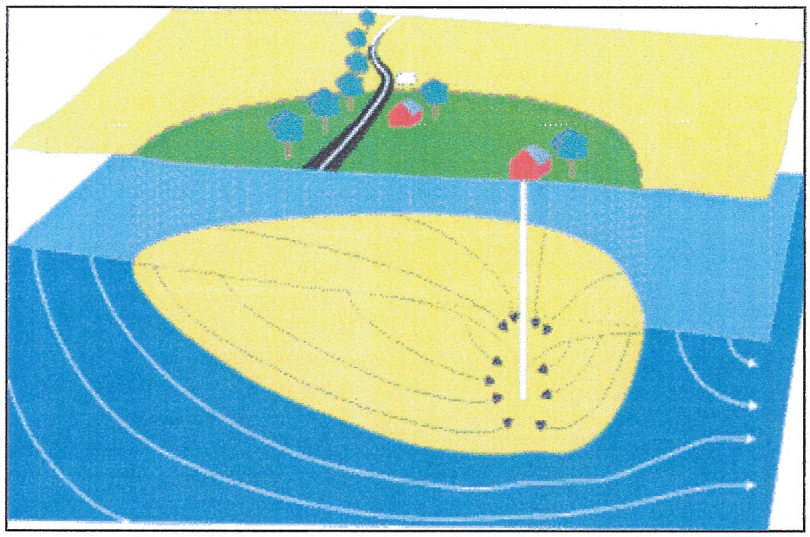
SOURCE WATER ASSESSMENT

FOR BENEDICTINE SCHOOL

CAROLINE COUNTY, MD



Prepared By
Water Management Administration
Water Supply Program
April 2005

MDE

Robert L. Ehrlich, Jr.
Governor

Kendl P. Philbrick
Secretary

Michael S. Steele
Lt. Governor

Jonas A. Jacobson
Deputy Secretary

TABLE OF CONTENTS

Page

Summary 2

Introduction 3

Well Information 3
Table 1. Benedictine School Well Information

Hydrogeology 3

Source Water Assessment Area Delineation 4
Table 2. Parameters used for the Wellhead Protection Area delineation

Potential Sources of Contamination 6
Table 3. Land Use Summary for the Wellhead Protection Area for Well 3

Water Quality Data 7
Table 4. Summary of Water Quality Samples for Benedictine School
Table 5. Nitrates exceeding 50% of the MCL
Table 6. Fluoride exceeding 50% of the MCL

Susceptibility Analysis 11
Table 7. Susceptibility Chart for Benedictine School's Well 3 Water Supply

Management of the Wellhead Protection Area 13

References 15

Other Sources of Data 15

Figures 16
Figure 1. Location of Benedictine School's Wells
Figure 2. Wellhead Protection Area for Benedictine School with Potential Contaminant Sources
Figure 3. Land Use in Bendectine School's Wellhead Protection Area

SUMMARY

The Maryland Department of the Environment's (MDE) Water Supply Program (WSP) has conducted a Source Water Assessment for the Benedictine Sisters of Saint Gertrude's Convent of Caroline County, known as Benedictine school. The major components of this report as described in Maryland's Source Water Assessment Plan (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 management of the assessment area conclude this report.

The sources of Benedictine's water supply are two Coastal Plan aquifers: the unconfined Federalsburg aquifer and the confined Aquia aquifer. One well is currently being used to pump the water out of each aquifer in approximately equal amounts. The source water assessment area was delineated for each well by the Water Supply Program using methods approved by the U. S. EPA.

Potential sources of contamination within the assessment areas were researched and identified based on MDE filed inspections, a review of MDE's databases and land use maps. Well information and water quality data were also reviewed. Maps showing land uses and sewer service areas in Caroline County and an aerial photograph of the well location are enclosed at the end of the report.

The susceptibility analysis for the Benedictine school is based on a review of the existing water quality data, the presence of potential sources of contamination, aquifer characteristics, and well integrity. It was determined that the Benedictine school's water supply is susceptible only to contamination by inorganic compounds, such as nitrate and naturally occurring fluoride. The system is not susceptible to volatile organic compounds, synthetic organic compounds, other inorganic compounds, radionuclides or microbiological contaminants.

INTRODUCTION

The Maryland Department of the Environment's (MDE) Water Supply Program has conducted a Source Water Assessment for the Benedictine Water System. The Benedictine School is located on the west side of Maryland Route 312, on the southeast side of Cherry Lane, in Oakland, Caroline County. The system is owned by the Benedictine Sisters of Gertrude and operated by Maryland Environmental Service (MES). It serves a population of about 300 day and boarding students and staff. Currently, the water is being pumped from two wells (Nos. 3 & 5) and treated at one plant located in the vicinity of the wells (Figure 1). Well No. 4 was taken offline in July of 2003 due to its high fluoride levels.

WELL INFORMATION

Well information was obtained from the Water Supply Program's database, site visits, well completion reports, and sanitary survey inspection reports and published reports. A review of the well data and sanitary surveys of the system indicates that both wells were drilled after 1973, when the State's well construction regulations went into effect, and meet current well construction standards for grouting and casing. Table 1 contains a summary of the well construction data. The database indicates that there is an unused well (#4) and another well that is being used for a ground water heat pump system.

SOURCE ID	SOURCE NAME	PERMIT NO	TOTAL DEPTH (ft)	CASING DEPTH (ft)	YEAR DRILLED	AQUIFER NAME
03	Benedictine Well 3	CO811934	75	45	1989	Federalsburg
05	Benedictine Well 5	CO880201	580	500	1991	Aquia

Table 1. Benedictine School Well Information.

HYDROGEOLOGY

The Benedictine School area lies within the Atlantic Coastal Plain physiographic province. This province, which in Maryland includes roughly the area east of Interstate 95, is underlain by unconsolidated clastic sediments of Lower Cretaceous to recent age, which thicken to the southeast so that they appear wedge-shaped. These sediments crop out in a concentric band that lies parallel to the Fall Line which marks the western boundary of the Coastal Plain. Benedictine School's wells pump water from the unconfined Federalsburg aquifer (well #3) and the confined Aquia aquifer (well #5).

Federalsburg is one of the Miocene aquifers that are the geologic units in the Chesapeake Group – a thick wedge of sediments between Columbia and Piney Point aquifers. The Chesapeake group sediments consist primarily of gray quartz sand and dark gray clay with abundant shell material. Transmissivity values have been reported between 170 and 470 ft^2/day. These sediments are a good source for the smaller water supplies due to their accessibility and excellent water quality, but are insufficient to meet large demands. The

quantity of water available from these sediments is very high but the water quality can vary dependant upon the local soil types and land use. Water quality impacts from farming and high-density development with on-site septic systems can lead to elevated nitrate levels. Residues of agricultural herbicides and pesticides are less common, but may be present in some wells. As expected in this shallow aquifer, the water is fairly acidic. Low pH (ranging from 3.8 to 6.7) along with high iron is a concern in some areas where there is more clay and silt. In these areas the percolation rate is slower allowing iron to dissolve in the water. Some sources have levels of iron high enough that the water must be treated before using (DNR, 1987).

The extent of the Aquia aquifer is limited to the northern and western borders of Caroline County and due to a change in composition, a poor aquifer in the rest of the county. In the northwestern part of the county where the Benedictine School is located, the top of the aquifer ranges from 400 to 500 feet below sea level and is about 100 feet thick. The Aquia is composed of fine to medium-grained sands, of varying composition that is generally quartz and glauconite rich with calcite cementation.
Due to the depth and areal extent of the unconsolidated sediments on the Eastern Shore of Maryland, water stored in these aquifers is very old and the water pumped from wells in these aquifers has generally traveled great distances from its origin at the land surface (Maryland Geological Survey Reports 1977, 1979, 1983, 1984, 1988, 1996, 2001). Transmissivity values range from 900 to 4800 sq feet/day.

SOURCE WATER ASSESSMENT AREA DELINEATION

For ground water systems, a wellhead protection area (WHPA) is considered to be the source water assessment area.

Well 5: The WHPA for this well was delineated using the methodology described in Maryland's Source Water Assessment Plan (1999) for confined aquifers in the Coastal Plain, often referred to as the "Florida Method". The area is a radial zone of transport within the aquifer and is based on a 10-year time of travel (TOT), pumping rate and the screened interval of the well and the porosity of the aquifer (see illustration below for conceptual model). The Florida Method is a modification of Darcy's Law for radial flow to a well and the WHPA was calculated using the following volumetric equation:

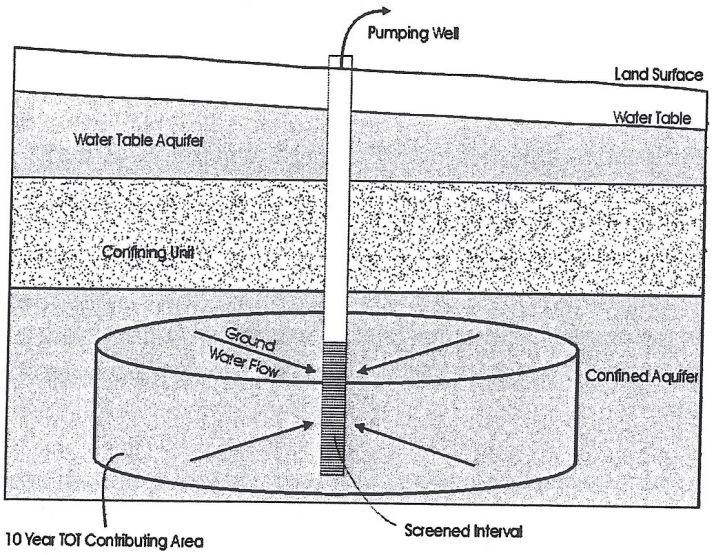
$$r = \sqrt{\frac{Qt}{\pi n H}}$$

where r = calculated fixed radius (ft)
Q = pumping rate of well (ft^3/yr)
n = aquifer porosity (dimensionless)
H = length of well screen (ft)
t = time of travel (yr.)

Benedictine school has two water appropriation permits, one for the withdrawals from Federalsburg aquifer and one for the withdrawals from Aquia aquifer. Table 2 gives the values used and the calculated radius for Well 5. The pumping rate (Q) used is the permitted daily average for the particular aquifer that the well is screened in. A conservative estimate of porosity (n) of 25% was used for each of the aquifers based on published report. The length of the well screen (H) was obtained from the well completion report. Using these parameters the radius was calculated for Well 5 with the above equation for the WHPA delineation. Well 5 has a screen length of 73 ft which resulted in a circle with a radius of 357 ft. The resulted SWAA for each of the aquifers is shown in Figure 2. The circle around Well 5 represents the aquifer zone of transport in the subsurface as illustrated below.

Well Name	Well pumpage (Q) in gpd	Well pumpage (Q) in ft3/yr	Screened interval in feet	Aquifer	Calculated radius for WHPA in feet	Comments on WHPA
BENEDICTINE SCHOOL WELL 5	15,000	731,898	73	AQUIA	357	Well #5 has a circle

Table 2. Parameters used for the Wellhead Protection Area delineation for Well 5



Conceptual illustration of a zone of transport for a confined aquifer

Well 3: The WHPA for the School's unconfined water supply Well 3 was delineated using EPA's WHPA Code version 2.0, a user-friendly two-dimensional ground water flow model. The model assumes uniform flow and calculates a capture area based on pumping rate and aquifer characteristics. The input values used in the delineation were: aquifer transmissivity (450ft^2/day), gradient (0.0001), direction of ground water flow (southeast), pumping rate (2005 ft^3/day), aquifer porosity (25%), and aquifer thickness (50 ft).

Delineation Zones

Zone 1: Zone 1 is the WHPA delineated using a 1-year time-of-travel (TOT) criterion. Zone 1 serves as a first zone of protection. The one-year criterion was selected based on the maximum known survival times of microbial organisms in ground water. The delineated Zone 1 WHPA is oval in shape and has a maximum diameter of 625 feet.

Zone 2: Zone 2 is the WHPA delineated using a 10-year TOT criterion. It would take any chemical contaminant present at the Zone 2 boundary 10 years to reach the well (if it moves at the same rate as ground water). Zone 2 provides adequate time for facilities outside the WHPA to address chemical contamination before it could reach the well. The delineated Zone 2 WHPA is oval in shape and has a maximum diameter of 1,960 feet.

POTENTIAL SOURCES OF CONTAMINATION

Sources of contamination at the land surface are generally not a threat to water supplies using confined aquifers (such as the Aquia) unless there is a pathway for direct injection into the deeper aquifer. Unused wells with corroded casings or wells without proper grout seals provide a pathway for contaminants present in the shallow aquifers at higher-pressure heads to migrate to the deeper aquifers. In the area around the School, there is little potential for other wells except those that are owned by the School itself. Therefore as long as there is no potential for direct injection into the deeper confined aquifers, Benedictine school's water supply from Well 5 should be well protected from ground water contamination.

Unconfined aquifers like the Federalsburg are in general more susceptible to activities on the land surface. Potential sources of contamination are classified into two types: point or non-point sources. Examples of point sources of contamination are leaking underground storage tanks, landfills, ground water discharge permits, feed lots, large scale feeding operations, and known ground water contamination 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.

Non-point sources are associated with certain land use practices such as pesticide and herbicide applications, land application of sludge or animal wastes, and row-crop farming, all of which may lead to ground water contamination over a large area. All of these potential sources of contamination are identified at the land surface and therefore have the potential to impact the shallow water table aquifer.

MDE Waste and Water Management databases were reviewed and a field inspection conducted to identify potential sources of contamination for this assessment. The field visit did not show any commercial land use within the wellhead protection area. Database search of Underground Storage Tank (UST) sites have revealed the presence of one on the school's property. UST sites are facilities that store petroleum on site in underground tanks registered with the MDE Waste Management Administration.

Based on the Maryland Department of Planning 2000 Land Use Map, two land use categories are identified within delineated WHPA for Well 3: institutional and cropland (Tables 3 & Figure 3).

LAND USE CATEGORIES	TOTAL AREA (acres)	PERCENTAGE OF WHPA
Institutional	9.02	84.5
Cropland	1.63	15.5
Total	10.65	100

Table 3. Land Use Summary for the Wellhead Protection Area For Well 3

A review of Maryland Office of Planning's Caroline County Sewer Map shows that the SWAP areas have no planned sewer service. The School has a wastewater treatment plant for treatment and disposal of its waste.

WATER QUALITY DATA

Water Quality data was reviewed from the Water Supply Program's database and system files 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 at or greater than 50% of a MCL, this assessment will describe the sources of such a contaminant and, if possible, locate the specific sources which are the cause of the elevated contaminant level. All data reported is from the finished (treated) water unless otherwise noted. The treatment currently used at Benedictine School is blending of water from the two wells (3 & 5) and hypochlorination for disinfection.

A review of the monitoring data since 1993 for Benedictine School's water supply indicates that it meets the current drinking water standards, but is just below the standards for nitrates and fluoride. The water quality sampling results are summarized in Table 4.

Nitrate		Fluoride		Other IOCs		VOCs		SOCs	
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 > 5 MCL 0%
127	56	123	97	6	0	15	0	2	0

Table 4. Summary of Water Quality Samples for Benedictine School

Inorganic Compounds (IOCs)

A review of the data shows that the only inorganic compound detected above 50% of an MCL are nitrate and fluoride. The water supplied to the School is a mixture of the two wells which each pump from the Federalsburg and Aquia aquifers. Previous water quality sampling data indicated that if all the water was only pumped from Well 3 it would exceed the MCL for nitrate which is 10 ppm, and if all the water was only pumped from Well 5 it would exceed the MCL for fluoride which is 4 ppm. In order to meet the MCLs for nitrate and fluoride the system pumps equal amounts from both the wells and conducts regular monitoring for nitrate and fluoride. The system discontinued using Well 4 which was screened in the Aquia, since it contributed to high levels of fluoride in the water supply. Nitrate levels exceeding 50% of the MCL in the water supply since 1993 are shown in Table 5 with values exceeding the MCL shown in bold print.

SAMPLE DATE	RESULT (ppm)
9-Feb-93	7.31
3-Mar-93	8.02
15-Apr-93	6.23
20-May-93	7.2
28-Jun-93	8.5
16-Jul-93	**10.2**
25-Aug-93	**12.6**
22-Sep-93	9.8
25-Oct-93	9.53
10-Dec-93	8.91
18-Feb-94	8.23
21-Apr-94	5.7
19-May-94	7.55
23-Jun-94	9.54
15-Jul-94	7.89
16-Jul-94	**10.2**
19-Aug-94	8.72
25-Aug-94	**12.6**
20-Sep-94	6.96
18-Oct-94	7.34
21-Nov-94	5.65
13-Jan-95	7.3
25-Oct-95	5.08
22-Oct-96	9.23
13-Nov-97	5.06
15-Dec-98	6.19
25-Feb-99	5.25
30-Jul-99	5.85
25-Aug-99	5.4
13-Sep-99	5.11
15-Oct-99	5.26
22-Nov-99	5.32
13-Dec-99	5.59
17-Jan-00	5.18
5-Jul-00	**10.2**
24-Jul-00	5.12
5-Dec-00	**11.0**
9-Jan-01	9.54
6-Feb-01	9.52
6-Feb-01	5.89
1-May-01	9.86
5-Jun-01	6.38
5-Jun-01	9.56
17-Aug-01	8.14
3-Oct-01	2.82
3-Oct-01	9.23
18-Dec-01	6.01
18-Dec-01	5.01
9-Apr-02	**11.3**
28-Jul-03	7.47
7-Oct-03	8.62
6-Feb-04	8.88
14-Jun-04	7.94
3-Aug-04	8.06
4-Oct-04	7.48
3-Dec-04	5.88
19-Jan-05	8.57

Table 5. Nitrates exceeding 50% of the MCL

Fluoride levels exceeding 50% of the MCL in Benedictines School's water supply since 1993 are show in Table 6 with two values exceeding the MCL in bold print. Fluoride also had a secondary standard of 2 ppm. The secondary standard requires public notification by the School to inform parents that consumption of water with fluoride levels above 2 ppm may result in dental fluorosis. Dental fluorosis is a brown staining and/or pitting of the permanent teeth. Since June 2003 all the fluoride levels detected have been below 2 ppm.

SAMPLE DATE	RESULT (ppm)
9-Feb-93	2.17
15-Apr-93	2.56
20-May-93	2.5
10-Dec-93	2.58
10-Jan-94	2.55
18-Feb-94	2.45
8-Mar-94	**4.75**
21-Apr-94	2.69
19-May-94	2.54
23-Jun-94	2.53
15-Jul-94	2.43
19-Aug-94	2.62
20-Sep-94	2.59
18-Oct-94	2.28
21-Nov-94	2.53
22-Dec-94	2.52
13-Jan-95	2.37
15-Feb-95	2.85
16-Mar-95	2.6
21-Apr-95	2.62
31-May-95	2.38
9-Jun-95	2.46
20-Jul-95	2.68
29-Aug-95	2.65
25-Sep-95	2.66
25-Oct-95	2.57
30-Nov-95	2.48
4-Dec-95	2.76
31-Jan-96	2.34
17-Apr-96	2.93
15-May-96	2.91
25-Jun-96	2.87
11-Jul-96	2.8
13-Nov-97	2.09
15-Dec-97	2.28
17-Feb-98	2.39
17-Mar-98	2.97
14-Apr-98	2.47
14-May-98	2.36
23-Jun-98	2.71
30-Jul-98	2.32
21-Aug-98	2.38
28-Sep-98	2.03
15-Oct-98	2.56
15-Dec-98	2.74
11-Jan-99	2.54
25-Feb-99	2.33
16-Mar-99	2.29
9-Apr-99	2.36
17-May-99	2.44
1-Jul-99	2.4
30-Jul-99	2.36
25-Aug-99	2.35
13-Sep-99	2.32
13-Sep-99	2.31
13-Sep-99	2.32
15-Oct-99	2.46
22-Nov-99	2.45
7-Dec-99	3.14
13-Dec-99	2.46
17-Jan-00	2.46
5-Jul-00	2.28
5-Jul-00	2.31
3-Oct-00	2.05
3-Nov-00	2.29
3-Nov-00	2.33
5-Dec-00	2.44
5-Dec-00	2.83
6-Feb-01	2.36
13-Mar-01	2.17
13-Mar-01	2.36
5-Jun-01	2.61

Table 6. Fluorides exceeding 50% of the MCL

SAMPLE DATE	RESULT (ppm)
5-Jun-01	2.65
10-Jul-01	2.87
10-Jul-01	3.14
14-Aug-01	3.38
16-Aug-01	2.98
18-Dec-01	2.49
18-Dec-01	2.49
18-Dec-01	2.00
26-Feb-02	3.70
26-Feb-02	2.01
26-Feb-02	2.01
20-Mar-02	2.13
9-Apr-02	3.77

SAMPLE DATE	RESULT (ppm)
7-May-02	2.23
21-May-02	2.84
9-Jul-02	2.67
8-Oct-02	2.40
14-Jan-03	2.49
17-Apr-03	4.92
17-Apr-03	3.42
7-May-03	3.20
7-May-03	3.17
7-May-03	3.07
7-May-03	3.05
24-Jun-03	2.68

Table 6 (contd). Fluorides exceeding 50% of the MCL

Volatile Organic Compounds (VOCs)

No VOCs have been detected in Benedictine School's water supply at the quantities equal to or greater than 50% MCL since 1993.

Synthetic Organic Compounds (SOCs)

No SOCs above 50% of the MCL have been detected in Benedictine School's water supply at the quantities equal to or greater than 50% MCL since 1993.

Radionuclides

No radionuclides above 50% of the MCL have been detected in Benedictine School's water supply.

Microbiological Contaminants

Routine bacteriological monitoring is conducted in the finished water for each community water system on a monthly basis and measures total coliform bacteria. Since Benedictine School's water supply uses disinfection for its treatment, the finished water data does not give much indication of the quality of raw water directly from the wells. Total coliform bacteria are not pathogenic, but are used as an indicator organism for other disease-causing microorganisms. A major breach of the system or the aquifers would likely cause a positive total coliform result despite disinfection and would require follow-up total and fecal coliform analysis. Benedictine School has been conducting routine bacteriological sampling, but no samples had any detection of total coliform bacteria.

SUSCEPTIBILITY ANALYSIS

One well serving Benedictine School obtains water from an unconfined aquifer. Unconfined aquifer wells are in general more susceptible to contamination from surface activities. For example, the use of fertilizers on surrounding agricultural fields is the most likely source contributing to the elevated nitrate levels in the School's water supply. If land use changes occur within the WHPA and surrounding area the system's susceptibility could change.

The other well serving Benedictine School's water supply withdraws water from a confined aquifer. Confined aquifers are naturally well protected from activity on the land surface due to the confining layers that provide a barrier for water movement from the surface into the aquifer below. A properly constructed well with the casing extended to the confining layer above the aquifer and with sufficient grout should be well protected from contamination at the land surface. Wells that are not being used or maintained will eventually corrode and provide a pathway for contaminants present in the shallow aquifers at higher-pressure heads to migrate to the deeper aquifers. Only improperly abandoned wells could cause a potential contamination threat to the supply.

The information that was used to conduct the susceptibility analysis is as follows: (1) available water quality data (2) presence of potential contaminant sources in the WHPA (3) aquifer characteristics (4) well integrity and (5) the likelihood of change to the natural conditions. The susceptibility of Benedictine School's water supply to the various contaminant groups is shown in table 7 at the end of this section.

Inorganic Compound (IOCs)

Nitrate has been detected in the Benedictine School's water supply provided by the Federalsburg well. The levels of nitrate have been consistently above 50% of the MCL and there has been no pattern of any increase or decrease with time. Sources of nitrate can generally be traced to land use. Fertilization of agricultural fields and residential lawns, and on-site septic systems are common non-point sources of nitrate in ground water. It is well documented by researchers at the United States Geological Survey (Denver et al, 2004) that fertilizers used on row crops contribute a significant amount of nitrates. In addition, Well 3(unconfined) is downgradient of land use designated by the Maryland Department of Planning as feeding operations (figure 3). If high numbers of animals are housed at this location animal waste may also contribute to the high nitrate in the water supply. Based on the history of nitrate testing results, it is evident that Benedictine School's water supply from the Federalsburg well **is** susceptible to nitrate, but **not** the other IOCs.

Fluoride has been detected in Benedictine's water supply at levels above 50% of the MCL. The presence of fluoride can be attributed to its natural occurrence in the Aquia aquifer. Since June 2003 the fluoride levels have dropped to below 50% of the MCL

probably to better blending of the water supplied by the two wells. Based on the consistent presence of fluoride in the water supply, Benedictine School's water supply from the Aquia aquifer **is** susceptible to fluoride but **not** to other IOCs.

Volatile Organic Compounds (VOCs)

No VOCs above 50% of the MCL have been detected in Benedictine School's water supply. Therefore, their water supply **is not** susceptible to volatile organic compounds.

Synthetic Organic Compounds (SOCs)

No SOCs above 50% of the MCL were detected in Benedictine School's water supply. Therefore, their water supply **is not** susceptible to synthetic organic compounds.

Radionuclides

No radionuclides above 50% of the MCL were detected in Benedictine School's water supply. Therefore, their water supply **is not** susceptible to synthetic organic compounds.

Microbiological Contaminants

Ground water is generally thought to be not susceptible to contaminants by pathogenic microorganisms due to the natural filtration ability of soil and aquifer material. There are no on-site septic systems in vicinity of Benedictine School's water supply well in Federalsburg formation. Based on coliform sampling data and the aquifer characteristics, the Benedictine School's water supply **is not** susceptible to bacterial or protozoan contaminants present on the surface, including Giardia and Cryptosporidium.

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 (Federalsburg)	YES	YES	NO	YES	YES
Fluoride (Aquia)	YES	YES	NO	YES	YES
Other Inorganic Compounds	NO	NO	NO	YES	NO
Volatile Organic Compounds	NO	NO	NO	YES	NO
Synthetic Organic Compounds	NO	NO	NO	YES	NO
Radionuclides	NO	NO	NO	YES	NO
Microbiological Contaminants	NO	NO	NO	NO	NO

Table 7. Susceptibility Chart for Benedictine School Well 3's Water Supply

MANAGEMENT OF THE WELLHEAD PROTECTION AREA

With the information contained in this report, Benedictine School's water system is in a position to protect its water supplies by staying aware of the areas delineated for source water protection. Specific management recommendations for consideration are listed below:

Public Awareness and Outreach

- The Consumer Confidence Report should list that this report is available to the general public through their county library, or by contacting the operator or MDE.

Monitoring

- Continue to monitor for all required Safe Drinking Water Act contaminants.
- Annual raw water bacteriological testing is a good check on well integrity.
- Review nitrate and fluoride samples carefully and note any increasing trends in concentration. Raw water samples should be collected from Well 3 for nitrates and Well 5 for fluoride to track the trends. Quarterly frequency is recommended.

Unused Wells, Managing Agricultural Sources of Nitrogen

- Conduct a survey of the WHPA and inventory any potential sources of contamination, including unused wells, that may not have been included in this report.
- An inspection should be performed to determine if animal waste is stored uncovered in the vicinity of the wellhead protection area for Well 3 (area marked as feeding operations on Figure 3). If animal waste piles are left uncovered, plans should be made to keep it protected from precipitation and applied in accordance with a nutrient management plan.
- Work with the Soil Conservation District/ Agricultural Extension Service to convert agricultural land around the School from row crop to pasture or hay or to take advantage of cost sharing for planting a fall cover crop. This would reduce the nitrogen leaching from the nearby fields to the underlying ground water resulting in and thereby eventually reducing nitrate levels.

Well Inspection/Maintenance

- Work with the County Health Department to ensure that there are no unused wells within the WHPA. An improperly abandoned well can be a potential source of contamination to the deeper Aquia aquifer. All unused wells must be abandoned and seal as per State well construction regulations.
- Water operation personnel should have a program for periodic inspections and maintenance of the supply wells and backup wells to ensure their integrity and protect the aquifer from contamination.

Changes in Use

- The system is required to notify the MDE Water Supply Program if new wells are to be added or increase in water usage is proposed. An increase in use or the addition of new wells may require revisions to the WHPA.

REFERENCES

Denver, J.M., Ator, S.W., Debrewer, L.M., Ferrari, M.J., Barbaro, J.R., Hancock, T.C., Brayton, M.J., and Nardi, M.R., 2004, Water quality in the Delmarva Peninsula, Delaware, Maryland, and Virginia, 1999-2001: U.S. Geological Survey Circular 1228, 30 p.

Maryland Department of the Environment, Water Supply Program, 1999, Maryland's Source Water Assessment Plan, 36 p.

Maryland Department of Natural Resources, 1987, The Quantity and Natural Quality Of Ground Water in Maryland, Water Resources Administration, 150 p.

Rasmussen, W. C., and Slaughter, T. H., 1957, The Water Resources of Caroline, Dorcester and Talbot Counties: The Ground-Water Resources, Department of Geology, Mines and Water Resources, Bulletin 18, 371p.

United States Environmental Protection Agency, Office of Ground-Water Protection, 1987, Guidelines for Delineation of Wellhead Protection Areas.

SOURCES OF DATA

Water Appropriation and Use Permit No. CO1949G003, CO1987G004
Public Water Supply Inspection Reports
Monthly Operating Reports
Monitoring Reports
MDE Water Supply Program Oracle Database
MDE Waste Management Sites Database
DNR DOQQ Ridgely NE and Price SE (1995)
USGS Topographic 7.5 Minute Quadrangle (Ridgely)
MD Department of Planning 2000 Caroline County Land Use Map

FIGURES

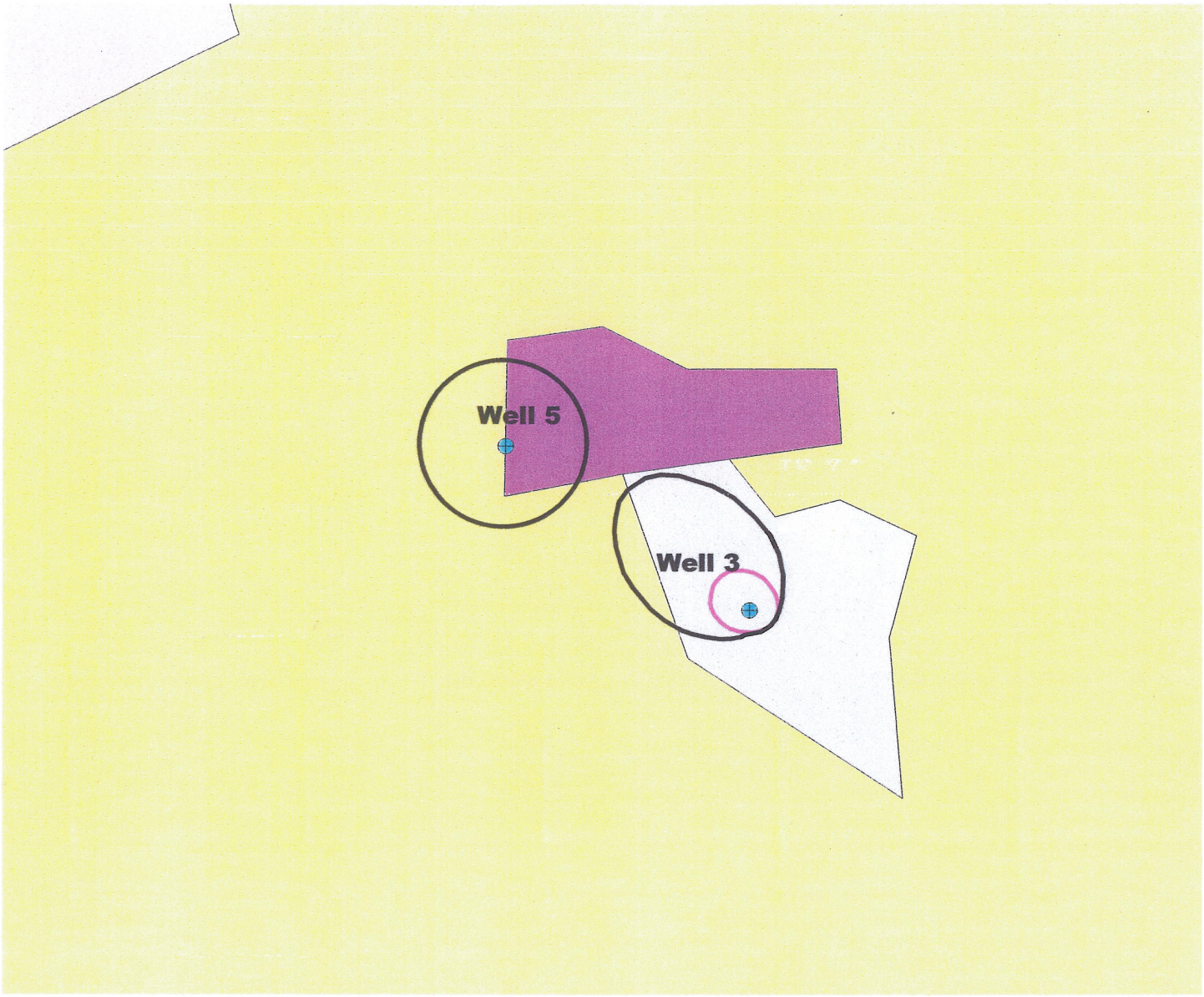


Figure 3. Land Use in Benedictine School's Wellhead Protection Area

LEGEND

- Supply Well

Wellhead Protection Area

- 1 yr TOT
- 10 yr TOT

Caroline County Land Use

- Low Density Residential
- Medium Density Residential
- High Density Residential
- Institutional
- Industrial
- Extractive
- Open Urban Land
- Cropland
- Pasture
- Orchards
- Forest
- Water
- Wetlands
- Feeding Operations
- Barren Land

500 0 500 Feet

N

Base Map: Caroline County Land Use Map (2000)