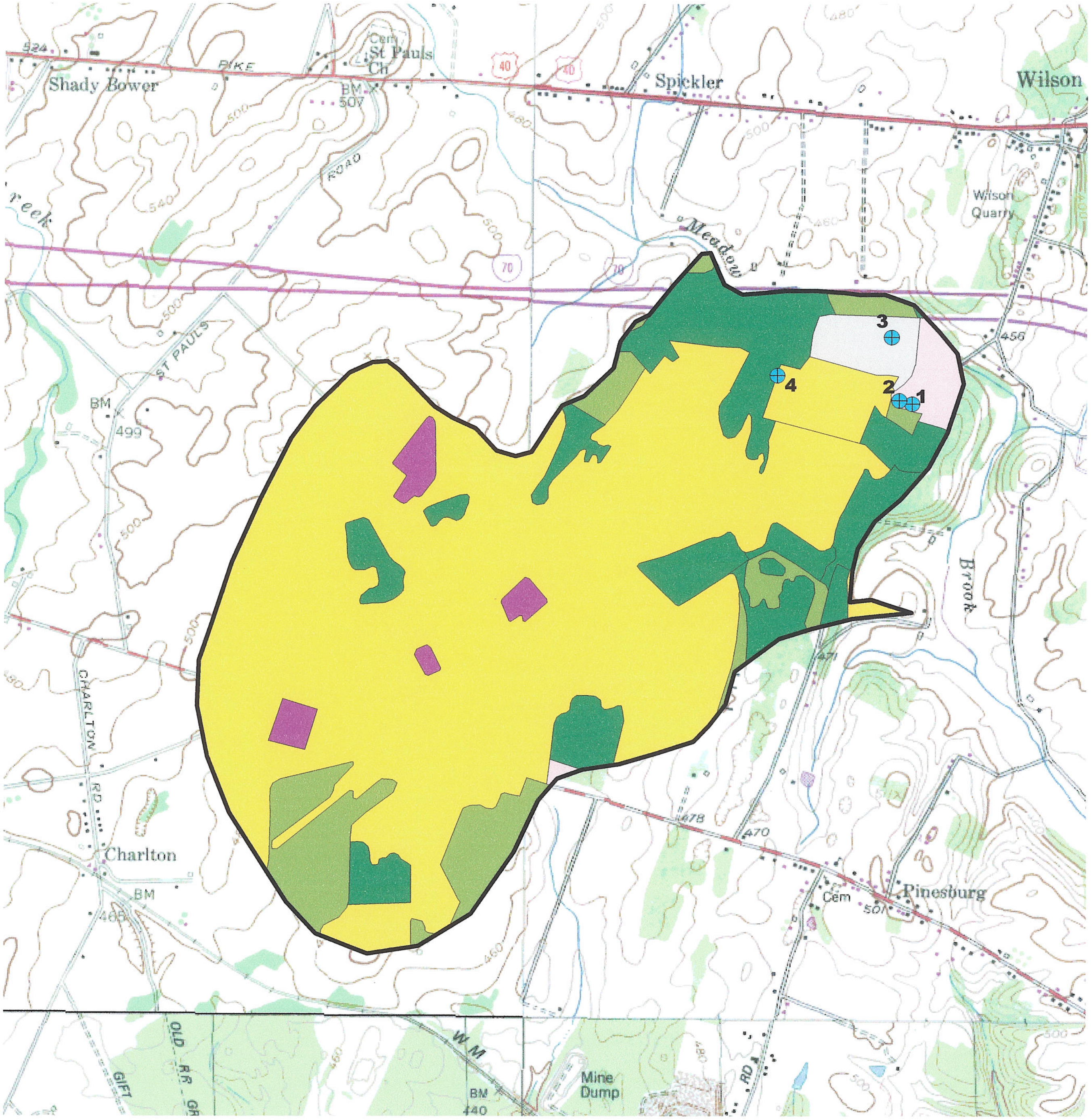
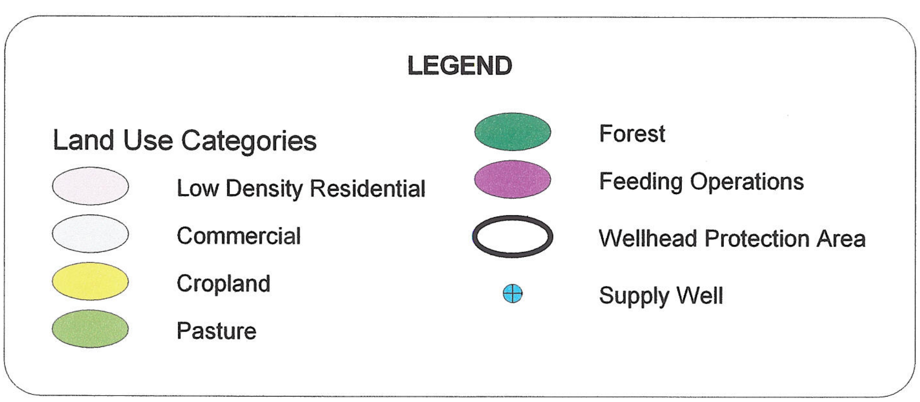
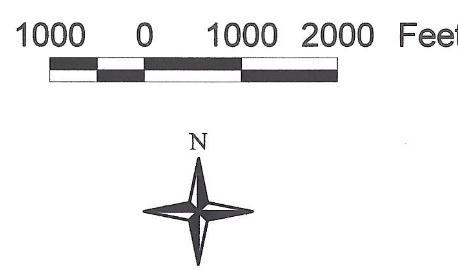


Figure 3. Land Use Map of Cedar Ridge Children's Home Wellhead Protection Area





Base Map: USGS Topographic
7.5 minute quadrangles- Clearspring

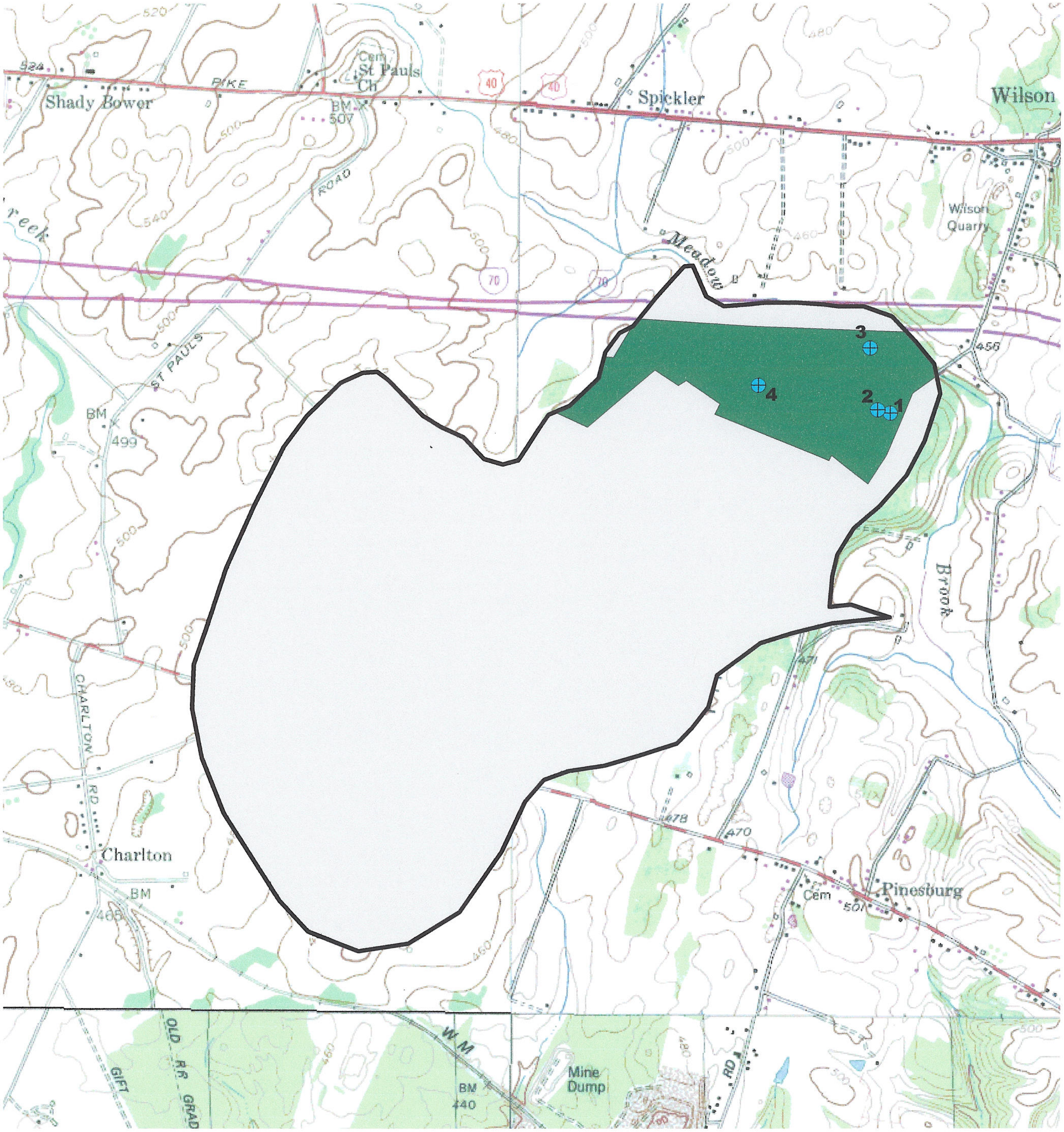


Figure 4. Sewer Map of Cedar Ridge Children's Home Wellhead Protection Area

LEGEND

Sewer Service Categories

- No Planned Service
- Existing Service
- Wellhead Protection Area
- Supply Well

1000 0 1000 2000 Feet

N

Base Map: USGS Topographic 7.5 minute quadrangle- Clearspring

REPORT: CEDAR RIDGE CHILDRENS HOME
DYE STUDY

Cedar Ridge Dye Study

January 2004

Submitted to

Maryland Department of the Environment
Water Management Administration
Water Supply Program

Submitted by

Maryland Department of the Environment
Technical and Regulatory Services Administration
Compliance Monitoring Division
Drinking Water Monitoring Section

MDE

Final Report

Prepared by

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and
John D. Holt

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Acknowledgements

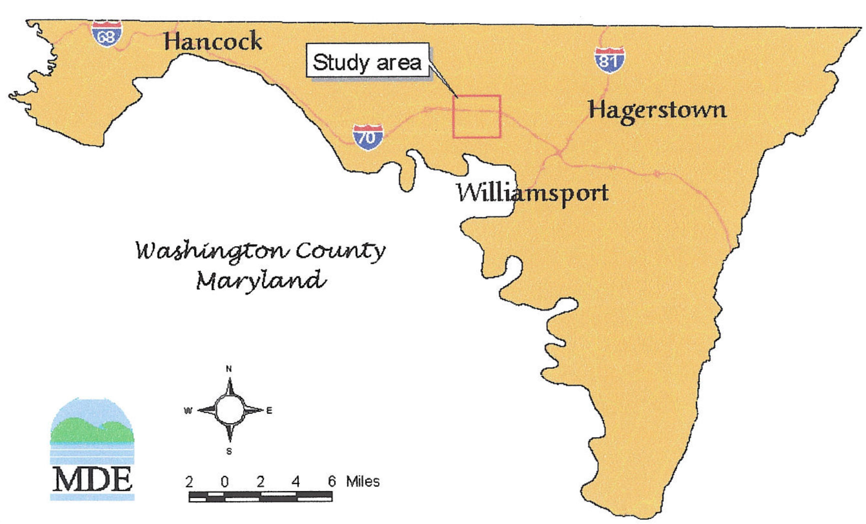
Employees of the Cedar Ridge Children's Home were extremely helpful in the design and initiation of this project. Knowledge of the water, sewer, and septic systems for the school was useful for prioritizing potential sources. Maintenance staff provided skilled assistance as well as materials to help construct the collection setup. Thank you Jeff, Ron, and Randy.

Introduction

The Maryland Department of the Environment (MDE) has administered the wet/dry weather bacteriological analysis of untreated (raw) water supplying public drinking water systems in Washington County, Maryland. Several drinking water systems within Washington County have exhibited elevated levels of the sanitary indicator organism fecal coliform coincident with precipitation, indicating that groundwater aquifers are under direct surface water influence, referred to as 'GWUDI' (i.e., Ground Water Under Direct Influence of surface water). Mandated under the Environmental Protection Agency's (EPA) Clean Water Act, MDE is required to formulate a Source Water Assessment Plan (SWAP) for these GWUDI systems. Under this plan, MDE utilizes tools for assessing systems under influence. This includes a detailed investigation designed to evaluate the source(s) of bacterial contamination and assist in source water delineation.

Cedar Ridge Children's Home is located approximately eight miles west of the City of Hagerstown (Figure 1), just south of Interstate 70. The Cedar Ridge water system uses water supplied from four wells located on the home's property (Figure 2). Three of the wells (Wells 1, 2 and 3) have experienced bacteriological contamination concurrent with rainfall events.

Figure 1. Location of study area

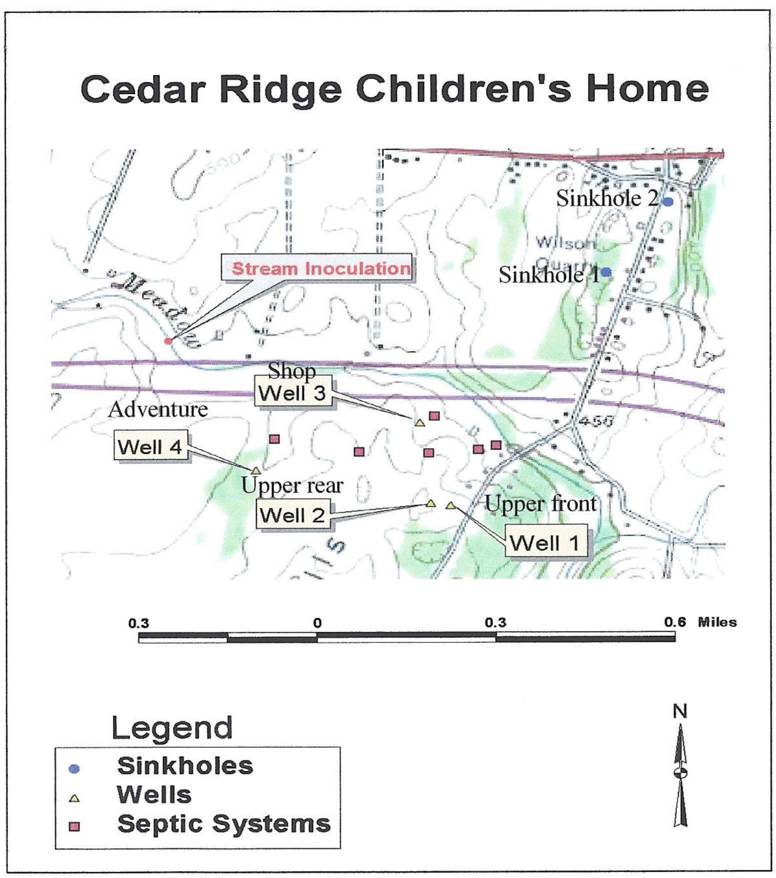


Site Description

The study area occurs within the Hagerstown Valley, a unique portion of the Valley and Ridge Province defined by its wide valley floor underlain by carbonate rock. Carbonate rock is highly susceptible to dissolution by water, resulting in features characteristic to the landscape including closed depressions and disrupted surface drainage. Other carbonate rock formations known as solution sinkholes and collapsed sinkholes can provide direct connection of potentially contaminated surface water to groundwater aquifers (Duigon 2001).

For this investigation, the potential sources of bacterial contamination include 1) six septic systems located on the Cedar Ridge property, 2) a small stream named Meadow Brook that is documented as losing surface flow just north of Cedar Ridge (Duigon 2001), and 3) numerous sinkholes in the vicinity. Several additional septic systems were recently connected to a new WWTP facility. At least one of these abandoned systems, located near well numbers 1 and 2 was failing. The location of drain fields for the septic systems that remain in use is uncertain. Two sinkholes were targeted for inclusion in the study based on 1) apparent potential to conduct contaminated surface water into groundwater aquifers and 2) proximity to GWUDI water systems (Figure 2).

Figure 2. Map of study area



Data Usage

Analysis of fluorometric data is intended to determine the source(s) of bacterial contamination impacting three of the primary wells at Cedar Ridge Children's Home. An investigation of this nature is required for GWUDI public drinking water systems to 1) evaluate potential contamination sources and 2) examine the recharge boundaries for system wells. Results of this study will be forwarded to MDE's Water Supply Program of the Water Management Administration. Data will assist local, County, and State officials to complete required source water assessments and to develop source water protection programs.

Methodology

1. Sampling Design

A) Dye recovery methods

Three collection methods were employed to detect the presence of tracer dyes. *Manual grab water samples* from individual wells were collected using new pre-cleaned 60mL-glass amber bottles. Grab samples enable detection of relatively large dye amounts at given points in time. Composite (from wells 1, 2, 3, and 4) *automated water samples* were collected using an ISCO automated sampler. Use of an ISCO sampler enables detection of relatively large dye amounts over a highly defined time period. The ISCO was programmed to collect 1-hour composite samples with aliquots drawn every 15 minutes into clean discrete 350 milliliter glass bottles. Recovery efforts using the ISCO continued for a 72-hour period following dye inoculation. *Charcoal dye receptors* were used to enable detection of trace amounts of dye that whole water analyses may not detect. Receptors were deployed as to characterize the fluorescence of each well prior to being combined in the automatic water sampler. Therefore, receptors could reveal from which individual well or wells dyes detected in the composite ISCO samples originated. Charcoal receptors were constructed using ~3x3 inch squares of nylon screen filled with 5 grams of 6-14 mesh activated charcoal. Charcoal receptors were immersed for seven-day time periods.

B) Recovery point setup

Dye recovery methods (charcoal receptors and automatic sampler) used in this study require access to 'flowing' water. Four new plastic storage boxes were used to create raw water pools from each well to contain charcoal packets. Raw water flow through the plastic boxes was maintained for the duration of the study. Effluent from the boxes spilled into a stainless steel bucket, providing a pool for the ISCO intake. ISCO collections from individual wells were not possible due to lack of equipment and space. Maintaining a continuous flow during the study also served to draw down the water table at each well to encourage groundwater and tracer dye movement.

C) *Sample handling and analyses*

All collections (water samples and charcoal receptors) were transported to the MDE Annapolis Field Office and stored appropriately until analyzed, which usually occurred within one week. Water samples (grab and composite) were maintained at room temperature in an enclosed container to prevent degradation due to ambient light. Charcoal receptors were collected using aseptic techniques, placed in individual plastic ziplock bags and manila envelopes, and refrigerated until elution procedures were conducted.

Charcoal receptors require an elution process (Appendix 1 *Elution Protocol*) to release any absorbed dyes so that analysis can occur. Elution procedures were conducted in MDE's biological laboratory located in Baltimore. The resulting elutant was analyzed for the presence of rhodamine WT dye, fluorescein, and Phloxine B, as were discrete water samples.

Eluted charcoal samples do not enable quantitative measurement of the amount of dye in the source water. Values are only semi-quantitative because many factors influence the quantity of dye absorbed by the charcoal, including dye concentration in the water, water quantity, water velocity, water temperature, duration of exposure, and turbidity. This study will adopt categories used by Center for Cave and Karst Studies of Western Kentucky University to interpret charcoal dye concentration rather than ppb (http://www.dyetracing.com/dyetracing/dy04005.html).

	Description	Expanded description for this study
ND	below quantification limit	net fluorescence less than 0.2ppb
B	background levels	net fluorescence less than 2x background value
+	Positive	net fluorescence greater than 2x background value
++	very positive	net fluorescence greater than 5x background value
+++	extremely positive	net fluorescence greater than 10x background value
NS	receptor not recovered	

Table 1. Description of categories used to report semi-quantitative rhodamine WT charcoal receptor results.

Qualitative analysis of samples occurred at MDE's biological lab using a Shimadzu RF-5301PC spectrofluorophotometer that emits spectra from its synchronous scan. The Shimadzu internally compensates for temperature. Spectrum integration and calibration curves stored in the computer are used in the qualitative analysis for fluorescein, Phloxine B, and rhodamine WT. Ranges of emission wavelengths that will be used to identify tracer dyes are listed in Table 2.

Dye	Normal Acceptable Emission Wavelength Range (nm) in water	Normal Acceptable Emission Wavelength Range (nm) in elutant
Fluorescein	508 to 513	514 to 518
Rhodamine WT	575 to 579	574 to 578
Phloxine B	553 to 560	557 to 563

Table 2. Emission wavelength ranges for tracer dyes.

2. *Background Fluorescence Collections*

A) Water samples

Fluorescence is the luminescence caused by radiation of some wavelength of energy immediately following the absorption of energy by a constituent. Analyses of ambient water were conducted to account for constituents that fluoresce at the same wavelength as tracer dyes used in the investigation. Charcoal receptors for background analyses were initially deployed on 9/25/03 and collection of grab water samples began on 9/26/03. Background collections continued through 11/5/03, just prior to dye inoculations (Table 3). A total of seven grab water samples were collected at each recovery point.

B) Charcoal receptors

A total of four background charcoal receptors were used at recovery points (instead of two) because additional charcoal receptors were used to address variable fluorescence in the first two receptors.

Date	Actions
9/25	Charcoal deployment
9/26	GRAB
10/2	GRAB& Charcoal collection/ deployment
10/7	GRAB
10/9	GRAB/ Charcoal collection
10/14	Charcoal deployment
10/21	GRAB& Charcoal collection/ deployment
10/28	GRAB/ Charcoal collection
11/5	GRAB

Table 3. Background sample collections.

3. Dye inoculation

Dye inoculation of sinkholes and septic systems occurred on 11/5/03 (Table 4). Inoculation of *septic systems* with fluorescein dye occurred after collection of final background grab samples to avoid background sample contamination. Dye was introduced into a septic system through the septic tank via an indoor fixture draining into the tank. Two *sinkholes* required water supplied by a water delivery truck for dye transport. Approximately 1000 gallons of pure spring water were used to inoculate sinkholes with 250g of phyloxine-b (Figures 3 and 4). Three liters of rhodamine dye were used to inoculate Meadow Brook (Figure 4). Table 4 lists details of each inoculation point.

Figure 3. Illustration of Phloxine B inoculation of sinkhole 1

Innoculation point	dye	dye volume	transport water volume added	date	time
Gymnasium septic	Fluorescein	1L	50+ gallons	11/5/03	0930
Adventure septic	Fluorescein	1L	50+ gallons	11/5/03	0945
School septic	Fluorescein	1L	50+ gallons	11/5/03	0955
Grace cottage septic	Fluorescein	1L	50+ gallons	11/5/03	1000
Shop septic	Fluorescein	1L	50+ gallons	11/5/03	1010
Sinkhole 1	Phloxine B	250g	1000 gallons	11/5/03	945
Sinkhole 2	Phloxine B	250g	1000 gallons	11/5/03	1010
Meadow Brook	Rhodamine	3L	NA	11/5/03	1050

Table 4. Dye inoculation details.

Figure 4. Illustration of Phloxine B inoculation of sinkhole 2

Figure 5. Illustration of rhodamine WT inoculation of Meadow-Brook

4. Post Inoculation collections

A) Water samples - GRAB

Grab samples were collected from recovery points following the dye release on days 1, 2, 6, 7, 11, 13, 14, 18, and 20. Sample times are listed in Table 5.

	Charcoal deployed	Charcoal collected	Grab water samples	ISCO automatic water samples
11/5	0915			Start program 0920
11/6			0945	replace bottles
11/7			1020	replace bottles
11/8				End program 0905
11/12	0925	0920	0925	
11/13			1140	
11/17			0930	
11/19	0910	0905	0855	
11/20			0925	
11/24			1000	
11/26		0940	1000	

Table 5. Post inoculation collections.

B) Water samples - ISCO

The ISCO program sequence previously described was initiated at 0920 on 11/05/03 and continued for 72 hours. Sample bottles were replaced with clean bottles every 24 hours to facilitate continuous sampling. The sample program was terminated on 11/08/03 following successful collection of 72 discrete water samples, representing hourly composites of aliquots drawn every 15 minutes.

C) Charcoal receptors

Charcoal receptors were immersed in 'flowing' water at most recovery points for 21 days following dye inoculation, replacing receptors every 7 days. Initial deployment of charcoal receptors occurred on 11/5/03 prior to dye inoculation. The third and final charcoal receptors from most recovery points were collected on 11/26/03, representing 21 days of continuous monitoring for trace dye amounts.

Results

1. Water samples - GRAB

The fluorescence of all post inoculation water samples was similar to background levels. Small increases in fluorescence intensity around 510nm (fluorescein-like) occurred in three upper rear (well 2) water samples. However, charcoal receptors deployed coincident with the collection of grab water samples did not confirm the presence of fluorescein dye and intensities were less than 2x-background fluorescence. Rhodamine-like peaks (575-579nm) occur in three-background grab samples collected just prior to dye inoculations. These rhodamine-like peaks were not discovered until after dyes were released. The peaks are considered anomalies because rhodamine dye was not detected in any post inoculation water samples.

2. Automated water samples - ISCO

Dyes were not detected in any of the 72 composite samples collected by the automated ISCO sampler.

3. Charcoal receptors

Charcoal results were confounded by high background fluorescence, inconsistent results between samples, and fluorescence peaks outside the acceptable ranges for tracer dyes (Table 2). While there were weak indications of dye presence, the results do not fully support this conclusion. Peaks at 618nm in all post inoculation receptors have been attributed isopropyl alcohol used during the elution procedures.

A small fluorescence peak at 552nm occurred in the third charcoal collected from the adventure well (Figure 7). While this peak could indicate a positive trace amount (>2x background fluorescence) of Phloxine B dye, the result is ambiguous because fluorescence was not detected in other charcoal receptors. Furthermore, the adventure well is not currently considered surface influenced, and background fluorescence is inconsistent.

Our initial conclusion that fluorescein entered the upper front was refuted by fluorescence peaks (520-521nm) that were outside the acceptable range for fluorescein when measured in an elutant (514-518nm). Furthermore, background fluorescence at this wavelength strongly confounds our initial conclusion. Background fluorescence sequentially decreases prior to dye inoculation. However, there is no way to distinguish the source of increased fluorescence after inoculation between our dye and the source of background fluorescence. The shop well (Figure 8) and the upper rear well (Figure 9) demonstrate no consistent patterns of fluorescence to indicate entry of dyes into the well water.

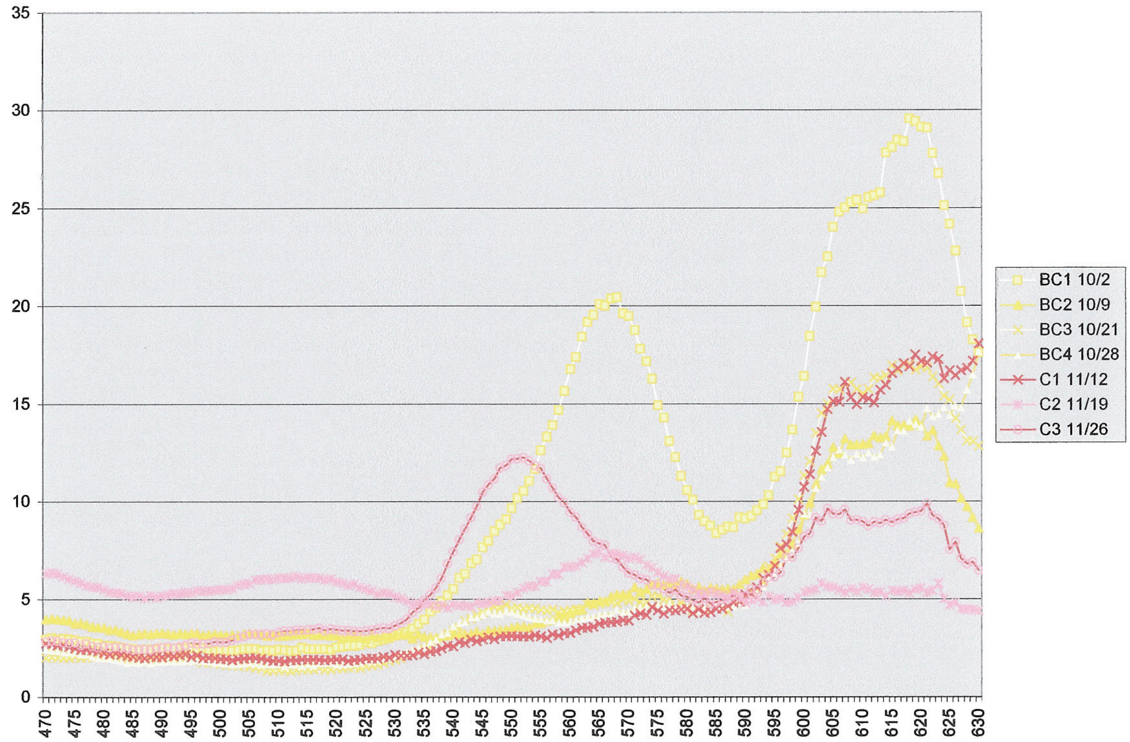


Figure 6. Graph illustrating fluorescence in the adventure charcoal receptors.

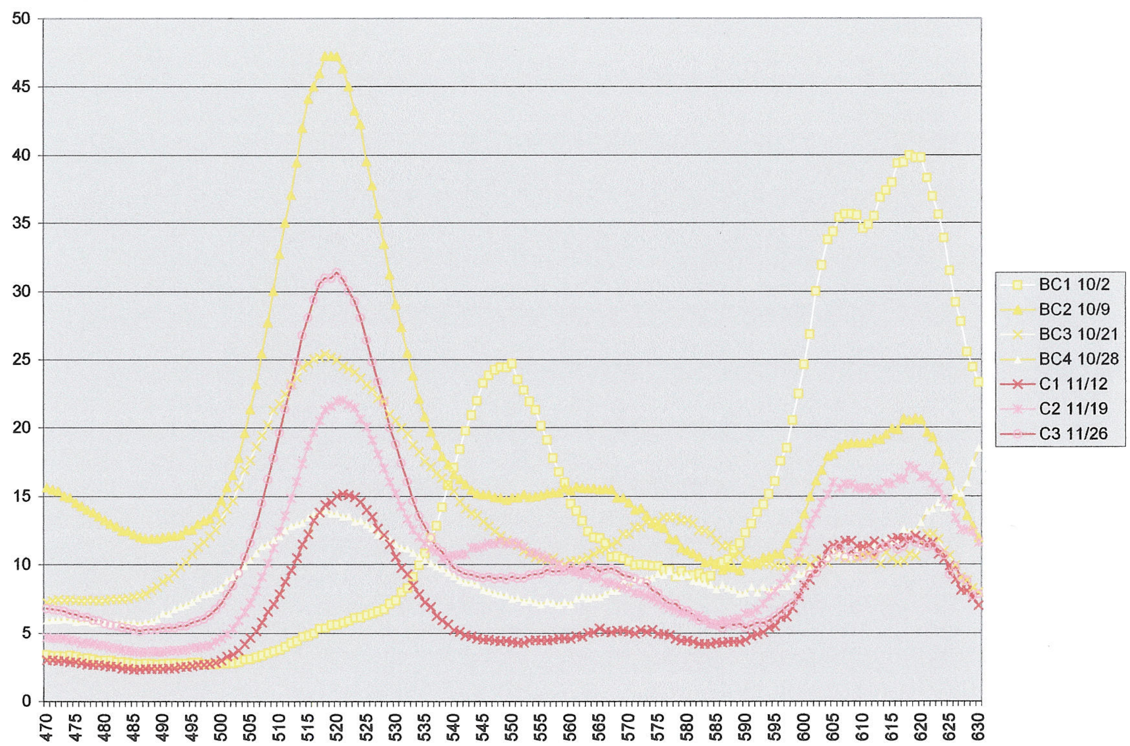


Figure 7. Graph illustrating fluorescence in the upper front charcoal receptors.

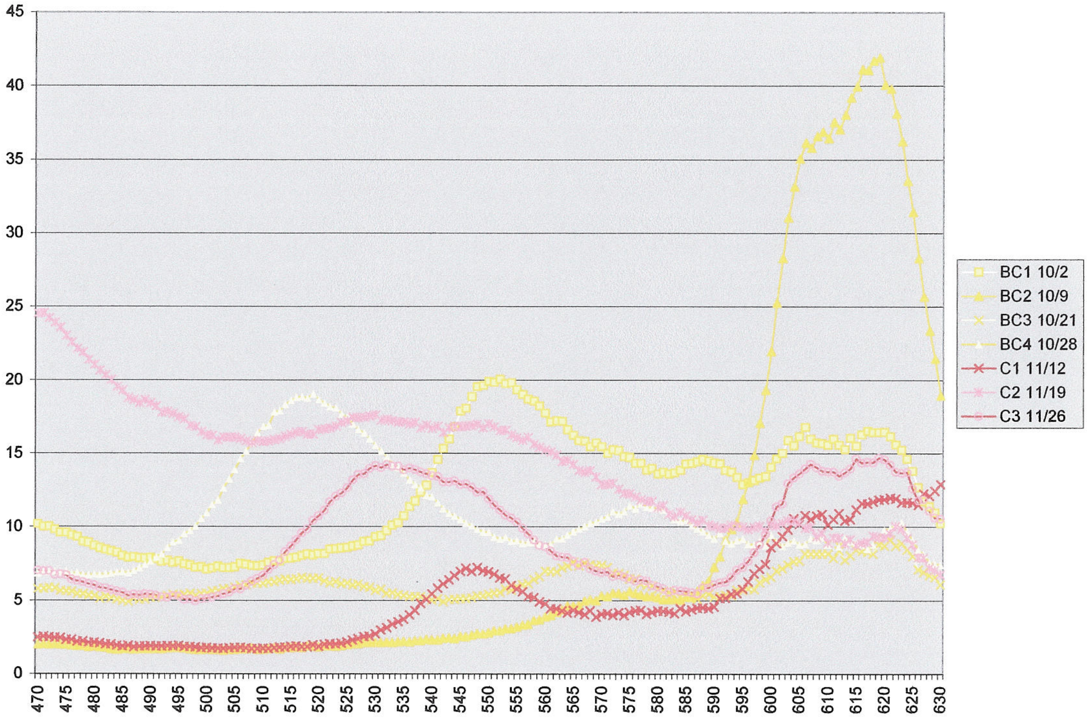


Figure 8. Graph illustrating fluorescence in the shop charcoal receptors.

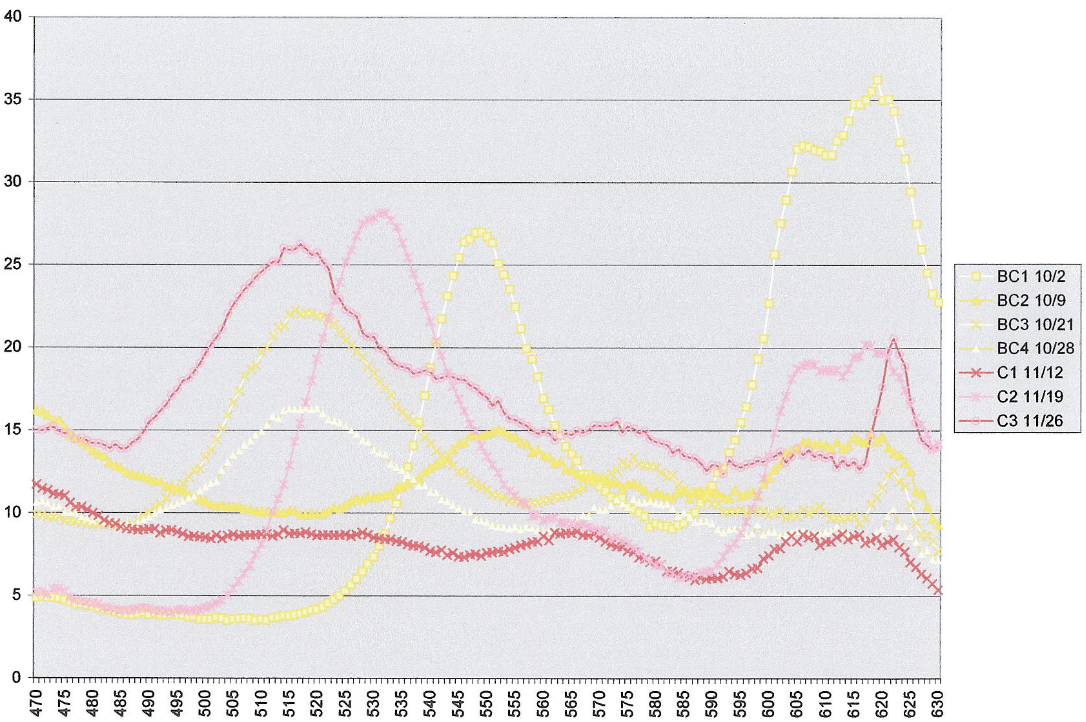


Figure 9. Graph illustrating fluorescence in the upper rear charcoal receptors.

Discussion

There is no obvious connection between well aquifers used by Cedar Ridge and on-site septic systems, surface water from Meadow Brook, or surface water from selected sinkholes to the north. There are many possible explanations for our inconclusive findings. The source responsible for bacteriological contamination may have been overlooked in this study. The study area is riddled with sinkholes that could potentially conduct water to well groundwater aquifers. Targeting all sinkholes was impractical and likely impossible due to their occurrence on private property. The study design may have limited our ability to detect tracer dyes. Perhaps greater quantities of dye or a greater length of recovery time were required to observe measurable dye concentrations in the wells. Inadequate precipitation during the study period may also have prevented adequate transport of dyes into ground water aquifers. It is also possible that the connection of old septic systems to a new wastewater treatment plant remedied the GWUDI problem before our study began.

The presence of variable background fluorescence greatly confounded our ability to detect trace amounts of dyes. Future dye studies could avoid this situation by altering experimental design. Additional background samples may be useful to confirm and monitor the intensities of ambient fluorescence. Shorter charcoal receptor deployment time periods and / or overlapping time periods may also help to confirm background levels. During this investigation, charcoal samples revealed no useful pattern of fluorescence.

Dye studies of this nature are best suited for small-scale investigations that address specific questions. Perhaps preliminary information gained from more regional data collection could help focus efforts to answer dye study questions more efficiently. Multiple antibiotic resistance (MAR) of bacteria entering a drinking water system could help focus dye tracing efforts on specific sources, (e.g., high resistance = human = septic systems, little or no resistance = wildlife = sinkholes). Chemical data from GWUDI groundwater systems collected over a variety of precipitation conditions could direct dye study activity to specific weather conditions. Water hardness variability is an indicator of the periodic introduction of surface water into groundwater (Duigon 2001). Water hardness data could be generated in the field using portable water chemistry labs. Regional groundwater flow investigations targeting specific sinkholes, springs, or streams under prescribed weather conditions could help determine predominant groundwater flow directions and therefore help elucidate contamination sources.

References

Duigon MT. 2001. Karst Hydrogeology of the Hagerstown Valley, Maryland. Maryland Geological Survey. Report of Investigations No.73. 128 p.

Appendix 1 *Elution Protocol*

MARYLAND DEPARTMENT OF THE ENVIRONMENT
SHIMADZU RF5301 INSTRUCTIONS FOR SAMPLE ANALYSIS
Fluorescein, rhodamine WT, and Phloxine B elution from activated charcoal

LABEL ELUTION CUPS TO MATCH SITE INFORMATION

MAKE ELUTANT WITH 5% $NH_4(OH)_3$ SOLUTION AND THE REMAINING 95% WITH 70%-ISOPROPAL ALCOHOL.

ADD AMMONIUM HYDROXIDE TO ALCOHOL AND TOP OF FOR NEEDED VOLUME (12 MILLILITERS OF ELUTANT PER 5 GRAM CHARCOAL PACKET.

ADD KOH FLAKES AND DISSOLVE UNTIL SUPERSATURATED SOLUTION DEVELOPS

RINSE CHARCOAL PACKETS THROUGHLY USING DEIONIZED WATER TO REMOVE SILT AND VEGETATION.

ANALYZE ELUTANT SOLUTION TO MAKE SURE NO FOREIGN FLUORESCENCE EXISTS

DECANT ELUTANT INTO DISPOSIBLE CUVETTE USING A DISPOSABLE PIPETTE. VERIFY OUTER EDGES OF CUVETTE ARE FREE FROM MARKS OR DEBRIS.

PLACE CUVETTE INTO INSTRUMENT AND PRESS START TO ANALYZE ELUTANT SOLUTION.

PRESS START TO ANALZE, MAKING SURE THERE ARE NO PEAKS BETWEEN 500 AND 600 NANOMETERS THAT ARE GREATER THAN 10.

ONCE VERIFIED, ADD ELUTANT TO CHARCOAL. SHAKE NYLON BAG TO REMOVE EXCESS WATER AND GET CHARCOAL TO BOTTOM OF PACKET.

CUT OPEN BAG AND PLACE CHARCOAL IN PLASTIC CUP, MAKING SURE NOT TO GET CHARCOAL IN OTHER CUPS.

USING LARGE GLASS SYRINGE FILLED WITH ELUTANT, PLACE 12 MILLILITERS OF ELUTANT INTO EACH CUP AND COVER.

MAKE SURE ALL CHARCOAL IS WET, AND THEN LET SIT FOR 60 MINUTES.
FOLLOW SAME PROCEDURES AS FOR ANALYZING ELUTANT